MANAGEMENT

OF RAPTORS

Proceedings of the Conference on Raptor Conservation Techniques,

Fort Collins, Colorado, 22-24 March, 1973 (Part 4)

Frederick N. Hamerstrom, Jr.,
Byron E. Harrell, and
Richard R. Olendorff, Editors

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RAPTOR RESEARCH FOUNDATION, INC.

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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 are appearing in parts as follows.

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The roles of the editors are as follows. The primary scientific review of all but one of the submitted papers was done by Hamerstrom. Olendorff's role was primarily development of the original concept and organization. Harrell edited one paper, the abstracts, and the informal discussion, handled all managing editorial aspects, and prepared the index, preface, and general format and design.

We hope that this publication encourages the use, development, and testing of raptor management techniques. The Raptor Research Foundation has set up a Raptor Management Committee under the chairmanship of Richard Fyfe to encourage the continued development of this field. We hope that an informal information exchange in this area can be started soon.

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THE LAW AND NORTH AMERICAN RAPTORS

Frank M. Bond

The birds of prey of North America are afforded protection with some exceptions in Canada, the United States of America, and Mexico. It was not until March 10, 1972 with the expansion of the annex to the "Convention between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Animals" (50 Stat. 1311) and the Migratory Bird Treaty Act (83 Stat. 282) that raptor protection was achieved in the United States and Mexico. The annex includes all birds of prey. In those states in the United States and Mexico where raptor protection did not exist or only partially existed, the federal treaty bound them to at least the minimum standards as set forth in the Migratory Bird Treaty Act. As of this writing, in the United States many of the various state legislatures are considering legislation which will bring their laws into compliance with the federal treaty act.

Canadian raptor protection has been achieved because the various provincial governments have decided individually to promulgate legislation and regulations toward this end. With any renewed negotiations concerning migratory birds between Canada and the United States, birds of prey may be added to the protected list, thus binding Canada at the federal level to similar protection.

Provincial, state, and federal laws and regulations deal with raptors specifically in the following areas: total protection without exception, captive propagation, falconry, raptor rehabilitation, and the raptor pet trade.

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1. *Total protection without exception.*

To my knowledge total protection of raptors without exception does not exist anywhere in the three countries under discussion. In some of the eastern states of the United States the only exception for raptors are those to hold in captivity as pets. In most cases these raptors are exotics.

2. *Captive propagation.*

Facilities for captive propagation of raptors have been built all across the United States and Canada by individuals and institutions. There are not any known propagation facilities in Mexico.

Provincial and state governments have normally dealt with captive propagation by regulating it under scientific permit. In some of the midwestern and eastern provinces and states of Canada and the United States, captive propagation is the only recognized legitimate use of native raptors.

In the United States, although the birds of prey are protected federally, it is expected that the propagation programs will be regulated at the state level.

3. *Falconry.*

Falconry is currently being practiced in Canada and the United States under a myriad of provincial and state laws. In Mexico falconry is regulated at the federal level.

Again in some Canadian provinces and various eastern states of the United States falconry is not a legal activity. However there are mitigating circumstances in some states of the United States. For example, in some eastern and midwestern states exotic raptors may be held and flown free, in some cases at wild quarry and in other cases not.

In the expansion of the annex to the "Convention between the United States of America and the United Mexican States for the Protection of Migratory Birds and Game Animals" and the Migratory Bird Treaty Act, falconry was included as a legitimate use of raptors. Consequently the U. S. Bureau of Sport Fisheries and Wildlife is writing a set of federal falconry regulations to be handled at the state level. The federal regulations will supersede the state regulations in those cases where the state regulations are not equal to or more stringent than the federal regulations. The proposed federal regulations do not mandate the sport of falconry; thus, where falconry is not now legal either by state legislation or regulation it will not necessarily be legal when the federal regulations are adopted. The proposed U. S. federal regulations on falconry will be included in Subchapter B, Title 50, Code of Federal Regulations when they are published in their final form.

4. *Raptor rehabilitation.*

Raptor rehabilitation is being carried on legally by individuals and institutions in various provinces and states. Normally this activity is regulated under a special rehabilitation permit. Some individuals work under the auspices of their falconry permits.

5. *Raptor pet trade.*

Many exotics are imported annually into the countries under discussion. A number of these imported birds go to captive breeders and falconers, but most are held by pet keepers for various reasons. In most states only a special import permit is required. However, if the exotic birds are to be used for captive propagation or falconry, the regulations governing these activities will prevail.

Federal Legislation

In the United States other extant and proposed federal legislation and regulation have or will have some impact on the handling of raptors.

1. The Lacey Act requires that an individual have a permit to transport interstate any native wildlife, which includes, of course, raptors.

2. The Bald Eagle Act protects the Bald Eagle and the Golden Eagle. The act was amended in 1972 to include stiffer fines and prison sentences for violations and to include the use of depradating Golden Eagles for falconry.

3. There are two bills before the 93rd U. S. Congress to provide for the conservation, protection, and propagation of species of fish and wildlife threatened with extinction. Both bills, H.R. 37 and H.R. 470, were introduced by Congressman John Dingell of Michigan. Under these acts, the Secretary of the Interior will publish annually an endangered species list. The Secretary will determine by regulation the extent of protection and under what circumstances endangered species may be used for propagation. Neither bill as of this date has had a hearing in Congress.

Federal Regulations

1. The federal falconry regulations were discussed above.

2. On January 26, 1973 the U. S. Department of Agriculture published a set of proposed regulations in the *Federal Register* to restrict the importation of all species of birds because of the exotic Newcastle's disease. In their present form the regulations require that the importer obtain an import permit prior to importation, have a health certificate from the country of origin, and quarantine the bird(s) for a minimum of 30 days in this country.

All of the laws and regulations which I have discussed here are subject to change at any time. Since many of the laws and regulations are in a state of flux, I urge that all of you working with raptors seek the most up-to-date information from your local wildlife/conservation agencies, the Department of the Interior (Bureau of Sport Fisheries and Wildlife), and the Department of Agriculture.

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suses both before and after one has applied a technique. In some instances, like Postupalsky and Stackpole (1974) erection of nesting platforms for Osprey where nest sites were deteriorating, the results were so dramatic that it is clear that Ospreys produced young that would not have existed without the platforms.

Most game managers were trained to supply game for sportsmen. The raptor people tend to be more global in their thinking and, as times have changed, they are more aware of rare and endangered species.

Providing nest sites will often prove to be only part of the problem. We need landscaping for raptors toward a workable relationship between nest sites and hunting areas. The Raptor Management Area in the Snake River in Idaho, instigated by Morlan Nelson, is a tremendous step ahead in meeting the need for land for raptors. Not all management units will need to be on the same scale. The scatter-pattern plan used by our Prairie Chicken Project in Wisconsin is an example (Hamerstrom *et al.* 1957). The principle is simple. Figure 1a shows a scatter-pattern of land purchase proposed in 1954 for Prairie Chicken Management—to infiltrate the entire 46,000 acre (18,607 ha) management area with Prairie Chickens. (The plan has been somewhat modified, but the scatter-pattern is successfully in operation.) Figure 1b shows exactly the same acreage (3182 acres; 1287 ha) in a single block. The zone of influence for Prairie Chickens of the single large parcel would have been limited to about five sections and their immediate vicinity if we had been forced into a block purchase. About 77 sections are infiltrated by the scatter-pattern. Blocking can be an administrative luxury.

Having presented a principle, I will further add that in the Lake States and

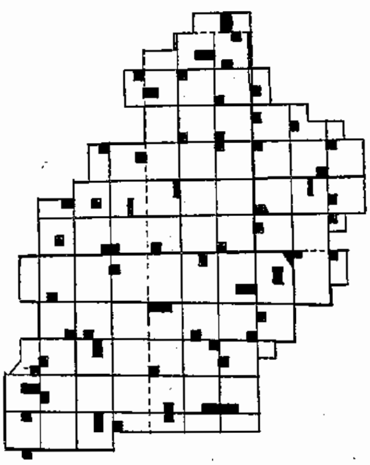

Figure 1a. Scatter pattern for infiltration of area.

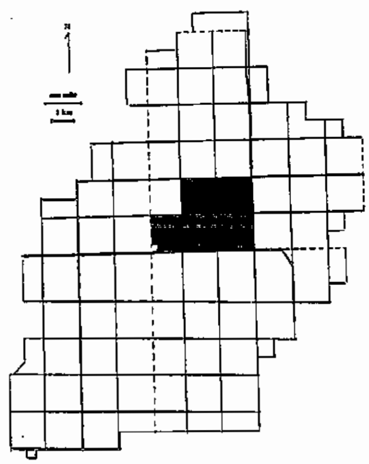

Figure 1b. Solid block management—less efficient for many species.

perhaps elsewhere, good Prairie Chicken management is also good Harrier (*Circus cyaneus*) management. Of 37 Harrier nests found on my entire area 1970-1973, 32 were on lands managed for Prairie Chickens.

Not only open country raptors benefit by game management; good Ruffed Grouse management can benefit Goshawks. The climate is ripe to share lands with the gun hunter.

Much game management has been inadvertent. We will find this to be true of raptor management as well. As pointed out by James K. Parker (1974), shelter belts are providing nesting sites for Mississippi Kites in southeastern Colorado, western Oklahoma and north Texas.

An enormous opportunity for raptor management exists by breaking up monotypes on both public and private lands. I will give two examples: SCS pasture improvement programs are entirely obliterating brush from pastures, especially in the Southwest. How many trees or clumps of trees would they need to leave standing to hold a raptor population? It is well known that ground squirrels increase with overgrazing. A number of species of raptors breed more prolifically when food is abundant, and many raptors eat ground squirrels. Leaving enough trees for raptors not only should provide a healthy diversity to the landscape, but might even benefit the cow. Research is needed on how many trees to leave, and whether in clumps or as singles and whether to supply exclosures. Exclosures provide a broader food base for the raptors, protect existing trees from cattle, and give seedling trees a chance.

Brushland management on pasture in the southwest and parts of Mexico is critically needed. Harris' Hawks are now extremely common, but the brushlands that they depend on are being obliterated at an alarming rate. Federal subsidies are helping to obliterate the Harris' Hawk over vast expanses in the name of pasture management. Brushland is being converted to plowland in many parts of south Texas and Mexico.

A wise approach would be to stipulate that a certain percentage of pasture be left in brush to qualify for ACP or similar programs. Hunting rights are an important part of the ranch income on many such lands. Perhaps here too we can cooperate with the gun hunters. Game managers and raptor managers not infrequently desire the same land-use patterns. Game managers are supplying quarry species for raptors too.

During this conference there has been considerable discussion of PRESERVING habitat. Let's expand our thinking beyond preservation. Leaving the land be is for specialized stable environments. They are relatively rare. As a rule we need to manipulate the land. I shall use fire as my example. Fire is natural and a management tool. Let me speculate on the Peregrine decline east of the Mississippi River. Fire suppression has changed the landscape: How did the Great Smoky Mountains get their name? They were burning when they were named. The early settlers in Boston had to take rowboats to get firewood from the islands—there was so little left on the mainland (Bromley 1935). Fire sets back the plant succession and releases a wealth of new habitat and quarry species. I do not question that it was pesticides that obliterated the *anatum* Peregrine from its range east of the Mississippi, but if we are to bring them back we need to recognize that other bad things were going on at the same time. Smokey Bear was holding sway. The Peregrine cliffs that I roped down to in the '30s' now have tall trees at their bases. Some have gone from Grade A cliffs to Grade C and the quarry species are fewer as well. Dense forests are not optimum habitat for most—if any—diurnal raptors in North America. Even forest raptors need openings.

The Swedes have an expression THE GREEN LIE. The Green Lie looks like a forest, but the site is so poor that few trees will ever be fit to harvest. We have plenty of Green Lie forest lands in North America—some of them are even monotype plantations. The creation of openings in such forests will benefit not only grouse, deer, rabbits and bear, but also many raptors. Richness occurs in a varied landscape.

Raptor management differs from game management in that raptor managers are dealing with the top of the food chain. One of the most fascinating innovations suggested (Jon Gerrard pers. comm.) is to supply Bald Eagles with open water by removing ice where fishing is good. Thus in cold parts of their range they can have the advantage of nesting earlier. Pothole excavation, artificial nests, captive breeding, reintroduction, adoption, artificial insemination may all sound to a pheasant manager like the little Dutch boy sticking his thumb into the dike. But top-of-the-food-chain approaches need to be recognized as operating in a different league.

However we approach these problems, if man does not limit his own population all our efforts will be in vain.

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DATA REQUIRED FOR EFFECTIVE STUDY OF RAPTOR POPULATIONS

Leslie Brown

I have been prompted to write this paper as, in the course of pulling together data for several books and papers, I have sometimes found it extremely difficult to make valid comparisons between studies on the same or similar species because of wide inconsistencies of approach and variations of technique. To an extent these are unavoidable, but I believe that we can study raptors more effectively if we make an attempt towards standardizing the approach to a variety of questions. In this way we may be better able to draw sound conclusions as to how any species of raptor lives, hunts, reproduces, and survives from the nestling stage to sexual maturity, so completing the life cycle.

Some data are best gathered from captive birds. Some of it can only be gathered from studies of live birds in as natural an environment as possible, that is, as free as possible from the factor of deliberate human interference or the effects of pesticides. The latter condition is hard to fulfill in developed countries at present, though from some of the papers delivered it is clear that there are remote parts of America where natural conditions apply. In underdeveloped countries it is easier to study populations of birds of prey which are less subject to human disturbance or the adverse effects of human beings on the environment.

The data which I believe are required for any raptor species can be summed up under the following heads.

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data to deal with controversial issues on a factual basis. However, a good deal of this is at present hidden in M.Sc. theses or unpublished reports not available in general literature.

In this connection, I would say that for a rare species 100 food items gives a useful indication; but this is totally inadequate for a common species with wide variation in food preferences according to availability. One thousand recorded food items are just about adequate, 2,000 good, and 10,000 is practically unarguable, at least by persons who have never in their lives actually recorded even ten specific instances of prey killed. The majority of the human enemies of raptors fall into this class.

There is also, here, much need for a multi-discipline approach. Too few bird of prey studies have been correlated with the numbers and availability of prey. Again, the work of the Craigheads (1956) is a shining exception, and of Tinbergen (1946) in his monumental study of the European Sparrowhawk (*Accipiter nisus*). The reason is relatively simple. It is because the raptor man is normally fully occupied in doing his own particular study and cannot, at the same time, count rats, passerines, and much more so, fish, reptiles, or insects. I believe there is a good case for a more intensive multi-discipline approach, including at least a raptor man, a mammalogist, and a plant ecologist, with access to geological and pedological information about the study area chosen (which they may broadly have to acquire if it is not already mapped). If, however, such a multi-discipline approach is impossible, half a loaf in the shape of good, accurate, copious data on actual food preferences is better than no bread.

Known food preferences again largely depend on what is brought to the nest but may not be representative of what the adults eat away from the nest, or what immatures may eat in wintering areas. We have had examples of the suggestion that wintering Golden Eagles may actually damage sheep rearing interests, at least locally, whereas the prey data from nests indicate no likelihood of serious damage, even at lambing time. Observation of direct kills by any species is obviously difficult, and isolated records tend not to be reported. However, if enough people send in two or three records a year to a center where they can be collated, a picture will eventually emerge of year-round food preferences based on direct observation in the field.

The health of any population of birds of prey depends largely on its breeding success. The Peregrine Falcon (*Falco peregrinus*) in Britain was able to survive sporadic but at times quite severe persecution from gamekeepers and others; but once its breeding success was depressed by pesticides it disappeared from much of England, Wales, and southern Scotland. Accordingly, a great many recent studies have been devoted to breeding statistics; but it is often not possible to get a true comparative picture because an observer records only the results from nests known to have contained eggs, or successful nests followed through to fledging. A great many observers fail to recognize the fact that non-breeding pairs exist, though these may amount to 10-30% of the population, and are thus an important component in the adult section of the total population, especially in the tropics.

Considering only the successful nests can be highly misleading. For instance, in the Peregrine Falcon in 1963 the number of young reared per successful nest in southern England was about two, almost the same as the national average. However, if the total of young reared was divided by the total number of territories normally occupied pre-World War II, then the breeding success over-all fell to less than 0.1 young per territory, so that it was not surprising that the Peregrine had become nearly extinct. For some species, notably small woodland species, good accurate data on the number of non-breeding pairs are hard to obtain; but for others, such as large eagles and Ospreys it is relatively easy.

For all breeding studies we need to know, at least:

(1) The total numbers of pairs in the area.

(2) The total number that actually breed, that is, lay eggs.

(3) The total number of young reared.

(1) and (3) give a good idea of the actual replacement rate per pair or per adult, while (2) g.ves an estimate of the proportion of the population actually breeding; if this is too low the species may be in trouble, even though apparently quite numerous and rearing average sized broods in successful nests. The figures will vary from place to place and from year to year, even in unmolested populations which are at capacity numbers, that is, as many as can possibly breed in any given area. However, the number reared per pair over-all is usually less than half the average brood in successful nests, and varies much more widely. In, for instance, the Red Kite (*Milvus milvus*) in Wales it has varied by as much as 800% over the last 20 years, whereas the number of young reared per successful nest has been much less variable.

Table 1, which details breeding success in a capacity unmolested population of African Fish Eagles at Lake Naivasha illustrates these points. It will be noted that in different parts of the lake, as exemplified by sectors, breeding success varied from 0.15-0.94 per pair over-all, whereas young per successful nest varied only from one to two. The variation in Sectors I and VI, ecologically similar with a good food supply situation, in 1968-69 and 1970-71 is also noteworthy. With a large enough sample, in this case of 56 pairs in both years, the variation in the number of young reared per pair per annum is reduced to 10%; and the final figure of 0.47 is probably a very good approximation of the replacement rate in this species at Lake Naivasha. Likewise, a long term study of Verreaux's Eagle (*Aquila verreauxi*) in the Matopos Hills of Rhodesia reveals an average breeding rate of about 0.51 per pair per annum, including non-breeding pairs.

Tables 2 and 3 give examples of adequate and inadequate data from British breeding species, including some earlier data from European studies. From these tables it will be seen that it is impossible to compare the accurate data for the Marsh Harrier (*Circus aeruginosus*) in Britain with most of the European data, because the latter take no account of non-breeding, or of the common phenom-

Table 1. Breeding success of African Fish Eagles on Lake Naivasha analyzed by sector.

	Sector	Total Pairs	Bred	Did not breed	Complete Attempts			Inc. Atmpt.	Total Young Reared	Young/pair		Yng./succ. Nest
					Succ.	Failed	Total			Over-all	Breeding	
1968-69	I	15	11	4	8	4	12	3	14	0.94	1.36	1.74
	III	8	6	2	4	1	5	4	5	0.63	0.84	1.25
	IV	14	9	5	4	6	10	0	4	0.29	0.44	1.00
	V	7	4	3	3	1	4	1	3	0.43	0.75	1.00
	VI	12	5	7	2	2	4	3	2	0.15	0.40	1.00
Total		56	35	21	21	14	35	11	28			
Mean										0.50	0.80	1.34
1970-71	I	14	10	4	5	3	9	2	7	0.50	0.70	1.17
	III	9	5	4	2	2	4	2	3	0.33	0.60	1.50
	IV	14	12	2	4	4	8	5	3	0.29	0.33	1.00
	V	8	3	5	3	1	4	0	6	0.75	2.00	2.00
	VI	11	6	5	5	0	5	2	6	0.54	1.00	1.20
Total		56	36	20	20	10	30	11	25			
Mean										0.45	0.69	1.25
Total		112	71	41	41	24	65	22	53			
Mean										0.47	0.74	1.28

enon of polygamy in harriers. The importance of being able to make such comparison is that in Britain the Marsh Harrier is now the rarest breeding species of diurnal raptor, and low breeding success could be a contributory factor in this situation. However, comparing the British sample (42 pairs over 15 years) with the only comparable example from Europe, in Lorraine, France (20 pairs in one year only) over-all breeding success in France was actually lower, though successful nests reared more young.

Having ascertained the number of young reared per pair per annum to the flying stage we must then ascertain the survival rate of these to sexual maturity. Up to now most such estimates have depended heavily or entirely on ringing records, which in turn depend too heavily on birds that have died an unnatural death, that is, they have been shot, electrocuted, run down by cars, and so on. A cynic studying American ringing records could be forgiven for concluding that the larger the species the more chance it had of being shot. In Britain, since 1954, when a new bird protection act was passed, raptors have most often been "found dead" rather than admittedly shot.

In some cases it can be demonstrated that life tables based on ringing records are inaccurate. The replacement rate per pair per year in Ospreys (*Pandion haliaetus*) in Britain has been 1.04 and the young per successful nest, 2.33. With at least 65% mortality before sexual maturity in the third year, as postulated by Swedish ringing results, this equals 0.34 sexually mature young per pair, or 0.17 per adult. In other words, every adult Scottish Osprey *must* live for about six years *as an adult* to replace itself. The mean adult age of 1.8 years, calculated from Swedish ringing records, would not permit the Osprey to survive, let alone increase, as it apparently has done both in Scotland and Scandinavia. The replacement rate per pair per annum may be higher in Sweden than in Scotland; but it is unlikely to be more than two-tbirds of successful brood size at best, and even then every adult Osprey would have to live for more than three years as an adult to replace itself.

In East Africa we have lately approached this problem from a new angle, selecting certain eagle species which are large, easily observed and sufficiently common to acquire a large bulk of data, and in which it is certainly possible to separate immatures from adults, and to age the immatures with some degree of accuracy, based on moult studies of captive birds. The species used have been the Bateleur and African Fish Eagle, and preliminary results were published by Brown and Cade (1971). In the Fish Eagle, however, a second year of study indicated that a mean replacement rate of 0.47 young per pair per annum in a sample of 56 pairs had permitted a total increase of the order of 35% in three years at Lake Naivasha. Most of this increase (about 42%) occurred in adults, whereas immatures increased by only 11%; this figure is not likely to be significant.

In 1968-69 the proportion of the late sub-adult segment of the population, which is the only sector from which fully mature replacements could be drawn for a bereaved adult, was calculated. In 1970-71 this was actually estimated by plumage characters at 4% of the adult population. On the basis of the 1968-69

Table 3. Examples of inadequate reproductive data, British, European, and North American species, from which it is impossible to calculate true replacement rate (data extracted from Brown, in prep.).

Species (Author)	No. of pairs studied	No. of pairs which bred (a)	No. of pairs succeeded (b)	No. of young reared (c)	No. of young/pair/annum (d)	No. of young/breeding pair (d/a)	No. of young/successful nest (d/b) (d/c)	Notes
Marsh Harrier								
Holland (Haverschmidt)	?	?	14	45	?	?	3.2	
Sweden (Bengtson)	?	26	18	57	?	2.2	3.2	
Germany (Creutz)	?	68?	55	193	?	2.8?	3.5	
Finland (Hilden)	?	79?	50	117	?	1.49	2.35	(1)
Hen Harrier								
Britain (Balfour)	?	562	331	794	?	1.58	2.4	(2)
Goshawk								
France (Thiollay)	8	5	4?	9	1.1	1.8	2.25	(3)
Buzzard								
Germany (Mebs)	?	95	95?	158	?	1.66	1.66	(4)
Golden Eagle								
Montana (McGahan)	46?	32	32	41	1.12?	1.28	1.28	
Montana (Reynolds)	92?	56+	50	73	0.79?	1.3?	1.46	(5)
Peregrine								
Britain (Ratcliffe pre-1960)	796	616	475?	900?	1.1?	1.45?	1.9	
Germany (Mebs pre-1960)	?	116	36	79	?	0.68	2.2	
Germany (Mebs post-1960)	?	73	38	76	?	1.04	2.0	
East Germany (pre-1960)	?	128	?	77	?	0.6	?	
East Germany (post-1960)	?	50	?	14	?	0.28	?	(6)

Notes

(1) These incomplete studies of the Marsh Harrier in the countries where it is not endangered (c.f. Axell, Britain Table 2) *suggest* a higher breeding rate but cannot adequately be compared.

(2) Even this otherwise superlative mass of data, gathered over more than 20 years, takes no account of non-breeding birds, though some are known to exist (Balfour: pers. comm.). Replacement rate/pair/annum is probably close to 1.50 young.

(3) Shows how even the same author in the same paper may give incomplete data; *Accipiter gentilis.*

Table 3 (continued)

(4) An otherwise very important paper which omits essential data.

(5) It is possible to estimate the total number of breeding sites from the data in McGahan and Reynolds (unpub. thesis) but they do not state the figure for non-breeding pairs as such.

(6) The Peregrine examples all show (a) the uselessness of estimating only young/successful nest, (b) that even incomplete data from pre-1960 demonstrates the severe relative decline of the species.

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results we calculated that the average life span of an adult Fish Eagle as an adult must be 16-22 years, a very high figure. From the 1970-71 results, with late sub-adults 4% of the adult population, the *mean* life span of adults must be about 25 years. Since this is a much higher figure than the observed mean wild life span of Crowned Eagles (*Stephanoaetus coronatus*) in three recorded life histories (about 10 years) it seems likely that the data are misleading in some way not yet understood.

Similar full long term figures for a capacity population of Verreaux's Eagles in the Matopos Hills indicate a mean replacement rate of 0.51 young/pair/annum. This may be compared with an estimated potential, in the absence of human interference, of 0.83 young/pair/annum in the Scottish Golden Eagle, which is reduced by human predation to 0.56 young/pair/annum. Even at that, the Scottish Golden Eagle is only just being held back from attaining and maintaining capacity numbers. The data suggest that, in unmolested populations at capacity numbers the breeding rate, even if apparently low, as in some tropical African eagles, is sufficient to build up a surplus of unmated adults and sub-adults from which a bereaved bird is able to draw a replacement with minimal delay. Such rapid replacements by bereaved Peregrine Falcons, even during the breeding season, appear well-documented.

To obtain such quantitative data for raptor populations I believe we should (1) concentrate studies on the commoner, more easily observed species rather than the very rare species, from which it takes many years to acquire adequate data. (2) Adopt a more uniform approach to the recording of such data, so that more meaningful comparative studies can be made; in particular, actual figures should be given as well as, or in preference to, percentages, which anyone can calculate from the actual figures. (3) Concentrate on the same study area for a period of years, the longer the better, unless circumstances make this impossible; in this way changes can be effectively monitored, even many years later.

To conclude, the sort of basic data needed for every raptor species include (1) body weight, in a large number of accurately weighed wild individuals, easily done at ringing stations, (2) food consumption, related to body weight, in varying conditions of temperature and exercise, (3) digestion data, including the amount wasted, (4) food preferences, the greater the number of prey items recorded the better, (5) breeding data including: (a) total number of pairs; (b) number that breed; (c) number that rear young; (d) total young reared; (e) mean replacement rate per adult or per pair of flying young. Finally, (6) the proportion of young surviving to sexual maturity, preferably expressed as a figure of sexually mature mate-replacements per adult member of the population (e.g., in the British Osprey 0.17:1).

Anyone familiar with the type of data recorded in the many papers at this session, and in earlier work, will be able to ascertain what proportion of this requirement can be adequately satisfied for any American raptor. I know from my own studies that it is impossible to provide all the data needed for any of the 14 regular British breeding species, even, for instance, the Hen Harrier (*Circus cyaneus*) and the Osprey; the latter, at one nest observed day and night continuously for 17 years; the most intensively observed pair of birds of prey anywhere in the world.

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RAPTOR REPRODUCTIVE SUCCESS: SOME PROBLEMS WITH METHODS, CRITERIA, AND TERMINOLOGY

Sergej Postupalsky

ABSTRACT. This paper stresses the need for a minimum of two checks of each occupied nest per breeding season in population surveys of large raptors in northern temperate regions. The first check, made during early incubation, is needed to count the population of territorial pairs, and the second, taken just prior to the time young are due to fledge, is needed to count the number of young raised. Both are required for calculation of reproductive success of the population. The shortcomings inherent to other methods, including single-trip surveys, and the resulting biases are discussed. A standard terminology for describing the status of nests and territories, and standard criteria for calculating reproductive success are proposed. Productivity of the population should be calculated on the basis of all territorial pairs, including the nonbreeders, because in raptor populations individual pairs may, under a variety of conditions, refrain from breeding in some years. Nonbreeding (i.e., failure to lay eggs) should be regarded as a type of nest failure, and its extent carefully assessed in population studies rather than ignored or dismissed as an attribute of subadult birds. The methods, criteria, and terminology discussed here have been developed during my long-term study of Bald Eagle and Osprey populations in Michigan and Ontario; they can be applied to studies of other raptors as well.

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Appropriately timed two-visit surveys have been working out adequately in northern regions, such as northern United States and Canada, where nesting in all pairs occurs more or less synchronously within each species. Farther south, however, this method may be less satisfactory because in some species (e.g., Osprey) individual pairs may differ by many weeks in initiation of breeding activity. Thus in a given area one pair may be feeding large young, while its neighbors may still be incubating. More frequent visits are needed under such circumstances to obtain a full census of breeding pairs and to determine the reproductive success of the population.

Terminology

Clear definitions of terms are essential if meaningful comparison of the data of different workers is to be made. The distinction between nest and breeding territory must not be overlooked. A nest can be anything from a mere scrape to an elaborate structure; a breeding territory, for our purposes here, is an area occupied by one mated pair of birds during the breeding season, containing one or more nests (be they just scrapes or structures).

A failure to make this distinction may give a false impression of population trends. For example, a report that 40 "active" and 60 "inactive" nests were found in a given study area might be taken to imply a recent sharp decline in numbers of breeding raptors in the area. Such misunderstandings may result from an author's failure to state clearly that some pairs of raptors may have more than one nest, and that therefore at least some of the "inactive" nests reported in reality represent second and third nests of extant pairs rather than abandoned territories with no birds. Again, one good windstorm can wipe out a large number of nests. If each pair at first rebuilds only the nest to be used immediately, we would find a greater proportion of occupied nests, and fewer nests per territory, in the following year, but these changes would bear no relation to population changes.

While all this may be common knowledge to raptor workers, our reports may be used by resource managers unfamiliar with raptor behavior. The total number of nest structures present may be of but limited interest in a population study (although in case of a rare or endangered species it may be important for purposes of protective management); it is the number of breeding territories which is important.

The terms relating to status of nests and breeding territories are defined as follows.

Nest or *eyrie:* a structure built or occupied by the birds for purposes of breeding. For cliff-nesters this definition denotes an individual scrape or ledge; for cavity-nesters, a tree hollow, box, etc. Some authors (e.g., Herbert and Herbert 1969) have used the term "eyrie" to denote a group of ledges and cliffs occupied by one pair of falcons, which is what I call "breeding territory."

Breeding territory: The term "breeding territory" is more restrictive than the usual definition of unmodified "territory." For the purposes of raptor population studies it is defined as an area containing one or more nests (including structures, scrapes, hollows, etc.) within the range of one mated pair of birds. Such nests may or may not have been built by the currently resident pair, but are typically situated more or less close together and farther from nests of other conspecific pairs. For our purposes here we are not concerned with the exact size of a "breeding territory" or whether or not it or any portion thereof is defended; we are interested in the *number* of such sites. Each breeding territory then indicates the known or inferred presence of a mated, territorial pair of potential breeders. Those who may not feel comfortable using the term "territory" in this context because of its generally accepted behavioral connotations, may prefer "breeding site."

Occupied nest: any nest at which at least one of the following activity patterns was observed during a given breeding season:

a. Young were raised;

b. Eggs were laid;

c. One adult observed sitting low in the nest, presumably incubating;

d. Two adults present on or near the nest, regardless of whether or not it had been repaired during the season under consideration, provided there is no reason to suspect that this pair had already been counted elsewhere;

e. One adult and one bird in immature plumage at or near a nest, if mating behavior (display flights, nest repair, coition) was observed. This category applies only to species in which immatures can be distinguished in the field.

f. A recently repaired nest with fresh sticks (clean breaks), or fresh boughs on top, and/or droppings and/or molted feathers on its rim or underneath. Such evidence is acceptable especially late in season in cases where no earlier check was made. Frustration nests (defined below) should be excluded if the original nest is counted, or vice versa.

All of the above observations indicate the known or inferred presence of one mated pair of birds associated with a nest. Usually I do not recognize the following observations as sufficient evidence for an occupied nest:

g. One adult near an empty, unrepaired nest;

h. Two adults seen together during the breeding season with no known nest. Such a pair may be included in a population count, but probably should not be used in calculations of reproductive success, unless one has reason to believe that this pair's nest may have been overlooked.

