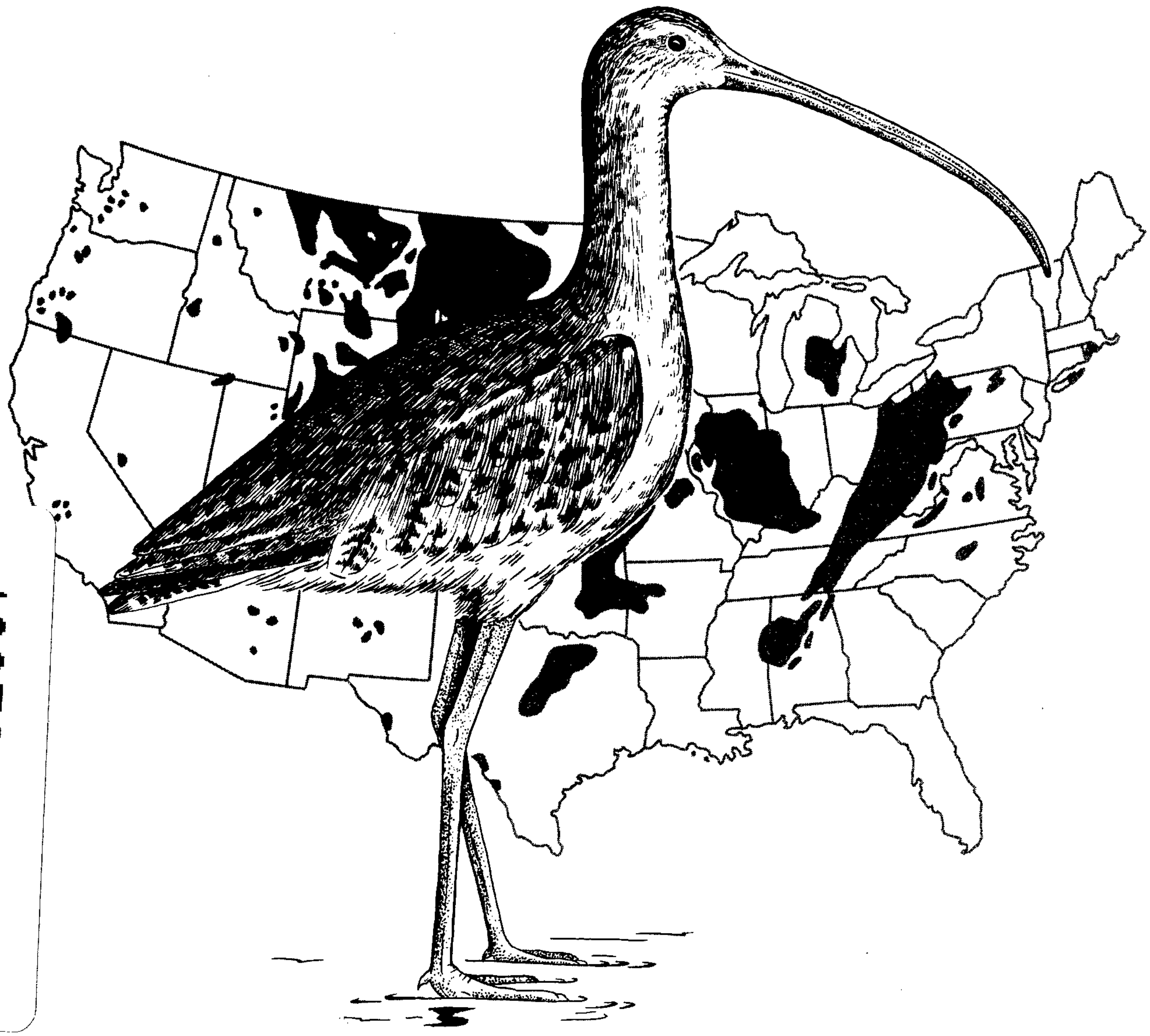
FWS/OBS-83/35
DECEMBER 1983

IMPACTS OF COAL SURFACE MINING ON 25 MIGRATORY BIRD SPECIES OF HIGH FEDERAL INTEREST



Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-83/35
December 1983

IMPACTS OF COAL SURFACE MINING ON 25 MIGRATORY BIRD SPECIES OF HIGH FEDERAL INTEREST

edited by

Judith Scherpelz Armbruster
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
2627 Redwing Road
Fort Collins, CO 80526-2899

Project Officer

Ralph Morgenweck
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
2627 Redwing Road
Fort Collins, CO 80526-2899

Performed for
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

This report should be cited as:

Armbruster, J. S., ed. 1983. Impacts of coal surface mining on 25 migratory bird species of high Federal interest. U.S. Fish Wildl. Serv. FWS/OBS-83/35. 348 pp.

PREFACE

Increasing development of mineral resources in the United States is resulting in increasing conflicts with wildlife resources. In response to these conflicts, the Fish and Wildlife Service and Bureau of Land Management have developed a list of migratory bird species of high Federal interest (U.S. Fish and Wildlife Service Memorandum, Federal Coal Management Leasing Program Unsuitability Criterion 14 Guidelines). These species are used in applying Unsuitability Criterion 14 to coal areas being considered for leasing. Federal lands which are high priority habitat for birds of high Federal interest may be considered unsuitable for all or certain stipulated methods of coal mining (Criterion 14 of 43 CFR 3461.1). Selection of species was based on factors including the species' national importance or public value; the potential for regional decline, regional jeopardy, or long term impact; and the species' status as an indicator species. The list includes both migratory and nonmigratory species protected under the Migratory Bird Treaty Act. Table I illustrates the distribution of the 25 species in those States having coal deposits.

This document is designed for use by general biologists in conducting preliminary assessments of potential impacts of coal surface mining on selected species of migratory birds of high Federal interest present during some part of the year in the area of potential development. The species accounts include life history, habitat use, and population status information contributed by the authors. Very little information has been published on impacts of coal mining and mitigation measures for particular species. Therefore, many of the impacts and mitigation sections are based on the species habitat requirements and potential impacts and mitigation recommendations discussed in:

Moore, R., and T. Mills (1977). An environmental guide to western surface mining. Part two: impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv., FWS/OBS-78/04; and

Samuel, D. E., S. R. Stauffer, C. H. Hocutt, and W. Mason, Jr. 1978. Surface mining and fish/wildlife needs in the Eastern United States. Proc. of Symp. U.S. Fish Wildl. Serv., FWS/OBS-78/81.

The focus of this document is coal mining regions in the 48 contiguous States. The impacts and mitigation sections may not be applicable to those species occurring in Alaska, because of differences in ecosystems unique to Alaska.

Table I. Occurrence of Migratory Birds of High Federal Interest in States with coal deposits.

Species	AL	AZ	AR	CA	CO	GA	ID	IL	IN	IA	KS	KY	MD	MA	MI	MS	MO	MT	NE
	States																		
Western grebe		X		X	X		X			X								X	X
American white pelican	X	X		X	X	X	X				X							X	X
Double-crested comorant	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-faced ibis	X	X	X	X	X		X			X	X						X	X	X
Wood duck	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cooper's hawk	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Zone-tailed hawk																			
Ferruginous hawk		X		X	X		X				X							X	X
Merlin	X	X		X	X	X	X								X			X	
Prairie falcon		X	X	X	X		X			X	X						X	X	X
Sandhill crane	X	X		X	X		X	X	X		X	X			X	X		X	X
Piping plover	X					X		X	X	X			X	X	X	X		X	X
Mountain plover		X		X	X						X							X	X
Long-billed curlew				X	X	X	X				X							X	X
Interior least tern			X		X			X	X	X	X	X				X	X	X	X
Burrowing owl		X		X	X		X			X	X						X	X	X
Spotted owl		X		X	X														
Lewis' woodpecker		X		X	X		X				X							X	X
Red-headed woodpecker	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pileated woodpecker	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	
Loggerhead shrike	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dickcissel	X		X		X	X		X	X	X	X	X	X	X	X	X	X	X	X
Bachman's sparrow	X		X			X		X	X			X	X			X	X		
Brewer's sparrow		X		X	X		X				X							X	X
McCown's longspur		X			X						X							X	X

Table I. (concluded)

Species	NV	NM	NY	NC	ND	OH	OK	OR	PA	RI	SD	TN	TX	UT	VA	WA	WV	WY
	States																	
Western grebe	X	X			X			X			X		X	X		X		X
American white pelican	X	X			X		X	X			X		X	X		X		X
Double-crested comorant	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-faced ibis	X	X			X		X	X			X		X	X				X
Wood duck	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	
Cooper's hawk	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Zone-tailed hawk	X	X											X					
Ferruginous hawk	X	X			X		X	X			X		X	X		X		X
Merlin	X	X			X	X		X					X	X		X		X
Prairie falcon	X	X			X		X	X			X		X	X		X		X
Sandhill crane	X	X		X	X		X	X			X	X	X	X				X
Piping plover			X		X					X	X		X		X			
Mountain plover		X					X				X		X					X
Long-billed curlew	X	X°			X		X	X			X		X	X		X		X
Interior least tern		X			X		X				X	X	X					X
Burrowing owl	X	X			X		X	X			X		X	X		X		X
Spotted owl		X						X					X	X		X		
Lewis' woodpecker	X	X					X	X			X		X	X		X		X
Red-headed woodpecker	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Pileated woodpecker			X	X	X	X	X	X	X	X	X	X	X		X	X	X	
Loggerhead shrike	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dickcissel		X	X	X	X	X	X		X	X	X	X	X		X		X	X
Bachman's sparrow				X		X	X		X			X	X		X		X	
Brewer's sparrow	X	X			X			X			X		X	X		X		X
McCown's longspur		X			X		X				X		X					X

Many limitations exist in attempting to predict impacts on wildlife species. Impacts will vary with the region of the country, location of the mine, and the species in question. Little information is available for many species on habitat requirements, population status, behavior, the ability to withstand habitat fragmentation, or the minimum viable population size, thus potential impacts on these parameters are unknown. Many impacts, such as increased stress, are difficult to quantify. The effect of cumulative impacts of several development projects in one region must also be considered.

Mitigation recommendations also differ in their applicability to various mining projects. Some measures are mandated by law, while others may depend on cost/benefit ratios and the financial resources available. Often the techniques required for effective mitigation do not exist; e.g., reclamation of arid western ecosystems is limited by moisture regimes and difficulty in re-establishing native vegetation.

Early planning and cooperation between biologists, State and Federal agencies, and mining engineers are essential in development of effective mitigation programs. The degree of impacts from coal mining, and success in reclamation efforts, will change as mining procedures and mitigation/reclamation methods improve. Impact assessments will also change as wildlife species are better understood with further research.

Scientific names follow conventions established by the following sources:

American Fisheries Society. 1980. A list of common and scientific names of fishes from the United States and Canada. 4th ed. Am. Fish. Soc. Special Publ. 12. 174 pp.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th edition. Allen Press, Inc. Lawrence, KS. 877 pp.

Association of Systematics Collections. 1982. Checklist of mammals of the United States and the U.S. Territories. Eastern Energy and Land Use Team, U.S. Fish Wildl. Serv. 31 pp.

Collins, J. T., J. E. Huheey, J. L. Knight, and H. M. Smith. 1978. Standard common and current scientific names for North American amphibians and reptiles. Soc. Study of Amphibians and Reptiles. Misc. Publ. Herpetol. Circ. 7. 37 pp.

Scott, T. G., and C. H. Wasser. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, DC. 58 pp.

The coal distribution shown in all figures is from:

Spaulding, W. M., and R. D. Ogden. 1968. Effects of surface mining on the fish and wildlife resources of the United States. U.S. Bur. Sport Fish. Wildl. Resour. Publ. 68.

SUMMARY

This document is designed as a database to be used in conducting a preliminary assessment of the potential impacts of a particular coal surface mining project on migratory bird species present in the area during some part of the year. Included are accounts for 25 migratory bird species of high Federal interest. These accounts discuss life history, habitat requirements, population status, effects of habitat changes and human disturbance, and management techniques that focus on both Eastern and Western ecosystems. Information on potential impacts and recommendations for mitigation measures are included, along with general suggestions for the reclamation of wildlife habitat.

CONTENTS

FIGURES

FIGURES (concluded)

TABLES

ACKNOWLEDGMENTS

This document is the result of the efforts of many biologists, both from the U.S. Fish and Wildlife Service and associated with universities. Many species experts contributed data and current information, and reviewed earlier drafts. Field personnel reviewed drafts and offered many helpful suggestions. Numerous hours of typing were also involved; C. Gulzow and D. Ibarra typed the final draft. K. Lindgren assisted in literature acquistion. J. Shoemaker prepared the illustrations. The efforts of all are greatly appreciated.

WESTERN GREBE (Aechmophorus occidentalis)

by

Susan K. Kraft
Montana Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
Missoula, MT 59812

SPECIES DESCRIPTION

The western grebe (*Aechmophorus occidentalis*) is a piscivorous diving bird of western North America. This species is dichromatic; Lawrence (*in* Baird 1858) first described the color phases as separate species, calling the dark-phase birds western grebes (*Podiceps occidentalis*) and the light-phase birds Clark's grebes (*P. clarkii*). The first edition of the American Ornithologists' Union's (1886) "Check List of North American Birds" recognized the two color phases as variants of the same species. The western grebe has since been classified as the only living member of the genus *Aechmophorus* (American Ornithologists' Union 1983). Storer (1965) redescribed the color phases, and he and Lindvall (1976) noted assortive mating within mixed-phase populations. More recent studies suggest that the two color phases possibly function as separate species (Ratti 1979, Nuechterlein 1981).

The western grebe is the largest North American grebe (Seabloom et al. 1978). Average weight of 13 birds (12 males, 1 female) from Puget Sound was 1,460 g (Phillips and Carter 1957). Sexes can be distinguished by the male's larger body size and stouter, more massive bill (Palmer 1962) and differences in advertising calls (Nuechterlein 1980). Plumage characteristics do not vary between sexes. The long slender neck, long sharp bill, red eyes, and sharp contrast of black crown, nape, and back with pure white underparts minimizes confusion with any other species. All grebes show a white wing patch in flight, but the western grebe is the only North American grebe with white extending into the primaries (Palmer 1962).

Plumage differences between dark- and light-phase birds occur primarily in the facial and flank regions (Storer 1965; Ratti 1981). Dark-phase birds have black crown feathers extending below the eyes, black lores, uniformly dark backs, and dull greenish-yellow bills. In light-phase birds, the black crown does not reach the eyes, lores are white, backs are paler grey, flanks are white mottled with black, and bills are yellowish-orange. The crown and nape of both phases are deep black, but the nape strip may be narrower in light-phase individuals (Storer 1965). Intermediate-phase birds, characterized by a black and white facial margin horizontally bisecting the eye, are rare in North American breeding populations. Less than 1% of 8,000+ birds observed in California, Nevada, Oregon, and Utah could be classified as intermediates, and may represent either hybrids, or phenotypic variants (Ratti 1979, 1981). Most wintering and breeding flocks include ≤ 15% light-phase birds, with local exceptions noted by Feerer (1977) and Ratti (1981).

Downy young western grebes differ from other American grebes in having plain, unspotted coloration (Bent 1919; Storer 1967). At hatching, the upperparts are smoke grey, with face and underparts pale grey to white. Young have a bare, triangular crown spot that turns from orange to scarlet if the chick is disturbed or excited (Palmer 1962; Storer 1967). Ratti (1979) described the differential development of plumage characteristics in light- and dark-phase young.

DISTRIBUTION

The western grebe is locally abundant throughout much of Western North America (Fig. 1). Breeding range extends from southeastern Alaska, central British Columbia and central Alberta to southwestern Manitoba, south into Nebraska and western Minnesota and northwestern Iowa, southwest across north-central Utah and southwestern Colorado to southern California, and northwest throughout most of California, central Oregon, and Washington (American Ornithologists' Union 1983). Wintering occurs mainly along the Pacific coast from central British Columbia to central Mexico, but many birds winter inland in central California (Ratti 1981), western Nevada (Pyramid Lake), and Arizona (Gila River) (Bent 1919; Dawson 1923; Palmer 1962). Resident breeding populations occur in southern Mexico (Pueblo and Jalisco) (Dickerman 1963).

Western grebes rarely fly except during migration. Migration is apparently primarily east-west in orientation, nocturnal, and probably occurs en masse. Spring migration occurs during late April and May; fall migration is more variable, extending from September to December (Munro 1941; Palmer 1962).

DIET

Western grebes rely more exclusively on fish than do other North American grebes. Food habits on the breeding grounds include fish (81% of total food volume), insects (17%), and aquatic plants (2%) (Lawrence 1950). Proportion of insects eaten decreased from May to September and the proportion of fish increased. Bluegills (Lepomis macrochirus) constitute up to 71% of all food ingested. Most of the insects eaten are from the orders Coleoptera, Orthoptera, and Hempitera. Important food items also include carp (Cyprinus carpio), and Sacramento perch (Archoplitis interruptus) (Wetmore 1924; Herman et al. 1969). Food items of western grebes wintering along the Pacific coast include herring (Clupea pallasii), smelt (Atherinops spp.), sea-perch (Cymtogaster spp.), shrimp (Padalus goniurus), and crabs (Spirontocaris sucklei) (Wetmore 1924; Munro 1941; Phillips and Carter 1957).

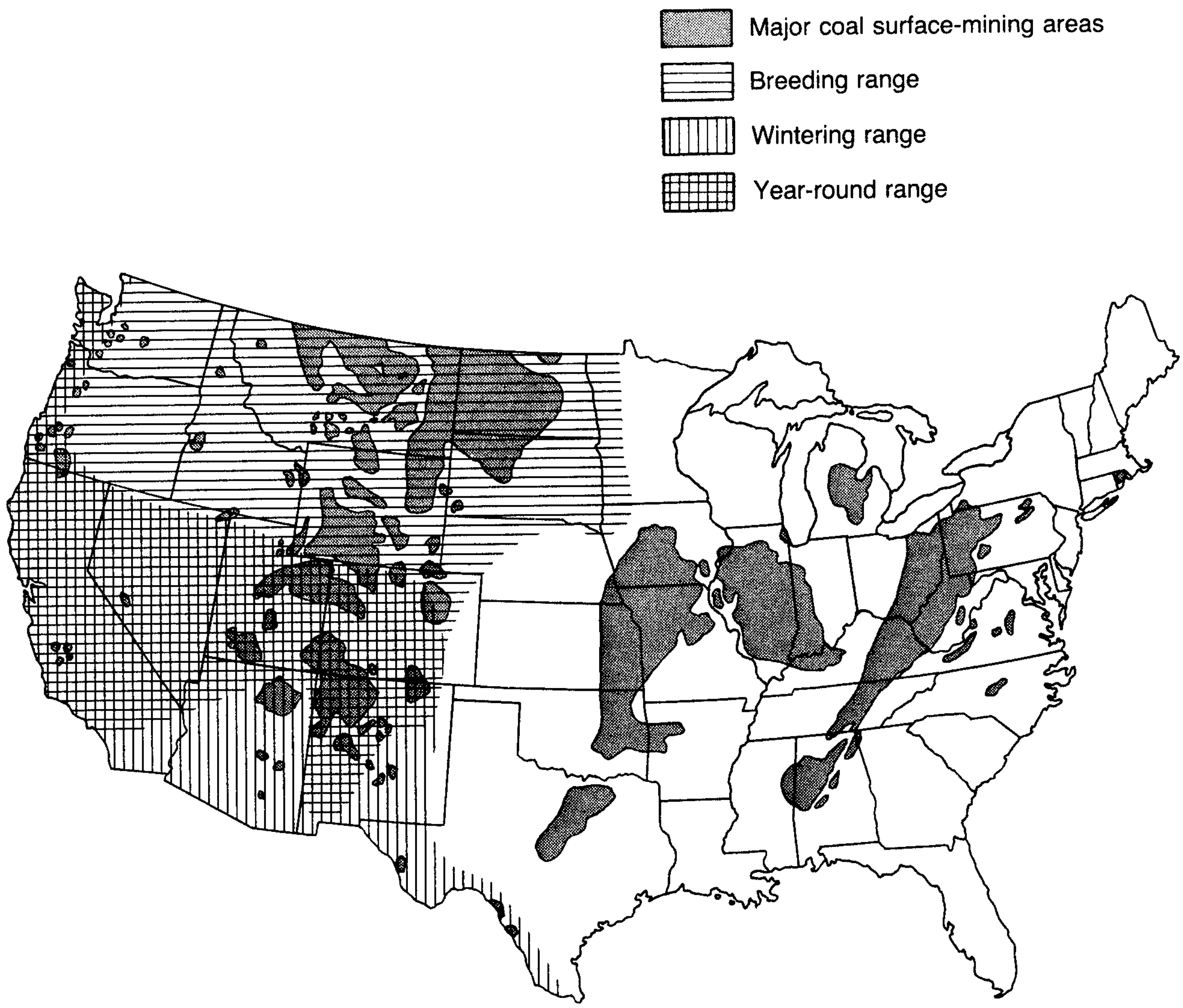


Figure 1. Geographical range of the western grebe in relation to major coal deposits in the United States. After Inkley and Raley (1983) and author.

