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HABITAT MANAGEMENT SERIES FOR ENDANGERED SPECIES

by Carol Snow, Research Biologist
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Report No. 1

American Peregrine Falcon *Falco peregrinus anatum* and Arctic Peregrine Falcon *Falco peregrinus tundrius*

INTRODUCTION

This Technical Note series on wildlife is designed to provide a literature review and summary of current knowledge pertaining to endangered and other wildlife species occurring on public lands. We in the Bureau of Land Management have recognized the need for basic wildlife information in order to do an effective job in land-use planning. Sound planning must identify the negative aspects as well as the positive benefits of any proposed land management decision or program. It is our hope, too, that this series will also prove useful to others--be they land managers, students, researchers or interested citizens.

Burt Silcock

Director
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Introduction

The objective of this report is to provide BLM personnel with the latest and most up-to-date information on rare or endangered species occurring on the public domain. This will provide a tool for improved understanding of the interrelationships between the species and its environment and encourage an end product of enlightened land management which will fully consider the species' welfare in all management decisions.

1. Species Description

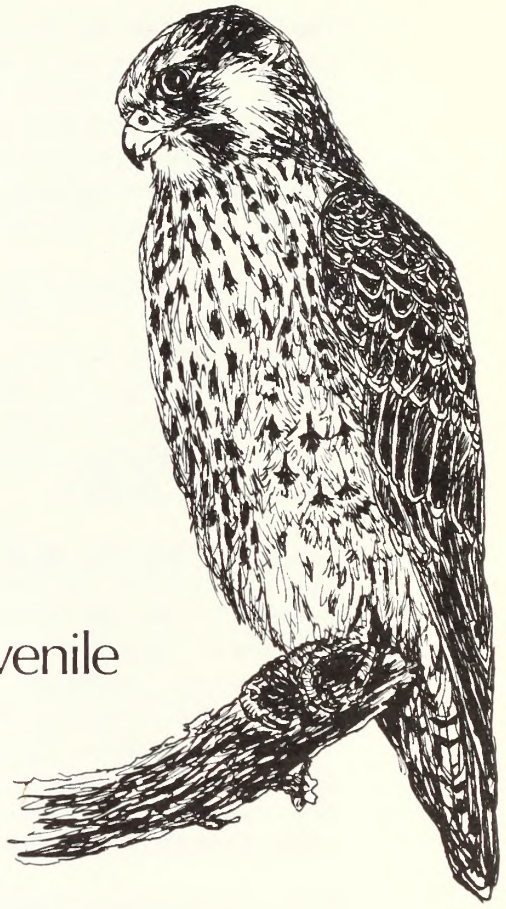
The peregrine falcon is practically cosmopolitan, with as many as twenty-two subspecies being described in various parts of the world. There are three subspecies in North America: Falco peregrinus anatum, Falco peregrinus tundrius and Falco peregrinus pealei.

Falco peregrinus pealei, the Peale's peregrine, is found along the coastlines of British Columbia and southern Alaska, particularly in the Aleutian Islands off the coast of Alaska and the Queen Charlotte Islands off the coast of B.C. Falco peregrinus tundrius, the Arctic peregrine (often called the tundra peregrine), is found in northern Alaska and across the Canadian tundra. Falco peregrinus anatum, the American peregrine (sometimes referred to as the anatum peregrine in the continental U.S. and the taiga peregrine in Alaska), has been distributed throughout the rest of North America.

Falco peregrinus anatum is a medium-sized falcon, with a body length of 13-19 inches, i.e. the approximate size of a pintail duck (Anas acuta). It has long, pointed wings and a long tail as compared with the tails of Buteo hawks. The flight of the peregrine is quick and ducklike. These birds are also excellent soarers. In flight they can be distinguished from the prairie falcon (Falco mexicanus) by the wingbeat. The peregrine has a fairly deep wingstroke about equally above and below the horizontal, whereas the prairie falcon's wingbeats are deeper below the horizontal and scarcely above the horizontal on the upstroke.

Adult peregrines are slate gray, slate blue, or bluish slate above. The ventral surfaces of the wing and tail feathers and the flanks are transversely barred with black. The head is black with heavy moustachial stripes. The ends of the tail feathers are tipped in light yellow brown. The throat and remaining underparts are white to sienna-orange, or shades of buff. The underparts are extensively spotted and barred

PEREGRINE FALCON



Juvenile

Adult

black. The beak is slate blue, the cere (protuberance at the base of the beak in which the nostrils are located), legs and feet are yellow. The talons are blue-black and the eyes are dark brown.

In juvenile peregrines, the head and neck are dark brown with sandy streaking. All subspecies tend to be dark headed with a wide line going down around the eye and across the cheek. The rest of the upper parts are dark brown with light amber-brown feather edging. Below, they are white to sandy and entirely vertically striped with dark brown. The cere is bluish-gray, and the legs and feet are bluish-gray to greenish-yellow.

Falco peregrinus tundrius tends to be smaller than F. p. anatum. The tundra birds are sometimes called "blond" peregrines because many of them are lighter in coloration than anatum birds. Falco peregrinus pealei tend to be larger than anatum peregrines and more heavily pigmented. Peale's peregrines are best characterized by their grayed tones and extensive heavy ventral markings. They are primarily resident in their range (BSFW, 1968; Brown et al, 1968; Grossman et al, 1964; Hickey, 1969; White, 1968; Enderson, 1972c; IUCN, 1969).

2. Distribution, Present and Former

Presently, anatum breeds across the United States from the taiga portions of Alaska south to Baja California (except the coast of southern Alaska and British Columbia), central Arizona, S.W. Texas, Mexico, Colorado, and Quebec. It winters chiefly in its breeding range, with the more northern birds moving somewhat south. It formerly also bred in the eastern United States and is now very rarely seen there (BSFW, 1968).

In New Mexico, the peregrine is a local resident in the north and west and rare in summer. It is probably now casual or occasional in most areas. Yearlong it is seen in San Juan, Rio Arriba, Los Alamos (irregularly), Santa Fe (occasional), San Miguel (casual, summer) and Hidalgo (casual) Counties. In the summer it is seen in Sandoval, Catron, and Grant (occasional) Counties. In the winter the peregrine is seen in Bernalillo, Torrance, Socorro, Chaves, Sierra, Dona Ana, Otero and Eddy Counties. There is evidence of breeding in San Juan, Rio Arriba, Sandoval and Catron Counties (Hubbard, 1970).