Occupied breeding territory: consists of one occupied nest and may also include one or more alternate nests (defined below). Since, by definition, there can be only one occupied nest per occupied territory, these two terms can be used synonymously in censuses of breeding populations and in calculations of reproductive success. For the unusual cases of polygamy and polyandry the number of breeding females is of interest in this context.

Unoccupied breeding territory: is a nest or group of alternate nests at which none of the activity patterns diagnostic of an occupied nest were observed in a given breeding season.

Active nest (or *active breeding territory*): a nest in which eggs have been laid. This category is more restrictive than occupied nest and should be used only in studies where sufficient early observations have been made to determine for each nest whether or not eggs have been laid. In short, this category excludes non-nesting territorial pairs (called "housekeepers" by some) and subadults (one-year-old Red-tailed Hawks, two-year-old Ospreys?) which may go through the early motions of nest building and mating but without laying eggs. Activity patterns (a), (b), and, in most cases, (c) above are diagnostic of an active nest.

Productive or *successful nest:* an occupied nest from which at least one young fledged during the breeding season under consideration, or, if actual fledging was not proven, an occupied nest in which at least one young was raised to an advanced stage of development (i.e., near fledging age).

Unproductive, unsuccessful nest, or *nest failure:* an occupied nest from which no young fledged due to any cause:

a. No eggs were laid;

b. Eggs were destroyed or otherwise lost;

c. Eggs failed to hatch (due to infertility, embryonic death, or abnormal development);

d. Young hatched, but are known to have died prior to fledging.

One should also distinguish between what might be called "natural" and "unnatural" mortality of nestlings. The latter category would include deaths due to direct human intervention, such as shooting, disturbance, or removal of young (for whatever purpose, legal or illegal). Similarly, deaths due to accidents, such as the crash of a nest, ought to be separated. These and similar instances should be noted either in the text of the report or in footnotes to tables. For rare and endangered species this information may be needed to identify pairs capable of reproduction which may be singled out for special management measures for their protection.

Alternate nest: one of several nest structures (or scrapes, hollows, etc.) within the breeding territory of one pair of birds, including frustration nests (defined below). Alternate nests may be on adjacent trees or stubs, or on the same or adjacent cliffs.

Frustration nest: an alternate nest built, repaired, or frequented by a pair of birds subsequent to a nesting failure at another nest during the same breeding season. The habit of building frustration nests is well pronounced in the Osprey. After failing to bring off young in its original nest, a pair may build a new nest later in the season, but as a rule will not re-lay in it, this is undoubtedly due to the advanced season. The term frustration nest then describes a special case of alternate nest. No implication relative to the psychological state of the birds is intended. The following year the birds may use the frustration nest or their old nest.

Under certain circumstances, a pair may be seen at more than one nest within their breeding territory during the course of a single breeding season. In addition to the phenomenon of frustration nests described above, the birds may inspect one nest just prior to laying, and then lay their eggs in another nest nearby. In such instances only one nest should be considered as occupied. Obviously, it is important to consider this habit if errors due to counting the same pair twice are to be avoided.

This classification of nests and breeding territories has proven useful in extensive population studies of Bald Eagles and Ospreys in which but brief and infrequent visits are made during each breeding season. It is applicable to studies of other raptors also; I have been using it for Red-tailed Hawks (*Buteo jamaicensis*).

Reproductive Success

The term "nesting success" as understood by most ornithologists refers to the percentage of eggs laid which develop into fledged young. In this sense it is not very useful in such extensive studies as some of the eagle and Osprey surveys, because the number of eggs laid often remains undetermined. Due to this lack of clutch size data, other criteria must be used to evaluate reproductive success.

1. The proportion of occupied breeding territories (for which the outcome of nesting is known) which produce at least one young to an advanced stage of development. This statistic, expressed as a percentage, may be referred to as *percent occupied nests producing young,* or, more briefly, as *percent nest success,* or simply, *nest success.* Note that the base is *occupied,* not active, nests.

2. The *mean brood size* (of large young or at fledging), expressed as the *number of young per productive nest.*

3. The *productivity* of the population, expressed as the *number of* (fledging or large) *young per occupied nest* with known outcome, is equivalent to the number of young produced per territorial pair and describes the annual production relative to the size of the population of potential breeders; it is the reproductive rate. Productivity, as defined here, is the product of nest success and mean brood size, and is an important datum in population dynamics.

Recently, Henny and Van Velzen (1972) in a paper on Ospreys recommended that reproductive success should be calculated on the basis of active nests only, thus excluding from consideration pairs which do not lay eggs, the so-called "housekeepers." They further suggest that the nonbreeding segment of the territorial population may be identical to the subadult (two-year-old Ospreys?) segment. I disagree and maintain that reproductive success should be computed from occupied nests, that is the entire territorial population of potential breeders, a view also expressed by Hickey (1969:28). My reasons are these.

The first point concerns species which do not breed until two or more years old. The suggestion that the nonbreeding pairs are identical to the subadult cohort has not been proven, and is almost certainly false. Granted, that an unknown proportion of these "housekeepers" may well consist of subadults, I find hard to accept the inherent implication that all adult raptors breed. Failure to lay eggs may be a response to environmental conditions which are less conducive to breeding, and ought therefore to be considered as another type of nest failure. In temperate regions, undisturbed raptor populations tend to remain stationary from year to year (Wendland 1953, Craighead and Craighead 1956, Hickey 1969:29-32), and may respond to changing prey availability by variable proportions of breeding attempts (Southern 1959, Rusch *et al.* 1972). Weather conditions at the onset of the breeding season may also depress the proportion of pairs which initiate a clutch. Nonbreeding adults have been reported in population studies of species in which immatures can be readily identified in the field: the Red-tailed Hawk (Orians and Kuhlman 1956, Craighead and Craighead 1956, Hagar 1957, Luttich *et al.* 1971), the Bald Eagle (Postupalsky, unpublished), and several African eagles (Brown 1952, 1955, 1960).

Secondly, the possibility that organochlorine pesticides may be involved in nonbreeding of raptors, as observed in the Golden Eagle (*Aquila chrysaetos*) by Lockie and Ratcliffe (1964), is another case for considering nonlaying pairs in calculations of reproductive success. Reduced egg production has been reported in several controlled studies with gallinaceous birds involving dosage with organochlorines, PCBs, and mercury (Genelly and Rudd 1956, Baxter *et al.* 1969, Dahlgren *et al.* 1972, Bitman *et al.* 1972, Fimreite 1971). To omit and ignore pairs which fail to lay eggs in field studies of toxic-chemical effects on reproduction would prejudice one's results.

Finally, in most of the extensive surveys based on only the minimum of two visits per nest the exact total of pairs actually producing eggs cannot be determined. The only datum available is the number of occupied nests, a more inclusive quantity than the number of active nests. To insist that all reproductive-success determinations be based on active nests only would invalidate the results of most, if not all extensive surveys done to date. Often these are the only practical studies that can be achieved with available resources.

While I agree with Henny and Van Velzen (1972) that ideally the incomplete nesting attempts of subadults should be excluded from calculations of reproductive success, I submit that a substantial proportion of the observed "housekeepers" are adults. Unfortunately, subadults of several species cannot be identified in the field. This problem emphasizes the need for more information on the behavior of members of this age group and on the age at which large raptors breed for the first time. This could be accomplished by color-banding large numbers of nestlings a different color each year to identify year-classes and then look for these birds in the breeding areas in later years. There is no reason to believe that all individuals of a given species of large bird start breeding at the same age. In the White Stork (*Ciconia ciconia*), for example, a few individuals first nest when three years old, most do so at ages four and five, while a few may not breed until six years of age (various authors, reviewed by Lack 1966). From my own studies to date I cannot show conclusively that two-year-old Ospreys of either sex breed, but I know that some three-year-olds do (successfully), and have one record suggesting that some may not breed until age five. For life-equation calculations we need to know at what age what proportion of individuals starts breeding.

Let me emphasize that the methods, criteria, and terminology outlined in this paper are not to be viewed as a straight-jacket into whick all data must be forced. Rather they should serve as a conceptual framework into which data can be organized. Obviously, not all observations will fit the categories listed. The latter can be further subdivided and added to. We may regard the results of the minimal two-visit survey, relating the ultimate total production of young to the number of territorial pairs, as a bare skeleton upon which the "meat" obtained on additional visits can be attached. Regardless of how detailed a study is (the amount of "meat"), the basic information (the "skeleton") should be in such a form to make it comparable to similar studies of raptors. Additional data of considerable interest in studies of reproductive success include: the proportion of nonbreeding pairs in the population, total number of eggs laid, mean clutch size, number of eggs hatched, number of eggs lost to any given cause, number of nests in which eggs hatched, number of young actually fledged (expressed relative to the number hatched and to the number of eggs laid), and mortality at different stages of the breeding cycle. Territories attended by single adults should also be recorded. Their frequency and the time it takes to replace lost mates may permit us to make inferences about recruitment rates and the status of a population.

The proportion in the population of adult pairs which do not breed in any given year, not measured or inadequately reported in many raptor population studies, may well be an important indicator of environmental conditions. We are remiss in not paying more attention to it. It may well be as important a datum as the number of young produced from active or occupied nests, which we have been measuring. To get this information, careful and repeated observations at nests early in the season are needed.

A combination of an extensive survey covering a large area with an intensive study of one or more small sample areas may well be the best way of handling studies of reproductive success of most raptors over much of their range.

Acknowledgments

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RAPTOR CONSERVATION AND MANAGEMENT APPLICATIONS OF BIO-TELEMETRY STUDIES FROM CEDAR CREEK NATURAL HISTORY AREA

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Introduction

Wildlife conservation and management need better understanding of the interactions among species and between species and their environment. There is a continuing need for criteria that can be used by land managers who manipulate raptor habitats.

The conservation of raptors presents unique problems because these birds are at the top of a food chain where they often exist in low densities. Suburbanization, industrialization, the use of pesticides, and persecution, have in many cases caused the elimination or reduction of local populations. Recent awareness of ecological concepts by professional biologists and the public is leading to programs that will enable raptors to be reintroduced into areas that may once again support a well-balanced environment. First, however, research must provide answers to questions concerning habitat use and preference, home range requirements, intraspecific and interspecific tolerances and the interaction among these factors. Then we will be able to predict how habitat changes will affect raptors. In many cases, bio-telemetry will play a key role in helping us understand these relationships.

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There is a permanent, automatic radio tracking system on the 6,000 acre (2428 ha) Cedar Creek Natural History Area in east central Minnesota (Cochran *et al.*, 1965). Telemetry data from this system are already revealing how important different habitats are to different species, and how many individuals make use of an area.

Few marking methods produce the continuous, minute-to-minute data necessary for evaluating short-duration movements of wild birds that will accurately provide information on home range, intensity of habitat use, or spatial-temporal relationships between one raptor and another. To overcome this problem, radio transmitters were placed on several species of raptors and their movements followed by the Cedar Creek Automatic Radio Tracking System. The following examples will illustrate the usefulness of radio telemetry in providing information that a land manager can use in raptor management.

Barred Owl Habitat Analysis

Location data on 10 Barred Owls were taken every 15 minutes during darkness and every 30 minutes during daylight. More than 28,000 owl locations were sampled from some two million locations recorded over a period of 1,182 days (Nicholls, 1973). From these data, home range and habitat use were determined by the following methods.

The Cedar Creek area was divided into a grid system consisting of 2,080, 1.6-acre (0.65 hectare) squares. Squares were numbered from 1 to 2,080 for computer identification. 1.6-acre squares were convenient in terms of accuracy of the radio-tracking system and also permitted detailed classification of habitat types.

Habitats were classified into seven habitat types characteristic of Cedar Creek. Each square was assigned a habitat type which was determined by aerial photographs, vegetation maps, and field observations. A computer-drawn map was made of all locations for each owl and placed over a habitat map of Cedar Creek as a further means of insuring accuracy.

The habitat information for each square along with all locations occurring in each square for each Barred Owl were programmed for computer analysis (Siniff, 1966). The results were presented as the number and percentage of owl locations occurring in each habitat type.

A determination of home range was necessary in evaluating habitat use. Home range boundaries were determined by drawing lines around the outermost 1.6 acre (0.65 hectares) squares with owl locations in them. The size of each owl's home range was determined by multiplying by 1.6 (acres) the number of squares within the boundary. The average home range of nine Barred Owls was 565 acres (231 ha). Home range size varied from 213 acres to 912 acres (86-369 ha).

After determining the acreage of each owl's home range, the total number of acres of each of the seven habitat types present within the home range was determined. Habitat preference was determined by comparing the observed number of radio fixes and the expected number of fixes that would have occurred if owls had entered the different habitat types by chance alone.

Data on the distribution of owl fixes with respect to different types of available habitat were tested for significance by chi-square methods of analysis. The conventional 0.05 percent or less probability level was used to indicate significance. The hypothesis for the chi-square test was stated as follows: If an owl entered different habitats by chance alone, the number of radio fixes in each habitat type will be proportional to availability.

The number of radio fixes in each habitat type was not proportional to availability. Thus, the hypothesis was rejected. Instead, Barred Owls showed definite and highly significant ($P < 0.05$) preference for or avoidance of different habitat types (Nicholls and Warner, 1972). The order of preference in decreasing intensity of use was oak woods, mixed hardwoods-conifers, white cedar swamps, oak-savannas, alder swamps, marshes, and open fields. There were no significant variations in this order with regard to sex, different individuals, phenological changes, changing seasonal weather conditions, time of day, night, or years.

Two of the seven habitats were preferred over the other five. They were the oak woods and the mixed hardwood-conifer habitats. The physical characteristics of these two habitats made conditions ideal for nesting, hiding during inactive daylight periods, and locating prey by sight and sound. These upland wooded areas were normally free of a dense understory. Very likely the lack of brush made it easy for owls to see, fly, and attack prey without hitting branches or leaves enroute and giving the intended prey victim warning of an impending attack.

The vertical use of the preferred oak woods and mixed-hardwood habitats varied with activity. In flying, the owls usually used air space which avoided dense vegetation such as that found in the overstory. Most flights occurred between four and twenty feet from the ground where understory vegetation was sparse. This was determined by the height at which owls hit mist nets ($N = 15$) and by direct observation ($N = 25$). Owls definitely used air space that had the least resistance for flying from one place to another.

The Barred Owl does not hunt on the wing but waits on a perch from which it detects its prey by sight and sound. It then quietly drops on its prey and kills it with talons and beak. Most hunting perches were within 20 feet (6.1 m) of the ground. We watched Barred Owls attack mice from perches three times. On numerous other occasions, we saw owls on hunting perches above small access roads that transected woodlots.

During daylight, Barred Owls spent much time roosting in dense foliage between 20 and 50 feet (6.1-15.2 m) from the ground. If windy, they perched on a branch next to and on the leeward side of the tree trunk. Hollow oak trees were used for nesting. Nests ($N = 4$) were between 12 and 30 feet (3.7-9.1 m) from the ground. Many dead or dying trees provided numerous homes for prey species such as mice and squirrels. The oak woods and mixed hardwood-conifer habitats had all the requirements for survival of the Barred Owl, so it was not surprising that these habitats were used more intensively than the others that had less than ideal conditions for survival.

The open field habitat was the least used. This habitat lacked cover for concealment, nesting cavities, and hunting perches. Prey species were present but

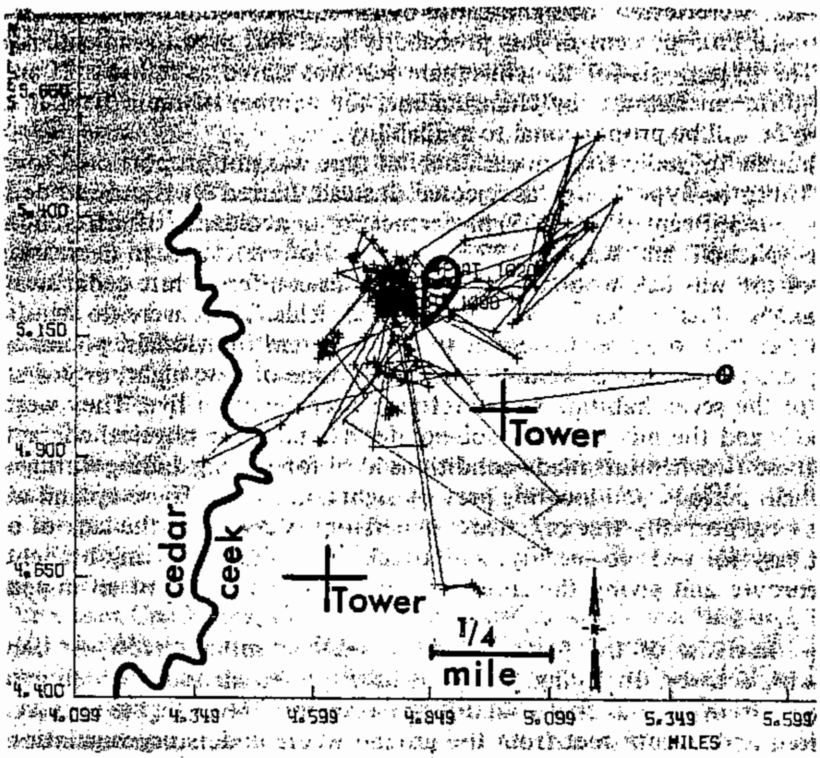

Figure 1. Barred Owl 709 intensively used a mixed hardwood and conifer habitat as indicated by the numerous plus marks west of Cedar Bog Lake. The lowland White Cedar habitat surrounding the upland island was not intensively used. An aerial view of the same area is illustrated in Figure 2.

probably not utilized to any great extent because of the unfavorable physical structure of the habitat.

The following examples will show how habitat preference was expressed in ways other than by the chi-square test. Figure 1 illustrates how a Barred Owl intensively used a mixed hardwood-conifer habitat. It shows a 10-day computer map of the movements of a Barred Owl from April 9 to April 19, 1966 based on 480 fixes. The numerous fixes to the west of Cedar Bog Lake outlined an almost circular mixed hardwood-conifer island that was completely surrounded by a lowland white cedar swamp. Figure 2 is an aerial photograph of the same area showing the intensively used island to the upper left of the lake surrounded by the cedar swamp that received little use. Other owls using the same area in different years showed the same preference. Computer maps showed quite clearly that owls often moved back and forth between such upland islands.

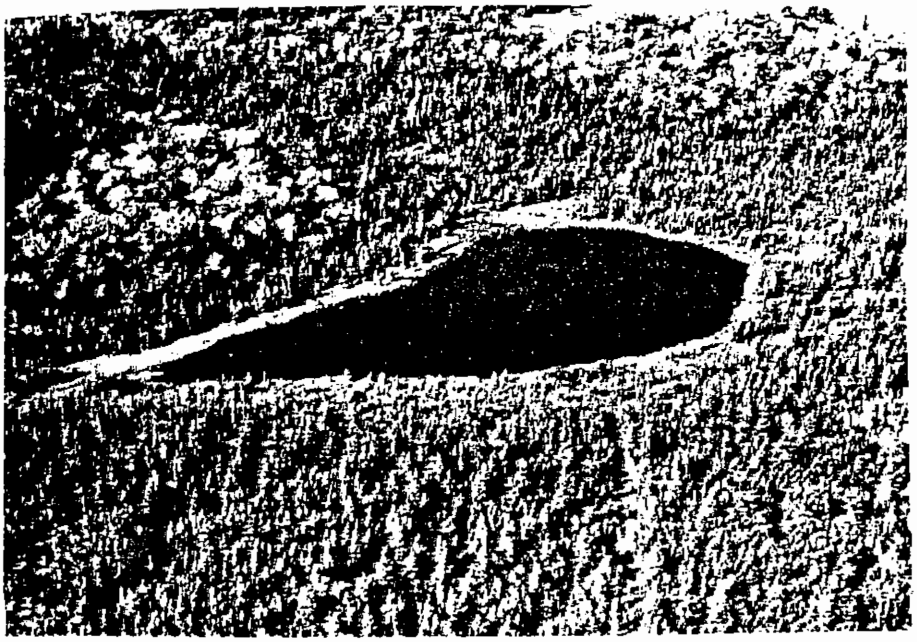

Figure 2. Aerial view of Cedar Bog Lake showing the circular mixed hardwood and conifer island adjacent to the lake, which was completely outlined with fixes, as seen in Figure 1.

Figure 3 is a 45-day computer map for another Barred Owl from August 24 to September 20, 1965 based upon 1,055 fixes. White areas on maps are wooded and shaded areas are open fields or marshes, Each black plus mark denotes one or more radio fixes. In the wooded areas the plus marks are so numerous that they are fused together. The wooded areas are almost completely outlined with radio fixes while the open fields and marsh along Cedar Creek have few. Lines between plus marks indicate movement between successive locations. The lines crossing the open areas show that the owl frequently flew back and forth between different woodlots within the home range. Figure 4 is an aerial view of the same area as seen in Figures 3 and 5. By comparing the use or lack of use of areas A, B, C, D, E, F and G, one is able to see the differing intensity of use of the various habitats. Figure 5 is a 258 acre (104 ha) home range of the same Barred Owl for a 65-day period between July 15 and September 20, 1965. Each square is 1.6 acres (0.65 ha) in size and numbers in squares indicate the total number of fixes falling within each square. Light areas on map indicate open fields or marshes. Note how little use was made of these areas compared to the intensively used deciduous woods. Little use was also made of the white cedar swamp.

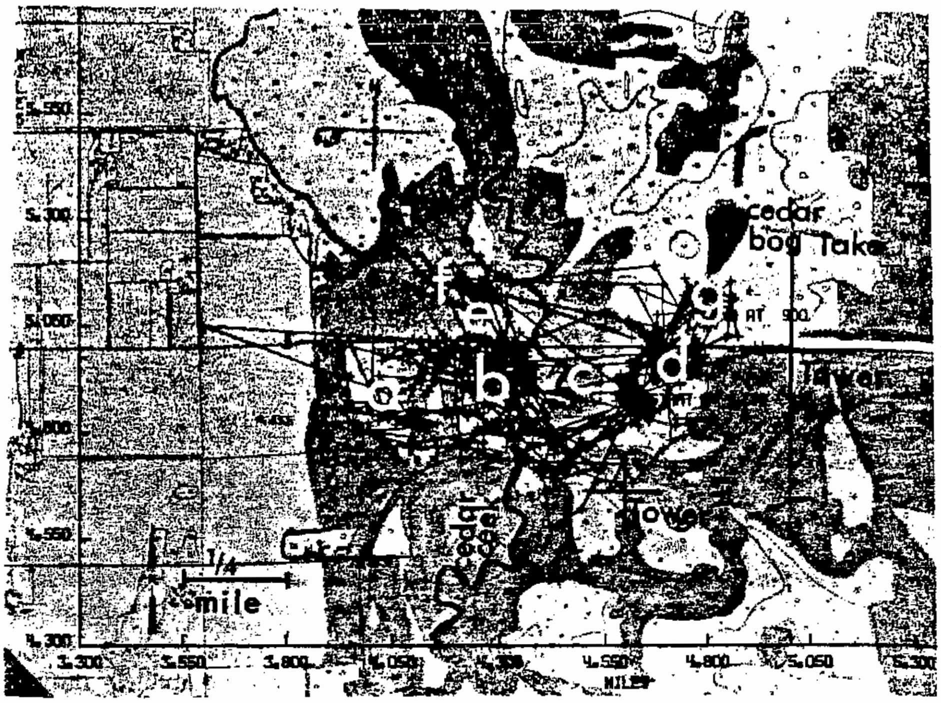

Figure 3. A computer-drawn map of locations and movements of Barred Owl 703. Compare areas A, B, C, D, E, F and G in Figures 4 and 5 to see how the owl used various habitats.

Interspecific and Intraspecific Spatial and Temporal Relationships

Continuous automatic monitoring of several raptors at the same time showed that the preferred habitat of the Barred Owl was also important to other raptors.

A family of Barred Owls and an adult Broad-winged Hawk used an oak woods habitat similar to that illustrated in Figure 5. One adult and one juvenile owl were radio-tracked from June 28 to September 7 and July 30, 1972, respectively. The hawk was tracked from July 2-6, 1972. The points plotted in Figure 6 represent locations of these three birds from July 2-6. The young owl left the nest cavity on June 29, but could not fly far. It moved about by walking, climbing, and by short glide-flights. The adult owl utilized the area indicated with the points connected by lines. The hawk used the same area, but the same-day locations were spatially separated. Tolerance between the two species while near each other may in part be due to nocturnal versus diurnal activity periods and

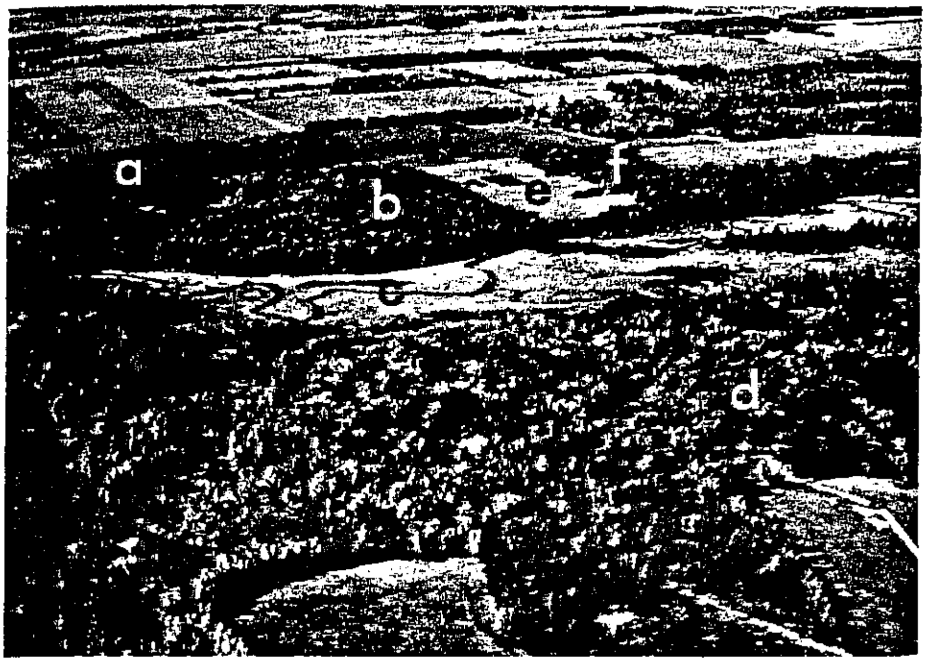

Figure 4. Aerial view of most of Barred Owl 703's home range as seen in Figure 5.

differences in resource use.

Figure 7 illustrates the area used by the owl family from July 10-30, 1972. The boundaries were obtained by connecting peripheral locations plotted at particular times each day. The young owl, upon gaining better flying ability, greatly expanded its use of the area. The adult bird primarily used the oak woods and mixed hardwood-conifer habitats.

Figure 7 also shows areas used by an adult Red-tailed Hawk and an adult Broad-winged Hawk between July 10-30. Their activity areas overlapped to a certain extent with each other and with those of the Barred Owls. The dated symbols for each bird represent selected locations at the same time of day. On the 13th, the Red-tailed Hawk was in the east-central part of its area while the Broad-winged Hawk was at its west-central border. The Barred Owls were in the center of their area. On the 17th, the Red-tailed Hawk was in the more northern end of its range. This was also the southern end of the Broad-winged Hawk's range. At the same time, the Broad-winged Hawk was using the northwestern edge of its area. When the Broad-winged Hawk occupied the south side of its range on the 28th, the Red-tailed Hawk was in the south end of its area. Other

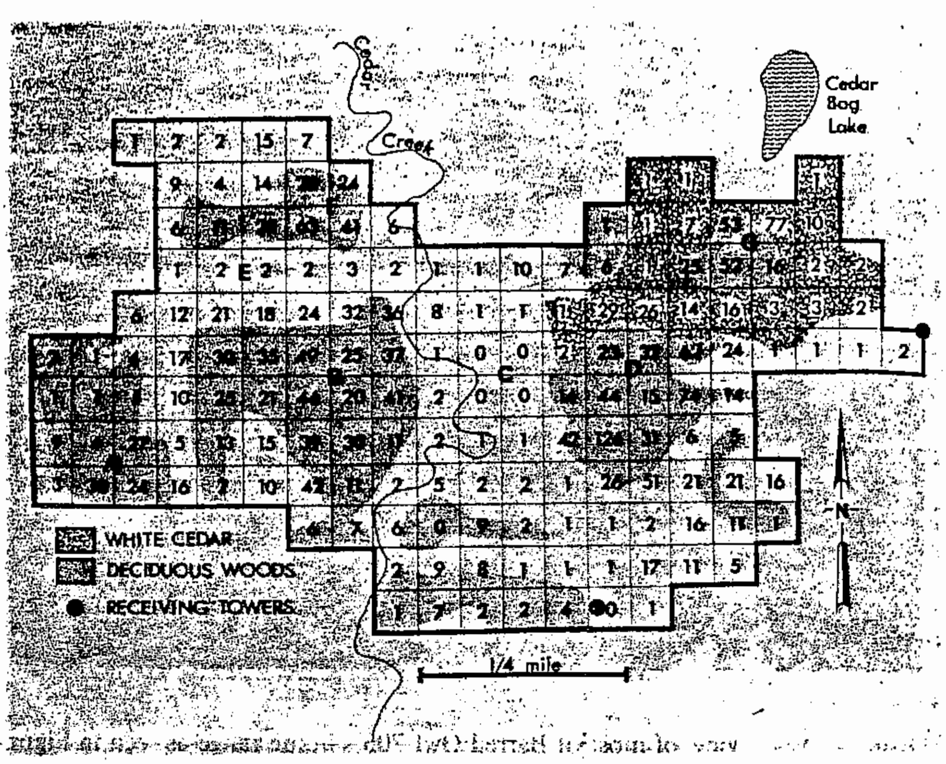

Figure 5. The 258-acre (104 ha) home range of Barred Owl 703. Each square is 1.6 acres (0.65 ha) in size; the numbers in squares indicate the total number of radio fixes falling within each square. Note how little use was made of the white areas that denote open fields or swamps compared to the heavy use of the deciduous woods. Areas A, B, C, D, E, F and G can be matched up with the same letters in Figures 3 and 4.

hawks and owls were also observed in the same area at the same time showing that even greater raptor densities were tolerated.

These examples show that certain species do coexist in the same area provided there is enough suitable habitat to space out individuals. This spacing would tend to reduce conflicts between species using the same area. These data do not reveal all the interactions among raptors, but further detailed study will lead to a better understanding of this phenomenon.