All stomachs collected for analysis, including those from downy young (Munro 1941), contained mats of feathers. Western grebes regurgitate pellets of feathers, chitin, and other indigestible materials; bones and other calcified structures are digested (Storer pers. comm. 1982). The feather mat may protect the stomach walls from being punctured by sharp bones, and prevent hard undigested materials from passing into the lower alimentary tract before they have been softened and eroded by digestive action (Wetmore 1924).

Peaks in diving and feeding activity at Clear Lake, California, occur at 0800 to 0930 h and at 1800 h (Lawrence 1950). Peaks may correspond to an optimal balance between critical light intensity needed for underwater vision and periods of greatest prey activity. At least 60 m of open water usually separate feeding individuals, a spacing that possibly minimizes disturbance of underwater prey by surface activity of other grebes. The level feeding dive, used most often, propels the bird beneath the surface with minimal effort and surface disturbance; the spring dive, initiated with a vigorous leap, is used in rough or deep water (Lawrence 1950; Neuchterlein 1980). Most feeding occurs in water 1 to 3 m deep.

REPRODUCTION

Western grebes begin pair formation activities soon after arrival on breeding grounds during April and May. The nest is built by both male and female; sometimes, material is brought by the male and arranged by the female (Palmer 1962). Nest mounds are usually constructed from bottom vegetation, either floating and anchored to the surrounding vegetation, or built up from the marsh floor. Nest platforms are usually located in emergent vegetation, most commonly in stands of bulrush (*Scirpus* spp.), cattail (*Typha* spp.), or cane (*Phragmites* spp.) (Finley 1907; Bent 1919; Munro 1941; Nuechterlein 1975). Western grebes nest in emergents, on open water, and on dry land close to open water (Lindvall 1976). Water depths > 20 cm near the nest appear important to accommodate the western grebe habit of diving to and from the nest site (Nuechterlein 1975; Lindvall 1976).

Western grebes are primarily colonial nesters. Pairs selecting nest sites are attracted to birds of the same color phase (Ratti 1979), and to established nests within a colony. Colony growth radiates outward from the earliest selected sites, yet territorial behavior in the immediate nest vicinity serves to space nests uniformly (Nuechterlein 1975). Only 5% of all nests were solitary at the Bear River Refuge in Utah (Lindvall 1976).

Egg laying occurs from late May (Lindvall 1976) to mid-August (Lawrence 1950; Nero et al. 1958; Nuechterlein 1975). Clutch initiation dates are synchronized within colonies but may vary between colonies (Nuechterlein 1975; Ratti 1979). Average clutch size is 3 to 5 eggs, but larger clutches have been described and are attributed to egg dumping (Finley 1907; Dawson 1923; Nuechterlein 1975; Lindvall 1976). Eggs are layed at 1 to 2-day intervals, incubation begins with the first egg, and both sexes have a brood patch and share in incubation (Palmer 1962). Incubation usually lasts 23 to 25 days (Bent 1919; Gould 1974; Lindvall 1976).

Within hours of hatching, chicks leave the nest and climb on their parent's back (Finley 1907; Dawson 1923; Munro 1941; Nero et al. 1958; Lindvall 1976). When all chicks have hatched adults leave the colony site and back-brood their young in open water. Both parents brood young until they are 4 to 5 weeks of age and feed them until 10 to 15 weeks (Lindvall 1976). Average brood size is 1.7 young (at fledging) per mated pair (Gould 1974; Lindvall 1976).

Renesting after nest failure or destruction is common in western grebes (Finley 1907; Dawson 1923; Palmer 1962; Nuechterlein 1975; Lindvall 1976). Major causes of egg loss are avian predation, wave action, and desertion. Avian predators include ravens (Corvus corax), American crows (C. brachyrhynchos) (Dawson 1923; Munro 1941), Forster's terns (Sterna forsteri) (Gould 1974), American coots (Fulica americana), and California gulls (Larus californicus) (Lindvall 1976). Nest losses occur from wave action and flooding (Finley 1907; Dawson 1923; Nuechterlein 1975; Lindvall 1976); abandonment of nests may occur following a drop in water levels (Lindvall 1976).

Western grebes require extensive areas of open water for breeding, brood rearing, and feeding (Lawrence 1950; Palmer 1962; Nuechterlein 1975; Lindvall 1976). Since western grebes rarely fly while on the breeding grounds, access to fish on the same body of water is essential (Nuechterlein 1975).

Most commonly selected nest sites are in emergent vegetation near open water of depths > 30 cm (Finley 1907; Bent 1919; Dawson 1923; Munro 1941; Gould 1974; Nuechterlein 1975; Lindvall 1976). Western grebes on the Delta Marsh, Manitoba, select nesting habitat types through the use of structural cues, including wave exposure, water depth, and stem density (Nuechterlein 1975). Most colonies are located in sheltered areas providing maximum protection from wave action, with water depths > 30 cm and interspersed clumps of dense emergent vegetation offering accessibility yet providing stability and wave protection for the nest platform.

POPULATION TRENDS

Skins of western grebes were in great demand during the 1890's for the millinery trade. Plume-hunters killed grebes by the tens of thousands on their breeding grounds, exterminating them in parts of the Klamath Lake region of northern California and southern Oregon. Formation of refuges, greater legal control over migratory birds, and prohibition of the plume traffic during the early 1900's halted the destruction, but the western grebe colonies of the Klamath Lake region were slow to recover (Finley 1907; Bent 1919; Dawson 1923).

Current overall population levels and status of western grebes are unknown because available studies deal primarily with large local populations. The status of western grebes breeding in California is poor and declining (Feerer 1977) and they occur on the National Audubon Society's Blue List (Tate and Tate 1982). Population levels appear relatively stable in Washington (Yocom et al. 1958), Utah (Lindvall 1976), and the Delta Marsh, Manitoba (Nuechterlein

1975). Breeding and migration records suggest that western grebes are expanding their breeding range in Colorado (Davis 1961) and Minnesota (Burger 1971).

Mortality, extended periods of reproductive inhibition, and low reproductive success of western grebes nesting on Clear Lake, California were attributed to trophic concentration of chlorinated hydrocarbon residues (Herman et al. 1969). Continued population declines at Clear Lake have been linked to repeated pesticide treatments of the lake, loss of food supply, and loss of breeding habitat with increased shoreline development (Feerer 1977). Gill nets are an important cause of mortality (Storer pers. comm. 1982). Lindvall (1976) monitored chlorinated hydrocarbon residues in western grebes at the Bear River Refuge in Utah. He reported a negative correlation between contaminant concentrations and the physical condition of the birds and eggshell thickness, but did not document any related reproductive failure.

Effects of Habitat Change

Location and size of western grebe nesting colonies may vary during a single nesting season or from year to year because of changes in water levels and available habitat (Dawson 1923; Davis 1961; Gould 1974; Nuechterlein 1975; Lindvall 1976). Moderately high water levels during spring and early summer can increase the quality, quantity, and diversity of available nesting habitat by flooding previously inaccessible areas of emergent vegetation (Nuechterlein 1975). Although periodic flooding generally improves nesting habitat, sustained high water levels can lead to deterioration of emergent vegetation (Love and Love 1954; Weller and Fredrickson 1973). Nero et al. (1958) described western grebes adopting dry land nesting sites after the emergent vegetation was flooded out by successive years of high water at Old Wives Lake in southern Saskatchewan, but this was highly unusual. Only a few young were observed and nesting success was believed to be extremely low. Poor nesting success also occurred in populations on several reservoirs in northern Colorado where establishment of emergents was prevented by fluctuating water levels. The birds nested only in years when existing marsh vegetation was flooded to depths $\geq$ 30 cm (Davis 1961). A large colony at Bear River Refuge in Utah was abandoned when dropping water levels prevented the grebes from swimming to their nests (Lindvall 1976).

Continuing declines of western grebe populations in California were caused by destruction of tule marsh habitat following alteration of water levels and commercial development of shorelines (Feerer 1977). Increased turbidity may interfere with foraging ability of grebes (Storer pers. comm. 1982). Newly created water areas may be utilized by breeding western grebes within 3 years after formation (Yocom et al. 1958).

Effects of Human Disturbance

Conspicuous courtship behavior and location of nesting colonies tend to predispose breeding western grebes to human disturbance. Repeated disturbance by boaters during colony formation can result in reproductive failure (Feerer 1977). Incubating birds usually leave the nest when disturbed by boats, aircraft, cars, or people. Incubation is not resumed until the disturbance ends, and repeated disturbance can cause nest abandonment (Nuechterlein 1975). Declining size of nesting colonies has been associated with increased disturbance by speedboats and industrial development (Stirling 1962).

In the absence of disruption by human activities, western grebe nests are rarely left unattended. The eggs are seldom covered by the departing adult, and elevated rates of avian predation on eggs are directly attributable to human disturbance (Dawson 1923; Munro 1938; Nuechterlein 1975; Lindvall 1976).

Management

Controlling water levels, maintaining nesting and hunting habitat, and minimizing human disturbance and pesticide contamination are the major considerations for management of western grebes. The following management recommendations are summarized from Nuechterlein (1975), Lindvall (1976), and Feerer (1977).

1. Water levels on the breeding grounds should be stabilized during periods of greatest nesting activity.
2. Alternating periods of high and low water levels can be used to increase availability of nesting habitat and maintain extensive areas of emergent vegetation.
3. Sufficient water levels should be maintained to ensure survival of a viable fish population.
4. Impacts on piscivorous birds should be considered before initiation of any rough fish control programs.
5. Nesting areas should be protected from destructive commercial development of shorelines.
6. Human access to and disturbance of colonies may be minimized by the remoteness of the marsh from human habitation, extensiveness of water areas, poorly developed or controlled access roads, and limitations on the use of motorized crafts and closure of nesting areas to boaters and fishermen during colony formation and incubation.
7. Use of pesticides on or around marsh habitats should be controlled and their effects on western grebes monitored.

Western grebes may home to natal marshes but not to natal colony areas (Nuechterlein 1975). Therefore, population data for a region should be grouped on the basis of bodies of water supporting viable breeding populations and not on individual colonies. Although aerial surveys may provide extensive coverage for determining colony locations, they should be followed by ground work for more accurate nest counts.

The Western Grebe as an Indicator Species

Breeding western grebes are a good indicator species for disturbance of some wetland resources by coal surface mining. Western grebe breeding range and coal reserves (Fig. 1) overlap extensively in the Western United States. Western grebes are sensitive to human disturbance, habitat alteration, changes in prey species density, and environmental contaminants. Population levels, productivity, food habits and tissue contaminant levels could be monitored to serve as indicators of the maintenance or recovery of wetland ecosystems. Grebe populations are easily censused using spotting scopes from the shoreline, because grebes flee to open water when disturbed (Nuechterlein pers. comm. 1982).

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts on western grebe populations may occur directly, through mortality, or indirectly, through increased stress and habitat loss or alteration. Direct mortality may occur during construction and mining phases if nests and young are destroyed. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to other wetlands, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). Displacement and increased competition may result in an ultimate reduction in the breeding population. Changes in water levels and drainage patterns on a regional basis could result in serious impacts to all nesting western grebes within the region. A decrease in water clarity may adversely effect the feeding efficiency of grebes (Storer pers. comm.).

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include: changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversion for a transport system; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; and increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas.

Further research is needed to assess the tolerance of western grebe prey and emergent vegetation to changes in wetland characteristics, such as increased sedimentation, changes in pH, increased contaminant loads, and altered flooding regimes.

Wetlands contribute significantly to the faunal diversity of semi-arid western coal lands. Considering the limited extent of this habitat type and the unique nature of its fauna, wetlands are classified as unsuitable for coal mining. Exceptions may be allowed when the use of appropriate mining or reclamation technology will not significantly affect the wetlands or will provide complete restoration (Stewart et al. 1979).

Other impacts may occur from increased noise levels and human activity causing nest abandonment and lowered productivity. Collisions with transmission lines may cause injury or death.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

The amount of disturbance from various mining activities that western grebes will tolerate before they abandon their nests is unknown, as is the rate or success of recolonization of wetlands on reclaimed lands. The following recommendations have not been tested and must be considered tentative and site specific. Sound mitigation procedures can be developed only after extensive study and continued monitoring of western grebe populations on and adjacent to surface coal mining sites.

Premining Phase

Western grebe populations should be surveyed on wetland areas that supply suitable nesting, feeding, and brooding habitat. Aerial surveys can be used to locate and map suitable wetland habitats and colony sites, and may be followed by ground surveys to locate individual nest sites and to provide a check for colonies missed during aerial surveys. These surveys could be conducted in conjunction with surveys for other waterfowl. After nesting colonies are located, baseline studies may document production, food habits, prey population composition and density, tissue contaminant levels, and water quality. Data collected during the premining phase will aid management and reclamation efforts.

Exploration, Mine Development, and Mining Phase

Avoidance of areas of emergent vegetation containing active nesting colonies from late April through late July will alleviate impacts to nesting birds. Establishment of a 0.8-km buffer zone around suitable nesting habitat may prevent any direct impacts. Impacts from unavoidable destruction of habitat may be lessened if preceded by improvement or creation of suitable alternate habitat. Management efforts such as protection of nesting habitat, development of suitable water impoundments stocked with prey species, and greater control of water level fluctuations might prevent the loss of displaced pairs from the breeding population.

Restricting the use of pesticides and other toxic chemicals may also alleviate impacts. Chemical storage areas and wastewater lagoons need to be properly constructed away from wetland areas to prevent contamination from spills and seepage. Monitoring programs with regular assessment of results and feedback will improve and refine the mitigation process.

Reclamation Phase

Diverse natural vegetation may be re-established on mine sites as rapidly as possible to minimize sedimentation and toxic runoff. Reclamation of surface mine lakes may serve to maintain or improve western grebe breeding habitat. Construction of lakes with convoluted shorelines, varying depths within lakes, planting of aquatic and emergent vegetation, and stocking with appropriate prey species may encourage rapid recolonization. Road closures, controlled recreational use and public awareness programs can be used to help minimize human disturbance after mine closure.

SUMMARY

Western grebes are dependent on permanent wetland habitat within their breeding range. Potential coal mining areas and current western grebe breeding range overlap extensively in the Western United States. Because the species is near the top of aquatic food chains and is sensitive to human disturbance and habitat alteration, breeding western grebe populations are good indicators for disturbance of wetlands by surface coal mining. Successful reclamation of wetlands may provide additional western grebe breeding habitat. Mitigation efforts should focus on preservation of existing wetlands, management of water level fluctuation, and rapid re-establishment of diverse marsh vegetation and fauna. Mitigation practices should include regular feedback from, and refinement of, monitoring programs.

ACKNOWLEDGMENTS

I. J. Ball assisted in all phases of report preparation. M. Rabenberg and E. Bakke assisted in gathering pertinent information. J. T. Ratti provided access to unpublished information and made many helpful comments on a draft of this report.

REFERENCES

American Ornithologist's Union Check List Committee. 1886. Check list of North American birds. 1st Edition. Am. Ornithol. Union, New York.

American Ornithologists' Union. 1983. Check-list of North American Birds. 6th ed. Allen Press. Lawrence, KS. 877 pp.

Baird, S. F. 1858. Birds. Pages 894-895 in Reports of explorations and surveys to ascertain the most practical and economical route for a railroad from the Mississippi River to the Pacific Ocean. Vol. 9. Part 2. Washington, DC.

Bent, A. C. 1919. Life histories of North American diving birds. Smithsonian Inst. Bull. 107. 239 pp.

Burger, J. 1971. The western grebe in Minnesota. Loon 43(1):4-9.

Davis, D. G. 1961. Western grebe colonies in northern Colorado. Condor 63(3):264-265.

Dawson, W. L. 1923. The birds of California. Vol. 4. So. Moulton Co., Los Angeles. Pages 1549-2121.

Dickerman, R. W. 1963. The grebe Aechmophorus occidentalis clarkii as a nesting bird of the Mexican Plateau. Condor 65(1):66-67.

Feerer, J. L. 1977. Niche partitioning by western grebe polymorphs. M.S. Thesis. Humboldt State Univ., Arcata, CA. 74 pp.

Finley, W. L. 1907. The grebes of southern Oregon. Condor 9(4):97-101.

Gould, G. I. 1974. Breeding success of piscivorous birds at Eagle Lake, California. M.S. Thesis. Humboldt State Univ., Arcata, CA. 94 pp.

Herman, S. G., R. L. Garrett, and R. L. Rudd. 1969. Pesticides and the western grebe. Pages 24-35 in M. W. Miller and G. G. Berg, eds. Chemical Fallout. C. G. Thomas Publ. Co., Springfield, IL.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Lawrence, G. E. 1950. The diving and feeding activity of the western grebe on the breeding grounds. Condor 52(1):3-16.

Lindvall, M. L. 1976. Breeding biology and pesticide-PCB contamination of western grebe at Bear River Migratory Bird Refuge. M.S. Thesis. Utah State Univ., Logan. 105 pp.

Love, A., and D. Love. 1954. Vegetation of a prairie marsh. Bull. Torrey Bot. Club 81(1):16-34.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: Impacts, mitigation and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Munro, J. A. 1938. Nesting of the western grebe in British Columbia. Rep. B.C. Prov. Mus., Victoria. (1938):16-17.

__________. 1941. Studies of waterfowl in British Columbia, the grebes. Occ. Pap. 3, B.C. Prov. Mus., Victoria. 71 pp.

Nero, R. W., F. W. Lahrman, and F. G. Bard. 1958. Dry-land nest-site of a western grebe colony. Auk 75(3):347-349.

Nuechterlein, G. L. 1975. Nesting ecology of western grebes on the Delta Marsh, Manitoba. M.S. Thesis. Colorado State Univ., Fort Collins. 105 pp.

__________. 1980. Courtship behavior of the western grebe. Ph.D. Dissertation. Univ. Minnesota, Minneapolis. 156 pp.

__________. 1981. Courtship behavior and reproductive isolation between western grebe color morphs. Auk 98(2):335-349.

__________. 1982. Personal communication. Museum of Zoology, Univ. Michigan, Ann Arbor.

Palmer, R. S. 1962. Handbook of North American Birds. Vol. 1. Yale Univ. Press, New Haven, CT. 567 pp.

