

POPULATION STATUS OF RAPTORS

Proceedings of the Conference on Raptor Conservation Techniques,
Fort Collins, Colorado, 22-24 March 1973 (Part 6)

*Joseph R. Murphy,
Clayton M. White, and
Byron E. Harrell, Editors*

With the assistance of—

William A. Burnham, Gervase Hittle, M. Allen Jenkins, James A. Mosher,
Steve K. Sherrod, Robert C. Whitmore, and Neil D. Woofinden

RAPTOR RESEARCH FOUNDATION, INC.

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The publisher of *POPULATION STATUS OF RAPTORS* is an organization with members in most states and Canadian provinces and Europe, Africa, Asia, Australia, and South America. It is a non-profit corporation whose purpose is to stimulate, coordinate, direct, and conduct research in the biology and management of birds of prey, and to promote a better public understanding and appreciation of the value of these birds.

Major activities are the publication of the quarterly *Raptor Research*, occasional *Raptor Research Reports*, an active committee structure and annual conferences.

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PREFACE

This volume is one of the results of the Conference on Raptor Conservation Techniques which was held on 22-24 March, 1973, at Fort Collins, Colorado, and was sponsored by the Raptor Research Foundation, Inc., and cosponsored by the Department of Wildlife Biology, Colorado State University, and the Colorado Division of Wildlife. The proceedings of the conference have appeared in parts as follows.

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The roles of the editors are as follows. The scientific review of all the submitted papers was done primarily by Murphy and White with the assistance of Burnham, Jenkins, Mosher, Sherrod, Whitmore, and Woofinden. Harrell edited the abstracts and the informal discussion, handled the managing editorial aspects and prepared the index, preface, and general format and design; Hittle provided assistance.

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FALCON

POPULATIONS

CURRENT STATUS OF THE PEREGRINE

IN NORTH AMERICA

Tom J. Cade

In September 1972 I received an astonishing request from the chairman of a committee of the National Research Council. He asked if I would document as thoroughly as I could the present status of the Peregrine, because a highly placed officer of the National Academy of Sciences had confronted his committee with the doubt that the Peregrine has actually declined in North America, based on information he had received in letters from falconers! Evidently even a scientist of prestige may be unwilling to accept a scientifically verified event, if he chooses not to believe it on some other grounds.

This is the report, somewhat updated, that I made to the committee; and it can serve as an introduction to the papers that follow on the Peregrine.

The present status of the Peregrine Falcon (*Falco peregrinus*) in North America can be summarized most clearly by dividing the original breeding range into five geographic subdivisions, in which falcon populations have experienced different degrees of decline since the late 1940's: (1) the United States and southern Canada east of the Rocky Mountains and south of the boreal forest; (2) the western United States from the Rockies to the Pacific Coast; (3) Mexico and Baja California; (4) the Pacific Northwest Coast and the Aleutian Islands; and (5) the subarctic and arctic regions of Alaska, Canada, and Greenland.

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1. **Eastern North America south of the taiga.**—Except for one aerie (nesting place) in southern Alberta, which Richard Fyfe of the Canadian Wildlife Service has under observation, there is no *known* breeding pair of Peregrines anywhere in the region east of the Rocky Mountains and south of the boreal forest in Canada and the United States. I know most of the older falconers who used to visit the aeries in eastern North America, some of the egg-collectors (those who are still alive), and all of the biologists who study the Peregrine. I do not know a single one who would deny this central fact. Even Frank Beebe (1971), the falconer who is the most outspoken protagonist for the non-endangered status of the Peregrine in North America, fully acknowledges that a major decline has occurred in southern Canada and the coterminous United States.

This situation has existed at least since 1964, when J. J. Hickey had a resurvey done on 146 of the 209 previously known aeries in the United States east of the Mississippi River (Berger *et al.* 1969). Not a single pair of falcons could be found. Since then many ornithologists and falconers have tried to locate an active aerie in the east without success. For example, W. R. Spofford—one of the foremost authorities on the eastern Peregrine—visited over 50 old aeries in New York and New England in 1970 and found not a single nesting pair, although he did find single, adult falcons at two cliffs. This past summer, S. A. Temple and I checked over a dozen old aeries along the north and south shores of the St. Lawrence and on the Gaspé, including Bonaventure Island; we saw a single falcon at one cliff but no active nest. The same situation prevails throughout eastern Canada—Ontario, southern Quebec, and the Maritimes (Cade and Fyfe 1970).

In the total region east of the Rockies and south of the taiga there were formerly about 391 known aeries, 275 in the United States and 116 in Canada, of which 85 to 90 percent could be expected to be occupied in any given year (Hickey 1942). In short, the eastern *anatum* or “Appalachian” Peregrine is virtually—if not quite—extinct.

2. **The western United States.**—The situation is not quite so bleak in the West, but even there the decline has been severe. For example, in 1964 Enderson (1969) found only 19 out of 51 aeries occupied in Alberta, Montana, Wyoming, Colorado, and New Mexico, but four of them had single adults only so that no more than 33 percent of the aeries were potentially productive. In 1969 he found only 10 out of 50 aeries in Montana, Wyoming, Colorado, New Mexico, and Arizona occupied (Cade and Fyfe 1970). A state by state listing is now possible for most of the western region.

Montana. There has been one, well-documented, active, producing pair for the last three years (J. Craighead *in litt.*), but according to falconers there may be as many as five cliffs presently occupied (M. W. Nelson, *in litt.*). Formerly there were at least 13 active aeries as late as the 1950's (Enderson 1969).

Wyoming. Neither the present nor the past situation in this state is well-

known. The Peregrine apparently was never common in Wyoming, perhaps four to eight active aeries 20 to 30 years ago, and recent observations by falconers, mountain-climbers, and others indicate that Peregrines are still seen at two or three cliffs in the mountains (W. J. Higby, Wyoming Fish and Game Commission *in litt.*).

Colorado. Eighteen to 20 aeries are known to have been occupied in this state. In 1972 J. Enderson (*in litt.*) had seven pairs under observation, but not a single one of them is known to have produced young; and two other pairs reported to me by C. M. White (*in litt.*) also failed to produce young.

New Mexico. Formerly there were at least six known aeries; in 1972 two pairs produced young (Tom Smylie, U. S. Forest Service, and F. M. Bond, *in litt.*), and there are unconfirmed reports that three other aeries were also active in 1972. One of the original six Peregrine cliffs has been taken over by Prairie Falcons.

Texas. There are at least four to five breeding pairs in the Big Bend region (C. G. Hunt, University of Texas, *in litt.*), where numbers do not seem to have changed in recent years. These pairs may represent a northern segment of a sparsely distributed breeding population in the Sierra Madre Oriental, where the Peregrine is known to breed as far south as 24 degrees N. in Tamaulipas (Wm. Wimsatt, in Hickey 1969).

Idaho. Two pairs of Peregrines were active at cliffs in 1972, and at least one of them fledged young; a single adult was present at another cliff (M. W. Nelson, *in litt.*). Formerly there were eight to nine active aeries in Idaho.

Utah. This state has been the subject of a detailed study by Porter and White (1973). Thirty-two to 40 nesting places were occupied in the past, most of them into the 1950's. A single pair fledged young in 1970, but no Peregrines are known for certain to be breeding in Utah at the present time, although there are unconfirmed reports of two active aeries in northern Utah in 1972 (M. W. Nelson, *in litt.*) and one in southern Utah in 1973 (C. M. White, *pers. com.*).

Nevada. I have no recent information for this state, but the Peregrine was always a very rare breeder in Nevada, with one certain and two other possible historical sites (Linsdale, 1936; Wolfe, 1937).

Arizona. This state has a list of approximately 15 aeries where Peregrines have nested at one time or another (A. R. Phillips, *in litt.* and D. Prentice), although occupancy of these sites seems to have been less constant than in most parts of the range, and Prairie Falcons have frequently alternated with Peregrines in the use of many of these aeries. Frank Bond and I visited seven of these areas in May of 1972. We saw a single, adult female at one place, and one

of the sites that we visited in southern Arizona had had a pair present earlier in the year (J. Enderson, *in litt.*), but the falcons were gone in May. In addition, two other sites in northern Arizona are known to have been occupied by Peregrines within the last two to three years (J. Murphy, Brigham Young University). There may be four to five pairs still occupying aeries in Arizona, but nothing is known about their reproductive performance.

Washington and Oregon. The current number of nesting pairs in these states is not well established, although Nelson (1969) estimated that the active aeries had already been reduced to 10 to 20 percent of the original number by 1965 in all of the northwestern states. Formerly there were 13 pairs nesting along the Columbia River palisades alone, plus additional pairs up and down the coastlines of Washington and Oregon, as well as scattered pairs around inland lakes such as Malheur and Crater lakes. The total number of known aeries for these two states falls between 33 and 38. One to three pairs are estimated to be still present in Washington (J. B. Lauckhart, Chief, Division of Game Management, *in litt.*; M. W. Nelson, *in litt.*), but some falconers claim to know more, while two pairs are said to have fledged young in Oregon in 1972 (M. W. Nelson, *in litt.*).

Nelson (1969) provided rather convincing evidence that an early decline in Peregrine numbers in the northwest, intermontane region—antedating the DDT-era—correlates with unfavorable climatic changes that occurred in the 1930's and 1940's, higher average temperatures and lower precipitation. These climatic trends have been dramatically reversed in more recent years, and habitat favorable to the Peregrine's chief prey, waterfowl and shorebirds, has returned to this region on a significant scale. Nelson (*in litt.*) now feels that the Peregrine may be starting to make a comeback in this region.

California. The information for California is rather more complete than for most states, thanks to the early work of R. M. Bond (1946) and the recent surveys by S. G. Herman for the California Department of Fish and Game. There are 98 verified aeries where Peregrines are known to have laid eggs or produced young in California and an additional 84 "rumored" sites (Herman *et al.* 1970; Herman 1971). In 1970 a careful search at 62 of the known aeries produced only two successfully breeding pairs and single adults at two other cliffs. The total breeding population in California—once the center of high density for the Peregrine in the west—is probably not more than ten pairs.

To summarize for the western states, there used to be at least 238 to 346 aeries where Peregrines nested. Today not more than 30 to 50 of these cliffs are still being used by Peregrines. In other words, only less than 20 percent of the breeding population present before the 1940's is still extant, and many of the remaining pairs are not reproducing successfully.

3. **Mexico and Baja California.**—The Peregrine reaches the southern limit of

its breeding distribution in North America between 23 degrees and 24 degrees N. latitude in Baja California and Tamaulipas, Mexico. The population status of the species has never been adequately determined for Mexico proper, where it is considered to be a rare, sparsely distributed breeder. It may be somewhat commoner in the sierras than generally supposed, especially along the escarpments of the east slope of the Sierra Madre Oriental (M. W. Nelson, *in litt.*).

The Peregrine is much better known in Baja California, where Banks (1969) was able to compile a list of between 55 and 66 known nesting places. A good deal of unpublished information exists for the period of the late 1960's and 1970's, but in deference to the investigators who keep the data to themselves I can only present a general outline of the situation. Apparently no pairs are known to be breeding on the Pacific side, where at least 24 old aeries are recorded, and other information indicates that the Peregrine population of Baja has experienced about a 50 percent reduction in numbers since the 1940's. High DDT residues in eggs, thin eggshells, and poor reproductive performance characterize the surviving population (Risebrough, in Hodson 1971).

4. The Pacific Northwest and Aleutian Islands.—This maritime region constitutes one of the last great strongholds for the Peregrine in North America. The falcon (*F. p. pealei*) is relatively common in many parts and locally reaches the highest densities known in the Western Hemisphere, mostly on islands. Except for one locality, there is no indication of serious population decline anywhere within this region. In the period 1965 to 1967 there were 43 aeries known to be active in the Queen Charlotte Islands and 60 other possibilities where adult falcons were seen at cliffs (Blood 1968, Beebe 1969). Only on Langara Island has a marked reduction in the number of pairs been noted, from approximately 15 in the 1950's to six pairs in the late 1960's (Nelson, in Cade and Fyfe 1970). The reasons for this reduction are not clear, but perhaps Wayne Nelson will be able to enlighten us later on.

The situation in southeastern Alaska is not well known, except that most of the large islands in the Alexander Archipelago do not support any significant numbers of breeding Peregrines (Cade 1960). On the other hand, the Aleutian Islands have been under rather intensive study for the past few years, owing to the AEC program on Amchitka and to the renewed interest of the U. S. Fish and Wildlife Service in cataloguing information on the islands in the Aleutian Wildlife Refuge in connection with their potential designation as "wilderness areas." As a result of four seasons of study on Amchitka and neighboring islands, C. M. White (see in Cade and Fyfe 1970; White *et al.* 1971, 1973) is now the main authority on the Peregrines of this region. He has found an average of about one pair of Peregrines per five or six linear miles of coastline on these islands. Based on that average figure, there could be between 300 and 500 pairs of Peregrines in the Aleutian Chain and islands adjacent to the Alaska Peninsula. The reproductive rate is high in this region, and there is no indication of any population change within recent years. This healthy condition is associated with relatively low DDT residues in falcon eggs, low levels in prey species, and only

slight eggshell thinning (Cade *et al.* 1971; White *et al.* 1973).

5. Subarctic and arctic regions.—The great bulk of the Peregrine's breeding population in North America has always nested in the boreal and arctic regions and "wintered" south of the United States, as far as Argentina. It is, therefore, a highly migratory segment of the continental breeding population. No one has any precise idea how large this population is (Cade, 1971a), although various estimates have been made. I once estimated 5,000 to 10,000 adults for all of North America, stating that probably not more than 1,500 to 3,000 nest south of 50 degrees N. latitude (Cade 1960), but I made that statement before the full extent of the decline in temperate latitudes was known. On that basis, my original estimate for the northern regions, including the northwest maritime populations, works out to be 3,500 to 7,000 adult breeders or 1,750 to 3,500 pairs. Fyfe (1969) estimated over 7,500 breeding pairs for northern Canada, but his figure is based on sample densities involving only 196 recorded aeries and on very large extrapolations to unknown territory. Extensive information on Greenland is still lacking, but an expedition headed by Wm. G. Mattox to western Greenland in 1972 has revealed a substantial density in one, local region coupled with good reproductive success (Mattox *et al.*, 1972), indicating that there may be a sizeable population in western and southern Greenland, as indeed the migrant population along our Atlantic Coast in the fall has suggested for a long time (J. N. Rice, in Hickey 1969; Ward and Berry 1972). Excluding the northwest, maritime and Aleutian populations, I still feel that 1,000 to 2,000 pairs is the right "order of magnitude" for the number of Peregrines breeding in subarctic and arctic regions of North America (see Cade 1971b).

A question that has produced a great deal of controversy and misrepresentation of information is whether these northern Peregrines have also suffered a decline in numbers, and if so, to what extent, and whether they should be officially designated as an "endangered" subspecies (see Beebe 1971; Cade 1971a and b). A rational answer to the question has been obscured by at least three factors. The first has to do with the meaning of the term "endangered" (see Cade 1971a). The second relates to various sorts of "vested interests" (falconers who want to keep taking Peregrines for their sport, researchers who want to keep on studying falcons, and people with agri-business interests who want to keep on using and selling DDT). The third factor has to do with the fact that the ecology of these northern falcons is complicated because they are long-distance, transequatorial migrants and because breeding success and population density in the Far North are often influenced by yearly vagaries in weather and food supply.

For instance, J. L. Ruos (unpub. report, 1970) has shown a highly significant correlation between the mean daily minimum July temperatures in the eastern Canadian arctic and the number of immature, migrant Peregrines observed per party-day in October along the Atlantic Coast of the United States in the period from 1960 to 1969. These results strongly suggest that cold weather in July, when Peregrines are caring for small, downy young in the North, adversely af-

fects survival. Late springs and cold spells with snow squalls or ice storms in summer are not unusual phenomena in the Far North, and their effects on nesting success certainly could make it difficult to see the influence of any factor that might operate to produce a long-term decline.

Nevertheless, local reductions on the order of 50 percent or more in the numbers of pairs of sampled breeding populations have been reported for three locales in Alaska—the Colville River, the Yukon River, and the Tanana River (Cade and Fyfe 1970; Cade *et al.* 1971)—and for five in Canada—the environs of Yellowknife, the District of Mackenzie, the Interior Barrens, Yukon Territory, and Ungava (Fyfe 1969; Cade and Fyfe 1970). While the trend has been downward in some of these populations for the past four to five years, or more, it is perhaps too soon to be certain that these changes represent the beginning of the same sort of serious decline that has occurred in the more southerly *anatum* populations. What is certain is that these populations have for several years been reproducing at a low rate—less than one young fledged per starting pair—the body tissues and eggs of northern Peregrines contain extremely high levels of DDT residues (in the form of DDE), and their eggs have shells that are 20 or more percent thinner than samples from the same regions prior to 1946 (Cade and Fyfe 1970; Cade *et al.* 1971).

Recent data obtained by J. W. Weaver (unpub. report to Quebec Wildlife Service) for Ungava Bay in 1972 are consistent with these generalizations. In 1967 he and D. D. Berger found 13 aeries with a total of 22 young (in 10 nests) and eight eggs; only one pair lost its eggs that year. In 1972 at the same 13 aeries, five nests contained ten young and one addled egg, two nests failed, and falcons were absent from the other six sites.

While the data on the autumn passage of Peregrines along the Atlantic Coast indicate that a sizeable number of falcons is still involved (Shor 1970), Ward and Berry (1972) have compared their recent trapping results and observations on Assateague Island in 1970 and 1971 with those of A. G. Nye, Jr. for the years 1939-1949, and they have added their data for 1972 in the paper that follows in this program. Their comparison indicates that the number of fall migrants in the 1970's is significantly less than in the years before 1950. It is conceivable that habitat changes and developments on the island could have modified the migratory habits of the Peregrines passing along its shores, but Berry (pers. com.) does not think so, because many of the Peregrines appear to strike the island as their first landfall after an overwater flight.

All of these facts about the northern Peregrines fit the now well documented relationship between DDT residues, thin eggshells, reproductive failure, and population decline for temperate zone *anatum* populations (Hickey and Anderson 1968; Hickey 1969) and for the Peregrines of Great Britain (Ratcliffe 1967, 1969, 1970, 1972). Indeed, the total picture of population changes in North American Peregrines parallels to a remarkable degree the pattern of changes that have occurred on a smaller geographic scale in the much denser falcon population of Great Britain.

Conclusion

The future of the Peregrine in North America no longer appears completely hopeless to me. In the East, there are a few summering falcons widely scattered along the United States-Canadian border and even farther south. While their origin is not known, these birds might—just possibly—reconstitute a nuclear breeding population in the years immediately ahead. Some pairs still breed successfully in the West, and we may have seen the bottom of the decline in this region around 1969-70, possibly earlier. There is some suggestion that a few aeries are being reoccupied in the northwestern states. The maritime Peale's Falcon stands virtually unchanged in numbers from pristine times; and it appears likely that our far northern Peregrines will level off at something like 50 to 75 percent of their former numbers. Hopefully the Peregrine may begin a comeback now that the use of DDT has been curtailed in the United States; but if the parallel with Great Britain holds in the build-up phase, we can only expect a very slow increase in the 1970's, unless we are prepared to give the species some help through the application of the principles of wildlife management.

"As a wild species, the Peregrine seems to be greatly menaced by certain aspects of modern civilization. The exact nature of the combination of forces that have brought entire populations in widely separated parts of the world to near extinction are not completely known and will probably never be known unless a domestic-bred population can be produced for controlled research" (F. L. Beebe 1967:61).

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*CHANGES IN THE PEREGRINE POPULATION
AND ITS SEA BIRD PREY AT
LANGARA ISLAND, BRITISH COLUMBIA*

R. Wayne Nelson

M. T. Myres

ABSTRACT. The resident population of Peregrines (*Falco peregrinus pealei*) at Langara Island, British Columbia, has been known to naturalists for over half a century. Reports indicate that, until recently, the numbers of falcons here have always been high. In the early 1950's the population was probably just over 20 territorial pairs. A decline appears to have set in during the late 1950's.

Between 1968 and 1972 the population has fluctuated between 5 and 6.5 territorial pairs. Biocide levels in addled eggs are substantial. Eggshells are at least 11-12% thinner than pre-1947. Productivity is not good. Of the eggs laid, 15.6% vanished during incubation, 20.0% failed to hatch, and 11.5% died as nestlings. Several instances of the simultaneous death of all brood-mates have occurred; an internal mechanism, via a pollutant, is suspect.

Compared to data from the 1950's, the falcons now experience more nest failures and produce somewhat fewer nestlings and fledglings per successful pair and per occupied site. The productivity does appear to be adequate to maintain (perhaps even increase) the population; a number of yearlings are seen each spring, and some new adults have appeared.

Territory sizes are large and there is a tendency to increase the size of terri-

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tories at the expense of neighbors. A form of pseudo-polyandry has appeared at two sites, preventing the males from forming new pair bonds after losing their mates.

The Ancient Murrelet (*Synthliboramphus antiquus*), the principal prey species of these falcons, has suffered a great decline in the last 20 years at Langara Island, the cause of which is not yet clearly understood. This decline appears to be linked to the murrelet's food supply—either by biocides affecting plankton (probably via the Davidson Current flowing north from California) or by an anomalous intrusion of warm water near the British Columbia coast for most of the period 1957-1971, reducing the supply of plankton. The murrelet decline is considered to be the immediate cause of the falcon decline.

It seems inconceivable that the Langara Peregrine population will be able to rebuild to its former numbers at any time in the foreseeable future. If the murrelet decline continues, it is probable that the Langara Island Peregrine population will dwindle even further, and perhaps vanish altogether.

Introduction

At Langara Island, northernmost of the Queen Charlotte Islands on the Pacific coast of British Columbia, there is a Peregrine (*Falco peregrinus pealei*) and seabird population that has been known to naturalists and ornithologists for over half a century. This paper will outline some of the changes in the size and productivity of the falcon population, the changes in the prey population and the possible causes of these changes.

On the Queen Charlotte Islands (Figure 1), the Peregrines appear to be resident year round, and their presence is closely linked to the presence of large numbers of potential prey in the form of auklets, murrelets and petrels which breed in spring and summer in burrows on parts of the Queen Charlotte coastline.

Size of the Falcon Population

Green (1916:473), visiting Langara Island for the purpose of collecting eggs, counted "thirteen eyries at the north-west corner of the main island [Graham Island] and on the rocky shores of Langara Island, just across Parry Passage . . ." A few years later, Allan Brooks (1921, 1926) mentioned being able to hear three broods calling from one vantage point on Langara, and "On North Island [Langara] in the breeding season one is never out of hearing of the birds . . . and probably thirty-five pairs nest on the twenty-five miles of coast-line of this small island alone" (Brooks 1926:77).

In 1937, Brooks wrote Joseph Hickey, stating, "On Langara (North) Island, which is only 8 miles long by 4 at its widest part, there are probably 40 nests occupied. In 1936, over 20 of these were climbed to by a visiting naturalist. The number of eggs was 4 in nearly every case." Unfortunately, neither Brooks' nor Green's accounts give a clear picture of just what portion of the coastline of Langara they actually covered while looking for falcons. In any event, both were greatly impressed with the size of the falcon population.

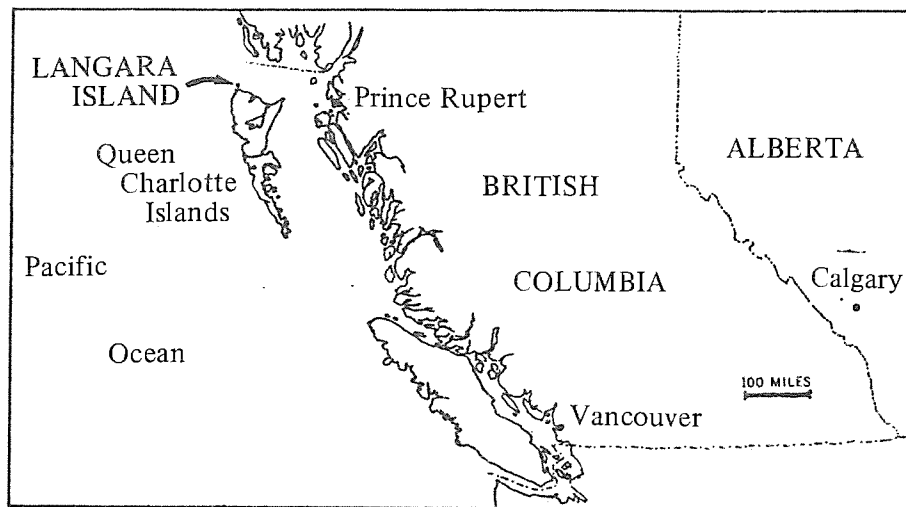


Figure 1. The Queen Charlotte Islands and Langara Island off the west coast of British Columbia.

In the 1950's, during five different years, Frank Beebe (1960) visited Langara Island. Beebe checked almost two-thirds of the coastline of Langara in most of the years he was there, and from the area he did not cover, C. J. Guiguet provided information on three additional sites which had been observed to be occupied. In 1952 Beebe recorded 13 occupied sites (see Beebe 1960: 173, Table 2); if the three Guiguet reported were also occupied that year, then 16 were known in the early 1950's (Figure 2).

For comparative purposes we restrict our interest to the two-thirds of the island that Beebe most frequently personally visited, the area containing the 13 occupied sites in 1952. In 1958, when visited by Beebe, this area contained five unoccupied sites, seven occupied sites, and one site was not checked (this site, on Cox Island, was almost certainly occupied). That is, when Beebe's Table 2 is reorganized to allow comparison between the different years, it becomes evident that rather suddenly (between 1957 and 1958) his study area population changed from one or two (probably two) unoccupied sites to five or six (probably five) unoccupied, out of the 13 falcon sites known in 1952. Table 1 presents Beebe's data in a different manner so that the changes through the years are more readily seen. The year 1958 may be important.

In 1966, 1967, and 1968 the British Columbia Fish and Wildlife Branch surveyed Langara Island (and other parts of the Queen Charlottes) for falcon eyries. Blood (1969:250), in summarizing the Langara results for these years, reported that "As only seven active eyries could be located at Langara in each of the years 1966 and 1967, and only five in 1968, it is apparent that there has

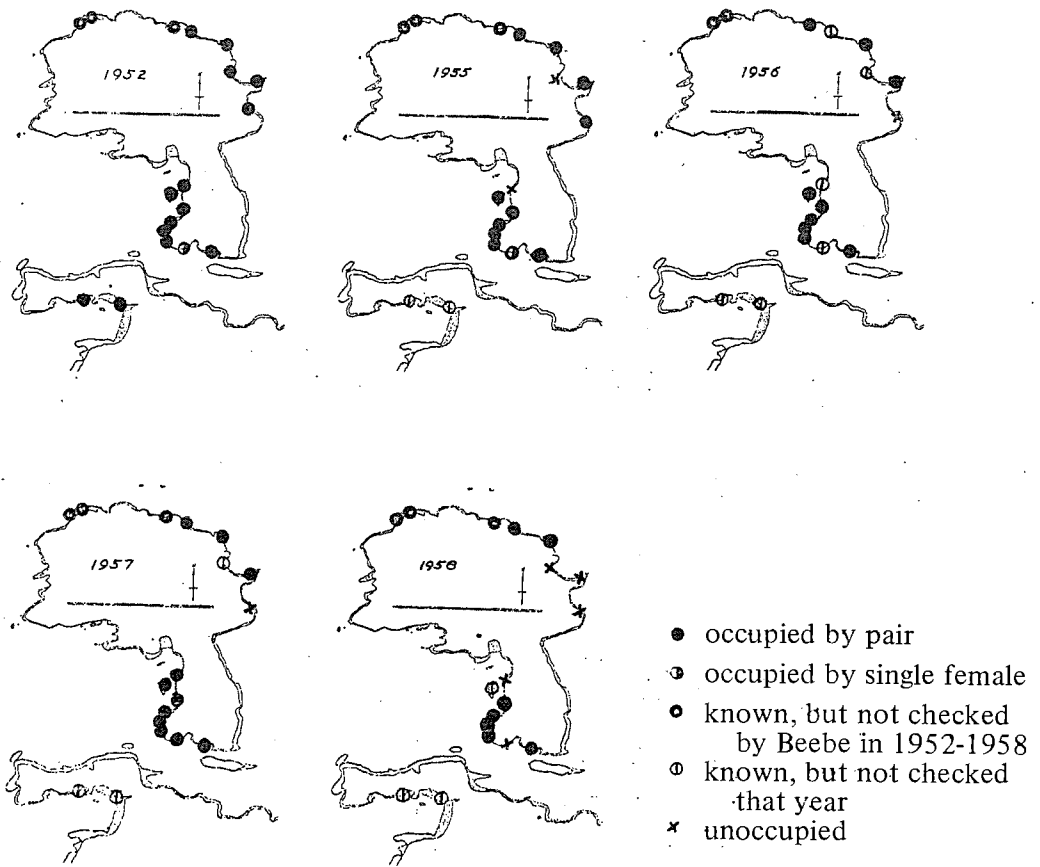


Figure 2. Occupancy of Peregrine sites, Langara Island 1952-1958 (derived from Beebe, 1960).

been a significant decline in Peregrine breeding densities there."

Since April of 1968, RWN and his wife have spent 24 months on Langara, primarily involved with studies on the behavior of the falcons. In these years the falcon population has fluctuated between five, and six and one-half territorial pairs (Figure 3). In 1969 two pairs were made up of an adult male and a yearling female each, with no production of eggs or young. One adult male has remained single on his territory for three breeding seasons, and another adult male was single through the 1972 season.

On the part of the island that Beebe recorded 13 occupied sites (12.5 pairs) in 1952, there were only three occupied sites in the period 1968-1972, and in 1972 one of these three was held by a single male. In the portion of the island covered by Beebe, only one-fourth of the former sites have been occupied during the last five years (Figure 4).

Table 1. Occupancy and productivity of Peregrine sites, Langara Island, 1952-1958. Data derived from Beebe (1960, Table 2 and Figure 8).

E = eggs
y = young
sm = small downies
lg = large downies
ff = fully fledged
F = flying young

Occ.(0) = occupied, no production
Occ.n.c. = occupied, eyrie not checked
Occ.(1♀) = single adult female at site
N.C. = site not checked
Un = unoccupied
Visits made on: June 2, 8, 19, 20, 17.

Site	1952	1955	1956	1957	1958
Radar Site	2 ff	2 ff	N.C.	3 F	3 lg
McPherson Pt.	4 lg	3 lg	3 F	3 F	Occ.(0)
Explorer Bay	Occ.n.c.	Un	N.C.	N.C.	Un
Andrews Pt.	2 sm	3 lg	3 F	2 F	Un
Coho Pt.	3 E	3 lg	Un	Un	Un
Dadens	2 F	Occ.(0)	2 F	2 F	2 F
Burial Cave	Occ.(1♀)	Occ.(1♀)	N.C.	2 F	Un
Iphigenia Pt.	Occ.n.c.	4 ff	Occ.n.c.	3 F	3 F
First Pinnacle	Occ.n.c.	3 F	2 ff	2 F	2 lg
Twin Pinnacles	Occ.n.c.	2 E	3 lg	3 F	2 E
Third Pinnacle	Occ.n.c.	1 ff	1 ff	2 ff	1 ff
Fourth Pinnacle	Occ.n.c.	Un	N.C.	2 F	Un
Cox Island	4 E	4 ff	2 lg	? F	N.C.

Summary

Not Checked (N.C.)	0	0	4	1	1
Checked	13	13	9	12	12
Total occupied	13	11	8	11	7
Occ. by pairs	12	10	8	11	7
No. of young: F	1 (2y)	1 (3y)	3 (8y)	10 (22y ⁺)	2 (5y)
ff	1 (2y)	4 (11y)	2 (3y)	1 (2y)	1 (1y)
lg	1 (4y)	3 (9y)	2 (5y)	0	2 (5y)
sm	1 (2y)	0	0	0	0
E	2 (7E)	1 (2E)	0	0	1 (2E)
Occ.(0)	1	2	0	0	1
Occ.n.c.	6	0	1	0	0
Unoccupied (Un)	0	2	1	1	5
Un/checked	0/13	2/13	1/9	1/12	5/12
Probable Un/checked	0/13	2/13	3/13-2/13	2/13	5/13

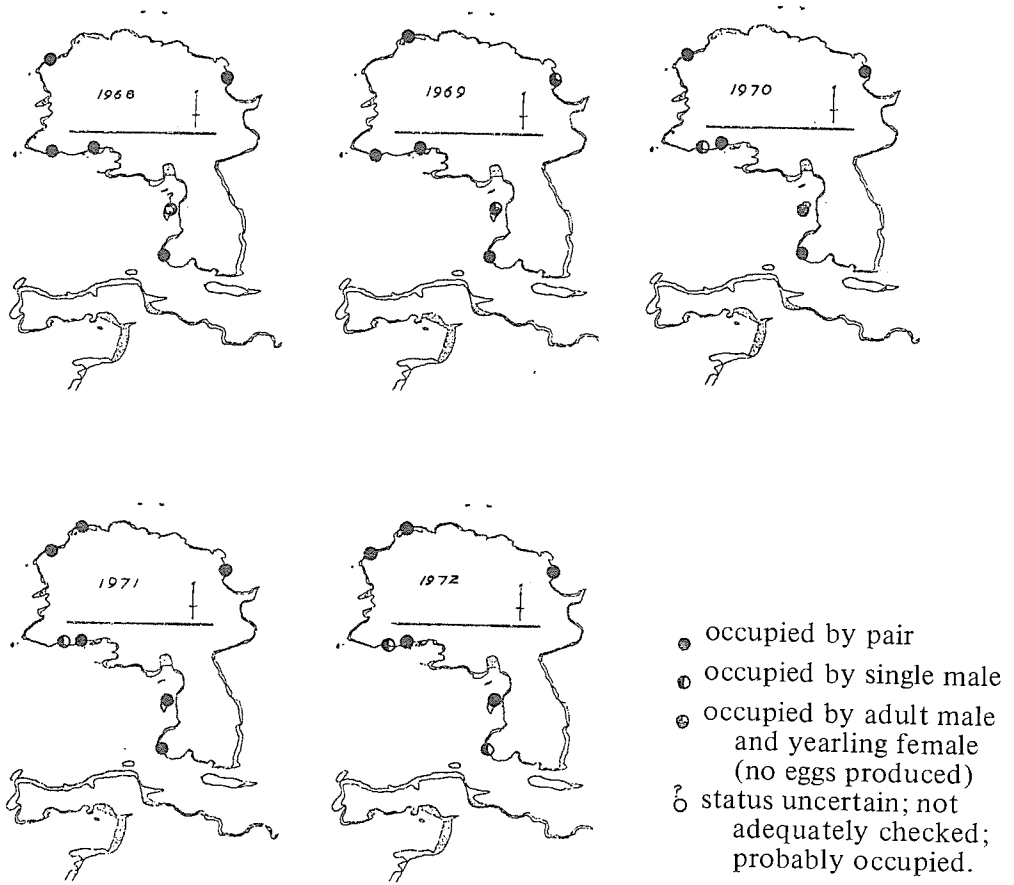


Figure 3. Occupancy of Peregrine sites, Langara Island 1968-1972.

In the remainder of the island there are (as of 1972) another 3.5 pairs. Just what the population in that part of the island might have been in the early 1950's is difficult to guess. Probably 8-10 pairs were nesting in this part of the island when Beebe visited the other section of the island, making a possible total population of approximately 21-23 occupied sites (Figure 5).

Before proceeding further, it should be noted that the present falcon population at Langara is considered to be a *saturated* population, incapable of holding any (or many) more territorial pairs.

Productivity of the Langara Peregrines

(1) In recent years, in 11 clutches in which the clutch size was observed early in incubation, the mean clutch size was 4.0 eggs (three nests with five eggs, three with three eggs, five with four eggs). Bond (1946) noted that eight clutch-

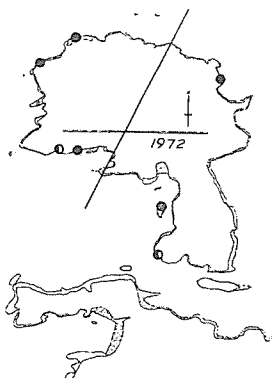
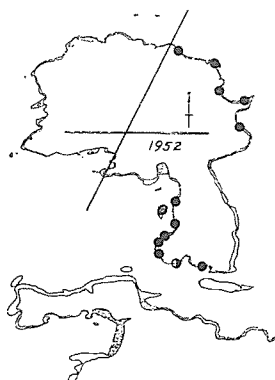


Figure 4. Occupied Peregrine sites, Langara Island, 1952 and 1972. Symbols as in Figures 2 and 3. The area Beebe studied (to right of the diagonal) in 1952 had four times the number of occupied sites found there in 1972.

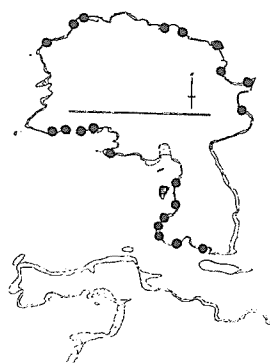


Figure 5. Probable occupancy by Peregrines of the whole of Langara Island in early 1950's.

es of *pealei* averaged 4.5 eggs, and Green (1916:475) at Langara found that "Peale's Falcon lays, of course, four eggs . . ."

(2) Ratcliffe (1970) noted that a small percentage (about 4%) of pre-pesticide clutches of Peregrines lost one or some eggs during incubation. At Langara, of 12 clutches (45 eggs) followed through all or part of incubation, five clutches (42%) lost eggs; one clutch lost all three eggs when a new female took over a site; four of the clutches (33% of all clutches studied) lost single eggs, apparently by accidental breakage, accounting for 8.9% of the eggs laid. These losses, a majority apparently caused by accidental breakage, account for 15.6% of the eggs laid. Such losses may be of importance to the population.

(3) Of the remaining 38 eggs, nine eggs did not hatch (three eggs of five in one clutch did not hatch). Hickey (1942) suggested that about one egg in each clutch (about 25%) fails to hatch in "natural" Peregrine populations. The failure of 20.0% of the Langara eggs to hatch may not be a drastic change from the normal situation. It should be noted, however, that several of the addled eggs were later collected and found to contain partially developed embryos. If the addled eggs are included with the eggs which disappeared during incubation, the loss from reproduction of 35.6% of the eggs laid might be significant.

(4) During the 1950's at Langara, counts in early and mid-June revealed a mean of 2.47 young falcons per nest with young (34 nests with 84 young in the nests or flying; calculated from Beebe's Table 2). In 1968-1972, similar counts in early to mid-June would have revealed 2.38 young falcons per successful nest at that stage of the breeding cycle (21 nests with 50 young). These values further suggest a depressed reproduction since the 1950's.

(5) During the nestling phase, ten nestlings are known to have died on the

ledges or have vanished between one observation period and the next; all of the missing are presumed to have died. This represents a loss of 17.9% of all nestlings known to have hatched, and about 11.5% of the eggs laid. Two fledglings are known to have died in their first week of flying. At least half of these deaths are suspected to have been unnatural (see below).

(6) Had those nestlings which died before early to mid-June in 1968-72 survived to that date and been counted, then 2.43 nestlings per successful nest (56 nestlings in 23 broods) would have been found—about mid-way between the 2.47 Beebe found in the 1950's and the 2.38 actually found in 1968-72. From this it is implied that the lessened productivity now observed may be partially split between losses of eggs and losses of nestlings. The principal factor, however, is the loss of eggs and failure of eggs to hatch.

(7) In the 1950's, Beebe observed 59 "fully fledged" nestlings and flying young at 25 nests (excluding one uncertain case) (Table 1), for a mean of 2.36 fledged falcons per successful nest. During 1968-72, the comparable figure is 2.30 (46 falcons at 20 nests; this includes three large nestlings taken illegally in 1968). Both Beebe's values and the present-day values are somewhat below the comparable values ("young reared per successful pair") of 2.4 in Cornwall (24 nests, 1930-1940, Ryves 1948, cited in Hickey and Anderson 1969), and 2.5 around New York (16 nests, 1939-1940, Hickey 1942).

(8) Beebe's data suggest that possibly as many as 14.6% of the sites with pairs might have failed in the 1950's (41 sites checked for productivity; 35 with young, four with eggs, two with no production) if we include eggs seen in June as indicating failures.

In 24 breeding attempts producing eggs in 1968-72, four (16.7%) failed. Including two pairs (in 1969) in which the females were yearlings that did not produce eggs, the proportion of pairs failing was 23.1%. In either case, at present there appear to be more pairs failing at Langara.

(9) In recent years the productivity of fledglings per occupied site (with known outcome) has ranged from 1.00 to 1.83 (mean of 1.53).

From Beebe's data it is difficult to derive a value to compare with present day values. A rough statistic might be derived by summing the 25 nests with fully fledged or flying young (59 birds) with the two occupied sites with no production, the two sites occupied by single females only and the four nests with eggs that may not have hatched (Table 1). Such a calculation indicates that 1.79 young may have been fledged per occupied site.

In Cornwall, Ryves (1948) found 1.7 young reared per occupied site.

Around New York, Hickey (1942) found 1.2 young reared per occupied site (1.5 in 1939; 0.7 in 1940, a "bad spring").

By most methods of measuring, the Langara Peregrines are presently producing at a slightly depressed rate compared to 20 years ago. The number of eggs per clutch (and possibly the number of eggs failing to hatch) appears to be normal. An unusual number of eggs disappear, apparently a majority due to accidental breakage. An unusual number of nestlings appear to be dying; and less nestlings and fledglings are found per nest. Of all the eggs laid, 15.6% are lost

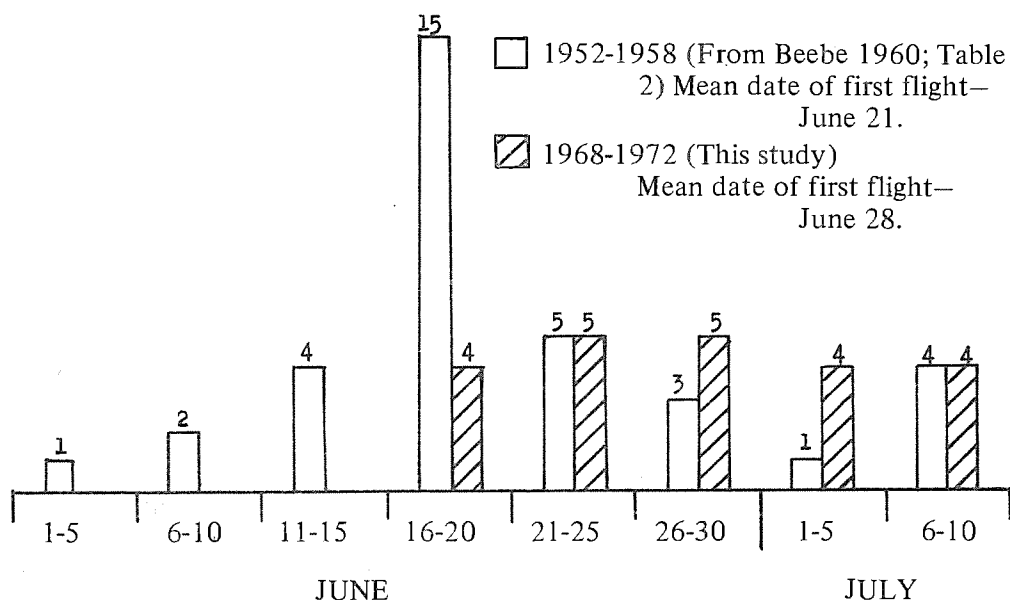


Figure 6. Comparison of dates of first flights by broods of Peregrines at Langara Island in 1952-58 and 1968-72. See text.

before hatching occurs, 20.0% fail to hatch, and 11.5% die as nestlings. Only 52.9% of the eggs laid produce flying young falcons.

Fledging Dates of Young Falcons

The date of the first flight of young falcons allows a close approximation to be made of the hatching date and the egg-laying dates. In order to compare roughly the dates of the first flights observed in 1968-72 with those in the 1950's, we have plotted into five-day periods (Figure 6) estimated dates based on Beebe's data, and the observed dates or calculated dates of the first flights of broods for recent years (usually at 41-43 days of age). From Beebe's data we have calculated the dates of first flights of broods on the basis of "small downies" being 5-10 days old, "large downies" being about 21 days old, and "fully fledged" referring to nestlings at 36-40 days of age. For the "flying" young falcons we have no way of knowing their flying dates, and have used the date on which they were observed to be flying as being the actual date of first flight. By means of these estimated ages and flying dates, we feel that the plotting of Beebe's data in Figure 6 is reasonably accurate—if anything, we have shifted it too far to the *right* by virtue of taking as the flying date that date on which young were observed (i.e. they might have been flying for two weeks when observed).

In recent years the mean date of first flying has been June 28. In the 1950's it was June 21, or earlier. It is possible that the close proximity of breeding

pairs in the 1950's may have in some way stimulated earlier egg-laying; there is a hint of this in the data from the colony of captive American Kestrels at Patuxent (Porter and Wiemeyer 1972).

Another possible factor influencing the egg-laying date of the falcons is their biocide content (see below). Jefferies (1967) and Peakall (1970) have pointed out that DDT in the diet is capable of causing a delay in ovulation in experiments with two species of birds. Risebrough *et al.* (1970) have suggested that PCBs also might be responsible for such effects.

How the later hatching and flying dates of the Langara falcons are affecting their survival is not known.

Adequacy of Present Productivity

Despite the facts that (1) the present falcon population is much reduced from 15-20 years ago, (2) in 1969 two sites had yearling females in attendance, (3) the two single males in 1972 were unable to reform pair bonds with females and (4) there appears to be a greater turnover of females than males in the adult population, the Langara population does appear to be producing sufficient numbers of young, and recruiting sufficient numbers of birds into the breeding population to maintain, perhaps even increase, the present population, all other factors remaining as they are, or improving.

(1) Productivity, while not good, does fall within the bounds found elsewhere in pre-pesticide times.

(2) In 1970-71 a new pair of adults somehow became established by taking over one alternate site of another pair.

(3) In 1971 and 1972, a number of yearlings have been seen in the spring, "testing" the adults at most occupied sites.

(4) In 1972 a new adult female evicted an incubating female from the territory she had held for three seasons.

These and other observations point out that productivity is still adequate to support this population.

Causes of the Falcon Decline

Overharvest. During the 1950's there was a considerable harvest of nestling Peregrines from Langara, possibly exceeding 50% of the nestlings on the whole of the island in two years, but generally it was much less than 50% (McCaughan 1964). While this degree of harvest might have had an effect on recruitment, the effect should have shown up *first* in the form of a number of single adults on territory. There is a possibility that single birds might have been missed in Beebe's June visits, however.

Since 1962 there has been only a small number of nestlings removed from Langara, the last being three taken illegally in 1968 (they are presumed to have fledged in the calculations above). *If* overharvest was the cause of the falcon decline, then four years of total protection from harvesting, plus a further six

years of minimal harvesting, easily should have permitted the falcons to make some kind of a comeback towards their previous numbers. Such a recovery has not occurred.

Biocides. The Langara Peregrines contain substantial levels of biocides. Addled eggs average 17.6 ppm DDE and 7.03 ppm PCB (wet weights); their eggshells have a mean thickness index 11.5% less than eggs taken pre-1947 on the Canadian west coast (Anderson and Hickey 1972). These DDE levels and the degree of shell-thinning are beyond the half-way point at which other falcon populations as a result of shell breakage, infertility, and embryonic death, have failed to maintain their numbers. Mercury levels (0.74 ppm) also may be beyond the half-way point towards large-scale embryonic mortality. (Details of the biocides in the falcons and their prey are being prepared for a later paper.)

At present an unusual number of eggs are lost during incubation, and a number of nestlings are dying. The comparisons between the Langara falcons in the 1950's and at present suggest that the somewhat depressed productivity seen today is due to loss of both eggs and nestlings, and possibly an increased likelihood of eggs failing to hatch. We feel that this depressed productivity is largely due to the effects of biocides.

Three instances of the simultaneous death of all brood-mates have been observed, all at different eyries and in different years. Parental neglect, infanticide, severe weather conditions, and critical shortage of food are not considered to be the causes of deaths of at least two of these broods. We suspect that, by means of some pollutant acting through their mother, the brood-mates are predisposed to death either at some specific age or when some common (to the brood-mates) stressful condition occurs.

Biocides are having a direct adverse effect upon the falcons, but, as already pointed out, both productivity and recruitment in this population appear to be adequate at present. Whether there is a trend in the biocide levels in the falcons or their prey, suggesting either an improved or deteriorating condition, we do not yet know.

Territoriality. For three seasons one site has been occupied by a single male, and another site by a single male for one season (Figure 3). These instances at first suggested that there is an insufficient number of females in the population.

In 1972 several observations at both sites showed what was in fact happening. In summary, both males are kept single by the adjacent paired females. In each case, the male courts (apparently) unattached females in the spring, but the neighboring paired female evicts all potential mates for the single male. In effect the neighboring female in each case is occupying a double territory, both that of her own male and that of the single male. These neighboring females engage only in certain early courtship activities with the single males. The relationship might be described best as "pseudo-polyandry." The reason for the tendency to increase territory sizes will be discussed.

In 1971 a new pair of falcons attempted breeding at the northwest corner of

the island, taking over the NE of the two alternate sites of the former pair. While this appears to be in direct contrast to the situations just described in which territories are tending to increase in size, it is of interest to note that at about the time the new pair became established, the previous female disappeared; perhaps with a new mate (or temporarily with no mate) the old male was unable to hold both alternate sites successfully. These two sites probably will revert to one again, by the route of "pseudo-polyandry."

I propose that the low size, widespread distribution, and territorial interactions in the present Langara Peregrine population are direct results of a considerable decline in the numbers of the principal prey species, the Ancient Murrelet (*Synthliboramphus antiquus*), evident at Langara in recent years.