Two examples of a minute-to-minute analysis of locations indicated that some species may not tolerate each others' presence at the same time and place. The possibility of interspecific avoidance is illustrated by a Great Horned Owl and a Barred Owl; both were "tracked" from December 10-30, 1971. The following

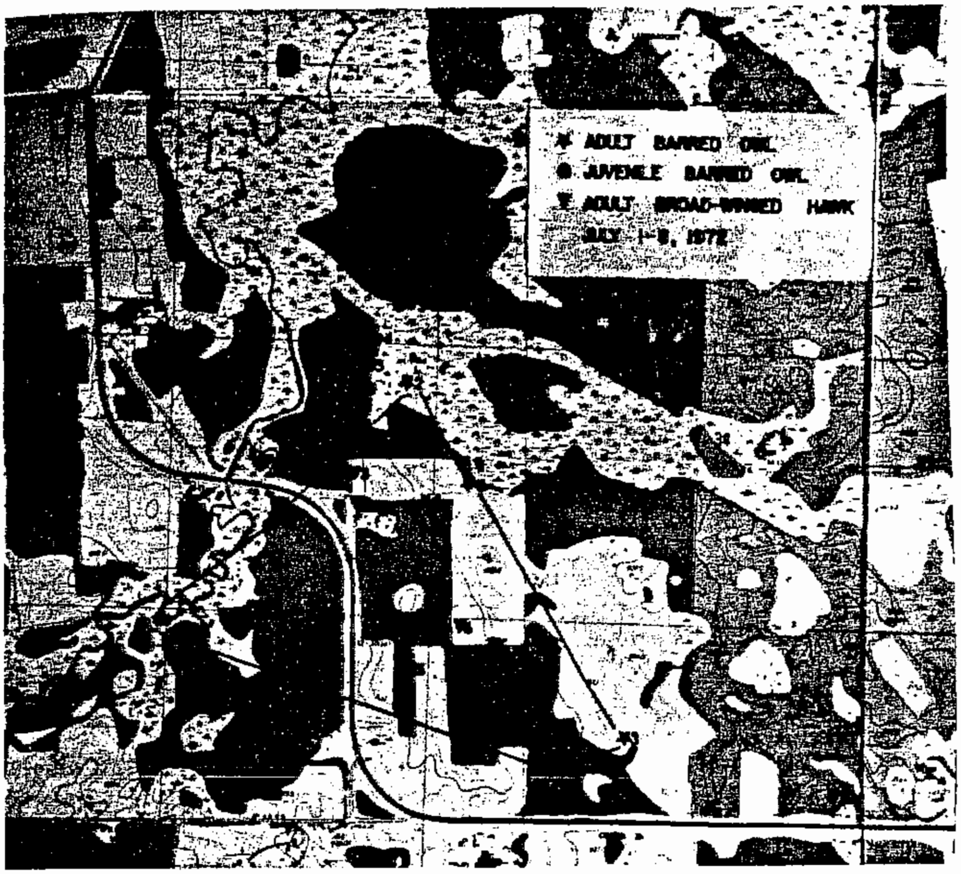

Figure 6. This map illustrates the simultaneous use of an area by three raptors. The locations and corresponding dates indicate that the adult owl and hawk use the same area, but at different times.

examples illustrate when the owls were in overlapping areas of their ranges, and the occasions on which they came closest to each other during the twenty-day period. Figure 8 shows that on the 13th, when the Great Horned Owl moved into the area used by a Barred Owl, the Barred Owl flew east to a woodlot different from the one it had occupied during the previous two days. On the 14th, when the Great Horned Owl moved toward the western part of its range, the Barred Owl returned to the same woodlot it had used on the 12th. On the following day, December 15, the Great Horned Owl occupied an area farther west, while the Barred Owl flew to the same woods the Great Horned Owl had used two days earlier. The Barred Owl eventually flew north into an oak woodlot

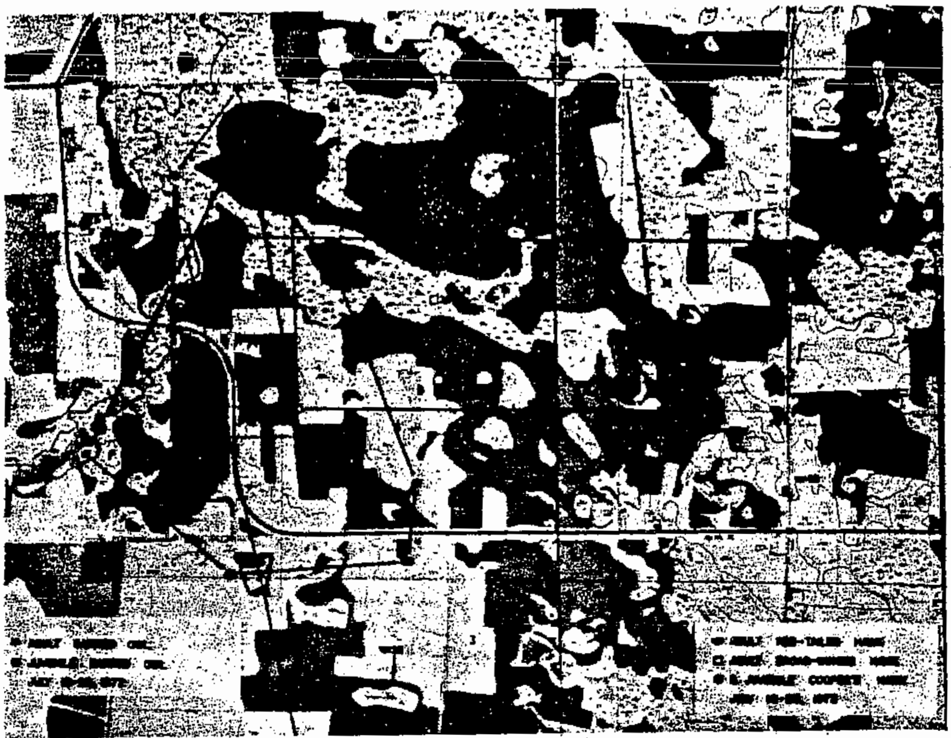

Figure 7. Peripheral locations of two hawks and two owls were connected to estimate the range of these raptors during the same time period. There were areas of overlapping use but the dated symbols suggest that the birds maintained spatial separation.

adjacent to the one used by the Great Horned Owl on the 14th. Later, the Great Horned Owl returned to that woodlot and, within two hours, the Barred Owl flew east out of the overlap zone.

Whether or not the owls communicated their location to one another is unknown. However, another incident later in the month reinforces speculation that the Barred Owl may have been avoiding the Great Horned Owl. The Great Horned Owl moved into the overlap area and the Barred Owl moved away to the east. Later, when the Great Horned Owl had flown to the west, the Barred Owl moved north, still avoiding the overlap area.

The Great Horned Owl is larger and potentially dangerous to the Barred Owl, yet the Barred Owl might prove formidable should a conflict occur. Perhaps the coexistence of two owl species using the same area is possible only when adequate resources and space enable them to avoid each other.

Figure 8. The dated and time labeled symbols on this map trace the movements of two owls. Though the birds used some of the same areas, the spatial separation indicates that they avoid use of these overlap areas at the same time.

Discussion

Habitat preference and intensity of use were determined by statistical methods. Those habitats (oak woods and mixed hardwoods-conifers) apparently having all the requirements necessary for survival of the Barred Owl were the habitats most preferred.

Determination of animal habitat preferences through the use of radio-telemetry will help the land manager in his planning. For example, to maintain a population of Barred Owls, one certainly would have to maintain a few densely wooded areas with some mature trees. Such areas are required by this species in order to complete its life cycle.

It is not enough to know what kinds of habitats are needed, but also how much. Through radio-telemetry, we have answered this question for Barred Owls by determining home range size. An average pair of Barred Owls requires 565 acres (231 ha) in which to live. Similar information is now being obtained for other raptors on the Cedar Creek Natural History Area.

Several organizations are establishing wildlife preserves, natural areas and educational nature centers. As lands are set aside for these projects, knowledge of habitat requirements is essential. In addition to natural occurrence of raptors in these areas, raptors are becoming available for introduction through rehabilitation programs and through efforts to trap and relocate those few individuals that interfere with man's activities (Fuller *et al.*, 1974).

The diversity of species and number of individuals to be maintained on an area requires knowledge of more than just habitat preferences. The interrelationships of raptors must be considered in various management and conservation contexts. The type of spacing that we found at Cedar Creek allows for a higher population density than would be possible if each pair occupied an exclusive home range. Telemetry can thus provide a basis for determining the optimum number of raptors which can occupy a given area. This information should be part of every population management plan, so that the manager can minimize intra- and inter-specific conflicts and thus contribute to a more interesting and stable community.

Conclusions

The Cedar Creek Radio-Tracking Station provides needed home range and habitat-use data and intra- and inter-specific spatial-temporal information that can be used in conserving and managing wildlife species. The techniques developed here may be especially useful in determining and saving the habitats required by rare or endangered raptors in many parts of the world.

Acknowledgments

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THE BUREAU OF LAND MANAGEMENT HABITAT MANAGEMENT TECHNICAL NOTE SERIES FOR ENDANGERED SPECIES

Carol Snow

The Conservation Library at Denver Public Library is currently receiving funding from the Bureau of Land Management to conduct a literature survey and evaluation on selected rare and endangered species occurring on public lands administered by the Bureau in the eleven western states and Alaska. This information is analyzed and prepared for reports with an emphasis on habitat requirements of each species and habitat management recommendations.

The orientation of the reports is towards BLM personnel, especially people involved with making land management decisions and field biologists who do not have the time to collect such information themselves. The primary objective is to provide BLM personnel with a basic reference tool to improve understanding of the interrelationships between the species and its environment so that the welfare of the species can be fully considered in all management decisions.

To date, reports have been published on the American and Arctic Peregrine Falcon and the Northern and Southern Bald Eagle. Reports in process include the Golden Eagle, the Gyrfalcon, the Prairie Falcon, and Ferruginous Hawk. These latter four species are not being considered by the BLM as rare or endangered, but as species of considerable interest occurring on a large percentage of BLM-administered lands.

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Categories of information include species description, former and present status, distribution, life history, particularly food habits, mortality factors, reproduction, habitat requirements and behavior, limiting factors, species and habitat management recommendations, authorities, private and government organizations actively concerned with the species' welfare, photographic material available, ongoing research projects and protective measures instituted.

References which are believed to be the most pertinent to BLM needs are included in a selective bibliography. Since the area to be covered is the western states and Alaska, information on a species in other parts of the United States is included only as necessary to enhance the value of the report. This means deleting a considerable amount of information in some cases, such as with the Bald Eagle. Rough drafts of the reports are sent off to species authorities for a critique and corrections are made before the report is published.

It would seem that these technical notes are performing a useful service by getting basic information to people who need it but have neither the time nor the resources to obtain it themselves. Perhaps the Raptor Research Foundation and/or some other organizations could consider funding a similar project for a complete series on all birds of prey and make these available to agencies, groups and individuals who have the greatest impact and control over management efforts concerning raptors.

The best raptor management programs in the world will remain ineffective without the full cooperation of the public and the people assigned to enforcing protective legislation. Not only is there a need for even more public education about birds of prey, but also education of the judges who determine fines and sentences for legal violations. Apparently birds of prey are of little or no value to many people, since light fines and sentences are being given to eagle shooters and poisoners, and shooting is still one of the most significant known mortality factors for raptors.

I truly hope that educational efforts will be a considerable part of raptor management programs. The BLM technical notes on birds of prey are one such effort. Copies of these publications can be obtained from BLM Director, Denver Service Center, Bldg. 50, Denver Federal Center, Denver, Colorado 80225.

THE POTENTIAL FOR MANAGEMENT OF RAPTOR POPULATIONS IN WESTERN GRASSLANDS

Richard R. Olendorff

John W. Stoddart, Jr.

ABSTRACT. A discussion of raptor management is initiated with the premise that management of wild populations of birds of prey is advisable, feasible and may be mandatory at this time to prevent further local declines in raptor numbers, or extinction of already threatened species. Field evidence for the potential for raptor management in western grasslands is developed mostly from new data. Differences in raptor nesting habits, the fact that nest site availability (not prey) limits raptor populations in many grasslands, and the advantage of remoteness and posting of land to the success of nesting raptors suggest that a number of raptor management techniques should be field tested immediately. Potential methods of increasing both breeding population levels and over-all production of young are enumerated and discussed in detail, including most management options involving the interplay between captive breeding, reintroduction and wild populations. We believe that the cause of raptor management—indeed, the welfare of birds of prey in general—will best be served by widespread knowledge of potential techniques before extensive raptor management programs get underway. This should hasten field testing and implementation of emergency conservation measures, and should catalyze grass roots management.

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The Current Status of Raptor Management

"Game management is the art of making land produce sustained annual crops of wild game for recreational use." (Aldo Leopold 1933, p. 3.)

Management of wild populations of predatory birds is advisable, feasible and may be mandatory at this time to prevent further local declines in raptor numbers or extinction of already threatened species. Both basic and applied aspects of raptor biology need questioning by professional and amateur enthusiasts to design research plans and to establish research priorities.

Historically, public interest in birds of prey has been directed toward either indiscriminate destruction or total protection of the birds. A trend toward the latter has developed in the United States during the past 30 years or more, e.g. the new migratory bird treaty between the United States and Mexico, signed in 1972, which placed all birds of prey under federal jurisdiction. Much other state and federal legislation protecting birds of prey has been passed in recent decades.

Protection of birds of prey as a valued natural resource can never be total or complete; direct and indirect pressures of human interference are relentless. Examples are the eagle poisonings, shootings and electrocutions in Wyoming and Colorado in 1971. Others include increased demand for raptors by falconers and zoological gardens, increased activity of amateur ornithologists and photographers, and shooting and trapping of birds of prey by irresponsible hunters and owners of gamebird farms. In addition to these direct factors, there are several indirect causes of raptor population decline such as habitat destruction, continuing global development of intensive agriculture and attendant use of chemicals, and continuing emission of environmental pollutants in general.

Most birds of prey are important components of balanced ecosystems and are pleasing to a growing number of people who appreciate birds and wildlife in general. As end-of-the-food-chain organisms, they have proven to be important barometers of environmental contamination. Many are declining in numbers, some to the point of being considered threatened species. Scientists, naturalists, conservationists and mankind in general all stand to benefit from basic and applied research aimed toward raptor management and conservation.

There is, nevertheless, no state or federal wildlife agency in North America which manages a single raptor (exclusing the California Condor (*Gymnogyps californianus*)) from a position of adequate knowledge of ecology and population dynamics. It was suggested in 1965 during the Madison Conference that one outcome of the conference should be "imaginative research and action ... to determine the extent that management of birds of prey is possible" (M. W. Nelson 1969a, p. 407). With California Condors the only approach is to eliminate all interference and hope for the best; there is little opportunity of doing imaginative research. All other North American raptors allow considerably more latitude for manipulation and research because of higher populations and a higher tolerance of human presence, but there is a fundamental lack of knowing just what to do. Mr. Nelson's suggestion has not been realized, now almost eight years later. Raptor management is still impracticable in the absence of field-tested techniques—techniques which wildlife agencies throughout the world urgently need.

One reason for the lack of raptor management today is the overwhelming emphasis, both historically and currently, on management of game species. This is changing, however, with development of management programs in most states for non-game species. The Colorado Division of Wildlife, for example, already has a staff position for a Raptor Management Biologist.

But this is a two-way street. Neither has most previous raptor research been conducted with management in mind. There has been raptor research aimed at managing populations of game animals, but very little raptor research directed toward managing raptor populations themselves.

There are several reasons for this latter circumstance. Most studies of raptor populations have been *seasonal and short-term.* Most major raptor studies suffer from biases resulting from determinations of densities of *only selected species in selected habitats,* as opposed to densities of all raptors in an area representative of all habitats locally available. Studies of population dynamics and food habits of raptors usually have not been conducted in conjunction with *simultaneous, quantitative studies of prey population levels.* Notable exceptions can be found in the papers of Hagen (1969), Craighead and Craighead (1956), Brown and Watson (1964), Hamerstrom (1969), Korschgen and Stuart (1972), and Lack (1966). Rarely, however, is energy flow from prey to birds of prey discussed in the literature because of the lack of prey population estimates on which to base calculations of rates of utilization, although some recent work is of great significance (Luttich, Rusch, Meslow and Keith 1970; Rusch, Meslow, Doerr and Keith 1972; and Rusch and Doerr 1972).

Thus, a multifaceted, penetrating research effort must be made if quantitative data concerning population dynamics, ecological impact, management and conservation are to be synthesized. Such research must involve relatively large land areas such as those available in many parts of the western United States. Only a piecemeal analysis of raptor management problems is now possible through literature review.

"The early attempts to apply biology to the management of game as a wild crop soon disclosed the fact that science had accumulated more knowledge of how to distinguish one species from another than of the habits, requirements, and inter-relationships of living populations." (Aldo Leopold 1933, p. 20.)

Included within the scope of raptor management is the development of *emergency conservation techniques.* Populations of some species and subspecies may be approaching biological thresholds beyond which even well-planned, purposeful research might be detrimental to wild populations. Examples in the United States are the California Condor and Florida Everglade Kite (*Rostrhamus sociabilis plumbeus*). Several other species, e.g. the Southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus),* Puerto Rican Sharp-shinned Hawk (*Accipiter striatus venator*), American Peregrine Falcon (*Falco peregrinus anatum*) and Hawaiian Hawk (*Buteo solitarius*) allow considerable more latitude for research. Species and subspecies like the Prairie Falcon (*Falco mexicanus*) and Arctic Peregrine Falcon (*Falco peregrinus tundrius*), although considered threatened species by the U. S. Department of the Interior, are in sufficient number to justify a complete range of management and conservation research.

The grassland birds of prey which warrant direct and immediate management attention in the western United States are the following: (a) THREATENED BUT NOT ENDANGERED SPECIES—Prairie Falcon (resident); (b) ENDANGERED SPECIES OR SUBSPECIES—American Peregrine Falcon (local and past resident) and Arctic Peregrine Falcon (migrant); (c) STATUS-UNDETERMINED—Ferruginous Hawk (*Buteo regalis*) (resident), American Osprey (*Pandion haliaetus carolinensis*) (migrant), Audubon's Caracara (*Polyborus plancus auduboni*) (resident), Northern Aplomado Falcon (*Falco femoralis septentrionalis*) (former resident) and Prairie Pigeon Hawk (*Falco columbarius richardsoni*) (resident); and (d) PERIPHERAL BIRDS—Zone-tailed Hawk (*Buteo albonotatus*) (resident), Sennett's White-tailed Hawk (*Buteo albicaudatus hypospodius*) (resident), Northern Gray Hawk (*Buteo nitidus maximus*) (resident) and Northern Black Hawk (*Buteogallus a. anthracinus*) (resident) (Source: *Threatened Wildlife of the United States, 1973 Edition.* U. S. Bureau of Sport Fisheries and Wildlife).

Management research should *not* be restricted to the above species. Use of ecological, phylogenetic and/or physical "near-equivalents" of threatened species has long been part of research programs developed after passage of the Endangered Species Protection Act of 1966. This has involved work with captives of various condors, kites, and races of Bald Eagles and Peregrine Falcons. There is no hurdle to extending this line of reasoning to field management studies, since many raptor management techniques will prove to be genus-specific, more so than species-specific. Some techniques will be applicable even beyond generic limits. Thus, management research involving many buteos, all large and some small falcons, and all eagles, regardless of their individual abundance, will, at least in part, be applicable to species now threatened with local extirpation or extinction.

Just as the research of the past decade pointed out the detriment of organochlorine contamination of food chains, the next decade or two will show the feasibility and see the implementation of raptor management programs arising out of captive breeding efforts and much new field research. The large response to the 1973 Conference on Raptor Conservation Techniques, the first major discussion of raptor management, is but one sign. The importance and urgency placed on development of management of non-game species by federal and state governments, conservation organizations, the academic community and raptor enthusiasts in general is increasing.

Field Evidence for the Potential for Management of Grassland Raptors

In the broadest context, our field work has been an evaluation of northeastern Colorado for raptor management (Olendorff 1972b, 1973a). Stoddart has 12 summers of spare-time and some recent full-time experience with nesting raptors there. In addition, Olendorff made a preliminary analysis of the potential for raptor research on the Atomic Energy Commission Hanford Reservation, a 615 square mile (1,593 km^2) reserve in southeastern Washington (Olendorff 1973b. At least six aspects of our research show potential for raptor management—a potential which certainly exists in much of the temperate grassland, chaparral and desert of the western United States. Some of the possibilities could be exploited worldwide in these and other biomes, e.g. tropical grassland (savannas) and tundra.

Evidence for this potential includes the following: (1) many species nest outside of their major nesting habitat, i.e., they are versatile with regard to basic components of a territory; (2) nesting raptors are totally absent where nest sites are unavailable; (3) there is extensive use of trees planted by man near now abandoned human habitations; (4) artificial or man-made structures are used as nest substrates, e.g. utility poles, steel towers, windmills and abandoned buildings; (5) there is often a large discrepancy between utilization and availability of prey; and (6) there is an advantage to nesting raptors of remoteness and limited access with "No Trespassing" signs. Each of these points is considered below in more detail.

Differential Utilization of Nesting Habitat. One important indication of management potential is the versatility of a species in its use of different habitats. Is the species limited to one habitat and one nesting substrate, or are a number of habitats and nesting substrates suitable? In our study areas there were four nesting habitats of large raptors, i.e., unbroken grassland, creek bottoms, cliffs and cultivated land. These types were used differently by the five species in the non-irrigable portions of northeastern Colorado (Table 1). The habitats are better defined elsewhere (Olendorff 1973a, in prep.). Within the habitats, the species used six major supporting substrates for placement of their nests (Table 2).

Ferruginous Hawks were the most versatile nesters, using all six nest substrates and all four habitats. Golden Eagles (*Aquila chrysaetos*) and Great Horned Owls (*Bubo virginianus*) used at least three or four of both the habitats and the substrates. Swainson's Hawks (*Buteo swainsoni*) nested in three habitats, but only in trees. Prairie Falcons were the least versatile, being restricted to cliffs. Some species tend to fledge more young per attempt in one of the habitats: both Swainson's and Ferruginous Hawks more in unbroken grasslands than in all of the other habitats combined, and Golden Eagles more in cliffs. The differences in fledging success were significant only for Ferruginous Hawks and Golden Eagles as shown by X^2 tests of the results of contingency table analysis of fledging success (Golden Eagles $X^2 = 6.599$, $P < 0.1$, 4 d.f.; Ferruginous Hawks $X^2 = 8.451$, $P < 0.1$, 4 d.f.; Swainson's Hawks $X^2 = 3.404$, $0.5 < P < 0.75$, 4 d.f.). Simply stated: (a) Swainson's Hawks were as successful in unbroken grasslands as in their dominant nesting habitat, and (b) there is more than a 90 percent chance that Ferruginous Hawks and Golden Eagles fledged significantly more young in their dominant nesting habitats, unbroken grasslands and cliffs, respectively. We accept the 0.1 level of significance because a 0.9 probability of being right in a wildlife management decision is quite ade-

Table 1. Differential utilization of shortgrass prairie habitats by nesting birds of prey—northeastern Colorado, 1970-1972. Sample sizes in parentheses.

	Unbroken Grasslands		Creek Bottoms		Cliffs		Cultivated Land	
Swainson's Hawk								
Percent Use	30.0%	(45)	63.3%	(95)	–		6.7%	(10)
Fledglings/Nest	1.19	(37)	0.90	(83)	–		1.10	(10)
Ferruginous Hawk								
Percent Use	57.8%	(41)	35.2%	(25)	5.6%	(4)	1.4%	(1)
Fledglings/Nest	1.73	(33)	1.33	(21)	3.00	(2)	4.00	(1)
Golden Eagle								
Percent Use	14.5%	(8)	32.7%	(18)	52.8%	(29)	–	
Fledglings/Nest	0.88	(8)	0.40	(15)	1.18	(22)	–	
Prairie Falcon								
Percent Use	–		–		100.0%	(30)	–	
Fledglings/Nest	–		–		3.41	(27)	–	
Great Horned Owl								
Percent Use	7.3%	(3)	80.5%	(33)	9.8%	(4)	2.4%	(1)*
Fledglings/Nest	1.33	(3)	1.45	(29)	2.00	(2)	2.00	(1)*

*Nest at a school house in a small town, not actually in cultivated land.

quate in all but extreme cases, and the consequences of being wrong are not great.

Absence of Breeding where Nest Sites Are Unavailable. Cliff-nesting Golden Eagles fledge more young than tree nesters. This is not of much value as a management option because new cliffs cannot be created. For Swainson's and Ferruginous Hawks, however, the moderate to high success in unbroken grasslands as opposed to woods is of great importance.

On both of our study areas there were large areas (up to 100 square miles (259 km^2) or more) where most or all species were completely absent. In most cases, raptors did not breed unless suitable nest sites were available and an adequate prey base was present. There was clumping in the most suitable habitats.

Although data are incomplete, the best examples of the importance of nest sites and (probably) prey were found on the Hanford Reservation (Olendorff 1973b). Three adjacent regions were most illustrative (Table 3). Region 1 was a large, generally barren sagebrush-sand dune area stretching from the Columbia River 7-10 miles (11.3-16.1 km) inland, and 14 miles (23.5 km) in north-south extent, beginning about five miles (8.1 km) upstream from the town of Richland, Washington. This region was never heavily settled; no native trees and only one planted tree (one potential nest site) were found.

Table 2. Supporting structures of raptor nests in the shortgrass prairie—northeastern Colorado, 1970-1972. Sample sizes in parentheses.

	Tree	Small Rock Outcrops*	Creek Bank	Cliff	Ground	Man-made Structure
Swainson's Hawk						
Percent Use	100.0% (150)	— —	— —	— —	— —	— —
Fledglings/Nest	1.00 (130)	— —	— —	— —	— —	— —
Ferruginous Hawk						
Percent Use	69.0% (49)	11.3% (8)	5.6% (4)	5.6% (4)	5.6% (4)	2.9% (2)
Fledglings/Nest	1.52 (44)	1.60 (5)	0.00 (1)	3.00 (2)	2.75 (4)	3.00 (1)
Golden Eagle						
Percent Use	25.5% (14)	5.4% (3)	16.3% (9)	52.8% (29)	— —	— —
Fledglings/Nest	0.79 (14)	0.67 (3)	0.00 (6)	1.18 (22)	— —	— —
Prairie Falcon						
Percent Use	— —	— —	— —	100.0% (30)	— —	— —
Fledglings/Nest	— —	— —	— —	3.41 (27)	— —	— —
Great Horned Owl						
Percent Use	85.3% (35)	— —	4.9% (2)	9.8% (4)	— —	— —
Fledglings/Nest	1.35 (31)	— —	3.00 (2)	2.00 (2)	— —	— —

*In otherwise unbroken grassland.

Table 3. Large raptor nesting densities and availability of nest sites in three regions of the Atomic Energy Commission Hanford Reservation, southeastern Washington.

	Area		Density		Nest Sites	
	(sq.mi.)	(km^2)	(pr./100 sq.mi.)	(pr./100 km^2)	(Sites/100 sq.mi.)	(Sites/100 km^2)
Region 1	108	280	0.0	0.0	1	0.4
Region 2	79	205	7.6	2.9	9	3.5
Region 3	28	73	46.4	17.9	400*	154.1

*Calculated on the basis of an estimated average of one potential site in every quarter section of land.

Region 2 lies adjacent to, but west of, Region 1. Habitats are very similar in the two regions, except that seven groups of trees exist in Region 2 near old gun batteries and/or abandoned farmsteads, and near one or more permanent ponds. Of the seven sites, five were occupied by Swainson's Hawks, one by Great Horned Owls and one by Common Ravens (*Corvus corax*). This total occupancy of Region 2 by raptorial and semi-raptorial species may indicate (a) that prey populations are probably adequate for some raptors, at least, in much of Region 1, and (b) that the management potential is great in both regions.

Region 3 is an area with scattered and locally dense stands of trees near the old towns of Hanford, White Bluffs and East White Bluffs along the west bank of the Columbia River. These towns were abandoned when the Atomic Energy Commission tood over during the early 1940's. Signs of past human habitation are nearly everywhere in well planned (but now levelled) townsites, near long-abandoned farmsteads, beside old irrigation ditches, or in now mostly unproductive orchards and vineyards. Nests of 13 pairs of large raptors noted in this area included the following: four Red-tailed Hawk, six Swainson's Hawk and three Great Horned Owl. Nesting densities of large raptors far exceeded those found in Regions 1 and 2, even though raptors did not seem to use Region 3 to the fullest potential of available prey. Thus, availability of nest sites apparently had a profound effect on raptor nesting densities up to a point.

Use of Man-created Nest Sites. Raptor densities were comparable on the highly populated parts of the two study areas. However, in any adjacent 144 square miles (373 km^2) (four townships) at Hanford and in Colorado, the lowest densities of large raptors were 0.7 and 6.2 pairs per 100 square miles (0.3 and 2.4 pairs per 100 km^2), respectively. Thus, in areas least densely populated by raptors, there were nearly nine times as many in northeastern Colorado, i.e., raptors were more uniformly distributed there.

The latter resulted from the past influence of man. Northeastern Colorado was quite uniformly settled during the early decades of the 1900's before the

Table 4. The influence of past and present land use practices on the nesting of birds of prey in the shortgrass prairie—northeastern Colorado, 1970-1972. Percentages compare the number of nestings at man-created situations to the number at natural situations. Sample sizes in parentheses.

	Man-created Nesting Situations		Natural Nesting Situations		Total No. of Nestings
Swainson's Hawk					
Percent Use	40.0%	(60)	60.0%	(90)	150
Fledglings/Nest	1.12	(51)	0.95	(79)	130
Ferruginous Hawk					
Percent Use	40.8%	(29)	59.2%	(42)	71
Fledglings/Nest	1.42	(24)	1.85	(33)	57
Golden Eagle					
Percent Use	9.0%	(5)	91.0%	(50)	55
Fledglings/Nest	1.00	(5)	0.85	(50)	55
Prairie Falcon					
Percent Use	–	–	100.0%	(30)	30
Fledglings/Nest	–	–	3.41	(27)	27
Great Horned Owl					
Percent Use	24.0%	(10)	75.6%	(31)	41
Fledglings/Nest	1.20	(10)	1.60	(25)	35

droughts in the 1920's and 1930's drove homesteaders out. Hanford, on the other hand, apparently was not uniformly settled; the distances between abandoned homesteads are great in the more remote and desolate sections. The result of man's settlement and subsequent abandonment of the Colorado study area was that the trees planted by man near farmsteads, ditches and other water sources (windmills and temporary ponds) made it possible for Swainson's Hawks to make better use than before of the vast, historically treeless shortgrass prairie for nesting.

The influence of past and present settlement of northeastern Colorado on the current nesting habits of five species of raptors is shown in Table 4. Taking all species together, 104 of 347 nestings (30.0%) were at man-created nest sites. Both Swainson's and Ferruginous Hawks used man-created nest sites about 40.0% of the time. Swainson's Hawks tended to fledge more young per nesting attempt in man-created situations than in natural situations during the years studied, but the difference was not statistically significant. Ferruginous Hawks, on the other hand, fledged more young per nesting attempt where no evidence of past human habitation was found ($X^2 = 7.989$, $P < 0.1$, 4 d.f.). Golden Eagles nested in man-created situations only 9% of the time and fledged 1.00 young per nesting attempt from such sites, more than average for the population available for study. Man has had no hand in creating nest sites for Prairie Falcons. Over 24% of the Great Horned Owls nested in man-created nest sites over a three-year period; fledging success was higher in natural nests.

The influence of past activities of man on nesting of the two buteos in unbroken grasslands is particularly noteworthy. That Swainson's Hawks fledged as many young per nest from 45 nests in unbroken grasslands as from nests in other habitats has already been mentioned (Table 1). Of those 45 nest sites 44, or 98%, were at abandoned farmsteads, ditches, windmills or man-made ponds. At the possible exception, past activities of man were suspected, but not actually found.

Ferruginous Hawks show similar trends, but to a lesser degree. Twenty-eight of 41, or 68.3%, of the Ferruginous Hawk nests in unbroken grasslands were in man-created situations. The percentage does not approach 100 in this case because of the diversity of nesting habits of Ferruginous Hawks.

All three Great Horned Owl nests in unbroken grasslands were at abandoned farmsteads.

Are there more of these raptorial birds in northeastern Colorado now than there were, say, 150 years ago? Have there been positive effects of man's habitat alterations which have resulted in inadvertent, but positive, management of raptor populations? These are difficult questions, of course, since no quantitative studies of nesting raptors have ever been conducted in the area with the exception of Enderson's (1964) work with Prairie Falcons and research herein reported. If historical occupancy of eyrie sites is used as a criterion for population stability, comparisons of Enderson's and our data show that the number of adult Prairie Falcons has apparently not changed during the past decade. Productivity was substantially higher in the early 1970's than in the early 1960's, but the same number of adults occupied essentially the same eyries. Furthermore, since nesting habitat for Prairie Falcons has precise limits (Table 1), and since man has not inadvertently improved the available nesting habitat (Table 4), it is likely that similar numbers of Prairie Falcons have occupied the area for many decades.

On the other hand, it is reasonably certain that Swainson's Hawks were less abundant during the late 1800's and early 1900's than in the early 1970's. We found Swainson's Hawks nesting only in trees (Table 2). Until man planted trees away from creek bottoms—trees such as boxelder (*Acer negundo*), Chinese elm (*Ulmus parvifolia*), Russian olive (*Elaeagnus angustifolia*), honeylocust (*Gleditsia triacanthos*), cottonwoods (*Populus* sp.), and willows (*Salix* sp.)—Swainson's Hawks could not nest in the otherwise unbroken grasslands. In addition, the extremely detrimental effect of cultivation on the nesting of raptors is not as serious for Swainson's Hawks as for many other raptors (Table 1).

Furthermore, nest sites in creek bottoms and near natural springs, where Swainson's Hawks must have nested historically, have not been wiped out by settlement. In general, man cannot live close to creeks because of periodic flooding. Disturbance is rather slight in gallery forests along creeks in spring due to strict posting of the area, closed hunting seasons and intense patrolling of newborn calves by ranchers. This eliminates much casual interference with nesting raptors by irresponsible people, and local farmers and ranchers rarely interfere, recognizing the value of predatory birds to their interests.