Phillips, R. E., and G. D. Carter. 1957. Winter food of western grebes. Murrelet 38(1):5-6.

Ratti, J. T. 1979. Reproductive separation and isolating mechanisms between sympatric dark- and light-phase western grebes. Auk 96(3):573-586.

__________. 1981. Identification and distribution of Clark's grebe. Western Birds 12(1):41-46.

Seabloom, R. W., R. D. Crawford, and M. G. McKenna. 1978. Vertebrates of southwestern North Dakota: amphibians, reptiles, birds, mammals. REAP Rep. 78-4. Inst. Ecol. Studies, Univ. North Dakota, Grand Forks. 549 pp.

Stewart, R. E., Jr., C. T. Gulliver, and C. L. Towle, Jr. 1979. Land unsuitability criteria in the Department of Interior's coal leasing program. Pages 67-82 in D. E. Samuel, J. R. Stauffer, C. L. Hocutt, and W. T. Mason, eds. Surface mining and fish/wildlife needs in the Eastern United States. Addendum to proceedings of symposium. U.S. Fish Wildl. Serv. FWS/OBS-78/81A.

Stirling, D. 1962. Another western grebe colony in British Columbia. Murrelet 43(3):51.

Storer, R. W. 1965. The color phases of the western grebe. Living Bird 4:59-63.

__________. 1967. The patterns of downy grebes. Condor 69(5):469-478.

__________. 1982. Personal communication. Museum of Zoology, Univ. Michigan, Ann Arbor.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Weller, M. W., and L. H. Fredrickson. 1973. Avian ecology of a managed glacial marsh. Living Bird 12:269-291.

Wetmore, A. 1924. Food and economic relations of North American grebes. U.S. Dept. Agric. Bull. 1196.

Yocom, C. F., S. W. Harris, and H. A. Hansen. 1958. Status of grebes in eastern Washington. Auk 75(1):36-47.

AMERICAN WHITE PELICAN (*Pelecanus erythrorhynchos*)

by

David L. Evans
Eileen K. Bartels
Northern Prairie Wildlife Research Center
U.S. Fish and Wildlife Service
Jamestown, ND 58401

Judith Scherpelz Armbruster
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Ft. Collins, CO 80526-2899

SPECIES DESCRIPTION

The American white pelican (*Pelecanus erythrorhynchos*) is one of two North American representatives of the pelican family (Pelicanidae). It is a large white bird with black primaries and an orange, pouched bill. The feet are webbed between all four toes, a trait common to the pelican family. It has a 2.7-m wingspan and weighs about 6.8 kg (Kolstoe 1966).

DISTRIBUTION

White pelican colonies in the United States are located in the Western and North-central States and Texas (Figs. 2 and 3). The largest colony, with 8,000 to 10,000 breeding adults, is located at Chase Lake National Wildlife Refuge (NWR), North Dakota (Lies and Behle 1966; Sloan 1973). Other large colonies are located on Great Salt Lake in Utah, Medicine Lake NWR and Bowdoin NWR in Montana, Pyramid Lake in Nevada, Clear Lake NWR in California, and LaCreek NWR in South Dakota. White pelicans winter from north-central California, central Arizona, the Gulf States, and Florida south through Mexico to Guatemala (American Ornithologists' Union 1983).

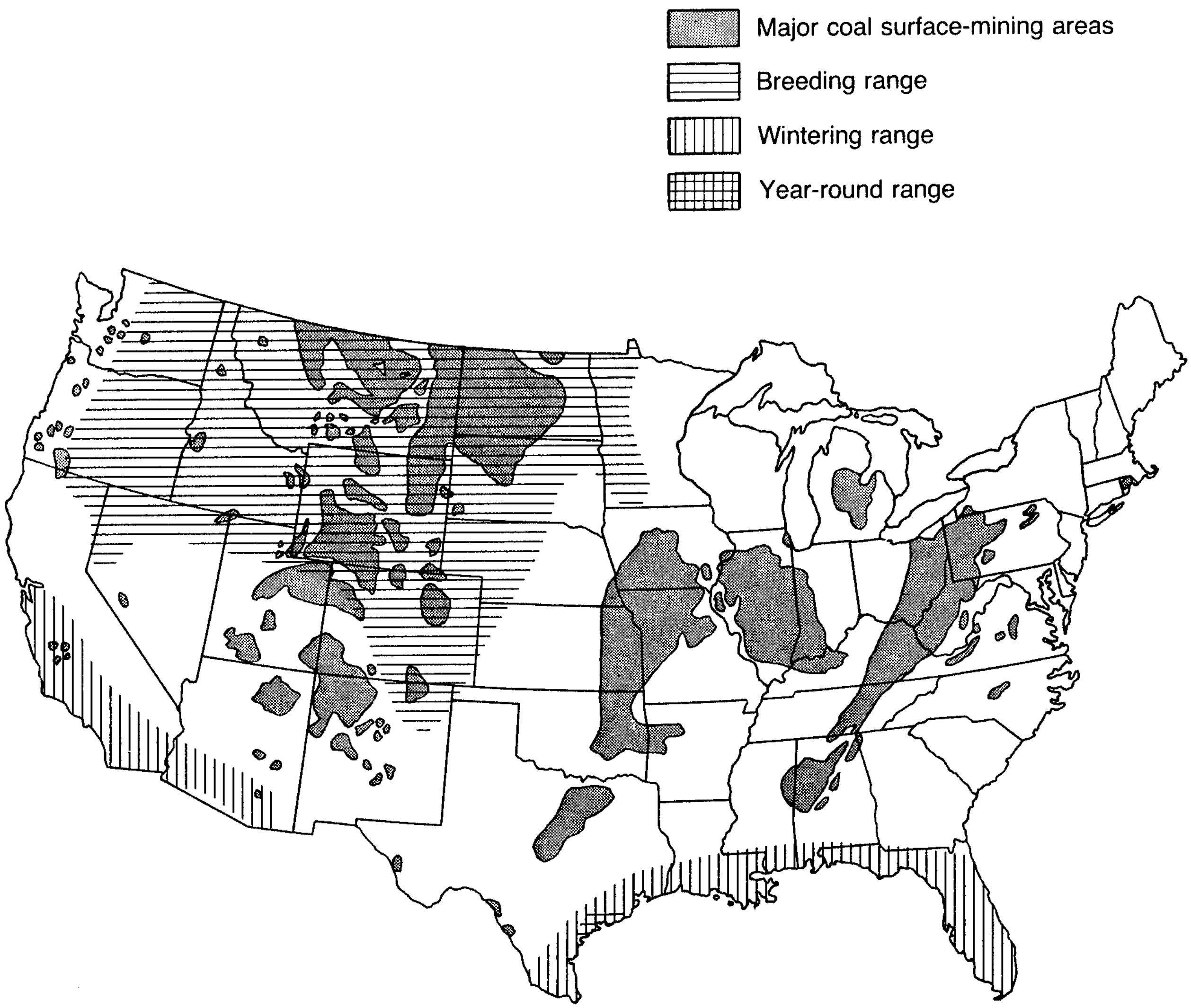


Figure 2. Geographical range of the white pelican in relation to major coal deposits in the United States. After Inkley and Raley (1983) and National Geographic Society (1983).

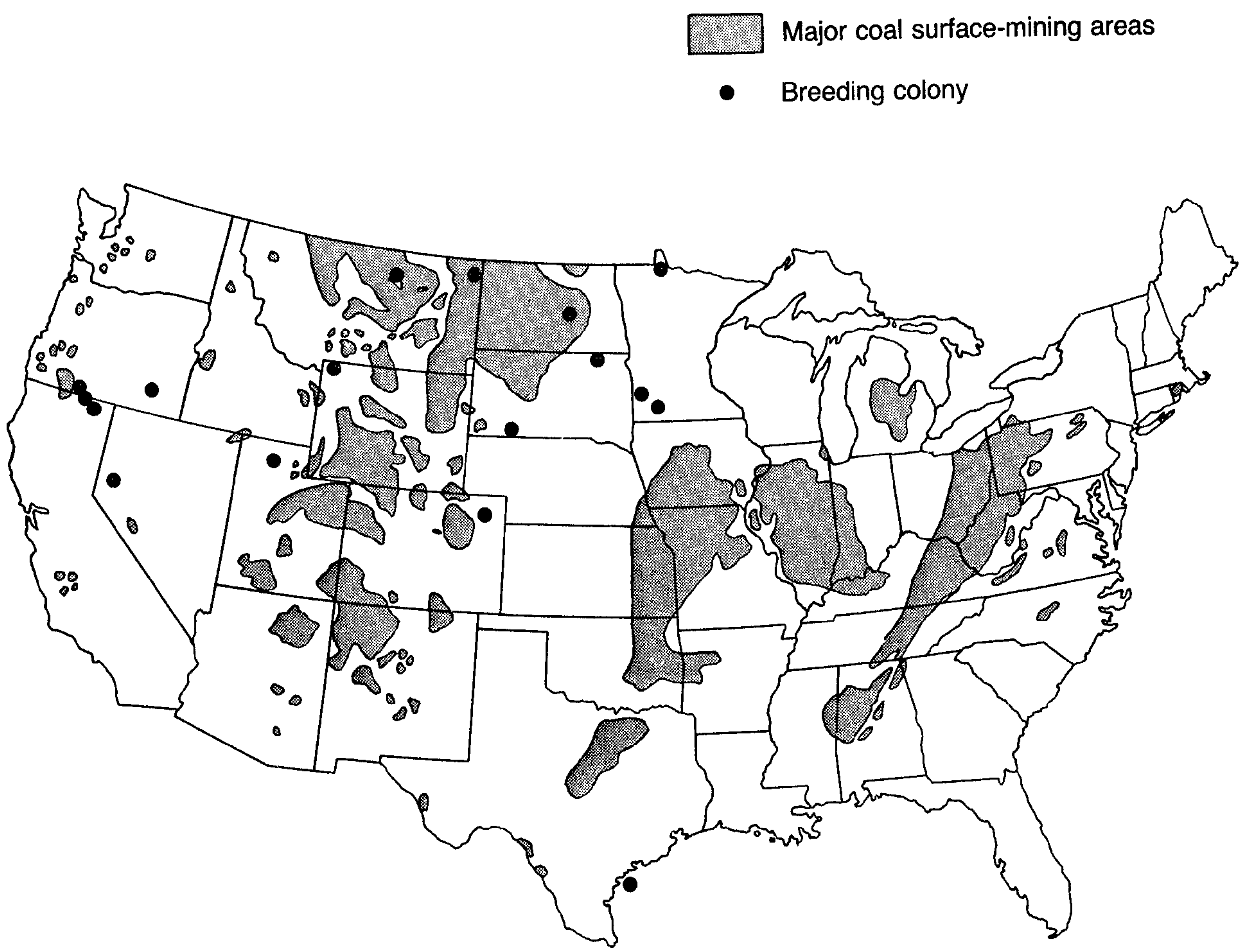


Figure 3. Western breeding colonies of the white pelican in relation to major coal deposits in the United States. After Sloan (1973a) and Janssen (1974).

DIET

White pelicans feed primarily on fish (Bent 1922; Alcorn 1943; Schaller 1964; Vermeer 1970). At Pyramid Lake, Nevada, the most important food species are carp and lake minnow (Hall 1925; Bond 1940). However, the most important food source at Chase Lake, North Dakota, is the tiger salamander, which forms about 60% of the diet. Black bullhead comprise 13% of the diet; carp, yellow perch, crayfish, and northern pike range from 4 to 10% of the diet at Chase Lake (Lingle and Sloan 1980).

White pelicans often forage great distances from the colony. At Lavallee Lake, Saskatchewan, nonbreeding juveniles forage on the lake, while adults may fly 48 km or more from the lake (Trottier et al. 1980). Breeding pelicans travel up to 48 km from the colony on Great Salt Lake, Utah (Behle 1958). At Pyramid Lake, adults were reported ranging as far as 272 km from the nesting site (Hall 1925). Fish tags recovered from the Chase Lake, North Dakota colony came from fish marked up to 304 km from the colony site, although most (90%) were within 128 km (Johnson 1976).

REPRODUCTION

Pelicans return to their breeding colony from late February in Nevada (Alcorn 1943) to mid-April in Saskatchewan (Trottier et al. 1980). At Yellowstone Lake, Wyoming (elevation 2,356 m), they do not appear until early May when most of the local lakes are often still frozen (Schaller 1964).

A breeding colony is typically comprised of a number of subcolonies located on a nesting island (Schaller 1964; Strait 1973; Johnson 1976; Diem 1979; Knopf 1979; Trottier et al. 1980). Subcolonies are spatially and temporally finite, being composed of breeding pairs in a similar physiological state (Knopf 1979). Also, subcolonies may represent geographical aggregations where colonies have birds from both eastern and western populations. Reproductive events within these colonies are highly synchronous, with hatching occurring over an interval of 2 to 9 days. Among colonies on a nesting island, initiation of breeding spans a period of 12 to 13 weeks (Knopf 1979).

A nest is usually a circular scrape lined with plant portions, stones, driftwood, and debris (Diem and Condon 1967). At Chase Lake, North Dakota, nests are on trampled and barren areas with little vegetation; gravelly areas are avoided (Sidle and Ferguson 1982). Colonies generally use the same location every year.

White pelicans lay two eggs per clutch (Bent 1922). However, nests occasionally have three to five eggs; these large clutches are invariably a result of egg retrieval from adjacent abandoned nests and almost always fail to hatch due to inadequate incubation (Knopf 1979). White pelicans do not develop a brood patch, but instead incubate by covering each egg with a foot (Knopf 1979). Incubation requires 29 to 30 days; each member of the pair usually incubates for 2 days before being relieved by its mate (Schaller

1964). The eggs hatch asynchronously; the smaller young often dies of starvation and harassment by the larger young (Schaller 1964; Johnson 1976; Knopf 1979). Young are fed at least four times daily and are brooded almost continuously until they are 2 weeks of age. By the age of 1 month, young can stand and walk well and begin to associate with other young away from the nest. At this stage, the young are fed once a day, with each parent feeding it on alternate days. The young join increasingly larger aggregations, or "pods," and are singled out by their own parents for feeding (Schaller 1964). Although the young fledge at about 10 weeks, they are still fed by the adults when away from the nesting island (Hall 1925).

POPULATION TRENDS

The population status of white pelicans in the United States is not clear. Comprehensive surveys have been limited. Comparisons among these surveys are tenuous due to differences in methods used and considerable annual variation in productivity. An estimated 20,000 to 25,000 pelicans were breeding in the United States in the early 1930's (Thompson 1933). Lies and Behle (1966) estimated an average breeding population of 34,722 birds in 1962-1963. Sloan (1973) estimated a breeding population of 33,690 birds in 1971-1972, an apparent decline of some 3%. Although Nehls (in Tate 1981) thought that the white pelican was declining throughout its range, Sloan (1973) reported increasing populations in six States and decreasing populations in only three States. No comprehensive survey has been conducted since Sloan's (1973), so confirmation of any trend is lacking. The white pelican was formerly on the National Audubon Society's Blue List (Tate 1981), indicating noncyclic population declines, and in 1982 was added to the List of Species of Special Concern (Tate and Tate 1982).

Diem and Condon (1967) and Davenport (1974) suggest that the considerable longevity of the white pelican permits the various populations to survive a variety of environmental impacts, providing the impacts do not continue over a period exceeding 2 consecutive years; and further, that opportunities must exist between the impacted periods for the production and survival of at least a fair number of young. The short and long term consequence of various environmental insults should be evaluated in any rehabilitation or mitigation planning process.

Effects of Habitat Change

The white pelican is vulnerable to disturbance of its nesting habitat. Since nesting occurs on islands, high water levels could flood nest sites and force abandonment of colonies (Knopf 1974). Low water levels could reduce isolation of nesting islands and allow humans and predators access to eggs and young. Contamination of water resources may reduce fish populations or cause concentration of contaminants in pelicans and affect reproductive success.

Habitat changes in wetlands within 100 km of a nesting colony, including drainage, flooding, or habitat destruction, may impact nesting pelicans dependent on those areas for foraging (Knopf and Kennedy 1980).

Slow, long-term declines in the continental population have resulted chiefly from human disturbance during the breeding season and destruction of nesting sites by fluctuating water levels (Thompson 1933; Lies and Behle 1966; Vermeer 1970; Sloan 1973; Tate 1981). Synergistic pesticide interactions and chronic pesticide loading may produce more frequent and radical population oscillations (Diem 1979).

Effects of Human Disturbance

White pelicans are very susceptible to human disturbance, especially during the breeding season. The presence of human visitors in a colony may cause incubating pelicans to flush, breaking eggs or leaving them vulnerable to gull predation. Juveniles may become excited and regurgitate food, suffer heat stress, stampede and trample smaller chicks, or leave the nesting island and risk being lost by parents (Johnson and Sloan 1976). Harassment of birds in nesting colonies would probably cause the colony to be abandoned (Adolphson and Adolphson 1968). Motorboat traffic in Yellowstone Lake was a serious disturbance to nesting pelicans (Diem and Condon 1967). Shooting is also a major mortality factor for this large, conspicuous species, especially for those birds using major waterfowl migration routes (Diem and Condon 1967).

Management

Management techniques for white pelicans should focus on protection of nesting colonies and maintenance of water resources. Surveys should be conducted using aerial censusing techniques (Sidle and Ferguson 1982). Nesting colonies should be protected from human disturbance, with no more than four 15-minute visits per year. Wetlands within 100 km of nesting colonies should be protected to provide foraging sites for nesting pelicans.

The American White Pelican as an Indicator Species

The white pelican may serve as an indicator species for breeding areas, because of the species' dependence on bare substrates on islands and its fidelity to nesting colonies. The abandonment of a nesting colony in the vicinity of development activity may indicate degradation of habitat, including destruction of colony sites, human disturbance, deterioration of water resources, or degradation of feeding wetlands.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts of coal mining on white pelicans may occur through mortality, habitat loss, or increased stress. Direct mortality may occur if nests and nestlings are destroyed during construction and mining activities. The most serious impacts would be from habitat loss and human disturbance. Displaced individuals would be forced to move to other habitat, if available, resulting in increased stress and competition (assuming suitable habitat is already occupied), and ultimately a decrease in the overall breeding population.

The increased human presence may result in harassment of breeding birds, abandonment of nests, and thus a lowered productivity. Illegal shooting may also increase, along with disturbance from boats and recreation activities. Collisions with transmission lines may cause injury or death.

Impacts on wetlands within 100 km of breeding colonies may potentially cause increased stress on breeding birds from a deterioration of food resources and thus affect productivity levels.

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversion for water transport systems; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; and increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas.

Western surface coal mining is not likely to have a substantial impact on white pelicans in the United States unless water resources are altered. The only active colony near strippable coal deposits is at Medicine Lake NWR, Montana (Fig. 3). Although the nesting island is protected, some nearby feeding areas may be destroyed in the future. It is not known to what degree this activity may affect the colony. Whether food availability is presently limiting colony size or productivity has apparently not been investigated at this, or any other, white pelican colony. There is no mining activity in the area at this time (Bellinger pers. comm.).

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys should be conducted on suitable wetlands within 100 km of the proposed development to locate breeding colonies and foraging areas. Colonies may be surveyed for numbers of breeding pairs, productivity levels, and habitat use. Data collected from foraging areas may include numbers of pelicans, timing and extent of use, and numbers and types of forage species.