From these and similar observations it becomes clear that (1) the falcons at Langara today are a saturated population, and (2) they are somehow assessing the changing prey population and adjusting their behavior and territory sizes accordingly.

Decline in the Ancient Murrelet Population. While there are considerable records regarding the Ancient Murrelets breeding at Langara Island (e.g. Drent and Guiguet 1961), there are very few estimates as to numbers. Certainly, in the 1950's, the breeding population of murrelets at Langara was very large, probably many hundreds of thousands.

Since 1968 it has become apparent that the number of murrelets in the area has been greatly reduced from what it was in the 1950's. On the water about the island, and in the colonies when the murrelets arrive at night, the previous accounts of large numbers cannot be duplicated. Since the 1950's, and in one instance since as recently as 1966, whole colonies or segments of large colonies have been abandoned (S. G. Sealy, pers. com.; pers. obser.). There still are many thousands of murrelets in the vicinity of Langara, but nothing resembling the descriptions of 15-20 years ago.

Further, another small seabird, the Cassin's Auklet (*Ptychoramphus aleuticus*) which was found "nesting over much of Langara's shoreline as well as on Cox and Lucy Islands adjoining" (Drent and Guiguet 1961:99), appears to have all but vanished from this area (S. G. Sealy, pers. com.; pers. obser.). The numbers of nesting gulls, cormorants, and guillemots appear to be similar to those recorded in the 1950's.

Except on a very local scale, such factors as predation by rats (present on the island for many years) and habitat change are not considered to have been of major importance in influencing the murrelet and auklet numbers. Sealy (pers. com.) has found the productivity of the murrelets to be good through to departure of the young from the island.

It is of interest to note that several fishermen at Langara have remarked to us on the fact that in recent years they have noticed fewer surface aggregations of shrimp-like plankton as compared to a number of years ago. This, coupled with the fact that the Ancient Murrelet and the Cassin's Auklet feed largely upon shrimp-like plankton (Sealy, pers. comm.; White *et al.* 1973; Payne 1965,

cited in Bédard 1969), suggests that problems within the food chain have caused the murrelet decline.

Two possible contributing factors need to be considered in detail, and will be only outlined here.

1. *Biocides affecting the food chain.* The shrimp-like zooplankton just mentioned are dependent upon phytoplankton. Phytoplankton have considerably decreased photosynthesis and growth when exposed to minute levels of DDT (Wurster 1968), PCB (Fisher *et al.* 1973), or mercury (Harriss *et al.* 1970, cited in Peakall and Lovett 1972) in water. Because the murrelets do contain amounts of these biocides, their zooplankton food, the phytoplankton and the ocean water itself all must contain small amounts as well. It appears to be unknown whether or not the present levels of biocides in the *northeastern Pacific* are sufficient to damage any parts of the food chain below the level of the falcons. It is possible that any or all of these biocides have adversely influenced the lower end of the food chain upon which the coastal Peregrines depend.

For reasons which will not be elaborated upon here, the occurrence of biocides in the region of the Queen Charlotte Islands is not felt to have originated as fallout, but is thought to have travelled to the islands in ocean currents. The Davidson Current is a northwest-flowing current as much as 90 miles (145 km) wide, adjacent to the west coast of North America, especially evident in winter, but present off the British Columbia coast year round (Sverdrup *et al.* 1942; Barber 1957; Fairbridge 1966; Bane 1969; Wyatt *et al.* 1972) (Figure 7).

Within 1400 miles (2250 km) to the south of Langara Island are the mouths of the Fraser and Columbia Rivers and the coastline of California. The use of the Pacific Ocean (and the Davidson Current) as a catch-all for toxic wastes in California is known (E.D.F. 1971; Schmidt *et al.* 1971); the Columbia River is known to be carrying agricultural pesticides to the ocean in run-off (Stout 1968). A chlor-alkali plant, and several pulp mills which have in recent years used mercury slimicides, on the southwest coast of British Columbia (Fimreite *et al.* 1971) may have put mercury into the ocean which has reached the Queen Charlottes.

2. *Changes in ocean currents.* Aside from the Davidson Current, the West Wind Drift ("Japanese Current") has a great influence on the ocean conditions and weather of western North America. In the winter of 1956-57 this current shifted such that an anomalous intrusion of warm surface water (to 500 m deep) passed northward along the British Columbia coast—until the fall of 1958 (Tully *et al.* 1960). In the summer of 1957 and spring of 1958 the surface waters surrounding the Queen Charlottes were 2-4 degrees F warmer than the 30-year mean temperatures for those seasons. Several biological phenomena are probably reflections of these changes. In 1958 the whale catch off the Canadian Pacific coast showed more than twice as many finback whales as the highest year in the six preceding years; the sperm whale catch was only slightly greater than half of the average of the previous six years' catches; and sockeye salmon

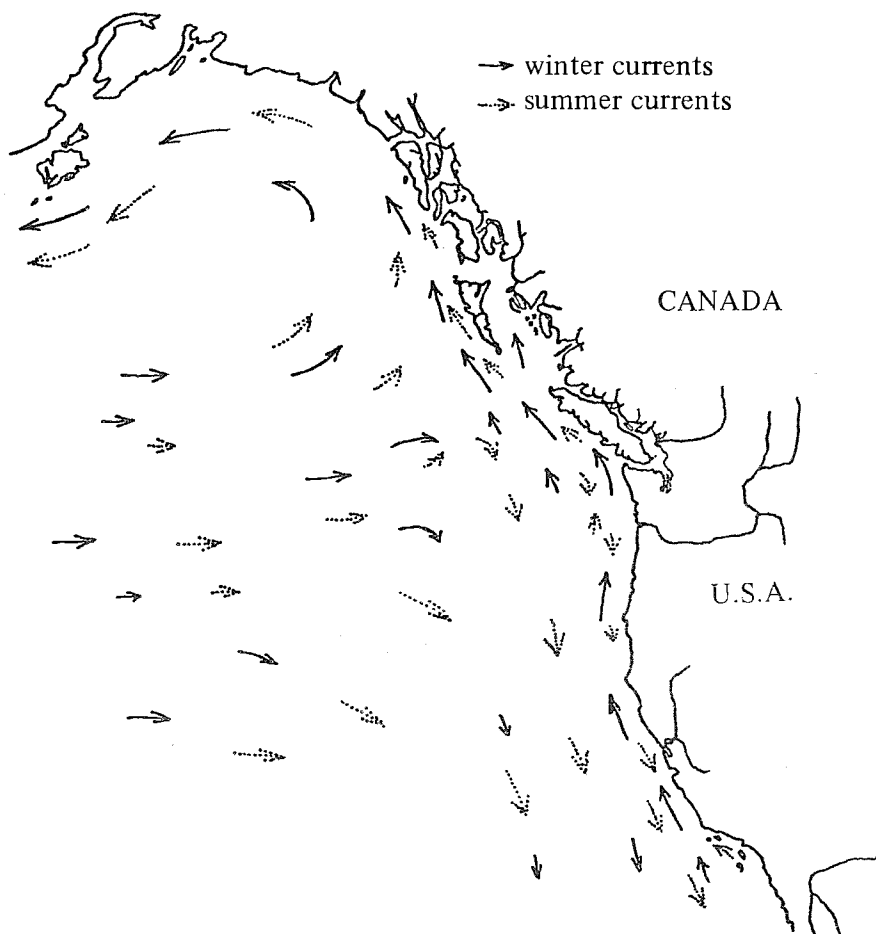


Figure 7. Ocean currents on the surface of the northeastern Pacific.

migrations were shifted considerably (Tully *et al.* 1960).

Tabata (1965) reported that summer 1961 saw a new anomaly approaching North America. Wick (1973) reports that this anomaly remained until 1971, then the ocean (and weather) conditions returned to "normal".

Bary (1963) has related the presence of certain plankton species to certain ocean temperatures and salinities. The Ancient Murrelets in the Queen Charlottes are at the southern extent of their breeding range, perhaps limited by the abundance and availability of a "cold-water" plankton. If the anomalous condition of 1957-58 and the 1960's shifted the preferred plankton species northward, then the decline of the Langara murrelets might be explained by a shortage of food.

The Cassin's Auklet decline at Langara poses some problems to both of these

hypotheses regarding the murrelet decline. First, if biocides are responsible for reducing murrelet food supplies, then these auklets should be in decline also at colonies much farther south in their range, we are unaware of any collapses in more southerly colonies. Second, if the warming of the Queen Charlotte waters has shifted much of the preferred food of the murrelets farther north, then the Cassin's Auklet might be expected to be *increasing* at Langara, since at Langara this auklet is near to the *northern* extent of its range. These apparent contradictions may be explained by further knowledge of the size and stability of auklet colonies to the south and of specific aspects of each species' feeding ecology. Perhaps southern Cassin's Auklet colonies are in decline. Perhaps the anomalous warm water diminished the food of both species at Langara.

In Britain in recent years it has been realized rather suddenly that a number of Puffin (*Fratercula arctica*) colonies are in a drastic decline, for as yet undetermined reasons, while other seabird species in the same areas are doing well (Flegg 1971; Parslow *et al.* 1972). Flegg (1971) has suggested that possibly the Puffins are particularly susceptible to one or some pollutants encountered in the ocean. While the British Puffins and the Langara Ancient Murrelets are oceans apart, the fact that the cause of their problems might be common must be given consideration.

Summary. While the foregoing comments may have belabored the point, it is clear that the proximate cause of the decline of the Langara Peregrines is the decline of their principal prey. What the ultimate cause might be—biocides, alterations in ocean currents, or other factors—is yet to be determined.

While the Peregrine and murrelet and auklet declines at Langara *appear* to be unique, this may be because of the lack of historical data from elsewhere in the Queen Charlottes. Very little detailed work was carried out on the falcons and seabirds elsewhere on the Queen Charlottes until the early 1960's, so that any declines that occurred in the 1950's or early 1960's were not detected. It is possible that the declines are unique to Langara. It is also possible that the other parts of the Queen Charlottes once had much greater populations of these seabirds and falcons than are now present. Further studies on seabird distribution and colony size in the Queen Charlottes such as conducted by Ken R. Summers (1974) in 1971, and repeated surveys and inventories of falcon numbers through a substantial part of the Charlottes as are carried out by the British Columbia Fish and Wildlife Branch, are needed for some years to come in order to determine whether the situation at Langara is being (and has been) paralleled elsewhere.

Prospects for Improvement

Any sizeable increase in the falcon population will require a considerable increase in the Ancient Murrelet population.

If biocides are the cause of the murrelet decline, by damaging their food supply, then, with recent moves to curtail the use and disposal of a number of biocides, perhaps we might expect some recovery of plankton stocks, then murre-

lets, then falcons. But over what time-span such a recovery might occur, we have no precedent by which to judge. Harrison *et al.* (1970) suggest that the DDT contamination of the environment might be expected to become worse before it gets better, even with complete cessation of input of DDT into the environment, by virtue of the food chain relationships and long life of this and related chemicals. We can only hope that the marine food chain cleanses itself before the coastal Peregrines are eliminated (either through disappearance of their food supply or through shell-thinning), and that new pollutants will not be found in the northeastern Pacific, nor introduced there (e.g. via oil tanker routes) in the future to further jeopardize these marine ecosystems.

If the ocean current anomaly hypothesis is, in fact, the cause of the murrelet and falcon declines, and with the return to "normalcy" of the anomalous condition in 1971, then the falcon population should have reached its low ebb in 1971 or 1972. There is some hope, then, that in the future the area might become repopulated (or populated more densely) by plankton, murrelets, and falcons. Again, there appears to be no precedent from which to gauge the length of time it might take for a repopulation trend to become recognizable, and certainly there is nothing to indicate how long it might take for the Peregrines to achieve the densities recorded twenty years ago.

If these two hypotheses prove incapable of accounting for the murrelet decline at Langara, and some other factor is at work, then it is entirely possible that the murrelets might continue to decline, to the point at which the falcons, and possibly the murrelets themselves, vanish altogether.

Recommendations

From the suggestions in the foregoing, several recommendations are automatically forthcoming.

(1) Research into the management and the effects of biocides should continue, particularly in the marine environment.

(2) The British Columbia government should continue to conduct inventories of the Peregrine populations on the British Columbia coast to attempt to detect and assess population changes over larger areas than that covered in this study.

(3) Intensive ongoing research should be initiated into documenting the distribution and size of seabird colonies on the Pacific coast.

(4) Research into the captive breeding of a wide variety of small seabirds should be initiated.

(5) Efforts should be made to get a sizeable nucleus of *pealei* breeding successfully in captivity *now*, in case the Langara Ancient Murrelets, Cassin's Auklets, and Peregrines are actually indicating worse things yet to come.

Acknowledgments

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STUDIES ON PEREGRINE FALCONS IN THE ALEUTIAN ISLANDS

Clayton M. White

Introduction

During extensive studies on avian biology associated with the activities of the U. S. Atomic Energy Commission, between 1967 and 1973 at Amchitka Island in the west central Aleutian Islands, data were gathered on the Peregrine Falcon (*Falco peregrinus pealei*). Once the analysis of data is terminated, a comprehensive report will be completed. For the time being, the present report will consider the topics of production, mortality, some nesting history, and nesting density. Following the Amchitka data, the Rat Island group will be treated as a unit in discussing population density, and finally I will present data used in deriving an estimate for the size of the population in the Aleutian Islands as a whole.

Although the data from Amchitka were derived from material gathered over a six year period from 1968 to 1973, the data for some years are not complete and so are not used in the computations of all the values presented. In all, I have made observations every month of the year except March for about 371 days of observations on my part, but there have been better than a total of 689 man days considering all observations.

Amchitka Island is about 42 miles (68 km) long, averages about three miles

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(4.8 km) wide, and has about 120 miles (193 km) of shoreline. (Coast and Geodetic Survey values are placed at about 120 miles although the value of 106 miles (171 km) is frequently given. My values are figured based on the larger value and thus tend to be on the conservative side.) Amchitka is an island covered by tundra vegetation and is essentially flat on the eastern two-thirds although there are mountains on the western end. Other islands of the Rat group bound it on the north and west with the nearest island about 14 miles (22 km) to the west. Because of fog or cloudy conditions these islands, however, are visible from Amchitka only about one day in five.

Production

For the three year period, 1970 to 1972, a total of 57 nesting attempts occurred (a pair with a territory and undergoing nesting behavior is considered an attempt). Of those, 38 were successful for about 66% success. In all some 101 young were fledged in those years for an average of 33.6 young per year. Fledging success was about 2.66 young per successful nest and 1.77 young per attempted nesting. Data from Peale's Falcons populations in British Columbia suggested a fledging success of 2.36 young per successful pair between 1952 and 1958 (Beebe 1960). Unfortunately Beebe's data do not, however, indicate what percent of the attempts failed completely, and one must know that to say anything about net productivity. The only comparable data giving net productivity I found to examine were from 67 pre-1942 nesting attempts in Great Britain and New York (Hickey 1969:29). Of the 67 sites occupied, 40, or 60%, were successful for a fledging rate of 2.45 per successful pair and 1.5 per total attempt. The percent of successful nests from these two populations compares favorably with that from Amchitka.

Fledging dates on Amchitka average about 22 June with a range of 15 June to 4 July. On the Queen Charlotte Island (although farther north than Amchitka) some young apparently are flying as early as 2 June (Beebe 1960).

Mortality

Survivorship data on young Peregrines are available from some populations. Mortality of young as suggested by banding returns for the combined North American populations has been estimated by Enderson (1969) at 70% from fledging to the end of the first year and 25% per year thereafter. Band returns from Germany and Finland show a similar distribution of age class mortality (Mebs 1971). However, the mortality in Europe is known to be mainly shooting or trapping. We have suggested (Cade *et al.* Ms) that a more realistic figure for all North America populations combined (considering high latitude migrant and low latitude residents which seemingly have different mortality rates as suggested by different fledging rates and clutch sizes) in order to have a balanced breeding population based on reproductive rates, age at first breeding, and presumed life span of adults, is about 50% in the first year of life and 20% thereafter; values also similar to those postulated by Hickey and Anderson (1969:29). This average is, of course, made up of higher and lower mortality rates and

it may be that the Aleutian populations are at the upper end of the range of variation. A fledging rate of 2.66 young per successful nest is on the higher end of fledging values given by Hickey and Anderson (1969:25) for North America and Europe. This rate suggests that at least two factors, either a relatively higher mortality of immatures or a relatively shorter life span of adults, are operative in relation to Peregrine populations with a lower fledging rate. Evolution is geared to promote those strategies that maintain the maximum possible population size when at equilibrium with its resources and when survival balances mortality. Selection will favor high productivity in order to offset environmental resistance in cases where high natural mortality occurs. For Amchitka we have some values on natural mortality. By 5 June, 1971, one fledgling had been killed by eagles at the "Charlie Cove" eyrie. Remains of young, presumably killed by an eagle (at least eaten by an eagle) were found on the tundra opposite the "Rim Point" eyrie on 22 August, 1971. On 23 August, 1971, the Fish and Wildlife agent on the island found a dead fully fledged young ten miles (16 km) up the coast from the eyrie in which it was banded on 26 June, 1971. This latter bird was in fine physical condition and had a full crop estimated to contain about 80 to 100 grams of food. There were no external injuries on the bird, and the cause of death is unknown. For 1971, then, 11.6% of the young fledged were known to have died within two months of fledging. We have no way of estimating what the total mortality was during that time period. In January of 1970 at least 10 different immature falcons were still present on the island as determined by helicopter surveys. This represents about 30% of the young fledged on Amchitka that previous summer. Throughout May, 1970, only one immature was seen and for the summer of 1970 the observations suggest that as many as two or three immature year-old birds may have survived the winter and were present on Amchitka. This represents about a 10% survival of the young in the first 12 months of life assuming that the young remained on the island such that they could be counted.

Helicopter flights have been made to check eyries and count falcons in the non-breeding season (September, October, November, December, and January) and in April. In these months, first year young are always seen though in noticeably reduced numbers (as shown by actual counts) by November. In November adults are still found at or "defending" eyries in at least 50% of the breeding locations. As we have reported earlier (White *et al.* 1971), adults can be found at eyries every month of the year. In January 1970 we found pairs at eight eyries. Between 3 and 9 October, 1972 we visited all the eyries several times. Thirteen eyries had adults present and pairs were seen at five; and at the Constantine Harbor eyrie the adult male was aggressive towards us.

The data cited indicate that the majority of the falcons are resident on the island, as we assume they are for most of the Aleutians, except for a small percentage of the young that apparently disperse or engage in post-fledging wandering. Certainly some adults also move about after nesting, and a few may even migrate some distance, but our only band returns (of 53 banded) come from Amchitka itself. I do not accept the tenet that the young move to some "un-

known and presumably yet undefined" region and there pass their first year. From what is known about *pealei* distribution, the birds would have to be in a region occupied by other breeding Peregrines which are also producing their own population of young. The situation is totally different from that of Peregrines of Arctic origin which migrate to winter in parts of Central and South America where there is apparently no breeding Peregrine population. (This would not apply to those individuals that overwinter in the range of *F. p. cassini*. However, there are records, for example, of Peregrines of northern hemisphere origin, both adults and immatures, for every month of the year from Ecuador.) Specimens or other authentic records of *pealei* far from coastal localities have been reviewed and they are practically non-existent, especially in late spring, summer, or early autumn (White 1972) although winter specimens are known from northern coastal Baja California north throughout the breeding range. Individuals south of central coastal California are by no means common however. Therefore, the data suggest that most of the individuals away from the breeding grounds are on the coast or at least within 200 miles (322 km) of coastal localities north of central California. A full order of magnitude more falcons would have to be seen in this region than we are currently seeing to account for part of the scores of falcons raised in the Aleutians if indeed they did commonly move out of the Aleutians. Data to support the idea of a large scale movement out of the Aleutians is totally lacking. The major mortality, therefore, seems to be very local in nature since most falcons remain on the island, and perhaps some young birds are lost at sea in times of high wind during the winter (winds are frequently in excess of 60 knots and may last several days) or in the course of dispersal (see also Beebe 1960). At any rate, a conservative minimum of 50% of the birds hatched at Amchitka apparently do not survive the first year of life, and the value probably more realistically approaches 80 to 85% mortality in the first year.

History of Some Selected Sites

There are several interesting histories associated with some selected sites as follows.

Constantine Harbor Site. The female laid four eggs in a "pot-hole" on a sea stack, 1968 and 1969, but deserted the 1969 clutch when it was about one-half incubated. Murie's description (field notes) of the eyrie he found in Constantine Harbor suggest that this same stack was used in 1936. In 1970 either she or a new female occupied a new site about 100 yards (91 m) away, laid a single egg, and deserted. The male was found injured at the site in the early winter of 1970. In 1971 a new male was present, and the nest was moved one-half mile down the beach to a hillside where four young were fledged. In 1972 a new female, about 10 months old, was at the 1971 site in April; she remained throughout the summer but failed to lay eggs and was still present with only a few immature feathers remaining in October 1972. No birds were present at any of the three sites in May or June 1973.

Limpet Creek. The female laid four eggs and raised three young on same ledge

in 1969 and 1970. In 1971 there was apparently a new female as suggested by different behavior and by only two eggs, one abnormally shaped and colored, being laid in a new site. In 1972 yet a different site only 10 feet (3 m) off the ground was used and contained only one young.

Charlie Cove. The same female (color banded in 1969) and presumably the same male as suggested by color and behavior, present for four years and used two different ledges within 100 feet (30 m) of each other.

North Bight. The same pair, as indicated by behavior and markings, for five years nested on the same ledge. In 1973 there were five scrapes along the ledge all within 15 feet (4.6 m).

Clover Eyrie. The same pair as indicated by voice, behavior, number of eggs, and nesting site used for the past five years. The ledge is on a hillside and can easily be walked into. Karl Kenyon visited this site with me in July 1973 and showed me where he had found a similar "hillside" eyrie in 1956 about 100 feet (30 m) from the present eyrie. Interestingly there are cliffs with ledges of the type usually associated with Peregrine eyries all around these two sites, but there is no indication (upon examination of some) that they have ever been used.

Bird Cape No. 1. In 1968 and 1969 what appeared to be the same female used the same ledge. Within 15 feet (4.6 m) of this ledge were six other ledges with signs of old scrapes, some containing castings and bones as though young had been raised there in past years (apparently a long history at this cliff). In 1970 a pair was present but had moved to a second cliff about 100 feet (30 m) away. In 1971 a pair was present on 23 April but when next checked in late May, only a fresh scrape and a few molted feathers were found at the 1970 site. In 1972 what appeared to be the same female as in previous years used a new site about 30 feet (9 m) from the 1970 site. In 1973 a first-year female (all brown, about 11 months old) was paired with an adult male and occupied the two cliffs. We could not determine if she was banded. Not only were they defensive at the set of cliffs at the Bird Cape No. 1 location but also at a second set of cliffs (called Bird Cape No. 2) about 0.8 mile (1.3 km) away. These are occasionally occupied simultaneously with No. 1 by two pairs of falcons. That this pair, one of them less than a year old, recognized both specific sets of cliffs as eyrie locations, even though there are many cliffs between the two locations, is in itself interesting.

The main facts gained from this sample of histories are that some sites are very stable both in location and use and others are ephemeral in both factors. The less stable ones seemingly are those with young birds as members of pairs (this is also supported by two other examples). Second, the less stable sites are seemingly characterized by a frequent turnover of individuals. This latter impression may be simply a function of the loss of one member of a stable pair and the resultant dynamics as a "stable pair bond" is in the process of being achieved again. It may take several different individuals trying to form the pair before a compatible, well-matched mating is accomplished; and in the over-all picture, there may be an extremely stable and long lasting pair bond once it is

achieved.

The problem of turnover rates in an adult breeding population is an intriguing one, and a person searching for research projects with Peregrines would do well to investigate this problem in a well-defined, delimited population.

Population Density

Nests are rather uniformly distributed around the shoreline of the island (Figure 1), although there is some clumping near the east end on the Pacific Ocean side and at the west end of the island. There are several cliffs in the uplands, but eyries have never been recorded away from the beaches. The closest eyries used simultaneously are about 0.8 mile (1.3 km) apart. At each of two different locations there is a series of three eyries, and at both localities each eyrie is about 0.7 mile (1.1 km) from its nearest neighbor (it is as though the distance had been measured equally for each of the six eyries). I am tempted to suggest, then, that if all other things were equal, such as food supply, cliffs, etc., the value of 0.7 miles (1.1 km) would represent that distance which would be obtained in optimum spacing between pairs to achieve a "saturated population" condition for the island.

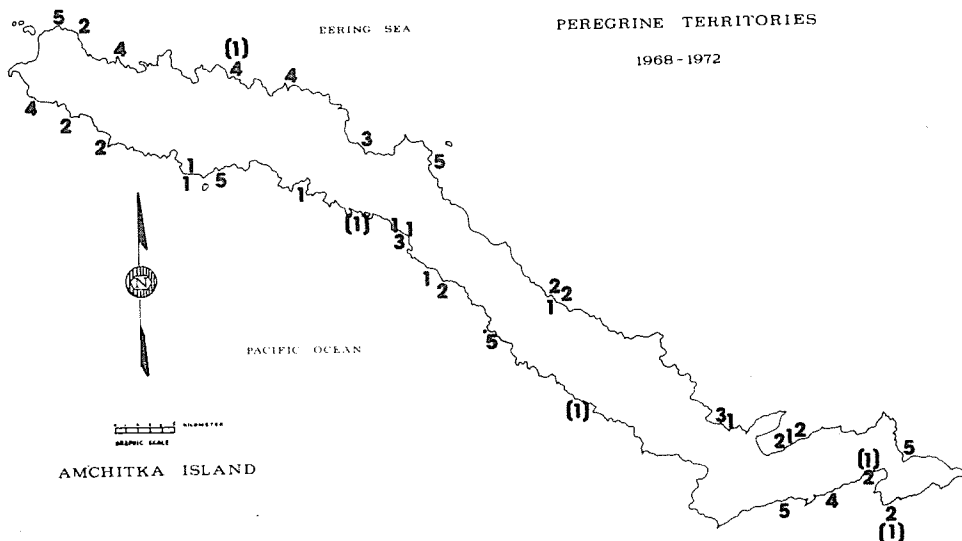


Figure 1. Distribution of the 25 areas of eyrie or territory localities on Amchitka. Numbers indicate years eyrie was used. Numbers in parenthesis indicate the territory was held by a single bird in one year. In some cases the specific eyries were moved to different locations in the same area (all within 400 yards (366 m) of one another) as shown by the close placement of sets of numbers.

However, the following number of territorial units (a unit is a pair or defending single adult), as located per year, were 17 in 1969, 19 in 1970, 22 in 1971, 19 in 1972, and 16 in 1973. (1973 was an abnormal year because of early egg loss, apparently caused by weather, before I arrived on the island and some pairs had probably already deserted their eyries thereby giving a low count. The data from that year will be discussed in the final report.) The five years give an average of 18.6 pairs per year. Based on the value of 120 miles (193 km) of shoreline, the average density is one pair per 6.3 linear shoreline miles (10.1 km) (high of 5.5 (8.8) and low of 7.5 miles (12.1 km) per pair).

Theoretically the density of falcons could be as high on Amchitka as it is in certain parts of coastal British Columbia, also occupied by *pealei* (Green 1916; Brooks 1926; Beebe 1960, 1969; and Blood 1968), but that is not the case. This presents a challenging problem. The idea that nest site availability is a limiting factor is not supported by a knowledge of the multiple types of sites selected by the falcons (from large open hillsides to small potholes in cliffs) and of the frequency and distribution of such sites (geomorphology of the islands shoreline). After spending a day in the offshore waters around Amchitka observing auklets one also gets the initial impression that the availability or vulnerability of food is not an element limiting summer or breeding density. The idea of a non-limiting food source is even more convincing after considering the numerous birds inhabiting the tundra or intertidal areas which receive only limited summer predation pressure. It appears, however, that there is no simple answer to the question of density regulation factors and that at least three factors may be working in concert, of which the complex interaction of food and weather is important, in limiting the population. These points will be considered.

First, perhaps the breeding pairs are self-limiting through some sort of social convention or traditions that have become fixed on certain cliffs as advanced by Wynne-Edwards (1962) and alluded to by White and Cade (1971) for some arctic falcon populations. We have, however, no way of investigating the selection forces regulating such a thing. **Second**, the clumping of nests at the west end of the island may offer a clue to the question of food resources. In the roughly 13 shoreline miles (20.9 km) from Finger Point (Bering Sea side) around the west end to Rim Point (Pacific Ocean side) there are six eyries, or one eyrie per 2.16 miles (3.48 km). Of that distance, however, some four miles have no cliffs so the density could be stated as one eyrie per 1.50 inhabitable shoreline miles (2.4 km). This area of Peregrine concentration is adjacent to Oglala Pass which separates Amchitka from Rat Island. The pass has extensive tide ribs and thus is a prime foraging area for auklets and contains a high density of them. The pass is also that point adjacent to Amchitka which is nearest to the Auklet colonies on Segula and Little Sitkin islands. It appears that the local density of breeding Peregrines near Oglala Pass is a direct function of the nearness of an abundant food source. We do not have quantitative data on the abundance of auklets in the waters surrounding Amchitka and although they appear to be "common", the flock size is normally smaller than in areas near colonies and the flocks are more thinly spread over an equivalent surface area. For a Pere-

grine to exploit auklets successfully there must be a lower limit to the numbers of encounters per unit time spent hunting below which hunting them becomes energetically uneconomical for a falcon. The rate at which these birds will flush in front of a falcon or that a falcon will have an opportunity of passing over one sitting on the water is directly proportional to the flock size and frequency of flocks of auklets. The rate of encounter may be that factor which acts in spacing breeding falcons in order that they avoid actual competition or at least the stress of interaction between individual falcons for that certain quantity of available auklets. Along either side of the island (but not considering both ends which are adjacent to passes) that quantity of vulnerable auklets available from February to April may support only 10-12 pairs of falcons. **Third**, if the combined impact of environmental rigors do dictate a considerable mortality rate, as I interpret from the data, then perhaps there is not a sufficiently large "floating" population of adults at any one time to establish both new nesting sites and traditions and also provide annual recruitment to offset the attrition rate without exhausting that population. Survival may be just sufficient enough that only a status quo in population size, considering both breeders and a certain size non-breeding adult population, can be maintained at a level lower than would be seemingly predictable. The suggestion that there is a substantial mortality rate among the adult cohort in the Aleutians, thus resulting in a lesser number of individuals in a "floating" population than has generally been suspected, gains some support from data on turnover rates of some of the eyries. We have been able to determine that there have been at least seven birds replaced at eyries, mainly females, in the past five years. (This is where a marked adult population would be important because we do not know how many adults are indeed replaced but go unnoticed.) Of the seven, two were less than a year old (still all brown plumage) and one was probably two or three years old as she retained some immature plumage on the underwing.

The relationship of food, weather and mortality may fit together in the following fashion to explain partially breeding density. In autumn, prey items are abundant both on land and in offshore waters because of the crop of new young. Except for the exodus of longspurs and the two terns, the majority of other prey items remain in the same relative abundance through November or December. Intense weather with sub-freezing temperatures, high winds lasting for many days and deep snow most frequently occurs between January and March. To that time there has been a slow, steady attrition of prey species. With the bad weather an acceleration of mortality would be expected to occur and rough seas act further to disperse auklets. Additionally, in late January adult falcons are starting to defend territories and reinforce pair bonds. This presumably further drives unmated falcons into marginal areas which would increase mortality. By the time Peregrines are ready to lay eggs in April the auklets still have not returned to their breeding colonies nor are concentrated flocks seen in near-shore waters until about late May.

The end result is that in those critical periods of January through March when territories are being established, (1) food is least available and (2) weather is at

its worst and, presumably, accelerated mortality of falcon and prey items is occurring. Even though the auklets' population from May through July could support a larger breeding population of falcons, there are not enough of the minimum requirements available in February through April when the biological systems are being geared up for breeding. Both time periods are independent of each other as far as breeding falcons are concerned. Also in February through April more dense populations of auklets would be expected to occur in the tide rips, in passes at either end of the island, than along the middle portions of the island. Since the density of falcons is apparently related in some fashion to the density of vulnerable prey items one would expect a greater density of falcons to occur near that food source at both ends of the island and that is exactly what the data show.

With those points in mind corroboration for the picture presented tends to be derived from the fact that many young falcons are seen up to February and very few after April, that there is a local concentration of breeding falcons near Oglala Pass, and that greater average distance separates breeding stations along the middle portions of the island.

Populations in the Rat Island Group

On 30 June and again on 22 October I visited Semisopochnoi Island (Figure 2). This island is about 40 miles (64 km) in circumference and 35 miles (56 km) northeast of Amchitka. The island was circumscribed and surveyed from helicopter and some parts were visited on foot. Ten adults (pairs or singles) were seen to fly from the cliffs at eight localities. Their actions were similar to terri-

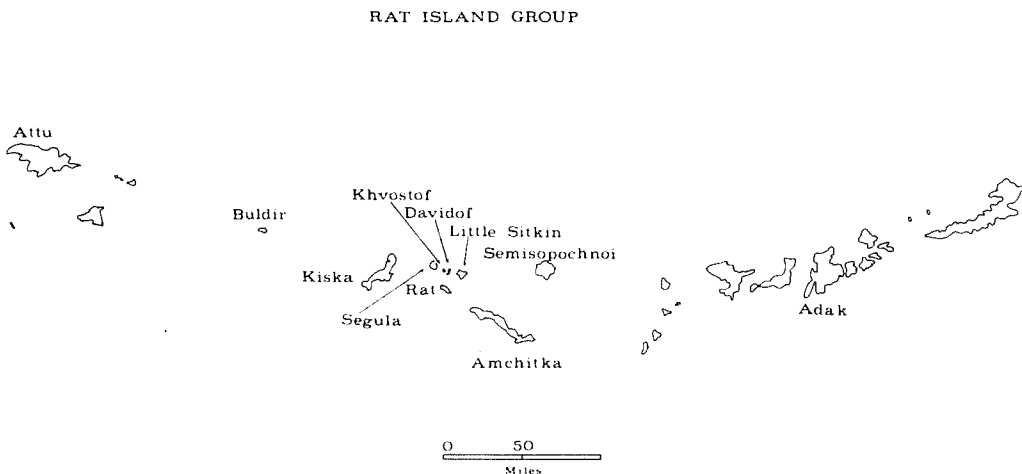


Figure 2. The Rat Island Group. Buldir Island is sometimes not considered part of the Rat group. Adak and Attu are not part of the group but are labeled for reference points.

torial falcons at eyries on Amchitka when flushed by a helicopter. Adults were seen at the frequency of one (or a pair) on the average of every 5.0 miles (8.0 km)—similar to Amchitka. At Sugarloaf Head, where a Least Auklet colony of roughly 50,000 birds is located, at least three pairs of falcons were seen along the front of the colony which is perhaps four shoreline miles (6.4 km) across. On an October trip, only 11 falcons were seen, but weather conditions were so poor that the helicopter could not get close enough to the island on some stretches to flush falcons. However, for similar flying times and under similar weather conditions, as many falcons were seen on Semisopochnoi as on Amchitka, once again suggesting similar population densities on both islands.

In early July, 1971, my colleague, William Emison, went to Rat Island from Amchitka to survey it for Bald Eagles and Peregrines by helicopter. This island is about 21 miles (34 km) in circumference and 14 miles (22.5 km) to the west of Amchitka. Eight adult falcons were seen at six different locations on this trip. The falcons acted as though they were territorial.

Assuming that the eight birds represented four territorial pairs, the density is roughly one pair per 5.3 miles (8.5 km) of shore line; once again roughly the same magnitude as that of Amchitka. On an October trip I saw only three falcons on Rat Island.

Between 30 June and 9 July 1972, while en route to Buldir Island, we spent three days on Kiska and circumscribed four other islands by boat. On Little Sitkin one eyrie with one young was seen from the boat. On Davidof one adult was seen; on Khvostof, two adults were seen; and on Segula, one adult was seen. We stayed $\frac{1}{4}$ to $\frac{1}{2}$ mile (0.4-0.8 km) offshore and the small number of falcons seen is not surprising. At Kiska a pair occupied the "Great Cliffs" at the head of the harbor as they did in 1886 (Turner), 1936 (Murie), and 1943 (Nelson, pers. com., see beyond).

Buldir, which is a small island about four miles (6.4 km) long, two miles (3.2 km) wide, and roughly 12 miles (19 km) in circumference, was visited between 5 and 9 July 1972. It is about 65 miles (10.5 km) east of the Near Island and 130 miles (209 km) northwest of Amchitka. Two pairs of falcons were found in the same vicinity they were in 1963 when found by Kenyon (Fish and Wildlife trip report). At one eyrie at least two young were on the wing. In addition, we found defensive adults at two other localities, thus giving a density of one defensive pair per 3.0 shoreline miles (4.8 km) on the average. This island has at least two auklet colonies with a total of between 50,000-100,000 individuals plus both a petrel and a large kittiwake colony. Following Beebe's (1960) and Blood's (1968) statements, one would expect more Peregrines on islands containing seabird colonies than on other islands.

Populations on Other Islands

Between June and August 1971, Palmer Sekora and Daniel Gibson (Fish and Wildlife Service) made preliminary and somewhat superficial and spotty faunal studies to determine wilderness status of much of the Andreanof group of islands (though about two weeks were spent with us on Amchitka, Rat and Semi-

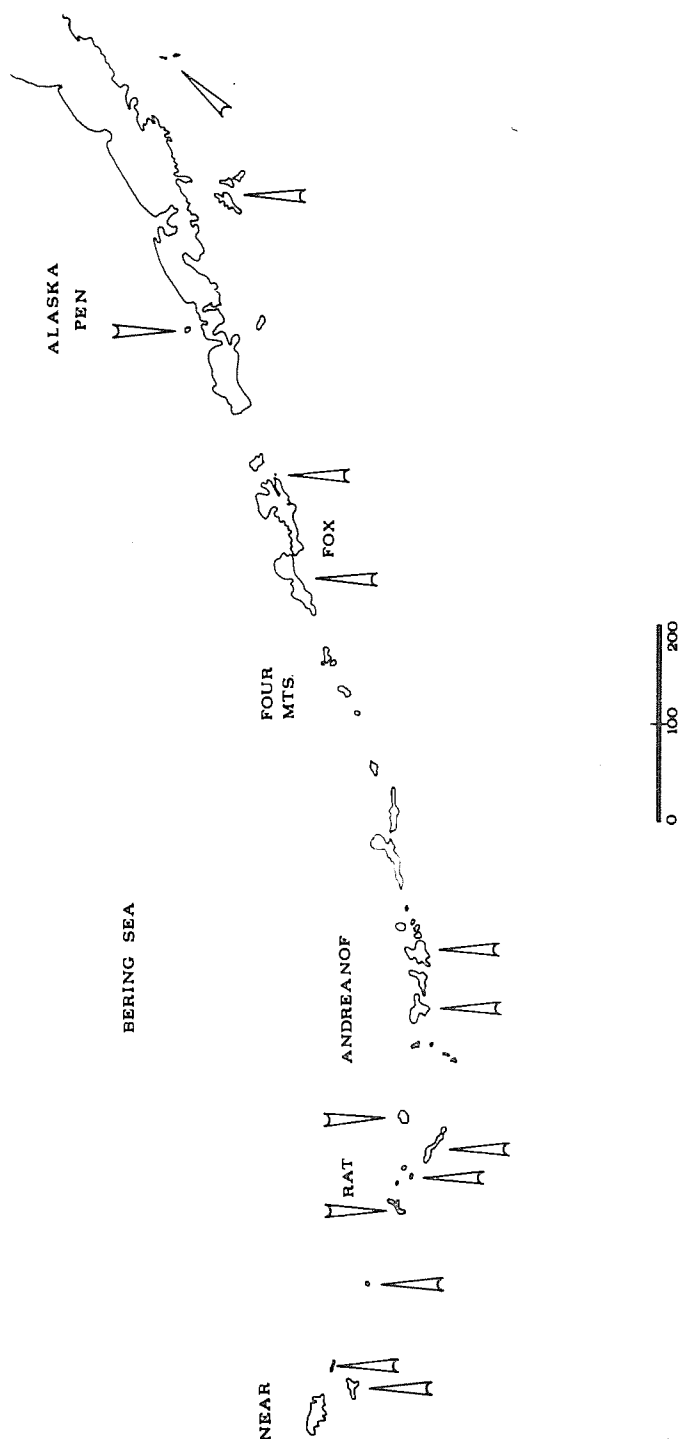


Figure 3. Distribution of islands in the Aleutian chain for which there are some data on Peregrine density. From east to west the island groups are labeled: Fox Islands, Islands of the Four Mountains, Andreanof Islands (also including the Delarof's), Rat Islands and Near Islands. The islands indicated by arrows from east to west are Semidi's, Shumagin's, Amak, Egg (small dot), Umnak, Adak, Tanaga, Semisopochnoi, Amchitka, Rat, Kiska, Buldir, Semichi's, and Agattu. Many of these islands are mentioned in the text.

sopochnoi Islands). Although Peregrines were not specifically looked for, a total of 15 Peregrines were seen at 12 localities (refer to Figures 2 and 3 for many of the main localities mentioned) as follows: Kanaga Island, June; Adak (four different localities, but three may have been the same bird), July and August; Great Sitkin, three calling at what appeared to be an eyrie, 10 August; Tanaga Island, pair of adults circling, August; Ulak, adult among the thousands of puffins on cliffs, probable eyrie, island only one mile (1.6 km) long and one-fourth mile (0.4 km) wide, 11 August; Umak, four together along high cliffs, 12 August; Kagalaska, August. These observations were made from boat some distance offshore. Their data for a similar survey but in a different set of islands in 1972 are not yet available. Olaus Murie (field notes, 1936-37) had similar spotty sightings on Peregrines though he was not specifically looking for them in the course of general faunal studies in 1936-37. Murie found nests on 15 islands and saw adults on 23 others. To demonstrate the spotty nature of his observations, I have selected the following. He mentions only one seen at Umnak on 6 June (1936 field notes; compare with data beyond where as many as six pairs have been found at the eastern end in 1968 and 1970); one pair at Agattu (Robert Jones, Fish and Wildlife Service, Cold Bay, reported three pairs at Agattu, Narrative Report, 1964); one noted on Buldir in 1937 (at least two pairs, near Northwest Point, Buldir in 1963, Fish and Wildlife Narrative Report, and in 1972 four pairs were found upon critical examination of the entire island); and Kiska, one pair seen [in harbor] in 1937 (Morlan Nelson, as stated later, found several pairs in 1943). Finally, for the Rat Island group, Murie reported about three pairs (*in litt.*) on Amchitka (only one pair was listed in his 1937 report, however) where today there are a minimum of 16 pairs annually; for Semisopochnoi he reported only two pairs in 1937 (doubtless the same areas as the eyries at the auklet colony where Murie was known to have spent considerable time) and for Rat Island (1937) he reported no Peregrines. The earliest literature for the Aleutians usually refers to Peregrines in general terms as indicated by Turner's (1886:106) statements "On Agattu it is reported to be very common; . . . the natives assert that it is common enough at Agattu and the Semichi Islands." The point to be made is that unless specifically searching for Peregrines, the types of faunal studies that are generally carried out reveal only a minor percentage of the total Peregrines present. The surveys do indicate, however, the widespread and abundant nature of the Peregrines in the Aleutians. It is clear that more money and time needs to be allotted to Aleutian studies in order to determine the true nature of the Peregrine in those islands.

It is readily apparent that the known number of falcons nesting on Amchitka, Semisopochnoi, and Rat islands suggests a density far in excess of that reported for the Aleutians (Murie, 1959; Gabrielson and Lincoln, 1959; Cade, 1960) where it has been said that there is at least one pair per island or islet. We have recently shown (Cade *et al.* 1971; White *et al.* 1973) that the Peregrines in the Aleutians have extremely low pesticide levels and that they appear to be in no danger of a decline. Therefore, one could assume that the numbers of falcons seen in the 1930's (Murie's field notes, 1936-37) and 1940's represent a mini-

mum of falcons in a very stable population condition that still persists today. There is every reason to assume that there has been no decline. Morlan Nelson, reported (*in litt.*, 13 December, 1971) that in the summer of 1943 while in the armed forces he had the opportunity to check with some thoroughness certain areas of Adak (Andreanof group), Kiska (Rat group) and Umnak (Fox group, eastern Aleutians) islands for falcons. His data show that breeding birds were distributed on these islands on the average of one pair per 5-8 miles (8.0-12.8 km). He found what appeared to be three pairs breeding in the harbor at Kiska. His values agree closely with that already mentioned for the Rat group 30 years later. Further, the values are partially corroborated for Umnak Island where in June 1970, Dr. Robert Moss, Nature Conservancy, Scotland, and Dr. David Kline (pers. com.), Alaska Wildlife Cooperative Unit, made casual observations of at least three different pairs of Peregrines on some 40 miles of coast east and north of Fort Glenn, Umnak Island. These three pairs were in different localities than the three pairs found by members of the American Ornithologists' Union while working by foot on a one-day layover of Umnak on 15 June 1968 (Walter Spofford, pers. com.). The indicated density from these two separate sets of observations on Umnak approximate Nelson's 1943 observations there as to density of pairs per average shoreline mile.

Total Population Estimate

Since the Aleutian Islands, Southeast Alaska and Greenland are perhaps the prime areas left to survey for Peregrines in the Nearctic, I have attempted to fill in part of the gap in our knowledge by equating known data for the Aleutians to arrive at a possible population value. As already pointed out by several investigators, I, too, recognize that extrapolations on population densities are "gloriously wild guesses" of the true population size. The following, however, may have some value if the expected frequency values derived from the Rat Island group can be tested at other islands selected at random in the far western and in the eastern Aleutians. Although much of the following is based on the assumption that we have a fairly clear picture as to the distribution of cliffs, of auklets and petrels, and of marine Peregrine food habits, I should also mention that several pairs of falcons subsist largely on kittiwakes at one locality in the Cook Inlet and another pair seemingly derives its main food from large rafts of summering, non-breeding phalaropes in a bay in Southeast Alaska (R. Weisbrod, pers. com.). These data emphasize that, when in large numbers, there are many "substitution" prey items to what has been reported as "normal or typical" food for the *pealei* population of Peregrines. And, although I have emphasized the relationship between Peregrines and small alcids, other prey species may override that apparent relationship.

For the Aleutian Islands Cade (1960) arrived at the value of about 100 pairs based in part on Murie's observations of nests on 15 different islands, adults on 23 others, and Murie's statements that for the entire chain one pair per island would not be excessive. A higher value is generated based on the following assumptions mainly from Amchitka Island data.

(1) Despite the fact that breeding colonies of petrels and auklets do not occur on the island, four auklet and one murrelet species form the prime food items in our sample (60% combined; N=548 through 1972) of Amchitka Peregrine food during the breeding season from May through July (White *et al.* 1973). Two petrel species although uncommon at Amchitka and usually several miles offshore provide 7% of the food items.

(2) To obtain auklets, Peregrines apparently travel some distance to sea. Although the closest Least and Crested Auklet colonies to Amchitka are some 18 miles (29 km) away, auklets apparently travel widely at sea and they may be found 2-3 miles (3.2-4.8 km) offshore from Amchitka at most seasons. These may be non-breeding auklets. Ancient Murrelets, however, may breed on Amchitka based on the fact that eggs ready for shell formation were found in some females.

(3) In late July, 1969, a pair of adult Peregrines was seen cooperatively hunting auklets some four miles (6.4 km) offshore near Segula Island and we have several observations of them two miles offshore at Amchitka. This further emphasizes the hunting pressure of Peregrines on small alcids when one considers the large numbers of land birds on the island closer to the Peregrines, and presumably readily accessible, but not found in a proportional frequency in prey remains (see White *et al.* 1973 for a discussion of prey choices of Amchitka Peregrines).

(4) In both the aspect of the lack of breeding auklets and in some of the physiographic features of the island, Amchitka is atypical as an island in the chain in general and the Rat Island group in particular.

(5) Beebe (1969) found the highest breeding density of *F. p. pealei* on the British Columbia coast in areas of small alcid colonies and the lowest density or lack of breeding Peregrines in sections of the islands where alcid colonies did not occur.

(6) Auklet, murrelet, and petrel colonies largely circumvent Amchitka but occur at rather regular intervals throughout much of the chain (Murie, 1959; Urdvary, 1963; and G. V. Byrd, Asst. Manager, Aleut. Isls. Nat. Wildlife Refuge, pers. com.). Even though the absolute distribution of colonies may have changed since Murie's studies, as suggested by recent surveys by the Fish and Wildlife Service, the relative abundance and distribution appears to be about the same (G. V. Byrd, pers. com., and pers. obser.). Colonies at any rate are uniform enough in their distribution to cause either petrels, auklets, or murrelets, or all three jointly, to be found in nearly all Aleutian waters within striking distance of Peregrines. An exception to this might be the Near Islands, but in those islands there are several colonies of kittiwakes and Horned Puffins with a combined minimum of 22,000 and 12,000 individuals respectively (Palmer Sekora, Wilderness Study, mimeo., 1973). Both species are ideal food for Peregrines and are used extensively. Another possible exception may be Unalaska for which we need new data concerning small alcid abundance and distribution although the older literature indicates that they are not uncommon there, especially Crested Auklets (Dall 1873).

(7) L. M. Gard, U.S.G.S. field director for the Aleutian Islands from the Denver Office, has been on and mapped a considerable number of the islands. He is very familiar with Peregrines. He reports that except for large flat areas on Tanaga and Kanaga islands (similar to the eastern portion of Amchitka) the shorelines of most of the remaining islands are physiographically equal to or better than Amchitka in supplying Peregrines' nesting requirements.

(8) Amchitka would thus appear to be a sub-optimal island for Peregrines in many factors, and I feel that the density values for Amchitka Peregrines are thus at the lower end of a theoretical population number.