We do not know whether Ferruginous Hawks increased in northeastern Colorado after the coming of white man. Ferruginous Hawks did not depend solely on trees for nest sites during our study (Table 2), and they rarely nested near extensive cultivation. Of 71 nestings only one was in farmland (Table 1). Even though 68.3% of the Ferruginous Hawks that nested in unbroken grasslands nested in man-created situations, it is more difficult than with Swainson's Hawks to weigh the relative importance of such negative factors as cultivation and other human interference against the advantages of inadvertent improvement of nesting habitat. Ferruginous Hawks tended to be less successful when nesting in trees than when nesting in other situations. Similarly, these hawks were less successful at fledging young at abandoned farmsteads, ditches and man-made ponds than elsewhere (Table 4).

Thus, there may have been a decrease in the population of Ferruginous Hawks since white man arrived, primarily due to destruction of habitat through cultivation. Another possibility is a shift from ground and cliff nesting to tree nesting without a decrease or increase in numbers. We will have more to say about this later (Olendorff and Stoddart in prep.).

Great Horned Owls nested in man-created situations 24.0% of the time (Table 4), yet such nestings appear inconsequential as a means of allowing this species to utilize the shortgrass prairie more uniformly. First, Great Horned Owls fledged fewer young at man-created nest sites than at natural nest sites, although the difference was not statistically significant. Second, we found an obvious dependence upon gallery forests along creeks. Dispersal of nesting pairs away from creek bottoms was not common. Thus, although man has inadvertently created nesting situations for raptors in unbroken grasslands, Great Horned Owls have not adapted to them as readily as buteos. It is unlikely that there are more Great Horned Owls in northeastern Colorado now than before white men came.

Since Golden Eagles used man-created nest sites only 9.0% of the time, man has probably had little positive effect on this species. Indiscriminate shooting of these large and conspicuous raptors by the general public and destruction of nesting habitat by ranchers and farmers probably hold the number of nesting Golden Eagles below the number present during the late 1800's. Likewise, electrocution of eagles by electric power lines figures heavily as a mortality factor on the Pawnee National Grassland and adjacent areas (Olendorff 1972a).

It is plain that raptor management, inadvertent or planned, can be fruitful. Although the examples given involve rather common raptors which may not require management in most areas now, such species often need local management. In such cases, management must exploit those biological aspects which make that species common, thereby allowing day-to-day preventive management, not just emergency management of the serious symptoms of population declines. The early settlers of western grasslands inadvertently showed the way.

Use of Man-made Structures as Nest Substrates. In addition to unnaturally planting trees in grasslands, man has also littered the countryside with windmill towers, buildings, telephone and power poles, and all manner of other structures that sometimes double as raptor nest sites. Ferruginous Hawks were the only raptors to nest on man-made structures on the Colorado study area from 1970-1972. Two young were fledged from a nest atop a stone house chimney in 1972; another attempt on a power pole was unsuccessful. In 1973, three young Ferruginous Hawks successfully fledged from a nest on a power pole. Several ranchers we met during our studies mentioned eagles nesting on windmill towers and Swainson's Hawks (apparently) on telephone or power poles. We noted a successful Swainson's nest on a telephone pole on the study area in 1968.

A low level of use of man-made structures has been noted in other grasslands and prairies. On and near the Hanford Reservation we found three pairs of Red-tailed Hawks nesting on steel electric transmission line towers. A pair of Great Horned Owls has nested on one of the reactor buildings on the Hanford Reservation for many years. A pair of Golden Eagles nested on a 36-foot (11 m) high gunnery tower in Rush Valley, Utah, in 1967 and 1968 (Camenzind 1969). Smith and Murphy (1973) found Great Horned Owls, Golden Eagles, Red-tailed Hawks and Prairie Falcons nesting in abandoned quarries in the hills between Rush Valley and Cedar Valley, Utah.

Outside of grasslands, raptors have nested on a variety of man-made structures. Large falcons provide some of the most interesting examples. Hickey and Anderson (1969) reviewed the behavior of Peregrines nesting on buildings and other (usually stone) edifices. Another notable example for Peregrines is the use of abandoned shooting platforms and shallow willow baskets placed in trees in northern Germany during the 1950's (Mebs 1969). White and Roseneau (1970) noted the use of gold dredges and other mining structures in Alaska as nest sites for Gyrfalcons (*Falco rusticolus*). Ospreys have nested on off-shore duck blinds, channel markers, power line support poles, and a variety of other structures (see Dunstan 1970). Other examples could be noted.

Thus, use of man-made structures as nest sites by raptors, although relatively uncommon, is widespread with regard to species and geography. It seems to happen most often where nest sites are few. For this reason alone, the potential for management of birds of prey is probably greater in temperate and tropical grasslands, tundra, chaparral and desert than in forests or in mountains where complex zonation of habitats occurs. Many parts of the vast temperate grasslands and deserts of the United States represent untapped resources with regard to utilization by nesting birds of prey (see below). Provision of man-made structures for nesting in these areas may redirect population trends of some species which have elicited concern of conservationists. Management may prevent serious population declines of species now considered abundant.

The Low Level of Utilization of Prey Resources. Brown and Amadon (1968) point out that there is a superabundance of food in home ranges of large raptors during and immediately after the breeding season, although wintering raptors may locally be limited by food. One might expect *a priori* that where nest sites are an important limiting factor, prey resources will not be fully utilized.

Such areas could probably support more large breeding raptors. The existence of untapped renewable resources indicates that the resources are, in a sense, being wasted. Unused prey resources indicate a potential for raptor management. The situation in the shortgrass prairie during our studies provides an excellent example.

We can compare raptor biomass (weight per unit area) (adults only) with non-raptor avian and rodent biomass on a 414 square mile (1072 km^2) portion of the Colorado study area in 1971 and 1972 (Table 5) in order to show that a large biomass of prey existed. Non-raptor avian biomass was between 62 (1972) and 95 (1971) times greater than large raptor biomass. Rodent biomass was over 200 times raptor biomass during both years. Thus, average non-raptor avian and rodent biomass during the spring and summer months was 288 (1972) to 375 (1971) times raptor biomass. (Prey densities from unpublished IBP data of D. K. Porter, R. A. Ryder and W. E. Grant).

Table 5 suggests that the prey base was not a limiting factor of raptor populations in either year, but such a conclusion must be based on requirements for prey *throughout* the breeding season by both adults and young. In very general terms, large raptors remove food from the ecosystem equal to an average of about 8% of their body weight per day during the spring and summer months (Craighead and Craighead 1956). During the 152 days from 1 April through 30 August 1972, the 125 g/100 ha of adult raptors present (Olendorff 1974) removed food equal to about 12 times their own biomass. Each young bird produced during the breeding season (57 g/100 ha) removed about five times the biomass of an adult in food through 45 days of age (Olendorff 1971b). Together, adults and young removed about 2,145 g of food per 100 ha or about 6.0% of the combined non-raptor avian and rodent biomasses [1145/(7697 + 28300) x 100 = 5.96%]. Similar calculations for 1971 showed that large raptors took only 3.8% of the non-raptor avian and rodent prey [1526/(10143 + 30000)

Table 5. Comparison of raptor biomass with biomasses of some components of the potential prey base.* The inputs to the ratios are g/100 ha; the ratios are unitless.

Ratio	1971	1972
$\frac{\text{Non-raptor Avian Biomass}}{\text{Raptor Biomass}}$	$\frac{10143}{107} = 95$	$\frac{7697}{125} = 62$
$\frac{\text{Rodent Biomass}}{\text{Raptor Biomass}}$	$\frac{30000}{107} = 280$	$\frac{28300}{125} = 226$

*Lagomorphs and pocket gophers not included; see text.

x 100 = 3.80%].

Cottontail rabbits (*Sylvilagus* sp.), jackrabbits (*Lepus* sp.) and northern pocket gophers (*Thomomys talpoides*) were not included in the calculated prey base because their population densities were unknown for 1971 and 1972. The combined biomass of lagomorphs and gophers would contribute considerably to the prey base because of their large size. Using 1970 hare densities (Donoho 1971) as an example, addition of black-tailed (*Lepus californicus*) and white-tailed jackrabbits (*Lepus townsendi*) alone could nearly double the prey base and halve the percents of utilization.

Circumstantial evidence for the potential for raptor management in the presence of untapped prey resources is provided by comparisons of nesting densities in Regions 1 and 2 at Hanford (Table 3). These two comparable habitats were used to their full potential in respect to nests but, most likely, far below in respect to prey utilization.

The Effect of Remoteness and/or Posting. If birds of prey are more successful at fledging young from nests to which access is limited, as compared with freely accessible nests, a potential for management is indicated. Limiting access does benefit some species (Table 6). All Ferruginous Hawk nestings from 1969-1972 (for which fledging successes were known) were categorized as being either (a) physically remote or posted with "No Trespassing" signs, or (b) freely accessible. The same was done for Swainson's Hawk nestings, but only on the western half of the 2,000 square mile (5,180 km^2) area in Colorado. Remoteness, as used here, means that the birds' nests were generally hidden from view or at least a quarter mile from a road—in any case, in situations where the general public would not interfere simply by getting out of their automobile. Plinkers usually shoot hawks from the comfort of their cars whenever possible.

Thirty-nine of 57 (68%) of all Ferruginous Hawk nests were in remote or posted situations; 28 of these 39 nestings were on posted land, while the other 11 were physically remote. Ferruginous Hawks fledged more young in remote or posted situations ($X^2 = 8.81$, $P < 0.1$, 4 d.f.). Swainson's Hawks tended to fledge more young in remote or posted nest sites, but the difference was not

Table 6. A comparison of nesting by Swainson's and Ferruginous Hawks in remote or posted situations as opposed to nests which were freely accessible.

Species	Remote or Posted	Free Access
Swainson's Hawk		
No. of Nests (% of Total	49 (47.1%)	55 (52.9%)
Young Fledged per Nest	1.24	1.00
Ferruginous Hawk		
No. of Nests (% of Total)	39 (68.4%)	18 (31.6%)
Young Fledged per Nest	1.95	1.06

statistically significant. This implies that Swainson's Hawks fledged the same number regardless of accessibility, and that other factors were of greater importance. Data indicate that wind-caused nest destruction was a more severe burden on Swainson's Hawk fledging success than human interference. As most Swainson's Hawks did not have eggs in the nest until after trees had leafed out, they were harder for the public to find. Ferruginous Hawks, on the other hand, built large, sturdy nests which usually survived wind storms, but which were conspicuous and occupied before trees had leaves. Thus, where Ferruginous Hawk nests were freely accessible, the hawks were less successful. Limiting access by posting is another example of positive, inadvertent management of raptor populations by man, a protection that could be extended to many more grassland raptors at a very nominal cost.

Potential Field Techniques for Raptor Management and Conservation

The only on-going large-scale raptor management program with wild populations in North America is being sponsored by the Canadian Wildlife Service. Under the direction of Richard W. Fyfe much pioneering research is being done. Other national and local governments have not followed the lead of the Canadiand, yet there is great need for international cooperative research in this field. Migratory birds know no political boundaries, and breeding ranges of most threatened raptors cross international borders.

Only Ospreys have received noteworthy management efforts in the United States. Several cooperating ornithologists throughout the eastern United States have begun to show promising success with clutch-size manipulations (see below). Studies by Sergej Postupalsky in the north-central United States (Postupalsky and Stackpole 1974) have demonstrated the effectiveness of artificial nest platforms for Ospreys. Others have also used this technique on a smaller scale (see Dunstan 1970). Management plans for Ospreys primarily involving habitat improvement and nest site protection have been developed for the Deschutes National Forest in Oregon (Roberts 1970), Lassen National Forest in California (Garber, Koplin and Kahl 1973) and the six National Forests of Region 1 of the U. S. Forest Service (northern Idaho and northeastern Washington) (Johnson and Melquist 1973).

Any raptor management program needs the following information: (a) an evaluation of both need and feasibility, (b) past and present knowledge of population levels and local distributions of the critical species, including competitors of the species in need of management, (c) habitat and nest substrate preferences and (d) some indication that the prey base is sufficient for a larger raptor population. Such information will guide management and will as well serve as a basis for increasing success. The latter is of particular importance in the early field testing of potential techniques—all of which still need quantified proof of their effectiveness.

Experimentation with many of the management techniques suggested below is illegal except with the sanctions of state and federal wildlife officials because birds and eggs are directly involved. In addition, some of these techniques will generate controversy because of the risks involved. We fully understand the drastic nature of some of our suggestions. Nevertheless, one must consider the alternatives. Which is more drastic: doing nothing and risking further extirpations and possible extinctions, taking birds into captivity as a hedge against extirpation and extinction, or trying to manipulate wild birds for their own good? Each of these alternatives has merit in particular areas and with particular species. We do feel, however, that in light of recent population trends, the worst possible course is to do nothing. The last two alternatives must come into play.

Thus, we do not suggest that all of the management techniques proposed below should be implemented now or ever at the grass roots level. Nor are we sure that all of our suggestions will work. All should be field tested, at least! Subsequent application of the most successful techniques will fall mainly to wildlife managers after each is field tested. The results of the tests should categorize each technique as (1) a limited-use, emergency measure, (2) a useful but risky program to be carried out only by professional biologists or (3) a widely applicable technique for use at the grass roots level. Everyone's reaction to the following material—be it agreement or criticism—should be tempered by the realization that implementation of many of the suggested techniques is years away or never will occur if field tests turn up negative.

Field management programs for birds of prey fall into at least two large categories: increasing the breeding population and increasing the production of young. Each potential technique will be discussed below.

Increasing Breeding Population Levels. Potential methods of directly increasing numbers of breeding raptors include: (a) development of new nest sites and (b) introduction of new breeding stock.

Development of New Nest Sites. The major assumption of this paper is that availability of adequate nest sites is a major limiting factor in temperate grasslands and other relatively treeless biomes. There are areas saturated with raptors, of course. Data which support the above assumption for shortgrass prairie (northeastern Colorado) and sagebrush-bunch grass prairie (southeastern Washington) have been presented above. Addition of artificial nest structures is one potential method of allowing more uniform utilization by raptors of habitats now lacking nest sites. Raptor populations could be expected to increase permanently to a point that some other factor, such as intraspecific competition (ideally) or prey availability, becomes limiting.

All designs of artificial nest structures for grassland raptors are still untested or are in experimental stages. Possibilities include: (1) elevated platforms, wooden barrels and nestboxes, (2) trees planted near casual water in otherwise treeless habitat, (3) alteration of cliffs which do not have adequate ledges and cavities for nest sites and (4) management of wildlife species (prairie dogs, badgers, birds that build stick nests, etc.) that create raptor nest sites.

(1) Elevated Platforms, Barrels and Nestboxes. Platforms have been readily adopted by Ospreys. Grassland raptors occasionally nest on work platforms of windmills. Fyfe (pers. comm.) will soon report success with elevated platforms for Ferruginous Hawks. Of the potential techniques for increasing numbers of nest sites, use of platforms, barrels and nestboxes has the widest application and, in many cases, the fewest logistical problems associated with implementation. Interference with the birds can be minimized by installation during the non-breeding season.

One possible design of an artificial nest platform is shown in Figure 1. Alterations of this basic design might include eliminating the shading device, placing the nest platform atop the pole, and not constructing the fence where cattle are not grazed or where trees planted in the exclosure would not grow (see below). Barrels, nestboxes or combination structures could be used instead of open platforms where applicable.

One important catalyst to artificial nest structure programs will be permission of utility companies to install platforms, barrels and nestboxes on existing poles and steel towers. Platforms could very easily be adapted to poles, crossbars and support structures of steel towers.

Wooden barrels—actually excellent imitations of nest cavities—also hold great potential, particularly for (but not limited to) large falcons. One general management plan might involve spreading a bird population into new niches. A prime example is the Prairie Falcon which is limited to habitats with cliffs. In both of our study areas (as elsewhere) nesting Prairie Falcons are clumped together on a small portion of the available land. Experiments could be designed for many parts of western North America to entice Prairie Falcons to use oak barrels on poles—*existing* poles and towers in many cases. The long-term strategy would be to develop a barrel-nesting population of Prairie Falcons and to move them progressively further and further away from traditional cliff nesting habitat. Such a project may seem grandiose, yet similar things have been accomplished for birds such as Canada Geese (*Branta canadensis*) (Grieb 1970) and Eastern Bluebirds (*Sialia sialia*) (Kirk 1963).

Two other uses for barrels are noteworthy. Even where Prairie Falcons are able to nest, there are sections of cliffs which are too low or lacking nest ledges and cavities. The latter circumstance will be discussed later. Where cliffs are too low to prevent predation or to provide good lookouts, an extra 20 feet of height attainable through artificial nest structures might allow their use. Opportunities for this type of management exist on both of our study areas.

Barrels could also be suspended by small cables over sandy, gravel banks that cave away too often to allow year-to-year constancy of nest site occupancy, or those that deteriorate in a way that nest cavities are never created. In such cases, alteration of the cliffs themselves may be impractical, but a barrel hung over the cliff which would swing out and come back after each cave-in would endure with relatively little maintenance. For example, this may be the only way to encourage full utilization of the sheer sand and clay loam cliffs of the Hanford Reservation—those nearest the river and highly susceptible to river action. Many

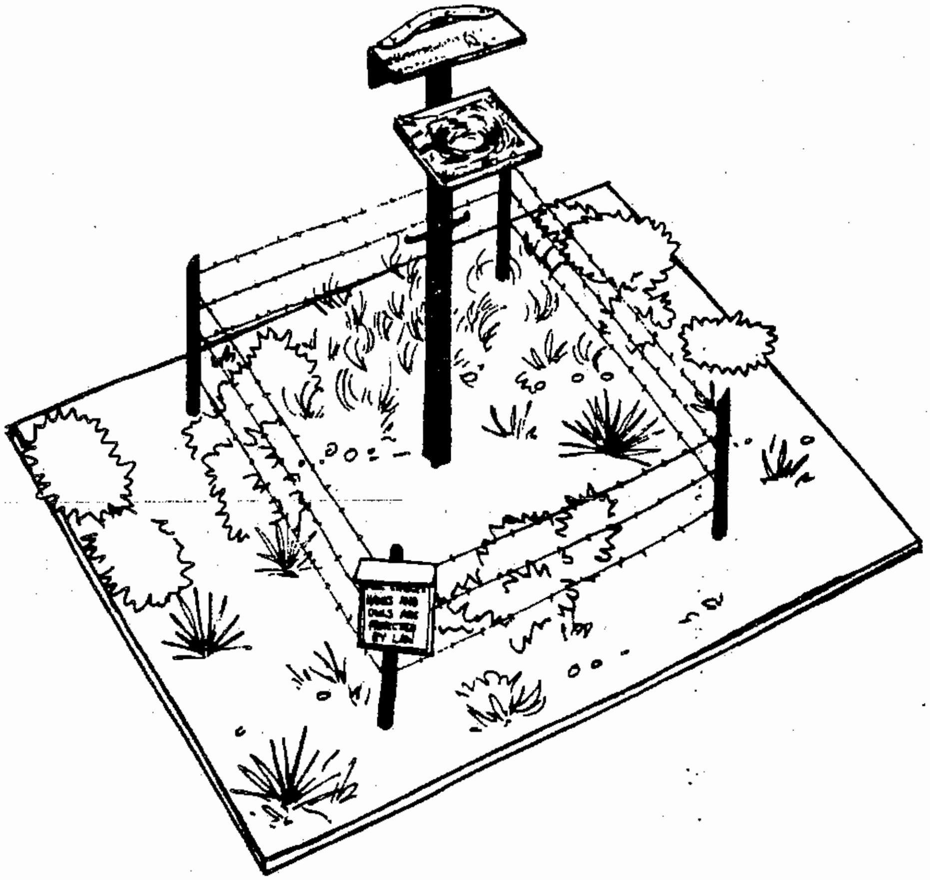

Figure 1. Proposed artificial nest structure for Ferruginous Hawks. Over-all height would be about 16 feet (4.9 m). The fence is to prevent cattle from killing newly planted trees (not shown).

miles of these cliffs were totally lacking nesting Prairie Falcons in 1973, because Great Horned Owls occupied the only two suitable cavities. Thirty or more sites could be developed along 15 miles (24.1 km) of cliffs that are adequate in vertical extent. The chances for adoption (by both falcons and Canada Geese) would be excellent. Natural dispersal from healthy populations of Prairie Falcons on other parts of the reservation and throughout eastern Washington would probably suffice to supply birds for new sites.

Nestboxes have rather limited use because only small falcons and owls would utilize them. Nevertheless, populations of American Kestrels (*Falco sparverius*) could be greatly increased on a local scale where needed through active nestbox campaigns. This has been done in central Wisconsin (Hamerstrom, Hamerstrom and Hart 1973). Although direct management may not be vital to perpetuation of a species or local sub-species, a nestbox program is the type of activity which local conservation groups, scouting organizations and bird clubs could handle well—just for the satisfaction of doing it. In other parts of the world there are kestrels, particularly some insular forms, that critically need management.

Investigations into the use of nest boxes to help dwindling populations of prairie Pigeon Hawks is presently included in widespread and commendable efforts of the Canadian Wildlife Service (Fyfe pers. comm.).

In the above discussion, emphasis has been on development of totally unnatural nest sites. Platforms, barrels and nest boxes could also be fastened to trees, both in grasslands and forests to attract adult pairs. Willoughby and Cade (1964) noted the importance of nest holes as a stimulus to breeding in American Kestrels. Traditional use of nesting sites as a result of psychological adaptation to external stimuli is discussed at length elsewhere (Hickey 1969: 11-12, 410-416). It is reasonable to suggest (and the consequences of being wrong are not serious) that placement of artificial nests in trees might attract pairs from floating adult populations.

(2) Planting Trees. Planting trees near semi-permanent water may be impractical in most cases. It merits mention, however, because of the impact of homesteading (and the concurrent planting of trees) on the nesting habits of some grassland raptors (Table 4). Use of man-planted trees by raptors as nest sites may add practicality to planting trees for other purposes, such as wildlife habitat management in general or rehabilitation of previously destroyed habitat. In addition, recognition of the importance of trees to raptors should be incentive for protecting existing trees from premature death (see below).

Thus, in conjunction with other activities, which may or may not involve raptor management at all, planting new trees has far-sighted importance. When choosing sites for artificial nest structures, semi-permanent water and the higher concentration of prey in such situations (particularly in arid prairies) should be exploited by planting trees. Eventually the artificial nest could be relocated in the trees and the structure removed.

(3) Cliff Alterations. Alteration of existing cliffs to provide more nesting cavities (without introducing man-made materials) has its greatest potential use in management of large falcons. Prairie Falcons provide a case in point. If holes or ledges of adequate size are not available on a cliff, Prairie Falcons will not nest or will go somewhere else to nest. There are four major lines of cliffs in northeastern Colorado and two on the Hanford Reservation in southeastern Washington. In each case, one group of cliffs supports a low number of (or no) nesting Prairie Falcons. This is due, apparently, to the absence of nest sites. Along several miles of cliffs in one region of the Colorado study area (as noted by Stoddart), geological forces and erosion produce overhangs, but few ledges or cavities. On the Hanford Reservation the problem cliffs are beset with continual undercutting by river action and rapid deterioration of higher sand banks. Nevertheless, terrain and habitat surrounding the low-yield cliffs are comparable to areas where high numbers of young Prairie Falcons are produced.

All information seems to indicate that digging nest cavities in low-yield cliffs in both study areas would be a fruitful management program. Nesting habitat can be created for new populations—in this case for a species considered to be threatened. The feasibility and success of this technique have been shown in Canada (Fyfe pers. comm.).

On the two long lines of unsuitable cliffs noted above there were also fewer nests of other raptors than might be expected. In these relative voids, potential for very selective or very broad management exists—selective or broad with regard to the number of species for which new sites could be developed. It is possible to create sites large enough for Prairie Falcons but too small for species such as buteos, eagles and ravens which build large stick nests. Unfortunately, most sites large enough for Prairie Falcons are also adequate for Great Horned Owls. This is a problem because the Great Horned Owl, a species not in need of management, nests earliest of all raptors and usually chooses the best and sometimes the only nest sites. It is not necessary, however, to eliminate Great Horned Owls (or any other species) from an area selected for Prairie Falcon management. On the cliffs of the Hanford Reservation, now occupied only by owls and Red-tailed Hawks, nowhere do two sites occur close enough for intraspecific competition between owls to allow interspecific occupancy of the same cliff by owls and falcons. The latter is a common occurrence elsewhere in the range of Prairie Falcons. Thus, it may prove necessary to develop two sites close together in each area occupied by Great Horned Owls.

(4) Management of Burrowing Mammals and Certain Large Nest-building Birds. Raptors often nest in abandoned habitations of other animals. They reuse stick nests of other raptors, crows, ravens, etc., and burrows of small to medium-sized mammals. The primary case in point in western grasslands is the dependence of Burrowing Owls (*Speotyto cunnicularia*) on burrows of badgers (*Taxidea taxus*), prairie dogs (*Cynomys* sp.) and ground squirrels (the larger *Spermophilus*) for nest sites. All of these mammals suffer from widespread persecution and extermination. Where these mammals have been extirpated, Bur-

rowing Owls have declined or disappeared.

Protective measures, such as re-establishment and protection of evenly spaced size-controlled prairie dog towns, should be taken. Existing dog towns should be posted with signs stating that only prairie dogs, not owls are legal targets.

Introduction of New Breeding Stock. Morlan Nelson (1969a) noted the practicability of reintroducing birds of prey into areas of local extirpation using wild nestlings. Very few attempts have been made to reintroduce captive-bred birds of prey into the wild, however. Not even one management area for reintroduction research has been chosen in the United States, even though there is need for field-tested reintroduction methods to culminate several captive propagation studies now in progress. Few people now working with propagation have addressed themselves to this problem with sufficient accomplishment, although Fyfe has made some small-scale, apparently successful, attempts. Nor have the breeders approached (due to lack of opportunity) the problem of whether or not captive-bred raptors will successfully enter wild breeding populations. We should not wait until captive-bred birds are available in quantity to begin developing reintroduction techniques. Many management options can be field tested immediately with wild birds.

One objective of captive breeding is to work toward reintroduction of birds into areas where raptors have (a) never nested historically, (b) been reduced to critical, non-viable population levels, or (c) been extirpated completely. Included in these categories is cultivated land which may be reinhabitable by raptors using artificial nest structures.

Figure 2 is a diagram of management options involving captive breeding, reintroductions (controlled releases) and wild populations. Processes shown nearest the center of the diagram represent the captive regimen, while those around the periphery are natural (optimal) processes. At each point in the life cycle–fertile eggs, nestlings, juveniles and adults–three major options are shown. Designs of most pioneering experiments, ongoing research projects and future studies using captive populations to augment wild populations can be derived from Figure 2. This includes many techniques for increasing the production of young (see below).

For example, some believe that captive populations can be used to maintain particular gene pools. Birds for such an experiment must be taken into captivity at some point, after which proceeding around the inside path of Figure 2 would constitute the most natural breeding possible in captivity. Movement outward in the diagram may be necessary to circumvent specific problems. Mating in captivity has been a stumbling block in many captive breeding efforts, but the option of artificial insemination may eliminate this block. If captive birds lay fertile eggs but have a history of neglecting incubation duties, artificial incubation might be used. If unsatisfied with artificial incubation (a continuing problem with raptor eggs), a researcher might even entrust eggs to a wild pair under ideal circumstances.

The ultimate goal of reintroduction research is to get more birds into wild

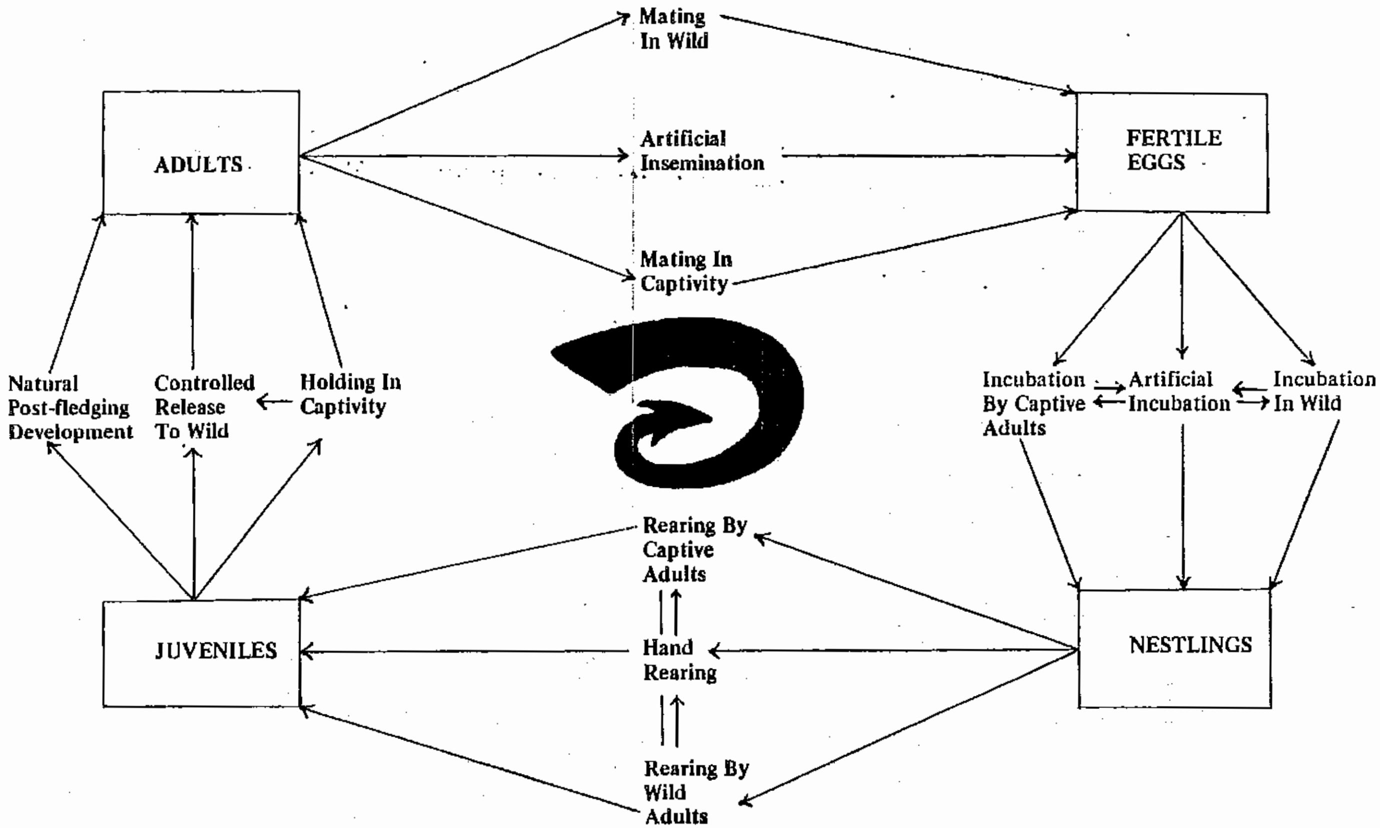

Figure 2. Management options involving captive breeding, reintroduction and wild populations. Note that the options can include both intra- and interspecific fostering when dealing with fertile eggs and nestlings. See text for further explanations.

breeding populations than would be possible through total reliance on natural breeding in the wild. Reintroduction—movement to the periphery in Figure 2—can be implemented at any of four stages in the life cycle: (1) captive or displaced wild adults could be released in the management area; (2) fertile eggs or (3) nestlings from captives or distant wild populations could be put in nests of problem birds; and (4) juveniles could be reintroduced through controlled release (termed "hacking" by falconers) either at the normal time for fledging or later.

(1) Release of Adults. Already captive adults of threatened species or those in need of local management are more valuable in captive breeding projects than in the wild. At present, releasing raptors of breeding age would be wasteful. Controlled release of adults is a complete unknown.

The practicability of displacing breeding adults from other populations is also questionable. It would seriously jeopardize the production of young (if not the lives of the adults). Dispersal and/or homing could preclude all success in the management area. Such experiments should be carried out first with common species and only after less drastic management measures are thoroughly explored.

(2) Transfers of Fertile Eggs. This and transfers of nestlings probably have the highest chance of success of all reintroduction techniques. Two problems exist. First, production of fertile eggs by captives, although increasing, remains at a low level. Except in pilot transfer experiments, the research value of captive-produced eggs is too great for their wholesale placement into the wild. Second, with wild or captive-produced eggs there must be a recipient pair in the management area for intra- or interspecific fostering. This limits the technique's applicability.