Tree
line
Tree
line
Falco peregrinus
anatum
F. p. tundrius
F. p. pealei

Approximately 100 pairs of peregrine falcons were reproducing successfully in California in 1946. A decline began in the early 1950's and intensified later in that decade. By 1969 fewer than 10 nesting sites were estimated to be active in California. In a 1970 survey, ten peregrines were present at four sites. There were two breeding pairs, which produced a total of four young. Two single birds were observed at two other sites. One was definitely unmated and occupied a site where a female peregrine died in 1969. The other falcon was seen at the fourth site only once. On the basis of this census it is concluded that the breeding population of peregrines in California is reduced at least 95 percent from the numbers that nested there as recently as 25 years ago. All evidence indicates that the total number of successful pairs in California in 1970 did not exceed five (Herman, 1971; Herman et al, 1970).

In 1969, Nelson indicated that 80-90% of the nesting peregrines in Utah, Idaho, Oregon, Washington, western Wyoming and western Montana have deserted their former nesting sites. Enderson (1969), in a 1964-65 survey, estimated approximately 25 breeding pairs of peregrines in Colorado and Wyoming and 25 pairs in Montana. In a 1972 cursory survey, Enderson (1972a) indicates six active eyries with pairs and two with lone birds in Colorado.

In 1960, Cade gave a population estimate of 600-1200 breeding pairs for all of Alaska, stating at that time that he believed this to be a conservative figure. In 1970, Shor offered a population estimate of at least 1000 Alaskan tundrius adults, based on banding data from Assateague Island, Maryland.

Cade (1960) lists three centers of high peregrine densities in Alaska: the inland foothill tundra of the Arctic slope in northern Alaska with an area of 45,000 square miles (mainly tundrius); the great interior Yukon system, which drains an area of about 140,000 square miles, excluding the delta and the drainages of the high mountains (mostly anatum); a third is centered in the Alaska Peninsula and the Aleutian Islands (mostly pealei).

3. Status and Population Trend

Both Falco peregrinus anatum and F. p. tundrius are on the USDI endangered species list. Population estimates for either subspecies are largely conjectural.

In 1946, Bond conservatively estimated that the breeding population of western North America might be 750 pairs (including all three subspecies). He felt that less than half of these pairs were anatum in the continental U.S., but believed that there might be a maximum high of 1500 breeding pairs in western North America. Enderson (1972a) believes there may be 200 breeding pairs of anatum in the continental United States at present.

At the times of the 1946 and 1960 estimates by Bond and Cade, the breeding populations were assumed to be stable, for the peregrine populations were maintaining themselves. In the 1950's, population declines were noted in Great Britain and the eastern U.S. (Hickey et al, 1969). The Alaskan populations were just barely stable until recently (Cade et al, 1971).

The peregrine populations in Alaska are declining on the Colville River. Occupancy of known eyrie sites here has decreased to between 50-60% where breeding is still occurring. An increasing number of these breeding pairs are failing to reproduce at all (Cade et al, 1970). The Yukon River peregrines are experiencing eggshell thinning, but in interior Alaska, populations are near their former numbers with a fairly good production of young. Enderson (1972a) believes that there may be 2000 breeding pairs of tundrius peregrines. Anatum populations are in a much more precarious situation at present than tundrius falcons.

White (1972) has estimated that there are around 300 breeding pairs of Peale's falcons on the Aleutian Islands.

4. Life History

In man's recorded history the falcon is a primary deity in Egypt: Horus, the "Lofty One," representing the sky and the sun. Falcons originally were worshipped there, but the use of falcons for hunting was discovered around 2000 B.C. in central Asia. By the twelfth century A.D., falconry was widely practiced throughout Europe.

The peregrine falcon was traditionally reserved for the pleasure of the nobility because of the bird's intelligence, strength and spectacular aerial performance. The peregrine is still highly valued as a hunting hawk by twentieth century falconers and accounts for the intense interest of many of that group in the falcon's welfare (see section 14).

Rapid wingbeats, interspersed with long glides on extended wings, are characteristic of the peregrine, and its speed in a dive is seldom exceeded by any other bird. This rate has not yet been determined with absolute accuracy, but has been estimated to be in excess of 200 mph.

When hunting aerial prey, the peregrine attempts to keep its quarry from going too far up or down, for if the bird can get into the trees, or if it can get above the peregrine, it can get away. When the peregrine is able to "ring up" and get above its prey to a reasonable height, the falcon can "stoop" (dive) and knock it to the ground. The falcon does not depend on speed alone, but may use the element of surprise, stooping from the direction of the sun or suddenly appearing from behind a cliff to strike its quarry.

Mated pairs of peregrines may hunt together, one of them "waiting on" (flying high above its mate, waiting for the mate to flush quarry) while the other frightens potential prey into a vulnerable position for attack. Sometimes a pair of falcons will develop a preference for a certain species of prey and may nearly eliminate the breeding population of this animal within their hunting territory.

The peregrine's principal food items are passerine birds, waterfowl and shorebirds. The vulnerability of the prey depends in part on the particular habitat they are in and the skill of the peregrines hunting them. Peregrines are very particular eaters, thoroughly plucking the birds before they eat them and tending to dine only on the choice parts, such as the breast, when food is abundant (Hickey and Anderson, 1969; Bent, 1937; Grossman et al, 1964; Brown et al, 1968).

The food requirement of a peregrine is about 11-12% of its bodyweight in warm weather, increasing to 15-16% in cold weather. The average daily consumption is 80-100 grams, according to temperature. Peregrines living in the Arctic probably consume from 120-150 grams (Brown et al, 1968).

Peregrines may occasionally live for twelve years or longer in the wild state, but this is very unusual. The average life span is probably four to five years. Life tables based on North American band recoveries from the now-extirpated Eastern population show a calculated immature mortality rate of 70% and an average adult mortality of 25%. These rates are representative of sharply declining populations in view of the former productivity of the Eastern birds. Several factors may bias these figures: immature falcons appear to be more vulnerable to shooting than adults; band loss alters the data; the date taken as the beginning date for age determination has an influence.