Thanks to the efforts of Palmer Sekora, Fish and Wildlife Service, the size and shoreline mileage for most of the islands in the Aleutians has been determined. For the 91 islands in the Aleutian Island Wildlife Refuge, including parts of the Sanak group, there is a total of 2,429 miles (3908 km) of shoreline. This value does not include the following islands not in the refuge: Unalaska, Umnak, Unimak (three of the larger islands in the chain), Sanak, Akun, Akutan, Tigalda, and Sedanka. I have made a rough calculation from a 1:250,000 scale USGS map and arrive at a value of some 1,062 shoreline miles (1709 km) for these eight islands. Thus, for the 99 islands there is a total shoreline mileage of somewhere near 3,491 miles (5617 km).

Given one pair of falcons, on average, for each 10 miles (16 km) of shoreline, a value in keeping with densities in other parts of Alaska such as the Yukon and Colville rivers (Cade *et al.* 1968; White and Cade, 1971), there would be about 349 pairs for the Aleutians. Using the Amchitka figure of one pair per 6.3 miles (10.1 km) (which I feel is an average, if not a conservative value for the reasons stated above) there would be about 554 pairs. Additionally within 140 miles of the eastern end of the Aleutians (eastern end of Unimak) are the Deer (one island), Pavalof (five islands), and the Shumagin islands (20 islands). Because the Shumagins are known to harbor large numbers of at least one murrelet and two auklet species (Murie 1959), these additional 26 islands might be properly included in the calculations for the Aleutians in an expanded sense. Based on our knowledge of the Shumagins, it is realistic to suggest that one pair of falcons occurs on each of the above islands for 26 additional pairs. Some of these islands are small but none are smaller than Egg Island, in Akutan Pass, with a shoreline perimeter of 2.9 miles (4.7 km) and which has a breeding pair of falcons (McGregor 1906) nor do they have any less readily available food supply than Egg Island.

Assuming that the above argument has a semblance of accuracy, I propose that the Aleutian Islands, in the expanded sense, has a population of Peregrine Falcons numbering somewhere between the values of 375 and 580 breeding pairs. Including immatures based on a fledging rate of 1.77 young per pair, the values for late summer may fall between 664 and 1,027 individuals.

Summary

For this conference data on production, mortality, a brief history of some selected nesting sites and population density from studies on Amchitka Island

are reported. Additionally, data from the Rat Island group and other parts of the Aleutians are given and extrapolations presented to support what is believed to be the population size within the Aleutian Islands.

On the average, about 66% of the nesting attempts are successful in producing young. Fledging success per successful nest is about 2.66 young per year and 1.77 young per year per attempted nesting. The data suggest that a rather high mortality rate occurs in which 80-85% of the young may die in their first year. Some nesting sites show consistency in frequency of use and stability in the pair bond of the falcons. Others are used more erratically and there is a high turn rate in the adults.

The nesting density of falcons is about one pair per 6.3 shoreline miles (10.1 km). Food or nest site availability are not believed to be factors regulating population density. Studies in the Rat Islands and other islands, studies on availability and distribution of prey species, and data on the geomorphology of the Aleutian Islands suggest that between 375 and 580 pairs of falcons breed in the Aleutians.

Addendum

Since the writing of this report, I have had the opportunity to visit and examine closely additional islands in the western Aleutians. All the localities mentioned are shown in Figures 1 and 2. Three eyries and a lone unmated adult were found on Little Sitkin for one pair per 7.2 miles (11.5 km) of shoreline. Two eyries and two 11 month old Peregrines on Segula for one pair per 7.9 miles (12.6 km) of shoreline. One pair each on both Davidof and Khvostof for a combined value of one pair per 5.2 miles (8.3 km) of shoreline. Lastly, a research crew worked on Agattu from May through August, 1974. Something less than three-fourths of the island was walked. Seven pairs of falcons were found on that coastline covered for a density of one pair per 7.6 miles (12.2 km) (Charlie Craighead, pers. com. and pers. obser.).

As more data are gathered, the average density appears to support that which was postulated, at least for the western Aleutians.

One of the significant food items that we found on Attu in late April and early May, 1974 was Red-faced and Pelagic Cormorants. The same two cormorants were commonly killed and eaten on Shenya (Semichi Islands) during 1973 and 1974 (Wm. Baird, pers. com.). These species were not utilized on Amchitka where small alcids were available. If cormorants are commonly taken in regions where auklets, etc. are in lesser numbers, then the spectrum of preferred foods is greatly amplified since cormorants are abundant throughout the Aleutians.

Acknowledgments

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SUMMARY OF WEST GREENLAND

PEREGRINE SURVEY, 1972

William G. Mattox

William A. Burnham

General descriptions of the Peregrine Falcon (*Falco peregrinus tundrius*) in Greenland have been published, but little quantitative data exist on nesting density, breeding success, and possible existence of pesticide residues in this population. Because of this lack of information on the status of the Greenland Peregrine Falcon, the "West Greenland Peregrine Falcon Survey, 1972" was planned and led by Dr. William G. Mattox and Lt. Col. R. A. Graham (Mattox, Graham, Burnham, Clement and Harris, 1972).

According to Salomonsen (1950-51), the Peregrine Falcon breeds commonly on the southern parts of the west coast of Greenland, northward to Nugssuaq Peninsula (74 degrees N). However, farther north in the Thule area (77 degrees N) they are rare and uncommon breeders. In the southern part of East Greenland the Peregrine is also common, but in the Angmagssalik District (71 degrees N) the number quickly decreases making it a sparse breeder there. It is met with farther north on the east coast during the breeding season but only rarely. This would indicate a larger number of birds breeding on the west coast than on the east coast.

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Recently White (1968) included most of West Greenland as a breeding area of the newly described *tundrius* subspecies. Previously, Peregrines in Greenland (as well as in Alaska and northern Canada) were classified as *F. p. anatum*. Only two records of Peregrines banded in Greenland and recovered elsewhere are known: a nestling banded in southwest Greenland in August, 1941, was found dead near Cienfuegos, Cuba, in December of the same year; another nestling banded in West Greenland in July, 1956, was recovered 150 miles north of Montreal in October of that year (Salomonsen 1967). Two Peregrine Falcons banded in October 1956 and 1957 at Assateague Island, Maryland, were recovered (shot) later in West Greenland. The falcon banded in 1956 was recovered in November, 1959, the other in September, 1958 (Salomonsen 1967). These few returns suggest that at least some Peregrines from Greenland migrate past eastern Canada and the United States to winter in Central and South America and the Caribbean Islands.

Purposes of the 1972 Study

The main purpose of the survey was to study a sample area of West Greenland to supply baseline data about Peregrine Falcons from which future surveys could determine the status and trends of this bird in Greenland.

Our goals were:

- (1) to determine the density, distribution and reproductive success of nesting Peregrines in a sample area;
- (2) to band all Peregrine nestlings found;
- (3) to determine prey species of the Peregrine;
- (4) to make interspecific observations of Peregrines and Gyrfalcons (*F. rusticolus*);
- (5) to make detailed observations from a blind of a sample Peregrine Falcon eyrie;
- (6) to conduct a breeding bird census in the area of the sample eyrie;
- (7) to make a photographic record in color slides and movies of the investigations.

Field Methods

The survey team of five men was in the field in Greenland from 20 June to 14 August. During most of that time, Clement and Harris made detailed observations at a selected Peregrine Falcon eyrie. They lived in a permanent camp within good sight and hearing distance of the Peregrine cliff from 23 June until 3 August, with an additional visit to the eyrie on 12 August. The six weeks covered a period from one week before hatching to one week before fledging. During the second week after hatching, Clement placed a blind on the cliff 30 feet (9 m) from the eyrie. A total of 231 hours of direct observation was recorded, including 51 hours from the blind and 157 hours from a lookout position about 330 feet (100 m) from, and of equal elevation with, the eyrie. The observers took data on development of the young, activity cycle, prey species, and the behavior and role of the parents. This last included intra- and interspecific

behavior, hunting, and care of eggs and young. They collected pellets and egg-shell fragments for analysis, noted weather conditions and the reproductive and diurnal activity cycle of the prey species. Harris made a census of breeding birds in a sample area in the immediate vicinity of the nesting cliff. Photographs and movies were taken mainly of the parents and young in the eyrie along with photographs of the cliff and general area.

Burnham, Graham and Mattox traversed the reduced survey area on foot, locating nesting sites of both Peregrines and Gyrfalcons. Later in the season, Clement joined these men to form two-man parties to revisit the located eyries to band nestlings and collect prey remains. The survey traverses were made by self-supporting back-packing trips varying from two to eight days from the main basecamp. The maximum total distance covered by one man (Burnham) in back-packing was about 600 miles (965 km). Limited use of helicopter (ca. 2 hours) and small boat (ca. 12 hours) aided the survey. In all, 1500 color slides, 540 black-and-white negatives, and 3500 feet of color movie film were exposed.

Results

We found eight Peregrine Falcon eyries and three Gyrfalcon eyries in the survey area. The eight Peregrine eyries held a total of 18 nestlings. Of the eight eyries, one had no young, but on 6 August showed signs of occupancy (a scrape, bits of down, etc.) and was defended by an aggressive pair of falcons. Of the other seven eyries where we found hatched young, one had four young, four had three young, and two had one young bird each. Of the 18 nestling Peregrines, we banded 13 but five were fully-fledged and unable to be caught for banding. Of the Peregrine nestlings banded, nine were males and four were females. The number of nestlings in the eight Peregrine eyries gave a production rate of 2.25 per eyrie, or 2.57 if an average is taken of the seven eyries actually producing young. At one eyrie a young falcon was found dead (the eyrie with four young, three of which fledged). We know that at least eight of the remaining 17 young fledged successfully, but we are uncertain about the success of the others and cannot therefore make a definite statement on fledging ratio. We estimate, however, that the fledging rate of the Peregrines in our survey area was at least 2.00 per producing eyrie. The maximum dimensions of our irregularly-shaped survey area were 39x34 miles (63x55 km). The estimated area of the survey was about 800 square miles (2072 sq km) or about 700 square miles (1813 sq km) when the surface area of fjords and lakes is excluded. The nesting density of the active, young-producing Peregrine eyries (seven) was about one pair per 100 square miles (260 sq km). Large portions of the area were gently rolling and had no cliffs and therefore did not suit requirements of the Peregrine.

At the three Gyrfalcon eyries we found eight nestlings or fully-fledged young, of which we were able to band three. This figure is somewhat misleading as to total number breeding. From remains collected and observations made by native inhabitants, two more Gyrfalcon eyries probably existed on the fringes of the study area. Because of limited time and early fledging of Gyrfalcons we

were unable to check these eyries. This would suggest an eight to five ratio of Peregrine to Gyrfalcon eyries in the study area. Peregrines and Gyrfalcons (and a rare White-tailed Sea Eagle, *Haliaeetus albicilla*) are the only avian predators nesting in southern West Greenland, although Ravens (*Corvus corax*) competed for some nesting cliff sites.

Addled eggs (two) from two Peregrine eyries were collected and analyzed for pesticides. Of the two eggs collected, one appeared to be infertile and had a level of 364 ppm DDE. The second contained a three week old embryo and had a DDE level of 300 ppm (Walker, Mattox and Risebrough 1973). The fertile egg which was found in an eyrie producing three fledged young appeared to have been accidentally pushed into a crack and could not be retrieved by the falcon, thus causing the death of the embryo. The thickness of eggshell fragments collected from five Peregrine eyries averaged .298 mm which, when compared to 42 eggs collected before 1940 (D. W. Anderson, unpub. data), shows a 14% decrease in eggshell thickness.

To preclude the possibility of disturbing the parents and causing egg cooling before the eggs had hatched, we purposely did not attempt to determine the clutch size or exact eyrie site early in the nesting season. At two eyries, however, we located the eyrie to count and found four eggs in each eyrie.

Prey remains collected and identified showed that the Peregrine Falcons in the survey area were feeding mainly on passerines (two species) with an occasional ptarmigan and phalarope included in their diet. Four passerines nested in the study area: Lapland Longspur (*Calcarius lapponicus*), Snow Bunting (*Plectrophenax nivalis*), Redpoll (*Carduelis flammea*) and Wheatear (*Oenanthe oenanthe*). Of these four passerines, the Lapland Longspur and Snow Bunting were found to make up approximately 80% of the Peregrine diet. Observations made by the researchers manning the blind showed that the falcons sometimes hunted from, and within sight of, the eyrie, returning with small passerines. The Gyrfalcons in the study area preyed largely upon Ptarmigan (male) with occasional duck remains being found.

Preliminary Conclusions

Peregrine Falcons in West Greenland appear to have a high nesting density (1/100 sq mi, or 1/260 km²) and a high production rate (2.25/eyrie), especially in light of the unusually severe conditions during the winter and late spring of 1971-72. Apparently even the reduced eggshell thickness in Greenland Peregrine eggs is not sufficient to lower reproductive success.

Little interspecific competition for prey species was observed between Peregrines and Gyrfalcons, probably because of the distance between occupied eyries. The Gyrfalcon is already nesting in West Greenland before the Peregrines arrive from their winter migration to the south. The Gyrfalcons could therefore be expected to be aggressive in defense of their nesting cliffs and thereby occupy optimal cliffs. Despite this, not only the Gyrfalcons, but all the Peregrines we studied occupied high, sheer, and quite optimal nesting cliffs with a southern

exposure. However, the Gyrfalcon eyries overlooked a larger expanse of area than those of the Peregrine. Gyrfalcons seemed to prefer a nesting site located in the bottom third of the cliff and the nest consisted of a stick structure. The Peregrines placed their nesting site in the upper half of the cliff. We did not observe interaction between Gyrfalcons and Ravens for nesting sites because of the early nesting date of these birds. However, Ravens were relegated to lower, less desirable (more accessible) cliffs for nesting.

In the study area we found the four passerines mentioned previously plus ptarmigan, phalarope, Iceland Gull, Glaucus Gull, White-fronted Goose, Red-throated and Common Loon, cormorant, Mallard, Old-Squaw and Purple Sandpiper. With this large assortment of prey, the Peregrine appeared to be selectively feeding mainly upon the passerines, mainly two of the four available. By our observations, however, the Lapland Longspur was by far the most abundant passerine and this would possibly indicate why it made up a large percent of the Peregrine diet. The Gyrfalcon, like the Peregrine, preyed upon only a few of the available prey species.

Future Research Needs

Research on Peregrine Falcons in Greenland in the future should be concentrated on obtaining more observations from coastal areas, in addition to resurveying and expanding the 1972 survey area. A survey might also be made of traditional nesting sites scattered along the west coast as recorded in the literature. Both a resurvey of the 1972 sample area and visiting historic nesting cliffs to determine current occupancy would provide a good indication of the present status of Peregrines in West Greenland. Also required is a larger sampling of falcon eggs and prey species for pesticide analysis. This should be done for both Peregrines and Gyrfalcons. A time-lapse photographic study (Temple 1972) of several eyries would be desirable particularly if conducted in conjunction with detailed observations by skilled observers from a blind. A return visit will be made in 1973 by a party of researchers led by Dr. William G. Mattox.

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*AUTUMN MIGRATIONS OF
PEREGRINE FALCONS ON
ASSATEAGUE ISLAND, 1970-1972*

Robert B. Berry

F. Prescott Ward

ABSTRACT. From 1970-72 the autumn migrations of Peregrine Falcons (*Falco peregrinus tundrius*) were studied on Assateague Island in Maryland and Virginia. During a 22-day observation period in 1970, 68 Peregrines were sighted and 28 were trapped, including five recaptures of falcons banded earlier in the survey. In 1971, 120 Peregrines were sighted in 16 days, 35 were banded and 10 were recaptured. In 1972, in 32 days 39 Peregrines were sighted, eight were trapped and banded, one was retrapped. Of the falcons banded, immature birds comprised 87%, 89% and 63% respectively of the samples in 1970, 1971 and 1972. Of the falcons sighted that could be positively identified, 85% in 1970, 91% in 1971 and 66% in 1972 were immatures. These data, when compared with other records kept intermittently since 1939 suggest that the abundance of Peregrine Falcons in 1970 and 1971 was probably not different from that of recent years. Age ratios of sighted and trapped birds, reported to be a reliable indicator of reproductive success, correspond favorably with all previous data, except 1972. The dramatic decline in birds sighted in 1972 over prior years, coupled with the low indices for immatures sighted and captured (adult sight-

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ings were lower, but capture rates were about the same) suggests poor reproductive success in 1972. Comparisons of Peregrine sightings in 1970, 1971 and 1972 with those recorded by a single observer between 1939 and 1947 suggests that a significant population reduction occurred after 1947.

The objectives of this study are (1) to count and to determine age and sex ratios of migrating Peregrine Falcons from sightings and captures, and to compare these data with records from previous years; (2) to establish standard observation and capture techniques and a base period (28 September through 12 October) on which observations are made each year so that the results of this study can be used as a baseline for interpreting future migration statistics; and (3) to band as many Peregrines as possible to augment scanty information on the origin of Assateague migrants, the migration routes and wintering grounds used, and population dynamics of the species.

Study Area

Assateague is one of the chain of narrow, sandy barrier islands that parallel most of the Atlantic Coast. It is 36 miles (57.9 km) long and nearly a mile wide along most of its length, increasing to more than three miles (4.8 km) in width near the southern tip. Only a few small areas are designated off limits for our study.

Materials and Methods

A trapping party consisted of one of the authors and usually one or more observers. Two vehicles were operated simultaneously. No other falcon trappers were present during the study periods. Daily observations were begun at dawn and ended shortly before sunset.

We selected two techniques for the survey because of the habits of migrating Peregrines. Many birds land to rest or feed on scattered portions of the island. These birds could be counted only by traveling the beaches and levels in a four-wheel drive vehicle. Because we could miss some flying birds while we were traveling the island, we selected the best (according to falconers' records) trapping spot on Assateague for stationary observations. For several hours each day, one author scanned this area from his vehicle while the other traveled the beach. The mileage and amount of time spent driving and observing were tabulated according to sector and survey technique. We used noose-jacketed pigeons and attempted to trap all falcons seen. Captured birds were banded with Fish and Wildlife Service bands.

Results

During the 22-day study in 1970, we drove 3,750 miles (6034 km) and spent a total of 310 hours on the beach, traveling and observing. In 1971, we reduced our effort to a 16-day study—3,160 miles (5084 km) of driving and 222 hours of driving and observing. In 1972, we increased our study effort to 32 days and

drove 6,050 miles (9734 km) and spent 328 hours observing.

In 1970 we sighted 68 Peregrines, but not all were different birds; of 28 captures, five had been banded earlier in the survey. In 1971 120 falcons were observed, 49 were captured, but only 35 of the trapped falcons were different birds. In 1972 we saw only 39 Peregrine Falcons and captured eight, of which one was recaptured. Our high recapture rates (20 of 86 birds or 23%) indicate that, because of repeated sightings of the same birds, our counts of falcons sighted are too high. These rates also strongly suggest that we see a large proportion of the Peregrines migrating at Assateague.

Discussion

Age ratios during migration are reported to yield a valuable clue to the reproductive health of raptor populations. Age ratios in 1970 and 1971 were similar to those recorded since 1938. However, in 1972, the ratio of immatures to adults fell from 84% of birds trapped and 82% of birds sighted in all prior years to 63% and 66% respectively (Table 1). Other banders on the Atlantic beaches corroborated our observations of a paucity of young falcons. 1972 was also the poorest year on record for Peregrine sightings at Hawk Mountain, Pennsylvania, and at Cedar Grove, Wisconsin. Biologists studying waterfowl also reported diminished proportions of immature birds in their autumn flights. They attribute this apparent reduced productivity to adverse weather conditions in the eastern arctic during the breeding season.

Table 1. Age ratios of immature to adult Peregrines; numbers of immatures are in parentheses.

	Pre-Survey*	1970-71	1972
Trapped	84% (488)	88% (51)	63% (5)
Sighted	78% (232)	88% (137)	66% (26)

*Data gathered by Alva G. Nye, Jr.

Although we had access to most of Assateague in 1970 and all of the island in 1971 and 1972, and although public use during the study periods was extremely light, our sighting and trapping records are in marked contrast to the early data of Nye. In 10 consecutive seasons beginning in 1938, Nye visited the island a total of 21 days corresponding with our base period; he sighted at least 353 Peregrines for a daily average of 16.8 falcons. We saw 227 falcons in 70 days of trapping or only 3.2 falcons per day. On only one day did our combined total sightings exceed Nye's average—we saw 37 falcons on October 6, 1971 (Table 2). Our next highest total was 16 sightings (October 7, 1971).

Table 2. Peregrine sightings.

	Days	Sighted	Average/Day
1938-1947*	22	353	16.8
1970-1972	70	227	3.2

*Data gathered by Alva G. Nye, Jr.

Nye probably selected days for his visits on the basis of what he considered to be good migration weather. However, even if he was completely successful in choosing the days of maximum migration, we should have had at least two days per season (Nye averaged 2.1 days per year during our base period) on which our mean number of sightings approached his. The implication is that a substantial population decline occurred sometime after 1947, but data from many additional annual surveys will be needed to corroborate this.

PEREGRINES ON SOUTH PADRE ISLAND:

RECENT YEARS

Ralph R. Rogers

Grainger Hunt

Although the Peregrine Falcon (*Falco peregrinus*) has declined drastically in many portions of North America, there remains a substantial breeding population in Alaska and Northern Canada. Prior to 1969, reproduction in these arctic Peregrines was reported to have been normal (Hickey and Roelle 1969; Cade, White, and Haugh 1969). However, in 1969 and later years, arctic investigators disclosed some local and often severe reproductive failures (Cade and Fyfe 1970). To assess the situation, a Raptor Research planning conference was held at Cornell University in 1969. Data were presented at this conference which suggested a substantial decline in northern Peregrines beginning in 1966 (Cade, Lincer, White, Roseneau, and Swartz 1971). As a result, *F. p. tundrius* was added to the U. S. Department of Interior's Endangered Species List (U. S. Department of Interior 1973).

Peregrines of northern origin are highly migratory. Large numbers of falcons move through Texas each fall en route to wintering areas in Central and South America (Hunt 1966). Offshore barrier islands along the Gulf of Mexico, such as Padre Island, act as a "leading line" causing a concentration of falcons (Mueller and Berger 1967). Fall migration of northern Peregrine Falcons has been

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observed yearly on Padre Island since 1956.

Until recently, Peregrine population dynamics have been interpreted solely from Arctic nesting surveys. Enderson (1965), and Ward and Berry (1972) have suggested that population trends may be detected by monitoring autumn migrations. This research is to test the possibility that a decline in migrant Peregrine Falcons has occurred in Texas since 1966.

Study Area

South Padre Island runs parallel to the mainland of Texas in a north to south direction from Port Isabel to Mansfield Channel 34 miles (55 km) to the north. The Gulf of Mexico lies to the east and the Laguna Madre to the west. The island is approximately one mile wide (1.6 km) throughout its length. A resort community lies on the southern end of the island with a causeway to the mainland at Port Isabel which provides the only automobile access to the island. The portion of the island north of the resort community is uninhabited and has changed very little in the past 15 years.

Materials and Methods

Our methods follow those described by Enderson (1965) for the censusing of migrant falcons. We traveled the beach on the gulf side of the island between the dunes and wet sand line attempting to capture each falcon encountered. South Padre Island has a number of large sand flats similar to those described by Ward and Berry (1972). These are the result of storm tides destroying the dune formation. Peregrines not sighted on the beach are frequently seen in these areas through the use of spotting scopes or binoculars. Whenever possible each falcon observed was classified as to age and sex.

Traffic on South Padre Island is scant during the month of October. Its effect today is considered insignificant and is believed to have been even less in the late 1950's and early 1960's. Other hawk trappers were rarely present during the years selected for this study and the effect of their presence is judged to have been negligible.

After reviewing data collected from 16 migration years, 1956 through 1972, eight years that were deemed comparable were used in this study (see Figure 1). Other years were excluded only because observations were made in some other manner, such as from a blind, or because too few days were recorded during the study period. During selected years, only data collected between October 5 and October 17 were utilized totaling 68 days of observation. These dates fall within the peak of migration and by limiting data to this period, the effort expended for each year is considered equal. A total of 497 sightings and 91 captures were made. Observers were present a minimum of 50% of this period.

The data from the years of 1959, 1960, and 1961 are taken from the personal notes of the late Col. R. L. Meredith. During the years 1965, and 1969 through 1972, at least one of us was present, and at times were accompanied by other observers.

Results

Figure 1 compares the data over the entire study period. The horizontal lines give the arithmetic means for each year, vertical lines represent the ranges, and the rectangular boxes show the standard deviations. The number of days spent during the October 5 through 17 period are indicated in parenthesis, and the total number of sightings for each year are indicated by $N=$. Standard deviation compared to range, in this case, reflects the fact that most migrations are typified by some very good and poor days. Because of the large influence of weather, and other factors, population trends are difficult to detect on a yearly basis. We feel that population changes should be analyzed through a number of years.

Reductions in arctic Peregrine reproduction were reported to have begun in 1966 (Cade *et al.* 1971). All years prior to 1966 should indicate normal migration since they occur before any population changes suggested in the literature. In Figure 2, 1959-61 and 1965 were considered together and compared to 1969-72. A comparison of the most recent to the later four year period should reflect variation in the Texas migrant population through an increase or decrease in the average daily sightings.

The earliest four years of the study are referred to as period I, the last four years as period II. During period I, 38 days of observations recorded 259 Peregrines, resulting in a mean of 6.82 per observation day. Period II included 30

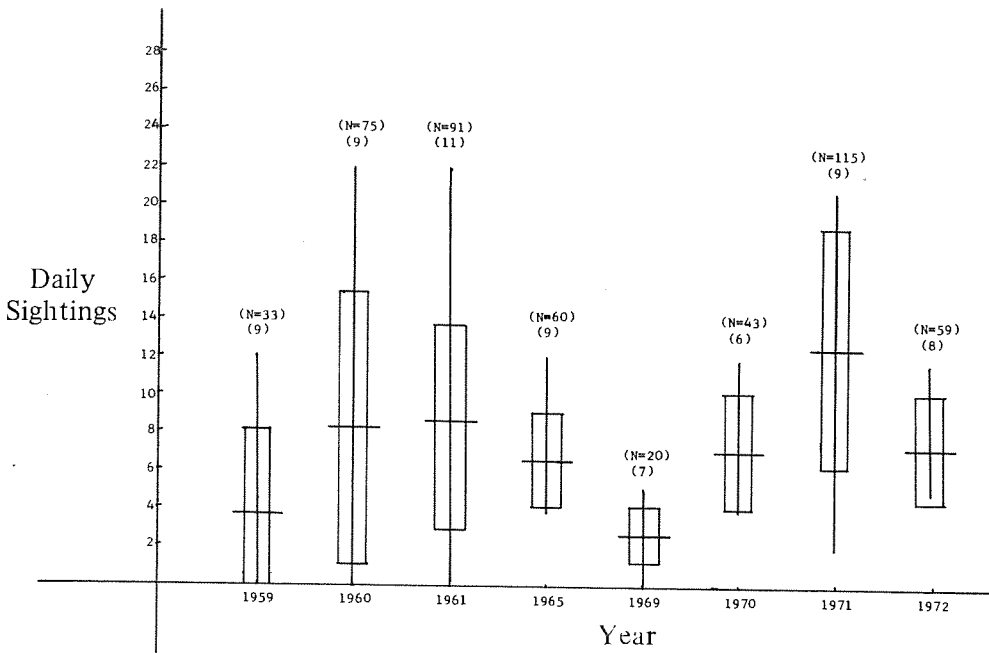


Figure 1. Average daily sightings of Peregrines in October over eight years.

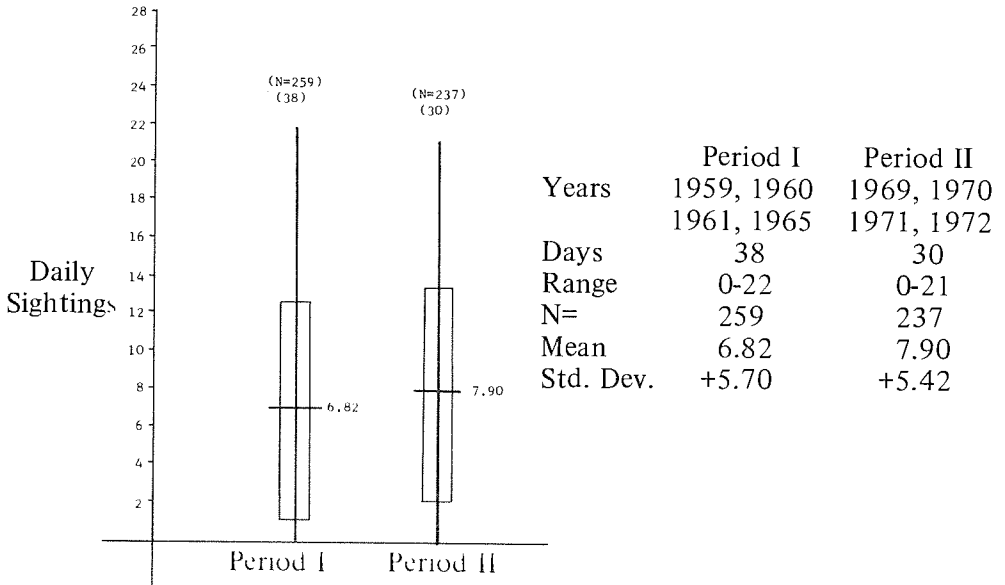


Figure 2. Comparison of average daily sightings during two periods.

days of observations and 237 sightings, with a mean of 7.90 per observation day. The increase indicated during period II is not statistically significant. The standard deviation is comparable for both periods.

Another index of Peregrine Falcon population dynamics is the adult to immature ratio. Shor (1970) referred to this ratio as "the most sensitive indicator of an impending decline." Reproductive failure would be reflected by a smaller proportion of young in the population and in an expanding population the inverse would be true. Table 1 gives the ages of 91 Peregrines captured during both period I and II. The ages of captured falcons were used because early observers did not always record these data for sighted Peregrines that were not also trapped. A Peregrine was considered an adult if it had fledged prior to the calendar

Table 1. Peregrine Falcon adult to immature ratios.

	Years	Number Captured	Adult	Immature	Ratio (Adult::Immature)
Period I	1959, 1960	41	13	28	1::2.15
	1961, 1965				
Period II	1969, 1970	50	8	42	1::5.25
	1971, 1972				
Totals		91	21	70	1::3.33

year of its capture. Of 41 Peregrines captured during period I, 12 were adults, resulting in an adult to immature ratio of 1::2.15. In period II there were eight adults in 50 captures, and 1::5.25 was the resulting ratio. Due to small sample size the difference in these two ratios is not significant by chi square. Results indicate no variation has occurred in Texas since 1966.

Conclusions

In summary, our data indicate that over the past 12 years no significant change has occurred in the numbers of Peregrines observed on migration in Texas. Ward and Berry (1972) have reached a similar conclusion in their evaluation of Peregrine migrations on the coast of Maryland. They suggested that the reason for the discrepancy between their findings and those of the Alaskan and Canadian nesting surveys is a possible Greenland origin for the East Coast migrants. Although the origin of the Texas migrants has not been discovered through band returns, it is difficult to imagine that they come from Greenland.

There is little doubt but that the Peregrine is in serious trouble over much of its range. It should at least be encouraging that this research indicates the Texas migrant population remains as plentiful as historical data will allow us to judge.

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*NESTING DENSITY AND REPRODUCTIVE
SUCCESS OF THE PRAIRIE FALCON IN
SOUTHWEST IDAHO*

Verland T. Ogden

Prior to 1970, Prairie Falcon (*Falco mexicanus*) populations in Idaho had not been studied. In 1967, 1968, and 1969, while assisting with the Golden Eagle (*Aquila chrysaetos*) research, I made a preliminary survey of the relative abundance of the Prairie Falcon in southwest Idaho. This paper presents the results of research conducted in 1970, 1971 and 1972 on the nesting density, reproductive success, mortality factors and food habits of the Prairie Falcon in the Swan Falls Birds of Prey Natural Area of southwest Idaho.

The study area encompasses 45 linear miles (72 km) of the Snake River between Grandview and Walter's Ferry, Idaho. Most of the raptors in the canyon nest on volcanic ash, basalt and sandstone cliffs from 25 to over 400 feet (7.6-122 m) in height. Swan Falls Dam is located approximately midway through the area and the reservoir behind it greatly facilitates movement and observation in this sector of the canyon. Below the dam unimproved dirt roads provide observation and access routes.

A big sagebrush-cheatgrass desert extends 15 to 20 miles (24-32 km) south to the Owyhee Mountains and 10 to 15 miles (16-24 km) north toward the Sawtooth Mountains. These desert areas provide the hunting range for the Prai-

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the Falcons, Golden Eagles and other raptors which nest in the canyon.

Little of the desert adjoining the canyon is cultivated but on the cultivated areas potatoes, sugar beets and alfalfa are the major crops.

I located falcon eyries by systematic observations of suitable cliffs and used standard rock climbing equipment to determine if a suspected nest site was occupied. I tried to visit each nest once before the eggs hatched and from one to four times after hatching to determine the number of nestlings and their survival. During each nest visit I collected all prey remains and castings in or near the nest site. When fledged young could not be observed around the site, I visited the eyrie once again to ascertain fledging success.

I allocated each nesting cliff to an arbitrary "class" or "type" according to composition, height and aspect, and I estimated cliff and eyrie heights from known-length climbing ropes. I noted the exposure and type of each nest. The height and composition of some cliffs made them unfeasible or impossible to visit even though many contained known eyries. At these cliffs I used weekly observations to estimate nesting density.

I first observed falcons near nesting cliffs in late January and most pairs had established nesting territories by late February. By backdating from the dates of hatching it appeared that March 20 was the earliest date of clutch completion. Peak hatching date was approximately May 7 and the latest hatching of first clutches occurred on June 22.

Because nesting cliffs nearly parallel the river the entire length of the study area, I used minimum distance between occupied territories as a measure of nesting density. In 1970 I found 56 occupied territories in the 45 mile area (average 0.87 miles (1.40 km) between eyries). In 1971 I found 74 territories in the same area (mean, one eyrie per 0.67 miles (1.08 km)) and in 1972 I located a total of 101 falcon territories in the area (mean, one eyrie per 0.59 miles (0.95 km)). The increase in the number of occupied territories found is due to a greater knowledge of both falcon habits and the study area. I do not feel that there has been a significant increase in the number of pairs nesting in the canyon although several territories located in 1972 were known to have not been occupied for several years.

In 1972, 80% of the territories were less than one mile (1.6 km) apart; the remainder ranged up to 2.85 miles (4.58 km) from the next nearest eyrie. I found pairs attempting to nest (unsuccessfully) less than 250 feet (76 m) apart and found several successful attempts less than 300 feet (91 m) apart.

The majority of the eyries studied intensively were situated on lower cliffs because nests on these cliffs were often easier to locate and reach. Eighty percent of the nests studied were on cliffs less than 150 feet (45 m) in height and average nest height was 50 feet (15 m).

Nesting success averaged 89, 81, and 81 (mean 83) percent during the three years of study. Nearly 65% of the nest failures occurred during incubation. Hatching success averaged 76% with infertility, predation and missing eggs the most frequent causes of egg mortalities. Sixty-eight clutches counted during 1971 and 1972 averaged 4.4 eggs (range 2-6). Eighty-three eyries visited within

10 days of hatching contained an average of 3.47 young (range 0-6). Of young hatched, 17% died before fledging; predation, disease, inter-specific conflict and missing young were the most common causes of nestling mortality. One hundred and ten nesting attempts provided an average of 3.1 young fledged (range 0-6) and successful attempts averaged 3.70 young fledged.

I banded 336 nestlings at 91 eyries during the study (163 male and 173 female).

I could not accurately quantify the results of prey collections because falcons constantly remove uneaten prey and castings from the nest. Castings were the most common evidence of diet; unfortunately this source gives no indication of the numbers of individual prey items brought to the nest. Townsend Ground Squirrels (*Citellus townsendii*) were found in 98% of 178 prey collections. The three next most commonly found prey species were Horned Lark (*Eremophila alpestris*) 22%, Western Meadowlark (*Sturnella neglecta*) 13%, and Western Whiptail Lizard (*Cnemidophorus tigris*) 11%.

Mean eggshell thickness of 38 unhatched Prairie Falcon eggs was 0.319 mm which represents a 12.9% decrease in the thickness from pre-1947 eggshells (mean 0.366).

My data indicate this falcon population is stable or increasing slightly and is reproductively healthy.

*POPULATIONS OF GYRFALCONS ON THE
SEWARD PENINSULA, ALASKA, 1968-1972*

L. G. Swartz

Wayman Walker II

D. G. Roseneau

Alan M. Springer

Work began on the raptors of the Seward Peninsula, Alaska in 1968 when David G. Roseneau started a survey of Gyrfalcon (*Falco rusticolus*) populations and distribution under the auspices of the Alaska Department of Fish and Game. Since that time support has shifted to the University of Alaska, the National Audubon Society, the International Council for Bird Preservation, the Alaska Cooperative Wildlife Unit and various smaller agencies and funds. The scope of the project has been widened from a relatively simple survey of populations and distribution to include several specific aspects of Gyrfalcon ecology such as food habits, breeding biology, the role of environmental pollutants such as chlorinated hydrocarbon pesticides and PCB, and interactions with other cliff-nesting species.

The initial impetus for this study was the need for more information on species potentially threatened by increasing development and environmental pollution and the fact that most raptor studies until recently have been done on relatively small areas due to logistic and other problems. Since predators are generally more thinly distributed than species of lower trophic levels, studies of small areas are likely to be representative of local conditions and to suffer from small

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sample sizes (Roseneau, 1972). Gyrfalcon studies in particular have been so characterized because of the difficulties of finding and monitoring large numbers of nests.

Methods

The study area includes 44,000 km² (17,000 sq mi) of the Seward Peninsula west of 162 degrees west longitude. Virtually all of this area was examined from the air during the first two years of the study. In subsequent years search was confined to those portions known to contain potential breeding cliffs. Counts of eggs and young were made from the air whenever possible. Nesting sites located from the air were visited on the ground when distances from roads made it practicable.

Results and Discussion

Although nestings were scattered over the Seward Peninsula, about 70% were contained within two areas of favorable nesting topography totalling about 5,700 km² (2,200 sq mi). The remaining approximately 38,300 km² (14,800 sq mi) was divided between about 15,500 km² (6,000 sq mi) with essentially no nesting Gyrfalcons due to lack of nesting sites and about 22,800 km² (8,800 sq mi) in which nesting density was low. The total numbers of nesting pairs for the entire 44,000 km² studied are given in Table 1.

During 1968 one of the two areas of favorable nesting topography mentioned above was not discovered until too late in the season to complete the aerial survey. Thus the totals for 1968 are below their actual value. Nestings in the other areas surveyed in 1968 were comparable to the same areas surveyed in later years. We believe that the actual numbers of Gyrfalcons nesting in 1968 on the whole peninsula were very close to those nesting in 1969 and 1970. Thus the first three years of the study were characterized by a stable population and,

Table 1. Breeding pairs of cliff-nesting raptors on the Seward Peninsula, Alaska, 1968 through 1972.

Species	1968	1969	1970	1971	1972
Rough-legged Hawk (<i>Buteo lagopus</i>)	35	43	82	10	44
Gyrfalcon (<i>Falco rusticolis</i>)	34	48	49	13	36
Raven (<i>Corvus corax</i>)	6	21	16	3	23
Golden Eagle (<i>Aquila chrysaetos</i>)	12	9	16	9	12
TOTAL PAIRS	87	121	163	35	115

judging from our perspectives gained from other areas of Alaska, high numbers. The summer of 1971 was characterized by a dramatic decline in numbers of breeding pairs and fledging success was very low. There were only 0.85 young per nesting attempt instead of the 2.2 to 2.9 young per nesting attempt observed in the previous years. The total number of adult birds seen was also drastically lower and evidence of aberrations in breeding were seen among the birds that did attempt to breed in the form of desertions and dead young in the nest. Pairs of birds and single birds of both sexes were seen at cliffs at which no nests were found. Although definitive data could not be gathered on the point, we feel that 1971 was not only a year in which many birds did not breed but that the adult population on the Seward Peninsula was lower. In 1972 the breeding population returned to about 74% of former high levels and fledging success recovered to levels essentially the same as in the earlier years.

The factors operating in population oscillations are always difficult to establish firmly, especially retrospectively. The literature contains frequent references to apparent responses of Gyrfalcons to microtine rodent and ptarmigan population changes (Dementiev and Gortchakovskaya 1945; Hagen 1952; Cade 1960; Gudmundsson 1970; Bengtson 1971). Roseneau (1972) points out that many of the areas in which clear responses are alleged tend to represent situations in which Gyrfalcons are primarily dependent on these two categories of food. In our own case it appears likely that during the summer Gyrfalcons are rather well protected against food induced population declines because of a relatively great diversity of available prey (Roseneau 1972). But it is important to clearly distinguish between summer and winter conditions. Prey diversity is essentially never present during more than half of the year since ptarmigan constitute a nearly universal sole winter food item.

It appears clear that the population "crash" of Gyrfalcons in 1971 was primarily due to unusual winter and early spring weather conditions that secondarily imposed food stress. The winter was severe including freezing rains, heavy snowfall and high winds which converted much of the Seward Peninsula into a hard pavement with only the tips of willows, the winter food and cover for ptarmigan exposed. Ptarmigan were notably absent from the peninsula and on a December visit including about 320 km (200 mi) of surface travel only one small flock of 20-25 was seen and only two other ptarmigan. No Gyrfalcons were observed although many known eyries and perches were examined. According to local residents, ptarmigan had "all left the peninsula." Snow melt was late as well (although similar to 1968) and birds that remained or returned were probably denied the preparative period of fattening on abundant food that presumably is necessary for good breeding and which might have saved the 1968 breeding season. Populations of microtines remained low even after snow melt and during most of the summer. The role of microtines in the diet of Gyrfalcons is discussed by Roseneau (1972), but microtines may at times serve as a significant nutritional buffer. The hypothesis of rigorous winter and early spring weather conditions as an explanation for the poor Gyrfalcon year in 1971

is supported by the marked reduction in Rough-legged Hawks (*Buteo lagopus*) and Ravens (*Corvus corax*) and the less conspicuous reduction in Golden Eagles (*Aquila chrysaetos*) (see Table 1). An over-all reduction in the numbers of breeding cliff-nesters from 163 pairs to 35 pairs occurred between 1970 and 1971.

While a perspective of many years is needed to help settle the issue, the fact that the 1971 breeding population and the total number of birds observed was substantially less than during the three previous years suggests that either significant adult mortality occurred or that the birds had moved off the peninsula. That the 1972 breeding population, while rebounding nicely, did not return all the way to previous levels is consistent with both of the above possibilities. The present winter (1972-73) has been mild through mid-March and the 1973 data should help to clarify the situation. If adult mortality did occur and the Seward Peninsula has a more or less coherent population of its own, growth of the breeding population this coming summer may be nil or even down since presumably mortality of the potential recruitment component from 1970 and 1971, which may not yet be of breeding age, was high.

Nesting cliff tenacity is low on the Seward Peninsula, perhaps lower even than that reported by Cade (1960) for Gyrfalcons on the river cliffs and bluffs of the Colville. Over the three early years of abundance only about four percent of cliffs used on the Seward Peninsula were used in all three years. Four species of regular cliff-nesters are found on the Seward Peninsula: Gyrfalcons, Golden Eagles, Rough-legged Hawks, and Ravens. Data for these species were recorded during all years (Table 1) and it is evident that the interrelationships between the species with respect to nesting are complex. While the principle does not hold in all regions (for example in the Alaska Range), Gyrfalcons on the Seward Peninsula almost always use old stick nests built by other species, perhaps most often those built by Rough-legs. The extent of real dependence on the other species may well depend on the nature of ledge structure in a given region but cannot be evaluated at this point. We do not feel that nest-building by Golden Eagles, Rough-legged Hawks, and Ravens is irrelevant and it seems probable that the availability of good nesting sites in this region is enhanced for Gyrfalcons by these other species.

It is potentially significant for the management of Gyrfalcons that nesting on man-made structures is not uncommon. Pairs have been found nesting on abandoned gold dredges and other relics of mining operations such as pile-drivers. Since there are very large areas of the north with abundant prey for Gyrfalcons it seems possible that relatively cheap structures might be built and placed in areas which are otherwise adequate to encourage Gyrfalcon populations. Although current environmental values may cause the removal of derricks and other structures related to oil development, the eventual practice is not clear at this time. If such structures are left at drilling sites it is a point for raptor managers to consider with respect to Gyrfalcons, Golden Eagles, Rough-legs and even Peregrines—artificial nesting provisions could easily be added.

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FALCON POPULATIONS:

ABSTRACTS OF OTHER PAPERS AND INFORMAL DISCUSSION

ABSTRACTS OF OTHER CONFERENCE PAPERS

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Present Status of the Peregrine Falcon in the Rocky Mountain States.

ABSTRACT. Field data on the occupancy of Peregrine sites in New Mexico, Colorado, Wyoming and Montana from 1964 to the present are examined for possible trends. In that nine-year period the number of sites and former sites known to the author grew from 16 to 37, and the number of sites investigated varied from two to 24 in different years. In the period, the average number of sites studied was 10.8, the average number occupied by at least one bird was 7.5, while sites with pairs averaged 5.9. The most thorough surveys were made in 1964, 1965, 1969 and 1972 when 15, 14, 24 and 17 sites were visited, respectively, revealing 9, 9, 9, and 10 pairs. Because the most likely sites were usually visited from a growing list of known sites and former sites in successive years, the seemingly stable number of pairs was seen only as a result of an increasing quality of effort. However, data for eight sites, each visited in at least six of the nine years, show that about an average of 70% of these were occupied in any one year with little variation through the period. Although about half of the known sites became inactive by 1964-65, there is no evidence that a decline

has continued since that time. Information on reproductive success in the period is scanty, but no more than eight young were fledged from nine sites with pairs in 1964, three from seven in 1969, and no more than four from five sites in 1971. In 1972, 10 pairs could not have produced more than about six young.

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Populations and Toxic Chemical Residues in Western Canadian Prairie Falcons and Merlins.

ABSTRACT. Survey conducted in western Canada indicated local population declines in populations of Prairie Falcons and Richardson's Merlins in the 1960's. Analysis of samples of eggs of these two species together with samples of their food species indicated that both the falcons and their prey were carrying varying residues of organochlorine and mercury compounds.

In 1969, 1970 and 1971 restrictive regulations in the use of DDT, Hg, Dieldrin and Heptochlor together with voluntary limitations in seed treatments resulted in a marked decrease in the use of these toxic chemicals in western Canada. Subsequent samples of Prairie Falcon eggs in western Canada indicate a corresponding decrease in residue levels of these toxicants.

Recent population surveys further suggest a trend towards the recovery in the Prairie Falcon population in areas where suitable habitat is available.

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The Effects of Organochlorines on the American Kestrel (Falco sparverius Linn.) [author not present; paper not presented].

ABSTRACT. The objectives of this study were two: (1) using the Kestrel as an example, to show possible cause and effect relationships between ubiquitous organochlorines (e.g. DDE and PCB's) and the eggshell-thinning phenomenon recently observed in many wild raptor populations, and (2) to examine the Kestrel as a raptorial species in its own right by surveying a local, wild population for residues of common environmental contaminants and eggshell-thinning. A captive colony of Kestrels was maintained. Experimental groups were given dietary p,p'-DDE and/or the polychlorinated biphenyls (PCB's) Aroclor 1254 or 1262. Eggs were sampled for residue analyses and eggshell thickness measurements. Female Kestrels were sampled for hepatic enzyme activity and RNA production and oviduct carbonic anhydrase levels. Eighty-five wooden nest-boxes were placed in the Ithaca area in an effort to establish an easily accessible source from which eggs for residue monitoring and eggshell measurements and young for laboratory and aviary experiments could be obtained. DDE residues in wild Kestrel eggs collected around Ithaca, New York averaged 35, 42, and 33 ppm

(OD) for 1969, 1970, and 1971, respectively. Eggs collected during 1970 contained 37 ppm PCB's, almost 3 ppm Dieldrin, less than 1 ppm TDE or DDT and less than 0.5 ppm (WW) mercury, copper, cadmium or lead. Based on Ratcliffe's Index, eggshells of the local Kestrel population averaged nine percent lower than eggshells collected before 1947. An inverse correlation exists between DDE residues in wild Kestrel eggs and the eggshell thickness ($r = -.470$). Kestrel prey items in the Ithaca area contained 1/60 the amount of DDE shown to be necessary under aviary conditions to result in the observed Kestrel egg residues and eggshell-thinning. The Kestrels probably accumulate the bulk of their stored DDE on their more southern wintering grounds where prey species contain higher residues of DDE. Both PCB's and DDE share some similar biochemical effects (*in vitro* microsomal breakdown of estrogen and increase in cytoplasmic RNA), but dietary DDE alone results in a reduction of oviduct carbonic anhydrase, correlated with a decrease in eggshell thickness. Dietary DDE ranging between 0.3 and 10 ppm (OD) result in egg DDE residues approximately seven times higher than diet levels. The relationship between egg DDE residue levels and eggshell-thinning is biphasic showing an initial sharp decrease in shell thickness correlated with low egg residues. The relationship between eggshell-thinning and egg DDE content observed in local, wild Kestrels is replicated under controlled aviary conditions with dietary DDE. Ten ppm Aroclor 1254, by itself, does not result in eggshell-thinning. Ten ppm Aroclor 1254 plus 3 ppm DDE, however, results in eggshells significantly thinner than DDE alone ($P < .025$) indicating synergism. Using the supportive experimental data on the Kestrel, a discussion of organochlorines, eggshell-thinning and the decline of several populations of North American raptors is presented. It is shown that a *causal relationship* exists between the ingestion of prey highly contaminated with DDE and the consequent eggshell-thinning and egg breakage. The breeding failure that follows and the subsequent population declines of several raptor populations represent a simple, logical and well-documented sequence. In particular, three invariable facts conclude the discussion: (1) small decreases in eggshell thickness are correlated with predator species feeding primarily on low trophic levels and/or resident northern prey, (2) more drastic decreases in shell thickness are associated with predators preying on higher trophic level prey quite often associated with the aquatic habitat, and (3) not one single raptor population has been able to maintain a stable, self-perpetuating population.