One pressing need for field-tested fostering techniques involves reintroduction of *anatum* Peregrine breeding stock, for example into the Rocky Mountains and the Columbia and Snake River drainages. Many old Peregrine eyries are now occupied by Prairie Falcons (Nelson 1969b; Enderson 1969; Porter and White 1973). These close relatives of Peregrines should serve well as recipients of fertile Peregrine eggs for hatching and subsequent fledging in management areas. Different cross-fostering techniques will need to be developed for reintroduction of Peregrines in the eastern United States.

Similar management could benefit other species that have been locally extirpated through natural or unnatural causes. One example will suffice. Although all facts are not proven, it is possible that relatively low food availability may prevent nesting of Ferruginous Hawks (and probably Golden Eagles) on the Hanford Reservation. Many suitable nest sites for Ferruginous Hawks are available but unoccupied. Jackrabbit and cottontail populations on the reservation have been low in recent years. Townsend ground squirrels (*Spermophilus townsendi*) are abundant only in limited areas (O'Farrell, Hedlund, Gies, Olson and Gilbert 1972). Ground squirrels and rabbits are the principal prey of Ferruginous Hawks and Golden Eagles (Smith and Murphy 1973; Olendorff 1973a).

It is reasonable to assume that prey numbers could rebound to the high levels that occurred in the area as late as 1948 or 1950 in the case of black-tailed jack-rabbits. At the first sign of such a trend, return of the two expected (but absent) resident species of raptors might be expedited in the following manner. By placing two Ferruginous Hawk eggs (or young) in each of several Swainson's or Red-tailed Hawk nests for three or four years in succession, the foster Ferruginous Hawks might return to the area, perhaps to the same nest, to breed. Fyfe (pers. comm.) has evidence that some young Peregrines and Prairie Falcons return to their birthplaces, if only briefly. Enderson (1964) found that a small percentage of Prairie Falcons return to nest near their hatching site. Further discussion of this phenomenon can be found in the literature (Hickey 1969: 416-418).

It may be possible, however, to displace a portion of the population of a common species with pairs of a less common or more troubled species through interspecific fostering, particularly if the troubled species nests earlier in the season. It could have firm hold on the territories before others nest. The greatest potential use for this technique would be reintroducing species to their ranges (in case of local extirpation) and into marginal habitat where necessary. One caution: cross fostering may cause behavioral abnormalities when the foster young are simultaneously presented with mates of their own species and of the species that raised them.

(3) Transfers of Nestlings. The logistics and expected results are similar when transferring eggs or nestlings, unless distances travelled are great. Nestlings are easier to transport hundreds or thousands of miles than eggs. The question with nestlings is whether or not foster parents will accept young other than their own. Although many captive pairs do not lay fertile eggs, most will continue their abortive attempts by successfully rearing foster young. Apparently, reintroduction of captive-bred nestlings by fostering has never been tried. We see no difficulties, however. Wild Ospreys incubating addled eggs have accepted and reared foster young (Fernandez and Fernandez in Dunstan 1970). Young Golden Eagles and Ferruginous Hawks have been successfully switched from one nest to another (Craig, Olendorff and Stoddart unpubl.).

Interspecific fostering also merits considerable research. Any attempt to re-establish decimated Peregrine Falcon populations in the United States must be preceded by field tests of fostering. This has been done successfully with wild Prairie Falcons put into Ferruginous Hawk nests (Fyfe pers. comm.). Meyberg (1970) used Black Kites (*Milvus migrans*) to rear young Lesser Spotted Eagles (*Aquila pomarina*). Other combinations in need of field verification include (a) Peregrine Falcons placed into Prairie Falcon, Red-tailed Hawk and Ferruginous Hawk nests, and (b) Golden Eagles into Ferruginous Hawk nests.

(4) Controlled Release of Fledglings and Juveniles. Captive-bred or wild nestlings can be allowed to "fledge" from shelters or artificial nests in the management area. After being fed for ten days to two weeks while developing flight

and hunting skills, the birds will become increasingly independent of their release points. Finally, they will leave completely. Several falconry books contain useful chapters on hacking (Michell 1900; Blaine 1936; Mavrogordato 1966). The only difference with complete reintroduction into the wild is that, as the birds are not trapped back into captivity, food must be supplied as long as handouts are needed.

One danger with controlled release is that the young birds may be preyed on by resident raptors. Post-fledging parental care will be unavailable. Also, there is considerable research time involved. Release points must be visited at least daily. Early hacking attempts should also include an effort to follow birds for a period of time after independence is gained. Radio-telemetry and color marking would be useful in this regard.

If possible, advantage should be taken of those areas lacking the species being released. It would be better to supply artificial nest structures or new nest cavities in a relative void of raptors, than to try to sandwich new pairs between existing ones. If there is any chance of released birds remaining in or returning to the release point to breed, they would more likely be drawn to an area with numerous unused nest sites and a relatively low level of interspecific competition. The bonus might be long-term followup of the birds in order to make the ultimate determination—whether they actually enter a breeding population. As mentioned above, such areas exist both in northeastern Colorado and Washington. Doubtless, others could be found.

Of all reintroduction techniques, however, transfers of eggs and small downy young to nests in the management area require less time. Hundreds of eggs or downy young could be transferred (if available) while just a few are hand reared and later released. Where practicable, we should let birds serve every possible function in the wild, ultimately managing only the necessary aspects of their life histories. The high mortality rate of juveniles is one important target for management (Cade 1971, 1974) which may justify a large investment of time. Cade proposed the following experimental design: mating in wild, incubation in wild, rearing by wild adults (at least for most of the nestling stage and then hand rearing), holding in captivity by falconers and, finally, release to the wild as breeding adults (see Figure 2). This innovative plan should be implemented immediately, if not with Peregrines, at least with Prairie Falcons. We need to know if a young bird will use a feeding station if released as a one-year-old or even later as suggested.

Increasing Production of Young. One characteristic of a healthy population is an adequate number of floating adults of breeding age to fill nest site vacancies which arise. Efforts to increase productivity of a healthy population may increase only the number of floating adults and not the breeding population level unless additional action to provide more nest sites is taken.

There are exceptions to the latter statement. Unhealthy populations could benefit from productivity increases in adjacent populations by natural dispersal of juveniles and/or floating adults. Increased productivity of healthy populations could also be used to create greater than normal harvestable surpluses for captive research and recreational purposes. After establishment of base line population statistics in an area, any excess created through management would be harvestable.

The methods of increasing field production of young include: (a) nest site improvements, (b) egg manipulations and (c) nestling manipulations.

Nest Site Improvements. One result of intensive study of raptors is recognition of specific problems related to nest failure. Total nest site failure over a period of years may be recognized if historic data are available. On our Colorado study area some specific instances of nest failure could be remedied easily. These problems include cavity nests of Golden Eagles filling up with sticks, and young Prairie Falcons killed by the blood-sucking larvae of ticks. Nesting raptors also have problems without solutions. For example, an adult and two fully-feathered Swainson's Hawk nestlings were killed by lightning in 1972; a clutch of Ferruginous Hawk eggs was destroyed the same year when dead branches supporting the nest snapped off in the wind or under the weight of the nest and the incubating adult.

In fact, the discrepancy between the number of nests from which young actually fledge is one of the great disappointments of doing field research on raptors even in highly productive populations. Nest successes (percent of nests which fledge at least one young) for five species of large raptors in northeastern Colorado for 1971 and 1972 combined were as follows: Prairie Falcon—88.8%; Great Horned Owl—74.0%; Ferruginous Hawk—70.4%; Golden Eagle—69.7%; and Swainson's Hawk—55.0%. Of 231 total nests of the five species, only two-thirds (66.2%) were successful. This is not different from other grassland areas (Ogden 1973, Smith and Murphy 1973), but in Colorado, at least, most failures could be prevented.

(1) Conservation of trees. In addition to short-term nest failure, western grasslands also have a somewhat unique, long-term problem. The man-created nest sites in Colorado (as elsewhere) are now deteriorating as trees planted years ago reach maturity and die, or simply die from lack of water (Figure 3a). Death of trees is hastened by cattle which seek shade from trees or use them as rubbing posts. In doing so they destroy grass around the trees, and wind blows the soil away. This exposes the tree's roots and, coupled with abrasion of the bark, kills them (Figure 3b). Many former nest trees have already disappeared completely. One-third (8 of 24) of those Ferruginous Hawk nests in man-planted trees on the Colorado study area are in dead trees. Large nests may make dead or dying trees more apt to blow down.

Management attention is needed. Where grazing is allowed, threatened trees should be fenced. Ranchers probably would not object to this. Most dislike having trees in their arid grassland pastures because cattle seek shade instead of eating throughout the day. Where trees are still alive, but in obvious difficulty (Figure 3a), artificial nest structures should be provided and natural nests remov-

Figure 3a. Ferruginous Hawk nest site near an abandoned farmstead. The nest is in the tree furthest to the right. Note the dead trees on the ground and the dead material in the living trees. Fencing these trees would probably save this nest site.

Figure 3b. A closeup of one of the trees shown in Figure 1a. Note that the tree stands in a slight depression where the cattle have destroyed the grass and some major roots of the tree. The bark of the tree has been completely destroyed in places by the rubbing of cattle.

ed to spare the trees during their recovery. Personnel of the U. S. Forest Service, the agency responsible for the Pawnee National Grassland, are now fencing trees wherever practical. Observations in other parts of the western United States and Canada indicate widespread need for this type of management.

(2) Placement of Artificial Nests in Known Nest Trees. This technique is proposed as a means of preventing failure of nests through total collapse. It could also be used to create new nest sites through attraction of floating adults (previously discussed). Stable artificial nests in trees could prevent the following: (a) wind destruction of nests, particularly flimsy nests of Swainson's Hawks, and large nests of Golden Eagles and Ferruginous Hawks, (b) progressive destruction of nests by active nestlings, and (c) breaking of dead limbs which support nests. For northeastern Colorado, our considered opinion is that over half of the nestling mortalities of tree-nesting species could be eliminated by this technique.

Stabilization of territories of the more abundant raptors is another potential use of permanent, artificial nests. It is possible that early-nesting Great Horned Owls could be forced to use less desirable sites by providing permanent nest substrates at such sites, and by partially destroying stick nests built by hawks each year. In grasslands broken only by scattered trees (such as the Colorado and Washington study areas) owls could be placed as desired by persons managing the raptor populations.

(3) Limiting Public Access to Active Nests. The possible techniques of limiting free access include: (a) posting land with "No Trespassing" signs (see above), (b) blanket prohibition of unauthorized public use of selected federal lands during critical nesting periods, (c) protective legislation for raptors, and (d) eyrie wardens. Protective legislation is not a field endeavor, but law enforcement is. Unfortunately, enforcement of even the existing laws relating to raptor protection—prevention of illegal acts in the field—is unworkable on a large scale. This will not change in the foreseeable future even in light of the new Mexican and Japanese bird treaties.

Blanket, time-limited prohibition of recreational use of selected federal lands during critical nesting periods is a viable technique, in principle. Such restrictions are sometimes imposed in national forests when fire danger is high. Support from the general public may exist for proposals to limit recreational use of some federal lands during the months of April, May and June as a comprehensive wildlife conservation measure—not just for raptor protection.

The use of eyrie wardens is not practical except in extreme, local situations. Scrutiny that is close enough to prevent access by irresponsible individuals is close enough to cause birds to desert, the end result being the same in either case. Although such protection has met with some success in Europe, there is just too much land in the western United States to patrol effectively. Wardening might be adequate to prevent accidental and ignorant interference with nesting raptors, but purposeful, illegal actions will be curtailed only by precedent setting assessments of penalties for violations of stringent possession laws now being developed at the federal level of government.

(4) Enlargement of Ledge and Cavity Nests of Inadequate Size. Like putting artificial nests in known nest sites, this technique was considered above as a method of creating new nest sites. It is important to recognize, however, that even some existing eyries are too small for large broods. This is an uncommon situation with Prairie Falcons, but one noted several times through the years.

A more common occurrence is for Golden Eagles to so fill up small cavities and closely overhung ledges with sticks as to build themselves out of a nest site! At least two nests on the Colorado study area are apparently in a period of disuse for this reason. Presumably, the nest material will settle and decay over the years and allow reuse. The study of alternate Golden Eagle nests to determine if this is a common phenomenon merits the attention of active Golden Eagle researchers.

The solution to the problem is obvious, of course: clean out the filled cavities. One caution: these spent eagle nests make excellent Prairie Falcon eyries—which may be of greater importance than renovation for eagles. Management decisions may not be the same in all areas.

Egg Manipulations. In addition to reintroducing young into the wild, transfers of fertile eggs can offset losses dur to infertility and nestling mortality. Potential techniques include: (1) recycling (= double clutching), (2) removal of eggs from indeterminate layers, and (3) artificial incubation of thin-shelled eggs.

(1-2) Recycling and Indeterminate Egg-laying. That falcons will "recycle" and lay a second clutch of eggs when the first clutch is removed has been known since the days when egg collecting was an active hobby (see Olendorff 1971a: 43-45). Double clutching of captive falcons has been a common practice since the early Peregrine propagation attempts by Beebe (1967).

Only recently, however, has the potential for indeterminate laying been recognized in hawks and falcons. Indeterminate laying is a phenomenon whereby birds will continue to lay if eggs are removed as they are laid, except for one left in the nest each time. Critical references regarding this aspect of raptor biology include Hamerstrom (1970), Porter and Wiemeyer (1972) and discussions in Olendorff (1972c). Indeterminate laying is untested in wild falcons; it may be a useful management tool, but we question its potential due to the disturbance factor. Field testing still has merit, however.

The research outlined below is designed to test recycling and indeterminate laying in wild Prairie Falcons and, through judicious replacement of eggs and young into the wild, to increase productivity of wild populations. Similar management of other species will require small deviations from the suggested designs. A pilot recycling project has been suggested for Peregrines (Lejeune 1972). Richard Fyfe (pers. comm.) has accomplished forced recycling on a pilot basis with both wild Prairie and Peregrine Falcons (ten or more times with Prairies, once with Peregrines).

Experiment 1.—As soon as full clutches of eggs are laid, remove all eggs from a portion of the available nests and place them in several other nests (up to six eggs per eyrie with Prairie Falcons) or in artificial incubators. Prairie Falcons can rear six young, although clutches of six eggs are uncommon (Ogden 1973). Fourteen days later the recycled birds should begin second clutches in the same eyrie or one nearby. It is necessary to work with two populations or to divide managed populations into two parts; recycled birds will be two weeks behind the original clutches.

Experiment 2.—Locate nests with incomplete clutches, preferably those with only one or two eggs. Remove all but one egg, and return every other afternoon to remove all new eggs until egg laying ceases or eggshells appear abnormal. Return full clutches to the managed pairs. Initial attempts to show the feasibility of indeterminate egg laying in captive hawks and falcons indicate that the number of eggs raptors can produce may be limited (Enderson and Goben in Olendorff 1972c: B30).

The goal of forced laying whether by recycling or robbing indeterminate layers is to approximately double productivity of the managed pairs and to bolster productivity of threatened populations through transfers of "extra" fertile eggs and nestlings. In conducting such management the consequences of making incorrect decisions are greater than with all other management techniques herein proposed. Desertion of the managed pairs is a recognized and serious problem, particularly during the egg period (see Fyfe and Olendorff in prep.). Nevertheless, some raptors are strikingly resistant to human disturbance short of actual destruction of nests, eggs and birds. Recycling is a one-time disturbance. Data indicate that many raptorial species will overcome *early* removal (during the first week of incubation) of all of their eggs by renesting. Later in incubation or during the nestling period, removal of all eggs or young will not result in a second nesting attempt. The birds will be unable to recycle, presumably for physiological and/or psychological reasons.

Much must be known about populations earmarked for these types of management. The need for such management should be clearly shown. It is important to know the nesting phenology and recent reproductive success of populations from which eggs are taken. Each species must be treated differently, according to its manageable problems, nesting habits, behavior (such as the potential for desertion), and physiology. Above all, field technique must be well-planned and proper; there are ways of minimizing desertion even when intrusions must be made during the egg period (Fyfe and Olendorff in prep.).

(3) Artificial Incubation of Thin-shelled Eggs. Populations suffering from the effects of sublethal doses of organochlorine pesticides typically lay thin-shelled eggs when contamination is severe enough to interfere with calcium metabolism.

The degree of thinning that can be tolerated is known for some species. The capability of measuring eggshell thickness in the field is being developed (Glen A. Fox pers. comm.). When this becomes possible, the following management procedure may be locally applicable: (a) field detection of thin shells, (b) removal of eggs and replacement with dummy eggs, (c) artificial incubation and (d) placement of hatched young in their original nests.

Again, a nest visit early in the incubation period is necessary, but such risks may be acceptable in some cases. With this technique, at least those thin-shelled eggs that are fertile will come to some productive end. The difficult decisions regard the degree of thinning at which eggs would be pulled and determining who is capable of doing it. Also, where the situation is sufficiently critical to use this technique, the presence of a control population to evaluate the success or failure of the management is unlikely. Nevertheless, the procedure should be field tested for future reference within populations not suffering from eggshell thinning.

Nestling Manipulations. Once eggs hatch, the number of applicable management techniques—indeed, the number of reasons for management—decreases. Nestling mortality can be prevented in many ways not directly involving manipulations of nestlings. Nestlings are totally dependent on nest site adequacy, fair weather, the absence of human interference and the quality of parental care.

There are two ways in which management can benefit nestlings directly: (1) transfer of runts to foster nests and (2) field treatment of diseases and parasites.

(1) Transfer of Runts. Sometimes several nestlings achieve serious physical dominance over one of their nestmates. The result is a poorly developed bird in danger of starving or, at least, one that is a victim of slow physical development, tardiness in fledging, and other abnormal situations rendering it unable to compete after fledging.

An incident of this type was watched for four weeks in a Ferruginous Hawk nest in 1971. The runt disappeared long before physically able to fledge. Similar circumstances were observed in two Ferruginous Hawk nests in 1972; runts were transferred to nests containing nestlings at the same stage of development. In both instances all birds fledged. This simple management technique should be used only during the course of other research; it is hardly justifiable to visit nests just to look for runts. For example, banders are often in a position to rescue runts.

A parallel occurrence with a potential for management involves transferring nestlings, where obligatory Cain and Abel fratricide occurs, or, in a broader sense, where any danger of fratricide is suspected. The intensity of Cain and Abel battles diminishes with age, often completely two to three weeks after hatching. Where fratricide is expected, hand rearing of one bird and its subsequent replacement into the original nest would be practicable. If more than a week behind its nest mate, it should be placed in a foster nest with similarly developed nestlings.

A pioneering experiment of this type was conducted by Gargett (1967, 1970) with Black Eagles (*Aquila verreauxi*). Two Black Eagle chicks are rarely, if ever, raised in the same nest because of Cain and Abel conflicts. Gargett alternately took one chick and then the other into captivity for one week at a time for hand rearing. This alternating process (see Figure 2) resulted in two young being fledged from the nest. Such one-step deviations from the wild situation may prove crucial to success of future population management of some raptors.

(2) Field Treatment of Diseases and Parasites. Although the effects of diseases on population dynamics of wild raptors are unknown, the potential exists for serious local problems (see Hickey 1969: 425-454). Diseases and parasites may work in combination with other mortality factors. In northeastern Colorado, for example, from 17 Prairie Falcon nests in 1972, 3.18 young fledged per nest. If seven infertile eggs had been viable and seven young birds infested with blood-sucking tick larvae (*Ornithodorus* sp.) had been reared, productivity would have been 4.00 young per nest, an increase of 26%. On our Colorado area, where Prairie Falcons are currently producing well, such an increase might not significantly affect the population dynamics of the species. In other areas, now and in the future, such an increase might be very welcome.

The tick problem may have a simple solution. Ticks seemed to occur in great numbers only in nests that rarely or never received direct sunlight. Where sunlight hit the nestlings or the nest litter for at least a portion of the day, infestations of ticks were less severe. Ledge alterations to widen nest openings, destruction of the proven unsatisfactory sites, and/or construction of adequate sites nearby may provide a long-term solution to tick infestations. If nót, treatment of sick birds with pyrethrum in their nests may be feasible. Halliwell (pers. comm.) suggests treatment of the eyrie with 5% carbaryl (serin) powder.

Further Considerations

The above management techniques were proposed as possible solutions to some problems of grassland raptors. They are not, in most cases, discussions of what worked; rather, they are techniques in need of field testing. We feel that the cause of raptor management—indeed, the welfare of birds of prey in general—will best be served by widespread knowledge of potential techniques. We hope that management efforts will be catalyzed by public discussions before the fact. Hindsight about what should have been done for an extirpated or extinct species or subspecies makes distressing commentary.

There are cautions, however, which must temper any overzealous attempt to lend a helping hand to birds of prey through field management. For example, threatened and endangered species should receive only the best professional management that available money can buy. There are instances, however, in which well-coordinated local efforts might be fruitful. The following discussions relate more to specific problems and further management suggestions for application at the grass roots level, as opposed to emergency conservation measures. Some of the discussions will have application in the latter case as well.

General Habitat Management. The single most important factor (in the absence of pesticides) which determines population levels of grassland raptors is land use. Control and use of both private and federal lands are complex matters which make only general suggestions relevant and only local action (in the majority of cases) practicable. Each area is unique, from the ownership of land to the prevailing fauna, flora and topography.

Three potential avenues of general management of grasslands for the benefit of raptors became apparent during our field studies. All would serve the cause of raptor management indirectly. Two involve agricultural interests: (a) limiting cultivation and (b) keeping large ranches intact. The third requires action by national and local governments and encouragement from the general public: (c) maintenance of existing national grasslands including reseeding, expansion of federal holdings and development of wildlife (birds of prey) sanctuaries.

Limiting Cultivation. Cultivation is a form of habitat destruction. To limit farming is very difficult, however, since people have historically been able to utilize their land in any way they desire. It is not necessary, for example, to file an environmental impact statement in conjunction with the development of land for cultivation.

The only attack on this problem may be education of the farming community concerning the detrimental effect of cultivation on wildlife. Their effective counter is the benefit farming has in feeding people. Nevertheless, enlightenment of farmers might convince them that new cultivation should at least include scattered areas of wildlife habitat, much as was suggested for Prairie Chickens (*Tympanuchus cupido*) by Hamerstrom, Mattson and Hamerstrom (1957). It also follows that the current policy of not allowing farming on national grasslands should be continued.

Preservation of Large Ranches. The largest, most closely controlled private ranches in northeastern Colorado make the best nesting habitat for most of the raptors in the area. Cattle ranchers have been managing raptor populations for decades by keeping human disturbance at a minimum on their land. Such management has been inadvertent, but effective. Large ranches should not be opened up by new county roads or other public access.

Although a few ranchers (primarily sheep ranchers) have recently conducted campaigns to exterminate large birds of prey, the vast majority understand and appreciate the natural beauty and wildlife of their land. Many, in our experience, are both aware and protective of birds of prey that nest on their property. It is unfortunate that illegal actions of a few sheepmen in poisoning and shooting Golden Eagles have hurt the image of all ranchers. Much raptor management will require the permission (and will receive the plaudits) of ranchers.

Maintenance of National Grasslands. Early in 1973 a presumptuous bill was introduced to the Colorado House of Representatives to request that the federal government sell the Pawnee National Grassland. Such a proposal is the opposite of what is needed in terms of raptor management and maintenance of grassland communities.

Large tracts of relatively pristine habitat—private or federal—should be viewed as reservoirs of breeding populations of raptors. Some probably serve a greater purpose as prey sources. The 615 square mile (1593 km^2) Hanford Reservation and the 2,000 square miles (1593 km^2) in and surrounding the Pawnee National Grassland are but two of many examples in the western United States.

Although more raptors nest on private than on federal grasslands, the latter provide considerable habitat stability where farmers were defeated by the elements during the Dust Bowl days. On the Pawnee National Grassland alone over 60,000 acres (24,300 ha; 93 sq mi, 236.8 km^2) have been reseeded. More non-irrigable land is committed to grass each year. Such programs merit support on both national and local levels as indirect methods of wildlife conservation.

Behavioral Idiosyncrasies of the Species Concerned. The eggs and young which may be placed in jeopardy by nest transfers, egg manipulations, etc., are the means to an end: the production of fledglings and, subsequently, new breeding stock. Raptor management research must not suffer from disregard for the birds. This is particularly true of efforts involving raptors showing population declines. Refined field techniques must reflect a concern for the study material—a concern dependent upon common sense for the most part.

When a nest is visited: (1) parent hawks may become so vexed that they desert their eggs and young completely; (2) the chances of egg breakage by parent birds are increased, as are chances of cooling, overheating, loss of humidity and avian predation of eggs; (3) newly hatched birds of prey may be chilled or overheated and even die in the absence of brooding; (4) one or more feedings may be missed by the nestlings; (5) the parents may not return before nightfall if the nest is visited late in the day; (6) older nestlings may fledge prematurely and break bones at the end of a futile first flight, or be forced to spend one or several nights on the ground where vulnerability to predation is high; (7) mishandling may damage developing feathers, bones and claws; (8) mammalian predators may follow scent trails directly to the eggs or young; (9) the attention of other humans may be attracted; and (10) on cliffs, rocks might inadvertently be knocked onto eggs or young birds.

Some people would hold that the risks of management are too great. Nevertheless, correct field conduct will minimize (but not eliminate) the adverse effects of direct human interference. We believe that raptor management, properly planned and conducted, will more than offset any detrimental effects of carrying out the management.

The failure of parents to return to eggs or young is probably the most serious, and certainly the most unpredictable, problem of raptor management. Nest building, egg laying and incubation phases are critical periods during which the slightest disturbance may cause abandonment. The most critical time is likely just prior to laying when females spend many hours sitting on their empty nests (Nethersole-Thompson and Nethersole-Thompson 1933). There is much variability depending on general species tolerances, idiosyncrasies of individuals and the "level of acceptability" of nest sites (Ratcliffe 1962; Hickey 1942; and many others). A few examples follow.

Ferruginous Hawks are prone to desertion during the early stages of nesting. In our studies we do not climb to active Ferruginous Hawk nests until after hatching. In Colorado, Swainson's Hawks and Prairie Falcons rarely deserted after a visit during the incubation period, yet this is not consistent from area to area for Swainson's Hawks. Ospreys seem to be the most tolerant of all raptors during the early stages of nesting. They can be trapped, banded and color marked at their nests, and will tolerate their eggs being moved from nest to nest without deserting. Great Horned Owls are about as tolerant.

It is necessary, then, to fit management techniques to the behavioral reactions of the managed species. It may only be practicable to collect data pertinent to these problems as management efforts progress. The lack of field-tested techniques may limit the types of management that should be undertaken during the next several years.

Interference of Other Raptors with Management Efforts. Those who wish to manage birds of prey on a local, Good Samaritan basis may not care which species actually benefit. What one man sees in a Peregrine Falcon, another might see in a Great Horned Owl. However, attempts to re-establish populations, to reintroduce new breeding stock or to increase populations of threatened raptors must be more selective. Circumstances working against selective management include: (1) differences in nesting phenologies of raptors present in the management area and (2) greater success of generalized raptors, i.e., those which prey on a wider variety of animals. Much time, effort and money could be wasted if these problems are not evaluated properly.

For example, on our Colorado study area Great Horned Owls began nesting about 37 days before Ferruginous Hawks, 43 days before Prairie Falcons and 64 days before Swainson's Hawks (Figure 4). Of all nest sites available, Great Horned Owls had first choice and often chose the best available. Evidence that this natural prerogative was asserted each year is presented elsewhere (Olendorff 1973a). The losers were the hawks and falcons. The potential exists that Great Horned Owls—not Prairie Falcons, Ferruginous Hawks or some other species selected for management—will take over new nest sites. Attempts to manage Arctic Peregrines might be similarly hampered by Gyrfalcons (just to illustrate how difficult the decisions might be). Prior knowledge of raptor population dynamics and natural histories would permit an assessment of such problems.

No Ferruginous Hawks or Golden Eagles were found nesting or seen on the Hanford Reservation in 1973, although these species were expected and many adequate nest sites were present (see above). Food habits studies of grassland buteos have been conducted in Colorado (Olendorff 1973a) and Utah (Smith and Murphy 1973). These studies suggest that Swainson's Hawks prey on more species than other buteos or Golden Eagles do. The Swainson's Hawk is a more generalized predator because it eats more insects and fewer rabbits and ground

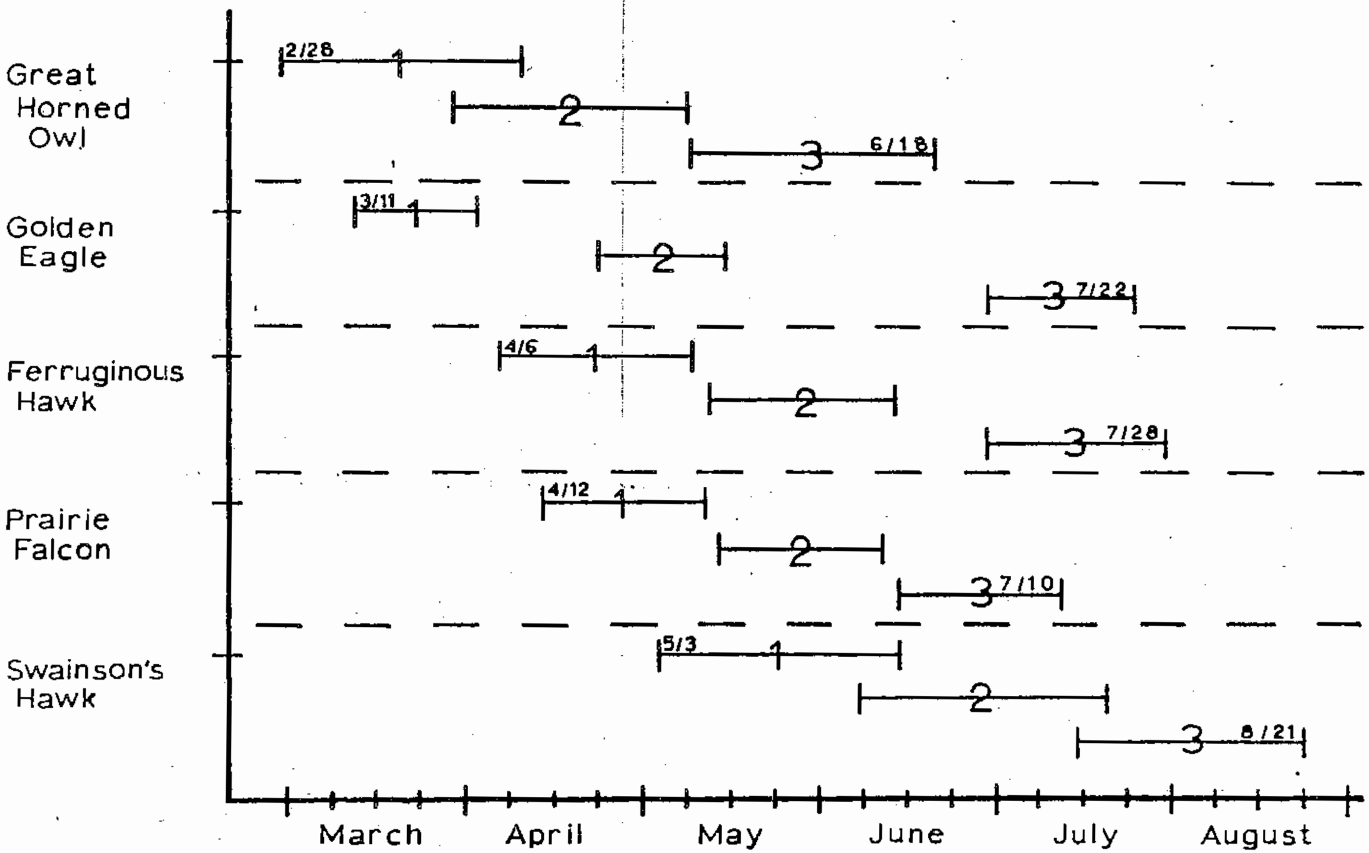

Figure 4. The phenology of nesting by five large raptors in northeastern Colorado. 1 = egg laying period. 2 = hatching period. 3 = fledging period. Dates on which the first eggs were laid and the last young fledged (1970-1972) are shown.

squirrels.

Using Utah data, the percentage (of the total number of prey items identified) of rabbits and ground squirrels in the diet decreased with the size of the raptor: Golden Eagle—94.0%, Ferruginous Hawk—70.3%, Red-tailed Hawk—66.4%, and Swainson's Hawk—44.1%. Corresponding figures for northeastern Colorado were Golden Eagle—91.6%, Ferruginous Hawk—65.6%, and Swainson's Hawk—23.8%. The average size of prey taken also decreased with the size of the raptor: Golden Eagle—1,825 g, Ferruginous Hawk—1,394 g, Red-tailed Hawk—1,386 g and Swainson's Hawk—905 g (Smith and Murphy 1973). These data suggest that in a given area, with closely related species, specialization increases with size. Lack (1966: 309) states simply that "the large prey on which large raptors depend are in general much sparser than the small prey on which small raptors depend . . ." These facts have management applications.