Exploration, Mine Development, and Mining Phase

Exploration activities will have minimal impacts on pelicans if wetlands are avoided by exploration crews. Proper disposal of wastes and byproducts and control of dust and erosion may help to alleviate degradation of water resources. Placement of transmission lines to avoid wetlands and major flight pathways may decrease injuries and deaths from collisions. Buffer zones around colonies, including restriction of boating, to prevent disturbance of breeding birds would help to alleviate impacts during the breeding season.

Reclamation Phase

Reclamation activities may include establishment of wetlands and augmentation of fish populations. Potential colony sites may be created by development of islands with bare ground suitable for nest sites. Islands in reservoirs may be protected with rip rap to prevent wave action from destroying the perimeter. Restriction of activity around the island, and use of transplanted juvenile pelicans, may possibly allow formation of a new nesting colony (Olson 1977).

SUMMARY

The American white pelican is a large piscivorous bird nesting in colonies in wetlands in the Western U.S. Nests are on bare ground on islands; most pairs produce one or two young. Pelicans are very sensitive to human disturbance, and nesting islands may be destroyed or degraded by wide fluctuations in water levels. Coal mining may impact pelicans through increased human disturbance or degradation of water resources. Mitigation measures include buffer zones around existing colonies, protection of water resources, and creation of new wetlands and nesting habitat.

REFERENCES

Adolphson, D. G., and M. Adolphson. 1968. Size, distribution, and population of three colony nesting species in South Dakota. South Dakota Bird Notes 20:4-10.

Alcorn, J. R. 1943. Observations on the white pelican in western Nevada. Condor 45:34-36.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Behle, W. H. 1958. The bird life of Great Salt Lake. Univ. Utah Press, Salt Lake City. 230 pp.

Bellinger, J. R. Personal communication. Refuge Manager, Medicine Lake National Wildlife Refuge, Montana.

Bent, A. C. 1922. Life histories of North American petrels, pelicans and their allies. U.S. Natl. Mus. Bull. 121. 343 pp.

Bond, R. M. 1940. Birds of Anaho Island, Pyramid Lake, Nevada. Condor 42:246-250.

Davenport, M. B. 1974. Piscivorous avifauna on Yellowstone Lake, Yellowstone National Park. Completion Report to Yellowstone Natl. Park. Mimeo. 62 pp.

Diem, K. L. 1979. White pelican reproductive failures in the Molly Islands breeding colony in Yellowstone National Park. Pages 489-496 in R. M. Linn, ed. Proceedings of the 1st Congress on Scientific Research in the National Parks. U.S. Natl. Park Serv. Trans. and Proc. Ser. 5. Vol. I. 681 pp.

Diem, K. L., and D. D. Condon. 1967. Banding studies of water birds on the Molly Islands, Yellowstone Lake, Wyoming. Yellowstone Library and Mus. Assoc., Yellowstone Park, WY. 41 pp.

Hall, E. R. 1925. Pelicans versus fishes in Pyramid Lake. Condor 27:147-160.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Janssen, R. B. 1974. New nesting location for the white pelican in Minnesota. Loon 46:36-37.

Johnson, R. F. 1976. Mortality factors affecting a white pelican population, Chase Lake National Wildlife Refuge, North Dakota. M.S. Thesis, Michigan Tech. Univ., Houghton. 74 pp.

Johnson, R. F., and N. F. Sloan. 1976. The effects of human disturbance on the white pelican colony at Chase Lake National Wildlife Refuge, North Dakota. Inland Bird Banding News 48:163-170.

Knopf, F. L. 1974. Fluctuating levels of Great Salt Lake: effects on island wildlife. Proc. Utah Academy Sciences, Arts, Letters. 51(2):34-41.

______________. 1979. Spatial and temporal aspects of colonial nesting of white pelicans, Pelecanus erythrorhynchos. Condor 81:353-363.

Knopf, F. L., and J. L. Kennedy. 1980. Foraging sites of white pelicans nesting at Pyramid Lake, Nevada. Western Birds 11:175-180.

Kolstoe, S. O. 1966. The white pelican. North Dakota Outdoors 29(3):17-20.

Lies, M. F., and W. H. Behle. 1966. Status of the white pelican in the United States and Canada through 1964. Condor 68:279-292.

Lingle, G. R., and N. F. Sloan. 1980. Food habits of white pelicans during 1976 and 1977 and Chase Lake National Wildlife Refuge, North Dakota. Wilson Bull. 92:123-125.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

National Geographic Society. 1983. Field Guide to the Birds of North America. National Geographic Society, Washington, DC. 464 pp.

Olson, E. A. 1977. The white pelican of Colorado. Our Public Lands 27:10-13.

Schaller, G. B. 1964. Breeding behavior of the white pelican at Yellowstone Lake, Wyoming. Condor 66:3-23.

Sidle, J. G., and E. L. Ferguson. 1982. White pelican populations at Chase Lake, North Dakota, evaluated by aerial photography. Prairie Nat. 14(1):13-26.

Sloan, N. F. 1973. Status of breeding colonies of white pelicans in the United States through 1972. Inland Bird Banding News 45:83-96.

Strait, L. E. 1973. Population dynamics of a white pelican population, Chase Lake National Wildlife Refuge, North Dakota. M.S. Thesis, Michigan Tech. Univ., Houghton. 76 pp.

Tate, J., Jr. 1981. The blue list for 1981. Am. Birds 35(1):3-10.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds. 36(2):126-135.

Thompson, B. H. 1933. History and present status of the breeding colonies of the white pelican (Pelecanus erythrorhynchos) in the United States. U.S. Natl. Park Serv. Occas. Pap. 1. 84 pp.

Trottier, G. C., R. J. Breneman, and N. A. Young. 1980. Status and foraging distribution of white pelicans, Prince Albert National Park, Saskatchewan. Can. Field-Nat. 94:383-390.

Vermeer, K. 1970. Distribution and size of colonies of white pelicans, Pelecanus erythrorhynchos, in Canada. Can. J. Zool. 48:1029-1032.

DOUBLE-CRESTED CORMORANT (*Phalacrocorax auritus*)

by

Katherine Marois
and
R. Michael Erwin
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The double-crested cormorant (*Phalacrocorax auritus*) is a polytypic member of the pelican order, and is widely distributed along all the major coasts of North America and in many parts of the interior of the United States and Canada. The most widely distributed subspecies, *P. a. auritus*, occurs from central Canada to Texas and from the North Atlantic coast to Utah (Mitchell 1977). The subspecies *P. a. albociliatus* and *cincinatus* are confined to the lower west coast and northern west coast to southern Alaska, respectively (Bent 1922). A fourth subspecies, the "Florida cormorant", *P. a. floridanus*, occurs in the Southeastern United States, centered in Florida.

For the purposes of this report, the interior population (*P. a. auritus*) in potential coal-mining areas will be emphasized. In many cases, however, general ecological information is available only from populations in other regions.

The double-crested cormorant is a large, dark, gooselike bird with a long s-shaped neck, distinctive orange throat pouch, and slender hook-tipped bill. The "double-crest" refers to the recurved, earlike pair of feather tufts on the head of mature birds. The plumage of mature birds is almost totally black with some parts having a greenish or coppery sheen. Immature birds can be most readily distinguished from adults by their whitish breast and brown belly.

Although no sexual differences occur in the plumage of double-crested cormorants, adult females are slightly smaller than adult males (Lewis 1929; Palmer 1962). Wing lengths reported for 11 males averaged 311 mm, compared to 303 mm for eight females (Palmer 1962). Average weights of Maine birds were 2,233 g for 10 adult males and 1,861 g for 12 adult females (Kury 1968).

Average size of both sexes, however, increases from south to north along both coasts and from east to west in the range of the species (Palmer 1962).

DISTRIBUTION

The habitat of the double-crested cormorant is generally along coasts, or on inland lakes, rivers, and swamps (Palmer 1962). Its coastal breeding range extends along the Pacific from Baja, California to Alaska; along the Atlantic from Florida to Virginia, then farther north from New York to Newfoundland; and along the Gulf coast from Florida to Texas. Inland breeding is scattered throughout the Central and Great Plains but is more concentrated in the Northern Plains States of North Dakota, South Dakota, Montana, Minnesota, and Wisconsin; and in the southern parts of Alberta, Saskatchewan, Manitoba, and Ontario. Further west, breeding colonies occur in Wyoming, Idaho, Utah, Colorado, New Mexico, Arizona, and Nevada (American Birds 1975-1980).

The winter range of the double-crested cormorant is along the Atlantic coast from New York to Florida; along the Pacific coast from Alaska to Baja, California; along the Gulf coast from Florida to Texas; down the Mississippi River Valley from Tennessee to Louisiana; and along the Colorado River Valley from Texas to New Mexico (Robbins et al. 1966). During migration and post-breeding dispersal, flocks of double-crested cormorants may occur farther inland in the United States and farther north in Canada. Figure 4 illustrates the present breeding and wintering range of the double-crested cormorant in North America and Figure 5 details the location of some recent breeding colonies in the Western United States.

DIET

The feeding habitat of the double-crested cormorant is entirely aquatic and includes a variety of fresh and saltwater areas such as open seas, bays, estuaries, lakes, ponds, rivers, and swamps or sloughs (Palmer 1962). The species usually feeds by diving from the surface of the water and swimming underwater in pursuit of prey. Feeding occurs singularly or in flocks, with foraging ranges extending up to 32 km from a roost or colony (Mendall 1936; Lundquist 1949).

The diet of double-crested cormorants from many coastal and inland locations in the United States and Canada consists almost entirely of fish with occasional occurrences of eels, crustaceans, or amphibians (Lewis 1929; Mendall 1936; Palmer 1962). Saltwater fishes commonly eaten by double-crested cormorants include gunnel (Pholidae), sculpins (Cottidae), sand lance (*Ammoclytes* spp.), capelin (*Mallotus villosus*), cunner (*Tautogolabrus adspersus*), flounder (Bothidae, Pleuronectidae), herring, shad (Clupeidae), tomcode (*Microgadus* spp.), and sea catfish (Ariidae). Commonly eaten fresh-water fish include perch, sunfish, crappie, largemouth bass (Perciformes); catfish (Ictaluridae), northern pike (*Esox lucius*), suckers (Catostomidae), and minnows (Cyprinidae) (Mendall 1936; Palmer 1962). The fish-eating habits [especially salmon (Salmonidae) consumption] of cormorants have led to their

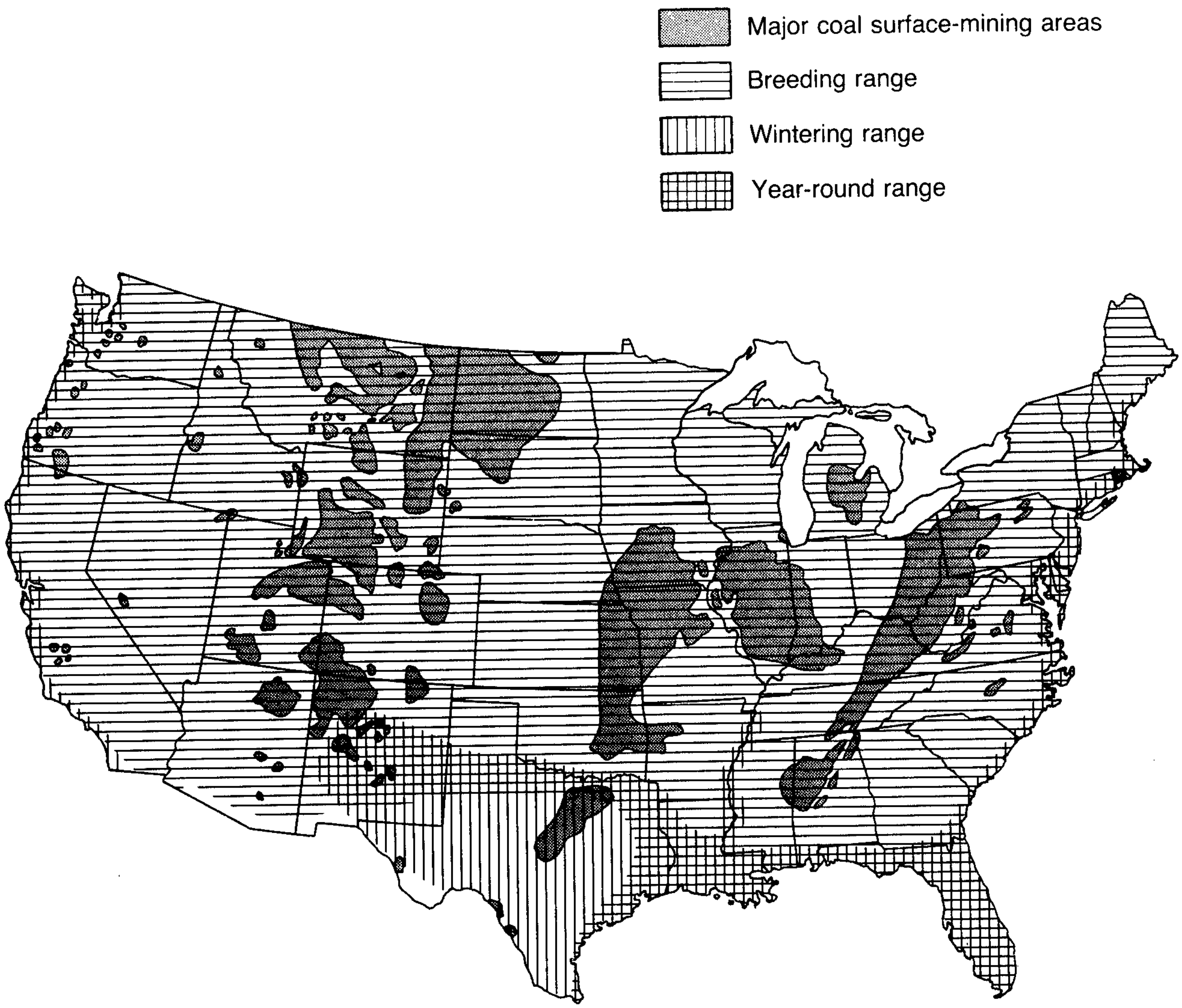


Figure 4. Geographical range of the double-crested cormorant in relation to major coal deposits in the United States. After Inkley and Raley (1983).

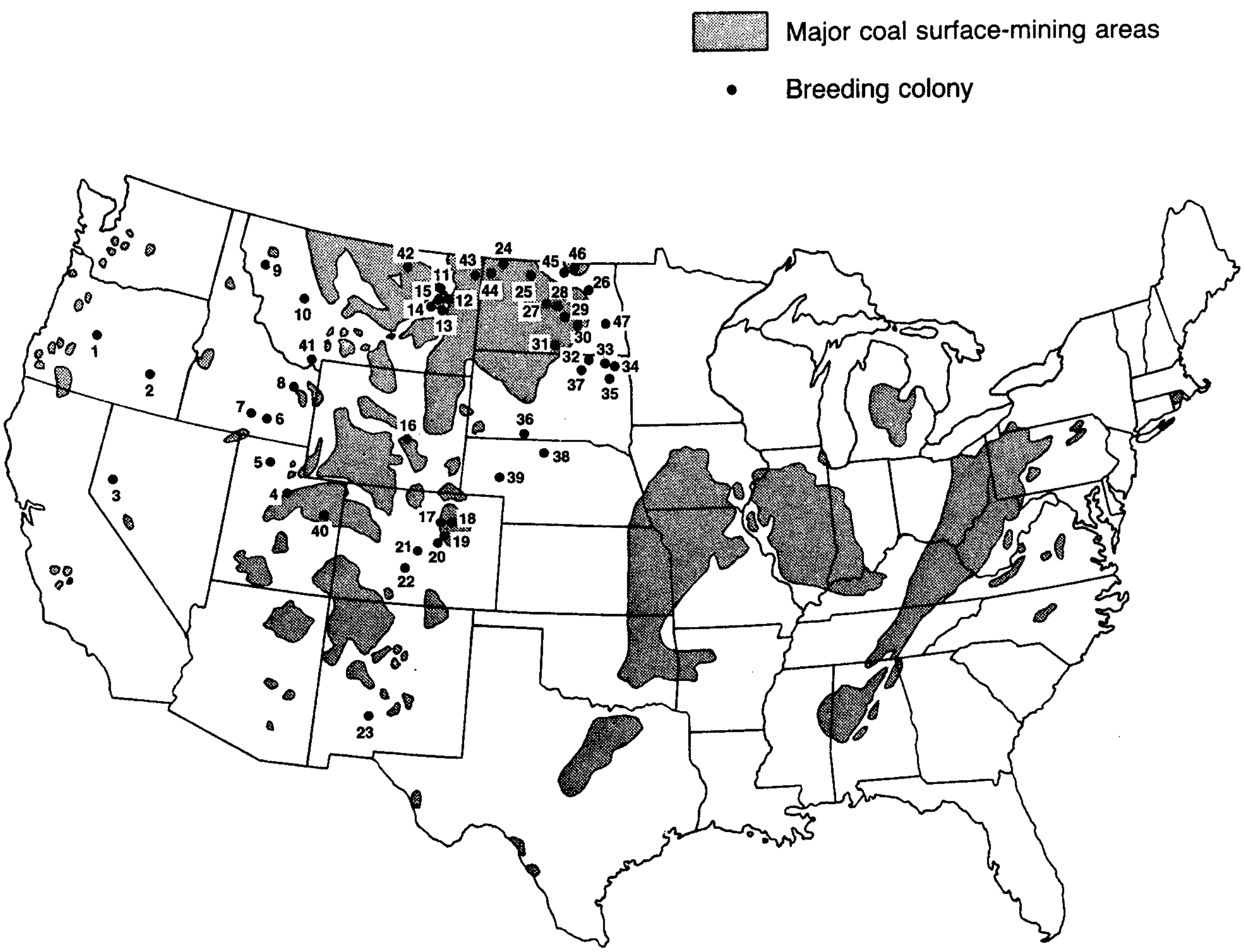


Figure 5. Western breeding colonies of the double-crested cormorant in relation to major coal deposits in the United States. Numbers refer to colonies listed in Table 1.

persecution by fishermen and have caused population declines in many areas in the past (Buchheister 1944).

In the 1940's, pressure from Maine fishermen complaining that double-crested cormorants were eating large numbers of commercial fish resulted in State and Federal control programs to reduce cormorant populations (Gross 1950). These control programs continued for several years despite studies which showed that fish predation by double-crested cormorants had no significant effect on commercially valuable species (Mendall 1936; Scattergood 1950; Robertson 1974).

REPRODUCTION

Flocks of double-crested cormorants generally arrive at their breeding grounds between March and May, although considerable variation exists among different areas (Palmer 1962; Mitchell 1977; Erwin 1979; Scharf 1979). Establishment of territories by males and subsequent courtship and nest building occur shortly after arrival (Palmer 1962). Double-crested cormorants usually do not breed until they are three years old but immature males may establish territories and engage in courtship and nest building (Palmer 1962). In mature birds, however, both sexes share in nest building, usually using sticks and aquatic weeds (Mendall 1936).

Although the date of first egg laying also varies with breeding location, most of the laying within a colony is completed within 2 weeks after the first eggs are deposited (Palmer 1962). Average clutch size for the double-crested cormorant is three to four eggs, which are incubated by both parents for 24 to 30 days (Palmer 1962; Mitchell 1977). If eggs or nests are destroyed, pairs will usually renest; however, only one case of double-brooding has been reported for this species (Drent et al. 1964). The altricial young are fed by both parents until they are approximately 9 weeks old, although they can fly at about 5 to 6 weeks of age. At 10 weeks, the young are fully independent and may leave the colony to roost alone or with other young (Palmer 1962).