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The Peregrine Falcon Decline in California. III. The Contributing Causes [Authors not present; paper not presented].

ABSTRACT. Potential causes of the decline of the Peregrine Falcon in California include loss of wild habitat, shooting, human encroachment, parasites and

diseases, falconers and pollutants. It is concluded that the major contributing factor was a pollutant—DDE and perhaps other pollutants—and also that falconers pose the greatest threat to the residual population that would form the nucleus for Peregrine recovery in California.

INFORMAL DISCUSSION

Peregrine Falcon—Productivity

BRUCE WOLHUTER. Why is the productivity low in your Peregrines, less than one young? Can you try to pinpoint the reasons?

JAMES ENDERSON. For the most part, we really have no information on what happens to the young since visits are made to these eyries only intermittently in the period. The data on organochlorine pesticide loads in these birds is scanty, in fact the only data that I have are residue levels from a single adult female. Fat levels from western Colorado are very high, but that very bird, at the time that we took the biopsy, had a nest of three large downy young. What I'm saying is that it is possible that laden birds can produce young, as anyone knows that looks at the data very carefully.

JOSEPH PLATT. Have you noticed any kind of trend among the nests that survive, might they use a different prey source than those nests that go?

ENDERSON. My observations on prey taken are scanty. My impression is that most of the prey taken are non-migratory resident species. In the eyrie near Colorado Springs the Scrub Jay is probably one of the most important prey species. One trend that I see in many of these eyries is that year after year the pairs appear and never lay eggs or produce young. In only a few sites do pairs consistently lay eggs and hatch them.

TOM CADE. What I think is really a critical thing to know is whether they are not laying eggs, or whether the eggs are not hatching, or whether the young are disappearing in eyries. This is what we need to know in terms of all the controversy over harvesting and taking of falcons, for example.

ENDERSON. What happens is that you visit the site, for example, at about the time of egg laying, and the birds are apparently not incubating; then you visit the site later on at about the time young should be fledging and the adults are there and nothing's around. So, the data tend to be very scanty. What we want to do this year is to spend enough time at least during three visits to each site to find out really what's going on. Ratcliffe was appalled that the data on Peregrine Falcons in the contiguous United States is as poor as it is. On the other hand, he is working in a country that is much simpler to handle.

Peregrine Falcon—Location of Subadults

ROBERT COLEMAN. Can you add anything from your observations on Amchitka and the Aleutian chain on what happens to subadult Peale's Falcons?

CLAYTON WHITE. Our data on Amchitka Island strongly suggest that they don't go anywhere but remain right on the island, or, at least, if they do go somewhere, other birds move in and occupy their places. There has been a specimen collected in the Hawaiian Islands, so obviously it wandered from somewhere and I'm at a loss to try to explain the influx of Peale's Falcons into California unless they're from southeast Alaska which seems to be a little milder climate even than the Aleutians. If you look at the Aleutian data, openly admitting that we may miss 20 percent of the birds that are there, we can start counting birds fledging around the periphery of the island, but the ratios, the number of subadults versus adults, are rather consistent. Starting in October we may find 25 subadults, in November 20 subadults, and in January 15 subadults. A rather high mortality, apparently, takes place in March, a time when the resident adults are setting up territories and the weather is very severe and the prey populations have experienced high mortality. Then in April you will see three or four at most. So I'm not prepared to talk about this except for the Aleutians, where they appear to remain right there, and appear to suffer local mortality, probably as a function of weather, lack of food, and perhaps aggressive attitude by adults on them as breeding season starts. The adults are at the eyrie sites displaying in late January, driving eagles away in late January.

Peregrine Falcons—Pesticides

COLEMAN. There are many old captive adult Peregrines in the United States. Do you have any data on pesticide residue on wild falcons as compared to captive falcons?

CADE. I have data on eggshells. I don't have data on residue levels. Eggshells from the arctic Peregrine that bred for us last year are somewhat thinner than the old eggs but they are not anywhere near 20 percent.

COLEMAN. I personally know of perhaps 25 at least five-year-old falcons in captivity, if some comparative data could be used to see what is happening in terms of captive Peregrines and wild Peregrines.

CADE. What are you trying to learn from this?

COLEMAN. Well, there is some indication, at least there are some people who say that eggshell thinning is not occurring.

CADE. You're saying it may be related to age?

COLEMAN. Yes, I am suggesting the possibility.

LAURENCE FRANK. Can anybody give us an idea what the pesticide use situation in South America is in which the migrant arctic Peregrines are getting exposed?

GERALD SWARTZ. I might suggest that you read a paper which is in press now by Walker and Risebrough. I don't really feel that I can comment on those data now; it's interesting though. I should emphasize this is not information directly bearing on how many tons are used in South America; this is how it is reflected in raptors' tissues.

MORLAN NELSON. The thing that I was going to say—for those of you that have gone down through Mexico along the route that they migrate below Veracruz, the area where people are living in those miserable swamps—is that you get an area of high use of DDT by the Mexicans, and there is no question that the Peregrines are going down the east coast all the way. I doubt if there is much use in South America, but the use in Mexico of DDT in preventing malaria is really high and it's getting higher every year.

SWARTZ. Just a tiny bit of information on that situation. I tried back in about 1968 or 1969 to get some direct information on this question. I wrote to a number of people in South America. I got about four responses. These were from sympathetic people, who perhaps went a little out of their way to say there weren't any raptors there any more. One small bit of actual fact was that the Germans had built a great big new factory in Brazil somewhere and the implication was that they were going to build some more to make DDT, but I don't know any more than that.

NELSON. Well, that's true in Mexico too. It's a significant factor in what we're talking about. Now, I don't know how you go about getting the tons that are used but that is a high malaria area and I mean there are no mosquitoes. It's a good indication of what's going on.

SERGEJ POSTUPALSKY. Some work done in the Department of Wildlife Ecology, at the University of Wisconsin, by Hickey and Faber with fish-eating birds and water birds in Colombia shows residues that would indicate considerable use of pesticides in that country at least.

JAMES KOPLIN. I heard a second hand report on Colombia during the summer of 1970, where the application of DDT to the cotton drop was in the neighborhood of 40 to 70 times the directions.

JOSEPH MURPHY. That would seem to be of significant use.

DON PAUL. I would just like to ask what the relationship is between the use of the prey source of passerines as compared to water associated birds. I noticed that Mr. Burnham said that they had found that passerines were the major prey item of the species.

WHITE. Rather than looking at whether it's a water bird or a passerine, I think it would be more important, for example, whether it's a resident bird living in an area of high usage or low usage, or whether it's a migrant bird. Peregrine Falcons in the Aleutian Islands have picked up the residue, but they apparently pick most of it up from migrant passerines, since the water birds there are very, very clean in terms of the total body burden. The auklets don't go anywhere and fortunately this makes up about 70 percent of the bio-mass of their food. However, in areas of the tundra Peregrine, for example, it's pretty clear that in shore birds and in ducks and very fat birds that migrate, which they eat, it seems to pick up, I would think, more from those than from the passerines. I don't know whether anybody else will agree with me. So I think, don't look just at the prey species but rather the biology of the species.

ERNEST NICKENS. I wonder if anyone here is doing any work on chlorinated phenols, specifically pentachlor phenols? For example, I don't know, I'm a chemist and I've become acquainted with the chlorinated phenols and also some of these side effects they have on chickens.

CADE. What sorts of products are involved? What's it used for?

NICKENS. Pentachlor phenol is used in place of creosol for treating posts and things like this to prevent them from being eaten by termites and other insects. This is something that is relatively new.

LESLIE BROWN. I think the answer is apparently not. I think it is worthwhile bringing it up.

Peregrine Falcons—Human Influences

TOM RAY. Dr. Cade, you mentioned that there were several areas in the arctic that have been sampled that have shown a reduction in Peregrine population. I think with one exception those areas that you mentioned were areas that received an increased human activity, in the arctic at least. I'm wondering if you would care to comment on whether you feel the harvest decline was due to human activity or whether you attribute it to organo-chlorines.

CADE. I won't speak about Canada, because I'm not personally familiar with that area, but the area that I know in Alaska, certainly, I think that there is a strong case for the Tanana River as possibly being rather badly disturbed by a

variety of types of people using the river for one reason or another, in part by falconers who have taken birds, in part by photographers who've been careless about the way they set up blinds around nests, in part by people who just travel down the river by boat and like to scramble up on the cliffs, and in part by geologists and so on. One might also make a lesser claim along those lines for the Yukon River as well, but I think probably not for the Colville.

RAY. Do you care to comment on the shifting of Peregrines to new sites after the Kanichan blast? Was there any shifting?

WHITE. As you may be aware, the Atomic Energy Commission had a substantial underground detonation on Amchitka Island in 1971. Incidentally, they don't call it Amchitka, they call it Am-ka; they blew the "chit" out of it. There was some damage of sites, but to our knowledge, all but a few Bald Eagles were able to shift successfully to new sites. Regarding the sites that were damaged, the bird involved had an alternate site which it used successfully this year and fledged three young on a tiny ledge about something like four inches by two inches; she fledged some young off of that. The only bad result is that we had one site, a cave, that was partially filled up by dirt, and in my bumbling way, I didn't go clean the dirt out. The birds came back, tried to get in it and couldn't, then selected a very marginal site about a hundred yards away, laid one egg and then deserted. Steve Sherrod and I cleaned the site out in October so I suspect there will be birds back there this year. The damage was negligible in terms of short-term damage.

Peregrine Falcons and Seabird Populations

BROWN. I would like to make a comment in reference to Peregrine population in Britain which is somewhat relevant to the paper by Mr. Nelson on the Queen Charlotte Islands. I think that I have it right in quoting Dr. Ratcliffe recently to the effect that the Peregrine population in 1972 has bounced back to about 55 percent of the pre-war level from a low of about 45 percent of the pre-war level in the late 60's, but that the increase has occurred in certain inland localities and that the maritime Peregrines have failed to show any increase. And it is also, I think, relevant that the puffin populations in the western islands of Scotland, notably St. Kilda, have shown a spectacular decrease in recent years, and it is possible that the failure of maritime Peregrines to recover may be associated with this sort of thing in just the same way as the lack of auklets in the Queen Charlotte Islands affects your Peregrines up there.

WAYNE NELSON. The puffin situation, as I read it, may be similar to what's happening to the Ancient Murrelets in the Queen Charlottes or it may be quite different. Apparently it is unknown as yet what is causing the decline of puffins. The other species of sea birds which are nesting in the same area seem to be getting along fine and the puffins are in a real crash phase, so the speculation

is that maybe the puffins are particularly susceptible to some pesticide or other contaminants in the ocean food chain.

Also I did not state it and I do not want to imply that Langara decline is typical of that on the Queen Charlottes. There are no historical data going back into the 1950's or earlier for any area other than Langara on the Queen Charlottes. British Columbia Fish and Wildlife Branch have been doing surveys at Langara and the rest of the Queen Charlotte Islands and it appears that there is a reasonably healthy population elsewhere on the islands; but I have to emphasize that we do not have historical data to say whether or not the present numbers of perhaps 40-60 pairs is half or whether that is the original population of say 50 years ago.

Peregrine Falcons—Territory Problems

WAYNE NELSON. I should mention the territoriality thing and why we have two single males on the island. Last year we got this straightened out in our own head just through being in the right spot at the right time to see what was going on. There are two males on Langara now that are in effect sterilized because the adjacent female in a pair will not allow the male to take on a new mate. She is occupying a double territory, mating only with her own mate, but keeping the neighboring male from picking up a new female and I attribute this to an "eyeball" situation. The birds are "eyeballing" the prey situation out there and they are saying we can't allow another pair adjacent to us. Whether anyone here can prove this through laboratory experiments or anything else, I don't know. But when you see it you come away very, very impressed with the fact that something is going on between predator and prey and I think what is really happening is the falcons are "eyeballing" the situation and spreading themselves out accordingly.

MURPHY. Shades of V. C. Wynne-Edwards.

Prairie Falcons—Lead Poisoning

MORLAN NELSON. I want to add here a thing that happened with captive falcons. This year we had a Prairie Falcon die of lead poisoning. I was feeding duck heads. The duck hunters kill 40,000 ducks a month, so I scrounge the heads. Two years ago a Peregrine and two Prairie Falcons lost their depth perception in a very strange manner. They had beautiful color and everything was all right. This year one died, and since we've been cooperating on the pesticide research, we discovered the bird was tremendously high in its brain and body tissues with lead. So then we went back to the ducks. And Idaho doesn't want to say anything about this but the ducks in Idaho are loaded with lead, in their body tissue, in their body fat, in their pectoral muscles and in their brains. So we no longer feed wild birds to trained falcons. Now if the ducks are having this

problem, then too the shore birds because, as I understand it, it comes from the shotgun shot falling down and the ducks and the shore birds eat it up, getting into their body this way.

Prairie Falcons and Ground Squirrels

CADE. I want to ask a question generally of all of you who have worked with the Prairie Falcon. The figures on population density and particularly the papers on productivity are really phenomenal, at least from my point of view, having had more experience with Peregrine Falcons. It would seem to me that the ground squirrels have got to be the key to this. What I would like to know is, does anybody have information about what's going on with the ground squirrel population. Do they for instance undergo cycles in an area like the jackrabbits do? Do they have stable high populations? Have they been increasing over the last ten years? For instance, did your Prairie Falcon feed mainly on ground squirrels 10 years ago?

ENDERSON. Only locally. They did in other regions.

CADE. Something's happening to this rodent population. I'm convinced that this response is responsible for the tremendously vigorous Prairie Falcon population.

PLATT. If you get an overgrazed area you find an increase in ground squirrels. So as long as we keep abusing our land . . .

MICHAEL KOCHERT. I noticed something especially in the Idaho area about the distribution of these squirrels. You go on the north side of the river where you have a somewhat different vegetative type, you'll find a high abundance. Especially on the north side of the Birds of Prey Area, you'll find a phenomenal number. But all you have to do is cross the river and go to the south side and you're hard pressed to find a ground squirrel. You'll find burrowing rodents but the Townsend's Ground Squirrel is hard to find. And as you go upstream, toward Twin Falls, and these areas, I don't know if it's land use change or vegetative type change, but you run out of ground squirrels. This is something that needs to be looked at.

ENDERSON. In regard to the ground squirrel in northeastern Colorado, perhaps Olendorff will verify this. This is the area I worked in several years ago. The ground squirrels, at that time at least, were not all that prevalent; Meadowlarks, Horned Larks, McCowan's Longspurs, and Lark Buntings were important prey species.

RICHARD OLENDORFF. They're very important now. We have acquired four and five years' data from IBP.

RICHARD FYFE. The situation in Alberta maybe doesn't apply here at all. In Alberta and Saskatchewan about 15 years ago, there was a tremendous population crash of Richardson's Ground Squirrels, to the point that a ground squirrel was a rare animal. I grew up when they were very common; I've gone through this crash, and they've now come right back up in areas of prairie. In areas of intensive cultivation that I've mentioned, you just don't get these populations of ground squirrels. But in the prairie areas, this crash was one of the most severe crashes of a mammal that I've known.

MORLAN NELSON. There's no question that ground squirrel population is the key, but the ground squirrels wherever you go in the world are geared to silty clay soil. The reason you don't find the ground squirrel south of the Snake River, in the Birds of Prey Area there, is the fact that the texture of the soil changes and when they try to dig their holes it's gravelly soil and the hole falls in on them, so they just can't make it; there are just a few there. The grazing problem is a function of two things. We say that it was overgrazed, but the climate changed to a point in the 1930's where we had one third to one tenth the rainfall on that desert that we've got today and the ground squirrel came up. There's no question about the overgrazing, but my position is that the squirrels are there whether the grazing is there or not. It does not kill the squirrels to overgraze, it may even help. But the real key to the problem is the delineation of the soil types themselves. And you can prove this any place you want to go and study the soil. There's the key to the populations of ground squirrels—the texture of the soil, all other things being equal. You go right across the soil type, right there in Idaho—where Ogden got all these Prairie Falcons, and Bam!—the ground squirrels stop. They are studying the cycle and it has gone up and down. But I've watched those squirrels for more than 20 years and it is not one like Fyfe is talking about. There may be that day coming and when that day comes, there's not going to be a hundred pairs of Prairie Falcons in that canyon.

VERLAN OGDEN. I can add to that, in watching the Prairie Falcons go out to hunt, they don't go south, they go north.

Gyr Falcon—Winter Movements and Food

WAYNE MELQUIST. I wanted to mention that in Idaho around the Moscow region, periodically in winter a Gyr Falcon will show up, and I wonder what the reason for this is.

SWARTZ. We were of course very interested in the movement patterns that were going to occur in this bad winter, but we haven't really got that sorted out very well yet. We do of course know there are places in Alaska where Gyr Falcons do apparently move in in the winter. Cold Bay is fairly famous for having an influx, but I have never examined that situation.

MELQUIST. What sort of movement is there of Gyrfalcons in the winter under harsh conditions, into more favorable areas?

SWARTZ. I haven't the vaguest idea. We would like to know that very much and that's one reason we were interested in hanging radios on the birds. We were unable to do it, however. That's really about as far as I can go.

DAVID BIRD. I wonder if you have any knowledge at all of the number of ptarmigan in Greenland as prey species for Gyrfalcon as compared to those in Alaska?

WILLIAM BURNHAM. As far as the number of ptarmigan, no; I'm not aware of any data that are available, compared to Alaska. So I can't help you there.

EAGLE AND OSPREY
POPULATIONS

STATUS OF A GOLDEN EAGLE POPULATION IN CENTRAL UTAH, 1967-1973

Joseph R. Murphy

ABSTRACT. A Golden Eagle population involving some 40 nesting pairs in west-central Utah has been under investigation since 1967. Continuous breeding records have been kept for 16 pairs; these data indicate that high or optimum breeding success in the early years of the study was followed by a marked decline in over-all productivity of young in more recent years. There is strong evidence to suggest that these trends are related to fluctuations, perhaps of a cyclic nature, in populations of the major prey species, the Black-tailed Jack-rabbit. Patterns of nesting behavior which appear to be related to differences in prey density are also discussed.

The nesting eagles are subjected to varying degrees of stress and human disturbance, and differences in tolerance to human activities have been observed. The proximity of most of the nesting areas to livestock operations, mainly sheep husbandry, has afforded opportunity to study eagle-livestock interactions. It is suggested that those nesting areas located on public lands be given more effective management by the resource agencies involved.

This paper presents a summary of data collected over a seven-year period relating to a Golden Eagle (*Aquila chrysaetos*) nesting population comprising some 40 known nesting territories in west-central Utah. A majority of the nests,

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most of which have been under surveillance since 1967, are located in Utah County, with portions of Juab and Tooele Counties also involved. The nests occur in a variety of habitat and topographic situations, ranging from desert shrub communities to montane forest ecosystems; further details of the study area are supplied in previously published reports (Murphy *et al.* 1969; Smith and Murphy 1973). Elevation above sea level ranges from *ca.* 1400 m (4500') to *ca.* 2600 m (8500') for actual nest sites. From all indications, Golden Eagles are year-round residents (i.e., non-migratory) in this area. There may be local movements from areas of higher elevation down to the desert valleys during winter, although Golden Eagles can be seen in the canyons of the Wasatch Range during winter months. The few accumulated returns of Golden Eagles we had banded as nestlings indicate movements of no greater than 40 or 50 miles (64-80 km) from the nest locations where the birds were banded.

Table 1 presents cumulative data on 16 nesting pairs for which we have the most complete continuous records for the seven year period 1967-73. The data for 1967, the first year for which records were kept, are incomplete; five of the 16 nests were not found until the following year. Hence, there were likely more than five successful nests in 1967, and if so the productivity data for that year, especially the number of young/pair/annum, would have more closely approximated the data for the ensuing two or three years. The data shown in the table indicate that there was a period of relatively high breeding success in the years 1968-70, followed by an obvious decline beginning with the 1971 nesting season. In terms of over-all productivity of young, 1973 proved to be the poorest

Table 1. Summary of breeding data for 16 pairs of Golden Eagles in Central Utah, 1967-1973.

	1	2	3	4	5	6	7
	No.Pairs	No.Pairs	No.Pairs	No.Young	Young	Per	Pair
	Studied	Bred	Succeeded	Fledged	/Annum	/Which	/Successful
					Over-all	Bred	Nest
					(4/1)	(4/2)	(4/3)
1967*	16	9	5	9	0.56	1.00	1.80
1968		15	10	14	0.87	0.93	1.40
1969		10	9	17	1.06	1.70	1.89
1970		11	10	16	1.00	1.46	1.60
1971		6	6	10	0.62	1.67	1.67
1972		6	6	7	0.44	1.17	1.17
1973		4	4	5	0.31	1.25	1.25
Totals		61	50	78			
Means					0.69	1.31	1.55

*The 1967 data are incomplete; see text discussion.

year of record, with the value for young/pair/annum falling to 0.31 (as opposed to a high of 1.06 in 1968).

While the observed decline in productivity of young could conceivably result from a reduction in density of mature eagles, or could be related to some intrinsic cyclic phenomenon within the population, I feel that there are compelling reasons for attributing the decline to a significant reduction in the density of lagomorphs, especially the Black-tailed Jackrabbit (*Lepus californicus*). This species has been shown in previous studies (Camenzind 1969; Arnell 1971) to account for the great majority (usually in excess of 90%) of the biomass of food brought to the nests of Golden Eagles in the central Utah area. A drastic decline in the density of this key species could cause nesting or potentially nesting eagles to resort to alternate prey species, if such are available. There appear to be very few appropriate alternate prey species in the semi-arid valleys which constitute the hunting areas for most of the eagles in this particular population. Hence in years of low rabbit density, the eagles would be required to expend greater amounts of energy in search of prey than in "good" rabbit years. The increased time and effort required to meet normal maintenance energy demands would undoubtedly preclude the eagles' obtaining sufficient additional energy for reproduction.

There is good evidence, both quantitative and subjective, to support the notion that a marked decline in jackrabbit density did occur in this area beginning after the peak year of 1969. Evidence for the decline in the rabbit population and its attendant effects on breeding raptors have been discussed elsewhere (Smith and Murphy, MS). According to all available information, the rabbit densities were moderately low in 1967, rose to a peak in 1969, then began a precipitous decline, falling to very low levels in 1973.

The response of the nesting Golden Eagle population to this marked fluctuation in prey density is best exemplified by the number of young produced per annum by the total population (Table 1, column 5). These data show that the number of young produced per pair increased from about 0.56 in 1967 to a high of 1.06 in 1969, then gradually fell to a low of 0.31 in 1973. The mean number of young/pair for the seven-year period is 0.69, a figure which compares favorably with results derived from other studies on eagles of various species as summarized by Brown (1974). It will be useful to monitor the density of the rabbit population for the next few years, and to observe whether or not an increase in lagomorph productivity is accompanied by a corresponding rise in eagle young produced per annum.

Some other conclusions and hypotheses may be drawn from the tabulated data. It would appear that in low prey years, even though fewer pairs of eagles breed, there is a high potential for success on the part of those which do nest. Thus in the years 1971-73 all pairs which bred were successful in fledging at least one young. It is tempting to theorize that the birds which successfully nested were those most adept at obtaining rabbit prey in years of low lagomorph density, but it would be difficult to support this subjective notion without additional observations and data.

In years of high or at least adequate prey density, there is a tendency for two or more pairs of eagles to nest unusually close together, a situation which might be designated "saturation nesting." This was best exemplified by the nesting season of 1968, when in two different parts of the study area there were groups of three active Golden Eagle nests in relatively close proximity. One trio of nests formed a triangle embracing an area of only 0.5 square miles (1.3 km^2) the minimum distance between two of the nests was 0.7 miles (1.1 km), and the maximum distance between nests was 1.5 miles (2.4 km) (Camenzind 1969). Observations of the hunting behavior of these eagles indicated that the adults did not extensively overlap each other in areas searched, and hence competition between pairs was minimized. In periods of low prey density, this same area supports no more than one nesting pair; hence the close-nesting phenomenon seems to occur only in years of optimum prey density, and would appear to be an indirect indication of the more ready availability of prey.

This study also emphasizes the fallacy of attempting to determine the "population status" of a group of raptors based on only one or two years of survey and observation. The abundance and availability of prey will obviously have a determining effect on the reproductive performance of a given raptor population over a period of years; this effect will be particularly marked if cyclic phenomena are detected in prey population dynamics. Actual trends in the population structure of the raptors will therefore become apparent only when data are collected for a continuous series of years.

The nesting eagles comprising this population are subjected to varying degrees of stress in the form of human disturbance, and this could conceivably account for some of the observed drop in eagle productivity. Although it is difficult to assess the impact of a specific type of disturbance on a given pair of nesting eagles, it may be significant that much of the study area has received increasing human use, primarily for recreational purposes, in recent years. It is also worthy of note that nests previously occurring along the densely populated Wasatch front are for the most part no longer active, although there are some interesting exceptions to this. In one instance, eagles formerly occupying a historic eyrie at the mouth of a canyon overlooking an area now largely "developed" in housing have evidently relocated farther back in the range; in so doing they have moved from a nesting elevation of about 1800 m (6000') to one of about 2600 m (8500'), with implications of a more rigorous environment, shorter nesting season, and perhaps reduced prey availability. That not all interactions with human activities are necessarily detrimental to the eagles is illustrated by a pair which has nested for several years within a maximum security area of the Tooele Army Depot's South Area (formerly the Deseret Chemical Depot). These birds have become proficient at nesting on artificial structures (cf. Figure 3, Camenzind 1969), and as a result they are able to utilize an otherwise unexploited prey population and at the same time receive protection from most types of human disturbance at this well-guarded installation.

A majority of the eagle nesting areas under surveillance are in close proximity to livestock operations, principally various aspects of sheep husbandry. There is

an interesting synchrony of the eagle nesting cycle with the time of lambing in this area, and eagles thus potentially have access to newborn or stillborn lambs as a food source. However, a recent study of food utilization by nesting Golden Eagles in central Utah (Arnell 1971) revealed that no livestock material of any kind was brought to the eaglets in any of the 29 nests that were surveyed over a two-year period. We have encountered some instances of apparent predation on lambs and sheep by Golden Eagles, but such losses do not appear to be significant in the total livestock operation; the subject of eagle-livestock interactions in the Utah study area is treated in greater detail in a related report (Heugly MS).

At least five forms of land ownership or administration are involved in parts of the present study area, viz.: private ownership, Bureau of Land Management administration, U. S. Forest Service lands, Utah State Parks, and a military reservation (Tooele Army Depot). Other agencies, such as the U. S. Fish and Wildlife Service and the Utah Division of Wildlife Resources, also have legal or administrative jurisdiction in the area. Resource managers charged with the administration of the various categories of the public lands have recently expressed much concern regarding the protection and management of eagles and other birds of prey within the areas which they supervise. It would appear that in most cases more effective means of protection are indicated. This might involve such measures as posting of lands, limiting access to nesting areas at critical periods, establishment of additional natural areas for birds of prey, and in the long run, better education of the public. Some innovative approaches to management have been instituted by the agency personnel themselves and other suggestions have been sought from individuals from the non-government sector. Obviously, specific populations or pairs of nesting birds will require unique or at least different management techniques and recommendations. The continued survival and success of the central Utah nesting eagles, as well as many similar populations elsewhere, may well depend upon management decisions made in the very near future.

Acknowledgments

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THE EAGLE SURVEY IN WYOMING

L. Warren Higby

ABSTRACT. A few years ago special interest became evident in eagles not only in Wyoming where certain incidents focused national attention on the birds, but throughout the rest of the North American continent as well.

The large scale shooting of eagles in Wyoming, along with renewed activity in all phases of raptor biology, prompted the governor of the state to order a full scale census of Bald and Golden Eagles in Wyoming.

The Wyoming Game and Fish Commission designed and executed a still continuing, statistically sound, survey-census which indicates the wintering population of eagles within the state the last two years.

An aircraft flew 5,450 miles (8956 km) of transects in 1972 and 6,300 miles (10,137 km) in 1973. Of the 272 randomly selected transects to be flown, 109 were actually completed in 1972. In 1973, 126 transects were flown.

This paper deals with the organization, techniques, execution, results and conclusions of the two years that the survey has been conducted.

Planning, Techniques and Execution

In the fall of 1971, Governor Stanley K. Hathaway requested that a study be initiated by the Wyoming Game and Fish Commission to determine the num-

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bers of Bald (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*) within the state of Wyoming. It was decided to initiate such a survey during the month of January at which time eagles are generally more concentrated on their wintering areas. Because the success of a survey of this type hinges on the accumulation of sufficient data, the timing was also important from the standpoint of actually being able to observe the birds from aircraft most efficiently.

The state was divided into four regions: (1) a high mountain region with little or no wintering population of eagles, and an area mass that could hardly be flown under any conditions, (2) the major river drainages and their banks which usually have a concentration of eagles, especially Bald, (3) those wintering areas of the state deemed to have a high density of wintering eagles, and (4) a low density area which comprised the rest of the state.

County maps as designed by the Wyoming Highway Department with a scale of three-eighths of an inch to the mile (5.9 mm/km) were used as a base map for laying out 50 mile (80.5 km) long transects. Transects were placed on section lines and were generally horizontal, or east-west in configuration, but since the boundaries of some regions were not straight, it was necessary to impose some north-south and some back-and-forth transects to cover completely the area. The transects did not cover the high mountain areas, nor did they overlap the census areas along the major river drainages (Figure 1).

On the recommendation of Mr. Erwin Boeker, Bureau of Sport Fisheries and Wildlife, the width of the transects was limited to one-quarter of a mile (0.4 km) on each side of the aircraft. Transects were flown at between 200 and 400 feet (61-122 m) altitude. Thus an area of 25 square miles (66.2 km²) was observed along each 50 mile (80.5 km) transect.

Each transect was numbered and samples were drawn through use of a random table. In 1972 the high and low density area transects were separately numbered and each set was randomly sampled; the high density area was sampled more frequently than the low. The same transects were again counted in 1973, but without any distinction between high and low density areas, and in addition those transects which were selected but not counted in 1972 because of insufficient time, were flown to provide more complete coverage with consequently greater statistical accuracy.

The allowable flight time, roughly a two week period using four aircraft, indicated that a maximum of 272 transects could be flown if counting conditions were good, and no allowance was made for traveling from the end of one transect to the beginning of another. A starting place in the random numbers table was selected and numbers were obtained until 272 different transects were selected.

At this point an explanation is due for the selection of high density areas in 1972, and not in 1973. In 1973 the survey did not delineate areas of high and low densities. Instead, only the major river drainages and the large habitat areas excluding only the high mountain areas were flown. Delineating high and low density areas in 1972 was attempted primarily because it was anticipated that there might not be enough final data to be statistically valid. This did not prove

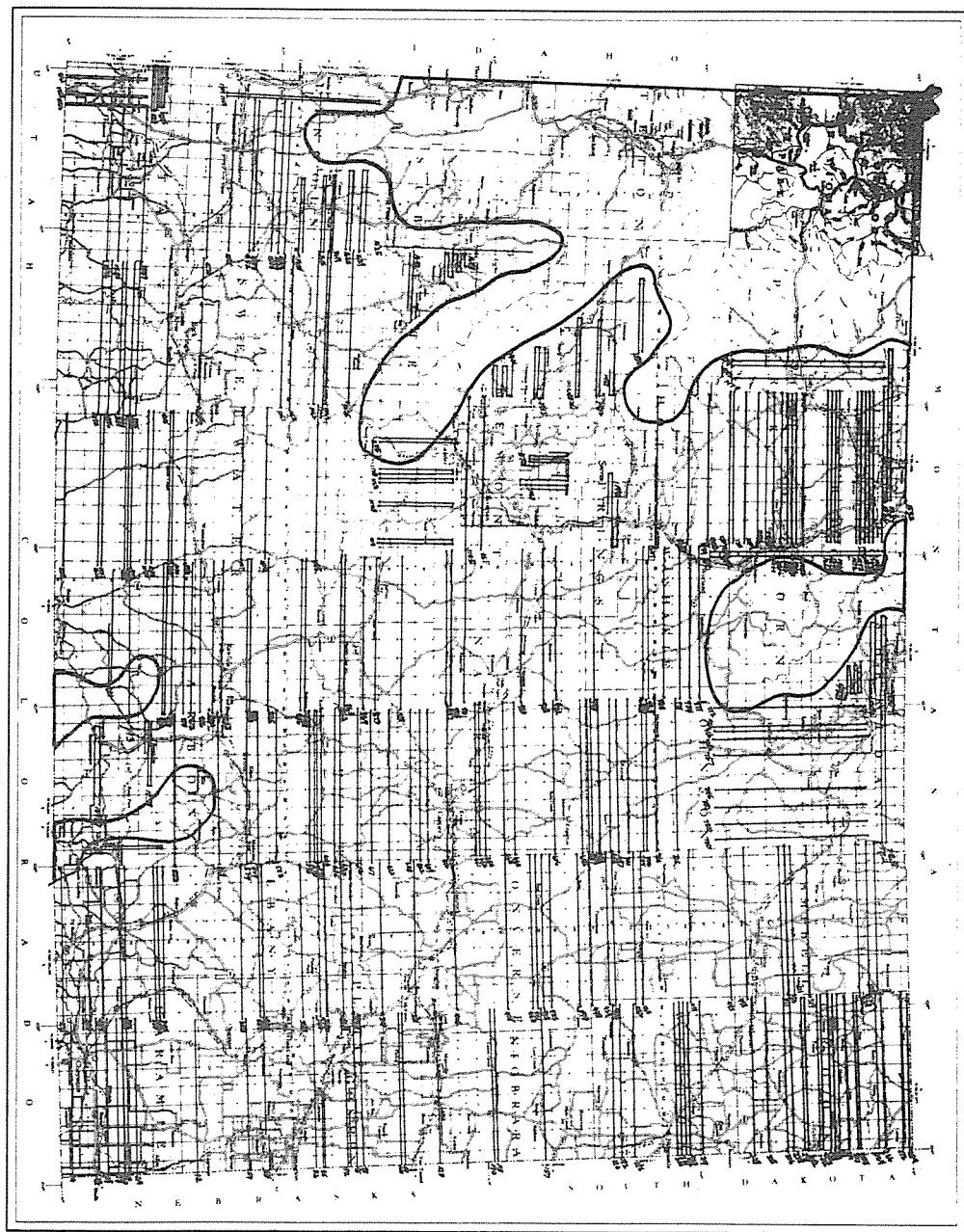


Figure 1. 1972 Eagle Survey Transects.

to be the case. We counted enough transects, and enough eagles, to yield satisfactory statistical validity. Following the 1972 census, we tested for significant statistical difference between the high and low density areas. We found none. Therefore, in 1973 we dropped the high-low area designation and used the randomly numbered transects over the entire habitat area.

It will be noted that we counted 109 of 272 randomly selected transects in 1972. In 1973 we counted 126 transects. It had been anticipated that only a percentage of the 272 transects would actually be flown, with the statistical accuracy of the survey decreasing proportionally. But we needed to cover the entire habitat area of the state with reasonable certainty for maximum statistical accuracy. We realized that, because of unpredictable counting weather in mid-January and other variables, some sort of priority system for counting the transects was desirable, if not imperative, that would not upset the statistical validity of the survey. Therefore, to accomplish this, the order in which the transects were selected (from the random table) was noted and recorded, with the first 50% of the transects to be counted first. These were coded red on the transect map. Then the next 25% would be counted if time permitted, and similarly the last 25%. These transects were coded blue and green, respectively. By proceeding thusly, we established the priority system we required, and at little cost in statistical accuracy. Another reason we proceeded by this arrangement was in case we ran out of count time with a large block of land uncounted due to the systematic nature of the airplane flights over the randomly selected transects.

Results and Conclusions

Table 1 shows the actual numbers of eagles counted during the survey in 1972 and 1973 along the transects. Table 2 presents the total numbers of eagles estimated to be in Wyoming by statistical projection of the data. Added to the total projected estimate was the number of eagles actually counted along the major waterways of the state, and the number given to us by Yellowstone Park officials in 1972 (Table 3).

Although severe weather conditions somewhat hampered the survey in both 1972 and 1973, neither year experienced weather that endangered the performance of the survey. It was felt that the winter season, sometimes contributing snow cover and generally providing better conditions for observation, was the best time to perform the survey.

The numbers of eagles counted along the transects represented a percentage of the total estimated numbers in proportion to the area observed along the transects compared to the total habitat area of the state. The projection of the transect data was done by the statistician, who also established limits at the 95% confidence level.

The total number of eagles estimated to be in the state in 1972 was 11,965 plus or minus 1,792. The total number of eagles estimated to be in the state in 1973 was 10,554, plus or minus 1,482. This indicates that there was probably a slight decrease in the total eagle population in 1973. It will be noted, however,

Table 1. Eagles observed on survey transects within the state of Wyoming, January 1972 and 1973.

Year	Golden Eagles			Bald Eagles		Eagles Unidentified
	Adults	Immature	Unknown	Adults	Immature	
1972	236	87	63	16	3	13
1973	184	74	109	22	3	36

Table 2. Projection of estimated eagle numbers within the state of Wyoming, January 1972 and 1973.

Year	Golden Eagles			Bald Eagles		Eagles Unidentified
	Adults	Immature	Unknown	Adults	Immature	
1972	6,485	2,556	2,028	372	43	481
1973	4,523	1,829	2,694	544	74	890

Table 3. Eagles observed on major river drainages within the state of Wyoming, January 1972 and 1973.

Year	Golden Eagles			Bald Eagles		Eagles Unidentified
	Adults	Immature	Unknown	Adults	Immature	
1972	49	9	9	55	5	2
1973	26	5	-	64	5	7

that the number of Bald Eagles in the state markedly increased in 1973. This increase in Bald Eagles could be statistically significant, according to Dr. Bowden, but the over-all decrease indicated by the total estimate probably was not. Putting it another way, there may or may not have been a decrease in the total number of eagles in Wyoming in 1973, but there probably was. On the other hand, the increase in the number of Bald Eagles observed was large enough to be statistically significant, indicating a definite increase.

As a result of this survey, it has been determined that, at least during January, Golden Eagles were fairly well distributed throughout the state. The 1973 survey indicated a probable slight decrease in Golden Eagles, but there was a definite increase in Bald Eagles. Bald Eagles were generally restricted to the river courses, as was expected, but a surprising number of Bald Eagles were seen in the prairie sections of the state in association with Golden Eagles.

1974 and Beyond

The eagle survey in Wyoming is scheduled to run through 1974, performed exactly as in 1972 and 1973. It will then be suspended until evaluation is complete.

Resumption of the survey will depend on several factors. If the methods and estimates are dependable, as we believe they are, it may be that it will resume in two or three years. Perhaps a yearly effort will prove productive and practical, especially if refinements of the survey can be effectively accomplished.

Wyoming would recommend that a coordinated survey effort be made involving all of the United States, perhaps all of the continent if possible. It should be coordinated by the Federal Agencies. We believe that our experiences these past two years indicate that it is possible.

Acknowledgments

George Wrakestraw, Waterfowl Supervisor of the Wyoming Game and Fish Commission, undertook the initial formulation of the survey. Dr. David Bowden, statistician at Colorado State University, provided the statistical expertise. Grateful appreciation is extended to our personnel of the Wyoming Game and Fish Department who played such an important role in the survey.

PATTERNS OF BALD EAGLE PRODUCTIVITY IN NORTHWESTERN ONTARIO, 1966-1972

James W. Grier

ABSTRACT. Fifteen nesting territories of Bald Eagles (*Haliaeetus leucocephalus*) with a complete seven year history, part of a large continuing study involving approximately 100 Bald Eagle territories in northwestern Ontario, Canada, showed a significant ($p < .01$) decline in productivity from 1966 through 1972. Within this over-all decline, however, and as tested by fitting to binomial distributions, patterns of productivity were random, with no evidence that territories consistently fail or produce. A preliminary analysis also detected no geographical patterns of failure within the study area. (Note added in proof: A later analysis with a larger sample size contradicts one of the conclusions of this paper; see *Addendum*. Author.)

As part of a larger, continuing study of reproduction of Bald Eagles in northwestern Ontario, Canada, I investigated the temporal patterns of productivity in 15 territories in which the nests were censused for seven consecutive years. I have been following the nesting success of approximately 100 eagle territories in this region. These 15 individual territories, however, are the only ones that have been maintained by the eagles and also censused each year for all years, 1966-72, thus making the data complete. Other territories were abandoned by the birds (fallen nests not replaced), were not discovered by me until later in

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the survey, or were otherwise not censused all seven years. I also tentatively assessed the geographical patterns of productivity within the study area by comparing all territories for three different years.

Yearly results of the over-all census, along with considerations of levels of toxic chemical residues in addled eggs and body tissues of a nestling found dead, have been analyzed and will be presented elsewhere. The purpose of this paper is to present the results of the pattern analysis.

I would like to thank the National Audubon Society, National Wildlife Federation, the Canadian Wildlife Service, J. B. Nethercutt, R. and Joyce Newcom, and Dana Murphy for funding various parts of this project. R. Buckler, C. R. Sindelar, Jr., D. L. Evans, J. B. Grier, George Allez, T. Erdman, and my wife, Joyce, assisted with field work during different years. I received much help and cooperation from the Ontario Ministry of Natural Resources, particularly from V. Macins and personnel at Sioux Narrows, throughout the study.

Study Area and Methods

The study area (Figure 1) involves approximately 40,000 square miles (103,600 km²) of boreal forest, lakes, and rivers in the western corner of Ontario, located between 49-53 degrees north latitude and 92-95 degrees west longitude. Travel has been accomplished by outboard-motor boat and pontoon-equipped aircraft. Detailed descriptions of the study area, travel methods, and definitions of terms are presented elsewhere (Grier, 1969; Grier *et al.* in press).

To investigate possible regional differences in productivity, the study area was divided into two subregions. Nests to the south of the trans-Canada highway (Highway 17) were placed into one group and nests to the north in another. This division is not entirely arbitrary since this highway roughly coincides with the northern limit of white pine (*Pinus strobus*), the birds' preferred tree for nest sites in this region. North of the range of white pine the Bald Eagles nest almost exclusively in trembling aspen (*Populus tremuloides*). The two regions are also served by somewhat different drainage systems.

Comparisons between years and for the two geographical regions were tested for statistical significance with Chi-square contingency tests (Conover, 1971). I compared productivity patterns of individual nests by fitting the observed distributions to theoretical binomial distributions using the Kolmogorov goodness of fit test (Conover, 1971). A lack of fit would indicate that nests consistently failed or produced young.

Results and Conclusions

The number of productive territories decreased significantly ($p < .01$) from 1966-72 (Table 1). A comparison of all territories in the survey showed the same significant decrease, as described and discussed in detail separately (Grier, in press).

The observed frequencies of empty nests, however, or of nests producing one or two or more young in individual territories did not depart significantly from the theoretical binomial frequencies (Table 2). It appears that patterns of failure

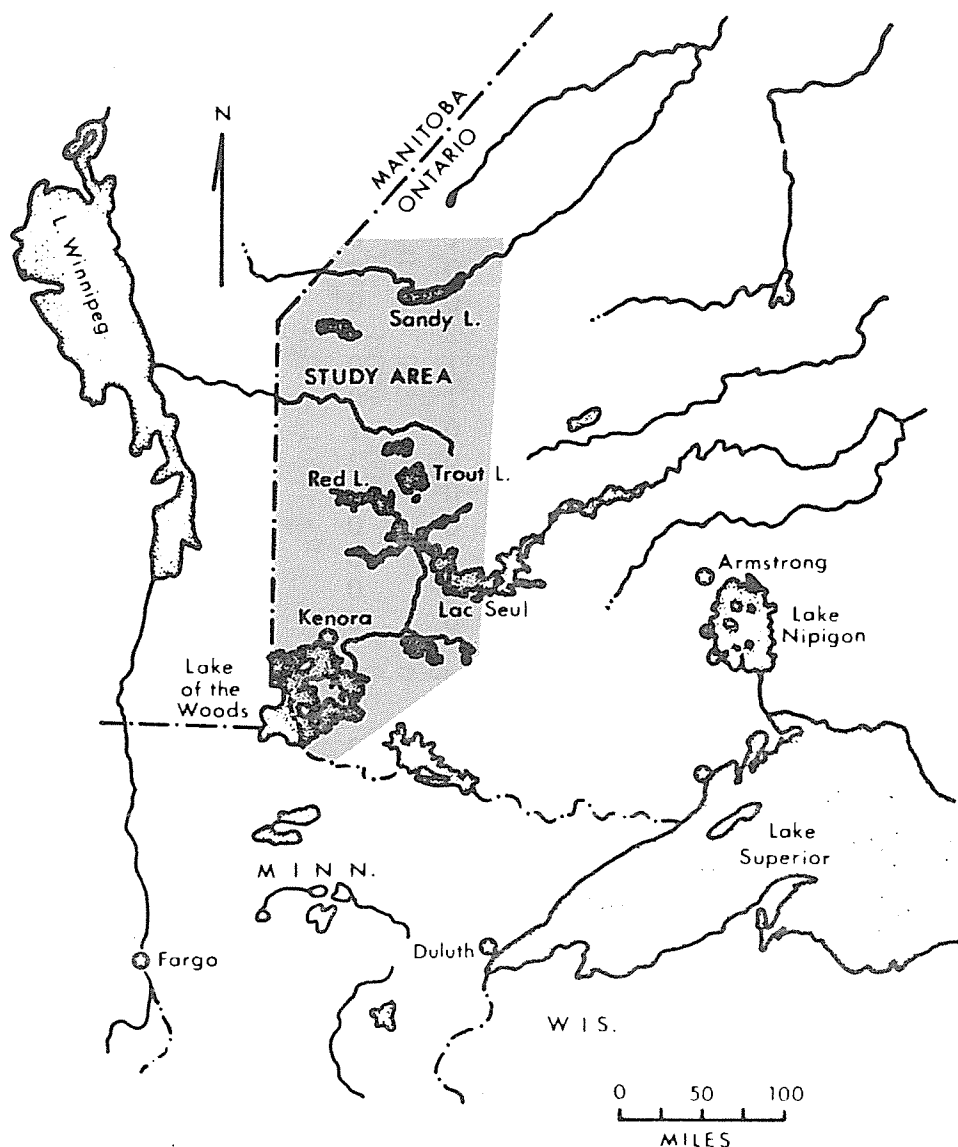


Figure 1. Location of the study area.

or productivity are occurring at random throughout the territories, and there is little evidence that birds in particular territories consistently fail or produce. The sample size (15 territories for seven years) is relatively small, however; I may simply be failing to detect an effect that might show up with a larger sample size (see *Addendum*). But no pattern is obvious even by superficial inspec-

Table 1. Productivity of individual territories of Bald Eagles in northwestern Ontario, 1966-72.

Year Territory	1966	1967	1968	1969	1970	1971	1972	Total
A	2	2	1	2	0	0	0	7
B	1	2	0	1	0	2	0	6
C	2	1	2	2	0	1	2	10
D	1	1	1	0	0	0	0	3
E	2	0	1	0	0	0	2	5
F	2	0	2	2	0	0	1	7
G	1	2	2	1	0	0	0	6
H	0	0	0	1	0	1	1	3
I	1	0	0	0	1	0	0	2
J	2	2	2	0	2	0	3	11
K	0	1	0	0	1	0	2	4
L	0	0	0	0	0	0	0	0
M	0	2	1	0	0	0	1	4
N	2	2	2	0	0	0	0	6
O	1	1	1	0	0	0	0	3
Total	17	16	15	9	4	4	12	77
With young	11	10	10	6	3	3	7	50
Empty	4	5	5	9	12	12	8	55

Chi-Square = 17.87, 6 d.f., $p < 0.01$

tion of the data, except for territory "L" (Table 1) in which no young were observed.

On a regional basis there is also no evidence of a pattern of failure within the study area (Table 3). I analyzed the data for only three years, one year (1969 when productivity was mediocre and two years (1971 and 1972) when it was poor. Until all of the years of census are analyzed, which is planned for future analyses, I regard the conclusions concerning regional differences to be somewhat preliminary.

In conclusion, I have detected a significant pattern of decline from year to year during seven years of census. This decline and possible reasons for it are discussed in detail in a separate paper (Grier, in prep.). Beyond this yearly change, however, I am unable to detect any patterns among individual territories or between geographical regions within the study area.

Table 2. Frequency of nests with zero, one, and two or more young per nest in individual territories of Bald Eagles, northwestern Ontario, 1966-72.

Number of nests with no young for indicated number of years				Number of nests with 1 young for indicated number of years				Number of nests with ≥ 2 young for indicated number of years					
Number Years	Obs. number	Cumulative distribution		Obs. number	Cumulative distribution		Obs. number	Cumulative distribution					
		Obs.	Binom. ^a		Obs.	Binom.		Obs.	Binom.				
0	0	.000	.008	3	.200	.210	5	.333	.134				
1	1	.067	.062	3	.400	.577	2	.467	.445				
2	1	.133	.227	6	.800	.852	3	.667	.756				
3	4	.400	.500	3	1.000	.967	3	.867	.929				
4	7	.866	.773	0	1.000	.995	1	.933	.987				
5	1	.933	.938	0	1.000	.999	1	1.000	.999				
6	0	.933	.992	0	1.000	1.000	0	1.000	.999				
7	1	1.000	1.000	0	1.000	1.000	0	1.000	1.000				
diff. ≤ .100, n.s. ^b										diff. ≤ .177, n.s.		diff. ≤ .199, n.s.	

^aBinomial probability estimated by dividing the total number of observed cases (e.g., of an empty nest) by the total number of observations (105) and rounding off to nearest tabulated value (e.g., Conover, 1971, Table 3). For empty nests, binom. $p \approx .50$; for territories with 1 young, $p \approx .20$; for territories with ≥ 2 young, $p \approx .25$.