An example will be made of the three regions of the Hanford Reservation discussed previously (Table 3). Briefly, the regions were characterized as follows: Region 1—no nest sites, low prey availability, no nesting buteos; Region 2—limited number of nest sites, low prey availability, a few nesting Swainson's Hawks; and Region 3—abundant nest sites, moderate prey base, numerous nesting Swainson's and Red-tailed Hawks.

Comparative mammal data were not available for the three regions except through casual observations. In general, jackrabbit numbers have been low for many years (perhaps since the late 1940's). No jackrabbits were seen on the nearby Arid Lands Ecology Reserve (part of the Hanford Reservation adjacent to Region 2) during the years 1968-1971 (O'Farrell, Hedlund, Geis, Olson and Gilbert 1972). Ground squirrels were abundant in some parts of the Hanford Reservation, but were scarce or absent in the regions under discussion. Nearly all Townsend's ground squirrels on the Reservation estivate by the end of May, before hawks and eagles need maximum numbers of prey.

All this suggests that raptor management in Regions 1 and 2 would increase only the most generalized species, the Swainson's Hawk. When man inadvertently created nest sites in Region 2, Swainson's Hawks—not Red-tailed or Ferruginous Hawks—moved in. Similarly, evidence was presented elsewhere in this paper that showed the greater ability of Swainson's Hawks to exploit grasslands made available to tree-nesting raptors through planting of trees by homesteaders in northeastern Colorado.

In Region 3 at Hanford, nest site availability and prey populations were high enough to allow two buteos to nest. Nowhere on the secluded portions of the reservation were enough rabbits and/or ground squirrels available to support the most specialized species: Golden Eagles and Ferruginous Hawks.

This background information will have great bearing on raptor management efforts on the Hanford Reservation. Generalized species are often widespread, abundant and not in need of management, even on a local, Good Samaritan basis. They may, in fact, interfere with selective management of more specialized species. Establishment of priorities and choice of proper techniques for the most selective management possible are important—even at the grass roots level.

Summary

"Although management in Europe came first and biology afterward, there is plenty of evidence that biological guidance is now increasingly sought as a means of making management more effective, and fairer to non-game species of wild life." (Aldo Leopold 1933, p. 13.)

Although urgently needed for several species, raptor management is still impracticable in the absence of field-tested techniques. A multifaceted, penetrating research effort must be made if quantitative data concerning population dynamics, ecological impact, management and conservation are to be synthesized.

Field evidence for the potential for management of grassland raptors include: (1) many species nest outside of their dominant nesting habitat, i.e. these species are versatile with regard to basic components of a territory, (2) nesting raptors are absent where nest sites are unavailable, (3) trees planted by man near now abandoned farmsteads, windmills, etc., are extensively used, (4) artificial or man-made structures are accepted as nest substrates, (5) a large discrepancy often exists between utilization and availability of prey, and (6) there is direct advantage to nesting raptors of remoteness and land posted with "No Trespassing" signs.

In taking advantage of the potential for management of grassland raptors, two large categories of techniques merit field testing: (1) increasing breeding population levels by developing new nest sites and introduction of new breeding stock, and (2) increasing the production of young through improvement of existing nest sites, egg manipulations and nestling manipulations.

New nest sites can be developed through the use of artificial nest structures (elevated platforms, barrels and nest boxes), by planting trees, by digging cavities and ledges in cliffs which lack adequate nest sites, and through management of other birds and mammals which create raptor nest sites during their own life cycles. Artificial nest structures and cliff alterations have the greatest potential for field application.

New breeding stock can be introduced into an area at any stage of the raptor life cycle—eggs, nestlings, juveniles or adults. Releasing adults would be a wasteful technique at this time. Transfers of fertile eggs either from captive to wild populations or from one wild population to another probably have the highest chance of success of all reintroduction techniques. Both intra- and interspecific fostering of nestlings may be more practicable with species likely to desert during the egg period. Controlled release (hacking), although time consuming, may have application in some situations.

Nest site improvements aimed toward increasing the production of young in existing nests include conservation of trees, placement of artificial nests in known nest trees, limiting public access to active nests, and enlargement of those cliff nests too small for large broods. These types of management (which can be accomplished during the non-nesting season) are excellent for use by local conservation organizations and private individuals.

Other methods of increasing the production of young include egg manipulations such as recycling or double clutching, removal of eggs from indeterminate

egg layers and artificial incubation of thin-shelled eggs. These are emergency conservation measures which require proper planning, timing and field conduct. General use is not recommended until after further field testing because adults may desert nests visited during the egg period.

General habitat management is something that every raptor enthusiast could be involved in. Fruitful avenues include limiting cultivation, preservation of large ranches, maintenance of national grasslands and conservation of wildlife habitat in general. These are all public education problems.

Of particular importance in technical planning are behavioral idiosyncrasies of the species concerned, interspecific differences in nesting phenologies of competing raptors, and population dynamics of all raptors, particularly of the more generalized species which might interfere with management of threatened species.

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PLANS FOR MANAGING THE SURVIVAL OF THE PEREGRINE FALCON

Tom J. Cade

Introduction

The Peregrine, more than any other threatened bird, has focused public attention on the problems of survival for raptors in the closing decades of the 20th Century. No other species evokes so much discussion, so many divergent and opposed views. I shall argue for management, in its broad sense, as the best way to insure the survival of the Peregrine and other birds of prey in an increasingly man-dominated world, rather than relying solely or mainly on "complete protection" to safeguard dwindling raptor populations.

First, some words of wisdom, not my own: "We of the industrial age boast of our control over nature. Plant or animal, star or atom, wind or river—there is no force in earth or sky which we will not shortly harness to build 'the good life' for ourselves.

"But what is the good life? Is all this glut of power to be used for only bread-and-butter ends? . . . Are we too poor in purse or spirit to apply some of it to keep the land pleasant to see, and good to live in?

"Every countryside proclaims the fact that we have, today, less control in the field of conservation than in any other contact with surrounding nature. We patrol the air and the ether, but we do not keep filth out of our creeks and rivers. We stand guard over works of art, but species representing the work of aeons are stolen from under our noses. . . . In a certain sense we are learning

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more rapidly about the fires that burn in the spiral nebulae than those that burn in our forests. . . ."

Does that sound like some *avant garde* member of the environmentalist movement speaking? The words certainly have the ring of the 1970's in them, do they not? They speak to the central issues of our times as far as environment is concerned, but they were actually written in 1932–41 years ago–in Madison, Wisconsin, by Aldo Leopold. They appear in the preface to a textbook with the unassuming title, GAME MANAGEMENT (Leopold, 1933).

Leopold goes on to say: "Control comes from the co-ordination of science and use.

"This book attempts to explore the possibilities of such co-ordination in a single, limited field–the conservation of game by management. Its detail applies to game alone, but the principles are of general import to all fields of conservation.

"The central thesis of game management is this: game can be restored by the *creative use* of the same tools which have heretofore destroyed it–axe, plow, cow, fire, and gun. A favorable alignment of these forces sometimes came about in pioneer days by accident. The result was a temporary wealth of game far greater than the red man ever saw. Management is their purposeful and continuing alignment.

"The conservation movement has sought to restore wild life by the control of guns alone, with little visible success. Management seeks the same end, but by more versatile means. . . ."

The basic idea of game management has been around for a long time. Leopold, for example, calls attention to the elaborate techniques of management employed in China under the Great Kublai Kahn, as described by Marco Polo. But as a science in the United States, game management–or wildlife management as it is now more generally applied–is of rather recent origin and essentially dates from the time of Leopold in the 1920's and 1930's, having received its first great impetus during the New Deal Administration of Franklin D. Roosevelt.

The application of the principles of wildlife management to birds of prey *for their conservation* is very new indeed and is just beginning to replace the outmoded practices of predator control, which for centuries have been the main kinds of "management" directed at raptors. It is encouraging to note, for instance, that the State of Colorado now has a full-time raptor biologist on the staff of its wildlife department. Also, that the Canadian Wildlife Service has an experimental program in raptor management under way in Alberta, where both field techniques and captive propagation are being carried out on an impressive scale, while the Rare and Endangered Species Program of the U. S. Fish and Wildlife Service has several long-term projects concerned with various birds of prey.

We are at the beginning of some exciting times as far as man's relations with the birds of prey are concerned. There are going to be some revolutionary changes, and I think we are going to see some important results in preserving habitat, restoring habitat, and even improving habitat for raptors, as well as in replenishing lost stock where species have been extirpated.

Here are one or two quick examples of demonstrated success that presage future application on a much broader scale. In Alberta, Richard Fyfe has been able to increase the number of nesting pairs of Prairie Falcons on a stretch of cliffs by dynamiting additional potholes for nest sites. In one area where there had been seven pairs nesting, he was able to increase the population to 11 pairs by placing nesting sites between the original pairs. But this was in an area where the falcons feed on ground squirrels. In another area where they feed on birds, additional sites effected no change in the number of breeding pairs. In the first case, nesting sites apparently were limiting, whereas in the latter instance food supply seems to have been more critical.

The augmentation of breeding pairs resulting from the use of man-made nesting structures has also been well demonstrated for the American Kestrel and the Osprey. One of my graduate students, Paul Spitzer, has also shown the feasibility of supplementing the productivity of remnant Osprey populations, whose reproduction has been severely affected by organochlorine poisoning in the Long Island Sound region, by transferring healthy eggs or young from other Osprey populations to these failing nests. In 1972, five of these fostered young returned in their third year of life to the region of their foster nests, and three of them joined the breeding population there.

How do we go about managing birds of prey? As Leopold pointed out more than 40 years ago, the principles are known; they only need application to the raptors. The first thing that must be done for any species is to inventory the breeding stock—find out how many nesting pairs there are, what their productivity is, and then determine what the critical limiting factors are on numbers, reproduction, survival, and so on. Then, if need be or if it is deemed desirable to do so, we can set about to manipulate those factors to favor larger numbers or greater productivity, just as Richard Fyfe has begun to do with his Prairie Falcons. Essentially what we need to have in hand is a good knowledge of the basic population ecology of the species to be managed. We do not yet have this basic information for very many species of our native raptors in North America, except for some of the more popular species such as the Peregrine.

The Peregrine, A Case History for the Application of Management

After the decline of the Peregrine in Europe and in North America became generally known in the late 1960's, and particularly when the involvement of DDT became clearly established shortly after the Madison Peregrine Conference in 1965 (Hickey, 1969), various concerned groups of people—conservationists, research biologists, ornithologists, aviculturists, and falconers—began to think about ways to do something to save the Peregrine. Obviously the first thing that needed doing was to get some effective government restraints placed on the use of DDT, and the Peregrine became a *cause célèbre* in the great DDT debate of the past six years. After a long and bitter confrontation in the courts and before various hearing examiners, that issue now appears to have been settled in favor of the Peregrine and other wildlife, at least as far as continued use in the United States is concerned (Wurster, 1973), and we can hope for a time when chemical contamination of their food supply will no longer be a serious problem for falcons.

Meanwhile, four basic plans of action for saving the Peregrine have emerged. While they are not mutually exclusive and, indeed, should be integrated into one over-all program, they tend to be espoused by different groups of proponents who disagree in their philosophy for the preservation of species. The four plans are: (1) increased legal protection, (2) preservation of essential habitat, especially nesting sites, (3) management of wild populations, and (4) captive propagation for "domestication" and for eventual restocking of vacated range.

Legal protection.—Despite generally favorable legislation protecting the Peregrine in most states, and now also by federal law and international agreements, providing maximum legal protection to the remaining Peregrines has a long way to go to achieve any practical result. There are three principal threats to birds of prey, the same three that all forms of wildlife must face. The first is "overkill" or over-exploitation by man for whatever reasons—predator control, "sport" shooting, commercial trapping for the pet trade and falconry, and so on. The second is outright destruction of natural habitats or the degradation of habitats to the point that they can no longer support raptorial bird populations, brought about by man's technological uses of the land. The third is chemical pollution of ecosystems by persistent poisons, such as DDT and PCB, chemicals that magnify as they move up food chains to become highly concentrated in the bodies of predatory birds and that often act, even at sublethal concentrations, to alter reproductive performance and to cause population decline. Legal protection addresses itself only to the first of these hazards.

Direct killing or molestation by man is *the least* important threat to birds of prey, some of the recent spectacular cases of massive eagle kills in the West notwithstanding, and notwithstanding the much propagandized Morro Rock incident in California (McNulty, 1972). Except for very localized instances involving a few species only, there are no data to support the contention that direct human depredations, of any sort, have played an important role in permanently decreasing raptor populations. All the shooting that used to take place at Hawk Mountain, however much we decry it on esthetic and moral grounds, all the winter Golden Eagle shooting in Texas and elsewhere, the bounty-hunting of Bald Eagles—for years—in Alaska, and all the egg-collecting merely took a fraction of the natural, excess production of individuals that characterizes any healthy species population. These activities exerted no significant, long-term impact on the *breeding populations,* which have maintained densities that are basically determined by the biological adjustments of the raptors to environmental influences other than human predation, chiefly to qualitative and quantitative changes in habitat and food supply. Even a deliberate and concerted attempt in Britain during World War II to exterminate the Peregrine by shooting the adults and destroying eggs and young in the nests was only partially successful, and the Peregrine population was well on its way to full recovery in the early 1950's when the DDT problem hit Britain (Ratcliffe, 1972, p. 154). These few examples, which could be multiplied, show how resilient raptor populations are to the more usual forms of direct persecution (see Cade, 1968).

Some conservation and protectionist groups are urging laws and regulations that will afford "complete protection" to endangered species, particularly the Peregrine Falcon. Complete protection means that no adult bird, young, or eggs could be taken from the wild for *any purpose*. Legal protection as a measure for saving a species from extinction can work well when the problem is "overkill"—when the take exceeds surpluses and recruitment to the breeding population is decreased thereby. In the past we have witnesses some dramatic examples of wildlife populations that bounced back from the brink of extinction after they were afforded protection. On the other hand, the California Condor, which has been the most completely protected bird of prey in North America for many years, provides an equally dramatic example of how futile complete protection can be when it is applied too late and without any latitude for alternative plans of action.

I fear that those who advocate complete protection for the Peregrine are blinded by their remembrance of better days, when our environmental problems were simple and direct. They want to apply an old remedy that worked well for a simple problem of overkill to a whole array of new environmental problems unprecedented in their scope and nature. When the overriding problems are deteriorating habitats and chemical pollution of the environment, protection alone becomes a meaningless gesture. Management must not stop there.

There is room for much improvement in law enforcement and public attitudes before we can say we have effective protection for the Peregrine, or other birds of prey for that matter. Penalties should certainly be increased for illegal acts perpetrated against the Peregrine and other birds of prey, as I have publicly urged for 20 years (Cade, 1954; 1971). For critically endangered populations, such as those few Peregrines that still occupy aeries in the United States south of Canada, a system of state and federally organized wardens should be set up for each occupied aerie during the nesting season to intercept any unauthorized human intruders at the cliffs and to apprehend thieves. Such a cadre of wardens could importantly involve concerned citizens—youth groups, conservation organizations, and falconers—and would not require large outlays of money.

Preservation of essential habitat.—Nesting habitat continues to be destroyed or rendered uninhabitable by human land uses that disregard the locations of historic and irreplaceable falcon aeries, and in the long run the preservation of these falcon cliffs intact and free from surrounding disturbances is the most essential action required to insure the survival of wild Peregrines. It is encouraging to note that many state and federal agencies responsible for the administration of public lands have become aware of the Peregrine and of its dependence on these few, specific habitat formations for nesting sites. Increasingly the long-range plans of these agencies take the needs of the Peregrine and other birds of prey into account, as do the numerous "impact statements" required by the National Environmental Policy Act. But there is need for constant public vigilance and for a truly national and international policy for the preservation of endangered species and endangered habitats. Ambitious developmental projects, such as the proposed trans-Alaska oil pipeline and the Woodchopper dam-site proposal on the Yukon River, must be carefully scrutinized for their impact on falcon aeries. The latter, for example, would flood out more than 20 known Peregrine aeries in the Yukon River valley.

The best hope for preservation of falcon habitat lies in the creation of more wilderness areas and more nature preserves of whatever sort. Since the majority of the surviving Peregrines within the borders of the United States are in Alaska, the final outcome of the present jurisdictional squabbles between the state and the federal government, and among the agencies within the federal government, which have resulted from the Alaska Native Land Claims Act, will be most significant for the future of the Peregrine in our northern wilderness state. If most of the foothills of the Arctic Slope and the drainages of the Yukon River above its confluence with the Tanana receive some kind of protected status, then a large percentage of our arctic nesting Peregrines will be secure. If the Aleutian Islands and other islands of the Bering Sea and the Pacific Northwest Coast become incorporated into the wilderness system, our magnificent maritime Peregrines (*F. p. pealei*) should also be secure for the distant future.

On all our public lands, regardless of their specified uses, restricted zones should be established around historic falcon cliffs. Each aerie should have an undisturbed perimeter around it with a radius of about half a mile in which no permanent human occupation or disruptive land use is allowed. An Interior Department policy, modeled after the U. S. Forest Service policy in Alaska to leave an uncut tract around Bald Eagle nests, is what we need for falcon aeries. A recent "Technical Note" from the Bureau of Land Management on habitat management for endangered species makes just such a recommendation (Snow, 1972).

Management of wild populations.—Several manipulative techniques have potential for increasing the numbers of wild Peregrines, and they should be tried on a limited scale to test their applicability for management.

For example, it should be possible to increase the productivity of wild pairs by the technique of "double-clutching." The Peregrine is an indeterminate layer, and most females will produce a second clutch when the first is destroyed or removed early in incubation. The old egg collectors used to take advantage of this fact and sometimes got as many as three sets in one season from the same female (Hickey, 1969, p. 27). There are even records of four. Since the advent of the DDT-thin-eggshell phenomenon, many female Peregrines lay eggs year after year but fail to hatch them because the eggs break during the course of incubation. I am told there is one female in Colorado that has laid but failed to produce any young for six years running. From our Alaskan data, I expect that most of these lost eggs are viable but are simply mechanically damaged in one way or another before hatching.

Given these circumstances, the removal of the first clutch of eggs is a justifiable way to try to increase the productivity of wild falcons. In most cases the wild female can be expected to renest with the possibility of rearing some of her own young, and where a female has a history of egg failure, taking her eggs for experimental rearing would have no impact on natural productivity in any event.

The removed eggs can be handled in two ways. They can be artificially incubated and hatched in a laboratory, or they can be fostered to other wild parents, such as Prairie Falcons or other suitable species. Similarly, any young falcons hatched artificially can either be hand-reared in captivity and later released to the wild under appropriate circumstances, or they can be fostered to wild parents.

These are all techniques that have been proved to work with one species or another. Federal and state agencies are, therefore, urged to cooperate with qualified researchers to obtain Peregrine eggs from first clutches for experimental hatching, rearing, and fostering.

Another possibility is to increase the survival rate of immature Peregrines by holding them in captivity during the first critical year or two of their lives and then releasing them back to the wild as fully matured adults. While survivorship curves and life tables have not been worked out with great accuracy for wild Peregrines because of insufficient information, various estimates of mortality have been based on available banding data from North America and Europe (Enderson, 1969; Young, 1969; Shor, 1970). Most investigators agree that not more than 40 to 50 percent of the fledged young survive beyond their first year of life, whereas subadult and adult mortality rates appear to fall between 15 and 20 percent per year. If Peregrines start breeding near the age of two years, these figures mean that for every 100 Peregrines fledged in the wild no more than 34 to 40 survive to breeding age. Potential recruitment to the adult breeding population could be increased if this rate of survival were increased.

The techniques of falconry, properly used, could result in an increased rate of survival of first- and second-year falcons. If specially qualified falconers were permitted to take eyasses or passage Peregrines with the stipulation that the falcons have to be released at the end of their first or second winter, in time for spring migration, the wild falcon populations could benefit from a bonus of adult birds added to them. Good falconers can keep a higher percentage of first- and second-year birds alive than naturally occurs in the wild. I suggest that for every 100 young taken in their first summer or fall at least 60 and perhaps as many as 75 could still be alive at the end of their second winter, if carefully managed and conservatively flown, or roughly twice the number that can be expected to survive in the wild. Diseases that are often fatal to immature falcons in the wild are usually curable today in captivity. Moreover, the captive falcon never has to face the consequences of an inadequate food supply, severe weather, or most other forms of natural mortality.

The principal unknown factor in this equation is that there are no statistical data on how successful trained falcons are after they revert to the wild. Falconers generally feel that birds properly handled and in top physical condition can hold their own equally with their wild counterparts. Unflown captives, on the other hand, should never be released until they have been brought into condition by daily flying exercise. In the falconer's parlance, they must be "hacked back" to the wild. This can be done through the practice of falconry—by daily exercise with a lure or by releasing live pigeons or other birds for the falcon to cahse. When a trained falcon can stoop 100 times at a swinging lure without becoming exhausted or can "wait on" overhead for 20 to 30 minutes without perching, she can be considered strong enough to make it on her own. A falcon does not have to be taught how to hunt and kill, although serving her some bagged quarry for practice is probably a good idea. Gradually such a trained bird can be left out for longer and longer periods, until she is on her own.

There are individual records of trained falcons having been retaken a year or more after release, and there are several cases in which trained falcons have held their own against wild birds in territorial battles or in fights over food. Indeed, trained falcons have occasionally killed wild interlopers. The initial lack of fear of man is their main handicap, but they regain their wildness rapidly once they are free.

A three- to four-year, experimental program involving the Atlantic and Gulf Coast migrant Peregrines could produce important results for management. Such a program would need to involve cooperators drawn from the ranks of the North American Falconers' Association and the Raptor Research Foundation, Inc., working under the direct authority and supervision of federal and state agencies, which would coordinate the program and establish guidelines. The idea simply would be to trap a limited number of immature migrants each fall and place them in the hands of master falconers who would train the birds in the usual way but who would also agree to follow the specific guidelines established for the program and who would keep detailed, written records on their birds. The falcons, for instance, should be flown only with the aylmeri-type jess and a radio transmitter, and they should either be worked regularly at wild game, where feasible, or given bagged quarry. Some might be flown only to a lure for comparison.

Early in the spring, the falcons would be fitted with FWS lock-on bands, and possibly colored markers, and then gradually hacked back to the wild. Some might also be equipped with long-lasting radio transmitters to allow the determination of distances and directions of movements after final release. This time for release seems best because it corresponds to the normal period of northward migration, so that the falcons would soon move off into remote regions, and also because it is a time when they are least likely to be shot while reverting to the wild.

An experimental program of this sort could provide statistically treatable data on (1) what happens to Peregrines in captivity (incidence of different kinds of diseases, accidents, etc.), (2) how trained Peregrines react on being released to the wild and what they do during the first critical days after release, and (3) how well they survive over the long term after release. Information on whether they successfully enter the breeding population would be more difficult to obtain for this migrant, arctic breeding population. For this purpose it would be better to work with eyasses from the more localized, remnant populations of *anatum* Peregrines in the West.

This training and release program should also be coordinated with a greatly expanded and systematized trapping and banding program for fall migrating Peregrines, with trapping stations located at various sites along the Atlantic and Gulf Coasts. Each station would record standardized types of information and cooperate in a regional color-marking scheme like that used for the North American Swan project under the direction of Dr. Wm. Sladen.

Captive propagation and restocking.—While I have chosen to consider these two topics together, I should point out that restocking is not necessarily dependent upon a successful outcome of captive propagation. Most of the techniques for reintroduction could be carried out just as well with wild-produced young, or with young artificially hatched from wild eggs.

Today there is quite literally a worldwide effort to bring wild falcons under domestication—or semidomestication—for the first time, although the Peregrine and other large falcons have been kept by man for thousands of years. The goal is to use domestic propagation as a way of increasing the number of falcons and at least perpetuating the Peregrine and other desirable species in captivity, if not also in the wild. There are three main reasons why a number of people have been prompted to attempt the breeding of Peregrines and other birds of prey in captivity.

One concerns personal involvement and human motivation. It is what I refer to as the "Mount Everest Challenge." You climb a mountain, so I am told, because it is there to be climbed. You attempt to breed falcons in captivity because it is a challenge to succeed at something that most people consider impossible. The breeding project becomes an exciting intellectual and technological game—a true form of recreation and competitive sport—in which science and craft become inextricably bound together in the game plan.

The second reason has to do with the human desire to keep the Peregrine—not just for now but for the future—and not just to hold it in the hand but to be able to pass on to succeeding generations of men the opportunity to see and to know what a living Peregrine is. In other words, to develop a stock of captive produced falcons for continued scientific, educational, and recreational uses, including falconry. The Peregrine has always been *the* bird of falconry, and the other large falcons follow close behind in popularity. Falconers quite legitimately do not want to lose the use of these birds. If captive propagation becomes practical, then the use of falcons in sport would no longer place a demand on the wild populations. Some conservationists are most interested in the outcome of captive propagation from just this standpoint.

The third reason is to produce a supply of falcons that can eventually be use to restock natural areas where the Peregrine has disappeared as a breeding bir(Obviously this goal could only become feasible after there has been significar abatement of chemical pollution, but the hope is that during the period whil we are learning how to propagate Peregrines on a practical scale, the quality c the environment will improve and DDT residues will diminish to a level lo' enough to permit Peregrines to breed successfully again, in the eastern Unite States for instance.

The accomplishments in captive propagation of raptors to date are encoura; ing, although some problems remain to be solved before a practical scale of pr(duction can be achieved. First, the production of eggs by captive females hε become fairly routine for several species—the Peregrine, Prairie Falcon, Lann(Falcon, the European and American Kestrels, Harris' Hawk, Red-tailed Hawl Goshawk, and some others. For example, in 1971, 10 female Peregrines i North America produced at least 68 eggs, while in 1972 I have information o the fate of more than 100 eggs laid by captive Peregrines on this continent. U: fortunately, most of the Peregrine eggs have proved to be infertile. Obviousl the biggest problem still facing captive breeders is how to get more of these eg; fertilized. The fault lies in the mating process, which usually is not complete or is incompletely performed between captive males and females.

One technique that has proved to be helpful in some cases is artificial insen ination (Temple, 1972; Berry, 1972; Grier, 1972, 1974; Grier, Berry, and Ten ple, 1973). I do not want to dwell on the details now but just point out th: eight Goshawk eggs, six Red-tailed Hawk eggs, seven Golden Eagle eggs, and : least two Peregrine eggs (Richard Fyfe) have been fertilized by this techniqı in the last two to three years, and from them three Goshawks, one Red-taile Hawk, and one Golden Eagle have grown up to fly.

Incubation is another problem. Some parents will not sit on their eggs aft(they are laid, and the eggs must then be artificially incubated. The hatching ra is now up to 50 percent or more of fertile eggs in incubators, but we still ha' some things to learn about optimum incubator conditions. These problen should be solved during the 1973 breeding season.

Parental care of the young is not much of a problem, except sometimes wi the very first brood. Even pairs that fail to fertilize their eggs often turn out ι be perfectly good parents if they are given young to raise.

Despite these and other problems, an increasing number of Peregrines ar other raptors have been produced in captivity in the last three to four yeaı Approximately 20 Peregrine Falcons have been produced in North America captivity, and about the same number have been raised in Europe, but half (all these young were produced in 1972 alone (Cade, 1972). We can conclu(that the Peregrine can, indeed, be bred in captivity, and the situation is ev(more encouraging for some other species, particularly for the Prairie Falcon aı the Lanner, many broods of which have been raised in captivity in the last fe years.

The point I would like to make about captive propagation is that it really would only take half a dozen or a dozen pairs of proven breeders like Heinz Meng's Peale's Falcons, which have produced eight young in the last two years (Meng, 1972), in order to develop a self-perpetuating, productive colony of Peregrine Falcons. With the number of egg-laying females now in captivity and others showing good signs of becoming so, there is reason to think that captive propagation of the Peregrine will be routine business in a few more years.

I am encouraged enough about the prospects to suggest that we should begin now to consider the problems of restocking the Peregrine in vacant habitat. As I see the possibilities, restocking will work if pairs of falcons, or potential mates, can be psychologically fixed (imprinted?) or conditioned to accept suitable nesting structures in habitat where food is adequate. Merely turning inexperienced falcons loose in the hope that they will somehow establish themselves in a strange environment will only result in the loss of valuable birds.

In the wild, Peregrines are extremely attached to specific nesting sites (aeries) and typically return to them year after year to breed, and traditions of use spanning the lives of many individual pairs often result. In North America these sites are usually cliffs of some sort, although various man-made structures have been used, and some pairs have even nested in trees or on the ground. Falconers have long known that if a trained Peregrine is regularly flown in the same area she will develop a strong territorial attachment to it and defend it by driving away or attacking intruders. Falcons quickly learn the location of their mews or hack board, their bathtub, or any other biologically significant object in their environment, and when lost over familiar territory they will return home from several miles away. From these facts it is reasonable to believe that with proper treatment a pair of trained Peregrines can be established in a given area and that through repeated, daily association with a familiar area and familiar objects the mates can be conditioned to accept a suitable structure for nesting.

Although we are a long way from being in a position to attempt the reintroduction of captive-produced Peregrines in nature on a large scale, it seems desirable to begin now to develop the techniques that will eventually be required. There are several possibilities. One would be to rear young falcons at a natural or artificial nesting site—cliff, tree nest, special nesting tower, old silo, or abandoned building—and then allow them to fly at hack until they are fully independent and catching quarry on their own. If five or six young birds were hacked from such a site and if a permanent attachment for the area develops during this period of life, then it would be reasonable to expect two birds to survive and to return at breeding age. This procedure would be wasteful of birds but minimizes the amount of human effort required.

A technique that requires more work, but reduces the number of falcons needed, is to hack a pair of young falcons in the area where they are to be established and from the structure that is to serve as the aerie, but instead of allowing them to go free after fledging, they would be taken up, trained, and flown by the techniques of falconry through their first summer, fall, and winter. In this way they could be thoroughly conditioned to a free-flying existence in the territory and allowed to develop fixed habits and associations with the habitat and with the aerie, so that when finally allowed to go wild they would be strongly attached to the area as their "home." Also, in this way the heavy natural mortality on first-year falcons in the wild could be circumvented.

Some initial experiences that I have had near Ithaca, New York, with a single, three-year-old eyass female Peregrine and with a single, first-year captive-produced tiercel suggest that an old barn offers good structural possibilities for an "aerie." A large room or cage area in the hayloft of a barn—with an open window high above the ground for exit or entrance onto a gravel-filled nesting ledge inside—looks ideal. The male and female can be held in separate, adjacent compartments, if necessary, until they have formed a strong pair-bond, and trained to fly into the window and barn to roost and out of the window to the outside for daily flying exercise and supervised hunting. The window can be fixed to close behind the birds when they enter the barn or opened to let them fly out. In this way the falcons gradually become attached to the loft as their aerie and to the adjacent countryside as their territory, after which they can be given a good deal of freedom to come and go.

This approach to restocking is probably better than fostering young Peregrines to other species. There is little doubt that fostering will work as far as the successful fledging of young is concerned. The major drawback relates to the poor survival rate of nestling and first-year Peregrines. In a fostering program, many young would be "wasted" that might have a better chance for survival in the wild if held under a falconry regimen until they are adult and then released.

If the habit of nesting on cliffs can be broken by "imprinting" or other conditioning procedures, then the possibilities for building up a substantial breeding population of Peregrines will be greatly increased, as cliffs are limiting in many areas. The fact that the former Finnish Peregrine population consisted of sympatric cliff-nesting, tree-nesting, and ground-nesting pairs suggests that tradition rather than genotype determines choice of nest site. Basket nests, such as those used in Germany for wild pairs (Hickey, 1969, pl. 60), could be placed in suitable trees in parks, refuges, and other protected areas. Special nesting towers could be erected in rich feeding areas lacking suitable natural sites, and in some instances abandoned silos or tall buildings could be adapted for use by falcons.

In the eastern United States it will be particularly important to juxtapose a suitable nest site with an adequate food supply around the aerie. This can be done either by constructing a nest structure in an area where the falcon's prey is abundant, such as a wildlife refuge, or by supplementing the wild prey around suitable natural aeries with domestically produced birds. Pigeon lofts could be established near falcon aeries. The fantastic Spanish Peregrine population, which Frank Bond and I surveyed last year in the central part of the Iberian Peninsula, is largely supported by an equally fantastic population of feral pigeons, which have been nesting in the numerous palomars around the countryside villages since the days of the Moorish occupation. The villagers eat the squabs, and the falcons catch the adult pigeons as they feed over the open fields. Significantly, also, the falcon aeries are often close to the villages and within sight of daily human activity.