While juvenile mortality is high, it is not considered to be such a large figure for existing populations. Juvenile peregrines are very inexperienced, and this inexperience gets them into difficult situations that adults successfully avoid. They are not good hunters, have not yet achieved the fine coordinated flying of the adult, and are known to expend unusual amounts of energy in pursuit of game that they can't catch. All of these factors contribute to a higher mortality rate for juveniles (Enderson, 1969; 1972c).

Young (1969) constructed a hypothetical population model for peregrines with the following reasonable assumptions: longevity, twenty years in the wild; yearling mortality, 66-2/3% per year; adult mortality, 20% per year; nesting success, 60% per year; productivity, 2.5 fledglings per successful nest per year. With these parameters, the population maintains itself.

If adult mortality is increased by 10%, there is a 5% drop in population each year. A 10% increase in mortality over a three-year period results in approximately a 12% drop in total population.

If productivity is reduced by 10%, there is a 6% decrease in population in the same time span. If nest failure is increased by 10%, in three years there is a 5% population loss.

It would appear that adult mortality is a more important factor than either decreased productivity or increased nest failure. If each of these factors is increased by 10%, there is a 22% loss of the population in three years. Ten percent is not a very large increase, but there is a significant impact on peregrine populations. While the actual rates of these parameters in the wild are not known, it is obvious that many factors are operating simultaneously to the detriment of peregrine populations.

Trichomoniasis and botulism are two diseases known to occur in wild peregrines. At least 27 peregrines have been found in Utah that had botulism. They contract the disease either from ducks that already have it, dying animals, carrion or possibly from infected water. Botulism may have been one factor involved in the decline of peregrines in Utah (White, 1963; Trainer, 1969).

Trichomoniasis is known by falconers as "frounce" and is usually contracted from infected pigeons and doves. There are several strains varying greatly in pathogenicity. Some produce immunity in the bird, while other strains will kill them. Considering this variability of strains, it is not very likely that frounce has any appreciable effect on the pigeon and dove-eating peregrines (Stabler, 1969).

Peregrines apparently have very few natural predators. Raccoons may eat eggs and young falcons. Great horned owls will do the same when given the opportunity. Sonic booms may be a factor in some situations, perhaps cracking eggshells or disturbing the brooding adults (Hickey, 1969d).

The falcon's deadliest enemy is man. In the past, egg and skin collectors made serious depredations, but these were local situations and did not really have an influence on the overall population. The introduction of pesticides by man into the environment has been very detrimental to the peregrine's welfare. Peregrines at nesting sites are quite vulnerable to shooting, but the impact of shooting on the entire population is unknown.

Human harassment in the form of disturbance at eyries is a serious factor in some situations, particularly in parts of the West. Rock climbing is an increasingly popular activity and, when conducted at peregrine eyries during nesting season, usually causes the falcons to abandon their nesting attempts. Some falcons are exceedingly sensitive to disturbance and will refuse to breed if humans have been anywhere near their eyries. The increasing mobility of the human population has probably reduced the suitability of some habitat for peregrines.

Migratory behavior is largely restricted to tundrius falcons, although anatum in the more northern latitudes will move southward if the food supply is not adequate for the winter. Any migrating that anatum does apparently occurs in the interior of the United States but is not extensive. However, there is a major migration of tundrius birds in the spring and fall along the Atlantic Coast and the Gulf Coast of Texas. Tundrius falcons migrate as far south as Argentina during the fall (Enderson, 1969a, 1972c; Shor, 1970; Berry, 1971).

5. Reproduction

The reproductive cycle of anatum and tundrius is essentially the same. The variations exist in the timing. Tundrius birds seem to have a considerably shortened courtship compared to anatum at more southerly latitudes. Tundrius courtship may be only a week long, whereas the southernmost anatum falcons may have a two to three-month-long courtship before eggs are laid.

Tundrius peregrines generally arrive on their breeding grounds from the last week of April to the first week of May. This is the same time that the chief prey species (waterfowl, shorebirds and passerines) arrive.

Mating behavior and pair socialization for both tundrius and anatum can be classified into eight basic phases (Cade, 1960).

(1) Attraction of mates to each other. The nesting cliff is the geographic and ecological center about which most behavior between the mates occurs. Apparently the cliff itself draws peregrines, but the attractiveness of the cliff is increased by the presence of a peregrine of the opposite sex. The male or the female may arrive at a cliff site first. Either seems more willing to accept any other member of the opposite sex that happens along than to accept another cliff. An established male will attempt to drive away all other males, and an established female will attempt to drive away all other females.

(2) Mutual roosting on the cliff. The earliest indication of successful pairing is the quiet perching of the members of the pair on the same cliff or other favorite perching place in close proximity to each other and eventually sitting side by side.

(3) Cooperative hunting excursions. Around the same time that a mated pair start perching together they also start hunting together. While this is a casual event in the beginning, the hunting becomes cooperative, one falcon flushing prey for the other to capture.

(4) Courtship flights. The courtship flights of peregrines are spectacular aerial displays of rapid high climbing, spirals, steep rapid dives and exacting precision, especially when the male and female touch in mid-air. Courtship flight is apparently a modification of hunting movements, as these same techniques are used in the pursuit of quarry, although to different ends.

(5) "Familiarities" on the cliff. This behavior includes "billing" (touching beaks), nibbling at the beak or toes of the mate, and mutual preening of each other's wing coverts and scapular feathers.

(6) Courtship feeding. The male always feeds the female. He will carry food to her, chittering. When the female is receptive, she will approach him and accept the prey. This transfer of food occurs while both are in flight as well as when the female is sitting.

(7) Copulation. Mounting of the female by the male is frequent and increases as the time for egg laying nears. Copulation ceases shortly after the laying of the last egg.

(8) Nest-scraping. This activity occurs primarily before incubation. It often has little or nothing to do with the formation of the functional nest scrape in which the female lays her eggs, since scrapes made early in the courtship are not usually the ones which are finally used.

The female does about two thirds of the incubating and all of the brooding, while the male does most of the hunting. Incubation averages $\pm$ 32 days for each egg. Frequently, but not always, there may be a two-day interval between the laying of the eggs. In the tundra the eggs are laid close together so that there usually is no more than a three or four day age difference between the first and the last falcon to hatch. The fledgling period, when the young are living in the nest, is five to six weeks. The period of fledgling dependency after they leave the nest is about thirty days.