Breeding habitat is usually an undisturbed site fairly close to suitable feeding habitat. Coastal nesting sites occur on rocky islands, reefs, abandoned wharfs, and occasionally on power poles (Palmer 1962; Sowls et al. 1978, 1980). Inland nesting sites include islands in lakes, along lake and river margins, in swamps, and near reservoirs (Palmer 1962; Markham and Brechtel 1979). Nests are built directly on the ground or in dead or live trees; they are built in monospecific colonies or with gulls and other species of colonial waterbirds (Mendall 1936). A breeding territory within a colony usually consists of a nest plus an adjoining perching spot for the off-duty parent (Palmer 1962).

A cormorant colony commonly uses the same nesting site every year unless a severe disturbance occurs (Lewis 1929), but this philopatry is not universal (Mendall 1936). Shifting of cormorant colony locations from year to year is well documented in the western Gulf of Alaska (Sowls et al. 1978).

POPULATION TRENDS

Recent estimates of the total double-crested cormorant population over its entire North American range do not exist; however, specific estimates are available for certain regions of the United States and Canada. On the Atlantic coast from southern Maine to New York, the population in 1977 was estimated to consist of 2,676 breeding pairs in 18 colonies (Erwin 1979). On the Pacific coast, the 1979-1980 California population was estimated at 1,884 breeding birds in 17 colonies (Sowls et al. 1980) and the 1978 Alaskan population was estimated at 7,000 breeding birds in 82 colonies (Sowls et al. 1978). Estimates from the interior of the continent include one from the Great Lakes region which shows a 1976 population of 124 breeding pairs in four colonies (Scharf 1979), and one from Alberta in 1978 which shows 1,900 breeding pairs in 17 colonies (Markham and Brechtel 1979). All of the above population estimates are based on extensive aerial and ground surveys of the specified area such that the coverage can be considered nearly complete. Although estimates are available for individual colonies in many areas (Table 1), no other complete surveys exist for entire regions.

Estimates of population trends for the double-crested cormorant in the United States are available from the Breeding Bird Survey (BBS) conducted from 1968 to 1979 (see Bystrak 1981 for explanation of BBS) . In the area west of the Rocky Mountains, the double-crested cormorant population has been increasing by approximately 8% per year since 1968, based on 33 BBS routes. The region including California, Oregon, Washington, Idaho, and Nevada, which consists of coastal and inland routes, had a particularly significant increase. The only other region in the country to show a significant trend was the Great Lakes region, which has had a population increase of 7.3% per year since 1968 (Robbins pers. comm.).

A general increase occurred in the New England double-crested cormorant population following a severe decline due to human control efforts in the 1800's and early 1900's (Drury 1973). An increase in Alberta's double-crested cormorant population has occurred since 1970 (Weseloh et al. 1978). Populations in North and South Dakota also appear to be increasing in recent years (Stewart 1975; Blankespoor et al. 1979).

The double-crested cormorant has been listed on the National Audubon Society's Blue List since the list's inception in 1972. This unofficial "warning list" includes those species which currently exhibit potentially dangerous population declines in all or part of their ranges. In recent years, however, notes accompanying the Blue List have stated that the double-crested cormorant is clearly on the increase in many areas and should be deleted from the list. The only support for keeping the species on the Blue List came from inland and mid-continental areas. The only data on recent population declines came from the inland areas of Utah (Mitchell 1975), Tennessee (Pullin pers. comm.), and North Carolina (Grant 1970). Population declines may be occurring elsewhere; however, due to the scarcity of accurate historical data, it is difficult to determine long-term trends for this species in most states or regions. In 1982 the National Audubon Society moved the double-crested cormorant to its List of Species of Special Concern, indicating the western Great Lakes population should be monitored closely (Tate and Tate 1982).

Table 1. Some recent[a] colony locations and population levels of the double-crested cormorant in the interior United States.

Location	Map number[b]	Breeding population	Year	Source[c]
Oregon				
Crane Prairie Reservoir	1	20 Adults	1978	AB(32)
Malheur NWR	2	60 Nests	1975	AB(29)
		70 Pairs	1977	AB(31)
		20 Pairs	1978	AB(32)
		180 Pairs	1980	AB(34)
Nevada				
Anaho Island NWR	3	1,500 Young	1976	AB(30)
		1,250 Young	1977	AB(31)
Utah				
Springville	4	300 Adults	1976	CBR
Bear River NWR	5	110 Young	1975	AB(29)
		300 Young	1977	AB(31)
		440 Young	1978	AB(32)
		136 Nests	1979	AB(33)
		150 Young	1980	AB(34)
		183 Nests	1981	Croft
Ouray NWR	40	18 Nests	1981	Croft
Idaho				
Lake Walcott	6	70 Pairs	1979	AB(31)
		still exists	1980	AB(34)
Minidaka NWR	7	200 Adults	1978	AB(32)
		still exists	1979	AB(33)
Mud Lake	8	25 Pairs	1977	AB(31)
		20 Pairs	1978	AB(32)
		still present	1979	AB(33)
		still present	1980	AB(34)
Montana				
Ninepipe NWR	9	40 Nests	1977	AB(31)
		50 Nests	1981	Croft
Lake Helena	10	8 Nests	1976	AB(30)
		37 Adults	1976	CBR
Mid Eight Ridge	11	530 Adults	1976	CBR
Soap Creek	12	88 Adults	1976	CBR
Timber Creek Bay	13	272 Adults	1976	CBR
Snow Creek Bay	14	210 Adults	1976	CBR

Table 1. (continued)

Location	Map number[b]	Breeding population	Year	Source[c]
Montana (continued)				
Nelson Creek Bay	15	13 Adults	1976	CBR
Red Rocks Lake NWR	41	15 Nests	1981	Croft
Bowdoin NWR	42	197 Nests	1981	Croft
Medicine Lake NWR	43	450 Nest	1981	Croft
Wyoming				
Yants Puddle	16	Unknown	1978	AB(30)
Pyramid Lake	16	Unknown	1978	AB(31)
Colorado				
Latham Reservoir	17	5 Nests	1976	CBR
Riverside Reservoir	18	54 Young	1977	AB(31)
		110-150 Young	1978	AB(32)
Barr Lake	19	"population normal"	1975	AB(29)
Chatfield State Park	20	5 Nests	1979	AB(33)
		26 Nests	1980	AB(34)
Antero Reservoir	21	3 Young	1979	AB(33)
Trites Lake	22	9 Nests	1978	CBR
New Mexico				
Elephant Butte Lake	23	"hundreds of young"	1975	AB(29)
North Dakota				
Divide County	24	10 Nests	1977	AB(31)
Upper Souris NWR	25	Unknown	1979	AB(33)
Devil's Lake WMD	26	250 Nests	1976	CBR
		500 Nests	1981	Croft
Turtle Lake	27	265 Adults	1977	CBR
Audubon NWR		308 Nests	1981	Croft
Peterson Lake	28	259 Adults	1978	CBR
Pelican Lake	29	101 Adults	1977	CBR
Chase Lake NWR	30	746 Nests	1976	CBR
		469 Adults	1977	CBR
		746 Nests	1980	Croft
		"about the same as 1980"	1981	Croft
Redhorse	31	250 Adults	1978	CBR
Lake Zahl NWR	44	46 Nests	1981	Croft
J. Clark Salyer NWR	45	80-100 Indiv.	1981	Croft
Willow Lake NWR	46	423 Nests	1981	Croft
Valley City WMD	47	91 Nests	1981	Croft

Table 1. (concluded)

Location	Map number[b]	Breeding population	Year	Source[c]
South Dakota				
Columbia Road Reservoir	32	550 Nests	1978	CBR
Piyas Lake	33	350 Young	1975	CBR
		150 Young	1977	CBR
		180 Nests	1978	CBR
		501 Nests	1979	CBR
North Drywood Lake	34	165 Nests	1967	CBR
		740 Nests	1975	CBR
		12 Nests	1977	CBR
		12 Nests	1979	CBR
Drywood Lake		427 Nests	1977	AB(31)
Waubay NWR	35	860% increase over 1979	1980	AB(34)
		1,200 Adults, 1,248 Young	1981	Croft
LaCreek NWR	36	250 Adults	1976	Croft
		225 Nests	1977	Croft
		258 Nests	1981	Croft
Sand Lake NWR	37	258 Nests	1981	Croft
Nebraska				
Fort Niobrara/Valentine NWR	38	Unknown	1981	Croft
Crescent Lake NWR	39	115 Nests	1981	Croft

[a] Information concerning nesting from the period 1965-1981.

[b] Refer to numbers on Figure 5.

[c] Source codes: CBR = Colonial Bird Register data, Laboratory of Ornithology
AB = American Birds (Vol. 29-34)
Croft = R. Croft, U.S. Fish and Wildlife Service, unpubl. data.

Effects of Habitat Changes

The most damaging type of disturbance affecting cormorants is habitat alteration, because the impact is long-term and usually irreversible (Sowls et al. 1980). Inland cormorant colonies located on islands in reservoirs are threatened with habitat loss from the flooding and erosional effects of water level manipulation (Markham and Brechtel 1979). Cormorants nesting in emergent dead trees left after reservoir creation also face eventual loss of nesting habitat as the trees decay and fall down (Mitchell 1975; Blankespoor et al. 1979). A cormorant colony on a river island in Washington was destroyed as a result of the construction of a hydroelectric dam impoundment (Hanson 1968). Drainage and diversion of water for commercial uses, as well as increasing residential and recreational waterfront development, probably pose the most severe threat to cormorant habitat in the future (Markham and Brechtel 1979; Blankespoor et al. 1979).

Effects of Human Disturbance

Human disturbance of double-crested cormorant colonies has detrimental effects on the reproductive success of a colony. Visits to breeding colonies every three to five days caused nest abandonment and discouraged late breeders from settling in the colony (Ellison and Cleary 1978). Additionally, if adults are kept away from nests by continued human presence in a colony, mortality of eggs and young can result from exposure to extreme temperatures (Drent et al. 1964). In severe cases of human disturbance, entire cormorant colonies have been abandoned (Markham and Brechtel 1979).

When cormorants nest near gull colonies, the effects of human disturbance can be further exacerbated as gulls have been observed to prey heavily upon eggs and young left unguarded after adult cormorants have been flushed from a nest by approaching humans (Kury and Gochfeld 1975; Ellison and Cleary 1978). Predation of unguarded cormorant eggs also occurs by northwestern crows (*Corvus caurinus*), which in one case destroyed 60% of all eggs laid in a colony (Drent et al. 1964).

The reproductive success of double-crested cormorants is also indirectly affected by human contamination of their habitat with toxic chemicals. Eggshell thinning and subsequent reproductive failure caused by contamination occurred in several California cormorant colonies (Gress et al. 1973). Chlorinated hydrocarbons, polychlorinated biphenyls (PCB's), and mercury have also been found in cormorant bodies and eggs taken from the Great Lakes region and the Dakotas (Anderson et al. 1969; Greichus et al. 1973). Any pollutant that decreases fish populations would also affect cormorants through a depletion of the food source.

Management

Until recently, little work had been done on management of colonial waterbirds, including cormorants. In the last decade however, systematic surveys of waterbird colony sites have been performed in many parts of the United States and Canada (Sowls et al. 1978; Scharf 1979; Erwin 1979; Sowls et al. 1980). By providing comprehensive current data on colony locations and population status for many species, these surveys have been an important first step towards effective management of colonial waterbirds. Unfortunately, such surveys have not yet been completed for much of the western United States where coal mining impacts upon waterbirds are expected to occur.

A management plan for double-crested cormorants in Alberta is presented by Markham and Brechtel (1979), and should also be applicable to cormorants in other areas. The main goals of the plan are: (1) to monitor population status and trends; (2) to protect and maintain all known colonies; (3) to encourage the establishment of desirable colonies; (4) to maintain critical non-breeding habitat; and (5) to educate the public regarding colonial waterbird biology and status. The major management problems addressed by the plan were disturbance at the breeding colony, habitat loss, pollution, and incomplete management data.

Presently, double-crested cormorants are not actively managed in most of the United States. However, Federal, State, and private conservation organizations are involved in colony protection and, to a more limited extent, in habitat acquisition (Parnell and Soots 1980). In Wisconsin, artificial nest platforms erected for cormorants are successful in providing nesting habitat on impoundments where natural tree nesting sites were destroyed (Faanes 1981; Meier 1981). Although providing nesting habitat is important in managing cormorants, adequate wetland feeding habitats are also essential and may prove more critical in the coal-impacted areas of the West where water supplies are already limited.

The Double-crested Cormorant as an Indicator Species

Cormorants, like many other piscivorous colonial waterbirds, are top consumers within complex aquatic food webs. Because their survival and productivity depend upon the quality and quantity of lower-level trophic components, cormorant populations might be considered good indicators of the condition of an aquatic ecosystem. In addition, because cormorants are known to concentrate certain contaminants in their tissues (Gress et al. 1973), they are particularly good indicators of chemical pollution in aquatic systems. Finally, cormorants have been shown to be sensitive to various types of human disturbance (Kury and Gochfeld 1975).

The colonial nesting habits of the double-crested cormorant should also make it a good indicator species. The nests are usually highly visible and have been successfully censused by aerial methods in many areas of the country (Sowls et al. 1978; Erwin 1979). Unfortunately, however, in the Western United States, no complete systematic censusing has been performed to locate inland cormorant colonies. If the double-crested cormorant is to be used as an indicator species in determining the impacts of surface mining in the West, comprehensive surveys need to be performed in that area of the country to accurately assess inland colony locations and population status. If such surveys are not possible for the entire inland West, more limited surveys of potential mining areas with nearby control areas are desirable.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in rivers, lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping or diversion of water for a transport system; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). A problem in many Eastern surface mine areas has been the generation of toxic pyrites, causing acidification and sterility of streams and ponds (Spaulding and Ogden 1968). Acid drainage is normally not a problem in the West because alkaline soils cause drainage to be neutral or slightly basic (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas. Cormorant habitat losses could be dramatic. In other parts of the West, experience has shown that water diversions for agricultural or domestic use has harmful effects on water-bird populations (Mitchell 1977; Strong pers. comm.). If water is diverted from the large reservoirs in the Charles M. Russell Refuge complex (Montana) or the Garrison Reservoir (North Dakota) for energy development, cormorants and other waterbirds would be affected markedly.

Potential impacts to double-crested cormorants may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Mortality may occur during construction and mining activities if nests and nestlings are destroyed. Serious impacts may result from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). Displacement and increased competition may result in an ultimate reduction in the breeding population. Habitat loss may occur indirectly, through alteration of water levels, or contamination of water supplies with mining byproducts or runoff.

Increased human presence may cause disturbance to nesting birds, resulting in lowered productivity or abandoned nests or colony sites. Increased noise levels may also deter cormorants from using nearby habitat, though some species may become accustomed to noise. Collisions with transmission lines may cause injury or death to cormorants.

The distribution of known strippable coal deposits in the Western United States (Spaulding and Ogden 1968) shows that eastern Montana and the western Dakotas are prime target areas for coal mining (Fig. 4). Unfortunately, some of the largest cormorant colonies in recent years have been in that region, such as Medicine Lake and Bowdoin Refuges, Mid Eight Ridge, Timber Creek Bay, and Snow Creek Bay, all in eastern Montana (Table 1). The majority of the cormorant colonies in this region depend upon the vast reservoir system in the Charles M. Russell Refuge complex, a potentially major source of water for energy development in the West.

Cormorant habitat that could be disturbed with a minimal impact upon the regional population is in western North Dakota. The three colonies (Fig. 5) in this region are all small and the birds may relocate to colonies in mid- and eastern North Dakota.

Most other potential coal mining areas have few if any cormorant nesting colonies nearby.

In the Great Plains-Rocky Mountain regions with anticipated coal mining activities, a few small areas should be protected to preserve the important "nuclei" of cormorant populations: the Charles M. Russell reservoir complex; the areas near Chase Lake Refuge and Devil's Lake, North Dakota; and the Piyas Lake-Drywood Lake-Waubay area in South Dakota.

Water diversion or habitat loss in these areas might prove to be extremely harmful to the populations and their resilience. Development and disturbances in most other mining areas would have minimal impacts on cormorants.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

An important framework from which to assess change is the accurate assessment of current population (i.e., breeding) status and habitat use. In 1981, an attempt was made to solicit information concerning colony use by all waterbirds in the Great Plains-Rocky Mountain region (Croft pers. comm.). Additional work is needed to conduct complete surveys and censuses in areas where mining is expected as well as nearby control areas. Yearly surveys are important in documenting the natural population size changes and colony site movements that occur.

When time and funding permit, selected sites should be monitored to determine egg and chick production as an index to the quality of the site. Eggs and young could be collected for baseline analyses of environmental contaminants.

Exploration and Mine Development Phase

The direct impact of exploration and development will probably be minimal unless, as part of that development, large diversions of water are planned (see below). Impacts to nesting birds may be alleviated if exploration activities are conducted outside of the breeding season.

Mining Phase

Education of workers and a buffer zone around nearby colonies may alleviate impacts from increased human presence in the area. Proper storage and disposal of byproducts and wastes, and control of runoff may prevent degradation of water supplies.

Water storage facilities located adjacent to mining sites and maintained as wetland ecosystems might alleviate some of the problems of direct drainage from natural waterbodies. Such storage facilities could be filled during those parts of the year when the demands by fish and wildlife are reduced (late fall and winter).

Impacts from transmission lines may be alleviated if placement of lines and towers are planned to avoid flight paths around wetlands.

Reclamation Phase

Two aspects of reclamation are particularly germane in addressing mitigation issues: water quality change and contour alteration.

Reclamation of wetland ecosystems is important in maintaining the ability of the area to support double-crested cormorants. Artificial nesting platforms may provide nest sites in newly flooded impoundments where present nest sites are subject to deterioration (Meier 1981). Where water quality can be maintained at a reasonably high level and where altered contours create impoundments near mines, feeding habitat (and possibly nesting habitat) can be created.

SUMMARY

Coal mining and energy development in the West could have a significant impact on double-crested cormorant populations. Major nesting areas are centered in eastern Montana and North Dakota, where coal reserves are known to be substantial. The greatest impact on cormorants would occur if major reservoirs in these areas were used for water supplies. The reservoir complex within the Charles M. Russell Refuge, and several lakes in southeastern North Dakota and northeastern South Dakota are critical areas for preserving interior double-crested cormorant populations.

ACKNOWLEDGEMENTS

We are grateful to C. Kimball for his assistance in the preparation of the bibliography and to R. Croft for providing 1981 data on Western colonies.

REFERENCES

American Birds. 1975-1980. The nesting season, regional reports. Vols. 29-34.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Anderson, D. W., J. J. Hickey, R. W. Risebrough, D. F. Hughes, and R. E. Christensen. 1969. Significance of chlorinated hydrocarbon residues to breeding pelicans and cormorants. Can. Field-Nat. 83:91-112.

Bent, A. C. 1922. Life histories of North American petrels and pelicans and their allies. Order Tubinares and Order Steganopodes. U.S. Natl. Mus. Bull. 121.

Blankespoor, G., S. Archer, and D. Ode. 1979. Breeding colonies of double-crested cormorants and great blue herons on Lake Francis Case during the summer of 1978. South Dakota Bird Notes 31(1):4-19.

Buchheister, C. W. 1944. The comeback of the cormorant on the New England coast. Audubon 46(1):15-25.

Bystrak, D. 1981. The North American Breeding Bird Survey. Studies in Avian Biology 6:34-41.