Discussion of Some Unknowns

Schemes for management such as I have been describing should not be undertaken lightly on a large scale, until we have some reliable data on a number of presently unstudied aspects of such manipulations. I can do little more than outline, here, some of the variables that I think are important to probe on a limited, experimental basis now.

1. **Double-clutching.**—While there is little doubt that the number of eggs produced by a wild female can be approximately doubled by this technique, it remains to be shown on a statistically significant basis what the natural productivity of young from second clutches is. It probably is lower than from first clutches, and the difference between first and second clutches needs to be determined in order to arrive at a valid estimate of the utility of this technique for increasing over-all production of young falcons.

2. **Imprinting and related phenomena.**—There are also several unknowns about the role of imprinting or other age-dependent conditioning experiences that may be important for the acquisition of normal, adaptive behavior in the wild. For instance, if young Peregrines are reared by Prairie Falcons, will they later form social attachments and pair-bonds with other Peregrines, or will they be imprinted to Prairie Falcons as social companions? No data exist to answer this important question. Similarly, if captive-produced falcons are hand-reared by humans, what sort of social attachments will they be capable of forming with conspecifics at sexual maturity? All we really know is that some captive raptors acquire such strong sexual fixations on their human companions that full reproductive performance is achieved with man to the exclusion of any such response with conspecifics, while others do not fixate sexually on man; but the conditions responsible for this sort of sexual "imprinting" cannot be confidently stated at this time.

There is a growing body of evidence to indicate for birds generally that fixation to habitat, to type of nest site, and to geographic locales for breeding and for wintering are determined by experiences during certain critical periods in the life cycle of the individual bird and that a type of learning similar to social imprinting is involved (for reviews, see Thorpe, 1963, pp. 417-418; Marler and Hamilton, 1966, pp. 589-593; Hildén, 1965). This hypothesis needs to be tested with birds of prey. For example, if an arctic-nesting Peregrine, which normally would winter in South America, is trapped on its first fall migration, is held during its first winter in the environs of Philadelphia, and then later is released, where will it spend its subsequent winters? Some data from Starlings (Perdeck, 1958, 1964) and White-crowned Sparrows (C. J. Ralph and L. R. Mewaldt) suggest that it would return to Philadelphia. Would such a modification of the wintering habits of a migrant Peregrine affect its chances for survival? Lacking data, one can make an argument either way, but it so happens that an old, escaped Peregrine, still wearing a bell and remnants of jesses, has been wintering in Philadelphia for the last three years (R. B. Berry, personal communication).

We can ask the same sort of question about fixation to nesting area (Löhrl, 1959) and to nest-site formations. The point is this: once we know something about these fundamental learning or associative processes, we can put them to use in management, but if we choose to ignore them, then our efforts to increase productivity in the wild and to restock vacated range will probably fail.

The "specific searching image" (Tinbergen, 1960) and the development of feeding habits and specializations on certain types of prey may also be importantly affected by experiences during certain critical or formative periods in a falcon's life. Can a falcon be conditioned to seek out and kill certain types of quarry to the exclusion of others? I think the experiences of falconers suggest they can be (Brüll, 1937). Again, there may be an important application for management. If Peregrines that are intended for restocking could be conditioned to hunt blackbirds, grackles, and starlings preferentially, they could enjoy a virtually unlimited food supply in many areas of their former range in eastern United States. The factors that influence a raptor's choice of prey need much study, as recently discussed by Mueller (in press).

3. **Deprivation of normal experience.**—The effects of deprivation of normal experience—or stimulus deprivation—on birds that are held in captivity for a long time, and particularly on those that are produced by husbandry in confinement, are related to the problems I have been discussing. Can a captive-produced falcon ever cope effectively with the natural environment? What are the maximum tolerable limits for deprivation of normal experience that will still allow a falcon to lead a natural and productive life on release to the wild? Can a falcon that has never had experience in hunting and killing quarry during its first year of life ever develop the necessary skills to feed itself in the wild? No doubt the kinds and amounts of experiences that captive falcons are allowed to have—particularly in their first formative year of life—will measurably affect their performance upon release in nature, but nothing specific can be said beyond that safe generality.

4. **Self-perpetuation in captivity.**—Finally, the outcome of captive propagation will depend on the reproductive capability of $F_1, F_2, \ldots F_n$ generation falcons. F_1 reproduction in captivity has not yet been demonstrated for any large falcon to my knowledge, although it has been accomplished several times with both American and European Kestrels. F_1 reproduction is a frequent problem among captive "wild" animals, and it should be anticipated with birds of prey. The breeders of Peregrines, Prairie Falcons, and other large species should husband their F_1 progeny for further experiments on breeding and not be too eager to trade them off or to risk losing them in falconry, before we know whether one generation can succeed another in captivity.

Conclusion

These are admittedly optimistic and forward-looking plans, which will require a great deal of cooperation and understanding among federal authorities, state conservation departments, researchers, falconers, and the concerned public. They are worth support and united effort because the survival of the Peregrine has become a test of man's intent and ability to keep the global ecosystem intact. Our efforts in behalf of the falcons will also test the goodwill and tolerance that men of differing opinions and background are able to extend to one another for a common cause.

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ARTIFICIAL NESTING PLATFORMS FOR OSPREYS IN MICHIGAN

Sergej Postupalsky

Stephen M. Stackpole

ABSTRACT. Generally poor reproductive success in Michigan Ospreys, further aggravated by frequent nest blowdowns in two colonies, prompted us to erect 43 artificial nesting platforms for these birds during 1967-71. The breeding areas and platforms are described. A tripod-type platform, erected through the ice in late winter, has proven effective in marshes and shallow wildlife floodings. On Fletcher Pond, a storage reservoir and the site of Michigan's largest Osprey colony, ice damage requires that several platforms be repaired each spring. Occupancy was greatest at platforms placed near the sites of recently fallen nests. On Fletcher Pond a declining trend has been reversed and the population increased from 11 pairs in 1966 to 18 (17 on platforms) in 1972. At the Dead Stream Flooding the breeding population recently dropped to three pairs, despite an excess of platforms; this decline was associated with deteriorating habitat. Over-all productivity on platforms (0.9 young per occupied nest) during 1967-72 was somewhat better than that on natural nests (0.7 young per occupied nest) during the same period. Nestling mortality was reduced from 28 percent to seven percent by elimination of blowdowns. The platforms enable us to monitor more closely the Osprey population on Fletcher Pond and on several smaller wildlife floodings by making more nests accessible for regular inspection and facilitate other management measures.

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That Ospreys (*Pandion haliaetus*) occasionally build their nests on man-made structures is well known. Abbott (1911), Stone (1937), Bent (1937), to name just a few, reported this habit. The erection of nest support structures specifically to encourage Osprey nesting is nothing new—farmers along the Atlantic Coast many years ago placed old wagon wheels on posts to attract Ospreys in the belief that the fish-hawks kept other hawks away from their farms. More recently, Ames and Mersereau (1964), Reese (1970), and Rhodes (1972) have used man-made nest platforms of various types to assist this species. This paper is a report of our experiences with artificial nesting platforms for Ospreys in Michigan.

In the interior of North America Ospreys frequently build nests on dead trees on the backwaters of dams, sometimes in more or less dense aggregations. Berger and Mueller (1969) report one such colony on the Rainbow Flowage in northern Wisconsin and Roberts (1969) describes one on the Crane Prairie Reservoir in Oregon. In Michigan we have two such colonies: on Fletcher Pond and on the Dead Stream Flooding.

Fletcher Pond is a water storage reservoir in northeastern Michigan. It is maintained by the Alpena Power Company by a dam on the Upper South Branch of the Thunder Bay River in western Alpena County and extends into eastern Montmorency County. Large portions of its 7000 acres (2832 ha) of surface are marsh and very shallow water, studded with numerous stumps and snags, the remains of a cedar swamp that had been flooded during the early 1930's. Most of the larger trees in the center of the reservoir were cut near water level. Their stumps make pleasure-boating unattractive, if not hazardous; small, low-powered fishing boats are the only craft that can be used. The Ospreys built their nests on or near the tops of dead tree trunks, usually situated near the edge of stands of dead timber. With time the dead trees rotted away and tall, sturdy nest supports became scarce. Gradually, the Ospreys took to nesting on low, often very unstable, stumps and snags. This was the situation in 1962 when Postupalsky first visited Fletcher Pond. In subsequent years nests so low that they appeared to be floating on the water were built. These and the few high nests which were being built at that time usually lasted but a short time. In 1965 the top of the highest nest on the pond was only seven and one half feet above the water. A statewide survey, launched that year, revealed that Ospreys throughout Michigan were reproducing very poorly (Postupalsky 1969, and in press). On Fletcher Pond, a potentially good Osprey breeding area, the problem was further aggravated by nests blowing down or being washed away during windstorms. The colony declined from 13 pairs in 1964 to 11 pairs in 1966.

The other, smaller, Osprey colony is on the Dead Stream Flooding in Roscommon County in north-central Michigan. This wildlife flooding was established in 1941 by the Michigan Department of Natural Resources by a dam across the Muskegon River at Reedsburg, four miles west of Houghton Lake. The impoundment extends several miles upstream and along a tributary, the Dead Stream Creek—hence the name. During the early 1950's several observers reported up to five Osprey nests on dead trees, and in 1957 William E. Southern counted seven occupied nests (University of Michigan Biological Station re cords). The flooding and its birdlife were described by Pettingill (1961). The Osprey population evidently remained at seven pairs until 1964. A drawdown maintained throughout spring and summer of that year coincided with a total nesting failure in the resident Ospreys. Only six pairs returned in 1965 and 1966, and some of these nested on very low stumps.

This, then, was the situation on these two floodings in the mid-1960's. It was apparent that Ospreys could be reproducing much better than they had been doing in most of these years. The potential was there, as suggested by fair success at the Dead Stream in 1962 (eight young raised in seven occupied nests) and at Fletcher Pond in 1963 (11 young in at least 10 occupied nests). Although pesticides, especially DDT, were then suspect as a possible contributing factor in the abnormally high nest failures in this and several other species, conclusive proof was lacking at that time. This proof was yet to come from research, stimulated by the discovery of the thin eggshell syndrome, by Ratcliffe (1967) in some British raptors and by Hickey and Anderson (1968) in several North American species, including the Osprey. In the meantime, we had been considering other factors, such as predation and vandalism. The low nests certainly were potential targets for mammalian predators; we have records of predation on eggs and young. As for vandalism, anyone in a boat could pull up to a low nest and easily remove eggs or young or otherwise disturb the nesting. However, other than rumors of such incidents dating back many years, we have no reports or observations indicating that this was indeed occurring in recent years. We were also considering human disturbance and were concerned about eggs becoming chilled or young dying of exposure or heat if adults were kept off the nest by the numerous fishermen frequenting these floodings on weekends.

Early in 1967 Stackpole, well acquainted with some of the problems faced by Dead Stream Ospreys, was prepared to direct and finance the construction and erection of several artificial nest platforms on this flooding. This action marks the beginning of his involvement in and support of Osprey research and management in Michigan. Our collaboration produced the tripod-type Osprey platform design and the project was expanded that same winter to help the Fletcher Pond Osprey colony also.

The Platform (Figure 1) essentially consists of an either round or octagonal top, three feet across, made of marine plywood. It is mounted on three legs, made of 1-7/8 inch (4.76 cm) outer diameter galvanized steel pipe. The platform top contains drain holes and is equipped with two concentric rows of wooden dowels, six to eight inches high, to hold nesting material in place. More recently, to save costs, the dowels have been replaced by upright sections of board spaced along the margin of the octagonal platform. The bottom end of each leg is pounded flat and welded shut; the ends of individual pipe sections are plugged and sealed, tapped with a pipe threader, and joined at assembly with pipe couplings. The top section of each leg is capped and equipped with a welded-in bolt at a 13 degree angle to the axis of the leg; this bolt fits through a hole near the edge of the plywood platform top. Each leg forms an angle of about 13 degrees with the vertical. When completely assembled, the platforms are 12 to 16 feet

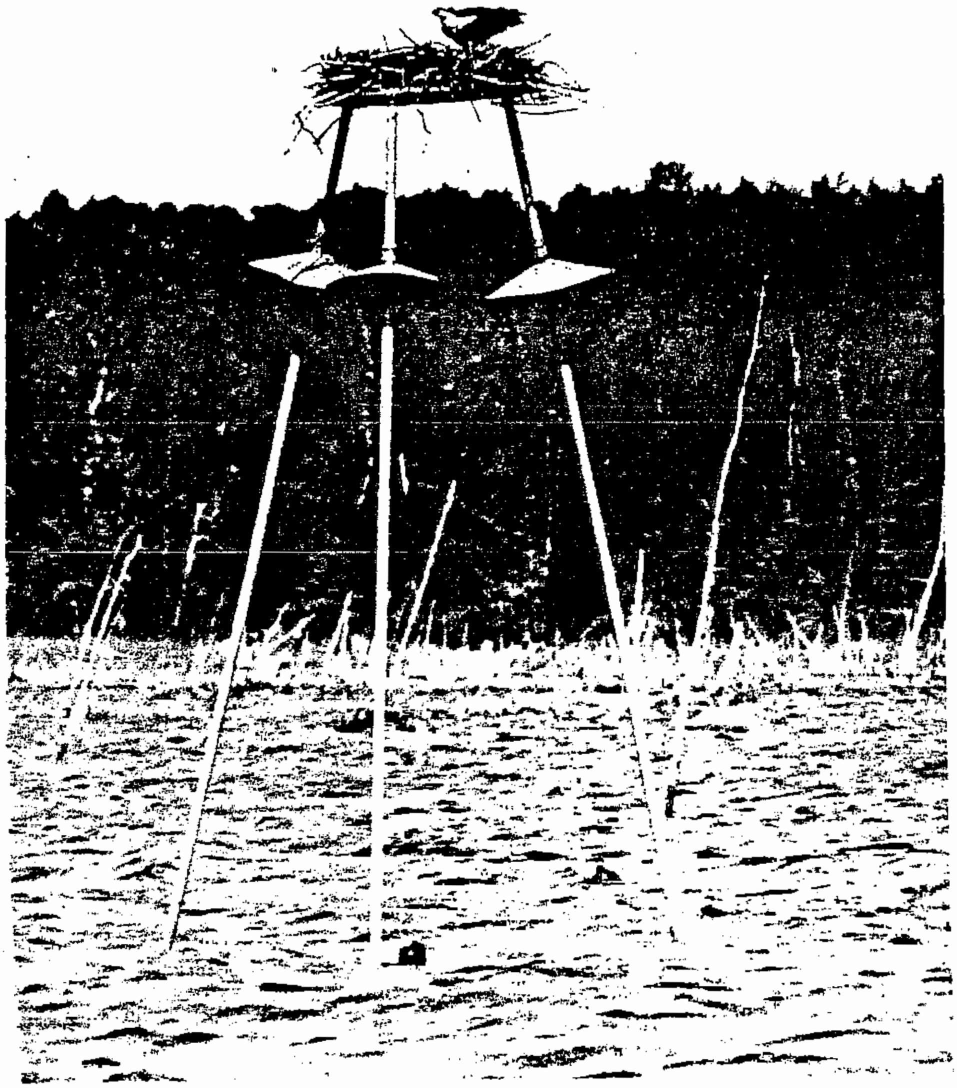

Figure 1. Adult Osprey on platform nest, Fletcher Pond, Michigan.

(3.7-4.9 m) above the water, well out of reach of people in boats. The tops and legs are painted a dull gray, making the structures less conspicuous than are most natural nests. The platforms were erected in late winter, through the ice, in previously selected shallow areas. As a final touch, sticks were gathered and arranged on top simulating a "nest" to enhance the chances of acceptance by the Ospreys.

Sites for platforms were selected (1) near existing, but unstable natural nests; in such cases the nest was moved to the top of the platform; (2) near recently fallen nests; (3) in apparently suitable sections of Fletcher Pond not containing nests; and (4) on impoundments with a history of Osprey nesting, but not occupied by the species at the time.

Distribution and Occupancy of Platforms

Twenty-six platforms were erected in time for the 1967 breeding season: 20 on Fletcher Pond and six on the Dead Stream Flooding. Eleven were occupied by Ospreys the very first season (Table 1). Four more platforms were added to each of these two areas in later years and nine were erected at six other localities in Michigan, for a total of 43 platforms. Thirty-nine were of the tripod-type described above; four were platforms of the same type but mounted on top of still solid tall stubs. Two of these stubs had supported natural nests with a history of blowdowns. One of the tripod platforms was destroyed by ice and, early in 1972, three which had been damaged and/or judged to be redundant were removed, leaving 39 available for the 1972 breeding season.

Fletcher Pond received over half of all platforms; the majority have been

Table 1. Occupancy of man-made osprey nesting platforms in Michigan.

	1967		1968		1969		1970		1971		1972	
	O[a]	A	O	A	O	A	O	A	O	A	O	A
Fletcher Pond	9[b]	20	13	22	14	24	14	24	15[b]	24	17	22
Dead Stream Flooding	2	6	5	7	4	8	4	8	5[b]	10	3[b]	9
Bear Creek Flooding	—	—	0	2	0	2	c	2	1	2	1	2
Backus Creek Flooding	—	—	—	—	2	2	1	2	1	2	2	2
Doc and Tom Creek	—	—	—	—	0	1	c	1	0	1	0	1
Grass Lake Flooding	—	—	—	—	0	1	0	1	0	1	0	1
Forest Lake Basin	—	—	—	—	0	1	1	1	1	1	1	1
Bond Falls Basin	—	—	—	—	0	2	0	1	0	1	0	1
Total	11	26	18	31	20	41	20	40	23	42	24	39

O[a] = occupied; A = available.
[b]plus one single adult on one additional platform.
[c]single adult present, no nesting.

occupied (Table 1). The Osprey colony grew from 11 pairs in 1966 to 18 pair in 1972 (Table 2), when all but one pair present were using the platforms. W had made no attempt to replace one natural nest built on a still sturdy ceda trunk. Were it not for this nest and an occasional new pair which comes in an builds a nest on a substandard snag (as occurred in 1968 and 1971), rather tha take one of the vacant platforms elsewhere on the pond, the entire Fletche Pond colony would be on platforms!

On the Dead Stream Flooding, although we had provided an excess of pla forms, the Osprey population remained at five to six pairs until 1971 and drop ped to three pairs plus one lone female in 1972. During the last eight years c so, this impoundment has become progressively choked with emergent and sut mergent vegetation, greatly reducing areas of open, shallow water which O: preys apparently need for efficient fishing. Sport fishing too, has deteriorate We observed Ospreys carrying fish from the direction of Houghton Lake thre miles (5 km) away.

In addition to these two colonies, we also have platforms at six other local ties. Ospreys last attempted nesting on the Bear Creek Flooding (Roscommc County), about eight miles (13 cm) south of the Dead Stream impoundment, 1965, when the snag supporting the nest of the last pair toppled over early the season. Although Ospreys were occasionally observed in the area, and w had put up two platforms early in 1968, no nesting took place until 1971 whe a pair occupied one of the platforms. One young was raised that year and anot er in 1972.

On Backus Creek Flooding (Roscommon County), about three miles (5 kn east of Houghton Lake, two pairs have been nesting with little success in rece

Table 2. Osprey reproduction on Fletcher Pond, Michigan, 1962-72.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
Occupied nests	10[a]	10[a]	13	12	11	12	15	15	15	17
Same; known outcome	10	10	13	12	11	12	15	15	13	17
Productive nests	3	7	3	3	3	5	7	8	7	10
Percent nest success	30	70	23	25	27	42	47	53	54	59
Number of young	6	11	5	5	8	10	12	13	11	21
Young/productive nest	2.0	1.6	1.7	1.7	2.7	2.0	1.7	1.6	1.6	2.1
Young/occupied nest[b]	0.6	1.1	0.4	0.4	0.7	0.8	0.8	0.9	0.9	1.2

[a]Counts based on only one visit, in late July; some unproductive pairs may ha been missed. Percent nest success and young/occupied nest may, therefore, biased upward.

[b]Nests with known outcome.

years. One of two platforms, erected early in 1969, has been occupied each year. The other pair used the second platform during two seasons and natural alternate nests at other times. No young Ospreys have been raised on this wildlife flooding since 1963, except in 1971, when one of the pairs was given a small chick taken from a brood of four on the Dead Stream.

We have had less success with single platforms at two other locations: In a large marsh at Doc and Tom Creek (Osceola County), our platform replaced a usually productive nest which had crashed in 1968. Although at least one adult was in the area until 1970, no nesting occurred and no new natural nests were found. We also put up a platform on Grass Lake Flooding (Benzie County), where a pair was reported nesting in 1966 and the nest was gone the following season. This platform has yet to find any takers. A recent search of the area from the air revealed no other occupied nests; we conclude that Ospreys are no longer breeding on this flooding.

All the sites discussed so far are in the Lower Peninsula of Michigan. The remaining three platforms were placed in the Upper Peninsula. Until 1966 Ospreys had nested on a stub in Forest Lake Basin (also known as AuTrain Basin), a power company reservoir in Alger County, and were still nesting in the vicinity in 1969 after we put up a platform early that year. The birds started using it in 1970; one young was raised in 1971.

Bond Falls Basin (Ontonagon County) is a storage reservoir of the Upper Peninsula Power Company on the Middle Branch of the Ontonagon River. Ospreys were reported nesting in dead timber on this flowage, along with Great Blue Herons (*Ardea herodias*) and Double-crested Cormorants (*Phalacrocorax auritus*) in 1949 (Clark and Reed 1950). No nests remained in 1962 when Postupalsky first checked the area. We erected two platforms near the south shore in 1969. Neither has been occupied and one soon tipped over, probably during ice breakup.

The tripod-type nest platform structure has worked quite well in marshes and small wildlife floodings which are shallow and where water level does not fluctuate much during winter. Some platforms have been in use for six years now, requiring no maintenance. We do have problems with ice damage on Fletcher Pond, which, like Bond Falls Basin, is a large reservoir, and is usually drawn down two or more feet in winter in anticipation of the spring thaw. Heaving and shifting ice tends to distort and may break or pull loose the legs, so that several platforms have to be repaired or rebuilt after most winters.

Discussion

Before we discuss further the effects of the platforms—what the structures did and did not accomplish—let us stress that our platform project was designed primarily as a management measure to help preserve the Osprey in Michigan; it was not designed as a controlled experiment. Consequently its effects cannot be evaluated in a rigorous fashion. The observed productivity of Ospreys using the platforms also reflects other attempts at management, such as the separation of large broods through placement of the odd-sized chicks in nests in which eggs failed to hatch. (In calculations of reproductive success parameters, the adopted young are credited to nests where they hatched.)

We use three measures to evaluate reproductive success: (1) the proportion of occupied nests producing at least one young (percent nest success), (2) brood size (young per productive nest), and (3) productivity (young per occupied nest) which is the product of (1) and (2) and is by far the most meaningful of the three. A definition of "occupied nest" is given elsewhere (Postupalsky, this conference).

A comparison of reproductive success during 1967-72 in platform nests with that in natural nests in each of the two peninsulas of Michigan shows that productivity averaged 0.9 young per occupied nest on platforms and 0.7 young per occupied nest in natural nests, in both the Lower and the Upper Peninsula (Table 3); the difference is not statistically significant. All but three of the 114 platform nestings occurred in the Lower Peninsula. Brood size and percent nest success for the entire six-year period were also higher in platform nests than in natural nests in either part of the state. These differences in reproductive success are admittedly small and were not consistent each year; as a whole, the data do show a tendency toward generally better success on platforms. As all platforms are situated well inland, away from the Great Lakes, only natural nests located inland were considered in Table 3. This limitation was deemed advisable because of a high incidence of reproductive failures in certain fish-eating birds nesting near and feeding on the Great Lakes (Postupalsky 1971, and in press; Sprunt *et al.* 1973).

Reproductive success in the Fletcher Pond colony improved steadily after platforms were put up in 1967 (Table 2). Productivity averaged 0.6 young per occupied nest during 1962-66 (N = 56) and 1.0 young per occupied nest for 1967-72 (N = 90). The average yearly production of fledglings rose from seven during 1962-66, to 11.3 during 1967-70, and to 20.5 in 1971-72. As mentioned earlier, Michigan Ospreys were reproducing very poorly during the mid-1960's when productivity varied between 0.2 and 0.4 young per occupied nest. A slow recovery began in 1967 in the Lower Peninsula and by 1970 also in the Upper Peninsula (Postupalsky, in press); during 1970-72 between 0.9 and 1.1 young per occupied nest were raised. The recovery was not confined to Fletcher Pond or to sites with platforms, however productivity in this platform-dominated colony has been equal or better each year than that in either peninsula taken as a whole.

The most significant achievement of the platform project has been the maintenance and growth of the Fletcher Pond Osprey colony. There can be little doubt that the decline in numbers of breeding pairs observed prior to 1967 would have continued in the absence of the man-made nest sites, as suitable natural supports became almost nonexistent. This colony, comprising one half of the known Osprey population of Lower Michigan, continues as an important breeding area in the state. Ospreys banded as nestlings in this colony have since been found breeding there as well as on the Dead Stream and Bear Creek flood-

Table 3. Osprey reproductive success on man-made platforms compared to that on natural nests.

	1967	1968	1969	1970	1971	1972	1967-72
Platforms							
Occupied nests	11	18	20	18[a]	23[b]	24[a]	114
Productive nests	5	7	9	7	15	10	53
Percent nest success	45	44	45	39	65	42	47
Number of young	10	12	14	13	32	24	105
Young/productive nest	2.0	1.7	1.6	1.9	2.1	2.4	2.0
Young/occupied nest	0.9	0.7	0.7	0.7	1.4	1.0	0.9
Natural nests (inland Lower Peninsula)							
Occupied nests	16	11	9	13	13	12	74
Productive nests	4	4	5	8	5	6	32
Percent nest success	25	36	56	62	39	50	43
Number of young	7	8	6	13	9	12	55
Young/productive nest	1.8	2.0	1.2	1.6	1.8	2.0	1.7
Young/occupied nest	0.5	0.7	0.7	1.0	0.7	1.0	0.7
Natural nests (inland Upper Peninsula)							
Occupied nests	25	29	22	31	27	30	164
Productive nests	6	10	4	12	17	15	64
Percent nest success	23	34	17	39	63	50	39
Number of young	11	14	7	25	32	28	117
Young/productive nest	1.8	1.4	1.8	2.1	1.9	1.9	1.8
Young/occupied nest	0.4	0.5	0.3	0.8	1.2	0.9	0.7

[a]includes one unproductive nest in the Upper Peninsula.
[b]includes one productive nest in the Upper Peninsula.

ings, about 80 air-miles (129 dm) away.

For breeding habitat, Ospreys appear to require (1) a body of water with an adequate supply of fish, (2) ample areas of clear, shallow water, where prey is vulnerable to Osprey attack, and (3) presence of suitable tree tops or sturdy dead trees nearby to support nests. Man-made platforms can maintain or even increase a breeding population in habitats which fulfill the first two requirements but are lacking in the third. This evidently was the case on Fletcher Pond, which contains extensive shallow areas and produces an ample supply of fish, as shown by its popularity with fishermen (the only place in Michigan with no size limit on northern pike!). At the Dead Stream Flooding, on the other hand, requirements (2) and probably also (1) may now be limiting the number of breeding Ospreys, even though vacant platforms are available (requirement 3).

As expected, mortality of nestlings was appreciably reduced on platform nests. We have adequate information on the number of eggs hatching only for the platform nests in the Lower Peninsula and for natural nests in the Fletcher Pond and Dead Stream colonies. Of 46 young hatched in natural nests during 1965-72, 13 (28 percent) are known to have perished in the nest. In contrast, only eight (seven percent) of 112 young hatched on platforms were lost (Table 4). An examination of the causes of nestling mortality (Table 5) shows that while nest blowdowns were the major cause of death in natural nests on the floodings, this source of mortality has indeed been completely eliminated on the platforms. We have never lost an entire brood on a platform; all losses on man-made nests involved one young out of broods of two, three, or four. Young dying or disappearing comprised six percent of young hatched on platforms and four percent of young hatched on natural nests. Our data, however, are not

Table 4. Osprey nestling mortality on natural nests compared with that on platforms.

	1965	1966	1967	1968	1969	1970	1971	1972	1965-72
Natural Nests[a]									
Number of young hatched	10	10	9	4	2	6	2	3	46
Number of young died	3	1	5	0	0	3	0	1	13
Mortality (percent)	30	10	56	0	0	50	0	33	28
Platforms									
Number of young hatched	–	–	11	12	14	14	35	26	112
Number of young died	–	–	1	0	1	1	3	2	8
Mortality (percent)	–	–	9	0	7	7	9	8	7

[a]Fletcher Pond and Dead Stream Flooding only.

Table 5. Causes of Osprey nestling mortality, 1965-72.

Cause	*Number of Nestlings Lost* Natural Nests	Platforms
Nest crashed	8 (4 nests)	0
Predation	3 (1 nest)	0
Young died in nest	2	2
Young disappeared	0	4
Young sick, then disappeared	0	1
Young died during banding	0	1
Total	13	8

sufficient to permit any conclusions concerning the role of platforms in nestling mortality other than that associated with blowdowns. Very few natural nests are left on the floodings, and those elsewhere are rarely accessible for close study. For the same reason we cannot quantify a change in egg losses attributable to platforms. Egg data prior to 1966 are very limited. We know of several natural nests which were blown down or washed out destroying eggs and can safely report that this source of attrition, whatever its former magnitude, is unknown on platform nests.

One side benefit derived from the platform project has been that while nest contents are generally out of reach of fishermen and casual sightseers, we have been able to monitor breeding activity more fully than had been possible prior to 1967. By their permanence and stability, platforms enable us to follow activity at the same breeding sites year after year. This used to be very difficult with the high turnover of natural nests causing frequent moves and new nest-building by the birds. We inspect nests with a mirror attached to a long pole. For use on Fletcher Pond, the site of our largest colony, we have an aluminum extension ladder mounted on a wide flat-bottom boat of shallow draught. This equipment allows us to make sufficiently frequent, but very brief visits to nests with a minimum of disturbance to count eggs and young, to collect addled eggs for toxic-chemical analysis and shell measurements, to record food remains, to band all young, to trap adults for banding and color-marking, and to undertake other management measures designed to maximize reproduction, such as the transfer of small chicks from large broods to nests in which eggs failed to hatch, and experiments with double-clutching.

There has been a dearth of detailed Osprey studies in the interior of North America, largely because in this region the birds typically nest in dense swamps, often very high on top of dead, deteriorating trees. Due to their general inaccessibility, relatively few Ospreys have been banded on this continent outside of the East Coast, and recovery data for determination of migration routes and winter quarters of Osprey populations breeding in the interior are very meager indeed (Henny and Van Velzen 1972). Our platform-nesting Ospreys, now comprising about 30 percent of known Michigan pairs, offer an excellent and perhaps unique opportunity for studies of population dynamics, behavior, food habits, and other aspects of Osprey ecology.

To summarize, the platforms have helped to maintain breeding Ospreys on several floodings and made possible the growth of one breeding colony on a productive reservoir. We have had less success in attracting Ospreys to areas in which they have not bred for several years. In essence the platforms allow Ospreys to continue exploiting an area long after one requirement for breeding—the availability of suitable nest sites—can no longer be satisfied by nature; that is, as long as other requirements, including an adequate and accessible food supply, are available. While platforms cannot increase the hatching rate of eggs contaminated with organochlorine pesticides and other potentially toxic pollutants, they do enhance the chances of survival of chicks that do hatch. In effect we are trying to counterbalance the effects of a man-caused source of attrition (breakage of thin-shelled eggs and embryonic death attributable to pollutants) by reducing one source of natural attrition (eggs and young destroyed in nest blowdowns).

Acknowledgments

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OSPREY MANAGEMENT ON THE LASSEN NATIONAL FOREST, CALIFORNIA[1]

David P. Garber

James R. Koplin

Jack R. Kahl

ABSTRACT. Rationale and procedures are presented for managing Osprey (*Pandion haliaetus*) nesting habitat on the Lassen National Forest in California. A numerical increase in Osprey nesting density was achieved locally with the construction of nest platforms, resulting in a 37 percent increase in the number of nests fledging young. Hypothetically, an increase in productivity was achieved.