Egglaying usually takes place from the last week of May to the third week of June in Alaska. In Arctic latitudes, peregrines must lay their eggs no later than the beginning of the third week of June to ensure successful rearing of the young. By mid-September the bulk of the food supply is gone, and young peregrines that hatch late in the season will die.

The mean clutch size for peregrines in Alaska has been three eggs. The mean for continental United States has been 3.74 eggs. Hatching success in Alaska has averaged 2.5 young per eyrie, 3.0 young in continental U.S. Fledged young have averaged .7 to 1.5 in Alaska, which interestingly enough has been about the same in continental states.

Addling of eggs and the accidental destruction of eggs and young are probably the most important early mortality factors. The disturbing presence of large mammals such as man, wolves, caribou, moose and bears is sufficient to cause an Alaskan falcon to leave her eggs unprotected. In the continental states, the intrusion of man, even at some distance from the eyrie, is sufficient to cause desertion in some instances.

Once they hatch, and barring accidental death or predation, young peregrines seem to survive well in the nest. There is little indication that starvation or sibling cannibalism is frequent among them.

In the past, peregrines laid second clutches fairly consistently if the eggs were removed early enough during the breeding season by egg collectors or by natural causes. Apparently egg eating also occasionally occurred, but not with any great frequency (Cade, 1960; White, 1969; Hickey et al, 1969; Enderson, 1972c; see section 8).

6. Habitat Requirements

A basic component of a peregrine falcon's habitat is a cliff. However, peregrines are also known to occasionally nest on slopes and river cutbanks, mounds, an occasional sand dune, and flat bogs and plains. They may sometimes nest in hollows of old and very large trees. They have also been known to attempt to nest on manmade structures, such as skyscrapers (Hickey and Anderson, 1969).

Cliffs are the most commonly used type of nesting site, and there are continuing arguments concerning the qualifications of a cliff that will be used by peregrines. Favored cliffs are often extremely high, frequently overlook water and permit an extensive view of the surrounding countryside (Hickey, 1942). However, there are many such cliffs in the western states which are not occupied by peregrines, for unknown reasons.

Since there is such variability in cliff occupation, Cade (1960) suggested another factor, namely the falcons themselves. He feels that a first class eyrie is one occupied by a pair of "effective breeders," i.e., a pair that is usually able to fledge one or more young each year because the mates have successfully established all the social adjustments required for a strong pair bond. These pairs are always adults and presumably the longer they have been mated the more successful they will probably be reproductively.

Cade feels that tradition is a factor linking generations of peregrines to the same cliff. A pair of falcons establishes a preference for a certain cliff. The mates return each year to breed, establishing a history of use in their lifetimes. When one mate dies, the other acquires a new mate. The process of sexual socialization is resumed and, if successful, the history of the cliff is continued. As the older mates die and new ones are acquired, a tradition is established. If both birds die at once, the sequence is broken. The cliff may be reoccupied immediately by other falcons or it may never be used again.

White (1969) has suggested that genetic continuity may be involved in eyrie maintenance, especially if the juveniles return to the eyries where they were born and function as a "floating" population to replace members of pairs as they are eliminated. He has observed that this idea does not account for the establishment of new eyrie sites or the breeding of birds hundreds of miles from where they were born.

If a nesting pair is shot each year when attempts at occupancy are made, there is no tradition established, but every spring a new pair will try to occupy certain cliffs.

V. C. Wynne-Edwards has advanced the theory that perching and nesting places are identifiable by the birds from previous signs left there and that this possibly accounts for the persistent use of some cliffs. Falcons excrete down the cliff face and various lichens and algae colonize these areas. Old eyrie ledges often have a luxuriant growth of grass, differing from ledges not used by falcons. Regardless of the lapse of time involved, when a cliff is occupied or unoccupied, used ledges are the ones that will be reused first.

Apparently there is a threshold of acceptability of a cliff by peregrines that is subject to differing environmental conditions and behavioral variations of the falcons themselves. Some cliffs are highly acceptable and others are marginally so. Peregrines that occupy a marginal cliff may have a very wide range of acceptability. When they are no longer there, it may be a while before another pair of falcons with a similar range reoccupies that site.

Cliffs that have been deserted by falcons for a long time tend to remain empty. Usually all signs of former occupation have been obliterated. Utilization of cliffs also depends upon (1) population pressure as it affects the demand for nesting sites, (2) changing environmental conditions around the cliffs (such as major alterations of the environment by human occupance and changes in the availability of prey), and (3) shifts in population density resulting from climatic or major biotic changes occurring over a long period of years (Cade, 1960; Hickey et al, 1969; Hickey, 1969b).

Peregrines accept cliffs in igneous and sedimentary formations. Where they are available, falcons readily utilize limestone cliffs, since these often have small caves which can be used as nest sites and night roosts.

The precise type of location on a cliff chosen by the falcon for her eggs varies with the geological character of the cliff. A big hole, wide slit, or recess seems to be used most frequently, then a broad ledge, buttress or shelf, and a very few use a basin-like formation lying between some pillar or pinnacle and the main cliff.

The number of different nesting ledges used by a single pair of peregrines over a long period of years may vary from usually one or two to as many as seven. The maximum distance between alternate cliffs in different years may exceed four miles. Renesting in the same year usually involves a shift in nest site.

Cutbank nests have been found in Montana, western Canada and Alaska. Cutbank eyries frequently involve the use of old stick nests constructed by other species. This low nesting has occurred in regions where human populations are relatively small. Peregrines also may nest on steep slopes along river banks in Alaska.

Cliffs tend to represent the equivalent of escape cover to the peregrine. Successful eyries may have to be at least one-half mile from the nearest human habitation, unless the cliff is particularly high and precipitous (Hickey and Anderson, 1969).

The altitude of eyries in Alaska is rarely above 2000 feet. A sampling of ten eyries by Cade (1960) on the Yukon River produced the following average vertical measurements: height of nesting sites above the river, 183 feet (range, 50 to 300 feet); distance below the brink of the cliff, 50 feet (range, 20 to 100 feet); distance above the base of the vertical face, 57 feet (range, 10 to 250 feet). Six of the ten cliffs were outcroppings of Birch Creek schist, the

predominant substrate of the area; three were sandstone or conglomerate. One was volcanic rock. Seven of the sites were on ledges; three were in potholes.