^bn.s. = not significant. Tested with the Kolmogorov test (see Text). Note: I originally used and presented (at Fort Collins) a Chi-Square goodness of fit test, based on numbers of nests; both tests yield the same results but the Kolmogorov is more appropriate since the expected numbers for Chi-Square are less than five for several categories. J.W.G.

Table 3. Preliminary analysis of regional differences in numbers of productive Bald Eagle territories in northwestern Ontario.

Year Region	1969			1971			1972			TOTAL		
	S	N	Total	S	N	Total	S	N	Total	S	N	Total
Territories with young	31	24	55	20	15	35	24	13	37	75	52	127
Territories without young	21	30	51	27	22	49	26	31	57	74	83	157
Total	52	54	106	47	37	84	50	44	94	149	135	284

Chi-Squares (1 d.f.): 1969 = 2.44, $p > 0.05$

1971 = 0.03, $p > 0.05$

1972 = 3.34, $p > 0.05$

sum of above (3 d.f.) 5.81, $p > 0.05$

Chi-Square of combined years = 4.00, $p \cong 0.05$

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Addendum

A different analysis of later, 1973, data (Grier and Fyfe, in press, in the Canadian Wildlife Service Report Series) resulted in evidence that productivity is higher in nests with the greatest previous productivity. Because of the larger sample size in the later analysis, I feel that the data presented herein (i.e. Table 2) are insufficient to test the hypothesis; a conclusion based on these data would constitute a Type II error. I left the body of this paper unchanged in proof for two reasons: (a) this is the way it was presented at Fort Collins, and (b) it serves as a good illustration of the ever-present danger of Type II errors. J.W.G.

A POPULATION STUDY OF SASKATCHEWAN AND MANITOBA BALD EAGLES

D. W. A. Whitfield

J. M. Gerrard

W. J. Maher

D. W. Davis

Studies of wintering Bald Eagles (*Haliaeetus leucocephalus*) in the United States have revealed large numbers of these birds in the interior states (Sprunt 1961). The breeding grounds of most of these eagles is not known. This paper describes a large breeding population of Bald Eagles in Saskatchewan and Manitoba which may migrate into this area in the winter. We made our first observations on these eagles in 1967 (Gerrard and Whitfield 1967). This report, based on more extensive surveys in 1968 and 1969, discusses the extent of this population, its density and its reproduction.

Study Area

The study area, as outlined in Figure 1, is in the boreal forest region of northern Saskatchewan and Manitoba. This approximately 95,000 square mile area (242,000 km²) of low forested hills and numerous lakes and rivers, is largely within the precambrian shield country. Water drainage is toward the Hudson

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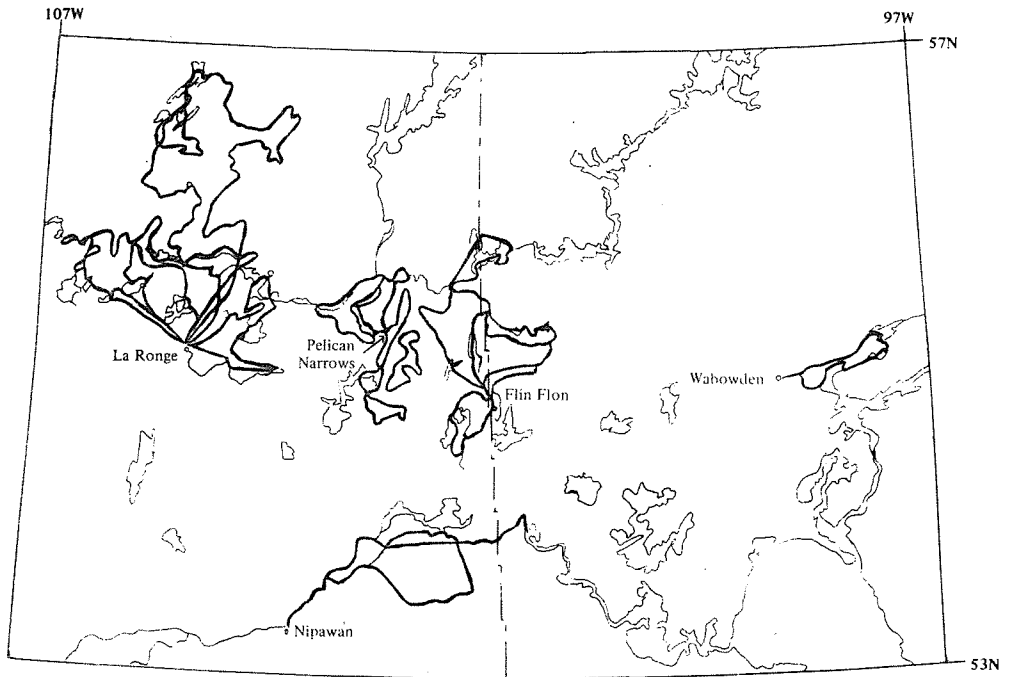


Figure 1. The study area. Dark lines represent flight routes. Shorelines are not drawn where they would obscure the flight routes. Locations of areas visited by surface travel are not marked.

Bay through the Churchill and Saskatchewan Rivers. Predominant trees include white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), and balsam fir (*Abies balsamea*).

There are few roads into this region, and most of it is sparsely inhabited. Major human uses include trapping, commercial and sport fishing, big game hunting, mining, and pulp-cutting.

Methods

Surveys were done in May 1969 during incubation and in July 1968 and 1969 when the young eagles were from four to ten weeks old. We located eagle nests by searching along the shores of lakes and rivers, using either a fixed-wing pontoon-equipped aircraft or a boat (boats were used in less than 10% of the survey). When flying, usually at a height of 50 to 300 feet (15-90 m), no attempt was made to follow a grid pattern. Rather we followed what we judged to be promising routes based on our contacts with local inhabitants, or on previous visits to the area. Each nest we found was marked on a map (scale 1:250,000). A Bald Eagle nest whether empty or active and any alternate nest or nest within

a circle of one-half mile diameter was considered to represent one breeding area. Breeding areas with two adults or signs of use were considered occupied. Those with an incubating adult were considered active. A subadult was out of the nest and in pre-adult plumage.

When measuring the length of shoreline, a map scale was used. Lakes with a shoreline of less than seven miles (11 km) were not included as few of these contain nesting eagles.

Results

We found 82 Bald Eagle nests with young in 129 breeding areas in 1968 and 137 nests with young in 245 breeding areas in 1969 (Table 1). Twenty-eight breeding areas, 19 of them with young, were in Manitoba, and the remainder were in Saskatchewan.

Population Density. Figure 2 shows the regional distribution of breeding areas seen in 1969. Since the amount of searching varied greatly among regions, partly for practical reasons and partly because of wide variation in suitable nesting habitat, we obtained only a rough representation of density.

Bald Eagles nest primarily along the shoreline. In our survey most (68%) of the nests found were within 50 yards (46 m) of a lake or river, and the vast majority (90%) were within 200 yards (183 m). Therefore, we calculated the number of breeding areas per mile of aircraft-searched shoreline. This was done separately for each region and was plotted in Figure 3. There was a variation from 0.040 to 0.153 breeding areas per mile (0.025-0.095 per km) of aircraft-searched shoreline with an average of 0.085 (0.053) and a standard deviation of 0.031 (0.019).

Population Size. The Bald Eagle population was estimated in the western or Saskatchewan half of the study area, after searching 2510 of a measured 17,290 miles (4039 of 27,820 km) of utilizable shoreline. First, presuming the area we searched was representative of all the shoreline, the 17,290 miles of utilizable shoreline would have $17,290 \times (0.085 \pm 0.031) = 1469 \pm 536$ breeding areas.

As our searching was not random and we often left out parts of lakes where eagle habitat appeared poor, a second more conservative estimate was made. For this estimate, the breeding areas we found were considered to represent

Table 1. Results of surveys.

Survey date	July 1-19 1968	May 3-4 1969	June 30- July 20 1969
No. of breeding areas	129	64	245
No. of occupied breeding areas		53-55	
No. of active breeding areas		51	
No. of successful breeding areas	82	36	137
No. of young	132-139	63-68	228-240

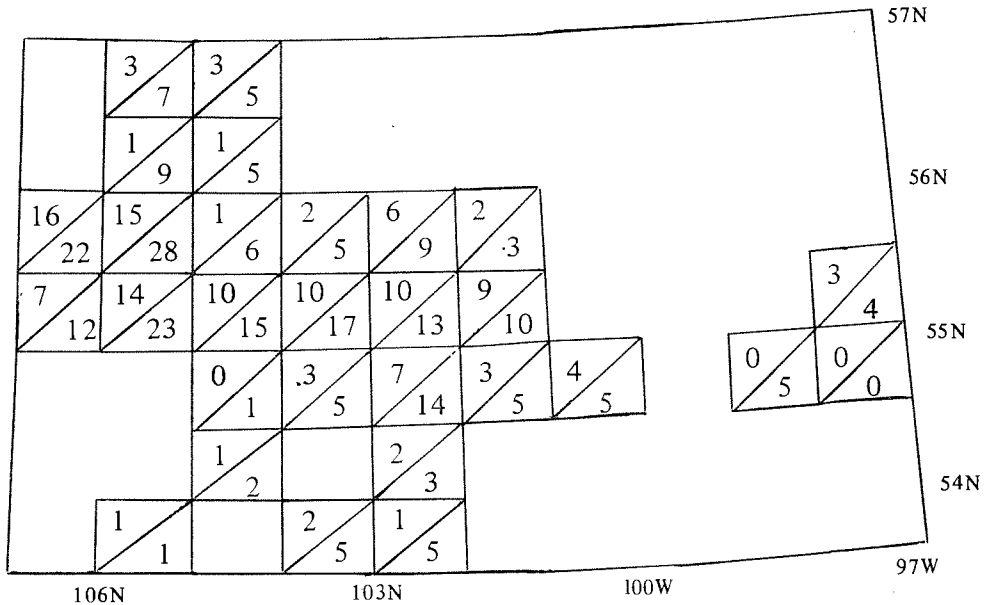


Figure 2. The regional distribution of the total number of breeding areas seen in July 1969 and those which were successful. The regions have a dimension of one-half degree latitude by one degree longitude. 3/7 represents an area with seven Bald Eagle breeding areas of which three were successful.

6,979 miles (11,229 km) of shoreline, the total for all lakes even partly searched by us. Using this method the estimated number of breeding areas would be 528 + 193.

Productivity. In 1968, 64% of 129 breeding areas were successful (i.e., contained young just prior to fledging) while in 1969, 56% of 245 breeding areas were successful. The difference between 1968 and 1969 is not significant ($p = 0.4$).

We found 1.6-1.7 young per nest with young in July 1968, and 1.7-1.8 young per nest with young in July 1969. In both cases the uncertainty was due to a few nests for which the number of nestlings was not determined.

Of 64 breeding areas examined in May 1969, 83-86% (53-55) were occupied. The uncertainty is due to two empty nests with only one adult nearby. Neither nest was examined closely for signs of use. Of the nests occupied in May, 65-68% (36) contained young aged 6-10 weeks old in July. 1.15-1.26 young were produced per occupied nest.

Of the 51 nests we found active in May, 11 (22%) were standing but empty

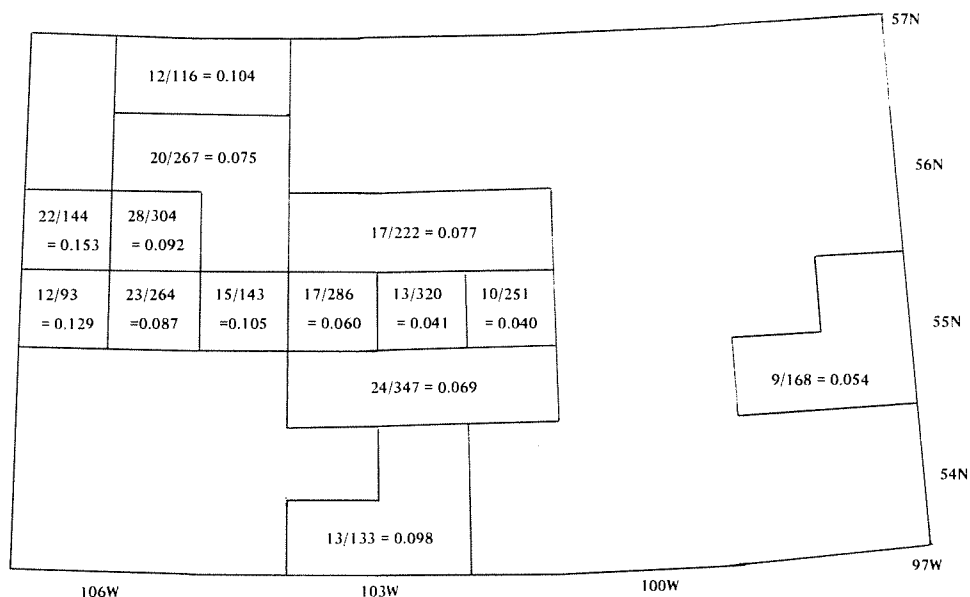


Figure 3. Regional variation in shoreline utilization by Bald Eagles in 1969. To obtain this figure the number of breeding areas was divided by the length of aircraft searched shoreline (in miles) for each region. Grouping of some areas was done to get larger samples.

in July. The cause of these failures is unknown, but two further observations suggest possible reasons. First the usual reaction of the incubating adult as we flew by the nests in May was to sit tight on the eggs. In seven cases the incubating adult stood up or flew from the nest; of these one was gone by July, four had failed and only two were still active. (The difference between this group of nests and the remainder of those seen in May is significant with $\chi^2 = 10.5$, 1 df and $P < 0.01$).

Second there was a statistically significant tendency for breeding areas empty in July 1968 and active in May 1969 to fail before July, 1969. (Table 2, $\chi^2 = 6.43$, 1 df, $P < 0.01$).

Sixteen percent (16/101) of Bald Eagles seen in May were subadults, and a similar proportion 16% (50/307) of the eagles seen in July were subadults. When the nestling eagles were added to the subadult population then 52% (278/535) of the eagles seen were immature at the time of our survey in July 1969. During the course of our survey we found an unusually high proportion of subadults and apparently non-breeding adults on Manawan, Wood, and Wintego lakes

Table 2. Status (in July 1969) of those breeding areas visited in 1968 and active in May 1969.

	Status in July 1969	
	Empty	Active
Empty in 1968	6 (60%)	4 (40%)
Active in 1968	3 (14%)	18 (86%)

where 12 subadults and 22 adults not at nests were seen in about 90 miles (145 km) of flying.

Discussion

Population Density. In assessing density of nesting Bald Eagles, wide variations can be seen simply as a result of variations in the amount of suitable nesting habitat. In order to compare one area of the province with another, it is most meaningful to measure density in terms of amount of suitable nesting habitat. We measured density in terms of breeding areas per mile of aircraft searched shoreline. There is remarkable consistency in this number from region to region suggesting that within Saskatchewan the nesting density of these eagles varies directly with the amount of suitable shoreline.

When one considers what the shoreline provides the Bald Eagle, this relationship is not unreasonable. Shoreline provides nesting sites. It provides flight paths as the wind hitting a densely treed shoreline after sweeping across an open lake provides updrafts on which the eagles glide. It also provides fishing opportunities as most of the fishing done by eagles during the breeding season is done from perches along the shoreline or when gliding using the updraft provided by the shoreline.

In contrast to this association between nesting density of Bald Eagles and the number of miles of suitable shoreline, there was no correlation between the density of Bald Eagles and the water area.

Population Size. An estimate of the population of Bald Eagles must take into account the breeding adults, the non-breeding adults, the subadults, and the nestlings. Because breeding adults may wander widely in search of food during incubation (J. M. Gerrard and P. N. Gerrard *pers. obs.*), it is difficult to determine the proportion of non-breeding adults. The proportion of adults occupying breeding areas but not breeding (4-7% in the May 1969 survey) underestimates the non-breeding population as repeated visits to some nests have shown that these adults are frequently not in the immediate vicinity of the nest during this period. The proportion of adults seen that were not at or close to active nests (23% in May 1969) overestimates the proportion of non-breeding adults as it certainly includes many breeding birds. Thus the non-breeding adults

make up somewhere between 4% and 23% of the adults.

Computing the proportion of eagles which are subadults is even more difficult. Our finding that 16% of the eagles seen in May were subadults underestimates this proportion of the population as they are more difficult to see. Also, subadults tend to arrive back later than the adults, and may not all have arrived back on the breeding grounds by early May. Studies on a large lake in late May and June in 1970 suggest that the subadults may make up as much as 41% of the population (Buckle *et al.* 1970).

From our findings of 80% of breeding areas being active, 4-23% of adults not breeding, and 16-41% of the population being subadult, each breeding area would represent 2.0-3.5 eagles in the spring. With the addition of one young per breeding area (our finding was 0.98-1.07) and assuming minimal mortality of adults and subadults during the summer months when food is plentiful, then each breeding area would represent 3.0-4.5 eagles just prior to fledging. With an estimated 572 to 1591 breeding areas in the western half of the study area this would represent a spring population of 1,050 to 5,200 eagles and a midsummer population of 1,600 to 6,700 eagles. A rough comparison of this area with the rest of Manitoba and Saskatchewan suggests that the total population of eagles in the two provinces may be as much as five times this amount. Thus, if these eagles migrate into the midwestern United States as early banding results indicate they do, they must make up a large proportion of eagles wintering in the United States outside of Alaska.

Productivity. Studies of Bald Eagle population dynamics have revealed that in areas where Bald Eagles are declining, they are not producing enough young (Sprunt 1969). It is therefore important to have several indices to assess the production of young. These can be compared with those from other regions to give an indication of whether or not the Saskatchewan eagles are producing enough young to maintain the stability and viability of the population as a whole.

In the evaluation of productivity one can compare the number of successful nests or the number of young per successful nest to the total number of breeding areas, the number of occupied breeding areas, or the number of active breeding areas.

As there is usually about a three week variation in the ages of young in any one region of our study area, our successful nests on July surveys included those with young aged 4-10 weeks. In the part of the survey covered in both May and July the young were 6-10 weeks old at the time of the July survey. As there is continuing mortality during this period, our sample may overestimate the success rate, but work in this area since this survey was done suggests the difference would be small.

In considering any index which deals with the number of young, one must realize that the number of young per successful nest will vary considerably from year to year in any one region (Mathisen 1969). In spite of this problem, this index alone may give some indication of the health of a population. Areas with stable populations as Florida 1941, Chesapeake region 1936, and Alaska 1963

(Sprunt 1961; Abbott 1967; Troyer and Hensel 1965), tend to have more young per successful nest (1.63-2.1) than those with declining eagle populations (1.0-1.7) in Maine 1962-3, Chesapeake region 1962-5, and Ohio 1962 (Abbott 1967; Sprunt and Ligas 1964; Sprunt 1963).

When using the number of breeding areas in an index, one must take several factors into account. The first time an area is searched, the presence of the adult with its white head makes an active nest much more visible than an empty nest, so that one will get a disproportionately high value. Secondly, in our area at least, it is not sufficient just to visit previously known breeding areas. To show the importance of this factor, each nest was placed in several classes and these data were placed in table form (Table 3). From this table, we took all breeding areas that were watched in two successive years. Only 57% (57/101)

Table 3. Status of Bald Eagle breeding areas in 1968 and July 1969 according to their status in 1967.

a.		A 1967						b.		E 1967					
1968	NB	0	0	1	0	2		1968	NB	0	0	0	0	0	
	B	0	0	1	3	2			B	1	0	1	1	0	
	E	2	0	2	0	1			E	0	0	2	1	2	
	G	0	3	0	0	2			G	0	0	0	0	0	
	G		NC	E	B	NB			G		NC	E	B	NB	
		July 1969								July 1969					
c.		U 1967						d.		Totals					
1968	U	X	X	58	23	54		1968	U	X	X	58	23	54	
	NB	5	4	12	8	14			NB	5	4	13	8	16	
	B	0	0	11	5	11			B	1	0	13	9	13	
	E	6	5	20	4	4			E	8	5	24	5	7	
	G	X	X	X	X	X			G	0	3	0	0	2	
		G		NC	E	B	NB			G		NC	E	B	NB
		July 1969								July 1969					

Symbol definitions:

- NB Nest contained young which were not banded.
- B Nest contained young which were banded.
- A Nest contained young.
- E Breeding area contained only empty nests.
- NC Breeding area was not checked.
- G All of the nests in the breeding area were gone.
- U The breeding area was unknown.
- X A logically impossible category.

of breeding areas that were active one year were active the following year. At the same time 22% (15/57) of breeding areas empty the first year were active the second year. This means that if we had only visited previously known breeding areas, without a concomitant search of the shoreline, then we would have found a 28% decline in the eagle population from 1968 to 1969. Eagles may be changing breeding areas from one year to the next or breeding areas in some regions may be larger so that nest sites further than a mile apart would be within the same breeding area. The increased mobility of Bald Eagles in this area may be a result of the high turnover of nest sites (16% of nests present in 1968 were gone by 1969) which occurs as a result of many nests being placed in precarious positions in spruce trees or in dead poplar trees. This makes comparisons between our area and areas further south difficult because there may well be more empty nests and therefore more empty breeding areas in a region where nest trees are larger and sturdier and nest sites tend to last longer.

When using the number of occupied breeding areas in an index, there is a tendency to underestimate the number as non-breeding adults are frequently absent from the vicinity of their nest (Gerrard and Whitfield, *unpub. obs.*). Thus, though the number of occupied nests is a better indicator of the status of the population as a whole, the number of active nests is a more precise value because once the eagles have begun incubating seriously they are off the nest less than 2% of the time, and rarely far from the immediate vicinity of the nest (P. N. Gerrard and J. M. Gerrard, *pers. obs.*).

Our nest success of 65-68% may therefore be high. However, even if all empty nests seen by us had been occupied, the nesting success would have been 56% which still places the Saskatchewan population among those populations known to be stable and reproductively viable (Sprunt 1969). Furthermore the produc-

Table 4. Reproductive indices of the Saskatchewan and Manitoba Bald Eagle population.

Survey date	July 1968	May 1969	July 1969
Proportion of breeding areas occupied		83-86%	
Proportion of breeding areas active		80%	
Proportion of breeding areas successful	64%	56%	56%
Proportion of occupied breeding areas which were successful		65-68%	
Proportion of active breeding areas which were successful		71%	
No. young per successful nest	1.6-1.7	1.7-1.9	1.6-1.7
No. young per active nest		1.23-1.35	
No. young per occupied nest		1.15-1.26	
No. young per breeding area		0.98-1.07	

tion of 1.15 to 1.26 young per occupied nest should be enough to maintain a stable population (Sprunt *et al.* 1973).

Nest Failures. Of 51 nests which we visited in May 1969, four were gone by July. In one case the tree had been chopped down. Whether the others had suffered a similar fate or whether they had fallen down in the wind we do not know.

Nests where incubating adults flew from the nest during the May survey tended to be empty in July. As no attempt was made to flush the adults and the plane was flown no closer to these nests than to others, we feel that this does not reflect the degree of our disturbance, but rather the attachment of the adults to the nest. It would seem likely then that adults with a closer attachment to the nest were less likely to desert the young.

Nests which were empty in July 1968 and active in May 1969 were more likely to fail than nests which had been active in July 1968. This may reflect the fact that some adults are better parents, or that some nest sites are in a better position, or that some nest sites are more often affected by human disturbance. At one particular nest site we suspect that the young were taken both years for food or feathers, though what happened to the other sites we do not know.

Summary

A large Bald Eagle breeding population is described in Saskatchewan and Manitoba. Sixty-five to sixty-eight percent of occupied breeding areas were productive, producing 1.15-1.26 young per occupied breeding area. These figures suggest the population is reproductively viable and stable.

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OSPREY POPULATION STATUS
IN NORTHERN IDAHO AND
NORTHEASTERN WASHINGTON—1972

Wayne E. Melquist

Donald R. Johnson

ABSTRACT. The survey of nesting Ospreys (*Pandion haliaetus*) in northern Idaho and northeastern Washington begun in 1970 was continued through the third nesting season. Productivity (the average number of young fledged per active nest) in 1972, was 1.08. The number of young fledged per occupied nest was 1.26, reported for most other populations under study elsewhere in the United States. This breeding population is the largest in the western United States.

We have continued the Osprey nesting survey conducted by Schroeder (M.S. Thesis, University of Idaho, 1972) in an effort to (1) census the breeding population, (2) determine nesting success, and (3) identify factors causing nest failure. Results of the 1972 census and productivity study are reported here. This study was supported in part through a grant-in-aid from the National Audubon Society. We wish to thank Robert Goodman, Ron Hendershott, Bob Cordingly, Keith Hawn, Don and Chris Erickson, Roger and Janice Inghram and the many others for field assistance. The Water Resources Research Institute, University of Idaho, provided a motor boat for census work.

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The Middle Fork of the Clearwater River, the Selway River to Selway Falls and the Lochsa River in the Clearwater watershed were surveyed. The census area in the Coeur d'Alène watershed included the Spokane River to the Washington border, Lake Coeur d'Alène, the Coeur d'Alène River to Cataldo, the St. Joe River upstream to Avery, and other small lakes and streams within this region. The Pend Oreille watershed included Lake Pend Oreille, the Pend Oreille River downstream to Metaline Falls, Washington, the Clark Fork River upstream to the Montana border, the Priest River watershed and the smaller lakes and streams within the region. The status of the breeding population in the Kootenai watershed will be reported when a complete survey has been made.

Of the 176 pairs under observation, 151 (86%) laid eggs. Another 25 pairs (14%) attended nests but did not lay eggs. One hundred ninety young were fledged, a productivity of 1.08 young for each territorial pair (Table 1). It is apparent that the total population consists of not only breeding pairs, but non-breeding birds which occupied nesting territories. They may eventually contribute to population recruitment.

Of the 267 nests located, 120 (45%) were built in dead snags, mostly ponderosa pine (*Pinus ponderosa*), and 82 (31%) were built in live conifers, primarily grand fir (*Abies grandis*). The remainder were built on pilings, in black cotton-

Table 1. Productivity of northeastern Washington and northern Idaho Osprey (%), 1972. Terminology from Postupalsky (*Raptor Research Report* No. 2, pp. 21-31, 1974).

Watershed	Clearwater	Coeur d'Alène	Pend Oreille	Totals
Total pairs (occupied nests)	12	73	91	176
Unproductive nests	1 (8)	12 (16)	12 (13)	25 (14)
Active nests	11 (92)	61 (84)	79 (87)	151 (86)
Successful nests	9	35	53	97
Unsuccessful nests	2	26	26	54
Total young produced	14	68	108	190
Young/success- ful nest	1.56	1.94	2.04	1.96
Young/active nest	1.27	1.11	1.37	1.26
Young/occupied nest (productivity)	1.17	0.93	1.19	1.08

wood (*Populus trichocarpa*), on utility poles and on bridges (Table 2). Forty-three nests (16%) were built on man-made structures.

Table 2. Osprey nesting locations (%), 1972.

Support Structure	Clearwater	Watershed Coeur d'Alène	Pend Oreille	Totals
Black Cotton- wood	0	20 (18)	2 (1.5)	22 (8)
Dead Snags	11 (61)	54 (50)	55 (40)	120 (45)
Live Conifers	7 (39)	14 (13)	61 (44)	82 (31)
Pilings	0	12 (11)	15 (10.5)	27 (10)
Utility Poles	0	8 (7)	3 (2)	11 (4)
Bridges	0	1 (1)	3 (2)	4 (1.5)
Gin Pole	0	1 (1)	0	1 (0.5)
Totals	18	110	139	267

Clutch size was determined in 18 nests: 11 nests on pilings in the Pend Oreille River contained 28 eggs, an average clutch of 2.5 eggs; seven nests on pilings in the Coeur d'Alène watershed contained 19 eggs, a clutch size of 2.7. More than one-half of the successful nests fledged two young (Table 3). Although we have found clutches of four eggs, there has been no incidence of four nestlings fledging from the 179 successful nests surveyed over three nesting seasons.

Threats to nesting success include removal of eggs and nestlings by malicious persons, shooting, nest destruction by wind, and probably predation by raccoons, Ravens and Crows. Nesting failure due to pesticide and mercury contamination is under investigation. Despite these inimical effects, this nesting population is the largest in the western United States.

Table 3. Number of fledglings in successful nests (%), 1972.

Watershed	1 fledgling	Nests with 2 fledglings	3 fledglings
Coeur d'Alène	8 (25)	18 (53)	7 (22)
Clearwater	6 (66)	1 (12)	2 (22)
Pend Oreille	11 (20)	29 (55)	13 (25)
Totals	25 (26)	48 (51)	22 (23)

*EAGLE AND OSPREY POPULATIONS:
ABSTRACTS OF OTHER PAPERS AND
INFORMAL DISCUSSION*

ABSTRACTS OF OTHER CONFERENCE PAPERS

Leo G. Heugly, Department of Zoology, Brigham Young University, Provo, Utah 84601.

Trends of Golden Eagle Numbers in Western United States.

Two studies conducted in the southwest indicate a stable population of Golden Eagles. The major source of data for the intermountain area came from aerial surveys which gave density estimates that suggested a healthy population of Golden Eagles. An estimate of over 40,000 Golden Eagles in the western United States was obtained based on density figures.

Leo G. Heugly.

Golden Eagle-Domestic Sheep Interaction in Utah.

Evidence of significant predation by Golden Eagles on domestic sheep was not found in Cedar Valley west of Utah Lake. Eleven Golden Eagles were observed over sheep (total of 63 minutes) with no aggression observed. Observations in the Uintah Basin suggested that avian predation did occur, but it was

not certain if the predatory species was the Golden Eagle or the Common Raven.

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Effects of Organochlorines and Mercury on Southwestern Idaho Golden Eagles.

Nesting success of Golden Eagles (*Aquila chrysaetos*) remained stable and averaged 62.7% from 1969-72. An average of 1.1 young fledged per nesting attempt. Nesting density was greatest in 1971 when 56 pairs nested an average of 2.7 miles (4.3 km) apart or one pair per 24.5 square miles (63.4 km²).

Mean eggshell thickness was the same as pre-1947 values. DDE concentrations in eggs and tissues of eagles were much lower than in declining species producing thin eggshells. DDE levels in eggs and tissues of eagles were 4-8 times as concentrated as levels detected in tissues of the major prey. PCB were detected and levels were less than 5.0 ppm (wet weight) in eagle tissue. Total mercury concentrations in eggs and tissues of eagles were less than 1.0 ppm. Evidence suggests pheasants were the main source of mercury for nestling eagles.

Symptoms commonly observed in populations affected by chemical contamination are discussed.

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Biology of Bald Eagles on Amchitka Island, Alaska.

The resident population of northern Bald Eagles on Amchitka Island, Alaska, was studied from 1968-1974. Nine population surveys from 1970-1972 average 214.6 eagles on the island. The average ratio of birds was 66 percent adults to 34 percent subadults.

From the time that a cohort of young birds fledged to the time that they reached the first adult year, 90 percent suffered mortality. This may be due to starvation, harsh weather conditions, or a number of other causes.

The eagles moved up and down the island as well as to the other near islands to utilize significant carrion food sources such as dead whales, sea lions, etc. Subadults participated in this carrion feeding to a greater extent than adults. The refuse dump on the island which the eagles regularly scavenged drew eagles from other islands especially during the winter months when the population counts revealed more birds on the island than in the summer months.

Nest building began as early as January on Amchitka. Due to high winds, harsh weather conditions and rapidly growing grass, nests usually do not last more than one year. The nests are built on sea stacks, ridges, connected sea stacks, islets, or hillsides. Fox predation may have influenced the placement of

nests in the past.

An increase in active nests occurred from 1969 (57 nests) to 1972 (71 nests). This probably resulted from the increase in food supply provided by the garbage dump.

The highest density of nests was found on the eastern and western ends of the island. This may be because of concentrations of pelagic birds which fed at the passes in these areas and which made up a considerable amount of the diet of the eagles. The placement of the dump on the eastern end of the island further influenced the yet higher concentration of nests in this area.

Egg laying took place in late March, April or May. Of all nests attended by adults in 1969, about 19 percent were never known to have contained eggs. By comparing population counts and nests, it appeared that all adults on the island were participating at least in nest building. Of 88 eggs laid in 1969, 37.5 percent did not hatch. Since 10 percent fewer nests were known to have contained young in 1969 than from 1970-1972, it was assumed that human disturbance during critical incubation periods was responsible. The average value for the percentage of nests containing young for the three years was 71.28 percent. The higher density of nests at the east end of the island did not influence the percentage of nests containing young. However, it apparently influenced the number of young per nesting attempt and the number of young per nest containing young. For 1970-1971, the average number of young known in a nest per nesting attempt was 1.24, and the average number of young known in a nest per nest containing young was 1.75. The nestling mortality was greater in nests containing more than one young. In 1972, 0.86 young fledged per nesting attempt, and 1.42 young fledged per nest fledging young.

The adult eagles on Amchitka were much more aggressive toward humans than those cited in the literature.

A total of 480 prey items were collected from nests during 1971 and 1972. As calculated by numbers 23.13 percent were mammalian, 61.25 percent were avian, 13.96 were of fish, and 0.63 percent were invertebrate. By biomass, 36.06 percent were mammalian, 49.42 percent were avian, 14.40 percent were of fish, and 0.12 percent were invertebrate. These values probably underestimated the percentage of fishes, carrion and invertebrates. Contrary to previous reports, Bald Eagles were found regularly to prey on sea otter pups. The eagles hunted by three methods: still hunting, hunting from an aerial height, or hunting while in direct flight.

The three species with which the eagles most commonly interacted were Glaucous-winged Gulls, Peregrine Falcons, and sea otters. Intraspecific interaction was influenced little by the age classes of the eagles.

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The Problems of Golden Eagles in the West [Author not present; paper not presented].

As pointed out in a landmark study by Leslie Brown and Adam Watson, sheep range provides a high biomass of carcass available to eagles. Although predation by eagles accounts for only a minute fraction of the available carcass, the mere presence of eagles over sheep range is a cause of angry concern and misguided action against scavenging eagles by the sheep and goat industry. The recent helicopter shoot-off of at least 700 wintering eagles in Wyoming made world headlines.

The presence of wintering eagles over most of the sheep range has little or no deleterious effect upon the lamb crop. With the exception of the Edwards Plateau and parts of the Trans-Pecos of Texas, lambing in the regions to the north takes place largely or entirely after the winter eagles depart. The Wyoming shoot-off took place from November through March, while lambing is mostly in May or very late April. Golden Eagles are already back in the Alaska and Brooks Range nesting grounds and have laid eggs before the first of May.

Nesting eagles in the mountain states do not feed upon livestock even in the midst of a densely populated sheep country, as attested by the intensive studies by McGahan, Arnell, Kochert, Boeker and Ray, and others. It is clear that any livestock damage in the sheep country, where any exists, must come, not from wintering eagles, not from nesting eagles, but from a third and less studied population.

Actuarial considerations suggest that resident eagle populations contain about as many non-nesting immatures together with some non-nesting adults, as are present in the actual breeding population. Although we do not have definite figures for the Golden Eagle, it seems clear from observations upon better known raptors, that given a thousand pairs of eagles, some 80% breeding in any one year will produce a crop of 800 fledglings. These reach the free population in July and August. During the next four or five years before nesting begins, probably at least 75% have disappeared. The August population would consist of 800 breeding pairs, 200 non-breeding pairs, a cohort of 800 fledglings, a much smaller cohort of one year old birds, perhaps 400, and smaller cohorts of two, three, and four year old birds.

This population has been considered by Brown and Watson, and just recently by Kochert. It is clear that we know little of the food habits of this non-breeding group, and of the feeding habits of breeding eagles during the non-breeding season. Hinman's study of the eagle in the Antelope grounds of western Utah indicated four nesting pairs of eagles as well as a number of non-nesting birds. The single antelope predation was by a non-nesting bird.

Whether the non-breeding population does affect the lamb crop is problematic, but it is clear that wholesale winter shoot-offs by mountain-states sheep-ranchers are not related to any real predator problem. In Texas, with winter lambing, the total number of eagles is so small that even if eagles took lambs regularly it could have no perceptible effect upon the Texas lamb crop, and most ranchers admit to me that the problem of weather far outstrips any other consideration.

INFORMAL DISCUSSION

Brown on Golden Eagles and Sheep

LESLIE BROWN. Although I know nothing whatever about the Golden Eagle in the west, I would mention that I do see the problem of eagles and sheep, which is one of the main problems from both sides of the Atlantic. The first time I ever came to the United States, I came here to learn about range management, which has been a study of mine ever since.

When it comes to the problem of Golden Eagles in the Western United States, it appears to me that there is only one problem, and that's the *human problem*. And the main problem is the competition between the Golden Eagle and sheep. Now this is not a problem peculiar to the western United States. It occurs in every country in the world where big eagles occur in sheep country. It occurs in Scotland, it occurs in South Africa, and it occurs in Australia, where the Wedge-tailed Eagle has been killed on a scale which puts anything that has been done in the United States well into the shade. Now, I personally know most about the situation in Scotland where we have a total of about 280 pairs of Golden Eagles, and they are permanently resident in the sheep range, and they breed at a time when the lambs are being produced, so that here we have a situation where you could get the maximum conflict between Golden Eagles and lambs.

This has been studied to some extent in Scotland by several people. And the end result always is that the Golden Eagle doesn't take very many lambs, even when they are abundant and lying about all over the place dead, and that most of those that it does take are dead already. A paper by Lockie in 1964 or thereabouts proved this on the basis of various wound criteria that you can find on the lambs. If you find that the Golden Eagle has picked up the lamb dead, then there's no extra-vascular blood, as Lockie put it, that is to say there is no obvious bruising and bleeding. But if the lamb has been killed by the eagle there is considerable bleeding and you can therefore identify the carcasses. Now in Scotland we have severe lamb losses every year, largely due to weather, in fact almost entirely due to weather. We estimate that in the highlands of Scotland about 85 lambs per 100 ewes are produced in April and May, and by the time of gathering the lambs for marking, which is done in June, there are usually somewhere between 65 and 70 lambs per 100 ewes. What this boils down to is that during April, May and June there are probably 500 to 700 dead lambs lying about in every Golden Eagle's breeding territory. And under these circumstances of course, it is not likely that a Golden Eagle would ever have to kill a lamb if it wanted to eat a lamb. And in fact, I personally have found on every occasion when I have studied this that the Golden Eagle, although it has this abundance of dead lamb lying about in the area, does not in actual fact feed upon lamb much. There is some evidence that they tend to feed more on lamb when there is a heavy lamb mortality, than in milder springs, when there is less lamb mortality. Which indicates that when there is an abundance of dead lamb lying

about they use it to a greater extent. But in fact even in sheep country, they usually feed their young mainly upon natural prey, which in this case is composed of extremely scarce mountain hares and relatively rare ptarmigan and grouse.

Now in the Golden Eagle in Scotland, we have a total as I say of about 280 pairs, and of these probably 20% do not breed each year so that we have about 220 pairs which breed, and of these about 80 are lost every year from human interference of one kind or another. Thus we estimate about 40 or 50 are lost due to deliberate human interference, in this case mostly by game keepers on grouse moors; also to some extent from shepherds. About 20 to 30 pairs would be lost by what we would call inadvertent human interference which includes things like mountain climbers, fishermen, and most of all bird photographers, who feel that they must have a picture of the eggs in the nest, and a few other cases of things of that nature. Actually people go on photographing the eagle as well sometimes and cause desertion, and finally there are a certain number of eggs taken by egg collectors. So human interference is the biggest single cause of loss in the Golden Eagle in Scotland. In recent years, in the last decade, this has sharply increased, and this has increased because of the rise in value of grouse shootings in eastern Scotland. People are now prepared to pay eight pounds, that is to say over 20 dollars, for a brace of grouse shot. And of this about one and a half pounds goes to the county council in rates, so that there is a strong opposition from the county councils to anything that will reduce the value of grouse shootings. And as a result larger numbers of more aggressive game keepers have been employed and they have been killing Golden Eagles in a big way, including on the estates of some very illustrious persons indeed. I won't mention any names, but you think it out. At that price, of course, people are going to see to it if they can that the Golden Eagle doesn't do any harm to grouse, and the paradox is that the worst persecution of Golden Eagles is in areas where grouse are most abundant and where the amount of grouse taken by Golden Eagles varies from 0.3% to 2% of the breeding population of grouse, according to figures provided by Lockie. So you have here the situation that, as usual, the persecution of Golden Eagles is not based upon any sound ground.

And this conclusion applies very very strongly, in my opinion, to what I've read about the persecution of the Golden Eagle in the United States. I have read a number of studies, and I have no doubt there are a number that I have not read, which indicate, in all sheep range in the United States the Golden Eagle takes only a very, very small proportion of its prey in the form of sheep. Usually under 2%, and often much less than that in the studies that I have read. And of these sheep most are lambs that are picked up dead. This has been recently quite clearly proven by a study that was done in Texas in which they have worked out very clear sets of wound criteria by which you can tell whether the lamb was taken by a Golden Eagle alive or dead. I believe that it would be very useful to bring together all the knowledge that is now known in one paper. And I think you could probably list from the known facts in the United States some-

thing of the order of 20,000 prey items of Golden Eagles and you would thereby have an indisputable body of evidence to show that the Golden Eagle can do practically no harm to sheep farming interests in the United States. I say this knowing that I myself am interested in range management, and I know this subject also from the range management viewpoint. So I don't consider that there is any ground whatever for persecuting the Golden Eagle in the United States.

You don't seem to have quite the same trouble here from other human pressures as we do in Britain, largely because you've got a much smaller human population in relation to the total land area. The average population of Britain is 600 people to the square mile, and they are now all much more mobile than they used to be, and they get around a great deal more. I have been looking at some mountains in southern Arizona and have been told that nobody ever goes there at all. This is the kind of situation you'd never find in Britain. If there was a range of mountains it would be plastered with all kinds of rock climbers and hikers of one kind and another.

Now to come to the other species of eagles which might be mentioned. The most important one probably is the Wedge-tailed Eagle in Australia, which has been accused of killing sheep for many years, by the Australians, and they have shot off tens of thousands, probably running into the hundreds of thousands, over the last 20 years, which is infinitely more than have ever been killed in the United States, even by the worst possible estimates, as far as I know. And again no studies whatever were done on the validity of this slaughter. Recent studies have been done, however, and one has been published by Starker Leopold, which indicates as usual that the Wedge-tailed Eagle takes only a very small proportion of lambs among its total prey. And indeed why should it when the whole place is covered with rabbits? I think a more recent study, a more thorough study done by the C.S.I.R.O. in Australia indicates the same thing and as a result they have withdrawn the bounties on killing Wedge-tailed Eagles in Australia, and the situation may change there. So the situation you have in the United States, the problem of the Golden Eagles in the United States, is the same one as occurs worldwide wherever big eagles occur with sheep.

Sometimes this persecution is even more ridiculous than it is in the United States. In South Africa Verreaux's Eagle is persecuted for the reason that it is supposed to kill sheep. But in fact food studies on this bird have indicated, at least in the areas where it has been most studied, that 99% of its prey consists of one animal, the Rock Hyrax (*Procavia* and *Heterohyrax* spp.). The killing off of the Verreaux's Eagles in the Karroo Desert for instance, and other predators in the Karroo Desert where they keep sheep has resulted in an enormous population explosion of the Hyrax which has seriously affected the sheep grazing. And the same sort of thing naturally occurs in the United States.

In the United States as far as I can see the Golden Eagle is definitely beneficial to sheep farmers in that it lives mainly on jack rabbits and on things like ground squirrels or other burrowing animals which could possibly have an adverse effect upon the sheep food supply. So the whole thing, the whole prob-

lem of the destruction of Golden Eagles in relation to sheep, is completely reasonless and it is quite time that the facts were brought out completely in the open and put together in such a manner that no one can be in any doubt whatever that the Golden Eagle is relatively harmless. Many years ago there was a publication produced by the Fish and Wildlife Service called "The Golden Eagle and Its Economic Status" and I would suggest that it is time that this publication be updated with full data on food usage by the Golden Eagle so that we all know exactly where we are.

One suggestion made by Walter Spofford is that although we know a great deal about the food supply of breeding pairs, most of the food data have been collected at nests; we know comparatively little about what the birds eat in winter and also we know comparatively little about what sub-adult and immature birds might eat. And in his abstract, he suggests that these, in wintering populations at any rate, might be approximately equal in numbers to the adult population. I don't know what he bases that on, whether he bases it on actual counts of immatures in relation to adults or whether it's just an idea of his. But I think that in general if you take the whole population, you would find that the immatures are not likely to be of that order of magnitude. They're not likely to be more than 25% of the total adult population of any large species of eagle. And some data that Tom Cade and I produced on the Bateleur and the Fish Eagle in Africa rather support this view. This may not be so in wintering populations of Golden Eagles, because in many cases, adult Golden Eagles remain on their territories in the winter and the young birds are forced to move out. This happens in Scotland, where the adults may remain higher up in their territories during autumn and are seen by deer stalkers on the high tops, whereas the juveniles may move out of the territories in October onto grouse moors where they are instantly shot by game keepers. And as a result the immature has rather a thin time. When the population is also depressed by human interference there is the possibility that immatures can then enter adult territories and hold them. I have seen immatures in their first and second year holding what is a perfectly good adult territory, although unable to lay an egg. And what happens to immature eagles is of some interest, for this reason.

Starker Leopold also in Australia suggested that the lamb losses if any might occur in relation to the sub-adult population of Wedge-tailed Eagles rather than the adult population. The adult population perhaps tends to remain in its breeding territory, whereas the sub-adult population tends to move out and perhaps concentrate in such areas as lambing areas. And he also suggested that by siting lambing areas properly you could avoid the worst effects of this. These big eagles tend to soar along certain ridges and if you site the lambing area in an area where they don't happen to soar they probably will not eat very many lambs. You might think that this is completely irrelevant, but recently a study has been done on the British Sparrowhawk in relation to the pheasant. Killing a pheasant in Britian in generally considered to be a worse offense than drug peddling and at that rate I ought to be in jail a good many times over. The Sparrow-

hawk has always been under pressure from game keepers in Britain because of the number of young pheasants it's supposed to take. The recent study has shown that the Sparrowhawk is only capable of taking young pheasants of a certain weight because it can't carry anything much bigger than that. And that therefore if you site the release pens well away from the Sparrowhawks' nests, practically no young pheasants are taken. This has recently been done actually in cooperation with game keepers, which is a most extraordinary state of affairs. So I think the important point to be brought out is that the Golden Eagle does very little harm to sheep farming interests. The main conflict that is observed is between sheep farming interests and Golden Eagles and it leads to reasonless destruction of Golden Eagles without any factual basis whatever. And I think that the most useful thing that can be done by these studies that are being done at the present moment and have been done in the past, is to demonstrate this in factual, quantitative terms which nobody can argue.

Golden Eagle and Cattle

CAROL SNOW. Concerning your Golden Eagle-livestock relationship, did the management method being used to manage sheep and goats show any differences in the number of kids or lambs being taken by eagles?

LEO HEUGLY. Yes, that is a very important consideration too. In west Texas they do not herd them because of various reasons, they just allow them to roam free; I think that it is a very important consideration where you have livestock roaming free with no one there to take care of them. They don't even want to visit the area during lambing; they will leave them for weeks without visiting the area. But it still doesn't preclude that possibly predation does occur even in herded areas such as occur in eastern Utah. This man had two herders and less than a thousand sheep and predation evidently still occurred there. You can eliminate, help eliminate the problem by having herders. I also recommended that they bring them in closer to one another, not to herding density, and although you create a problem with the range, I still think they can pack them more than they do. You can have a herder there and if an eagle happens to come over he can harass the bird away.

JAMES STUART. Would you say that the behavioral differences between the kids and the lambs would be the factor in the increasing predation on goats?

HEUGLY. There is certainly a difference in behavior. I'm not sure it's a difference in the behavior of the kids or lambs, not the young but the adult. The nanny goats will leave their kid for hours, leave them alone on top of the ridges and that is why they are really susceptible to predation, whereas usually in sheep right from birth the ewe will keep the young by her side. So behavior definitely is a factor.

MORLAN NELSON. I felt there was a discrepancy between your observations and the 1% figure that you come out. How many kids or lambs did you actually see taken by an eagle, taken by an eagle coming down out of the sky? Does that correlate with your 1 or 2%? Or my question would be, do you as a scientist feel that the 1 or 2% is a realistic figure with your studies from observing as you said when you were watching? What did you see when you were watching?

HEUGLY. Actually, predation is really difficult to observe. I tell you, this is a pain in the old neck, but I did observe it. But more often there was something in the way. I knew where the lambs were, or the kid goats, generally kid goats; I would see an eagle go down and of course when it goes down in a hurry you are somewhat suspicious. But in two instances there was a tree in the way and in another instance there was just a little rise in the hill. So in one instance I knew that the kid goat was there because I placed it there; I thought that the nanny had given birth just previously and the kid had gotten tied up in a cactus so I released it from that and since it is not unusual for kid goats to be left alone, I just put it under one of the trees. So I went back to my truck and I watched the eagle come over and it went down so I immediately took off and ran over to the area and flushed the eagle, and saw the kid was actually still alive but its side was opened up and its guts hanging out. And there are two or three instances like this that did occur.

NELSON. Well two or three observations, 1% of the lambs you are talking about even on the bottom is still a heck of a lot of kids and this is where the big argument still is. When you talk about percentages that are killed and the observations that men have made, including the sheep herders you can't find very many. In my life I have yet to find a sheep herder who will tell me that he has seen an eagle come out of the sky and grab the sheep. I know they are around; I have spent my life in all these states and I have yet to find one. But the question that I would ask, as a scientist do you feel your observations will support the 1 to 2% total loss of sheep by eagles coming down out of the sky and killing either live kids or lambs?