Colonial Bird Register. Laboratory of Ornithology, Cornell Univ.

Croft, R. Unpublished data and personal communication. U.S. Fish and Wildlife Service, Region 6, Denver, CO.

Drent, R., G. F. Van Tets, F. Tompa, and K. Vermeer. 1964. The breeding birds of Mandarte Island, BC. Can. Field-Nat. 78:208-263.

Drury, W. H. 1973. Population changes in New England seabirds. Bird-Banding 44(4):267-313.

Ellison, L. N., and L. Cleary. 1978. Effects of human disturbance on breeding of double-crested cormorants. Auk 95:510-517.

Erwin, R. M. 1979. Coastal waterbird colonies: Cape Elizabeth, Maine to Virginia. U.S. Fish Wildl. Serv., FWS/OBS-79/10.

Faanes, C. A. 1981. Birds of the St. Croix River Valley: Minnesota and Wisconsin. U.S. Fish Wildl. Serv., N. Am. Fauna 73.

Grant, G. S. 1970. Decline of the double-crested cormorant as a breeding bird in North Carolina. Chat 34:34-36.

Greichus, Y. A., A. Greichus, and R. J. Emerick. 1973. Insecticide, polychlorinated biphenyls and mercury in wild cormorants, pelicans, their eggs, food and environment. Bull. Environ. Contam. Toxicol. 9(6):321-328.

Gress, F., R. W. Risebrough, D. W. Anderson, L. F. Kiff, and J. R. Jehl, Jr. 1973. Reproductive failures of double-crested cormorants in southern California and Baja California. Wilson Bull. 85(2):197-208.

Gross, A. O. 1950. The herring gull-cormorant control project. Proc. 10th Int. Ornithol. Congr:532-536.

Hanson, W. C. 1968. Recent history of double-crested cormorant colonies in southeastern Washington. Murrelet 49:25-26.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Kury, C. H. 1968. Differences in weight of male and female cormorants. Auk 85:513.

Kury, C., and M. Gochfeld. 1975. Human interference and gull predation in cormorant colonies. Biol. Conserv. 8:23-34.

Lewis, H. F. 1929. The natural history of the double-crested cormorant [Phalacrocorax auritus auritus (Lesson)]. Ru-Mi-Lou Books, Ottawa. 94 pp.

Lundquist, A. R. 1949. The Waubay Lake colonies of double-crested cormorant. South Dakota Bird Notes 1:8-10.

Markham, B. J., and S. H. Brechtel. 1979. Status and management of three colonial waterbird species in Alberta. Proc. 1978 Conf. Colonial Waterbird Group 2:55-64.

Meier, T. I. 1981. Artificial nesting structures for the double-crested cormorant. Wisconsin Dept. Nat. Resour., Tech. Bull. 126. Madison, WI. 12 pp.

Mendall, H. L. 1936. The home-life and economic status of the double-crested cormorant, Phalacrocorax auritus auritus (Lesson). Maine Bull. 39(3):159.

Mitchell, R. M. 1975. The current status of the double-crested cormorant in Utah: A plea for protection. Am. Birds 29:927-930.

______________. 1977. Breeding biology of the double-crested cormorant on Utah Lake. Great Basin Nat. 37:1-23.

Moore, R., and T. Mills. 1977. An environmental guide to western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Palmer, R. S. 1962. Handbook of North American birds. Vol. 1. Loons through Flamingos. Yale Univ. Press, New Haven, CT.

Parnell, J. F., and R. F. Soots, Jr. (eds.). 1980. Summary of a planning workshop on the management of colonial waterbirds. Sea Grant Publ. UNC-SG-80-06. 55 pp.

Pullin, B. Personal communication. Tennessee Valley Authority. Norris, TN.

Robbins, C. S., B. Bruun, and H. Zim. 1966. Birds of North America. Golden Press, NY.

Robbins, C. S. Personal communication. Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service. Laurel, MD.

Robertson, I. 1974. The food of nesting double-crested and pelagic cormorants at Mandarte Island, BC, with notes on feeding ecology. Condor 76:346-348.

Scattergood, L. W. 1950. Observations on the food habits of the double-crested cormorant, Phalacrocorax auritus. Auk 67(4):506-508.

Scharf, W. C. 1979. Nesting and migration areas of birds of the U.S. Great Lakes (30 April to 25 August 1976). U.S. Fish Wildl. Serv. FWS/OBS-77/02. 113 pp.

Sowls, A. L., S. A. Hatch, and C. J. Lensink. 1978. Catalog of Alaskan seabird colonies. U.S. Fish Wildl. Serv. FWS/OBS-78/78.

Sowls, A. L., A. R. DeGange, J. W. Nelson, and G. S. Lester. 1980. Catalog of California seabird colonies. U.S. Fish Wildl. Serv. FWS/OBS-37/80. 371 pp.

Spaulding, W. M., Jr., and R. Ogden. 1968. Effects of surface mining on the wildlife resources of the United States. Bur. Sport Fish. Wildl. Resour. Publ. 68, Washington, DC. 51 pp.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-college Center for Environmental Studies, Fargo, ND.

Strong, M. Personal communication. U.S. Bureau of Land Management, Lakewood, CO.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Weseloh, D. V., S. Brechtel, and R. D. Burns. 1978. Recent population changes in double-crested cormorants and California and ring-billed gulls in Alberta, Canada, with a note on white pelicans. Proc. 1977 Conf. Colonial Waterbird Group 1:10-18.

WHITE-FACED IBIS (Plegadis chihi)

by

R. Michael Erwin
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The white-faced ibis (*Plegadis chihi*) is a medium-sized colonial wading bird occurring scattered throughout much of the Great Basin - Rocky Mountain region and along the Louisiana-Texas coast into Mexico. Often confused with the closely-related glossy ibis (*P. falcinellus*), the white-faced ibis is the size of a small heron [e.g., little blue heron (*Egretta caerulea*)] and has dark "glossy" plumage. A diagnostic field mark is its long decurved bill. The body plumages of both the white-faced and glossy ibises are virtually identical, with a chestnut, metallic sheen and wing coverts a greenish color (Palmer 1962). The distinguishing characteristic between the two species is the "narrow white feather border about bare facial skin" (Palmer 1962) in the white-faced ibis. The white extends "in back of the eye and under the chin" (Peterson 1947). In winter, the white "face" is lost, and streaking shows on the throat. Juveniles have dull, gray-brown underparts with obscure streaking on the head (Palmer 1962).

The neck and legs are outstretched in flight, the wings are rounded and the wingbeats are more rapid than most of the herons, with frequent glides interspersed. All the ibises form flocks, either in diagonal lines or in compact groups (Palmer 1962).

The taxonomic status of the two related ibises has been debated. Peterson (1947) called the species the "white-face glossy ibis," giving it a species name of *P. mexicana*. Palmer (1962) considered the two as subspecies, the white-faced being *Plegadis falcinellus chihi*, but the fifth edition of the American Ornithologists' Union Check-list (1983) accords it full species status.

DISTRIBUTION

White-faced ibises breed in colonies ranging from a few to several thousand birds in freshwater marshes from eastern Oregon sporadically across to North Dakota and south into parts of Kansas and Colorado; a disjunct U.S. population breeds in the brackish and salt marsh areas of coastal Texas and Louisiana (Fig. 6). They winter in the Southwestern U.S. and in Mexico.

In the late 1800's and early 1900's, the white-faced ibis bred in large numbers throughout California, from the lakes in northeastern California south to the Salton Sea and the tule marshes of San Diego County. With agricultural change and development, virtually all of these areas have been abandoned by ibises except for three locations in central and northeastern California. However, this loss in breeding range has been partially offset by recent expansion into the Dakotas and southern Idaho.

DIET

Little specific information is available on the diet. Collections of a few birds in scattered locations indicate that insects, worms, crawfish, mollusks, small frogs and fish, newts, and leeches are included in the diet (Bent 1926; Palmer 1962). The birds often fly long distances from their colonies or roosts to feed in marshes and pools, along rivers and streams, and increasingly in irrigated fields.

Feeding habitat, extensive marshes, ponds, or rivers, overlap considerably with nesting habitat requirements. Ibises have become increasingly dependent upon irrigated fields for feeding, often flying long distances from their colony or roost sites to do so (Booser and Sprunt 1980). This shift in habitats may be a result of the reduction in tule marsh habitats (Pough 1951) in much of the West with a concomitant increase in irrigated fields that produce an abundance of food.

REPRODUCTION

Arrival at the breeding colony may occur as early as March and early April in some years, and most birds complete egg laying sometime in early or mid-May in most States (Booser and Sprunt 1980). Eggs are laid at the rate of 2 every 3 days (Capen 1978). The normal clutch contains 3 to 4 eggs (Palmer 1962). Incubation lasts for about 21 days and is performed by both parents (Bent 1926; Palmer 1962). Both parents feed the young by regurgitation. A parent is in constant attendance at the nest until nestlings are about 5 days old. At 2 weeks of age, the young become more active, moving out of the nest onto limbs or adjacent emergent vegetation (Palmer 1962). Young fledge at about 6 weeks of age. They remain with the parents after fledging, following them to feeding areas and returning to the marsh at night to roost. The relationship between young and parents in the fall after the breeding season is unknown.

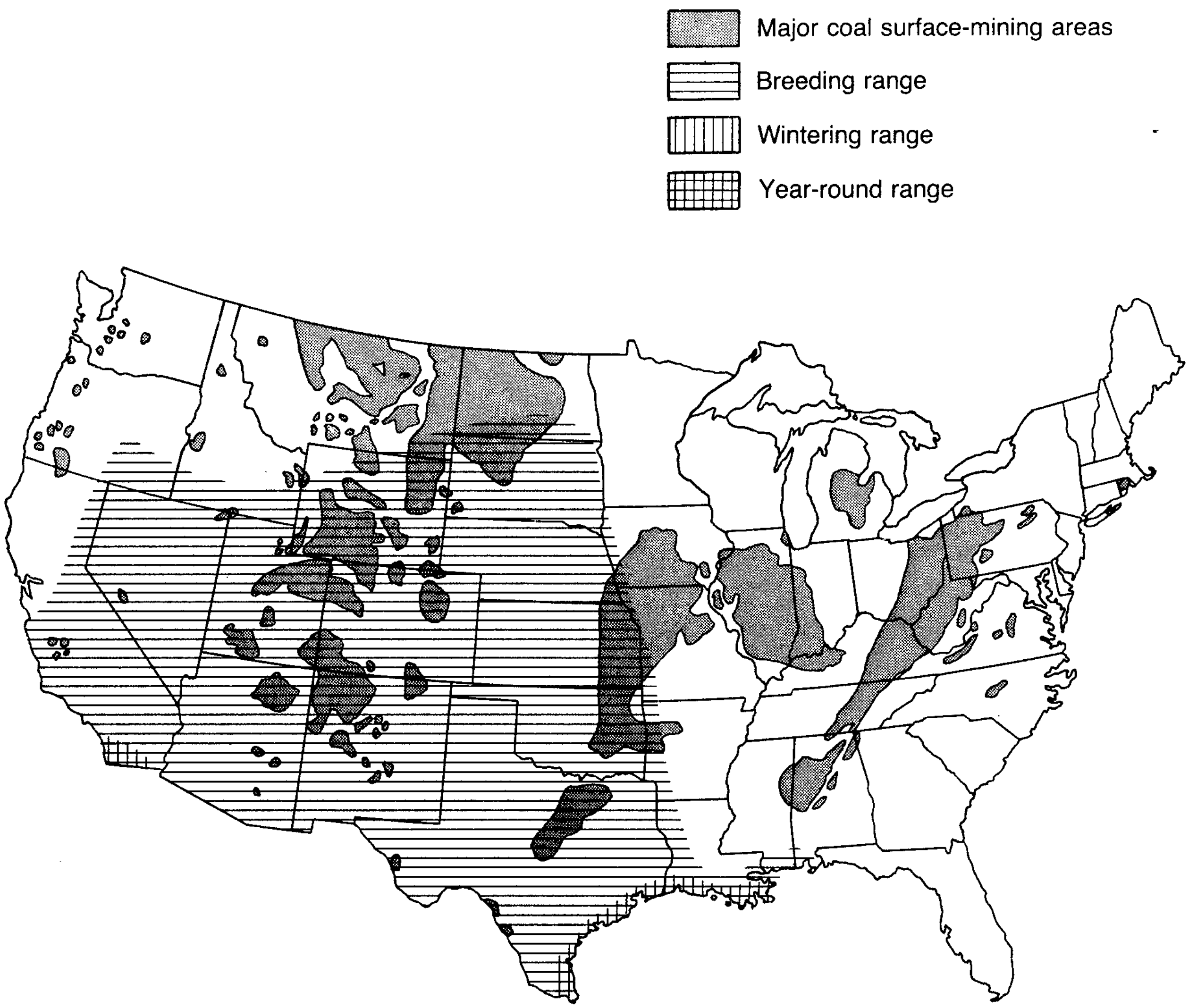


Figure 6. Geographical range of the white-faced ibis in relation to major coal deposits in the United States. After Inkley and Raley (1983).

White-faced ibis colonies are always associated with shallow water habitats. Along the coasts of Texas and Louisiana, mixed glossy-white-faced ibis colonies usually occur in buttonbush (*Cephalanthus occidentalis*), shrubby cypress (*Taxodium distichum*) or willow (*Salix nigra*) in ponds in the freshwater swamps or, in more marine habitats, in reed (*Phragmites* sp.), marsh elder (*Iva frutescens*), or groundsel (*Baccharis halimifolia*) bushes commonly found on dredge deposition sites (Portnoy 1977).

In the Great Basin - Rocky Mountain region, ibises nest in freshwater tule (*Scirpus* sp.) marshes, using bulrush or tule, cattail (*Typha* sp.), and reed (*Phragmites communis*) for nesting substrate. Ibises also commonly nest along the margins of lakes from Oregon to Colorado (Booser and Sprunt 1980).

Extensive water is required for successful reproduction. The ibis usually abandons the colony site where marshes are drained or where drought has reduced water levels (Ryder 1967, Booser and Sprunt 1980). Rising water levels (e.g., the Great Salt Lake) also result in flooding of nesting habitat in some years.

POPULATION TRENDS

The current population status of the ibis has recently been reviewed by Booser and Sprunt (1980). The species was included on the annual National Audubon Society's "Blue List" of vulnerable or declining species from its inception through 1980 (Booser and Sprunt 1980), but it was not listed in 1982 (Tate and Tate 1982). The total U.S. population is estimated to be about 10,000 breeding pairs (Ryder 1967). This figure, however, is probably fairly crude because the species has not been censused over most of its range during any one year. Figure 7 and Table 2 describe the recent breeding locations and abundance of the ibis based primarily on Colonial Bird Register data, Booser and Sprunt (1980), and Voeks and English (1981).

A pervasive characteristic of the breeding populations in the Western U.S. is the transience of nesting colonies as a result of changes in amounts of rainfall, irrigation practices, and other land-use modifications. Shifts in breeding ibises have frequently occurred among marshes in Nevada, Oregon, and northern California depending on drought conditions in Nevada. Further, Mexico may act as an important breeding refuge when dry conditions occur in the U.S. (Capen pers. comm.).

Local Populations

The following account synthesizes the current status of the species in each western State.

Utah. Utah seems to be the core of the breeding range in the Great Basin area, with the prime region in the Bear River marshes in northwestern Utah. Abundant nesting populations have occurred since the 1860's in the Great Salt Lake area (Hayward et al. 1976; Booser and Sprunt 1980). The Utah population has been high and relatively stable, with estimates of 5,000 pairs in 1928 and

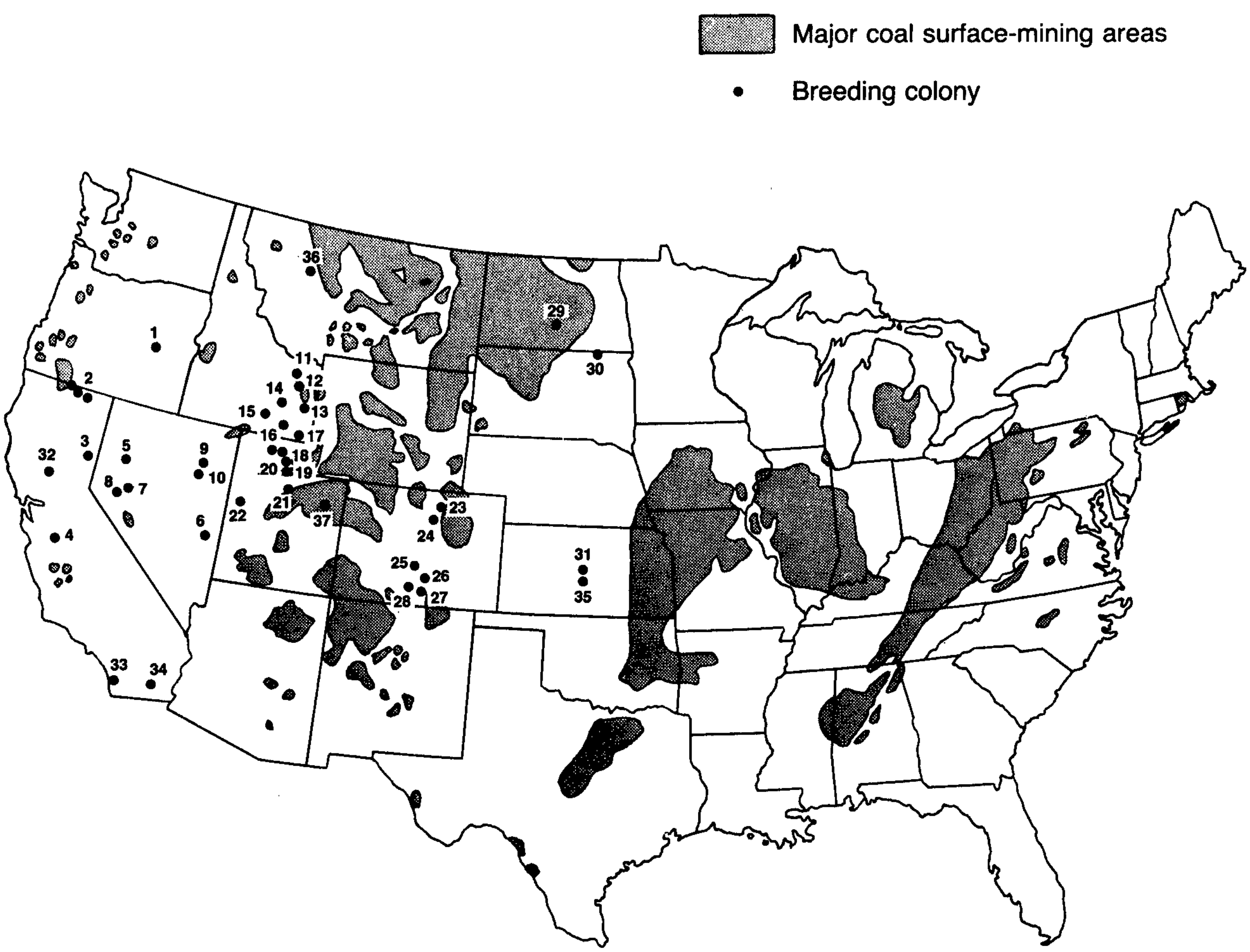


Figure 7. Recent breeding colonies of the white-faced ibis in relation to major coal deposits in the United States. Numbers refer to colonies listed in Table 2.

Table 2. Recent[a] colony locations and population levels of the white-faced ibis in the interior U.S.