Cade (1960) sampled 57 eyries on the Colville River and came up with the following averages: height of nesting site above the river, 110 feet (range, 10 to 300 feet); distance below the brink of the cliff, 44 feet (range 0 to 200 feet). Thirteen of the 57 were on shale formations, seventeen on sandstone or conglomerate, 27 on earth or talus banks. Thirty-one were on the ledges of precipitous faces, twenty-six were on the brink of the cliffs or at a prominant break in the slope of steep, but not vertical, bluffs. Eleven were in old nests of rough-legged hawks (Buteo lagopus). Many sites can be reached without ropes, unlike the inaccessible nesting sites of peregrines nesting on the coasts and Aleutian Islands.

The brinks of these cliffs are often overgrown with a dense thicket of alder and willow shrubs, especially on the Colville. Some of the Yukon River cliffs are overgrown along their brinks by briars of wild rose, which provides perhaps the best overhead protection for nesting peregrines.

On the Colville River, many nests are situated on the brinks of the cliffs with protecting screens of brush immediately uphill from the nest scrape, which is in the soil or, often, on the tundra mat. The nest site may also be located a few yards over the brink, down a more or less gentle slope at the "nose" of a second, sharp break in the slope of the bluff. About 45% of the eyries on the Colville are of these types, which have also been observed along the Old Crow River (Cade, 1960).

Rivers are significant to both the physical and biotic environment of the peregrine in Alaska. In many instances the erosional action of rivers created the nesting cliffs. In interior Alaska, rivers cut wide areas through otherwise heavily forested country, providing open expanses over which peregrines can hunt.

Peregrines bathe frequently, and the rivers provide excellent bathing facilities, particularly where gravel bars slope gently into the water. It may be of some significance that every peregrine eyrie that has been located on the Yukon and Colville Rivers is near such a gravel bar, or it may be just a coincidence (White et al, 1971).

Rivers also create conditions required by some of the prey species which are most frequently utilized by peregrines. On both the Colville and the Yukon, the extensive alluvial deposits in the form of gravel bars and islands provide habitat for shorebirds and waterfowl. In the foothill tundra of the Arctic slope it is only along watercourses that the important avian habitat of "tall brush" is found. This type of habitat is where passerines live. Peregrines will use the gravel bars for perching and as plucking places.

This close dependence on rivers produces a dendritic pattern of dispersion of interior peregrine populations during the breeding season. Coastal and insular populations have a basically perimetric pattern. These factors must be considered in any attempt to make population estimates of these species. The frequency with which clifflike formations occur over the terrain must also be taken into account (Cade, 1960).

Several investigators have observed that what seems to be suitable nesting habitat for peregrines is not occupied presently, and in some situations has never been used by falcons. The reasons for this remain unknown. Available data suggest that only certain cliffs out of all of those available are acceptable to peregrines and that these same cliffs will be used year after year (White et al, 1971). This factor may prove to be a critical one if reintroduction attempts are made in what appears to be appropriate peregrine habitat but turns out to be an area which the birds will not accept.

Another important requisite of peregrine habitat is an adequate food supply. If this is not available, the most suitable of nesting cliffs will not be occupied.

7. Protective Measures Instituted

(a) Legal or Regulatory

1. Falco peregrinus anatum is on the USDI and IUCN endangered species lists. Falco peregrinus tundrius is on the USDI endangered species list (Federal Register, 1970).

2. Both subspecies are protected by the treaty signed with Mexico in March, 1972.

3. F. p. anatum is fully protected in many continental states. It is illegal to kill any bird of prey in Alaska (with the exception of snowy owls in some areas). A permit from the Commissioner of Fish and Game is required to possess a live hawk. This regulation refers to F. p. anatum, F. p. tundrius, and F. p. pealei.

(b) Captive Rearing

There are at least sixty pairs of peregrines in breeding projects and there may possibly be up to 100 pairs involved. In Colorado there are at least fifteen pairs. Not all the birds in the National total are adults over three years old; neither are they all in excellent quarters, and some are probably being used for falconry (Enderson, 1972a).

A list of successful people in recent years includes:

1. Tom Smylie, Cibola National Forest, Albuquerque, New Mexico, 1972 - 1 fertile anatum egg and hatchling; the hatchling died.

2. Heinz Meng, New Paltz, New York, 1971-72 - 8 Peale's falcons

3. Tom Cade, Cornell, New York, 1972 - 3 fertile tundrius eggs hatched and died.

4. Bill Burnham, Canyon City, Colorado, 1972 - 3 fertile anatum eggs (no hatch)

5. Richard Fyfe, Canadian Wildlife Service, Edmonton, Alberta, Canada, 1972 - 3 fertile pealei eggs hatched and died.

6. Larry Schramm, Oregon or Washington, 1971, 1972 - several Peale's falcons (Enderson, 1972a, 1972c).

People who have been successful in previous years include Frank Beebe, Saanichton, B.C., who has had Peale's falcons breed in captivity.

There are many problems associated with these captive breeding projects. So far no set of standard conditions has appeared to insure success. Operating with any given set of conditions that have been tried, some falcons will breed and others will not breed under the same circumstances.

Variability of individual behavior of the falcons is, perhaps, the only consistent factor. Some peregrines have produced fertile eggs, while others have not. Some falcons will successfully hatch their eggs; other peregrines will eat their eggs. Some falcons never establish pair bonds. Some peregrines that experience egg failure will raise nestlings brought to them.

Even the people who have had peregrines breed in captivity disagree as to the conditions that contributed to their success. Captive breeding projects are still highly experimental and inconsistent in their results. Some researchers seem to be having more success than others, and it is hopeful that peregrines can be propagated in captivity.

Beebe (1967), Enderson (1967), Galicz et al (1971), Lejeune (1971), and Nelson (1971) provide a lot of information on the technicalities of captive breeding projects.

(c) Habitat Protection and Improvement

Deterioration of the habitat is not the major problem for the peregrine falcon. Much of Alaska still has all the necessary requisites for good peregrine habitat. Even states with dense human populations like California and Colorado have more than enough suitable nesting sites for the present populations. The major problem seems to be that relatively few peregrines are breeding (see Section 8).