HEUGLY. Yes, I do. Now the data do not only come from watching eagles attack. I have some data on that which I didn't present, but also in searching pastures and locating carcasses and examining them. Now I think you can pretty well determine if it has been killed by an eagle and especially if you have flushed an eagle off the carcass. Now if you go examine the carcass and as Leslie Brown and Clayton White mentioned, if you find abrasions under the skin, it is an indication that the animal was still alive when the eagle contacted the animal.

Golden Eagle—Population Evaluation

BRUCE WOLHUTER. You gave both a conservative and what you might call

a liberal estimate on the Golden Eagle population. Was this nesting density?

HEUGLY. Yes, that was nesting density, although somewhat averaged in was some wintering. But it was more towards nesting density.

WOLHUTER. You mentioned that you were using a factor of 20% in some of your estimates to account for single adults and juveniles. I was wondering why you apply that 20% figure you had for population estimates? It seems to me that that might be significant.

HEUGLY. That was included in the density estimate so it would be reflected in the total population density.

NELSON. Did you delineate the physiographic areas, in your nesting area, or did you take ten square miles against the total area? My question is, are you using ten square miles in Idaho for the entire state of Idaho, to compute the number of birds in Idaho? Did you take a physiographic weighting of the area in Idaho?

HEUGLY. First of all I didn't use those Idaho data because I realized that the data were in an area where you had higher densities. I tried to use this method in other studies like in western Utah, to come up with that nesting density. I would say it's not unusual to have one pair per township. I would say that is a pretty good average and certainly when you say that only 25% of the state has that density it would not be correct to extrapolate directly.

NELSON. I think that we would all agree with the total figure; it's a very reasonable figure. I really think your conservative figure is conservative and I think those other men who worked on this will agree.

MICHAEL KOCHERT. To give a little bit more on this type of data. This past winter I flew an aerial survey similar to what they've been doing in the southwest. I set up a 7000 square mile study area, within the Snake River Flood Plain; it's a wintering area. In my October flight I came up with a population estimation of 400 birds within this 7000 square mile area. Now I reflew it in February. In that same area I came up with a population estimation of 1100 and some odd birds, so this fluctuates. What we have to do is find out how much of this type of habitat is in Idaho and it's a rather difficult thing and we have not decided what time of the year we're going to assess it.

TOM RAY. Huegly is concerned primarily with the aerial transect technique used for gathering his data. I think that one thing that has to be taken into consideration that has been neglected is the fact that the transects are set up to achieve a random number of miles between each transect; however, nothing has been done to compute the time it would take for these eagles to go from one of

your transect lines to another one, and we have never given any consideration to the prevailing winds and their effect on pushing them perhaps ahead of us or pushing them over to the other transect. So I think that in evaluating numbers that come out of these transects, some consideration is going to have to be given to looking at the possibility that you are recounting birds.

And another thing that I would like to say is that data in Wyoming and Colorado taken during winter were from rodent control people and in my estimation they are not that excellent observers. I wouldn't doubt your data, but I do doubt theirs.

HEUGLY. On my estimates again, I would try to go from nesting summer densities and try to get away from the problem of the winter counts. There are a lot of problems with these winter counts. Some of the things you brought up should just average out. You get birds that you recount, but you miss birds that maybe left an area before you count; I think they average out.

RAY. But if you have a wind . . .

HEUGLY. That's a possibility but you've got the possibility of the wind going in the opposite way.

LEONARD BINGHAM. I'm an engineer, not a scientist, and this is a comment, not a question. Many years ago I had an old professor, the first question he would ask his class was how does an engineer measure the height of a mountain? The answer was, you guess the half and multiply by two. I think it would be very good if he had lived to notice scientists have been using that same method to determine bird populations.

BROWN. I have a comment, and it is that in Scotland, this has not been done on the basis of aiming at the mountain and multiplying the half the height by two. It's been done by a great deal of footwork and the estimate is within 5% of accuracy. And we do this by estimating the number of Golden Eagles in a particular area, and then extrapolating this on a large scale map, and we find what this comes out to within about 5% of accuracy in the area where we check. So the figure 280 pairs in Scotland is probably not very far off.

CLAYTON WHITE. I think an important item is the use of aerial coordination in surveying eagles as presented here by Warren Higby; perhaps state officials that are here might give that some very strong scrutiny and perhaps some coordination between states.

Golden Eagle—Inadequate Nest Site

ROGER THACKER. I wonder if Olendorff has figures on Golden Eagles

where he was talking about the lack of good nest sites.

RICHARD OLENDORFF. The nests on low creek banks are total failures. They build these things where the water comes down off the cliff and creates a hole in the gravel of the cliff. They build them there and the next torrential rain comes down and just fills the nests up and washes them down off the cliff. We found this in two or three cases. Also, I would have to look at the productivity figures in the other habitats but that was a major factor.

THACKER. Were those nests that you were just referring to included in the figures on this species?

OLENDORFF. Yes. I'm dealing here with per known attempt, not young per successful nest or anything except that one case. We were in the field early enough to detect early nest failures. In 1970 when we were not in the field early enough to detect nest failures, we had a very high young fledged per nest of Golden Eagles and because of this I threw all the 1970 data out for the presentation here.

Golden Eagle—Migration

RAY. You said that you considered only what you thought were resident birds and not migrant birds, is that right?

HEUGLY. No, I didn't say that.

RAY. Well, that was my impression. In any event Boeker's data obviously would be considering birds that migrated down from the Arctic, so my question is, are these estimates that you have strictly for resident nesting birds that have been in continental United States or do these also include migrants?

HEUGLY. First of all, are there any data to indicate that the birds are from the Arctic where they do go? I don't think you've got data to indicate this yet really. I could say that those birds of the Arctic go somewhere, that's true, but we don't know where. We have a lot of birds, for example out here in the Uinta Basin in eastern Utah which I think are right from the state of Utah. You get winter concentrations there at the foot of the Uinta Mountains. I would think you would have a tough time proving the same as in the west deserts that these birds are not from Utah or just Utah birds alone. The Arctic birds must go somewhere, but I think that we have high concentrations of resident birds. I think we need more research on this before we can answer this question.

STEVE SHERROD. Leo, I would like to ask a question. You say that you thought the eagle doing some damage could be trapped and transported to another area and you also stated that with kidding and lambing season you see a

big influx of eagles into the area. Don't you think that the eagles that are trapped will be replaced almost immediately by other eagles to fill that niche?

HEUGLY. I don't know. That's a good question. That's why I say we need more research in this area. Maybe it might not be feasible at all.

KOCHERT. There is a case in Sacramento where they were having trouble with four specific eagles; I don't know if they were immature. The Bureau of Sport Fisheries and Wildlife trapped these birds and they used a dead sheep as bait; they banded the four birds and removed them, I don't know what the distance was, but sometime later—maybe a week—they trapped four birds again, and they were the same four birds. This was an indication that we maybe have a certain set of problem birds. They wanted me to send down some leg markers and they were going to take that and see what happens then.

SHERROD. I was just thinking that the broad management of the sheep might be more appropriate than management of the eagles.

HEUGLY. That's a good point but I don't think we should put the whole responsibility on the rancher. I think the rancher can tighten up his management practices to eliminate most of the problem, but I think that you may have a killer bird which I'm quite certain exists once in a while. Perhaps the birds just happened to be moving through and found successful food and just stayed there for two or three weeks. So I think possibly you could trap these birds and move them 200-300 miles away. You may not have other birds replace them; possibly you would have more. I don't know. You need more research in this area.

BROWN. I don't think anyone in his right senses will deny that eagles do take lambs from time to time. Seton Gordon in his book on Golden Eagles in which he recounted 35 years of observation on the Golden Eagles reports two occasions when he saw a Golden Eagle take a lamb, one of them three weeks of age; they can take lambs that large. I have questioned a very large number of Scottish shepherds in the course of my time and I have met only one who did actually admit to having seen an eagle take a lamb and he had no animosity toward the eagles because he knew them through a lifetime of observation. If you examine the records in Scotland you will find as a matter of fact that lambs appear in the eyries far more often than they do in America; the records here are more scanty, but the fact is that the portion of the lambs eaten is greater in Scotland than is true in America. It is true that eagles do kill lambs from time to time in Scotland and I don't think it invalidates the general view, and I don't think you do either. If you take 20,000 food items you get a better spectrum, a better idea of what really happens than if you take 25 in one particular locality. It doesn't alter the fact that you do have to do research as you say in each locality.

Bald Eagle—Human Disturbance

WAYNE NELSON. You mentioned adults flushing due to aircraft early in the season. Can this happen later on in the season? I think this is a very important point. Is it a behavioral thing?

JON GERRARD. When we flew around there was no attempt to get particularly close to the nest during incubation. At a few of the nests. I think it was something like seven of them out of the 51, the adults flushed from the nest when the plane flew by. The question of disturbance on our part certainly comes up, but I think in view of the fact that there was no difference in those nests in this approach and the other nests, in the fact that the over-all success of those 51 nests was good, that it is probably more likely behavioral characteristic of the bird than a disturbance on our part.

WAYNE NELSON. Do you have pesticide levels on these? I am wondering if depressed hormone levels might cause lack of fidelity to the nest or lack of incubation tendency?

GERRARD. Yes, we got a few pesticide levels on the birds. They are all in terms of wet weight and some of the eggs have been around for a while. In general they are low.

Bald Eagle—Alternate Nests

JOHN SMITH. Did you have any information on alternate nests in Bald Eagles where they had two nests and they used one or alternated year after year?

SHERROD. I haven't analyzed the data for consecutive years yet; I intend to, however. I hope to be able to check that out further this summer. But they do, obviously alternate from nest to nest from year to year.

SMITH. We don't have many eagles in east Texas. Five nesting pairs, and four of them have an alternate nest a quarter of a mile away and some of them rotate. That is, if they are disturbed at one, they just go to the others. I was just wondering if they do that on the Aleutians and therefore you get a log of these dead-looking nests that are really kind of claimed by an active pair.

SERGEJ POSTUPALSKY. I wonder whether the density factor on Amchitka Island doesn't have something to do with the scarcity of these alternate or supernumerary nests. If there are that many birds around perhaps there is a certain amount of competition for suitable nest sites and alternate nests get taken over by other pairs. Is that a possibility?

SHERROD. Yes I believe it is definitely a possibility. There are a limited number of nest sites. On other islands, you see eagles-nesting only on stacks and many of them have very few stacks so there are very few eagles. I believe that is highly possible that the increased food source supports more eagles and there are fewer nest sites. Yes, I think that's true.

Bald Eagle—Territory

POSTUPALSKY. It strikes me that perhaps people working on Bald Eagles and Osprey and so forth might have a little better rapport and try to determine the kinds of information that would be meaningful for comparative purposes. On the whole problem of terminologies and types of data we should be getting and so forth which Dr. White mentioned, I think he hit the nail on the head there and I am going to say a few things in my paper later. However, I want to hit the iron while it is still hot after some of these very excellent papers that we have heard this afternoon. For one thing I am very glad to note that Mr. Melquist here has started to look at the non-nesting pairs and assess them quantitatively and I hope he will be able to continue this again to see if it is about a constant proportion every year, or whether this proportion of these non-nesting pairs from year to year has perhaps a relation to any particular environmental factor. This will be very interesting to know because in many studies this has been just kind of ignored or slopped away and I know I am partly guilty of that myself.

My other comment concerns Mr. Gerrard's paper, the table that compared a number of studies taking the brood size, the number of young per successful nest. An attempt was made to correlate this with the population trend and I submit that that is an involved comparison, because much more relevant is productivity. Productivity here I define as the number of young raised per occupied nest or territory, and this value is the product of two quantities: the nest success or the proportion of nests that produce at least one young, and the brood size. You multiply those two and you get the number of young per occupied territory. You can get this separately too of course. Now a recent paper just presented at the North American Wildlife and Natural Resources Conference deals with a comparison of the nest success of six Bald Eagle populations by Alexander Sprunt and others. This problem was looked at and among other things the authors have analyzed the variability, the variance, in these two quantities—nest success and brood size. I might add that among these six populations were some that were reproducing well and were stationary and some which were reproducing very poorly and were declining rather rapidly. Now here they have shown of the two contributing factors, first nest success, the proportions of successful nests in the total population, and second, brood size, nest success contributes much more to the variability and therefore is a much more important parameter to look at when you are trying to compare reproductive success with population trends. Now in some of these studies which were based on only one survey made late in the season you do not have those data, you only have

the brood size in the summer and you have no data whatsoever on the unsuccessful nests which are important. Now this type of comparison you could very well have done from your 1969 data, I believe, where you did a survey in May and a survey in July. Now in that particular set of data it would have been valid and I think you realize that, and that is why you have done this.

GERRARD. I did mention this. One of the big problems is defining an occupied territory. In other words, we counted as occupied territories where we could see the adult incubating. Whether there is an adult there, whether there are two adults there, whether there is no adult there, whether there is a pair in that area—you just really can't make any sense out of it. But if you use just the incubating adults, then you may have a parameter that is useful.

POSTUPALSKY. That's right—the incubating adult, certainly that will give you what I call the number of active nests, but to get that bit of information you need the early surveys. You certainly need that and I think that the kind of conclusions that you reach from the summer surveys only is rather limited for I think in this six population comparison, they found that the brood size, the number of young per successful nest in the Bald Eagle varied very little, I think only about between 1.2 in the worse populations to about 1.7 or so in good populations and that did not account for the whole difference. That accounted for only a small portion of the difference in nest success. The bulk was accounted by the nests which failed altogether. And I think from this one late summer survey you do not get a good estimate of the number of pairs that fail. But I am still very glad to know that there are all these eagles up there in the Canadian prairie provinces and that they are still apparently doing so well. This is something that certainly needs to be looked at and certainly should be continued.

BROWN. I regard the word territory as an extremely dangerous one to use in connection with birds of prey. In a recent study of British birds of prey in which there are only 14 breeding species you can define about five distinctive different types of territorial behavior, starting with the Common Buzzard with a successive territory both in summer and in winter, going from there to things like the Hen Harrier which is polygamous, males having territories into which, as their powers increase, they attract more and more females and then as their powers wane those females decrease. And then you get animals such as the Golden Eagle which in some subtle way without apparently using any noticeable territorial defense are practically speaking triangulated regularly over the countryside and down to things like Kestrels, which ~~are practically non-territorial~~ and only defend about 75 square yards around the nest itself. You had another case last night when you talked of the Mississippi Kite which is also of this nature. I think you should be extremely careful in the use of the word territory. It is one I don't like at all.

Osprey—Population Measurement

JOSEPH PLATT. What percentage of the birds would you guess that you have found on the study area? You survey all the miles of river?

WAYNE MELQUIST. I might answer that indirectly by saying a game warden reported to me, "I found a nest that is near Bovill." Well, Bovill is off in the sticks. The only stream or the only body of water near that is a little trickle about seven feet wide. But the next nearest water body was a holding pond about seven miles away. I thought I had looked over a lot of the favorable habitat where we might find nests, but when this occurs, why I wouldn't want to even dare guess. I have had reports on the Kootnai River of nesting birds but I haven't had the opportunity to check it out at all.

Osprey—Use of Signs at Nests

VINCENT YANNONE. How effective are the signs on the Osprey nests? It seems that in Montana it was an attractive force instead of a deterrent force and I don't know if the people can't read or are going to see the pretty picture on the sign.

MELQUIST. One thing I might say is that people might approach the nest, but once they've seen the nest and if they have any brains or they think at all or have any respect for wildlife they would move out of the area. A lot of people are totally unaware of the fact that they are disturbing them. They go right up to the nest and look at them and tie the boat up there. So the signs make them aware of the problems anyway.

CADE. The problem is that a thousand people may respect the sign but it takes only one who doesn't to do the job.

MELQUIST. Well, that's true but with a nest on a piling like that which is rather obvious, they are going to see it and they are going to approach it.

YANNONE. The people wanted to know what the sign said, and I had people going to see the signs, so I ended up taking the signs down and I was better off than before. In fact my nests were pinpointed if one looked for the signs.

POSTUPALSKY. I have had some experience with these signs too. In fact, we made up hundreds of them, I believe. On this one Osprey colony at Fletcher Pond we have encountered this very same problem and we thought the better way of solving it, rather than putting the signs on the nest or on our platforms, is to put one in a prominent position at each of the landings where there are boat rentals and so forth. I think they have been quite effective because when we have been there and worked with them and banding, we've had persons in

boats yelling “You leave those birds alone!”

MELQUIST. I must comment about that. Our funds are rather limited for making up signs. We don’t have any signs available at this time. Those signs that we had used were ones that Dr. Johnson picked up out east. But if we had them now, I think it would be a good idea to put them around, and I would like to put my picture on them where I’m doing my study, because I’ve been yelled at many times. I tell you, it’s nice to know people are aware of it, you usually find out about it.

OTHER RAPTOR
POPULATIONS

NESTING HABITS AND REPRODUCTIVE SUCCESS OF GOSHAWKS IN INTERIOR ALASKA

Jerry D. McGowan

ABSTRACT. Thirty active Goshawk (*Accipiter gentilis*) nests have been studied since 1970 near Fairbanks, Alaska. Nests were located from Supercub aircraft. Breeding densities of one pair per 16.0 and 18.8 square miles (42.4-49.8 km²) were recorded for 1971 and 1972, respectively. Paper birch (*Betula papyrifera*) woodlands offer preferred nesting habitat, and 70 percent of nests studied were in birch trees. Quaking aspen (*Populus tremuloides*) and balsam poplar (*Populus balsamifera*) were also selected as nest trees. Most active nesting sites had other stick nests of similar size within a few hundred yards, and such areas are assumed to be traditional Goshawk nesting sites. In 1971 and 1972 the number of young fledged per nest started was 2.4 and 1.6 respectively. Decreased production in 1972 was attributed to an increase in nest failure prior to hatching, lowered hatching success and poor chick survival. Lower fall trapping success and change in age ratios of captured Goshawks further suggested lowered production in 1972. Observed productivity changes are probably related to lower Snowshoe Hare (*Lepus americanus*) numbers.

Introduction

Breeding biology of the Goshawk has received little attention from biologists working in North America. This is partly due to the difficulty in locating enough

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active nests to reflect accurately yearly reproductive success. In 1970 I began a study to develop techniques to assess Goshawk reproduction in interior Alaska and to acquire basic life history information concerning this resident species. Survey techniques were developed in 1970, and since that time I have studied nesting habits and reproductive success at 30 active nests. This paper describes a technique which proved adequate for locating Goshawk nest sites, and briefly reports on 1971-72 nesting and production studies.

Study Area

The 144 square mile (372 km²) study area, located directly north of Fairbanks (147 degrees 40 minutes west longitude and 64 degrees 50 minutes north latitude) is composed of several forest types in various stages of succession. Gentle slopes, rising to approximately 1,200 feet (360 m) are covered with pure to mixed stands of quaking aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), white spruce (*Picea glauca*), and black spruce (*Picea mariana*). The vegetative pattern reflects, to a large extent, a history of burning over the last 70 years. Aspen and birch stands occur on south facing slopes, while birch dominates the east and west aspects. These types give way abruptly to scrubby black spruce on northern exposures. A mixture of these forest types, interrupted by willow (*Salix* sp.) and alder (*Alnus* sp.) thickets predominate in the lowlands. Homogeneous stands of white spruce are not widespread on the study area, but isolated pockets of white spruce, often mixed with mature birch, are common. The study area is typical of hilly, forested regions throughout central Alaska.

Procedures

Intensive nest surveys were conducted in early April of 1971 and 1972. A Piper Supercub was flown approximately 200 feet (60 m) above the tree tops while the observer systematically searched all suitable habitat for stick nests. Goshawk nests are easily observed from that altitude when snow covers the ground and the trees are devoid of leaves. Particular attention was given to mature hardwood and birch-spruce stands. Since the majority of pure spruce woodlands are composed of trees too small to support Goshawk nests, homogeneous stands of spruce were not surveyed. Hence, spring nesting surveys were not conducted at random, but based on physiographic and vegetative conditions.

Stick nests located by aerial surveys were visited on the ground each spring to determine activity. Attempts were made to locate all Goshawk nests within the study area; however, some active nests were probably overlooked. Data from several nests located off the study area have been used to augment productivity information.

Once active nests were located, about five ground visits to each site were required in order to determine clutch size, incubation time, hatching dates, hatching success, period of time spent in nest by chicks, fledging dates, and chick survival. Disturbance by investigators in the nesting area was minimized. When nest examination was necessary a nearby tree was climbed when possible. Customary lineman's gear plus a hard hat and heavy leather jacket for protection from de-

fensive adults, were used.

Seven Swedish Goshawk traps, similar to those described by Meng (1971) were operated during the falls of 1971 and 1972. Trapping was restricted to moderate-sized clearings within the study area. Captured hawks were banded with both U. S. Fish and Wildlife Service bands and colored, plastic bands. Because color bands were commonly lost and rarely proved adequate for individual identification under field conditions, their use has been discontinued.

Findings

Traditional Nesting Sites. Stick nests were found throughout the study area, and I feel certain that most nests were built by Goshawks. At 22 sites where nests were observed from the air, intensive ground searches revealed that only four contained a single nest. Sites with two or more nests clumped within an area 0.5 mile (0.8 km) in diameter were considered traditional Goshawk nesting sites. Not all areas containing stick nests have been used by Goshawks during the study. For example, approximately half the traditional nesting sites were active in 1972. Two sites known to be active in 1970 remained active through 1972, and of 11 active sites in 1971, seven (64 percent) were active in 1972.

There is little doubt that Goshawks in Alaska, like most raptors, are highly traditional in nest site selection. They may (1) repeatedly use the same nest, (2) alternate yearly between existing nests, or (3) build a new nest in the same area. Unfortunately, we have not attempted to mark nesting birds which would allow field identification of specific individuals in relation to specific nest sites. The risk of undue disturbance during the nesting season is, in my opinion, too high. Consequently, it is not known whether traditional sites are occupied yearly by the same individuals throughout their lives, or whether such areas are highly preferred and yearly attract breeding birds at random. Nevertheless, once the majority of traditional nest sites in a given area have been located, yearly nesting studies are facilitated. Some aerial survey work is required yearly in order to detect any new nest sites that may be established.

Nest Sites. Of 30 active Goshawk nests studied since 1970, 39 percent were in pure birch forests, 21 percent in homogeneous aspen stands, and the remainder in woodlands of mixed composition. Seventy percent of the nest trees were birch, 20 percent aspen, and 10 percent cottonwood (*Populus balsamifera*). No nests have been found in spruce trees. Mature birch trees may be preferred because of their greater tendency to have large branches or forks required for nest foundations. While birch nest trees averaged larger in diameter than aspen, in all cases birds appeared to select from among the larger trees available for nesting. Nests were usually in the middle to upper portion of the tree, and ranged from 15 to 50 feet (4.5 to 15.0 m) above the ground. The majority of nest sites were on hillsides of southerly exposure, the exceptions being those located off the study area in a region where suitable timber was restricted to relatively flat terrain along streams.

Nesting Period. Paired Goshawks have been seen in the vicinity of nests in early April. Nest construction has been observed on April 19, when existing nests still contained several inches of snow. Apparently Goshawks in interior Alaska are on territories and associated with a specific nest by mid-April. Egg laying probably occurs during the last week of April, with clutches being complete and incubation under way by May 5.

A summary of hatching and fledging dates and the number of days chicks were in nests appears in Table 1. In both years one nest hatched unusually late, but despite unseasonably cool spring temperatures and persistent snow cover in 1972, the mean hatching date did not differ greatly from that in 1971.

Table 1. Goshawk hatching dates, fledging dates, and number of days chicks were in nest, Fairbanks, Alaska, 1971 and 1972.

Year	Hatching		Fledging		Mean No. Days Chicks in Nest (n)
	Range	Mean*(n)	Range	Mean (n)	
1971	May 30 - June 23	June 5 (8)	July 5 - July 28	July 12 (8)	37 (8)
1972	May 25 - June 25	June 2 (12)	June 22 - July 15	July 8 (4)	42 (3)

*Mean hatching date excluding unusually late hatches of June 23 (1971) and June 25 (1972).

The earliest fledging was on June 22; however, the exact hatching date, in this case, was not determined. Assuming the chick spent the usual number of days in the nest, hatching would have occurred on approximately May 13, while the latest hatching date recorded was June 25. These probably approximate extremes in hatching dates for Goshawks in interior Alaska with the peak normally occurring between May 27 and June 7. Exact fledging dates are difficult to determine, but by the third week of July most of the broods are not found at the nest tree, though they may still occupy the general nesting area.

All females nesting in 1972 were in adult plumage; however, in 1971, four of 11 (36 percent) breeding hens were yearlings. Males have been observed at only 37 percent of the nests studied, and in all cases they were in adult plumage. We have never observed males in nesting areas occupied by yearling females. The significance of the decline in number of yearling females found nesting is unclear. Interpretation of age ratio changes among nesting Goshawks must await added knowledge concerning fidelity of individuals to specific nest sites, and relative success in competition for nest sites between members of different age groups.

Breeding Density. Seventeen active Goshawk nests were located in 1972. Nine of the nests were on the study area giving a minimal known density of one nesting pair per 16.0 square miles (41.5 km^2). Minimal nesting density recorded in 1971 was slightly lower, one pair per 18.8 square miles (48.6 km^2). Actual densities may have been greater because some active nests may have been overlooked. Active nests were situated as close as 1.5 miles (2.4 km) apart in 1971 and 1.9 miles (3.1 km) apart in 1972, further evidence that under certain conditions relatively high breeding densities can be attained. As a comparison, densities of approximately one pair per six square miles (15 km^2) have been recorded in Finland (Hakila 1969).

Production. In 1971, 11 clutches averaged 3.1 eggs, and 82 percent of the nests started were successful (Table 2). Among successful nests, 96 percent of the eggs hatched, and 100 percent of the young survived through fledging age. Hence, 11 nests contributed 27 young (mean 2.4 per nest started) to the fall population. In 1972, 16 clutches averaged 2.9, and only 75 percent of the nests started produced chicks. Among nests producing young, hatching success was 79 percent, and 80 percent of the chicks fledged. In 1972, 13 nests added 21 young (mean 1.6 per nest started) to the fall population.

Causes for reproductive failure in 1971 were desertion or death of the female in two cases, and at another nest, failure of one egg to hatch. All three cases of reproductive failure involved yearling females, but in one case a yearling hen successfully fledged four chicks. Mean clutch size did not differ significantly between yearlings and adults, and nests where total failures occurred contained fertile eggs. Consequently, it is not certain whether yearlings differ in reproductive capability from adults. While the mean clutch size was slightly lower in 1972, nesting failure prior to hatching, decreased hatching success, and poor chick survival were primarily responsible for relatively low productivity that year. Disappearance of entire clutches and absence of the females at nests were largely responsible for pre-hatching nest failures. In these cases the nests and nest trees showed no signs of disturbance and the cause of such failures is unknown.

Table 2. Goshawk production data, Fairbanks, Alaska, 1971 and 1972.

Year	Range	Mean (n)	Percent of Nests Successful*	Percent Hatching Success	Chick Survival	Production Per Nest Started
1971	1-4	3.1 (11)	82	96	100	2.4
1972	1-4	2.9 (16)	75	79	88	1.6

*Successful nests are those where one or more eggs hatched.

Production in 1971 is considered unusually high, and the 1972 data may more nearly reflect the rate of production for most years. Mean clutch size for Alaskan Goshawks has been lower than that recorded in Scandinavia, but yearly reproductive success has been within the range reported by Hakila (1969) and Sulkava (1964).

Fall trapping in 1971 yielded 50 Goshawks (one capture/nine trap days) compared with 13 birds trapped (one capture/30 trap days) in 1972. The juvenile to adult ratio of captured hawks was 4.8:1.0 and 1.0:1.0 for 1971 and 1972, respectively. Inherent inefficiency of the Swedish Goshawk trap makes population trend estimates based solely on trapping data questionable; however, trapping success and age composition of Goshawks captured in 1971 and 1972 reflected the observed change in productivity for the two years.

Productivity of Goshawks in Finland has been shown to vary with availability of prey (Sulkava 1964). The lowered reproductive success of Alaskan Goshawks in 1972 probably resulted from a decline in prey abundance. While drastic fluctuations in prey densities have not occurred, Snowshoe Hares (*Lepus americanus*), which have been the major prey species, decreased significantly in abundance between 1971 and 1972 (Ernest, in press). Grouse numbers have been low during the study. Hare populations in interior Alaska are expected to decline further during the next few years, and this coupled with a concurrent low in grouse numbers provides an excellent opportunity to investigate further Goshawk production in relation to prey abundance.

Acknowledgments

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*POPULATION STATUS OF THE FERRUGINOUS
HAWK IN SOUTHEASTERN IDAHO
AND NORTHERN UTAH*

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Rich Howard

Charles H. Trost

ABSTRACT. Historically the Ferruginous Hawk (*Buteo regalis*) has received little attention from researchers. Recent workers have found this species to be sensitive to interference, especially during early breeding season. This sensitivity to interference is a factor which should be recognized and seriously considered in any investigative effort. We feel that minimal nest abandonment resulted from our investigation. This hawk's versatile nesting habits in southern Idaho and Northern Utah are documented. Of 43 nests found to be active in 1972, 96% were tree nests and 3% on the ground. A single pole nesting attempt was observed to be unsuccessful. Throughout most of the region the Ferruginous Hawk was found along the juniper-sagebrush (*Juniperus-Artemesia*) ecotone, utilizing the sagebrush community for hunting and junipers for nesting sites. Preliminary indications of habitat selection and population density are discussed.

In an effort to follow daily activity and seasonal movements of individual birds, 75 fledgling hawks were banded and color marked using colored wing tags. This marking technique is discussed. Color marked individuals have been

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sighted on two occasions in southern California and once in Mexico. We are getting some indications of post-breeding season movements of fledglings. Behavioral and physiological study will be augmented by time-lapse photography and telemetry.

The Ferruginous Hawk (*Buteo regalis*) has received little serious study until about five years ago. Recent studies by Angell (1969) in Washington, Weston (1968) in Utah, and Olendorff (1972) in Colorado, have added considerably to our understanding of the natural history, ecology, and to some extent the behavior of this species.

Other known studies in progress are being conducted by Donald in Canada, Woofinden in Central Utah as well as our own work which centers primarily in southern Idaho.

A review of the above projects supplemented by our own experience points up a significant potential problem in studying Ferruginous Hawks. This factor, nest abandonment due to nest visits or other disturbance during early stages of the breeding cycle, has considerable impact on the productivity of these birds.

In west central Utah in 1967 Weston (1968) located 13 active Ferruginous Hawk nests during the first year of his study. He records that four nests ready for eggs, and three nests containing eggs, were abandoned early in the nesting season after one visit to each nest. That represents 54% nest abandonment during the first year of his study.

It might be significant to note also, that of nine of these active nests located in a smaller portion of his study area, only two (22%) were re-occupied during the following year. Weston found that using identical observation procedures the following year (1968), no nests were abandoned.

Olendorff (1972) found that of 10 Ferruginous Hawk nests located in north Weld County, Colorado in 1970, all of which were climbed during the egg period, six (60%) were abandoned. The following year he recorded that four of the 15 (27%) active nests failed. He notes that Ferruginous Hawk nests were not climbed during the egg period the second year, and felt that this fact plus less wind-caused destruction led to the lower rate of failure during the second year.

Donald (pers. com.) working in Alberta, Canada has indicated that nest abandonment has been recognized as a problem in their Ferruginous Hawk study.

Our study area in southern Idaho and northern Utah covers several valleys comprising 720 square miles (1864 km²). We have located 43 active Ferruginous Hawk nests. Due to the logistics and time involved in assessing the population of this large area, some nesting territories were infrequently visited. Many nests were considered active on the basis of nest attendance or the presence of an incubating bird. Of seven nest failures, evidence indicates that at least two nests, and possibly three others were a direct result of our indiscriminate nest visits during the laying and incubation periods. At least two other nest abandonments may have resulted from our visit during early nesting season; however, a lack of follow-up data on these nests leaves the issue open to question. Other nest failures

more likely due to such factors as proximity to roads, land conversion, or failure at later stages (remains of young in nest or dead fledglings at nest site).

It is our feeling that nest visits should be minimal, if at all, prior to hatching, for abandonment seems to occur most often at this time. During incubation, daily temperature regimes should be considered and utilized in scheduling nest visits. Two cases of nest failures in our study probably occurred because the nests were visited during late afternoon and early evening on cool days.

In our experience, once the incubating female is flushed from the nest, she may remain off for 20 to 45 minutes. We feel that late afternoon nest visits caused eggs to addle because of cool ambient temperature. Olendorff (1972) indicates from his studies in Colorado, that heat may be the cause. Regardless, this exposure of the eggs to high or low ambient temperature, along with the behavioral factor of nest abandonment should receive serious consideration in study methods dealing with the Ferruginous Hawk.

Our study area consists of two valleys—one, the combined Curlew-Black Pine Valleys facing south toward Salt Lake, and the Raft River Drainage facing north to the Snake River. An additional area, the Arco desert, in the Snake River Plain was surveyed to some extent for breeding birds.

The Ferruginous Hawk is known to be a versatile nester, although all of the northern Utah-southern Idaho nests were found to be tree nests. Eight ground nests were located in the Arco desert area. One instance of an attempt to construct a nest on the cross-arms of a utility pole was observed to be unsuccessful, with the nest collapsing before completion.

From combined areas, there were 89 nestlings, 85 of which fledged, or 2.8 per successful nest.

Throughout our study area this hawk inhabits the juniper-sagebrush ecotone, utilizing the sagebrush community for hunting, and junipers for nest and roosting sites. There is some indication that land use practices resulting in conversion of this sagebrush community to monotypic crested wheat grass (*Agropyron* sp.) and especially intense agriculture, is reducing nesting and hunting habitat for the Ferruginous Hawk. We feel that species diversity of the natural community and especially intense agriculture, is reducing nesting and hunting habitat for the Ferruginous Hawk. Sagebrush often becomes quite dense in areas which are grazed heavily, and federal agencies are attempting to reduce sagebrush and increase edible forbes and grasses over large areas. The reclamation technique of chaining seems to leave greater remnants of the natural community, resulting in greater species diversity of both vegetation and prey population. This contrasts markedly to areas where herbicides and plowing have been employed.

In order better to follow behavior of individual birds as well as daily and seasonal movements, 75 nestlings were color marked and banded in 1972. We employed a wing tag technique essentially the same as that used by Kochert (1972) on Golden Eagles (*Aquila chrysaetos*) in southern Idaho. Six colors of a plastic covered vinyl material called Armortite (Denver Tent Company) were used. The colors used were blue, green, yellow, orange, red, and white. Tags were fitted on young birds that were near fledging age. The tag is folded over

the proximal portion of the humerus and fastened together by a rivet at the rear of the wing between the tertiary and secondary feathers. The tag on one wing denotes locality and a tag on the opposite wing identifies the individual. Smaller color patches were sewn onto the wing tag to give additional color combinations. A year's observation indicates no adverse effects on the bird caused by the presence of wing tags.

After August 1, no hawks were seen in the study area until the last of November. However, we observed two marked birds in early September 1972, 200 miles (322 km) northeast of Curlew Valley, in a shortgrass prairie surrounded by pine, where ground squirrels (*Citellus* sp.) and pocket gophers (*Thomomys* sp.) seemed to be abundant. In addition, a band recovery was reported from this area on September 23. In a survey of the area we found approximately 50 immature birds and one adult. This fall gathering seems to be associated with cooler temperatures and food abundance. Two other independent observations of color marked birds have come from the southwest part of Idaho about 250 miles (402 km) northwest of the study area.

On October 23, 1972 Sanford Wilbur, field biologist working on the California Condor Study, reported a marked bird in San Luis Obispo County in south-central California. A second report from a different source came to us of a sighting on January 6, 1973, 30 miles (48 km) south of the first bird. The first report was incomplete, the observer seeing only one wing tag, whereas the second report gave us colors for both tags and a positive identification. There is a possibility that the two reports are of the same bird. The most recent sighting has come from New Mexico this spring, April 1973.

Weston noted that active nest locations implied a preference to inhabit particular areas instead of dispersing in a random distribution pattern, even when food availability and potential nest site locations seem to be uniformly distributed throughout the area. Spofford (in Weston 1968) made the observation that predatory birds often select nest sites for reasons unknown to scientists, as an apparent reason for the phenomenon.

In Idaho, Burleigh (1972) lists the Ferruginous Hawk's status as an uncommon summer resident. There seems to be a pattern where clones or local populations are present in some areas, but are noticeably absent in other areas of comparable habitat. Four such areas have been found in southern Idaho.

Conclusions

Our preliminary investigation during 1972 indicates that there is a nest abandonment problem with the Ferruginous Hawk. Researchers should weigh the value of information derived from visiting nests during the incubation period and the probability of inducing unproductive nests. Desert shrub and grassland conversion can be detrimental in decreasing the mean density of raptors within a given area. Cultivation of crops over the entire nesting area may insure the absence of the Ferruginous Hawk. The wing markers seem to be a good technique for marking birds though it may introduce a contributing variable to their mortality. Finally, our research indicates that local populations of high com-

parable densities exist in northern Utah and southern Idaho. Their reproductive success is similar to other studies in Utah, Colorado, and Alberta, Canada.

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POPULATIONS OF THE MISSISSIPPI KITE

IN THE GREAT PLAINS

James W. Parker

This paper summarizes briefly historic changes in populations of the Mississippi Kite (*Ictinia mississippiensis*), describes some characteristics of populations in the Great Plains today and comments on reasons for changes in abundance and breeding range. The Mississippi Kite is highly migratory, nests solitarily or colonially displaying no territorial defense and subsists on a wide variety of insects and vertebrates. The American Ornithologists' Union Checklist of North American Birds (1957) somewhat misleadingly describes the breeding range of the Mississippi Kite as northeastern Kansas, Iowa (formerly southern Illinois and southern Indiana), Tennessee, and South Carolina south to Texas, Louisiana, Mississippi, Alabama (rarely) and northern Florida.

Prior to publication of the most recent AOU Checklist (1957) the species was studied chiefly by Ganier (1902), Sutton (1939), Allen and Sime (1943), and Jackson (1945). There are unwarranted generalizations in many state avifaunal studies and elsewhere (Sprunt 1955; Brown and Amadon 1968) about its distribution, migratory habits, feeding behavior, clutch size and aspects of nesting behavior. More recent studies, by Eisenmann (1963), Wolfe (1967), Fitch (1963) and others have improved understanding of the Mississippi Kite, but its population ecology has previously received no systematic long-term study.

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During the summers of 1968 through 1972 I made periodic visits to breeding colonies of the Mississippi Kite in southwest Kansas, western Oklahoma and north-central Texas with the objective of monitoring reproductive success and the development of juvenile kites. The term colony refers here to a nest, or the nests, in individual woodlots whether small or expansive. For 1969-1971 data were obtained from 48 colonies (391 nests), but only 19 of these (261 nests) were observed every summer. Periods spent in research were: 1969, 10 June-12 August; 1970, 1-5 May, 25 May-6 June, 18 June-11 July, 18 July-9 August, 25-27 August; 1971, 10 May-8 June, 20 June-24 July, 31 July-9 August, 21-23 August. Nests were visited an average of 5.6 times each. The detailed results of this study and an extensive review of the history and status of the species have been prepared as a Ph.D. dissertation at the University of Kansas.

History

John Ogden and William Robertson (unpublished manuscript) provided the first summary of the history of Mississippi Kite populations in and east of the Mississippi River drainage system: Documentation of the 19th century range and abundance of this kite in Alabama, Georgia, South Carolina and Florida is poor, and is only a little better for the states adjoining the Mississippi and Ohio Rivers. However, they concluded that decreases in numbers of Mississippi Kites began well before 1900, continued into the 1940's and came about through the disappearance of kites in low-density areas (including upland sites and peripheral areas of their range) and decline in numbers along larger river systems.

It is impossible to estimate the magnitude of reduction in numbers, but the decline was probably not uniform, nor can we assume it occurred everywhere. A southward contraction of the breeding range, however, has been marked. The Mississippi Kite can be inconspicuous, even near large colonies (see later, p. 164), and extended observation is often required to confirm its presence. Thus, it should be noted that many early records do not justify statements about abundance. For example, for northern areas repeatedly listed within the breeding range, but for which documentation is scanty (e.g. Bailey 1918 for southeastern Iowa), the early presence and subsequent disappearance or change in abundance of this kite are nebulous.

Since 1950, any real downward trends have apparently reversed, with the re-appearance of kites in much of their former breeding range, including riparian and upland sites, and their appearance in areas for which previous occupancy is unknown (Ogden and Robertson, unpublished manuscript).

In the Great Plains states of Kansas, Oklahoma and Texas there is little evidence that Mississippi Kite populations declined similarly to their eastern counterparts. Records show the species to have been at least locally common in the area of Barber and Comanche Counties, Kansas, about the turn of the century (Goss 1886, 1891; Bunker 1913). Since 1950 (if not earlier) kites have been seen breeding in most Kansas counties south, and several north, of the Arkansas River (Graber and Graber 1951; Johnston 1964; Rising and Kilgore 1964; Tor-doff 1953; J.W.P. pers. obs.). Statements that kites bred in eastern Kansas are

apparently based solely on two nesting records and one occurrence during fall migration (Goss 1885; Wetmore 1909; Long 1940).

Western Oklahoma has probably remained a principal natural stronghold for the Mississippi Kite since early settlement. Short (1904), Nice (1931) and Sutton (1939) noted the presence of the species there in large numbers, especially in the northwest, and today it is common throughout the western quarter (or more) of the state (Sutton 1967; records from the files at the University of Oklahoma bird range; J.W.P. pers. obs.). There is some evidence that kite numbers in central Oklahoma may have declined before 1900 in riparian areas along the Arkansas River (Nice 1931; Sutton 1967), but since then kites have been recorded during the breeding period for many central (mostly north-central) and a few eastern counties (Sutton 1967, bird range files).

In Texas about 1900 and thereafter kites were resident in the panhandle, several northern counties east of the panhandle and apparently in some counties (Bexar and Lee) in the southeast (Beckham 1887; Singley 1892; More and Strecker 1929; Strecker 1912; Wolfe 1956). Strecker (1912) described the species as present locally throughout the state. From the 1940's to the present, breeding kites have been numerous in the eastern half of the panhandle south (possibly) to Tom Green County, east of the panhandle to Wichita County and south to Callahan County (Allen and Sime 1943; Brandt 1940; Jackson 1945; Stevenson 1942; Thompson 1952; Wolfe 1967; J.W.P. pers. obs.). Again, there is little evidence of major declines in number or range contraction.

To the west and southwest, Mississippi Kites appear to have colonized areas not within the recognized original range of the species. A colony of six nests, observed in 1971 near La Junta, Otero County, Colorado and along the Arkansas River about 75 miles west of the Kansas-Colorado border (Cranson 1972, these proceedings) is the first record of breeding for the state. The colony was again active in 1972 (W. Andersen, pers. comm.; J.W.P. pers. obs.). Judging from sightings of kites near La Junta prior to 1971 (Cranson 1972) kites have been there, and perhaps elsewhere near La Junta, since at least 1968. Cranson (these proceedings) now reports small breeding populations in Prowers and Baca Counties, Colorado.

Observations of kites in New Mexico have accumulated since the 1950's (Ligon 1961; Hubbard 1970, pers. comm.), and there is evidence of breeding in nine counties, as well as in nearby El Paso County, Texas. The most westerly record of the species is from Pinal County, Arizona (the first record for the state) where Levy (1971) observed as many as eight kites along the San Pedro River in 1971. Hopefully, anticipated channelization of the river there will cause only local relocation of the colony.

Figure 1 shows the approximate recent distribution of breeding Mississippi Kites in the Great Plains and southwestern United States.

Areas of Study

The 48 breeding colonies of the present study formed a more or less north-south transect extending along major state and county highways from near

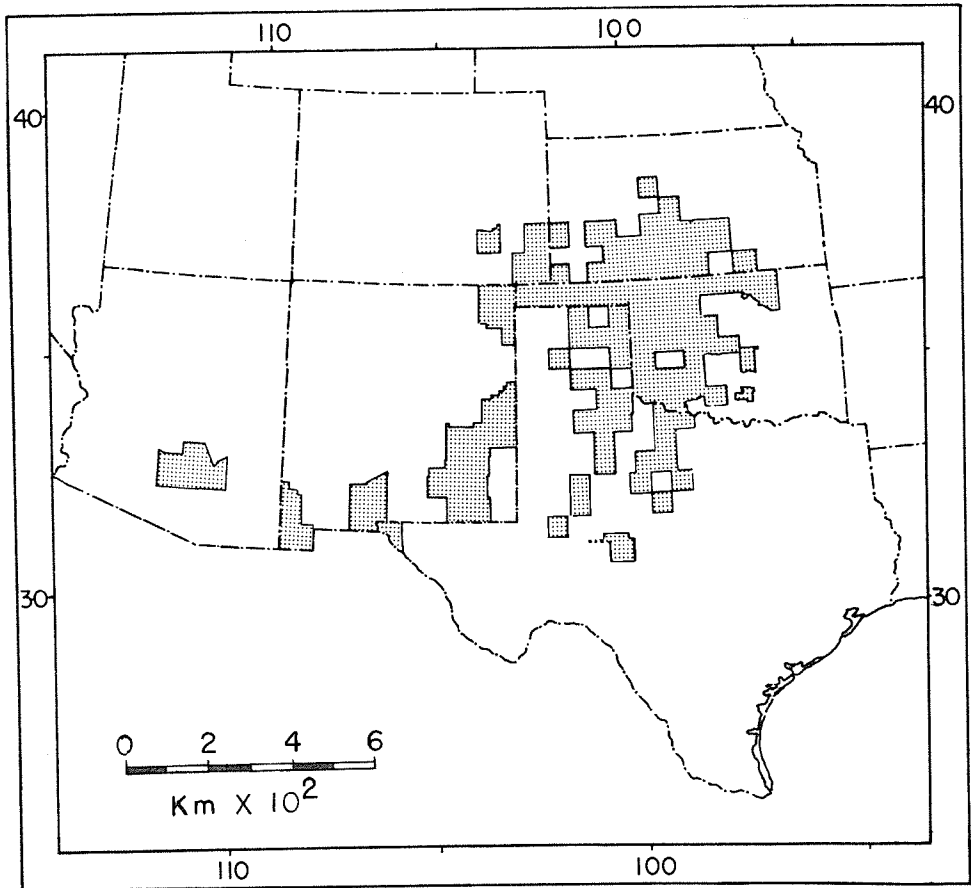


Figure 1. Distribution of Mississippi Kites in the Great Plains and southwestern United States. Shaded areas include counties where kites have been observed nesting, or under circumstances that strongly suggested local nesting, since about 1930. Density and distribution within counties are, of course, not uniform.

Dodge City, Ford County, Kansas, to near Abilene, Jones County, Texas. They were found in five distinct types of forest habitat.

I. Cottonwood (*Populus*) forests and woodlots. Three colonies were found in tall trees (21-25 meters); one large forest around a small lake and a smaller farm woodlot, both in Meade County, Kansas; and two small groups of trees in a farmed field in Harper County, Oklahoma. The extensive forest at Meade State Park and Lake, which varied from park-like to dense vegetation, also contained willow (*Salix*), elm (*Ulmus*) and a few other genera of trees. The farm woodlot

was comprised of widely spaced trees, many dead or dying.

2. Shelterbelts, windbreaks, and residential sites. Included in this group were 36 colonies in artificial tree plantings of about 30, to over 1370 meters in length. There were three colonies in residential woodlots, 14 isolated colonies in shelterbelts, and 19 colonies in six groups of nearby shelterbelts. Shelterbelts (windbreaks) are rectangular or nearly linear patches of nesting habitat containing one to 16 rows of trees. Trees commonly present were elm, honeylocust (*Gleditsia*), black locust (*Robinia*), hackberry (*Celtis*), mulberry (*Morus*), osage orange (*Maclura*), ash (*Fraxinus*), salt cedar (*Tamarisk*) and cedar (*Juniperus*). Cottonwood and walnut (*Juglans*) and a few other species occurred rarely. A row of cedar usually stood toward prevailing winds while deciduous genera occurred in rows of increasing height usually culminating in one or more rows of elms as one proceeded leeward through shelterbelts. Maximum canopy height was between 8-15 meters. Residential plantings lacked the regular tree arrangement characteristic of shelterbelts, but contained similar species and were generally park-like. Colonies (numbers in parenthesis) occurred in: Clark (12), Comanche (2), Ford (1), Kiowa (2) and Meade (1) counties, Kansas; Beaver (1), Beckham (1), Ellis (2), Greer (6), Harper (1) and Woodward (1) counties, Oklahoma; and Wilbarger (4) County, Texas.

3. Oak shinnery and cross timbers. In the "shinnery" country of Ellis and Roger Mills counties, Oklahoma, nests were often placed in short oak (*Quercus*) trees forming dense groves rarely more than 30 meters across. Literally hundreds of these groves could be viewed from near the crests of hills in the rolling prairie and in places they joined to form extensive "cross timbers" such as the oak savannah and forest of the Wichita Mountains Wildlife Refuge in Comanche County, Oklahoma where several isolated nests were located. In shinnery areas nests existed singly or nearby, but in different groves.

4. Mesquite woodlots. Four irregularly shaped woodlots in Jones County, Texas supported colonies, but two were only single nests. One rectangular grove in Baylor County was used by kites. These tree groves were dominated by mesquite (*Prosopis*), but also contained other trees such as hackberry. The largest woodlot was over 80 hectares.

5. Mixed mesquite woodlot. One large grove of trees at the base of the dam and spillway of Lake Kemp in Baylor County, Texas was the site for nests in 1969 and 1970. Elm, Soapberry (*Sapindus*) and hackberry trees grew densely along the banks of the Wichita River, but were replaced by mesquite on the uplands.