Location	Map Number[b]	Breeding Population	Year	Source[c]
Oregon				
Malheur	1	110 nests	1977	CBR
National Wildlife Refuge (NWR)		190 pairs	1978	CBR
Harney Lake		150 pairs	1979	Thompson et. al 1979
California				
Klamath Basin	2	10 pairs	1975	Ryder 1967
(Tule, Clear, and Lower Klamath Lakes)		2 nests	1966	Booser & Sprunt 1980
Honey Lake	3	"few"	1971-77	Booser & Sprunt 1980
San Joaquin Valley	4	"still breeds... in a few areas"	1974	Booser & Sprunt 1980
Colusa NWR	32	30 adults (may have nested)	1979	Voeks & English 1981
Buena Vista Lagoon	33	8 nests	1979	Voeks & English 1981
Salton Sea NWR	34	100 birds	1979	Voeks & English 1981
		250 birds	1980	Voeks & English 1981
Nevada				
Humboldt Sink (Lovelock)	5	125 nests (Lovelock)	1973	AB
		300 nests	1974	Booser & Sprunt 1980
Kirch WMA	6	13 nests	1979	Voeks & English 1981
		12 nests	1980	Voeks & English 1981
Carson Lake	7	2000 birds	1975	AB
		0 birds	1977	Booser & Sprunt 1980
		1200 nests	1979	Voeks & English 1981
		1500-1800 nests	1980	Voeks & English 1981
Stillwater Wildlife	8	no nesting	1960-78	Ryder 1967
Management area (WMA)		190 nests	1979	Voeks & English 1981
		190 nests	1980	Voeks & English 1981
Franklin Lake	9	100 nests	1980	Voeks & English 1981

Table 2. (continued)

Location	Map Number[b]	Breeding Population	Year	Source[c]
Ruby Lake	10	150 nests	1978	CBR
		200 nests	1979	Voeks & English 1981
		55 nests	1980	Voeks & English 1981
Idaho				
Camas NWR	11	Active colony	1977-78	Booser & Sprunt 1980
		300 adults (unconfirmed)	1980	Voeks & English 1981
Market Lake WMA	12	15 nests	1979	Voeks & English 1981
		300 adults	1980	Voeks & English 1981
Gray's Lake	13	20 pairs	1973	AB
American Falls Reservoir	14	Active colony	1979	Booser & Sprunt 1980
		300 adults	1980	
Lake Walcott, Minidoka NWR	15	20 pairs	1965	Ryder 1967
		6 nests	1979	Voeks & English 1981
		25-25 adults	1980	Voeks & English 1981
Oxford Slough	16	150 nests	1979	Voeks & English 1981
		200-300 adults	1980	Voeks & English 1981
Bear Lake	17	175 nests	1979	Voeks & English 1981
		120 nests	1980	Voeks & English 1981
Utah				
Bear River Marsh	18	1500-2000 nests	1977	Booser & Sprunt 1980
		8687 adults	1979	Voeks & English 1981
		3000-4000 adults	1979	Voeks & English 1981
Harold Crane WMA	18	400 adults	1979	Voeks & English 1981
		590 adults	1979	Voeks & English 1981
Ogden Vay-Howard Slough	19	4000 pairs	1965	Ryder 1967
		"small colony"	1968-76	Booser & Sprunt 1980

Table 2. (continued)

Location	Map Number[b]	Breeding Population	Year	Source[c]
Layton-Kaysville	19	6000 adults	1979	Voeks & English 1981
		6000 adults	1980	Voeks & English 1981
Farmington Bay WMA	20	4000 birds	1979	Voeks & English 1981
(Black Sloughs)		4200 birds	1980	Voeks & English 1981
Utah Lake	21	110 nests	1980	Booser & Sprunt 1980
Fish Spring NWR	22	30 nests	1979	Voeks & English 1981
		23 birds (nesting)?	1980	Voeks & English 1981
		24 nests	1981	R. Croft. pers. comm. 1981
Ouray NWR	37	50	1970	R. Croft. pers. comm. 1981
Colorado				
Latham Reservoir	23	5 nests	1976	CBR
Barr Lake	24	Suspected nesting	At least until 1965	Bailey & Niedrach 1965
Trites Lake	25	ca. 10 pairs	1965	Ryder 1967
(Russell Lakes)		11 nests	1976	Graul 1977
Head Lake-San Luis Lakes	26	7 nests	1976	Graul 1977
Adams Lake	27	12 nests	1976	Graul 1977
Monte Vista NWR	29	Active colony for some years	1970	AB
		30 nests	1981	R. Croft. pers. comm. 1981
North Dakota				
Long Lake	29	10 nests	1978	Booser & Sprunt 1980
Sargent		1 nest	1979	Harris 1983
South Dakota				
Columbia Road	30	4 nests	1978	Booser & Sprunt 1980
Reservoir (Sandlake)		4 birds	1981	R. Croft. pers. comm. 1981
Whitewood Lake		3 nests	1981	Harris 1983

Table 2. (concluded)

Location	Map Number[b]	Breeding Population	Year	Source[c]
Kansas				
Cheyenne Bottoms	31	12 pairs	1965	Ryder 1967
Quivira NWR	35	13 nests	1981	R. Croft. pers. comm. 1981
Montana				
Benton Lake NWR	36	2 nests	1981	R. Croft. pers. comm. 1981

[a]Information concerning nesting from the period 1965-1981.

[b]Refer to numbers on Fig. 7.

[c]Source codes: CBR=Colonial Bird Register data, Laboratory of Ornithology; AB=American Birds (Nesting Season Reports)

1957 and about 4,700 pairs in 1965 (Ryder 1967). Recent estimates may indicate a decline since Capen (1978) estimated about 3,600 pairs in the state in 1976, and three colonies totaling 2,600 pairs were noted in 1980 (Kingery 1980).

Nevada. As in Utah, ibises have nested in Nevada continuously since the late 1800's (Ryder 1967), with a concentration in the Stillwater-Carson Lake area of western Nevada. Ruby Lake refuge in eastern Nevada is also an important area (Bouffard 1978). In 1965, at least 560 pairs occurred in the State (Ryder 1967) and a peak population occurred at Carson Lake in 1973 with 3,310 nests recorded (Barber 1977, Booser and Sprunt 1980). Very little nesting occurred in 1977 but 800 nests were recorded in the State in 1978 (Kingery 1980). At least 1,200 pairs nested in three locations in 1979. In 1980, about 2,000 pairs nested in the State (Kingery 1980).

Oregon. The Malheur Lake area of southeastern Oregon has attracted ibises since the early 1900's (Ryder 1967) with populations varying between 100 and 500 nests from 1900 to 1925 (Booser and Sprunt 1980). In 1977, an estimate of 110 nests (Colonial Bird Register) was recorded, indicating a very persistent nesting nucleus. In 1979, 150 nests were estimated on the refuge (Thompson et al. 1979). A peak of 600 pairs nested at Malheur in 1980 (Rogers 1980). This refuge may become increasingly important as wetlands decline in Nevada.

California. In the early part of the century, before dense human populations developed in the State, the white-faced ibis nested from the Klamath Basin near the Oregon border south through the Central Valley to the Salton Sea and San Diego County (Booser and Sprunt 1980). In 1965, only 10 pairs were recorded in the State at Tule Lake National Wildlife Refuge (Ryder 1967). Human habitation and agricultural development have been responsible for much wetland habitat loss. In the past few years, small numbers have nested again at different locations in the Salton Sea (Booser and Sprunt 1980).

Idaho. Palmer (1962) did not include Idaho in the breeding range of the ibis but, in 1963, 25 nests were recorded at Minidoka Refuge (Ryder 1967). In recent years, six new colony sites were reported in the State, with 800 birds observed along the Snake River at American Falls in 1978 (Booser and Sprunt 1980). In 1980, a new colony of more than 100 birds was observed there (Rogers 1980).

Montana. With the northward expansion of ibises into Idaho and the Dakotas (Ryder 1967), sightings of summering birds have become very common and nesting has been confirmed recently (Skaar 1980).

Wyoming. Sporadic sightings of the species have been made with confirmed nesting in 1964 at Hutton Lake Refuge (Ryder 1967) and more recent records by Oakleaf et al. (1982).

Colorado. Small numbers nested in several localities in the early 1900's (Sclater 1912) but in the 1940-1965 period, only the San Luis Valley region was occupied (Ryder 1967). Numbers have fluctuated in recent years, with only

6 nests recorded in 1977, 80 in 1978 (Kingery 1980), and 50 nests at Adams Lake in 1979 (Ryder et al. 1980). Nesting was also recorded in the San Luis Valley in 1980 (Ryder pers. comm).

New Mexico. Nesting was confirmed (only one nest) in the state in 1974 (Hundertmark 1974).

Arizona. Birds have been seen in the summer in this state but no nesting has been recorded.

Kansas. Ibises first nested in the state at Cheyenne Bottoms in 1951 (Mossman 1952). Small numbers nested in 1962 and 1965 (Ryder 1967).

Nebraska. No recent nests have been recorded and only one nest was reported earlier in 1916 (Swenk 1917).

The Dakotas. Only recently has the ibis begun nesting in the Dakotas with small numbers recorded near Columbia, South Dakota and at Long Lake, North Dakota (Schmidt 1980).

Minnesota. Four pairs nested at Heron Lake in 1895-96 (Peabody 1896), but none has been observed since then (Ryder 1967; Booser and Sprunt 1980).

Effects of Habitat Changes

Man's activities have probably contributed most significantly to the changing distributions referred to above. The extensive nesting range in California has diminished, possibly shifting north into Idaho and the Dakotas. Increasing human populations with the subsequent drainage of wetlands for agricultural use has limited the feeding and nesting habitats available. However, the extensive agricultural land that is irrigated has possibly enhanced the feeding habitat area. Birds have been observed to fly long distances to feed in these areas (Booser and Sprunt 1980). The net effect of man's activities on ibis habitat has probably been negative. Most of the large nesting colonies occur on wildlife refuges where habitat change has been minimized.

Effects of Human Disturbance

Disturbance of wading birds has only recently been documented (Tremblay and Ellison 1979; Kushlan 1979). Very little is known about the tolerance levels of birds during the nesting period or at other times during the year. Human disturbance, coupled with loss of wetlands, may have caused the demise of the ibis in much of south-central California (Ryder 1967; Booser and Sprunt 1980), but separating these effects is difficult. Because ibises nest in patches of shrubs or emergent vegetation, usually surrounded by shallow water, direct contact with humans in recent years has probably been limited. In earlier years, when the millinery trade created a demand for egret plumes, disturbance must have been greater. Although ibises were not sought by plume hunters (they have no plumes), the other species associated with ibises in typical mixed species colonies were hunted, causing large-scale disruption and nesting failure. In addition, game hunting of ibis occurred in Texas and California until 1915 (Bent 1926). California had a bag limit of 20 birds.

The closely-related glossy ibis seems to be the wading bird most sensitive to human intrusion in the Mid-Atlantic coast region (Erwin pers. comm.). The glossy ibis was the only species (of seven wading bird species) to leave the nesting area when humans entered a colony. The glossy ibis typically circles the colony, then flies off and lands 100 m or more from the colony; other wading birds usually fly only a few meters from their nests, in the immediate vicinity of the intruder. Capen (pers. comm.), however, indicates that white-faced ibises are relatively "tame" compared to the glossy ibis. At Utah colonies, white-faced ibises remained close to their nests when he entered the colony. This phenomenon has also been observed during nest searches at the Bear River Migratory Bird Refuge, Utah (Schroeder pers. comm.).

Management

Historically, management of any colonial waterbird has been very limited (Parnell and Soots 1980). The major management strategy is passive, i.e., protection of nesting colonies. The U.S. Fish and Wildlife Service, National Audubon Society, and the Nature Conservancy, among others, have acquired refuges and sanctuaries since the early 1900's to protect important wetland areas for nesting and feeding waterbirds.

In recent years, the importance of islands created by material dredged from navigable water channels has generated an interest in managing deposition to maximize bird use of these habitats (Landin and Soots 1978). These habitats have become increasingly important as natural habitats deteriorate or disappear because of human encroachment.

The importance of irrigated fields for feeding has critical management implications for the white-faced ibis. If water levels cannot be maintained in June and July when the birds are nesting and when feeding of young places a premium on energy returns, the ibis populations will suffer (Strong pers. comm.). Further, water diversion from lakes and marshes for irrigation will limit areas suitable for colony sites.

The White-faced Ibis as an Indicator Species

Indicator species are those with limited ranges of tolerance to environmental changes, including those in direct response to human activity or indirectly through secondary environmental changes produced as a result of some activity. Changes in populations of indicator species may then serve as a warning of man's deleterious impact on a system.

Ibis populations often undergo major annual changes in certain localities because of natural variations in water regimes and other factors not fully understood. Separating population changes caused by natural versus man-induced phenomena may prove to be difficult. Thus, the white-faced ibis is not a good indicator species for impacts of coal mining.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Surface mining activities that may potentially have the greatest impact on white-faced ibis populations include changes in water resources and increased human activity resulting in colony desertion in formerly remote areas.

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversions for transport systems; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). A problem in many eastern surface mine areas has been the generation of toxic pyrites, causing acidification and sterility of streams and ponds (Spaulding and Ogden 1968). Acid drainage is normally not a problem in the West because alkaline soils cause drainage to be neutral or slightly basic (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas.

Changes in water distribution may have the greatest impact on ibises because of the ibis' dependence on wetlands for breeding. Habitat loss may impact ibises through mortality occurring from predators killing nestlings that are exposed if water levels recede during the nesting season, or through increased stress from loss of feeding areas. The destruction of wetlands will also result in ibises being displaced. Since wetlands are already a depleted resource, displaced ibises may be exposed to overcrowding and increased competition; the availability of suitable unoccupied marshes is unknown. Displacement will most likely result in a decrease in the breeding population.

Increased noise or human activity may cause ibises to abandon suitable habitat nearby. One result of disturbance is an avoidance of a disturbed area by renesters (Tremblay and Ellison 1979). Birds may suffer increased stress from harassment or illegal shooting. Collisions with transmission lines may result in injury or mortality.

Recent colony surveys indicate that more than 75% of the white-faced ibis population occurs in limited areas--the Bear River refuge area of Utah, the Malheur refuge in Oregon, eastern and western Nevada, and along the Texas-Louisiana coast. If surface mining for coal avoids those regions, the impact of mining should be minimal to this species. If expansion of coal mining occurs throughout the Rocky Mountains - Great Basin region, the ibis could be adversely affected.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

In some areas, baseline data already exist on nesting population size. Further studies should be conducted in areas of potential mining and also in nearby control areas with no planned surface mining. By examining physically similar marshes and water levels over a series of years predictive models might be developed to determine critical minima for nesting.

In addition to monitoring numbers of breeding birds in this phase, data could be collected on the production of eggs and young for 2 years prior to development as an index to the quality of the site. Further, the incidence of renesting and overall duration of nesting may be observed.

Exploration, Mine Development, and Mining Phases

The initial exploration of mining areas should not have a major impact on ibises since most of the coal development is expected in upland, xeric habitats. The actual mining phase could have a major impact on ibises, not only as a result of direct disturbance and habitat removal but also secondarily through changes in water quality and diversions. If lake and marsh waters are diverted, the impact on ibises will be maximized. If water diversion is restricted to major rivers, the immediate impact on ibises will be lessened somewhat.

If water could be stored near the mining facility in large reservoirs to reduce the drainage of natural water bodies, and reservoirs managed as wetland habitat, especially at critical times of the year (breeding season), the effects on ibises would be further reduced by the presence of these alternative nesting and feeding areas.

A buffer zone around nearby marshes restricting access, and education of workers, may alleviate harassment of ibises. Placement of transmission lines outside of migration pathways and away from wetlands may decrease injury and mortality from collisions.

Reclamation Phase

This phase could prove to be the most critical ecologically. Land contour changes and the creation of basins can have major effects on vegetation regeneration and water distribution and quality. Creation of wetlands including emergent vegetation and vertebrate and invertebrate life may provide habitat suitable for ibises.

SUMMARY

Western coal surface mining, if restricted to upland, xeric regions of the Great Plains, Great Basin, and Rocky Mountains, should have a minimal impact on the white-faced ibis. If mining occurs in the core area of ibis nesting in northern Utah, Nevada, and southeastern Idaho, major populations could be impacted. If coal is transported by water, the tremendous amount of diversion from remote natural water bodies will have a strong adverse effect on all aquatic wildlife, including the ibis, which depends on large marshes and lakes. Impacts may be mitigated by buffer zones around colonies, control of water levels to benefit ibises and creation of wetlands to provide new ibis habitat.

ACKNOWLEDGMENTS

C. Kimball assisted in the preparation of the references. D. Capen provided some useful information based on his thesis work in Utah.

REFERENCES

American Ornithologists' Union. 1983. Check-list of North American birds. 6th edition. Allen Press, Lawrence, KS. 877 pp.

Bailey, A. M., and R. J. Niedrach. 1965. Birds of Colorado. Denver Mus. Nat. Hist., Denver, CO.

Barber, M. J. Unpub. (1977). Monitoring program of wildlife habitat and associated use in the Truckee-Carson irrigation district, Nevada Prog. Rep. 5, Stillwater Wildl. Manage. Area, Fallon, Nevada.

Bent, A. C. 1926. Life histories of North American marsh birds. U.S. Natl. Mus. Bull. 135.

Booser, J., and A. Sprunt IV. 1980. A literature review and annotated bibliography of the Great Basin/Rocky Mountain population of the white-faced ibis. Natl. Audubon Soc., NY.

Bouffard, S. Unpub. (1978). Ruby Lake National Wildlife Refuge report.

Capen, D. E. 1978. Evaluating the impact of pesticides on the white-faced ibis in Utah. Proc. 1978 Conf. Colonial Waterbird Group 1:196-201.

Capen, D. E. Personal communication. School of Natural Resources, Univ. Vermont, Burlington.

Colonial Bird Register. Laboratory of Ornithology, Cornell Univ., Ithaca, NY.

Croft, R. Personal communication. Region 6, U.S. Fish and Wildlife Service, Denver, CO.

Erwin, R. Personal communication. U.S. Fish and Wildlife Service, Patuxent Wildl. Res. Cent., Laurel, MD.

Graul, W. Unpub. (1977). Nesting success of the white-faced ibis in Colorado. 1976. Colorado Div. Wildl., Ft. Collins, CO.

Harris, B. 1983. Whitewool Lake heron and ibis breeding surveys. South Dakota Bird Notes 35:4-7.

Hayward, C., C. Cotton, A. Woodbury, and H. Frost. 1976. Birds of Utah. Great Basin Nat. Mem. 6:45-46.

Hundertmark, C. A. 1974. Breeding range extensions of certain birds in New Mexico. Wilson Bull. 86:298-299.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Kingery, H. E. 1980. The nesting season-mountain west. Am. Birds 34:914-918.

Kushlan, J. 1979. Effects of helicopter censuses on wading bird colonies. J. Wildl. Manage. 43:756-760.

Landin, M., and R. Soots, Jr. 1978. Development and management of avian habitat on dredged material islands-synthesis of research results. U.S. Army Eng. Waterways Exp. Stn. Tech. Rep. DS-78-19.

Moore, R., and T. Mills. 1977. An environmental guide to western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Mossman, L. O. 1952. (Photograph). Kansas Fish Game. 9:7.

Nesting Season Reports. 1970, 1973. Am. Birds 24, 27.

Oakleaf, B., H. Downing, B. Raynes, M. Raynes, and O. K. Stott. 1982. Wyoming avian atlas. Wyoming Game Fish Dept., Cheyenne, WY.