Many of the remaining active nesting sites are being afforded whatever protection is possible. The best protection of all is received by peregrines with unknown nesting sites. Keeping known nesting sites unadvertised and therefore not subject to pressures from visiting human beings is another form of protection. In some situations there is surveillance of well-known eyries during nesting to prevent harassment by human beings.

(d) Reintroduction

To date there have been no attempts to reintroduce peregrines into parts of their former range or even their present range. For one reason, progeny that have been successfully obtained from captive breeding projects have usually been kept in those projects. There is also a great reluctance on the parts of successful individuals to release any birds back into what may be an excessively contaminated environment for them.

However, reintroductions eventually will be attempted. Nelson (1969a) believes that the peregrine falcon is one of the easiest raptors to re-establish in a new site. He has offered a technique to effect the re-introduction of golden eagles, which could be adopted for peregrines.

This technique essentially involves choosing an eyrie site for a male and a female eaglet, hand raising them in this location with the least association with human beings as is possible. A food supply would be maintained and the eagles watched to protect them. Presumably, when they reached sexual maturity they would pair and produce young.

There are numerous difficulties involved in adapting this technique to peregrines. One is the difficulty of establishing a pair bond where there is no choice available for the birds. A pair chosen at random may be quite unsuited for each other. Another serious problem is that the falcon's physiological ability to reproduce has been significantly reduced so that while a pair bond may be established, the male or female may be sterile, or the female may be unable to produce eggshells of sufficient thickness to function properly. Furthermore, the hazards produced by environmental contaminants have not been sufficiently reduced, so that the likelihood of a given pair remaining unaffected is very slim (see Section 8).

8. Identification of Limiting Factors

Up until 1970, the Alaskan peregrine falcon population as a whole was still maintaining itself (Cade et al, 1970). By that same year, the population of peregrines in the West was seriously reduced, and breeding falcons were completely extirpated in the eastern third of the United States.

This phenomenon has not been restricted to the United States. A rapid decline of the peregrine in North America and Europe began after World War II, which is the same time that organochlorine pesticides, specifically DDT, came into extensive use. The peregrine decline in North America began around 1947, accelerated greatly in the East during the 1950's, and has since spread west and north.

Two slow, long-term population trends may have had an influence on peregrine populations. Nelson (1969b) has suggested that climatic changes may have brought about a northward shift in falcon distribution. At the time that he presented this theory, the western mountain region was hotter and drier than it had been in the past, reducing the water supply and thus decreasing the number of waterfowl and shorebirds, which are a major component of the peregrine's diet. With a reduced food supply available, the falcons would not be able to maintain themselves in these areas. However, a thorough study has not been conducted on what effects climatic changes may be having on peregrine populations, and the theory remains conjectural (Enderson, 1972c).

Increasing development of the West, resulting in complete loss of peregrine habitat, is having an effect on western populations. The other trend which affected the eastern population was the effects of increasing human activity on nesting sites in the East. Neither of these factors accounts for the sudden population decline in the 1950's. This rapid crash was characterized by consistent reports of "nonbreeding" adults and by occasional descriptions of broken eggs which are now assumed to accompany the actual eating of the egg contents by the falcons.

The peregrine decline in Great Britain was marked by eggs that were laid but failed to hatch and many broken eggs. This was followed by the apparent inability of the birds to lay eggs. The final stage was the disappearance of the adults themselves (Ratcliffe, 1969).

The presence of broken eggs prompted several researchers to begin to measure the thickness of the eggshells. Hickey and Anderson (1968) found that an 18.8% decrease in peregrine eggshell weight took place in thirty-one eggs collected in California during 1947-1952. Each change reflected shell thickness, was statistically significant and without precedent in the previous history of each population recorded in museum collections.

The eggshell change also occurred in New England, beginning in 1947, as it did in Great Britain. This was around the same time that agricultural pesticides, particularly the organochlorine compounds, came into general use. 1947 is the year in which broken eggs were definitely reported as a significant occurrence (Hickey et al, 1969f).

A variety of chemicals such as dieldrin, BHC, heptachlor, endrin, DDT, TDE and DDE have been found in peregrine tissues. DDE, dieldrin, BHC, heptachlor and endrin have been present in lethal concentrations in a number of peregrines that have been autopsied in Great Britain. All of these chemicals are fat soluble and tend to be stored in the fatty portion of the vertebral organ tissues. The highest residues occur in the fat itself. Residues are also present in the yolks of eggs. Very small or no residues have been found in egg whites.

DDT has several metabolites, including TDE (DDD) and DDE. DDE has proven to be one of the most detrimental compounds to the peregrine. It is one of the most persistent pesticide residues in marine, aquatic and terrestrial ecosystems. DDE is the most potent eggshell thinner. As little as 5 ppm has produced eggshell thinning in prairie falcons (Enderson, 1972c).

There are two effects to be considered: acute poisoning and sublethal chronic poisoning. The actual range of DDT and TDE in the brains of animals killed in dietary experiments is from 31-181 ppm. In general, brain levels of 30 ppm of these two compounds offer a useful approximation of the lower limit that may be taken to represent serious danger and possible death. Peregrines probably feed primarily on prey weakened by high concentrations of pesticides. However, wild peregrines are rarely found with pesticide residues high enough to be lethal to the birds themselves.

It is felt that sublethal chronic poisoning is far more serious than acute poisoning. Some falcons may have normal or nearly normal reproductive success when there are relatively large DDT residues in eggs, but these eggs have thin shells and the likelihood of hatching is decreased.

Long-continued intake of small doses is far more lethal than once suspected. Birds receiving a few parts per million of endrin, aldrin, dieldrin, DDT, or alternate combinations may seem healthy, but may die when subjected to a stressful situation that ordinarily would not affect them (Hickey et al, 1969c, 1969f).

Since a peregrine may carry 1200 ppm DDE in its tissues and live, the hypothesis that pesticides are involved in the decline of the peregrine is still questioned, particularly by the chemical companies producing these compounds. Cade et al (1968, 1971) and Ratcliffe (1969) have contributed information substantiating the theory that pesticides are definitely detrimental to the species.

The peregrine falcon is the top predator in its ecosystem, a fact of particular significance in connection with concentrations of pesticide residues throughout the food chain. The peregrine contains one of the highest levels of DDE residues of any known vertebrate, an average of 24 ppm in some populations (Enderson, 1972c).