Most of the colonies were surrounded by cultivated or grazed lands, sometimes both, and several different crops often bordered a colony. The potential natural vegetation of the study areas (Küchler 1964) included grama-buffalo grass prairie (*Bouteloua-Buchloe*) in northwestern Oklahoma, bluestem-grama prairie (*Andropogon-Bouteloua*) in Kansas and small areas throughout western Oklahoma, sandsage-bluestem prairie (*Artemisia-Andropogon*) in Kansas and southwestern Oklahoma, shinnery and cross timbers (*Quercus-Andropogon*) in northwestern and southwestern Oklahoma, and mesquite-buffalo grass (*Proso-*

~~pis-Buchloe~~) in south-central and western Oklahoma and north-central Texas.

Colony Size and Nest Density

To estimate the number of nesting attempts for the 19 colonies observed for three consecutive summers I corrected for a difference in procedure between 1969 and later years. Censuses of all colonies were begun well into the incubation period in 1969, but they were done nearer the beginning of incubation and nest-building in 1970 and 1971. Thus, in 1970 and 1971 I found many early nesting failures, but in 1969 I found few, although it may reasonably be assumed that they occurred.

As a correction for early unfound failures I have here averaged the percentage of nests in 1970 and 1971 for which eggs were never laid or were lost early and have assumed this to be a valid estimate of the percentage of nests that failed early and went undiscovered in 1969. This correction was applied to colonies in each type of habitat and for the total sample, and should be sufficient for present objectives. A minor cause of over-estimation of population density, for which no correction was attempted, was the occurrence of a few suspected re-nestings. Nest densities are based on areas of woodland only.

Meade State Park and Lake was the site of the largest known colony and it provided most of the data for nests in cottonwood trees. The area has changed little since it was studied in 1961 by Fitch (1963). Cottonwood trees completely encircle Lake Meade and extend about two miles along a stream to an artesian well. The same 19 hectares were censused each year of the study. In all summers it was frequently possible to observe 20 to 30 kites hunting above the trees, and on 6 August 1969, when most juveniles were too young to fly, 100 were once counted (few of the 100 kites were visible with the naked eye). Nests were placed at roughly regular intervals in the trees surrounding the lake, and were somewhat concentrated where the tree groves were widest.

The number of nests in cottonwood colonies varied from 22 (corrected from 15) in 1969, to 18 in 1970, and to 22 in 1971. The maximum range of nest density for Meade State Park and Lake over three years was one nest per 1.0-1.4 hectares. For three nests in the cottonwood planting near Meade, Kansas, nest density in 1971 was one per 0.7 hectare.

Most shelterbelts dictated a linear arrangement of nests, which, as a rule, were evenly spaced more than 60 meters apart. Nests were sometimes placed less than 30 meters apart, and they were often concentrated in parts of long shelterbelts with as much as one half of the wooded area left unused. All species of trees were used by kites, but nests were usually in elms, locusts, and osage oranges and toward the leeward side of a woodlot or shelterbelt. Nest placement was not linear in the squarer windbreaks.

Single nests were placed in windbreaks of only 0.2 hectares and in shelterbelts of about 4.9 hectares. Nest density in shelterbelts containing more than one nest varied from one nest per 0.2-2.4 hectares, and 15 nests were found in one large shelterbelt. Also at this shelterbelt, in Ford County, Kansas, near the species' northern range boundary, I once frightened more than 60 kites from

their evening roosts.

The number of nests in shelterbelts increased from 55 (corrected from 46) in 1969 to 78 in 1970 and fell to 47 in 1971. The corresponding values of average nest density were one per 0.9 hectare (uncorrected), one per 0.5 hectare and one per 1.0 hectare. In several cases the number of nests in undisturbed large shelterbelts changed by one hundred percent, or more, from year to year, and the number of known nesting attempts in one shelterbelt fell from five in 1970 to one in 1971 after many trees were removed from the belt in the intervening winter.

Nests in mesquite woodland were sometimes isolated, sometimes loosely grouped. Although the sample size is small, the number of nests apparently fluctuated little over three years—10 nests (corrected from 7) to nine to six. Nest densities varied from one per 16.0 hectares in 1970 for the largest woodlot to one per 3.4 hectares in 1970 for the rectangular woodlot, and to one per 0.9 hectare for a smaller woodlot. The largest mesquite colony contained only six widely spaced nests.

Three adult kites were trapped on three different nests in one mesquite woodlot in 1969. These nests were abandoned or found by predators, and there is some evidence that the kites at these nests were part of a nearby mesquite colony in 1970 and 1971.

Few nests were found in oak shinnery because of the time required to inspect adequately large numbers of widely distributed groves. A tendency for colonial nesting was apparent because pairs of nests were often located in groves only a few hundred yards apart. It seemed that kites were widely, although not densely, distributed in shinnery.

An adequate census of the Wichita Mountains Wildlife Refuge was impossible in the time available. Six widely scattered nests were located there in 1969 (Gene Bartnicki, pers. comm.; J.W.P., pers. obs.), and, assuming that ten nesting attempts were made and that five percent of the 24,000 hectare refuge was wooded, a density of about one nest per 121 hectares is estimated.

The acreage of the mixed mesquite woodlot was not available, but an estimate of 120 hectares is probably reasonable. In 1969 two nests were placed in elms and one in a soapberry near the river. In 1970 three nests were in elms, one was in a soapberry, and two others were in mesquite on the uplands. Maximum density was about one nest per 20 hectares. Rechannelization of the river and reinforcement of the spillway by the Army Corps of Engineers began in 1970, and much of the mesquite was removed in mid-summer. In 1971 most of the trees, and all the kites, were gone.

For 19 colonies in all types of habitat the number of nesting attempts rose from 92 (corrected) to 133 (= 45 percent increase), and then fell to 75 (= 44 percent decrease). Variation in numbers was almost entirely due to changes of density in shelterbelt plantings. Causes of short-term changes in density, other than human interference, are not readily apparent, and are under study.

Nesting Success and Recruitment of Yearlings

Nests from all colonies provide useful data for the calculation of nesting success. As discussed above, late censusing in 1969 affected the estimation of certain measures of nesting success, and several other procedural problems also require attention.

Many nests were not reached because climbing to them was prohibitively time-consuming and dangerous; this was especially true of nests in cottonwood trees. Late in 1969 and in later years I was able to minimize this problem by using an extendable mirror and pole apparatus (Parker 1972). Unfortunately some very high nests remained inaccessible. For many of these, reproductive events were poorly documented.

Other problems arose from the extensive nature of the study. Many nests could not be visited frequently enough to provide complete documentation of events in the nesting cycle. Analyses of the development and behavior of juvenile kites suggested probabilities that young kites could survive away from the nest at given ages, but the fate of many eggs and juveniles remained uncertain. The fate of eggs is relatively unimportant here, but the uncertain fate of some juveniles directly affects the estimation of nesting success and estimation of the number of juveniles fledged per nesting attempt. Censusing did not continue uniformly throughout the summers, but successful late nestings or renestings were sometimes found. Early-failing late nestings and renestings were unlikely to be found. Therefore, minimum estimates of reproductive parameters are here accompanied by the values that would have obtained if all young of uncertain fate fledged, and neither of these values were corrected for late unfound failures.

Never in five years of study were more than two eggs seen in a nest. One of two eggs in a nest was frequently lost; hence, because of earlier discovery of nests in 1970, the percentage of observed two-egg clutches rose two percent from the 1969 figure. Likewise, the percentage of active nests where no eggs were seen rose from 1.2 in 1969 to 17.1 in 1970. Abnormally small eggs appeared in two two-egg clutches.

Over-all, 59 to 63 percent of all nesting attempts (391) successfully produced at least one young, and from 30 to 49 percent of all attempts fledged at least one juvenile. Between .40 and .63 juveniles fledged per nesting attempt. Nesting success was highest at 53-59 percent for 15 nests in oak woodland. Nests in cottonwood (63), in mesquite (24), and in shelterbelts, windbreaks or residential woodlots (280) were about equally successful at 22-50, 26-44, and 31-49 percent, respectively. Nesting success decreased steadily from year to year for mesquite and shelterbelt (etc.) colonies, and for cottonwood and oak colonies fell from 1969 to 1970 and increased in 1971. Nesting success for shelterbelts (etc.) for 1969 to 1971 was 45-71, 32-54, 26-39 percent. This fluctuation in nesting success is similar to those of other types of nesting habitat. The number of juveniles fledged per nesting attempt in oak, cottonwood, shelterbelt, and mesquite habitat was .71-.76, .34-.69, .40-.62, and .41-.59, respectively. Estimates of juveniles fledged per nesting attempt for each type of habitat and

for individual years rarely approached 1.0.

One-year-old Mississippi Kites can be recognized because they retain varying numbers of the flight and contour feathers of the juvenal plumage. Because several kites were often present as I inspected nests it was frequently impossible to determine the identities and, thus, the ages of the birds belonging to individual nests. However, considering only those nests (146) for which I felt confident of the identity of both attending kites, eight percent involved a one-year-old bird. Adding nests for which the involvement of a one-year-old was only suspected increased the estimate to 19 percent. Recruitment of one-year-old kites into the breeding population is, then, between 4 and 9.5 percent, probably nearer the lower value. I never found a pair of one-year-olds nesting.

There is no evidence that the reproductive performance of the Mississippi Kite is presently affected by residues of chlorinated hydrocarbon pesticides. Eggs were never lost in a way suggesting eggshell thinning. The thickness of 68 eggshells collected during my study and 178 pre-1940 eggshells borrowed from museums was measured with modified dial calipers. Analysis showed a statistically significant four percent maximum reduction in thickness of recent eggshells. Preliminary analyses of tissues from juvenile kites, embryos, eggs and a one-year-old kite indicate the presence of DDT, DDE, aldrin and dieldrin residues in concentrations below 1 ppm. Low levels of contamination are being verified by analysis of tissues from adults.

Food Habits and Population Regulation

When possible, the remains of prey were collected from nests and from the ground beneath nests. The remains of 15 birds, 8 mammals, 2 box turtles (*Terrapene*), 43 frogs, 11 horned lizards (*Phrynosoma*), 1 toad (*Bufo*), and 1 lizard (*Sceloporus*) were found in 175 collections. Meadowlarks (*Sturnella*), Yellow-billed Cuckoos (*Coccyzus americanus*), and Cliff Swallows (*Petrochelidon pyrrhonota*) were among the birds captured, and many were juveniles. Chimney Swifts (*Chaetura pelagica*) are also preyed upon (Seibel 1971). *Peromyscus*, *Dipodomys*, and *Sylvilagus* represent the mammals captured or scavenged. Gene Bartnicki, biologist in the Wichita Mountains Wildlife Refuge, reported finding collared lizard (*Crotaphytus*) remains in nests (in litt.). The remains of *Terrapene* were crushed and undoubtedly the result of road kills; a leg of *Sylvilagus* was probably of similar origin. Bats (Allen 1947; Taylor 1964), crayfish (Brandt 1940) and even fish (Sutton 1939) are also known prey.

The Mississippi Kite is obviously a more general predator than was indicated by Fitch (1963) and Brown and Amadon (1968) and it is sometimes a scavenger as well. Its scavenging habits may be a recent development prompted by the availability of road-killed vertebrates, and the frequency with which kites take small birds may have increased with habitat changes such as widespread tree planting and the building of highway bridges and other structures which provide nesting sites for small birds. Presumably then, Mississippi Kites are less susceptible to fluctuations in insect abundance than one would conclude from Brown and Amadon (1968).

The question of food limitation of kite populations is under study, but cannot be adequately considered here. It is sufficient to mention only that it is unlikely because: Mississippi Kites can exercise the options of efficiently preying on normally abundant insects and also of taking vertebrates; over-all nesting success of nests where two eggs are known to have hatched (44-77 percent) is equal to or greater than success of nests where only one egg is known to have hatched (37-76 percent), and the older of two young in one nest usually grows as fast or faster than a youngster raised alone; and kite numbers have increased in much of the Great Plains (see below).

Reasons for Changes in Population Size

Why Mississippi Kites declined in number or disappeared entirely in some areas is not clear; various authors have done little more than speculate that shooting (Ogden and Robertson, Ms; Mengel 1965) and egg-collecting (Sutton 1939) played the principal roles. Assuming so, western populations undoubtedly fared better than eastern populations because the former were exposed later to human populations of lower density. Notably, much of Oklahoma remained "Indian Territory" until about 1890, and was the last of the central plains states to suffer settlement (see U. S. Department of Interior, Geological Survey 1970; Hatton 1935). The effect of habitat alteration on kite populations cannot be discounted, but is rarely mentioned. How eastern populations responded to habitat change will probably remain a mystery. However, certain responses to changes in plains vegetation are evident and have been both negative and positive, but the latter response is far more pronounced.

For discussions of the primeval vegetation of the Great Plains see Aikman (1935), Bruner (1931), Cook (1908), Hatton (1935), Price and Gunter (1943), Rice and Penfound (1959), Rising (1970), Short (1965), and Wiedeman and Penfound (1960). In the mixed and short grass prairie of southwestern and south-central Kansas and parts of Oklahoma and Texas trees were nonexistent except for forests along large rivers such as the Arkansas, Medicine Lodge, Cimarron, Canadian, and Red; and except for small groups of trees in dry runs, ravines, and potholes. Gallery forests were often discontinuous. Much of central Oklahoma and north-central Texas was originally oak savannah, and shinnery was encountered by early explorers in western Oklahoma and was probably also present in the adjacent Texas panhandle. There were tall and mixed grass prairies in parts of the Texas panhandle, the northern Texas counties immediately to the east, and parts of southwestern Oklahoma, with more xeric growth, such as mesquite and shinnery oak, present on poorer and dryer sites.

The original response of white settlers to riparian forest was to cut it (Hatton 1935; see references in Short 1965). Trees were cut for building material and as fuel, and we may suppose that kite populations were sometimes disturbed or displaced as a result. But how widely the forests disappeared, and kites with them, is unclear. Riparian forests were seemingly still present along the Medicine Lodge River in south-central Kansas during the 1880's (Goss 1891), and were probably equally undisturbed along other subsidiary river courses.

The net effect of white settlement in the central plains has been a vast increase in woody vegetation. In tall and mixed grass plains of north Texas and southwestern Oklahoma several human activities associated with farming and cattle raising have caused the expansion of mesquite and its advance north and east (Cook 1908; Brandt 1940; Price and Gunter 1943; Bogush 1950). Tree planting by settlers was encouraged by governmental action beginning in the mid-1800's, and the Prairie States Forestry Project, begun in 1934, resulted in most of the shelterbelts which exist today (Stoeckler and Williams 1949). The trees at Meade State Park and Lake also owe their existence to this project (Fitch 1963). In much of the northern part of the kites' range, the early planting of trees on farms and in towns, often on upland sites, probably compensated the kites for loss of riparian nesting trees as quickly as they were cut. Today in Kansas, Oklahoma, and parts of Texas, windbreaks, shelterbelts and urban tree plantings stand as thousands of islands of nesting habitat that were non-existent prior to settlement. Often kites seem to prefer these artificial tree plantings to nearby, more natural riparian forests.

Eisenmann (1971) described and discussed the recent, dramatic increase in numbers of the White-tailed Kite (*Elanus leucurus*) and noted that White-tailed and Mississippi Kites are in some ways similarly endowed for rapid population growth: both are colonial; they both wander widely; their reproductive capacities are presently unaffected by pesticide residues; and their recent range expansions and increases in abundance are related to major habitat alteration. However, Mississippi and White-tailed Kites are distinctly different in several important ways.

1. In a single clutch White-tailed Kites usually lay twice (or more) the number of eggs laid by Mississippi Kites, and two broods may be reared by the former (Brown and Amadon 1968); all evidence indicates that the Mississippi Kite is strictly single-brooded although a female that renests when her first clutch is lost could be laying more eggs than a normal clutch.

2. The migratory habits of the Mississippi Kite may not impose mortality rates greater than those of the non-migratory White-tailed Kite, but major causes of mortality (and mate replacement, etc.) could, thereby, be quite different.

3. The principal types of habitat change benefiting the two species appear fundamentally different. The White-tailed Kite seems to have profited from an increase in suitable hunting habitat, the Mississippi Kite from an increase in suitable nesting habitat.

Mississippi Kites are present now at hundreds, if not thousands, of nesting sites in the Plains where they could not have been before the existence of artificial tree plantings, and although an estimate of crude density is not available it must have increased greatly. Continued increase in numbers may reasonably be expected if, as seems likely, kites are not food or predator limited. Suitable nesting habitat is now far from saturated; many shelterbelts near established kite colonies are unused. In short, the future of the Mississippi Kite in the Great Plains seems reasonably secure. The only foreseeable threat is the possible re-

moval of shelterbelts, windbreaks, and mesquite woodlots. Intentional destruction of these woodlands is not unlikely in the guise of increasing crop production, and poor land management can cause the loss of shelterbelts and windbreaks (Olson and Stoeckler 1935). Even so, riparian, urban and other residential woodlots would remain to provide ample nesting sites.

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POPULATION STATUS OF THE MISSISSIPPI KITE IN COLORADO

Babette F. Cranson

Many raptorial species in the United States have experienced a marked decline in population since the early 1900's. A notable exception to this trend has been shown by the White-tailed Kite (*Elanus leucurus majusculus*) in the nation's southwest corner. This raptor, after nearing extinction in the 1920's and 1930's, has been expanding its range and increasing in numbers since the 1940's (Lee B. Walan and Rey C. Stendall, "The White-tailed Kite in California with observations of the Santa Barbara population," *California Fish and Game* 56: 189, July 1970).

Concurrently, the Mississippi Kite (*Ictinia mississippiensis*) has shown a similar, although somewhat slower, increase in population in the central region of the United States. The range recorded by A. C. Bent (Life Histories of North American Birds of Prey. Part 1. *U. S. Nat. Mus. Bull.* 167, 1937) is shown on Figure 1. Recent reports in *American Birds* October 1972, Vol. 26 No. 5) have shown that the Mississippi Kite has expanded its range northward and westward with the most obvious movement along the western border of its range (see Figure 1). There were no sightings between Winkelman, Arizona, and the northwestern panhandle of Texas due to the lack of reporters in southern New Mexico.

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Figure 1. Marginal records of Mississippi Kites from Bent (1937) [●] and *American Birds* (1972) [◆].

The movement of the Mississippi Kite from Kansas to Colorado follows an orderly pattern. The kites seem to establish nesting colonies along the rivers, favoring the larger groves of cottonwood trees. To date there have been two nesting colonies discovered in Colorado, one two miles (3.2 km) east of La Junta on the Arkansas River and the other in the extreme southeastern corner of the state on the Cimarron River (see Figure 2). Mr. William C. Andersen and I have studied these two colonies since 1971 and it appears that the kites have entered the state via these two rivers. I have seen adult kites along the Arkansas River at Swink, La Junta and Granada in Colorado and at Kendall, Lakin, Deerfield, Holcomb and Garden City in Kansas (see Figure 2).

The kites in Garden City, Kansas, have reached the point where they are nearly as common as pigeons and it is probable that the kites being produced there have moved up the Arkansas River into Colorado. Similarly, the kites in the Cimarron National Grasslands in southwestern Kansas are serving as the source of production for the developing colonies in extreme southeastern Colorado. At the present time there are no data to substantiate this hypothesis. What is needed is a program in which the nestling kites produced in Garden City could be color banded and their movements traced.

Based on clutch size data of the Mississippi Kite, it should be the least likely of the four species of kites to show any sign of an increase in population. Whereas the Swallow-tailed Kite (*Elanoides forficatus forficatus*) has a normal clutch of 2-3 eggs, the Everglade Kite (*Rostrhamus sociabilis plumbeus*) 3-4 eggs, and the White-tailed Kite 4-5 eggs, the Mississippi Kite has a normal clutch

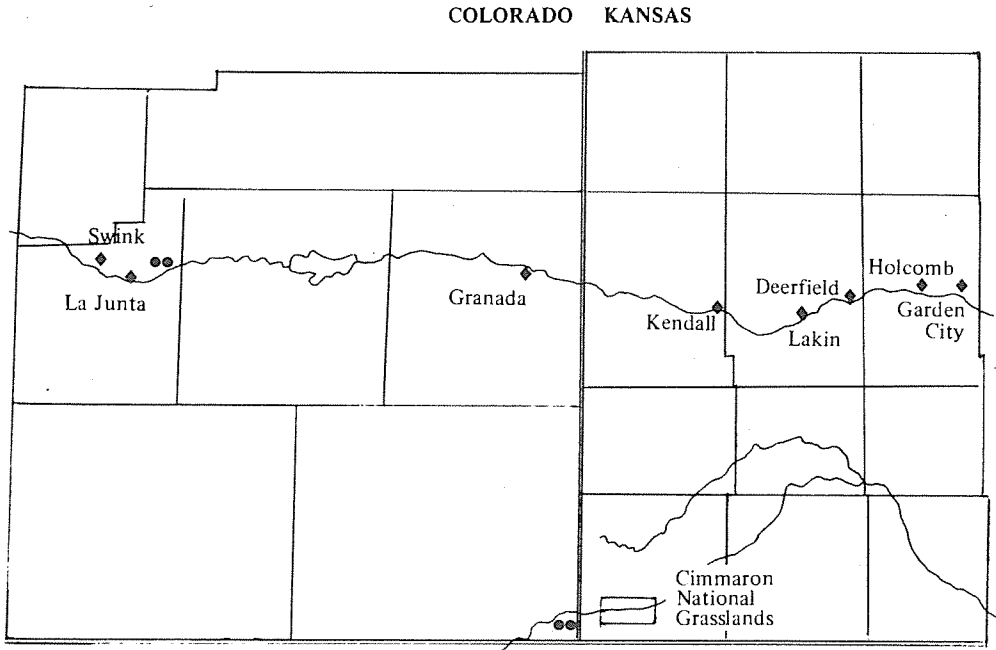


Figure 2. Areas in Kansas and Colorado where Mississippi Kites have been seen [◆] and location of Colorado nesting colonies [●●].

of only 1-2 eggs. Of the nine nests discovered in the Colorado colonies (Arkansas River: 6 nests in 1971, 2 nests in 1972; Cimarron River: 1 nest in 1972), only one nest contained more than one young. In this nest the age difference between the nest mates is so marked that it indicates that this is a result of two clutches of one egg each, rather than one clutch of two eggs. A possible explanation for this age difference is that the laying of a pipe through the center of the grove disrupted the breeding colony and destroyed nests of some of the other kites. These parents then renested two weeks later at the completion of the project. One set of adults renested extremely close to this nest and their courtship behavior possibly restimulated the parents causing them to recycle. This two week recycling date matches the two weeks age difference in these two young.

If this is the case, then it appears that the Mississippi Kite responds to social stimulus in breeding. This social response coincides with other social characteristics of this species. The kites participate in group defense of the nests, group foraging, and group roosting. At no time did we see signs of hostility between kites.

The hypothesis that the Mississippi Kite responds to social stimulus in breeding could explain why in some areas this species nearly always lays clutches of

two eggs and in other areas it nearly always lays clutches of one egg. It appears that wherever large groups of kites are nesting, a higher proportion of two egg clutches is found than in areas where small groups of kites are nesting, such as the La Junta area. The stimulation aroused by other courting pairs may be the factor necessary to produce the two or three egg clutches.

With all of the communal activities exhibited by the Mississippi Kite, nesting success is probably higher for it than it is for the other three non-communal species of kites and the other birds of prey. There are several other factors favoring the success of this species. The first is the high abundance of prey items such as cicadas, grasshoppers, and dragonflies during the breeding season. The second factor which favors the success of this species involves the placement of the nest. In all of my observations, the nest was well constructed and built as close to the trunk as possible, at an average height of 11.2 m. This location provides maximum protection from high winds and makes it less readily seen by predators.

Although these two factors aid in the success of the species, I feel the main factor is its compatibility with man. This is exemplified by the location of the first nest found in Illinois which was placed 5.6 m above a picnic table in the Kaskaskia State Park (*American Birds* 26(5):865, 1972). I have seen at least one other similar case in Garden City, Kansas, where a kite was feeding its three-week old young in a nest 6.5 m above the ground behind a root beer stand.

Although the Mississippi Kite has a high population density in Garden City, Kansas, and is expanding its range westward along the Arkansas River, there are two factors that may prohibit its further expansion into Colorado. One is the current project by the Army Corps of Engineers, which is as yet unfunded, to channelize completely the Arkansas River from Pueblo to La Animas. The plan intends to clear all vegetation from both sides of the river, restraighten the channel and line it with riprap.

The other factor involves water rights as related to the pumping of water in areas adjacent to the Arkansas River. It has been claimed and is being tested in the courts, that removal of phreatophytic vegetation would cause an increase in the water table in adjacent areas, thereby allowing increased pumping. If the courts decide in favor of the removal of the phreatophytes, all suitable nesting vegetation could be removed from the Arkansas River for its entire length, from Pueblo to the Colorado-Kansas border. This could set a precedent for further removal of trees along the Arkansas River and its tributaries throughout Kansas and thereby exterminate the Mississippi Kite from its extreme northwestern range.

One possible means of protecting the existing nesting colonies is to have their nesting sites designated as Wildlife Sanctuaries. This possibility is already being explored for the La Junta colony, and if that area can be preserved, then further action can be taken to protect future colony sites.

Without this and further assistance by concerned individuals, the Mississippi Kite could begin a decline in population that is so evident in most of our other raptor species.

THE STATUS OF EAST AFRICAN AND ETHIOPIAN RAPTORS

Leslie H. Brown

In this paper it should be understood that I am discussing only diurnal raptors (Falconiformes), not owls (Strigiformes) whose status is imperfectly known and certainly imperfectly known by me; I also do not have the space to discuss both.

In Europe, North America, Australia, South Africa, and other places where western developed man exists, natural populations of raptors are subject to a variety of adverse influences, the chief among which are:

1. Human interference. (a) Deliberate (shooting, trapping, poisoning, egg collecting, etc.); (b) inadvertent (disturbance of nesting sites by sheer weight of numbers, electrocution on wires, etc.).

2. Destruction of habitat—this is self-explanatory, and varies in intensity from place to place.

3. Pollution and its adverse effects—especially organochloride pesticides and polychlorinated biphenols.

It has become almost standard practice for cause number three to be blamed for the decline of all raptor populations everywhere; certainly its effects have been critical for some. In others its effects are negligible or slight, and one or both of the other two factors has a great effect. For instance, in the British Peregrine Falcon (*Falco peregrinus*) population, the decline is brought about primarily by pesticides, aggravated by deliberate human interference, and only slightly aggravated by inadvertent human interference. In the Golden Eagle (*Aquila chrysaetos*), Buzzard (*Buteo buteo*) and Hen Harrier (*Circus cyaneus*),

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however, pesticides have at present little or no effect, and deliberate human interference is the main cause of loss or reduction. In the Golden Eagle, deliberate and inadvertent human interference combined reduce breeding success in Scotland from a potential 0.83 to about 0.56 young per pair per annum over-all, that is, by over 32%.

In East Africa some of these influences are either non-existent or minimal. Losses from human interference, deliberate or accidental, are slight, and there are at present no grounds for supposing that pesticides have a marked adverse effect on any resident population. Few studies have been done on this; and such work may actually meet with official discouragement because the effects demonstrated may be inconvenient, for instance, for dairy and beef exports.

However, studies that have been done indicate that while DDT and other pesticide residues are present in the environment, the levels are at present very low and could not account for any decline observed. At Lake Naivasha a survey financed by the New York Zoological Society and the East African Wildlife Society and carried out in 1970-72 in collaboration with the Cornell Laboratory of Ornithology indicates pesticide levels among the lowest known in the world (Cade, in litt.).

Of the influences previously mentioned, numbers one and three can be generally disregarded in East Africa. Destruction of habitat, especially of primary forest, is the main cause for alarm, and even this is not acutely serious. So far it has not appeared to be immediately endangering any savanna species, since destruction often proceeds in patches. In Embu District, for instance, in a 146 square mile (378 km²) survey area there were 26 pairs of 10 species of eagles during 1948-52; and a shorter and less thorough survey in 1968 carried out with a small grant from the Chapman Fund of the American Museum of Natural History revealed relatively little change in total population, despite serious human alteration of the habitat through increased scattered cultivation and invasion of previously uninhabited areas (Table 1).

A longer and more thorough survey might have located more Wahlberg's Eagles and a pair of *C. cinereus* which was certainly present but not known to breed in 1968. The single pair of *A. verreauxi* disappeared in 1953, and has not been seen since, probably because of the lack of a really good nesting site. Cutting of forest along river banks has removed the big trees in which the two known pairs of Fish Eagles bred (= inadvertent human interference or destruction of habitat); but the species which would be regarded by Africans as most harmful to them, the Martial and African Hawk Eagles, have either remained stable or increased. The disappearance of one Wahlberg's Eagle pair is accounted for by the fact that a pair of African Hawk Eagles has taken over their breeding site.

It must also be remembered that some species actively benefit from mankind. The most abundant species of all, the Black Kite (*Milvus migrans*) is commensal with man. In Ethiopia, a country with an enormous stock population, very poor veterinary services, and negligible sanitation, scavenging species including kites, Tawny Eagles (*Aquila rapax*), and several species of vultures in

Table 1. Numbers of pairs of 10 species of eagles occurring in a 146 square mile (378 km²) area of the Embu district, Kenya.

	1948-52	1968
Fish Eagle		
(<i>Haliaeetus vocifer</i>)	2	0
Brown Snake Eagle		
(<i>Circaetus cinereus</i>)	2	0?
Bateleur		
(<i>Terathopius ecaudatus</i>)	2	3
Verreaux's Eagle		
(<i>Aquila verreauxi</i>)	1	0
Wahlberg's Eagle		
(<i>Aquila wahlbergi</i>)	11	7
African Hawk Eagle		
(<i>Hieraaetus fasciatus spilogaster</i>)	2	5
Ayres' Hawk Eagle		
(<i>Hieraaetus dubius</i>)	1	2
Long-crested Eagle		
(<i>Lophaetus occipitalis</i>)	1?	2?
Crowned Eagle		
(<i>Stephanoaetus coronatus</i>)	1	1
Martial Eagle		
(<i>Polemaetus bellicosus</i>)	3	3
	26(10)	23(7)

roadside counts make up about 85 percent of the total numbers and over 90 percent of the biomass; whereas in Kenya and East Africa, where veterinary services or sanitation are better, they amount to about 53 percent of the numbers and perhaps 65 to 70 percent of the biomass.

Even the Lammergeier (*Gypaetus barbatus*) which is a Red Book species in South Africa, is quite abundant in Ethiopia, and is throughout its range, in my opinion, commensal with primitive pastoral people who suffer heavy stock losses and consequently is provided with a regular plentiful supply of bones. The Lammergeier is threatened only by more efficient land use and stock keeping methods and cannot survive except as a rare bird where these improved methods exist. Vultures of all sorts are more abundant in inhabited areas occupied by human beings, perhaps because in such areas they do not have to compete so much with large diurnal predators, such as lions or hyenas, as they do, for instance, in game parks.

On a regional scale, I have summarized the situation with regard to diurnal raptors in Tables 2 and 3. It will be seen that of 75 species occurring, 18 are

Table 2. Summary of occurrence of 75 species of diurnal African raptors.

SPECIES	STATUS				ABUNDANCE	THREAT
	East African Resident	East African Resident with Palearctic migrant race	Intra-African Migrant	Palearctic Migrant	Abundant (10-100 seen on any day in good habitat) Common (1-10 seen daily in good habitat) Frequent (seen 2-3 times a week) Uncommon (seen 4-5 times a year) Rare (seen once a year or less often)	Unthreatened at present in East Africa or Ethiopia Threatened in breeding habitat but not in E. Africa Threatened as resident in East Africa
Osprey						
<i>Pandion haliaetus</i>		x			x	x
Kites						
<i>Aviceda cuculoides</i>			x		x	x
<i>Pernis apivorus</i>				x	x	x
<i>Machaerhamphus alcinus</i>	x				x	x
<i>Elanus caeruleus</i>	x				x	x
<i>Chelictinia riocourii</i>			x		x	x
<i>Milvus migrans</i>		x		x		x
Sea Eagles						
<i>Haliaeetus vocifer</i>	x				x	x
<i>Gypohierax angolensis</i>	x				x	x
Vultures						
<i>Neophron percnopterus</i>	x				x	x
<i>Gypaetus barbatus</i>	x				x	x
<i>Necrosyrtes monachus</i>	x				x	x
<i>Gyps africanus</i>	x				x	x
<i>Gyps rueppellii</i>	x				x	x
<i>Torgos tracheliotus</i>	x				x	x
<i>Trigonoceps occipitalis</i>	x				x	x
Snake Eagles						
<i>Circaetus gallicus</i>		x			x	x
<i>Circaetus cinereus</i>	x				x	x
<i>Circaetus cinerascens</i>	x				x	x
<i>Circaetus fasciolatus</i>	x				x	
<i>Terathopius ecaudatus</i>	x				x	x
<i>Polyboroides typus</i>	x				x	x
Harriers						
<i>Circus aeruginosus</i>				x	x	x
<i>Circus ranivorus</i>	x				x	x
<i>Circus macrourus</i>			x		x	x
<i>Circus pygargus</i>			x		x	x

Table 2. (Continued.)

SPECIES	STATUS				ABUNDANCE					THREAT	
	East African Resident	East African Resident with Palearctic migrant race	Intra-African Migrant	Palearctic Migrant	Abundant (10-100 seen on any day in good habitat)	Common (1-10 seen daily in good habitat)	Frequent (seen 2-3 times a week)	Uncommon (seen 4-5 times a year)	Rare (seen once a year or less often)	Unthreatened at present in East Africa or Ethiopia	Threatened in breeding hab- itat but not in E. Africa
Chanting Goshawks											
<i>Melierax metabates</i>	x				x					x	
<i>Melierax canorus</i>	x				x					x	
<i>Melierax gabar</i>	x				x					x	
Accipiters											
<i>Accipiter melanoleucus</i>	x							x		x	
<i>Accipiter ovampensis</i>	x								x	x	
<i>Accipiter nisus</i>				x					x		x
<i>Accipiter rufiventris</i>	x							x		x	
<i>Accipiter minullus</i>	x					x				x	
<i>Accipiter tachiro</i>	x				x					x	
<i>Accipiter brevipes</i>				x					x		x
<i>Accipiter badius</i>	x							x		x	
Sub-Buteos											
<i>Butastur rufipennis</i>		x			x					x	
<i>Kaupifalco monogrammicus</i>	x					x				x	
Buteos											
<i>Buteo buteo</i>				x	x					x	
<i>Buteo oreophilus</i>	x					x				x	
<i>Buteo rufinus</i>				x					x	x	
<i>Buteo auguralis</i>		x						x		x	
<i>Buteo rufofuscus</i>	x				x					x	
Aquila											
<i>Aquila pomarina</i>				x				x			x
<i>Aquila clanga</i>				x				x			x
<i>Aquila rapax</i>		x			x					x	
<i>Aquila heliaca</i>				x					x		x
<i>Aquila wahlbergi</i>		x				x				x	
<i>Aquila verreauxi</i>	x					x				x	

Table 2. (Continued.)

SPECIES	STATUS				ABUNDANCE					THREAT		
	East African Resident	East African Resident with Palearctic migrant race	Intra-African Migrant	Palearctic Migrant	Abundant (10-100 seen on any day in good habitat)	Common (1-10 seen daily in good habitat)	Frequent (seen 2-3 times a week)	Uncommon (seen 4-5 times a year)	Rare (seen once a year or less often)	Unthreatened at present in East Africa or Ethiopia	Threatened in breeding habitat but not in E. Africa	Threatened as resident in East Africa
Hawk Eagles												
<i>Hieraaetus fasciatus</i>	x						x			x		
<i>Hieraaetus pennatus</i>				x				x		x		
<i>Hieraaetus dubius</i>	x								x	x		
<i>Spizaetus africanus</i>	x								x	x		
<i>Lophaetus occipitalis</i>	x				x					x		
<i>Stephanoaetus coronatus</i>	x						x			x		
<i>Polemaeteus bellicosus</i>	x						x			x		
Falcons												
<i>Falco naumanni</i>				x	x					x		
<i>Falco rupicoloides</i>	x							x		x		
<i>Falco alopex</i>	x							x		x		
<i>Falco tinnunculus</i>		x				x				x		
<i>Falco ardosiaceus</i>	x							x		x		
<i>Falco dickinsoni</i>	x							x		x		
<i>Falco vespertinus</i>				x				x		x		
<i>Falco chicquera</i>	x							x		x		
<i>Falco subbuteo</i>				x		x				x		
<i>Falco cuvieri</i>	x							x		x		
<i>Falco eleanorae</i>				x				x		x		
<i>Falco concolor</i>				x				x		x		
<i>Falco biarmicus</i>	x						x			x		
<i>Falco cherrug</i>				x					x		x	
<i>Falco fasciinucha</i>	x								x	x		
<i>Falco peregrinus</i>		x						x			x	
<i>Polihierax semitorquatus</i>	x						x			x		
Secretary Bird												
<i>Sagittarius serpentarius</i>	x						x			x		
GRAND TOTAL	46	6	5	18	3	16	22	24	10	64	10	1

Table 3. Summary of occurrence and status of diurnal African raptors by groups.

SPECIES	STATUS					ABUNDANCE					THREAT		
	TOTAL	East African Resident	East African Resident with Palearctic migrant race	Intra-African Migrant	Palearctic Migrant	Abundant (10-100 seen on any day in good habitat)	Common (1-10 seen daily in good habitat)	Frequent (seen 2-3 times a week)	Uncommon (seen 4-5 times a year)	Rare (seen once a year or less often)	Unthreatened at present in East Africa or Ethiopia	Threatened in breeding habitat but not in E. Africa	Threatened as resident in East Africa
Osprey	1		1					1			1		
Kites	6	2	1	2	1	1	1		4		6		
Sea Eagles	2	2					1	1			2		
Vultures	7	7				3	3	1			7		
Snake Eagles	6	5	1			1	3	2			5		1
Harriers	4	1			3			4			1	3	
Chanting Goshawks	3	3				3					3		
Accipiters	8	6			2	1	1	3	3		6	2	
Sub-Buteos	2	1		1		1	1				2		
Buteos	5	2		1	2	1	1	1	1	1	5		
Aquila	6	1	1	1	3	1	1	1	1	1	2	2	
Hawk Eagles	7	6			1	1	3	1	2		7		
Falcons	17	9	2		6	1	2	2	10	2	15	2	
Secretary Bird	1	1						1			1		
GRAND TOTAL	75	46	6	5	18	3	16	22	24	10	64	10	1

Palearctic migrants, the remainder being purely residents (46 species), species breeding both in East Africa and the Palearctic (6 species), or intra-African migrant species (5 species). I include the Osprey in the second class, since it breeds in the Red Sea but not south of Cape Guardafui in continental Africa.

Of the 75 species, only three, one of them a migrant, can be called abundant, though vultures are certainly locally abundant and in Ethiopia three species—Hooded, White-backed, and Griffon Vultures (*Necrosyrtes monachus*, *Gyps bengalensis*, and *Gyps fulvus*)—even sometimes the Lammergeier, are locally or generally abundant. Where one sees vultures they tend to be in numbers, but averaged over a period, they are no more than common. Sixteen species of the 75, including the vultures, are common. Twenty-two, including most of the big breeding eagles and falcons, are frequent; 24 are scarce, some for reasons that are obscure; and 10 are rare, that is, one sees only one in a year or longer.

A distinction must be drawn between being *rare* and *threatened*. Of all the species mentioned, I suggest the Taita Falcon (*Falco fasciinucha*) is the rarest;

but it is probably no more threatened today than in 1900. The South African Lammergeier, *G. b. meridionalis*, of the Drakensberg is in the Red Book; it is also rare or very uncommon in Kenya and East Africa, where there may be 40-50 pairs. But in Ethiopia, there may well be 6,000 pairs or more and one could see 20 in a day. Other "inexplicably" rare species, including *Accipiter ovampensis* and *Hieraaetus dubius*, are not threatened either. If for some reason they are on their evolutionary way out, this is not because of threats from human beings.

Of East African species, only a few are threatened at all and most of these are threatened in their European breeding range rather than in East Africa, or perhaps en route to it. Any migrant bird of prey that passes through Israel and feeds there is threatened, and quite possibly the same applies to the irrigated areas of the Sudan. One East African species which is threatened *in situ* is the Southern Banded Snake Eagle (*Circaetus fasciolatus*). It is threatened by the totally uncontrolled spread of small scale African cultivation and destruction of forest, but should still be able to survive in parts of its range, which is more extensive than is generally known. The Secretary Bird (*Sagittarius serpentarius*) is also threatened by the advance of small-scale cultivation into grasslands, but should be able to survive in more arid pastoral areas or national parks.

The situation in East Africa as regards most resident species is thus a healthy one. The few exceptions are species which are naturally scarce but not actually threatened. Species occurring in East Africa and threatened in their breeding quarters, such as the migrant harriers, are not primarily our concern; but we can do something to monitor their numbers and exhort activity in their areas of origin.

POPULATION STATUS OF LARGE RAPTORS IN NORTHEASTERN COLORADO—1970-1972

Richard R. Olendorff

ABSTRACT. The population status of Swainson's and Ferruginous Hawks, Golden Eagles, Prairie Falcons and Great Horned Owls in northeastern Colorado is discussed. The following nesting parameters are reported: clutch size, maximum brood size, fledging success, probabilities of hatching and fledging, nest success, productivity of young in successful nests, and breeding density and productivity both on an individual basis and a biomass basis.

Introduction

The Pawnee National Grassland (PNG), administered by the U. S. Forest Service, and adjacent privately owned lands in northeastern Colorado provide nesting habitat and food for a dense population of raptorial birds. Birds of prey abound in shortgrass prairie, especially where it is broken by scattered trees, gallery forests along creek bottoms, isolated erosional remnants and major cliff lines. Of the 30 species of falconiforms in North America, 16 or 17 occur in this portion of northeastern Colorado, and six or seven of this continent's 15 species of owls are part of the same avifauna.

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The fact that 24 species of raptors occur in the study area, and that 11 of them breed there, provides an excellent opportunity to study them as a group of predators, emphasizing such aspects as intra- and interspecific relationships, population dynamics, differential utilization of grassland habitats, annual and long-term cycles, predator-prey relationships, migration patterns and many aspects of behavior. Since this study was done in conjunction with the Grassland Biome Project of the International Biological Program, the opportunity was provided for an in-depth analysis of the role of a group of birds in a grassland ecosystem.

The merit of northeastern Colorado as a study area also stems, at least in part, from the rather stable land-use practices of current owners. Acquisition of land by the federal government to create a national grassland was a definite stabilizing factor but so, too, were attempts at farming made by the settlers of the late 1800's and early 1900's. These early farmers learned by experience that non-irrigable land in northeastern Colorado was suitable only for two forms of agriculture: cattle ranching and dry-land grain production. Barring development of large-scale irrigation projects and unnatural decimation of birds of prey of the region, their habitat and nesting populations should remain relatively unchanged. The resistance to change that has developed in the ecology of the area is an attribute that may give researchers time to solve some of the basic problems of raptor biology and to test a number of applied raptor management and conservation techniques (Olendorff and Stoddart 1974).

In addition, as an area where dry-land farming prevails and forest insect control is not necessary, historical use of persistent pesticides near the PNG has been lower than in most other areas in the continental United States. Thus, with the possible exception of Prairie Falcons (*Falco mexicanus*) and Swainson's Hawks (*Buteo swainsoni*), adverse effects of pesticides are probably at a minimum. The relative lack of pesticide applications is an important attribute of the area making it more appropriate for long-term study of raptor populations than contaminated areas.

Another notable advantage of the study area, stemming from the ease with which nests can be located in grasslands, is that crude nesting densities of large raptors can be determined with an accuracy that approaches very closely what might be termed "absolute" nesting densities. Excellent visibility is complemented by accessibility provided by an extensive network of section line roads and trails by which ranchers monitor their cattle herds. Virtually no other biome in North America allows study of a large enough land area to evaluate adequately the use of that ecosystem by birds of prey.

This report establishes baseline raptor population levels on the shortgrass prairie of northeastern Colorado as a stage, hopefully, in the development of long-term raptor studies in the area.

The Study Area

Three different study areas were utilized in this investigation. The largest, hereafter called the "extensive study area," consists of the northern 34 miles (55

km) of Weld County, Colorado, excluding the highly populated and intensively farmed area west of Purcell and south of Nunn. The total land area is approximately 5,180 km² (2,000 square miles). Not all data from the extensive study area can be analyzed in terms of raptors per unit area because the eastern half was not systematically and completely searched for nests. The data from both halves of the extensive study area are, however, useful for analyzing over-all clutch sizes, brood sizes, fledging successes and nest site preferences.

The "2,590 km² study area" (1,000 square miles) comprises the western half of the extensive study area, including the IBP Pawnee Site, the Central Plains Experimental Range of the U. S. Agricultural Research Service, the entire western portion of the PNG, one large and several smaller creek bottoms, and a major line of cliffs. This area, a composite of unbroken grassland and grassland interrupted by gallery forests along creek bottoms, cliff lines and tracts of cultivated land, was designed (1) to include sufficient numbers of nesting raptors to allow fruitful study and (2) to eliminate biases introduced by studying small areas not representative of all available nesting habitats.

The "1,072 km² study area" (414 square miles) includes essentially unbroken grassland, i.e., shortgrass prairie with neither major cliff lines nor creek bottoms and attendant forests, and without large tracts of cultivated land. Geographically, this area corresponds to the western portion of the PNG and is included within the 2,590 km² and extensive study areas. Analyses of population levels and productivities are made for this area since it is shortgrass prairie of the type emphasized in IBP studies; it is similar in topography, flora and fauna to the IBP Pawnee Site (Jameson and Bement 1969).

When the 1,072 km² study area was searched for nests in 1971, each section was classified as either grazing land or cultivated land, and all trees and other potential nest sites were noted. Only about 70 km² (27 square miles) (6.5%) were cultivated. The remaining 1,002 km² (387 square miles) was potential grazing land. The largest continuous tract of cultivated land was about 18 km² (7 square miles).

Of the 414 sections (1 square mile [2.59 km²] each) only 79 contained trees suitable for nesting by large birds of prey (Table 1). Another eight sections contained creek banks or small erosional remnants (usually dirt outcrops) which might attract Ferruginous Hawks (*Buteo regalis*) to nest. Thus 87 sections (21.0%) had nest sites. Roughly 50 sections (12.1%) had occupied dwellings, i.e., about one for every eight square miles (21 km²). The remaining 250 square miles (60.4%) of the study area was grazing land without houses, trees or other suitable nest sites. All of the land, including cultivated fields, was suitable for use by birds of prey either as hunting or nesting territory with the possible exception of 50 quarter-sections adjacent to occupied dwellings. Thus about 97% of the land was usable by raptors with minimal interference from man.

I am reasonably certain that the nests of over 95% of all Golden Eagles (*Aquila chrysaetos*), Prairie Falcons, Swainson's Hawks, Ferruginous Hawks and Great Horned Owls (*Bubo virginianus*) were found on the designated study areas. It is possible that all pairs of Golden Eagles and Prairie Falcons were lo-

Table 1. Land use practices on the 1,072 km² (414 square miles) study area.

Land-use Practices	Square Miles	Square Km	Percent
Cultivated	27	70	6.5
Grazing			
With occupied houses	50	129.5	12.1
With raptor nest sites	87	225	21.0
Without houses or nest sites	250	642.5	60.4
TOTALS	414	1072	100.0

cated on the intensive study areas each year. A few nests of the other species may have been missed for various reasons: (1) Swainson's Hawks were very numerous and, apparently, were the most capable of renesting after nest failure; (2) Ferruginous Hawks occasionally nested on the ground making it difficult to find this small segment of the breeding population; and (3) Great Horned Owls began nesting before field study was initiated both in 1971 and 1972.

Population Levels and Productivities

THE EXTENSIVE STUDY AREA

Clutch Size, Maximum Brood Size and Fledging Success. Table 2 is a compilation of nesting parameters for the five important nesting species on the PNG. Data from 1970, 1971 and 1972 are treated separately and collectively. Averages of 1971 and 1972 data combined are also presented since in those years field efforts were of adequate extent. A nesting attempt must have at least produced eggs to be included in these calculations. Where attempts failed during the egg stage and only eggshell fragments were found, clutch size was not determined but zeros were included for maximum brood size and fledging success. Non-nesting pairs and single birds were ignored, although they are included in the analyses of breeding densities and productivities on the 1,072 and 2,590 km² study areas (see Tables 7-12). If observer interference was a possible cause of nest failure, the suspect data were discarded. The nests from which clutch size data were obtained may or may not be the same nests from which maximum brood sizes or fledging successes were obtained and vice versa.

Clutch size of Swainson's Hawks was fairly stable from year to year, averaging from 2.31 to 2.41. Maximum brood size (the number of eggs hatched in nests which at least produced eggs) averaged from 1.50 to 1.86 young per nest. Fledging success (the number of young fledged from nests which at least produced eggs) was comparable in 1970 and 1971 (about 1.12), but higher in 1972 (1.24 young fledged per nest). Apparently, the low fledging success of Swainson's Hawks in 1970 was due to a higher than average mortality of hatched young, since clutch size and maximum brood size were above or near the over-

Table 2. Clutch size, maximum brood size and fledging success of large raptors in northeastern Colorado—1970-1972. Sample sizes in parentheses.