Introduction

During the breeding seasons of 1969, 1970, and 1971, 136 nesting efforts of Ospreys were studied in Lassen and Plumas Counties, northeastern California (Garber 1972). Incubation phenomena exhibited by these Ospreys have been discussed (Garber and Koplin 1972). The nesting ecology and status of this population will be presented elsewhere (Garber *et al.* 1974).

[1]Study supported by the U. S. Forest Service, Humboldt State University, and by California Federal Aid Project W-54-R-2.

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The average productivity of the population during this study, 1.01 fledglings per nesting attempt, was below recruitment necessary for population stability in the eastern United States (Henny and Wight 1969). Causes of reproductive failure included human interference and the destruction of nests by wind, factors rectifiable by management practices.

Management Procedures

In an effort to minimize nesting failure caused by human disturbance and wind, and thereby to increase nesting productivity, the Lassen National Forest initiated a program for Osprey habitat management in 1971. This program provided for the maintenance of existing nests and protection of their occupants, the retention of potential nesting sites, and the creation of nesting structures in specific areas where the absence of such sites was suspected of limiting Osprey productivity.

Minimizing Human Disturbance.—To minimize human disturbance, metal signs were affixed to all nest trees requesting that visitors approach active nests no closer than 400 m from 1 April to 31 August, annually. More complete protection was afforded nests concentrated on the west shore of Eagle Lake, Lassen County, where an area of approximately 480 ha was designated as an Osprey Management Area. Within this area: (1) the discharge of firearms is prohibited from 1 April to 15 September, (2) motor vehicles will be permitted only on designated roads from 1 April to 15 September, (3) overnight camping is prohibited from 1 April to 15 September, (4) tree and snag cutting is prohibited, (5) and recreational development is limited to activities that advance human enjoyment of and are compatible with Osprey nesting.

Maintaining Potential Nest Sites.—The loss of potential nesting trees during timber harvest operations was recognized, at least theoretically, as a factor that might limit the number of nesting Ospreys. The probability that nest site loss might limit breeding numbers was greatest near lakes and reservoirs where other biological factors necessary for Osprey reproduction appeared to be adequate. To maintain potential nesting trees and generally harmonize future land use activities with the needs of nesting Ospreys, the following guidelines were established by the Lassen National Forest: (1) no timber or snags are to be cut within approximately 70 m of water bodies where Ospreys nest, except for individual trees hazardous to roadway or campground activities, (2) a minimum of two dominant live trees and two snags per acre will be preserved for approximately 400 m beyond the 70 m riparian zone, (3) all broken-top snags and live trees suitable as Osprey nest sites shall be preserved for a distance of approximately 3.5 km beyond the 400 m zone, (4) three to five trees suitable for nesting or roosting will be preserved within approximately 220 m of all Osprey nest sites, (5) and disturbance within approximately 220 m of active Osprey nests will be minimized from 1 April to 15 August, annually.

Artificial Nesting Structures.—An inventory of nesting sites revealed that the majority of nest trees in the Osprey Management Area were dead and in a deteriorated condition, and that there were few live trees that naturally would provide replacements for these short-lived nest sites. Since nests in the Osprey Management Area appeared to be advantageously situated with respect to a food source, and since most nest sites had been occupied in previous years, it seemed possible that creating artificial nest sites might encourage additional pairs of Ospreys to nest, as well as replace the deteriorated sites used by the pairs now present.

The tops of 15 live pine (*Pinus jeffreyi*) trees were cut off at heights ranging from 25 to 40 m, above a whorl of limbs where the trunk was over 60 cm in diameter. Spikes were driven around the circumference of the cut to help anchor prospective nests. The work was contracted to a tree surgeon at a cost of 25 dollars per tree.

To replace deteriorating nest snags in the Osprey Management Area, 20 cedar (*Libocedrus decurrens*) poles, 7 m in length and 1 to 1.5 m in diameter, were erected using a back-hoe and front-end loader. Platforms were constructed on the tops of the cedar poles using four 2.5 m lengths of 5x10 cm lumber and spikes. The cost of each artificial nesting site, including pole and platform, was approximately 57 dollars.

Discussion

During the 1972 breeding season, Ospreys nested at 12 of the 20 artificially erected nesting sites, one of the 15 topped trees, and three of the 13 natural nesting sites in the Osprey Management Area. Evidence suggested that the artificial sites were readily accepted and frequently preferred to nearby natural sites that had been utilized in previous years. Eighteen young were fledged at nine nests for an average of 2.0 young per successful nest, similar to the 2.2 average for the previous two years. The total number of nests producing young in the Osprey Management Area increased 37 percent over the average for the previous three years. Similar numerical increases in Osprey nesting concentrations have occurred elsewhere in the United States following the construction of artificial nesting sites (Rhodes 1972, Reese 1970, and Postupalsky, pers. com.).

We cannot be certain that the increase in active nests within the management area in 1972 represented an increase in nesting pairs throughout the total population in Lassen and Plumas Counties because the entire study area was not censused. It is entirely possible that pairs abandoned their former nests elsewhere in preference for the newly-available lakeside structures. Even if there has been no increase in the number of breeding pairs in the total population, we hypothesize that total productivity has increased with the use of artificial nest sites. These artificial sites have attracted additional breeding pairs to an area that traditionally has yielded the highest productivity of any geographical segment of the population; hence increasing the number of birds breeding in this area has tended to maximize the average number of fledglings produced per reproductive effort.

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OTHER CONFERENCE PAPERS ON THE MANAGEMENT OF RAPTORS

In addition to the papers included in this volume eight papers on management of raptors were presented. Another scheduled paper was not given since the author was unable to be present. Papers are listed below with the authors' abstracts when available.—*Editors.*

William C. Andersen, Ornithology Research Center, Otero Junior College, La Junta, Colorado 81050.

Raptor Management Techniques in Southeastern Colorado

ABSTRACT. Members of the Ornithology Research Center of La Junta, Colorado, have been conducting studies on the nesting density and reproductive success of grassland raptors since 1967. The 3.6 million acre study area in southeastern Colorado is an ideal location for an in-depth raptor management program. Human population density is low and decreasing, numerous trees exist, and the prey density is reasonably high. Current and projected management techniques include improvement of natural nest sites, control of predation at the nests, medical treatment of nestling raptors and the production of multiple clutches.

Gerald R. Craig—Colorado Division of Wildlife, 6060 Broadway, Denver, Colorado 80216.

An Approach to Improved Raptor Management in Colorado

ABSTRACT. Peregrine and Prairie Falcons, Golden and Bald Eagles, Ospreys and Burrowing Owls have been selected by the CDW for research to develop raptor management techniques. Aerial surveys, ground transects, nesting studies, analysis of mortality reports, and trapping and banding are some of the methods being used. Critical wintering and nesting sites are being designated for protection from encroachment. A citizen's council was recently established to advise the Division on programs relating to raptors. Public relation programs and in-service training sessions are being developed to better educate Division personnel as well as the public about raptors.

John E. Crawford—Bureau of Land Management, Denver Federal Center, Building 50, Denver, Colorado 80225.

Larry A. Dunkeson—Bureau of Sport Fisheries and Wildlife, Washington, D. C. 20240.

Powerline Standards to Reduce Raptor Losses on the National Resource Lands

ABSTRACT. In 1971, field reconnaissance of powerlines crossing the national resource lands (public domain) in the eleven Western States revealed annual electrocution losses of over 200 eagles. Since these were extensive field surveys, actual annual losses are undoubtedly much higher. Powerline standards are proposed to minimize losses. These standards include underground installation, spacing of hazards, keeping pole tops free of conductors, types of transformers, use of bird guards, non-conducting crossarm braces, types of grounding, eliminating roadside roosting hazards where birds may be shot, and identifying and correcting hazards on existing lines.

Richard W. Fyfe—Canadian Wildlife Service, 10015 103rd Ave., Edmonton, Alberta, Canada.

Raptor Management in Canada

ABSTRACT. Until the late 1950's, virtually all management of raptorial birds in Canada consisted of controlling numbers through indiscriminate shooting and trapping. More recently protective legislation has been passed in most provinces, and at least two provinces have permitted controlled harvests of some species for falconry or research.

A new era of raptor management was initiated in 1966 at the Madison Peregrine Symposium. This was prompted by the concern following the realization that in both Europe and North America we were experiencing population de-

clines in several species of raptorial birds, and in fact were in danger of potentially losing the *anatum* race of the Peregrine (*Falco peregrinus*).

In Canada, the Toxic Chemical Section of the Canadian Wildlife Service subsequently began investigating bird of prey populations and the factors influencing these populations. Investigations included sampling for toxic chemical residue determinations, habitat assessment, studies relative to the availability of nesting habitat and the effects of human interference. The resulting data influenced toxic chemical use patterns and initiated raptor management programs including breeding projects, habitat improvement and an input into environmental impact studies.

J. Richard Hilton—Society for the Preservation of Birds of Prey, PO Box 293, Pacific Palisades, California 90272.

The Harvesting Factor [Author not present; paper read by J. David Siddon]

ABSTRACT. On the basis of data held by the U. S. Department of the Interior, more species of raptors are declining in population than are remaining stable or increasing in numbers. Decline factors, although somewhat curtailed, remain present, and harvesting for falconry and research occur legally. A connection between falconry provisions and illegal harvesting is made. A summary and concluding statement ask for a halt to harvesting and are endorsed by 195 persons besides the author.

[*Editorial note:* We did not print Mr. Hilton's contribution because of prior publication, because it was submitted with a prohibition against editing, and because it included in the body of the paper remarks that border on the libelous. In addition, the list of endorsers of the concluding statement was presented without also including a list of those who declined or later withdrew endorsement. Since the paper is not published here, the discussion specifically critical of the paper is also omitted from the Proceedings. The paper has been published in *The Raptor Report* 1(4):[3-6], Dec. 1973.]

Michael N. Kochert—Boise District, BLM, 230 Collins Rd., Boise, Idaho 83702

The Bureau of Land Management and Raptor Management in Idaho

ABSTRACT. The Bureau of Land Management increased its involvement in raptor habitat management by establishing the Snake River Birds of Prey Natural Area in 1971. Presently, work includes studies on the nesting success and tolerance to disturbance of raptor species nesting in the Natural Area. Wintering and nesting status of Golden Eagles in southwestern Idaho is being assessed. Studies are being conducted to determine prey abundance stratified to habitat and land use type. Application of these studies to the BLM's raptor and Birds of Prey Natural Area management program will be discussed.

Steven P. Layman—3112 Main St., Union Gap, Washington 98903.
A National Park Service Study of Reintroduction Techniques Applicable to Golden Eagles [Abstract not prepared.]

Morlan Nelson—73 East Way, Boise, Idaho 83702.
The Problem of Electrocution of Eagles on Powerlines [Abstract not prepared.]

Verlan Ogden—Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho 83843.
The Snake River Birds of Prey Natural Area [Abstract not prepared.]

Spofford, Walter R.—I.C.B.P. World Working Group for Birds of Prey, Aguila Rancho, Portal, Arizona 85632.
Remarks on the Conservation of Birds of Prey [Author not present; paper not presented.]

ABSTRACT. Early efforts at conservation of raptors largely revolved about legislation to protect hawks and eagles from shooting and trapping. Now we are faced with situations which demand a much broader approach. Problems of land use are paramount. Birds, like all living things, are a renewable resource. Not only must the present living resource be protected from attrition, but adequate nesting habitat and food supplies must be present to provide for births equalling deaths in a unit time. Quite aside from the problems of chemical toxicants are the problems of specific habitat requirements for raptors differing widely in their nesting and food requirements. The California Condor Refuge in California is a major example of the reservation of a proper nesting habitat, but the problem of food supply requires the economic adjustment of land use practices for a wide area heavily populated by man.

On a small scale, Eugene Percy ran a Condor feeding station above his ranch on Hopper Mountain for many years. Feeding stations may be a high y necessary provision for the larger scavengers. In Spain, a "Vulture Restaurant" was established by the Navarrese Association of the Friends of Nature. Forty Griffon Vultures were soon regular diners on horse carcass, and at least five species of scavengers, including a whole family of Bonelli's Eagles, came to the food station. In South Africa, along the eastern Drakensburg, Director William Barnes of the Giant's Castle Game Refuge set up a regular food station for the Lammergeier with marked success.

Sheep range has a notoriously high carcass biomass, and despite constant attrition by the wool industry, large numbers of eagles and other raptors are supported by a readily available food supply . . . and this does not refer to actual predation, but the scavenging of carcass.

Demand for food and other resource by rapidly increasing man has produced vast agricultural deserts with no room for wildlife. In South Texas only the cattle industry and particularly the King Ranch prevent an almost total loss of habitat over vast areas.

The future of raptor preservation is difficult to foresee. We may have to choose what forms of wildlife we must make an effort to save. As with the Arabian Oryx, possibly intercontinental transplants may be the only solution in some cases. In such cases, captive propagation may provide a valuable link in establishing populations in the future. For instance, to re-establish the White-tailed Sea-eagle in Scotland, captive propagation could supply eaglets for exchange to foster parent Golden Eagles, in the Hebrides.

We are all familiar with the problems caused by chemical toxicants, and I will not touch upon this subject here, but rather call attention to the complexity of habitat preservation in a region such as tropical America where rampant destruction of the tropical forests for often only a "shoe-string" agriculture threatens the very existence of the large tropical eagles.

INFORMAL DISCUSSION

Laws and Regulations

ALLAN STUDHOLME: I'd like to make a couple of comments on Bond's paper. I think your presentation was good, I just want to point out that a treaty is just exactly that, it is a treaty and it is nothing until you have an act that implements it. Also, you inferred that probably in the future a treaty with Canada would be amended to include some raptors. I say this is very highly unlikely, not because we wouldn't like to do it nor because the Canadians would not like to do it, but the truth of the matter is that both countries are afraid to amend the treaty in any way because the legal structure in Canada is changed, and that treaty was entered into with Great Britain. If that treaty is amended or attempted to be amended in any way it opens the whole door on the treaty and that treaty must be ratified by each and every province or there is no treaty. Now we are not going to gamble on doing that. One thing that I'd also like to say basically is that we have negotiated a treaty with Japan which includes raptors and all that remains to be done on that is to have it ratified by the Senate, and I hope they ratify it this year.

FRANK BOND: I am very happy to have had Mr. Studholme make those comments.

VOICE: I wanted to ask one question of Mr. Studholme. I'm a little confused, what exactly do you mean by a treaty including raptors; exactly what does that mean?

STUDHOLME: Now in the first place it is semantic. A treaty is a convention. Let's use the vernacular and call it a treaty. And I don't know if you are referring to the treaty with Japan? That treaty will include raptors as well as 400 or some odd species of birds. This treaty is by species rather than by families and raptors that occur in Japan and in the states are included.

VOICE: Does that mean total protection, or what?

STUDHOLME: No, it just means that they come under the treaty and that there will have to be rules and regulations for their utilization development or they cannot be used at all.

GUSTAV SWANSON: Many of us would naturally wonder why the first of the important Migratory Bird Treaties, the one with Canada in 1916, did not include raptors rather than having to wait until 1972 with Mexico, but the fact is that back in 1916 it wouldn't have been possible to get the support to include raptors. If you read the working of the treaty then, it had to be placed on insectivorous birds because of their value to man, the waterfowl because of their value as food, and so on. And there is a great deal that has happened in the period since then to arouse and develop public interest in raptors as well as environmental problems generally.

ROBERT COLEMAN: Mr. Bond, I understand that you said that the ban on transportation has been lifted? Is that since last Monday?

BOND: No, it has not been lifted. That is a proposed rule mentioned by the Department of Agriculture on the basis of the exotic Newcastle's disease problem.

SWANSON: Another comment. Allan Studholme, who spoke, represents the Bureau of Sport Fisheries and Wildlife and although he isn't on the program, he will be given time tomorrow afternoon to explain more details of the present draft of the Federal Regulations to which Mr. Bond referred. Allan has been the Chief of the Division of Game Management, the law enforcement division of the Bureau of Sport Fisheries and Wildlife so he knows about these problems of law enforcement, how difficult they are, and he will be able to interpret that for us tomorrow afternoon.

JOSEPH MURPHY: It seems to me that we need to work together and not work to some polarized ends that are going to further fragment and divide opinion about how we should evaluate and use, and I say use because even if we are out bird watching with a pair of binoculars we are using a resource. And that is a legitimate use of a resource. The point I am trying to make is, we should join forces and not participate in more fragmentation. But above all, my suggestion is, let's not participate in the luxury of polarization any further, fragmentation again in this important area of management and conservation of wildlife simply cannot be abided any longer.

SWANSON: It occurred to me that abuses have a much better chance of being controlled when the Federal Regulations come into effect. We have many examples of that in the past. Wildlife conservation measures by the states have frequently been ineffective because they weren't uniform for one thing, they didn't involve cooperation one state with another, but when the Federal Government lent its assistance, as in the case of the Lacey Act back in 1900, then the market hunting of game birds particularly waterfowl and upland game birds such as grouse and so on, the days of this market hunting were numbered, because it took that Federal assistance making state laws Federal laws; in effect, it was one of the first of our Federal aid types of legislation. And now we have on the scene as a result of the Mexican treaty the opportunity to get this Federal assistance in the raptor regulations field and if as Dr. Murphy said, we would cooperate rather than polarize the interests of all of those who are really concerned about raptors, we have a much better chance of accomplishing the purpose that all of us are interested in.

Use of Wild Foster Parents

JEFFREY PETERS: I'd like to ask Mr. Andersen about the fostering of the Swainson's Hawk in nests from which young had already fledged. How much younger were the youngest offspring than the young that were originally in the nest? Had the young just fledged from that nest, within a day, say?

WILLIAM ANDERSEN: No, it was within three or four days as I recall it.

PETERS: How close were the young from that nest at the time you put the extra young in?

BABETTE CRANSON: They weren't really close, maybe a quarter of a mile away.

PETERS: How long after that was it until the artificial, the foster young fledged from the nest?

ANDERSEN: It was already capable of flight at that point but it stayed right in the immediate area.

PETERS: Did you observe it fed by the parents?

CRANSON: We observed them all in the same grove of trees. No, we did not see them feed the young.

PETERS: At any rate they survived and they couldn't have fed themselves.

BRUCE WOLHUTER: I just wanted to make a comment, somewhat echoing what Bill Andersen said. I've been working with some of the birds that are brought in to Colorado Springs. Probably the greater percentage of birds brought in were young birds that were confiscated and been brought in. One alternative that we've all considered in the past was training these birds and then re-releasing them; but I think we can make a lot of this work easier on ourselves by just taking these birds and putting them in foster nest situations. A lot of people are aware of how readily these birds will be accepted, but I think it's much preferable over the work of trying to train a bird if you've got natural parents that are more than willing to do the job for you and that will accept the bird. As far as I'm concerned it's much preferable; if people that are working with rehabilitation centers aren't already aware of the raptor populations and nest locations in the area, they should coordinate their work with these people that do, so that as many of these young birds that can possibly be replaced in nests should use this method rather than try to train the bird and release it later.

RICHARD FYFE: Right. I think that's a good point. However, I think that I would like to add a word of caution, and that is that there is some indication that foster parents do not readily accept young at all times during the breeding season and they may not accept young if they're very different in age from the young of their own that they have themselves in the nest. I think we need more work in this area so that we know exactly what we're doing. I think it's a very good technique and has a lot of potential but there is a caution there.

ANDERSEN: Yes, ours were actually meshed in age as closely as possible with the nest in which they were put.

Fish Kills as Bald Eagle Food

DAVID BIRD: Mr. Craig, you mentioned periodic fish kill providing food for Bald Eagles. Are these fish kills due to the pollution or just natural death?

GERALD CRAIG: Well, with regard to the fish kills it appears to be a winter kill situation where oxygen is cut off. It's historic that the bird is generally keying in on this and will show up in an area within a couple of days of ice off—it's not really pollution in most cases.

Raptor-Park Problems

MURPHY: Mr. Layman, you say this was an eagle reintroduction program supported by the National Park Service?

STEPHAN LAYMAN: Originally when I started the program, I helped the Woodland Park Zoo as an advisor, setting up their breeding projects. As a result of the breeding project itself and a few other birds being given to it by the Fish and Wildlife, there were several eagles that had to be released back to the wild. I had a summer free to conduct a study and an attampt to make some sort of generalizations for the Park. Well the Park Service found that the public relations aspects of it were advantageous to the Park so they hired me on as a park ranger and with that I could continue my work over the winter. They gave me help in the use of the lab and supported me for developing educational programs for the park; that was their main interest because they were having trouble. For example, their master plan for the park was to have boat launches, re-routing of that road you saw right down through the middle of the grassland, right through the Skylark area, and the eagle hunting area. From my activity in the park that winter they re-routed the road; they closed off Mt. Finlester, and are now reconsidering where the Bald Eagles were for nesting. They're now reconsidering not putting in the boat launches and having foot trails through the park out of the area behind there and establishing observation points for people instead of having them running all over the park chasing Bald Eagles and Golden Eagles off rabbits and wondering what happened, which is the case. From the result of it though, there was quite a bit of pressure from the Audubon Society. We made Audubon field trips in the park. The last group I had was fifty and when I got there to meet them they were running around through the Skylark nesting areas and interfering with Great Horned Owls and so the majority of my time was spent explaining to them and demonstrating to them proper etiquette within nesting territories of birds of prey.

Electrocution Problems

THOMAS RICHARDS: I'd like to ask Mr. Crawford about the fuses which you said you put on some of the poles. How do those work?

CRAWFORD: I don't really have an idea yet on how the fuses work. This is still pretty much in the proposal area. Perhaps Morley Nelson has some ideas from some of his work in Idaho on fuses and some of the modifications done there. Will you help me on that, Morley?

MORLAN NELSON: I don't understand the fuses. What do you mean by fuses?

CRAWFORD: This is on the transformers that would be equipped with bird guards and internal fuses, and insulated jumpers on the transformer part.

VOICE: Perhaps the power company or electrical engineers had something to do with this. It may be entirely for their own purposes. Preventing shorting out of the transformers in case there were any extraneous reasons for shorts which would cause shorts. This may determine the economics of it without any regard for protecting eagles.

NELSON: I think they do have a problem there.

CRAWFORD: I understand they've had damage on lines burning up transformers and so on, I would guess.

NELSON: I'm sure this is the reason. That is the function of the power company: protecting the installations so that it doesn't burn the whole thing up if a short does occur. The only comment I had on your proposal was that I didn't understand, when you ask for 30 inches of free wood above the insulator. According to our researches you saw on the film I don't really see any need for that extra 30 inches. Now I'm sure the power companies are going to say the same thing: why do we have to buy 30 inches more times 2000? Pretty soon you've got $50,000. So I do go along with the fact that if we can prove without the question of a doubt that the line in the vertical separation of the conductors is safe without the 30 inches on top, fine. I think that's the way we should go, unless there's some special reason as you pointed out for a special purpose in trying to help the bird. And that's another proposition.

NEIL WOOFINDEN: I'd like to make a comment on the fuses. It's pretty standard policy to put a fuse on each transformer. What they do is bring a lead down from the hot wire to the fuse box and then to the transformers. So there are additional wires in the area of the transformers so that the bird doesn't short it out.

STEVEN CHINDGREN: I'd like to direct my question to Mr. Crawford and Mr. Nelson. I was wondering if in your observations of electrocution if you've ever attributed any of the causes possibly due to wet storms or rain helping to ground the pole? Now I did witness an electrocution on a pole and it occurred after we had a big storm accompanied by high winds. The snow was wet and it stuck to all the poles. The next day was a clear sunny day and we were flying a trained falcon. The falcon lit on the pole and from a distance we saw the falcon fall. Now observing the pole where we found the dead falcon, the ground wire had been broken and was just extending out into the air. This pole was not grounded except possibly by the snow and the water. I just thought I might bring this up—I thought it could be a possibility also in electrocution of birds of prey.

CRAWFORD: It could be; I think there's quite a bit of conjecture on a wet cross-line—whether they will electrocute or not. I've heard pro and con myself. The point you raise though is very good.

NELSON: Well, the problem is in areas where there is salt in the air—naturally, we have a lot of salt going into the air. At certain times there is enough of an electrolyte in the rain or in the pole where the salt has been blown in a dust storm. Let's say, all around a salt lake this is particularly true. We get Salt Lake salt in our snow pack in the Teton Mountains of Idaho. This obviously happens on the pole line and when you've got a wet snow or wet rain preceded by a high wind carrying salt, that stuff on the cross-lines. Yes, the birds could short out, the birds being also wet and increasing its conductivity. But the program is not designed to save that five percent item; the program of insulating the lines is designed to save 95% of the problem with a reasonable expenditure of money. And I don't think there's any doubt that stuff in the wet snow on the poles can create a ground and that you could lose a falcon if he landed on this snow and then touched one of the lines. What you said was a broken ground was not truly broken when it was sitting in the ice; it had a lot of places to carry current.

CHINDGREN: But when the wire came down it extended out in the air.

NELSON: But the wire in the snow itself had a solution to carry electric current and therefore it would arc. This happens but that's a very rare proposition.

CHINDGREN: I think another thing with this could be, if you think about it a little bit more: when you have a heavy storm with a bad blowing day and it may go on for a few days. The bird of prey's hunting is limited in that type of weather so when you get a nice clear warm day with a big thaw and all the poles are wet, you get a large concentration of hunting during that period of time as well as a sitting on the poles.

Terminology Problems

CHARLES SINDELAR: I'd like to make one comment. Sergej, when you mentioned a frustration nest, you said in most cases it does not contain eggs. I would say that it could contain eggs in no cases, it would be a second attempt.

SERGEJ POSTUPALSKY: That is so for Ospreys and Bald Eagles. However, I have been doing some reading on Peregrine Falcons and there have been cases I think in the New York study where birds built one nest and after they lost their eggs they went on a different ledge and laid a few more eggs and sat on them for about a week or two and then they moved to a third ledge. This perhaps could be referred to as a frustration nest, but we're dealing with semantics and I said they are cliff nesters and I don't know very much about them and I'd be willing to get together with someone who knows more about these and fight it out with them.

BROWN: I need to use the blackboard to show a hypothetical situation. This is entirely hypothetical, let us say this is a Golden Eagle breeding area and this is a river; let's call this, if you like, range. Now within this area there is a Golden Eagle, a Ferruginous Hawk, a Peregrine Falcon, or whatever it may be, defending a smaller area which is called territory. Sometimes as we have seen from these telemetry experiments, the entire range may correspond to a territory. In other cases, as in the Buzzard or the kestrel it may be only an area around the nest so I would suggest we would start with a range and inside that is a territory of different size. Then in this there were places where the bird has had several nests. This is the nesting or breeding site, and each of these is a nest site. This seems to me to simplify the sort of situation. If we could agree to use terms of this nature this will get over the question of whether the territory is synonymous with the range or not. Apparently it is defined in general terms as any defended area and accordingly it can be of any size, the whole range, or even a little tiny area around the nest. And these seem to me to be possibilities you might like to consider.

One other thing I want to bring out and I want to bring out rather strongly, is the question of non-breeding pairs. In the case of tropical eagles I think this turns out more easily than in temperate species, we tend to get a much higher proportion of non-breeding pairs and they are also much easier to detect. In the species which I have recently been studying, the Fish Eagle, living the linear shoreline of Lake Naivasha, and the birds can always be found in a comparatively small area, about 300 yards apart and they are strongly territorial and they will fight with one another like that. And they are all adult without any question. There is no doubt whatever that birds that may be breeding for three years in succession are adults and the next pair which may not breed at all for three years in succession are equally adult. There is no question that these are immature birds at all; they are adults. And I class them if they don't breed as non-breeding pairs—they are in their territory which they defend, and they are not breeding. This is much more difficult to prove in a bird such as the Golden Eagle in the Highlands of Scotland, where you may have to search for several days in what you think is a breeding area to be certain that any particular pair is not breeding; time after time you've found the beastly thing in a gully after having walked miles and miles and miles. And this I think is an important point, this question of non-breeding pairs is an important point. And it is one which is very often completely overlooked. And you cannot relate breeding success, that is total young reared, to the total adult population, unless you know the number of breeding pairs. So I put these things into three categories. I say the total pairs which in general correspond to the total number of known ranges or territories in any particular area; then I say you need another—the pairs that bred—and those are the ones that actually laid eggs. Finally, you need to know the young reared. And this figure, young reared, over breeding pairs, is the one which gives you the real answer in relation to reproductive rate. To use this, young reared per successful nest, only, you get a completely misleading answer. Young reared per breeding pair can vary, for instance in the Welsh Kite (Red Kite) in the past 70 years, by 800%. And young per successful pair can not vary usually by more than 100%. So you get far less variation in the young per successful nest as compared to the young per pair altogether and this is the important comparison. I wanted to make it quite clear that there are non-breeding pairs of adults and I do think that everybody who is studying populations must take the non-breeding pairs into account even though it may sometimes be a frightful sweat to find them.

POSTUPALSKY: I would like to add something, if I may. I am not going to dispute anything that Leslie Brown says, because I agree with everything he says here. I am just going to add a couple of points and show how his and my tabulations relate. I have generated some hypothetical data of the type we should be getting. All right, the number of occupied nests—let's say we have 100—that is identical to Brown's "total pairs." Let's say we have 80 active nests, that is the same as Brown's "pairs which bred." Now among these we have, say, 60 productive or successful nests; this is another category, in addition to Brown's three main categories. Percent nest success is this latter value times 100 divided by the number of occupied nests (or "total pairs"), which solves to 60 percent. I tried to select simple figures. The total number of young raised, let's say there are 75, that obviously is identical to Brown's third category. Now you can calculate mean brood size, which in this case is 75 divided by 60, or 1.25 young per successful nest. This ratio is of limited use. Then you can calculate young per active nest, which in this case is 75 divided by 80, or 0.94. And finally, the productivity of the entire territorial population of potential breeders is obtained from the total number of young (75) divided by the number of occupied nests ("total pairs" = 100), which solves to 0.75 young per occupied nest which is the "real reproductive rate" of Brown. Now, unless you have made that early check, you cannot really determine the total number of territorial pairs (breeders and nonbreeders) in your study area, and consequently you cannot calculate real, over-all productivity. In my eagle studies and the state-wide Osprey survey as a rule, I do not have the number of active nests ("pairs that bred"). I do not know the proportion of pairs which actually laid eggs. This is because I have been generally unable to follow the nests closely enough to separate nonbreeders from early-failing breeders. So, what I have been doing is relating the total number of young raised to the total number of occupied nests ("total pairs") and obtaining the significant population statistic, which I call "productivity" and Brown refers to as "real reproductive rate."

I have seen a number of studies in which an attempt was made to relate the number of young per successful nest to population trends. This was the essence of my criticism of a part of the Saskatchewan study yesterday afternoon. In some populations, particularly those variously affected by pesticides, in which breeding success has been reduced, there has been, as a rule, only a small, often just barely perceptible, change in the number of young in successful nests. An example is the recent paper by Sprunt *et al.* (*Trans. N. Amer. Wildl. & Nat. Res. Conf.* 1973) which I mentioned yesterday. It compares the productivity of six Bald Eagle populations which varied from normal success to almost no success. Brood size in these six populations varied only between 1.3 and 1.6 young per successful nest. The big difference was in percent nest success. In some populations 50-70 percent of the pairs were reproducing, while in others only about 10 percent were producing young. The proportion of pairs which fail to raise young or refrain from breeding at all contributes much more to variability in over-all productivity and is responsible for the major portion of the recorded reduction in over-all productivity. That any significant change in brood size was detected at all is almost undoubtedly due to the large sample sizes (N = 156 to 592) available to the Sprunt *et al.* study.

Studies which ignore over-all productivity (based on the total territorial population) and just follow brood size, will, at best, record only a small portion of the breeding failure phenomenon. I saw one study dealing with the Cooper's Hawk in which the investigator used banding data to compare the number of nestlings in broods banded in the old days to the sizes of broods banded more recently. He reported a significant reduction of about 25 percent—I do not recall the exact figure. From this he concluded that productivity in the Cooper's Hawk had decreased by 25 percent during the period under study. I submit that he grossly underestimated the decrease, because total failures, as a rule, are not reflected in bird banders' records, for banders do not report nests with zero young.

Many population studies are very vague with definitions. Often they do not tell the reader what they mean by "active" nests or pairs. Do they mean pairs with young, pairs with eggs, or just territorial pairs? And, if productivity figures are given, you are often left wondering if they are based on breeding pairs only, or on total pairs including nonbreeders. The importance of distinguishing between these two categories increases with the proportion of nonbreeders in the population. That's all I want to say. Thank you.

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