Most of the Alaskan falcons' food consists of migrant birds. At least half of the birds that the peregrine eats are carnivores or insectivores, which contain higher pesticide levels than herbivores.

Resident prey species average only a few tenths ppm of DDE, TDE and DDT. Migrant seed eaters are slightly higher. Migrant insectivores are higher still and ducks and gulls contain even more. All peregrine materials and tissues measured to date have contained residues that were 10-100 times more concentrated than they are in the prey species. Adult tissues, especially fat, contained the highest concentration of residues.

The concentrations in any given tissue are 10-20 times higher in adults than in juveniles, four to six weeks old; but in a few weeks of life, the young appear to have acquired significantly higher concentrations of residues than commonly occur in their food species. Even in remote areas of Alaska, the peregrine's prey is contaminated with significant, measurable quantities of persistent residues of the chlorinated hydrocarbons.

Most advocates of the pesticide theory have felt that the population decline was initially brought about by sublethal effects associated in some way with reproductive failure.

Varying pesticide concentrations are being found in raptor populations which are declining. Species differences or even local population differences in susceptibility to pesticide effects may be involved. However, the levels in the brain associated with death seem to be rather uniform among a variety of species.

The effects of pesticides may be initially, if not mainly, on the reproductive physiology and behavior of breeding adults. It has been shown that hydrocarbons stimulate the induction of drug-metabolizing enzymes in the livers of laboratory mammals. These drug-metabolizing enzymes also hydroxylate steroid hormones such as progesterone. Hydroxylation of a steroid can interfere with its biological function. The induction of an enzyme that can alter steroid structure offers the possibility of a powerful mechanism that could cause abnormalities in behavior and physiology of the reproductive cycle at any point, depending upon which hormones were affected.

The significant decrease in eggshell weight associated with the peregrine decline is symptomatic of a disruption in the normal mobilization and metabolism of calcium during the period that the shell is being laid down in the oviduct. Estrogen, one of the hormones affected by enzymes induced by chlorinated hydrocarbons, is intricately involved with the parathyroid hormone and what happens to calcium during the period of ovulation (Cade et al, 1968, 1971; Hickey, 1969c, 1969f).

A substantial number of tundra and taiga peregrines (tundrius and anatum) now lay eggs with shells as thin as those associated with the decimated populations of California and the eastern U.S. Alaskan falcons have experienced a chronic, altered reproductive physiology which in its extreme is definitely involved in the extirpation of this species over many parts of its range.

The number of breeding pairs in the Colville and Yukon areas remained steady through 1969, but the production of young has been decreasing since 1966. This decrease in reproduction appears to be associated with an increase in the number of pairs that fail completely rather than a decrease in clutch size or reduced hatchability of eggs.

It is probable that Alaskan peregrines have maintained their numbers with a marginal reproductive physiology since the early 1950's. This is probably because they breed in areas where organochlorine residues have remained below the threshold that initiates population declines.

Many individual females probably can no longer reproduce because of the pesticide residues in their systems. Observations in 1970 indicate that the tolerable residue level has been exceeded and recruitment no longer equals the adult mortality rate. Paired falcons have begun to disappear from their historic nesting sites on the Colville and the Yukon Rivers (Cade et al, 1971).

A significant number of adults is being removed from the reproductive cycle by an inability to breed successfully. Failure to produce substantial egg shells seems to be one of the most serious problems. Abnormalities in behavior, such as eating eggs and nestlings, and failing to brood the young properly are also involved.

In the past, most peregrines have been quite tolerant of human intrusion into their nesting territories. In the extreme range of tolerance, they have successfully nested on skyscrapers in large cities. Researchers disagree on the impact of visits to the eyries. Some feel that they should not be visited at all, while others think that there are no harmful effects produced by human activities.

Nelson (1970) believes that there is a short period prior to and during egg laying when desertion of a nest ledge can be caused even by careful visits by man. Cade, Enderson, White and Craig have also questioned the possible effects of nest visitations on peregrine behavior.

Since accumulated pesticides apparently are producing abnormalities in behavior patterns, human activities may be much more influential than they have been. The critical period when desertion may occur is probably as variable as the behavior of the individual falcons.

An exceedingly detrimental result of the removal of breeding adults from the population is a reduction in the functional gene pool, increasing the importance of the variability of behavior. Five pairs of peregrines may tolerate activities by man that the sixth pair will not. However, that sixth pair may be the only one to reproduce successfully. Human disturbance of these falcons would have far more serious ramifications than disturbance of the other five pairs.

Despite the laws protecting raptors, people continue to shoot birds of prey, including peregrine falcons. Many of the band returns are from peregrines that have been shot. With the breeding populations declining, the effects of shooting are even more significant because of the possibilities of removing successful breeders. Intensive efforts may have to be made to re-educate people so that they will no longer do their target practicing on birds of prey.

Enderson (1972a) feels that human activities in Alaska will have an effect primarily on local populations. Compared to pesticides, the human impact there is negligible to the species at present. However, the effect of humans on the continental anatum populations is very significant and should be controlled as much as possible.

Obviously, if there is to be any chance of halting the decline of the peregrine, population and breeding surveys and other studies must continue. Cade (1971) has emphasized the need for coordinated efforts and control over these studies, which would also include the taking of birds for research in captive situations. Active participation and cooperation on the parts of all individual parties and agencies concerned should produce workable species and habitat management plans that would at least halt the downward population trend of the peregrine.

9. Recommended Species and Habitat Management Techniques

1. Conduct a survey of public lands to locate active peregrine eyries and institute measures favorable to their continued success, such as isolation and protection from human beings (Craig, 1972; Enderson, 1972a).

2. Cease using persistent pesticides.

3. Keep careful records of all peregrines in captivity (Enderson, 1972a).

4. Continue efforts towards captive propagation.

5. Reintroduce peregrines into suitable areas when it appears that their chances for survival and successful reproduction are good.

6. In Alaska, carefully and strictly monitor any exploration and construction activities occurring in areas that peregrines are known to inhabit. (Oil exploration teams have unintentionally caused the deaths of peregrine nestlings by frightening them from their nests while taking geologic samples from the nesting cliff. If the young falcons could not fly, they would be killed when they fell. In some instances, the adults have deserted their eyries (Craig, 1972)).