Species and Years	Clutch Size	Maximum Brood Size	Fledging Success
Swainson's Hawk			
1970	2.41 (22)	1.72 (18)	1.11 (19)
1971	2.32 (28)	1.50 (26)	1.13 (30)
1972	2.31 (45)	1.86 (51)	1.24 (70)
1971-72	2.31 (73)	1.74 (77)	1.21 (100)
Over-all	2.34 (95)	1.74 (95)	1.19 (119)
Ferruginous Hawk			
1970	2.50 (6)	1.22 (9)	1.22 (9)
1971	3.00 (14)	2.15 (13)	2.08 (13)
1972	3.38 (24)	2.32 (31)	1.87 (31)
1971-72	3.24 (38)	2.27 (44)	1.93 (44)
Over-all	3.14 (44)	2.09 (53)	1.81 (53)
Golden Eagle			
1970	1.86 (7)	1.62 (8)	1.50 (8)
1971	1.56 (18)	1.11 (19)	1.00 (18)
1972	1.69 (13)	1.00 (15)	0.93 (15)
1971-72	1.61 (31)	1.06 (34)	0.97 (33)
Over-all	1.66 (38)	1.17 (42)	1.07 (40)
Prairie Falcon			
1971	4.67 (6)	3.90 (10)	3.78 (9)
1972	4.33 (18)	3.94 (17)	3.24 (17)
1971-72	4.42 (24)	3.93 (27)	3.42 (26)
Great Horned Owl			
1971	2.25 (8)	1.64 (14)	1.64 (14)
1972	2.27 (11)	1.85 (13)	1.46 (13)
1971-72	2.26 (19)	1.74 (27)	1.56 (27)

all averages. The low fledging success of Swainson's Hawks in 1971 resulted from a lower than average maximum brood size.

Ferruginous Hawks apparently had poor success in 1970, although the sample size was small due to the lack of intensive field effort that year. Fledging success in 1970 was only 63% of that in 1971 and 1972 combined, apparently because of lower than average clutch and maximum brood sizes. A check of 1970 data dismissed the notion that hatching failure was caused by observer interference.

The highest fledging success of Ferruginous Hawks occurred in 1971, a year of considerable loss of eggs but very little nestling mortality. The lower fledging success in 1972 (compared to 1971) was related to greater mortality of young

birds rather than to low clutch or brood sizes. Fledging success in 1972 on the PNG was less than fledging success for the same year on a large study area in Utah and Idaho (Powers, Howard and Trost 1974), but is somewhat higher than the 1.52 young fledged per nest in 1967 and 1968 in the Cedar Valley of Utah (Weston 1969). On the same Utah area from 1967-1970 Ferruginous Hawks fledged 2.0 young per nest (Smith and Murphy 1973).

Clutch size, maximum brood size and fledging success of Golden Eagles averaged (for the three years combined) 1.66, 1.17 and 1.07 per nesting attempt, respectively. In 1970 all three of those parameters, particularly the figures for maximum brood size and fledging success, were higher than in 1971 and 1972. This does not represent an actual decrease in the success of Golden Eagles. In 1970 no early nest failures by Golden Eagles were detected because field work did not begin until late April and the field effort was not intense. In 1971 and 1972 many early nest failures were detected. In view of this, data collected in 1971 and 1972 are considered more accurate for the shortgrass prairie population under study. In the arid shrub-covered hills surrounding the Cedar Valley of Utah, and in the valley itself, Camenzind (1969) found that Golden Eagles fledged 0.84 young per nest in 1967 and 1968 (compared to 0.97 on the PNG in 1971 and 1972). Smith and Murphy (1973) report that 1.0 young were fledged per nest between 1967 and 1970 of the Cedar Valley study area.

To my knowledge, Prairie Falcon productivity was higher in 1971 and 1972 on the PNG than during any other study previously recorded in the literature. An average of 4.42 eggs were laid per nest of which an average of 3.93 hatched. Fledging success, 3.42 young per nesting attempt, was slightly more than triple what Enderson (1964) reported for 82 nestings of Prairie Falcons in northeastern Colorado and Wyoming from 1960 through 1962, exactly ten years earlier. The slightly lower success of Prairie Falcons on the PNG in 1972 compared to 1971 resulted more from nestling mortality than from lower clutch size since maximum brood sizes were comparable in the two years. Ogden (1973) found a mean clutch size of 4.41 eggs and a fledging success of 3.1 young per occupied territory between 1970 and 1972 at 110 eyries along the Snake River in southwestern Idaho.

The success of Great Horned Owls was comparable in 1971 and 1972, although as formulated (a nest must have contained eggs or shell fragments to be included) the analyses are biased for this species. Clutch size, maximum brood size and fledging success averaged 2.26, 1.74 and 1.56, respectively, for the two years combined. This compares favorably with Smith's (1969) finding that 1.64 young owls fledged per nest in 1967 and 1968 in the Cedar Valley of Utah. Although fewer Great Horned Owls hatched per nest in 1971 than in 1972 on the PNG, considerable mortality of nestlings occurred in 1972. At the same time, Great Horned Owls were in the throes of a serious, nearly population-wide, nesting failure. Only 30% of all pairs present fledged young on the 1,072 and 2,590 km² study areas in 1972, compared with 83% on the 1,072 km² area in 1971 (see below) and 79% of all known nests in 1971.

Variation in Nesting Parameters. Year-to-year variations in nesting parameters (Table 3) are useful in ascertaining (1) problem periods within life histories of individual species and, in some cases, (2) portions of the nesting sequence which control the level of productivity of a population within a given year. Year-to-year comparisons are more meaningful on a long-term basis, although two-year comparisons may alert researchers to look for specific problems during subsequent study. The presence of large numbers of non-nesting pairs (as was the case with Great Horned Owls on the PNG in 1972), the phenology of nesting and other factors must modify conclusions drawn from analyses of variations in nesting parameters, particularly when the parameters include data only from pairs which produce eggs.

Clutch size of Swainson's Hawks was relatively constant (0.4% variation from the 1971-72 average between 1971 and 1972), but maximum brood size varied considerably (13.8%; see Table 3). The causes of the latter variation and subsequent differing rates of nestling mortality resulted in only a moderate variation of 6.6% in fledging success. Thus, in 1971, low mortality of young Swainson's Hawks followed high hatching failure (and vice versa in 1970 and 1972; see Table 2).

It is doubtful that this "compensation" always occurs in Swainson's Hawk populations. Future researchers on the PNG should anticipate years when mortality of both eggs and young of Swainson's Hawks are high, with a resulting fledging success significantly less than 1.11-1.13.

Clutch sizes of the resident falconiform species varied most, while clutch size of the principal migrant (Swainson's Hawk) was nearly identical in 1971 and 1972. The resident species are exposed to local weather conditions for longer periods of time than migratory species. Weather conditions were extremely different in 1971 and 1972, with 1972 being relatively warmer and drier from February through May. This suggests that clutch size is affected by weather

Table 3. 1971 to 1972 variation in nesting parameters from the 1971-72 averages. Values are percents*. Percents in bold indicate lower values in 1972 than in 1971.

Species	Variation in Clutch Size	Variation in Maximum Brood Size	Variation in Fledging Success
Swainson's Hawk	0.4	13.8	6.6
Ferruginous Hawk	7.4	5.3	7.8
Golden Eagle	5.0	5.7	4.1
Prairie Falcon	5.7	0.8	10.5
Great Horned Owl	0.4	6.3	6.4

*Percent variation = (1971 value - 1972 value) - (1971-72 average) x 100.

conditions or some other weather-controlled factor, e.g. the phenology of breeding by the prey. Clutch sizes of Ferruginous Hawks and Golden Eagles were larger in 1972 than in 1971. The opposite was true of Prairie Falcons. If weather was the only factor involved, one would expect the variations to be parallel for all species.

Although clutch sizes of Ferruginous Hawks and Golden Eagles were greater in 1972, fledging successes were smaller (Tables 2 or 3). In fact, fledging successes of all resident species were lower in 1972. Swainson's Hawks, however, produced many more young in 1972 (see Table 8 below).

Probabilities of Hatching and Fledging. From the over-all averages of clutch size, maximum brood size and fledging success in Table 2, the following probabilities were calculated: (1) of hatching, (2) of fledging if hatched and (3) of fledging at the time of egg laying (Table 4). With the exception of Ferruginous Hawks, the probability of hatching decreased in the same order as clutch size, brood size and fledging success. This was determined by ranking the over-all averages in Table 2 and comparison with Table 4. In other words, the more eggs laid, the higher the probability of hatching. The low hatching rate of Ferruginous Hawk eggs is discussed elsewhere (Olendorff 1972, Olendorff this paper).

The probability of a Swainson's Hawk egg hatching was 0.746, but the probability of fledging if hatched was considerably lower than for all other species (0.688 as opposed to 0.865-0.941 for the range of the other species). This resulted in the lowest over-all probability of fledging (0.513). Thus just slightly over half of all Swainson's Hawk eggs laid resulted in a fledged young. Prairie Falcons hatched a higher percentage of their eggs than any other species and were reasonably successful at fledging young, resulting in the highest probability of a freshly laid egg culminating in a fledged young (0.774).

With the exception of Prairie Falcons, the over-all probability of fledging at egg laying was lower the later in the season egg laying commenced.

Golden Eagles were more successful at fledging young once eggs hatched than any of the other species. Over 94% of the hatchlings fledged.

Table 4. Probabilities of hatching and fledging of large raptors on the Pawnee National Grassland—1970-72.

Species	Probability of Hatching		Probability of Fledging if Hatched		Over-all Probability of Fledging at Egg Laying
Prairie Falcon	0.889	x	0.870	=	0.774
Ferruginous Hawk	0.666	x	0.865	=	0.576
Great Horned Owl	0.770	x	0.896	=	0.690
Swainson's Hawk	0.746	x	0.688	=	0.513
Golden Eagle	0.705	x	0.941	=	0.662

Table 5. Nest successes of the large raptors on the Pawnee National Grassland—1970-72.

Species Years	Nests	Successful	Percent
Swainson's Hawk			
1970	19	10	52.6
1971	30	14	46.7
1972	70	41	58.6
Over-all	119	65	54.6
1971-72	100	55	55.0
Ferruginous Hawk			
1970	9	6	66.7
1971	13	11	84.6
1972	31	20	64.6
Over-all	53	37	69.8
1971-72	44	31	70.4
Golden Eagle			
1970	8	7	87.4
1971	18	13	72.2
1972	15	10	66.7
Over-all	41	30	73.1
1971-72	33	23	69.7
Prairie Falcon			
1971	9	9	100.0
1972	18	15	83.4
1971-72	27	24	88.8
Great Horned Owl			
1971	14	11	78.5
1972	13	9	69.3
1971-72	27	20	74.0

Nest Success. Prairie Falcons had the highest nest success (fledged at least one young) of the large raptors on the PNG between 1970 and 1972 (88.8%, Table 5). Ferruginous Hawks and Golden Eagles had nearly equal nest successes (70.4 and 69.7%, respectively). As with the over-all probability of fledging, species which nested earlier in the season, and frequently in trees, had a higher nest success, Prairie Falcons excepted.

When nest success of Ferruginous Hawks and Great Horned Owls was less than 70%, Swainson's Hawk nest success was greater than 50%. The converse was also true. This strongly suggests that Swainson's Hawk productivity was directly affected by the success of the earlier nesters, possibly through inter-specific interaction involving the availability of better quality nest sites.

Productivity of Young in Successful Nests. This analysis is included here to show that grossly incorrect conclusions can be drawn using the number of young produced per successful nest as the only analytical parameter. From the figures in Table 6 the following conclusions could be reached: (1) Swainson's Hawks had a better year in 1971 than in 1972; (2) Ferruginous Hawks had a better year in 1972; and (3) Golden Eagles, Prairie Falcons and Great Horned Owls had comparable successes in 1971 and 1972.

The data presented in Table 2 show that conclusions (1) and (2) above are opposite from actual fact. This will be corroborated by breeding density and productivity figures presented below (see Tables 7-12). Golden Eagles actually experienced a 7.0% decrease in fledging success from 1971 to 1972, yet the number of young fledged per successful nest increased by 1.4% (a negligible change). Likewise, fledging success of Prairie Falcons was 14.3% less in 1972

Table 6. Productivity of young in successful nests of large raptors on the Pawnee National Grassland—1970-72.

Species	Young Fledged	Successful Nests	Productivity of Young in Successful Nests
Swainson's Hawk			
1970	21	10	2.10
1971	34	14	2.43
1972	87	41	2.12
Over-all	142	65	2.18
Ferruginous Hawk			
1970	11	6	1.83
1971	27	11	2.45
1972	58	20	2.90
Over-all	96	37	2.59
Golden Eagle			
1970	12	7	1.72
1971	18	13	1.38
1972	14	10	1.40
Over-all	44	30	1.47
Prairie Falcon			
1971	34	9	3.78
1972	55	15	3.66
Over-all	89	24	3.71
Great Horned Owl			
1971	23	11	2.09
1972	19	9	2.11
Over-all	42	20	2.10

than in 1971, while the number of young fledged per successful nest was only 3.2% less.

The possible conclusion that Great Horned Owls had comparable success in 1971 and 1972 is very inaccurate. Fledging success was 11.0% lower in 1972 than in 1971 but, of greater importance, about 70% of the Great Horned Owls did not produce eggs in 1972!

The foregoing suggests that if young per successful nest is the only parameter available, it should be reported, but care should be taken with any conclusions drawn from this information alone. At a time when some raptor populations are decreasing, inaccuracies in analyses of trends in population levels should be avoided. Although a decrease in the number of young per successful nest may occur in pesticide-ridden populations, the same probably will not occur in a population being extirpated by human encroachment on nesting habitat.

THE 1,072-KM² STUDY AREA

The definitions of clutch size, brood size and fledging success used in the present paper allow reasonably accurate analyses, but even they must be qualified by other nesting information (e.g. unusually high numbers of non-nesting pairs). Breeding density and productivity of young per unit area are much more meaningful nesting parameters than any of the above. If energetics of the populations are of concern, biomasses should be calculated. The remaining considerations of population levels and productivities in this paper utilize the latter three nesting parameters.

Breeding density, productivity and biomass data for the 1,072-km² study area in 1971 and 1972 are presented in Tables 7, 8 and 9, respectively. In 1971 experimental nests where intensive work was done (one each for Swainson's and Ferruginous Hawks) and nests with unknown outcome (two Swainson's Hawk nests) were compensated for by taking into account the over-all nest failure rates and the modal brood sizes for those species concerned. In 1972 no nests were considered experimental and nests with unknown outcome (possibly one or two Swainson's Hawk nests) were simply omitted from calculations.

Breeding Densities and Productivities. Totals of 42 and 50.5 pairs of large birds of prey were observed on the area in 1971 and 1972, respectively (Table 7). In 1971, 37 pairs were known to have nested. Thus 42.7% of the 87 sections with potential nest sites (Table 1) were occupied. In 1972, 45 pairs nested and used 51.8% of the available nest sites.

The number of young Swainson's Hawks produced per 100 km² in 1972 (4.56) was 258% higher than in 1971 (1.77) (Table 8). This resulted from (1) nearly 50% more pairs in 1972, (2) 70.6% nest success (compared with 33.3% in 1971), and (3) 82% more young produced per pair with known production (Tables 7 and 8). This high production occurred in spite of a lower number of young per successful nest in 1972 than in 1971 (2.43 as opposed to 2.12 from

Table 7. Breeding densities and nest successes of the large birds of prey on a 414 square mile (1,072 km²) shortgrass prairie study area consisting of essentially unbroken grassland—1971-72.

Species	Number of Pairs		Pairs per 100 Sq. Mi.		Pairs per 100 Km ²		Successful Pairs (Nest Success)	
	1971	1972	1971	1972	1971	1972	1971	1972
Swainson's Hawk	24	35*	5.80	8.45	2.24	3.26	8(33.3%)	24(70.6%)*
Ferruginous Hawk	10	6	2.41	1.45	0.93	0.56	7(70.0%)	3(50.0%)
Great Horned Owl	6	6.5	1.45	1.57	0.56	0.61	5(83.3%)	2(30.8%)
Golden Eagle	2	3	0.48	0.72	0.19	0.28	0(00.0%)	1(33.3%)
All Species	42	50.5	10.14	12.19	3.92	4.71	20(47.6%)	30(60.6%)

*Outcome of one nest unknown. Nest success calculated on basis of 24 out of 34 successful.

Table 8. Productivity of raptorial birds on the 414 square mile (1,072 km²) study area—1971-72.

Species	Young Produced		Young per Pair with Known Production		Young Produced per 100 Mi ²		Young Produced per 100 Km ²	
	1971	1972	1971	1972	1971	1972	1971	1972
Swainson's Hawk	19	49*	0.79	1.44	4.59	11.85	1.77	4.56
Ferruginous Hawk	16	8	1.60	1.33	3.86	1.93	1.49	0.75
Great Horned Owl	10	4	1.67	0.62	2.42	0.97	0.93	0.37
Golden Eagle	0	2	0.00	0.67	0.00	0.48	0.00	0.19
All Species	45	63	1.07	1.27	10.87	14.73	4.19	5.69

*Young produced in 34 nests.

Table 6.

The circumstances that led to such high production of Swainson's Hawks include at least the following: (1) There was a lower breeding density of Ferruginous Hawks in 1972 than in 1971, and their nest success and productivity of young were lower. The number of young produced per 100 km² was 50% lower. In 1971 nearly all of the young Ferruginous Hawks on the 1,072-km² study area were measured periodically during intensive growth studies. No young were abandoned, but it is suspected that the adults moved their nesting activity in 1972 to other locations (mostly off of the 1,072-km² area but still within the 2,590-km² area). The lower nest success of Ferruginous Hawks was caused by destruction (probably by humans) of four young in one nest, very early nest failure of another, and one non-nesting pair. (2) Although there were about the same number of adult Great Horned Owls present in each of the two years, nest success and productivity of young were very low in 1972 due to the presence of 2½ non-nesting pairs, human destruction of two nearly fledged young, and one nest failure of unknown cause.

The apparent result of (1) and (2) above was a relatively low level of interspecific competition between the early nesters and the late-arriving Swainson's Hawks as the latter set up territories. Swainson's Hawks filled a void made available by different nest site choices and general nesting failure of the potentially competitive species. It is clear that a relatively "good" year for one species can be a relatively "bad" year for another.

Biomass Considerations. The following analysis (Table 9) has several inherent assumptions. (1) All nesting and non-nesting pairs on the prescribed area were located; (2) the biomass of adult raptors remained stable (there was no mortality) throughout the breeding season; and (3) only adults and fledged young contributed to the biomass of the population. Calculations of adult biomass before the onset of egg-laying and biomass of the young after fledging (and the combination of the two) were calculated. Species were considered separately and collectively. Calculations are made in detail below for biomasses on the 1,072-km² study area in 1971. Biomasses for other years and for the 2,590-km² study area in 1972 were calculated identically.

Six pairs of Great Horned Owls were present on the 1,072-km² study area in 1971 representing a mass of 3,010 g/pair or 18,060 g. This calculated to a biomass of 16.8 g/km² (Table 9). The six pairs of adults fledged 10 young owls with weights of approximately 1,235 g each (average of only two individuals), i.e. 12,350 g. This reduced to 11.5 g/km². The combined biomass of Great Horned Owls—adults and young—was 28.3 g/km² after all birds had fledged (after late May and before appreciable mortality or emigration occurred).

Ten pairs of Ferruginous Hawks were present on the area in 1971. At 3,220 g/pair this amounted to 32,200 g or 30.0 g/km². These 10 pairs fledged 16 young at an average weight of 1,296 g each or a total of 20,736 g. This was 19.3 g/km². The total biomass of Ferruginous Hawks on about July 17 and

Table 9. Biomass of adult and young raptors on the 414 square mile (1,072 km²) study area at the end of the breeding season in 1971 and 1972. The units are g/km² wet weight followed by percentages (in parentheses) of the total of all species combined (of each column).

Species	Adults		Young after Fledging		Adults and Young	
	1971	1972	1971	1972	1971	1972
Swainson's Hawk*	44.2 (41.3)	64.5 (51.7)	14.1 (31.4)	36.3 (63.7)	58.3 (38.4)	100.8 (55.4)
Ferruginous Hawk	30.0 (28.0)	18.0 (14.4)	19.3 (43.0)	9.7 (17.0)	49.3 (32.4)	27.7 (15.2)
Great Horned Owl	16.8 (15.7)	18.2 (14.6)	11.5 (25.6)	4.6 (8.1)	22.3 (18.6)	22.8 (12.6)
Golden Eagle	16.1 (15.0)	24.1 (19.3)	0.0 (0.0)	6.4 (11.2)	16.1 (10.6)	30.5 (11.8)
All Species	107.1	124.8	44.9	57.0	152.0	181.8

*Outcome of one Swainson's Hawk unknown in 1972.

after was 49.3 g/km².

Twenty-four pairs of Swainson's Hawks had a total biomass of 47,448 g and a biomass of 44.2 g/km². These birds fledged 19 young at an average of 796 g each, representing a mass of 15,920 g, i.e. 14.1 g/km². Total biomass of Swainson's Hawks after mid-August was 58.3 g/km².

Two pairs of Golden Eagles were present. Neither reared young. Mass of the two pairs was approximately 17,252 g; biomass was 16.1 g/km² throughout the spring and summer.

At the end of the breeding season (again assuming no mortality of adults or of young during the post-fledging periods of the early nesters) the total biomass of all large raptors on the 1,072-km² study area was 152.0 g/km².

Weights used in further calculations include young Golden Eagles—3,450 g, an adult pair of Prairie Falcons—1,417 g, young Prairie Falcons—682 g, an adult pair of Red-tailed Hawks (*Buteo jamaicensis*)—2,252 g, and young Red-tailed Hawks—1,075 g.

Biomasses of adult and young raptors at the end of the breeding season on the 1,072-km² study area were greater or less in 1972 than in 1971 by the following percentages: Swainson's Hawks—73% greater, Golden Eagles—89% greater, Great Horned Owls—19% less, and Ferruginous Hawks—44% less. For all species combined, biomass was about 20% greater in 1972 than in 1971. Biomass averaged 166.9 g/km² for the two years including an average of 116.0 g/km² for adults and a biomass production of young of 50.9 g/km². The biomass of

young produced was less than half (43.9%) of the biomass of the adults present.

The biomass figures, both for adults and young, were dominated by Swainson's Hawks, although Ferruginous Hawks were a close second in 1971. The total biomass of adults and young was proportioned as follows in 1972: Swainson's Hawks—55.4%, Ferruginous Hawks—15.2%, Great Horned Owls—12.6% and Golden Eagles—16.8%. These percentages will be compared below with similar figures for the 2,590-km² study area (Table 12).

THE 2,590-KM² STUDY AREA

In IBP Technical Report 151 (Olendorff 1972) crude nesting densities were estimated on a 5,869-km² (2,266-square mile) area which included all nesting species and all potential nesting habitats in northeastern Colorado. Limitations of manpower and financial support precluded actual determinations of crude nesting densities on more than 2,590 km² (1,000 square miles), so such an area was designed as representative of most of northeastern Colorado. All future raptor research in the area should place the highest priority on yearly determinations of crude nesting densities and productivities on the 2,590-km² study area, a large (but manageable) task for two researchers.

Breeding Densities and Productivities. In 1972 the large raptor population of the 2,590-km² study area consisted of 42.8% Swainson's Hawks, 16.4% Ferruginous Hawks, 19.3% Great Horned Owls, 7.6% Golden Eagles, 8.8% Prairie Falcons and 5.1% Red-tailed Hawks. All species considered, there were 6.10 pairs of large raptors for every 100 km², or one pair for every 6.3 square miles (Table 10). Only about half (53.3%) produced at least one young (Red-tailed Hawks were not included in this statistic).

Comparisons between 1972 data for pairs per 100 km² on the 1,072-km² study area (Table 7) and on the 2,590-km² study area (Table 10) revealed quite different population levels, particularly when the species were considered individually. In essentially unbroken grassland (the 1,072-km² study area) there were 24% more Swainson's Hawks, 44% fewer Ferruginous Hawks, 49% fewer Great Horned Owls and 40% fewer Golden Eagles than in a combination of shortgrass prairie habitats (2,590-km² study area). Prairie Falcons and Red-tailed Hawks nested on the 2,590-km² area, but not the 1,072-km² area.

One would expect more Ferruginous and fewer Swainson's Hawks to nest on the 1,072-km² study area (unbroken grassland), because Ferruginous Hawks nested in unbroken grassland nearly two-thirds of the time (Olendorff and Stodart 1974). Swainson's Hawks nested in unbroken grassland only one-third of the time. Several factors may be responsible for the deviation from expected results. (1) Unbroken grassland on the PNG has been periodically interrupted by farmsteads, now abandoned and used by hawks as nest sites. Swainson's Hawks have taken advantage of these man-created sites. (2) As noted above, most young Ferruginous Hawks on the 1,072 km² area were measured periodically in 1971; the adults apparently moved into the surrounding area (the 2,590-

Table 10. Breeding densities and nest successes (1972 only) of the large birds of prey on a 1,000 square mile (2,590 km²) shortgrass prairie study area consisting of unbroken grassland and grassland interrupted by gallery forests along creek bottoms, cliff lines, and tracts of cultivated land.

Species	Number of Pairs	Pairs per 100 mi ²	Pairs per 100 km ²	Successful Pairs
Swainson's Hawk	68 ¹	6.80	2.62	38 (56.8%)
Ferruginous Hawk	26	2.60	1.00	16 (61.6%)
Great Horned Owl	30.5 ¹	3.05	1.17	8 (29.1%)
Golden Eagle	12	1.20	0.46	5 (41.6%)
Prairie Falcon	14	1.40	0.54	11 (78.6%)
Red-tailed Hawk	8 ²	0.80	0.31	?
All Species	158.5	15.85	6.10	78 (53.3%)

¹Outcome of one Swainson's Hawk and three Great Horned Owl nests unknown.

²Number of adult pairs is accurate, but productivity data for Red-tailed Hawks were not collected.

km² area) to nest in 1972. (3) Great Horned Owls and Ferruginous Hawks experienced a general nesting failure in 1972, leaving a void of interspecific conflict when the late-nesting Swainson's Hawks arrived. There were nearly 50% more Swainson's Hawks on the 1,072-km² area in 1972 than in 1971 (Table 7). (4) Cursory habitat analysis of the 2,590-km² area showed that more area of cliffs, grasslands without trees and cultivated land (poor or unsuitable nesting habitat for Swainson's Hawks) were added to expand the 1,072-km² area to 2,590 km². Cliffs and grasslands without trees are suitable nesting habitat for Ferruginous Hawks.

All species, with the exception of Swainson's Hawks, produced more young per 100 km² on the 2,590-km² study area than on the 1,072-km² area (Tables 11 and 8). This corresponds with the differences in breeding population densities. For all species combined, 201 young were produced or 7.74 per 100 km² (36.5% greater than on the 1,072-km² area). This is equivalent to 1.37 young per pair with known production. Most of the greater production of young on the 2,590-km² area was attributable to the high production of Prairie Falcons. The Red-tailed Hawk data are included for completeness. The estimated productivity figures for Red-tailed Hawks should be fairly accurate.

Biomass Considerations. For all species and age classes combined, the biomass of large raptors was 252.8 g/km² at the end of the 1972 breeding season, or 39.0% greater than on the 1,072-km² area (Table 12). Biomass of the young

Table 11. Productivity of raptorial birds on the 1,000 square mile (2,590 km²) study area—1972.

Species	Young Produced	Young per Pair with Known Production	Young Produced per 100 Square Miles	Young Produced per 100 Km ²
Swainson's Hawk	80	1.19	8.00	3.08
Ferruginous Hawk	48	1.85	4.80	1.85
Great Horned Owl	18	0.65	1.80	0.69
Golden Eagle	6	0.50	0.60	0.23
Prairie Falcon ¹	41	2.93	4.10	1.58
Red-tailed Hawk ²	(8)	(1.00)	(0.80)	(0.31)
All Species	201	1.37	20.10	7.74

¹One pair which fledged at least two young could have fledged three or four. Used two fledged in this analysis.

²All productivity data for Red-tailed Hawks are estimated. It is assumed that six of eight nests fledged a total of eight young. Only two nests were followed up and each apparently fledged two young.

Table 12. Biomasses of adult and young raptors on the 1,000 square mile (2,590 km²) study area at the end of the breeding season in 1972. The units are g/km² wet weight followed by percentages (in parentheses) of the total of all species combined (of each column).

Species	Adults	Young after Fledging	Adults and Young
Swainson's Hawk	51.7 (29.8)	24.5 (30.9)	76.2 (30.1)
Ferruginous Hawk	32.2 (18.5)	24.0 (30.3)	56.2 (22.2)
Great Horned Owl	35.4 (20.4)	8.6 (10.9)	44.0 (17.4)
Golden Eagle	39.8 (22.9)	8.0 (10.0)	47.8 (18.9)
Prairie Falcon	7.6 (4.4)	10.8 (13.7)	18.4 (7.3)
Red-tailed Hawk ¹	6.9 (4.0)	3.3 (4.2)	10.2 (4.1)
All Species	173.6	79.2	252.8

¹Data for young Red-tailed Hawks after hatching are estimated.

was 79.2 g/km² or only 45.6% greater than adult biomass. For each species individually, biomasses were increased by the following percentages: Swainson's Hawk—47.4, Ferruginous Hawk—74.6, Great Horned Owl—24.3, Golden Eagle—20.1, Prairie Falcon—142.2 and Red-tailed Hawk—47.8 (estimated). Variations in such figures (from species to species) are dependent upon the number of young produced by and the nest success of each species. Percentage increase in biomass, a very sensitive measure of productivity, is one of the best indicators of over-all reproductive performance and should be used wherever year-to-year comparisons are possible. Future data collection should be oriented toward such comparisons.

One cannot determine the relative impacts of the species with certainty from these data, but the order of their biomass percentages is a good estimate. Swainson's Hawks were most important (30.1% of the biomass). Energetically, the Swainson's Hawk has even greater impact, since it is the smallest species which accounts for more than 10% of the biomass, and smaller animals generally consume more food per gram of body weight than larger animals. In terms of bioenergetics, it is inefficient to be small. Ferruginous Hawks, Great Horned Owls and Golden Eagles each accounted for about 20% of the 1972 biomass (58.5% collectively). Prairie Falcons and Red-tailed Hawks together accounted for only 11.4% of the biomass.

The percentages of the total biomasses for the two areas in 1972 (from Tables 9 and 12) are displayed below, both to illustrate the dangers of considering a small, unrepresentative area during a nesting study, and to compare an area of essentially unbroken grassland with an area consisting of all available habitat types.

	1,072-km ²	2,590-km ²
Swainson's Hawk	55.4%	30.1%
Ferruginous Hawk	15.2%	22.2%
Great Horned Owl	12.6%	17.4%
Golden Eagle	16.8%	18.9%
Prairie Falcon	0.0%	7.3%
Red-tailed Hawk	0.0%	4.1%

Only Golden Eagles occurred in comparable proportions of the total populations of large raptors on the two areas. Prairie Falcons and Red-tailed Hawks (which were absent from the smaller area) accounted for 11.4% of the population on the 2,590-km² area. Swainson's Hawk biomass was reduced by over 25% of the total on the 2,590-km² area compared to the smaller area.

There were also large differences between population levels based on density (individuals per unit area) and those based on biomasses (weight per unit area). A comparison of percentages of the total population of adults and young in 1972 is shown below for the 2,590-km² area.

	Density	Biomass
Swainson's Hawk	41.7%	30.1%
Ferruginous Hawk	19.3%	22.2%
Great Horned Owl	15.3%	17.4%
Golden Eagle	5.8%	18.9%
Prairie Falcon	13.3%	7.3%
Red-tailed Hawk	4.6%	4.1%

Golden Eagles accounted for a much smaller percentage of total density than of total biomass. Red-tailed Hawk, Great Horned Owl and Ferruginous Hawk percentages were about comparable, while Swainson's Hawk and Prairie Falcon percentages of total density were greater than percentages of total biomass.

Summary

The major nesting raptors of the Pawnee National Grassland in northeastern Colorado are Swainson's and Ferruginous Hawks, Golden Eagles, Prairie Falcons and Great Horned Owls. Clutch size, maximum brood size and fledging success of these species were determined in 1970, 1971 and 1972 (Table 2). With the exception of Ferruginous Hawks the probability of hatching (comparing between species) decreased in the same order as clutch size, brood size and fledging success (Table 4). In other words, the more eggs laid by a species, the higher the probability of hatching. Swainson's Hawks experienced the lowest (0.513) and Prairie Falcons the highest (0.774) probability of a freshly laid egg culminating in a fledged young. With the exception of Prairie Falcons, the over-all probability of fledging at egg laying was lower the later in the season egg laying commenced. Prairie Falcons had the highest nest success (fledged at least one young per attempt) (88.8% from Table 5). If nest success of Ferruginous Hawks and Great Horned Owls was less than 70%, Swainson's Hawk nest success was greater than 50%. The converse was also true.

On the 1,072-km² unbroken grassland study area in 1971, 42 pairs of large birds of prey used 42.5% of the potential nest sites. In 1972, 50.5 pairs used 51.8% of the nest sites. Swainson's Hawk breeding density and productivity were higher in 1972 than in 1971 (Tables 7 and 8). I believe this was in response to at least three factors: (1) There was a lower breeding density of Ferruginous Hawks in 1972 than in 1971, and their nest success and productivity were also lower in 1972; (2) although there were about the same number of adult Great Horned Owls present in each of the two years, nest success and productivity of young were very low in 1972; (3) there were fewer days on which potentially nest-destructive winds blew in 1972. Swainson's Hawks apparently filled a void where interspecific competition for nest sites was at a low level; they were further aided by good weather conditions.

The biomass figures, both for adults and young on the 1,072-km² study area were dominated by Swainson's Hawks (Table 9). For all large raptors combined, biomass was about 20% greater in 1972 than in 1971. Biomass averaged 166.9

g/km² for the two years, including an average of 116.0 g/km² for adults and a biomass production of young of 50.9 g/km². The biomass of the young produced was less than half (43.9%) of the biomass of the adults present.

In 1972 on the 2,590-km² study area representing all locally available nesting habits, the large raptor population was constituted as follows: Swainson's Hawks—42.8%, Ferruginous Hawks—16.4%, Great Horned Owls—19.3%, Golden Eagles—7.6%, Prairie Falcons—8.8% and Red-tailed Hawks—5.1%. All species combined, there were 6.10 pairs of large raptors for every 100 km², or one pair for every 6.3 square miles (Table 10). Only about half (53.3% of all adult pairs produced at least one young. All species collectively produced 201 young in 1972 on the 2,590-km² area, or 7.74 per 100 km² (Table 11). This was 36.5% greater than on the 1,072-km² area during the same breeding season; most of the difference was attributable to the high production of Prairie Falcons on the larger area.

For all species and age classes combined, the biomass of large raptors on the 2,590-km² study area was 252.8 g/km² at the end of the 1972 breeding season, or 39.0% greater than on the 1,072-km² area (Table 12). The biomasses of the individual species were greater at the end of the breeding season (compared to the beginning) by the following percentages: Swainson's Hawks—47.4, Ferruginous Hawks—74.6, Great Horned Owls—24.3, Golden Eagles—20.1 and Prairie Falcons—142.2. Ferruginous Hawks excepted, the magnitudes of these percentages increase as the size of the raptor decreases.

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I wish to thank the Frank M. Chapman Memorial Fund Committee of The American Museum of Natural History, especially Dr. Dean Amadon; Personnel of the International Biological Program Grassland Biome Project, in particular Dr. Norman French; and several employees of the Colorado Division of Wildlife, including Gerald Craig and Wayne Sandfort. These people all helped in obtaining funding for my grassland studies. In addition, this paper reports on work supported in part by National Science Foundation Grants GB-7824, GB-13096 and GB-31862X to the Grassland Biome, U. S. International Biological Program, for "Analysis of Structure, Function, and Utilization of Grassland Ecosystems." At Colorado State University Dr. Ronald A. Ryder and Dr. Gustav A. Swanson have given considerable direction to my post-doctoral experience. Dale Wills and other staff members of the U. S. Forest Service, Roosevelt National Forest, have been helpful. John W. Stoddart, Jr., and Gerald Craig have assisted in the field.

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OTHER RAPTOR POPULATIONS:

ABSTRACTS OF OTHER PAPERS AND INFORMAL DISCUSSION

ABSTRACTS OF OTHER CONFERENCE PAPERS

David Howard, 4374 Broadview Dr., Richfield, Ohio 44280, and *Roger Thacker*, 310 Hanks Hill Road, Storrs, Connecticut 06261.

Population Trends and Breeding Success of Raptors in Northeastern Ohio.

The breeding success of raptors in northeastern Ohio is examined. Data presented include clutch sizes, hatchability, and fledging success for the years 1966-70.

Sara Jane Johnson, Department of Zoology and Entomology, Montana State University, Bozeman, Montana 59715.

Reproductive Success of the Red-tailed Hawk in the Gallatin Valley, Montana.

Data were collected on the reproductive success of the Red-tailed Hawk in the Gallatin Valley, Montana, during the spring and summer of 1971 and 1972. In 1971, a minimum of 73 young were produced by 64 pairs of birds, producing an average of 1.14 young per adult pair. Non-breeding pairs composed at least 9% of the total pairs observed. Of the birds that began nesting, at least 64% were successful in hatching young. Of 37 pairs hatching young, 91.8% suc-

cessfully fledged them. Of 34 pairs which fledged a known number of young, the average young produced per nest was 2.15.

In 1972, a minimum of 94 young were produced by 73 pairs of birds, or an average of 1.29 young per adult pair. Non-breeders composed at least 13.7% of the pairs observed. Of the birds that began nesting, at least 65% were successful in hatching young. Of 41 pairs that successfully hatched young, 95% also fledged young. Of 35 pairs which fledged a known number of young, the average number per nest was 2.69.

Estimated territory sizes ranged from 0.99 to 1.79 square miles. The highest constant density of nests, with an average distance of 1.14 miles between nests, occurred in areas along the Gallatin River, and the lowest constant density of nests, with an average of 2.47 miles between nests, occurred in extensive agriculture areas away from the river.

INFORMAL DISCUSSION

Goshawk—Population Size and Losses

FRANK BOND. Mr. McGowan, would you care to extrapolate the number of nesting Goshawks in your study area?

JERRY MCGOWAN. Well, we knew of nine nesting pairs on the study area in 1971 and slightly more than that in 1972, I think 11 known active Goshawk nests on 144 square miles. I don't know how many nests I overlooked; undoubtedly I did miss active nests in both years. I would say as a general estimate of how effective I am in finding all the Goshawk nests, that I might find 75% that are on the study area. I wouldn't think I was any more complete than that. As far as extrapolating to other regions of Alaska, I wouldn't be able to do that at all.

DAVID GRAHAM. You mentioned the one cause of decreased fertility in your Goshawks in your study area was death of females, and as a pathologist I would be curious about some of the circumstances of those deaths.

MCGOWAN. What I meant to say was that in two cases the females were there one week, and on the next visit they were not there. So it was either desertion or death of the female, we didn't know which. Unfortunately we didn't get hold of the birds.

Red-tailed Hawk—Interaction with Other Species

JOSEPH MURPHY. I'd like to ask about interspecific and intraspecific interaction in that high density Red-tail population. What kind of observations did you have on interaction with other species, for example other raptorial species

as well as within the basic population?

SARA JANE JOHNSON. The only other *buteo* that nests there is one Swainson's Hawk. And they were more or less excluded from the central part of the valley. Once you start getting out of the dry foothills then it changed from Red-tails to Swainson's. There really was not too much intermingling there.

MURPHY. What about Great Horned Owls? Was there interaction between the two species, since they compete for the same nests?

JOHNSON. Occasionally a Red-tail would use old owl nests or just the reverse. There weren't that many nests; I think only two that were really close together. In one they were only about 100 yards apart and both nests made it, and the other the nest was about a quarter of a mile away and the Red-tail nest didn't make it.

FREDERICK HAMERSTROM. Was there no competition between the Horned Owls and the Red-tails in that the Horned Owls got there first? It happens in a number of other places.

JOHNSON. Yes, they got there first.

HAMERSTROM. When the Horned Owl gets there and takes a nest that the Red-tail presumably had built, is there any friction then or do the Red-tails simply move off and make another nest and forget about the whole thing?

JOHNSON. Well, the owls are probably on the nest by the time I start checking for Red-tails so I never observed any friction. I guess there really isn't much of a fight because the owls are there.

HAMERSTROM. But they don't exclude the Red-tails by taking the Red-tails' last year's nesting territory.

JOHNSON. They take the nest.

HAMERSTROM. And how about the territory?

JOHNSON. In some territories like one, for example, there are two nests about a half a mile apart. And there is an owl and Red-tail on both nests both years except they both switched, things like that.

BRIAN MILLSAP. Do you have any data regarding the number of Great Horned Owls to Red-tails nesting in the area?

JOHNSON. The Gallatin River ran about 16 miles through my study area

and that was the only place I encountered owl nests and they were approximately the same density as Red-tailed Hawk; both about one every mile along the river.

Red-tailed Hawk—Population Status

LESLIE BROWN. Do you consider that this very high producing population in the Gallatin Valley is increasing, or is it static? It seems to be characteristic of these high productivity things that they are increasing. They reach a peak, then they drop off. I want to know whether you thought it was stable or whether there were any indications that there were new pairs moving in all the time.

JOHNSON. Of course, I did my study in the center of the valley where the population density was highest in the area. The nesting density was pretty much the same both years of the two-year study. I'd really hate to try to say anything more than that. I did not notice any increase in the number of birds from 1971 to 1972.

SERGEJ POSTUPALSKY. I suggest that, perhaps, your excess production of Red-tails may be moving north to Alberta because if I recall correctly Luttich and Keith took their reproductive figures for the Red-tail and constructed a life equation and concluded that their population could not be maintaining itself.

JOHNSON. They were fledging 1.7 young. Mine was 2.34.

Swainson's Hawk—Nest Success

BRUCE WOLHUTER. Everybody seems concerned and agrees that Ferruginous are prone to abandonment and no one seems to have mentioned anything about the Swainson's and yet as I understood it, you mentioned that approximately half the Swainson's eggs laid failed to hatch, higher than what I experienced. What would you attribute as the major factor to this?

RICHARD OLENDORFF. The Swainson's Hawk happens to be the Mourning Dove of the raptor world. And he takes about two tumbleweeds and sticks them up in the nest, then jumps up and down on it a few times. Then he lays his eggs in there. And not only that, he's been worried about mammalian predators for all these years that he stuck his nest way out here on the crown of the tree.

VOICE. She lays her eggs! Not he!

OLENDORFF. I have a correlation, a rough correlation between nest success of Swainson's Hawks and the number of days that strong or gusty winds have been recorded by IBP investigators out on the Pawnee. The winds just come

along and blow them out. Last year, when we had the highest productivity of Swainson's Hawks, we had only about four days of strong or gusty winds on the Pawnee during the period of time when eggs and very young were in the nest.

Ferruginous Hawk—Effects of Observers

JAMES ENDERSON. Powers reports the Ferruginous is alive and well in Utah and, commendably, has reported that workers create mortality in the birds that they study. I think a lot of studies in the past have completely overlooked it—perhaps it would be embarrassing to report the mortality that occurs as a result of the study. Anyone who has studied birds of prey knows that it has happened. It would be actually good if others would get a feel for how often it happens.

Have you made an attempt to relocate the nests of Ferruginous Hawks that have abandoned, possible re-nests of Ferruginous?

LEON POWERS. Yes, as much as logistics and time would allow us. We did cover a large area because our first year was primarily exploratory. We really had no idea as to what the population was and what we'd find when we started. Another factor that we're not really sure about and we haven't good data, is this factor of alternate nest. We may see activity in one nest and find that this nest is not occupied, but nearby there is an occupied nest; it may well be the same pair building on several nests.

RICHARD FYFE. We recognized the problem as you mentioned, and Tom Donald did our surveys last year where we split our population about in half. We were watching about 80 nests of Ferruginous; I'm not sure of the figure, but there were approximately 40 nests in each group. With one group we carried out a regular sampling; we went visiting the nests during egg laying, during incubation, early small young, and later with large young to band. The other group of nests we identified the pairs on territories and then left them. We didn't go near them, both in areas near roads and away from roads. And the desertion was almost identical. I think it was 19 deserted in the area that we didn't interfere with, and there were 18 desertions in the area where we did our work. Now we're trying to pin this down to see if we can come up with the parameters where the Ferruginous do desert. I think we all recognize this is a problem with large buteos and we'd like to see just where in the whole scheme of things this problem really does exist. Our data from last year certainly didn't suggest that; our activities didn't seem to have any detrimental effect on birds.

Our data suggest that the most critical period is when the birds are setting up their territories early in the season when they become progressively more territorial and more stable as incubation and the development of young progress. This is something that a person can always bear in mind, conducting surveys and things like that.

Ferruginous Hawk—Food

FYFE. I would like to make the point that what we were saying about the Prairie Falcon and ground squirrels, particularly in our part of the world, applies equally to the Ferruginous Hawk and its population. It is strictly dependent on the ground squirrel in that area.

TOM CADE. I wanted to make a comment along these lines too. I think we ought to be careful to distinguish between nest desertion as one kind of phenomenon and the killing of eggs when the female is off the nest. This is a completely different kind of problem, and I think that as far as the latter is concerned, one does not have to worry very much about cooling eggs—they can stand a lot of cooling without being damaged. On the other hand, one has to be rather careful about overheating. An egg is much more quickly killed by overheating than it is by overcooling.

Mississippi Kite—Food

PATRICK REDIG. Could you say anything about the food habits of kites and what effect this might have on their abundance?

JAMES PARKER. That hasn't been one of the things I've been budgeted to study, but I've had about 176 collections and out of these I found the usual insects, but I've also found the remains of two or three birds, eight mammals, about 43 frogs; frogs aren't surprising nor are the collared lizards, but the birds and mammals were interesting. I've come to the conclusion that the kites are more general in food habits than most people believe, certainly more general than the literature would lead us to believe.

Birds include meadowlarks and the mammals were kangaroo rats, *Peromyscus*, and in one other case a bat. Also interesting were two box turtles scavenged from roads.

REDIG. Would you say then that they were dependent on water? Not even for nesting?

PARKER. No, I would not at all. Most of my shelterbelt plantings were a considerable distance from water. I certainly feel that in the southeastern states the open areas around riparian areas are important in their incubation, but in the plains states it's a different story.

DAVID BIRD. Are there any records of killing mammals?

PARKER. There have been two records of kites taking bats. I did find two moles in and near a nest. The others, like the rabbit, were found in or near the nest.

WOLHUTER. I found Miss Cranston's observation of the great age of at least two weeks between two birds in the same nest to be quite interesting, and I think that she postulated that perhaps the birds were stimulated to recycle by other birds in the area. I wanted to ask Mr. Parker if he found any similar instances or examples.

PARKER. I did, and I had slides showing the same kinds of differences in developmental stages of these birds. I don't think that in my own experience I've ever seen any more than about six days. I do feel strongly that second youngster quite often is severely retarded, and this expresses itself quite often through plumage development. I think that's probably the source of this kind of a different appearance.

Agriculture and Raptor Populations

RICHARD PIERSON. In my job, I move around the country quite a bit of the time. I spent two years in a small town 98 percent farmed by Amish. With the four-mile radius of my study section, it was not unusual for me to find a buteo's nest in one corner of a wood lot, a Great Horned Owl's nest in the other corner and a Cooper's Hawk nest in the center. This ran two years running, with a very high rate of nesting raptors within this area. At this point, I attribute the success of these birds to the abundance of live food, not necessarily to the habitat, since the Amish people do not use chemicals on their land. The area that I'm living in now is very similar to that Amish area and the number of nesting raptors is substantially lower. Now I say at this point, I have no specific criteria and I have not presented a paper because I'm still not sure of the ground I'm standing on, but I feel that more work is needed in these areas that are farmed by Amish people or farmers that do not use a large quantity of pesticides and herbicides.

Ohio Raptors—Population Changes

POSTUPALSKY. The way you presented your data here, for example for the Kestrel, you say 105 nests, 311 eggs. In each case, were all these nests checked for eggs?

ROGER THACKER. All of these nests were individually checked, as I understand it.

POSTUPALSKY. They were? It seems to me in the case of the Kestrel that shows a rather small clutch size of about three eggs.

THACKER. 3.25 I think.

POSTUPALSKY. Kestrels normally lay about four or five.

THACKER. One thing I think you have to take into consideration is that the figures are a four-year accumulation.

POSTUPALSKY. On what do you base this idea that certain raptor populations have reached bottom in 1964 through 1966 and now there apparently is an improving trend, if I interpret your statement correctly.

THACKER. I think if you follow the figures made available mainly from the main migration points, that many of the species in 1964 to 1966 were on a decline and since 1966-1967 there has been a marked increase in the number of passage birds. I am sure if you took the figures of last year on the migration routes there were many species that were recovering quite well. If you take this over a three, four, five year average, 1967-1971, and put it in a computer and see if you come out with an analysis, I think you will find it follows through.

POSTUPALSKY. Well, I think this is very interesting because I have noticed much the same pattern in the reproductive success and population of the Osprey in Michigan. It was very low in the mid-60's, beginning with 1967 it became high. So I didn't mean to shoot you down or anything. I just wanted to see what your reasoning was.

African Raptors—Habitat Change Effects

MURPHY. Dr. Brown, you mentioned the impact of some types of habitat change on species such as the Fish Eagle and the Secretary Bird, the species you have studied extensively. The Crowned Eagle is primarily a forest bird, is it not? Are there not some reasons to be a little pessimistic about the destruction of forests and therefore the impact it has on the Crowned Eagle?

BROWN. I think that will be true in the long term; I doubt if it's true in the short term. In Kenya there has been practically no change in the extent of forest since independence. And I don't think there is any change in the number of forest dwelling raptors for that reason. There are one or two small areas of forest that have been cut out and there are one or two areas of what used to be forest on old European farms which have been taken over by small holders which have been destroyed. But I don't think that this has a very large effect. Obviously in the long term this would have that effect. I was speaking really in terms of what you might call a present day threat. Quite obviously forest destruction proceeding in Africa, generally, with population increasing at three and a half percent per annum is going to have a serious effect on forest species, and I did mention in the talk that forest species were probably the most likely to suffer in the long term. But at the present time, and taking the next four or five years into account, I doubt that any species will be seriously threatened by forest destruction except maybe the Southern Crowned Eagle.

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