7. Lack of knowledge of the effects of human activities has inadvertently caused some peregrine mortality. Educational programs to inform survey and construction crews about peregrines and other raptors should reduce this problem.

8. The peregrine falcon populations of Canada are also declining. The Canadian government has been involved in population and breeding surveys and close supervision of the harvest of Peale's peregrines for research purposes and falconry. The effects of pesticides have not been limited to peregrines living in the United States. The Canadian Wildlife Service should have useful information on their approaches to species and habitat management for the falcons. A cooperative program between the Canadian Wildlife Service and United States agencies may produce beneficial results to peregrines living in both countries.

9. A definite possibility for habitat management is the restriction of activities around known eyries during the breeding and nesting season, as there are certain times of the year when these sites are vulnerable to human interference and other times of the year when they are not. As an example, it is known that peregrines tried to nest during 1972 in the Black Canyon of the Gunnison in Colorado. Unfortunately the very area they chose for their eyrie also has much appeal to rock climbers. At least one climb was attempted in this particular part of the canyon, and the feeling is that the peregrines probably were unsuccessful, as juvenile peregrines have not been seen there. If this area were closed to climbing from mid-February to the end of July, the peregrines would have a chance to raise their young, and rock climbers could enjoy the canyon the rest of the year (Enderson, 1972c).

10. Ongoing Research Projects

1. Several captive breeding projects are in progress (see Section 7b).

2. Population surveys are being conducted every year by different individuals for migrating tundrius falcons. The Raptor Research Foundation usually disseminates this information.

3. Surveys of breeding success are being conducted throughout the continental United States and Alaska by state game and fish agencies.

4. Pesticide monitoring is being maintained by Clayton White and T. J. Cade and associates.

5. Dr. James Enderson at The Colorado College in Colorado Springs, Colorado, is applying for a grant to develop management techniques for raptors. Part of the research will include methods of increasing productivity of birds of prey, including the peregrine falcon.

11. Authorities

1. Dr. Tom J. Cade (F. p. tundrius and anatum)
Ecology and Systematics
Building 6, Langmuir
Cornell University
Ithaca, New York 14850

2. Dr. James H. Enderson (F. p. anatum)
The Colorado College
Colorado Springs, Colorado 80903

3. Dr. Clayton White (F. p. anatum, tundrius and pealei)
Department of Zoology
575 Widtsoe Building
Brigham Young University
Provo, Utah 84601

4. Steve Herman (F. p. anatum in California)
Department of Zoology
University of California
Davis, California 95616

5. Morlan Nelson
73 East Way
Boise, Idaho 83702

12. Governmental, Private and International Organizations Actively Involved With This Species' Welfare:

A. 1. Raptor Research Foundation, Inc.
c/o Dept. of Biology
University of South Dakota
Vermillion, South Dakota 57069

2. The Raptor Research Foundation 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. A major activity is the publication of Raptor Research News, which serves to convey information contributed by researchers on birds of prey.

3. Dr. Byron E. Harrell, President

4. The RRF is one of the main coordinators of captive peregrine breeding projects.

B. 1. National Audubon Society
950 Third Avenue
New York, New York 10022

2. The major objective of the National Audubon Society is to advance public understanding of the value and need for conservation of our wildlife, its habitat, and all natural resources, and the relationship of such wise use and intelligent treatment to human progress.

3. Charles H. Callison, Executive Vice-President

4. National Audubon has a series of leaflets and charts on birds of prey and has concentrated its efforts for raptors in the area of education and protective legislation. They have also funded some of the peregrine population surveys.

C. 1. Colorado Division of Wildlife
6060 Broadway
Denver, Colorado 80216

2. All raptors in Colorado are fully protected. Falconry is permitted and regulated. Peregrine falcons may not be taken for falconry purposes. Peregrine population and breeding surveys are being conducted.

3. Gerald Craig, Raptor Biologist

D. 1. California Department of Fish and Game
The Resources Agency
1416 Ninth Street
Sacramento, California 95814

2. The peregrine falcon is fully protected in California. Peregrines can no longer be taken for falconry purposes. Population and breeding surveys are being conducted.

E. 1. Bureau of Sport Fisheries and Wildlife
Patuxent Wildlife Research Center
Laurel, Maryland 20810

2. Facilities for peregrine breeding projects have been constructed and several falcons have been obtained. These falcons appear to be too young to reproduce.

13. Listing of Photographic Material Available for Duplication

Gerald Craig, Raptor Biologist for Colorado Division of Wildlife, has offered the use of his photographic material of peregrines (anatum and tundrius) to the BLM. Dr. James Enderson at Colorado College, Colorado Springs, Colorado will also make available any photographic materials on peregrines, including slides of suitable peregrine habitat in the West, which the BLM may find useful.

14. Falconry

Falconry is a factor that cannot be ignored. As mentioned earlier, the peregrine is a highly prized hunting hawk. Peregrine falcons bring high prices in some parts of the world. A few falconers have found it worth their while to illegally take these birds and sell them.

One of the major concerns of some falconers is whether or not they will be able to continue taking peregrines to train for hunting. This is a primary reason for their interest in the captive breeding projects. Many of them are hopeful of producing a domestic strain of peregrine that will supply them with birds for future hunting.

Surveillance of well-known peregrine eyrie sites may prove to be necessary in some situations. Unfortunately there are a few falconers who are determined to have a peregrine, regardless of the possible effects they may have on the falcon's ultimate well being as a species. Eyrie information should be carefully guarded, as these people would be eager to know where they could go to take a peregrine even if it is illegal.

However, this is a minority group among those who practice falconry. Much of the present information on peregrines has come from concerned falconers. Many have given up flying their peregrines to put them into breeding projects. Some of them have expended a great deal of their own money and time on research into peregrine problems. Many of them actively discourage the practice of falconry, and most of them abide by the laws protecting all raptors.

Many of the recognized authorities on the peregrine falcon are presently practicing or have practiced falconry. Falconers organized the Raptor Research Foundation and have sponsored many important research projects on the peregrine.

Falconers for the most part are a cooperative, resourceful, well-informed group of people highly concerned about the welfare of the peregrine falcon. The value of their assistance in efforts to establish management programs should not be overlooked.

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