Palmer, R. S. 1962. Handbook of North American birds, Vol. 1. Yale Univ. Press, New Haven, CT.

Parnell, J., and R. Soots, Jr. (eds.). 1980. Management of colonial water-birds. Univ. North Carolina Sea Grant Publ. UNC-SG-80-06.

Peabody, P. B. 1896. White-faced glossy ibis breeding in Minnesota. Auk 13:79.

Peterson, R. T. 1947. A field guide to the birds. Houghton Mifflin Co., Boston, MA.

Portnoy, J. 1977. Nesting colonies of seabirds and wading birds. Coastal Louisiana, Mississippi, and Alabama. U.S. Fish Wildl. Serv. FWS/OBS-77/07.

Pough, R. H. 1951. Audubon water bird guide. Doubleday and Co., Garden City, NY.

Rogers, T. H. 1980. The nesting season--northern Rocky Mountain-intermountain region. Am. Birds 34:911-914.

Ryder, R. A. 1967. Distribution, migration, and mortality of the white-faced ibis (Plegadis chihi) in North America. Bird-Banding 38:257-277.

___________. Personal communication. Dept. Fisheries Wildlife Biology, Colorado State Univ., Ft. Collins, CO.

Ryder, R. A., W. D. Graul, and G. C. Miller. 1980. Status, distribution, and mvoements of Ciconiiformes in Colorada. Proc. 1979 Conf. Colonial Waterbird Group 3:49-58.

Schmidt, R. A. 1980. First breeding records of the white-faced ibis in North Dakota. Prairie Nat. 12:21-23.

Sclater, W. L. 1912. A history of the birds of Colorado. Witherby & Co., London.

Schroeder, L. Personal communication. Refuge Division, U.S. Fish Wildl. Serv., Salt Lake City, UT.

Skaar, P. D. 1980. Montana bird distribution. 2nd ed. Bozeman, MT.

Spaulding, W., Jr., and R. Ogden. 1968. Effects of surface mining of the fish and wildlife resources of the United States. U.S. Fish Wildl. Serv. Resour. Publ. 68, Washington, DC.

Strong. M. Personal communication. U.S. Bur. Land Manage. Lakewood, CO.

Swenk, M. H. 1917. Revisory notes on the list of the birds of Nebraska. Wilson Bull. 29:112-117.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36:126-135.

Thompson, S. P., C. D. Littlefield, and R. A. Ryder. 1979. Historical review and status of colonial nesting birds on Malheur National Wildlife Refuge, Oregon. Proc. 1979 Conf. Colonial Waterbird Group 3:156-164.

Tremblay, J., and L. Ellsion. 1979. Effects of human disturbance on breeding of black-crowned night herons. Auk 96:364-369.

Voeks, R., and S. English. 1981. White-faced ibis (Plegadis chihi). Population and distribution in the Western United States:1979-1980. U.S. Fish Wildl. Serv., Reg. 1, Portland, OR.

WOOD DUCK (Aix sponsa)

by

William L. Lemons, Jr.
Oklahoma Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
Oklahoma State University
Stillwater, OK 74078

SPECIES DESCRIPTION

The wood duck (Aix sponsa) is one of North America's most colorful birds. The male's unmistakable breeding plumage consists of mostly iridescent colors on the sides and crown of its strongly crested head. Its brightly patterned bill is black, white and red, it has a white throat, a white line from its red eye to the tip of the crest, and a thinner white line from the base of the bill to the tip of the crest. The drake's back and upper wing are mostly iridescent blue and green. Secondaries have narrow white tips and the primaries have a silvery white sheen on the outer vanes. The breast is maroon with white spotting; vertical black and white bars separate the breast from the vermiculated yellow flank which has narrow white and black markings at the upper edge. The bird's belly is white; the tail is iridescent greenish-black with brown, blackish, and maroon coverts; and the legs and feet are yellow. In eclipse plumage, males resemble females except that they retain the white cheek and throat pattern, and have a pinkish bill.

Females are mostly olive brown above with large white spots on the flanks and a white belly. The crest is greenish black and the face is gray. A large white eye ring extends posteriorly as an eye stripe, and the hen's throat is white. The wings resemble the male's with less iridescence and large white spots. The female's bill is blackish, eyes are brown, and legs and feet are yellow. Immature wood ducks resemble females with mottled brown bellies (Johnsgard 1978).

An adult wood duck is 43 to 51 cm long. A folded male wing is 250 to 285 mm while the female's wing is 208 to 230 mm. Males weigh 539 to 897 g (x = 680 g), and hens weigh 482 to 897 g (x = 539 g). Wood duck eggs average 52 by 44 mm and weigh 44 g (Johnsgard 1978).

DISTRIBUTION

In eastern North America, the wood duck ranges from eastern Canada to Mexico and Cuba, and from the Atlantic to the Texas panhandle. The Western segment of the wood duck population occupies a more limited range in the western portions of California, Oregon, and Washington, northern Idaho, and southwestern British Columbia (Bellrose 1980) (Fig. 8). The wood duck breeds throughout its range and winters in the South and in California.

Seasonal

Some wood ducks are year-round residents along the East coast from Connecticut to Florida, in the southern Mississippi Valley States, and in the Gulf Coast States.

Some wood ducks that breed in the northern portion of the range disperse rather than fly directly to the wintering grounds after the breeding season. Once migration is underway, waves of wood ducks move southward and cause temporary increases in local populations along their route. Migrants start south from Iowa in late September, and most have departed by November (Hein 1965). Fall migration begins in Massachusetts in September, and wood duck numbers peak in October. Few remain in early November (Grice and Rogers 1965). The wood duck population increases rapidly in North Carolina during late October, peaks in November, and decreases in late November and December; although a few winter residents remain (Hester and Quay 1961).

Migration Patterns

Bowers and Martin (1975) determined a pattern of band recoveries by grouping eastern United States populations of wood ducks into summer units composed of several States each. They identified six distinct units: Eastern Canada and New York, with 14% of the Eastern birds, the Northeastern unit with 14%, and the Southeastern unit with 19%, comprised the Atlantic flyway units. The Mississippi flyway was also divided into three breeding areas with the North Central unit containing 25% of the total summer population, the Lake States 10%, and the Southern unit 18%. Overall totals were 52% in the Mississippi flyway, 38% in the Atlantic flyway, and 10% in Canada.

DIET

The wood duck diet changes with age and season. Ducklings rely heavily on animal foods, especially during their first week, then shift to plants at 2 to 3 weeks. In Tennessee, tubers from fennelleaf (sago) pondweed (*Potamogeten pectinatus*), curlyleaf pondweed (*P. crispus*), waterstar mudplantain (water stargrass) (*Heteranthera dubia*), and drupes from wild black cherry (*Prunus avium*) trees composed 80% of the total volume of all foods consumed by ducklings. Invertebrates consumed by ducklings were mainly insects from the orders Diptera, Coleoptera, Odonata, and Lepidoptera (Hocutt and Dimmick 1971). Wild ducklings require a high volume of invertebrates (Johnson 1971). Baker (1971) observed that duckling diets consisted of 85% animal food, mostly invertebrates and small fish.

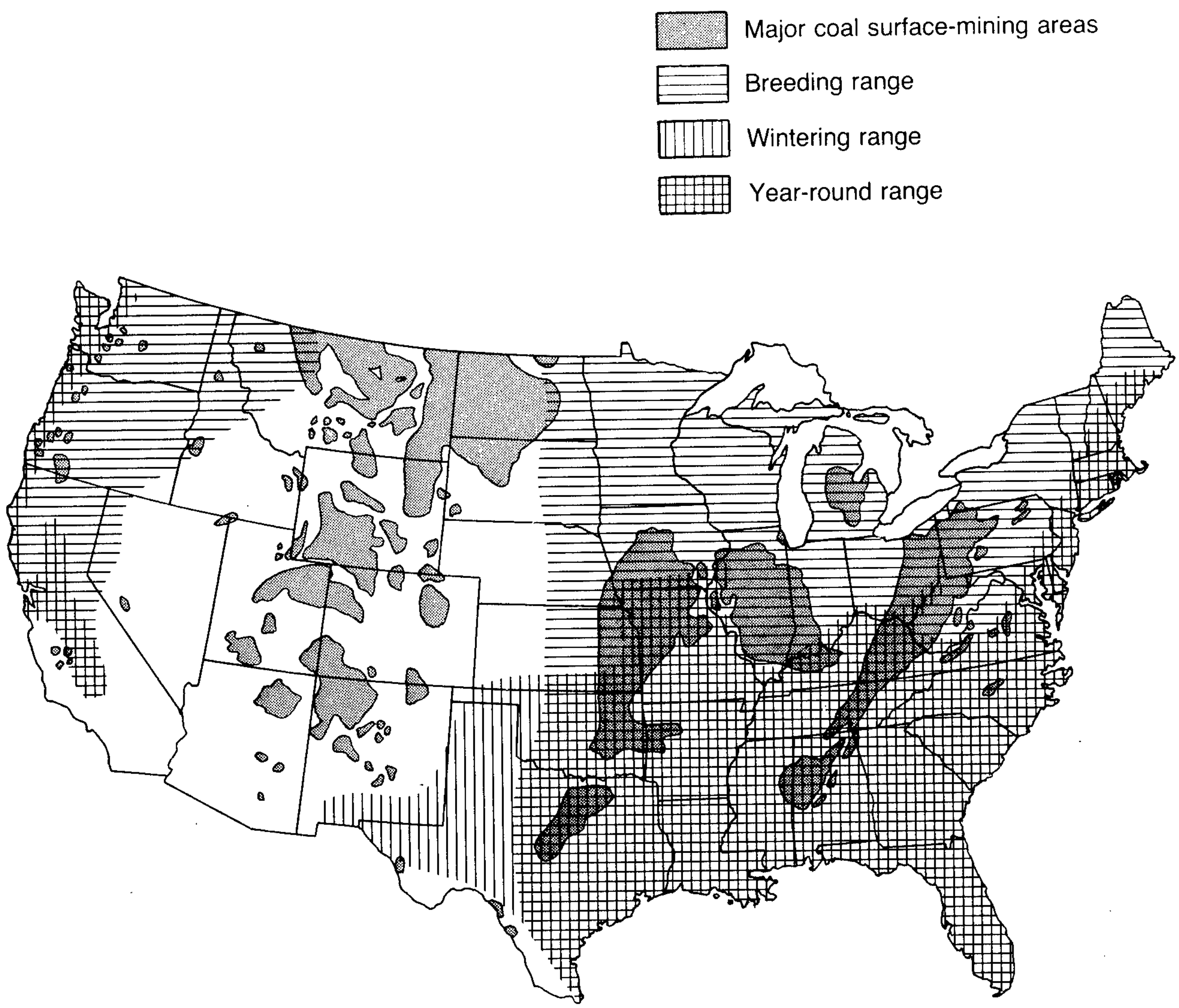


Figure 8. Geographical range of the wood duck in relation to major coal deposits in the United States. After Inkley and Raley (1983).

Breeding female wood ducks require different diets during the breeding season. The energy costs of egg laying and incubation are supplemented by changes in diet. They meet the protein requirements of egg laying by consuming large volumes of invertebrates. The other nutritional needs of hens are met by stored body fat. During incubation, hens return to a more vegetarian diet of 58% plant matter to meet energy needs (Drobney 1980).

The crops of wood ducks taken in South Carolina during the fall contained primarily mast (98% by volume) from the following plants: water oak (Quercus nigra); pin oak (Q. palustris); baldcypress (Taxodium sp.); sweetgum (Liquidambar sp.); water hickory (Carya aquatica); and corn (Zea mays). Ash (Fraxinus sp.), green hawthorne (Crataegus viridis), and American hornbean (Carpinus caroliniana) were also important (McGilvrey 1966).

In southeastern Missouri, the diets of hens during three stages of the breeding season consisted of the following proportions of invertebrates: prelaying, 54%; laying, 79%; and postlaying, 43%. Breeding males ate a diet of 34% invertebrates. Females not only ate more invertebrates, but also consumed a larger diversity, including more aquatic types. In the fall, hens ate 81% nonaquatic invertebrates, while 51% aquatic or 22% aquatic-associated invertebrates were included in their spring diet. The diets of drakes and hens were similar in the fall (Drobney and Fredrickson 1979). Stewart (1967a) observed that wood ducks tended to be opportunistic feeders as they ate to the capacity of their crops in corn-baited traps.

Feeding Habitat

The need for protein in the diets of breeding hens and ducklings requires a habitat rich in invertebrates (Baker 1971; Hocutt and Dimmick 1971; Johnson 1971; Drobney 1980). Wood ducks are visually oriented feeders and specialize in pecking rather than straining. They favor clear water for foraging (Haramis 1975). Grice and Rogers (1965) reported several sightings of wood duck broods dashing after prey on the surface of the water, jumping to pick insects from plants, and picking organisms from the blanket of duckweed (Lemna sp.) on the marsh. The diet of incubating hens and ducklings over 2 weeks old consists of emergent vegetation (Hocutt and Dimmick 1971; Drobney 1980).

After the nesting season, wood ducks favor flooded oak flats which cover most of their fall and winter range. They search for acorns in the forest floor litter or pick nuts before they fall (Brakage 1966).

Roosting Habitat

Hein (1962) observed wood duck roosts in areas of emergent vegetation that were open enough for movement on the water, and where the water was less than 1.3 m deep. He could not determine why some areas were chosen from blocks of seemingly similar habitat, nor could he determine a rule for roost distribution along the Mississippi River.

Suitable roosting habitat is limited and wood ducks are reluctant to leave it even when pressured by hunters. The ducks approach the roosts by two or three paths at an altitude of about 70 m. They land in the open and swim to vegetation. Morning flights leave along the same routes used the evening before (Hein 1965). Wood ducks used the same roosts year after year (Hein 1962). One roost was reported to have been used for 35 years.

REPRODUCTION

Chronology

Wood duck reproductive activity begins on the wintering grounds where mating pairs are formed. Birds arrive at their breeding areas in groups of 6 to 12 which usually contain equal numbers of males and females. The search for a suitable nest site begins about a week after the first arrivals, and ends in 5 or 6 days with egg deposition (Hester and Quay 1961; Grice and Rogers 1965; Leopold 1966). Wood ducks do not establish territories and pairs move about freely. Female wood ducks have a high tendency to home to the area of their first next box, sometimes to the same nest box (Hester 1962; Beshears 1965) or to a different box in the vicinity (Grice and Rogers 1965).

The hens visit their nests daily, usually in the morning. They remain just long enough to lay one egg and cover the clutch with the available litter in the cavity. Wood ducks do not carry nesting material to their nests. After about half of the average clutch of 12 eggs is laid, the hen begins to add down to the nest until incubation starts.

Incubation usually starts after the last egg is laid, and takes approximately 30 days. During this time, the hen makes morning and evening feeding flights. The drake accompanies his mate to and from the feeding grounds until she remains too long on the nest. Then the pair bond is broken.

After the ducklings hatch, the hen broods them for about a day. Then, usually after her morning feeding flight, the hen calls her young from the nest. The ducklings jump and climb to the nest entrance and exit by jumping out to the ground or water below. The hen then moves her brood to suitable rearing habitat by water courses or by direct overland routes. She rears the brood until they are able to fly at about 5 weeks (Grice and Rogers 1965; Hardister et al. 1966a,b; Hepp and Hair 1977). Wood duck hens keep broods together by calling to the ducklings. They avoid predators by remaining in good cover throughout the day and by using open areas in the early mornings and late afternoons (Alexander 1971).

Wood ducks maximize their use of nesting habitat by parasitic egg laying (dump nesting). Grice and Rogers (1965) defined a dump nest to be any wood duck nest containing a clutch of more than 15 eggs. Dump nesting is more prevalent in early than in late nests. Although small dump nests are often incubated, larger ones are frequently abandoned. Dump nesting results in increased production. Dump nesting may result from conflicts between adult hens and yearlings for the same nest sites; adult hens were more successful than yearling hens in competing for a nest site. Heusmann (1975) found that yearlings had smaller clutches and abandoned their nests more often; the survival of their young was lower than those of previous nesters.

Parasitic nesting in wood ducks is intraspecific. Bolen and Cain (1968) reported a wood duck hen incubating a clutch of nine wood duck eggs and four black-bellied whistling duck (Dendrocygna autumnalis) eggs. Mixed clutches of wood duck and hooded merganser (Lophodytes cucullatus) eggs incubated by either species are relatively common in southeastern Missouri (Armbruster pers. comm. 1983).

Wood ducks nesting in the southern part of the range occasionally successfully hatch and raise two broods (Baker 1971; Armbruster pers. comm. 1983).

Male wood ducks form post-breeding flocks after leaving their mates and move to secluded areas for molting. Females molt later after rearing the brood. After the molt, young and adult birds form premigratory flocks (Grice and Rogers 1965).

Reproduction Habitat

Wood ducks are among the few ducks that normally nest in tree cavities (Beckley 1965; Webster 1967). A typical wood duck nest is a hollow averaging 25 cm in diameter, with a bottom to support eggs, a top, and an entrance hole as small as 10 x 10 cm but averaging 15 x 20 cm (Hansen 1966).

Wood ducks usually choose cavities with small entrances which would be less likely to allow raccoons (Procyon lotor) to enter; the entrances are usually 16 meters or more above the ground (Weier 1966). Wood ducks also use cavities which have contained successful nests rather than those in which nests have been destroyed (Bellrose et al. 1964).

Cavity depth is directly related to the diameter at breast height (dbh) of the tree, cavity age, and rate of decay. Cavities with high rates of decay receive shorter use by wood ducks as the bottom recedes from the entrance too far for the ducklings to exit. The use of such cavities by wood ducks can be extended by woodpeckers and limb scar decay forming new entrances, and by squirrels (Sciurus spp.) and raccoons adding material to the cavity. At Mingo National Wildlife Refuge, elm (Ulmus spp.), ash, and maple (Acer spp.) trees were the greatest cavity producers, and all of the cavities used by wood ducks were in open areas (Weier 1966). In the Lake States, aspen (Populus sp.) may be important in providing natural cavities for wood ducks because of its high cavity-forming rate (Gilmer et al. 1978). Tree cavities used by wood ducks are located closer to water and canopy openings than cavities measured at random. Entrances are oriented more toward canopy openings and cavities are usually clustered in a stand rather than randomly distributed.

Leopold (1966) also noted the wood duck's preference for openness and tolerance of human activity. Wood ducks prefer nest boxes located in trees surrounded by mowed lawns though the boxes are within 6 m of houses. He felt wood ducks choose the boxes to avoid predators which they apparently fear more than humans.

Brood habitat must provide the physiological needs of food, loafing areas, and cover. It must also provide the psychological need for a sense of security and well being. In general, it consists of patches of cover among a network of open water passageways. The cover of herbaceous or woody plants and downed timber may occur in various combinations. Invertebrates and duckweed must be available for the young birds (Webster and McGilvrey 1966).

Food availability is important in breeding habitat. Overwintering seeds, plant parts, and invertebrates are necessary foods. Cover, consisting of shrubs or trees or both, should occur in a 50:50 ratio with open water. Trees or shrubs should overhang the water with a 60 cm clearance above the surface. Water should range between 8 cm and 1 m in depth with a flow of less than 4.8 km/h. Water should be present when migrants arrive, and persist through half of the incubation period. There should be 8.1 ha of trees of cavity-producing size and species for each 0.4 ha of breeding habitat. The trees need to be within 800 m of suitable rearing habitat. Usable cavities should occur at a rate of 1 for every 2 ha of woodland.

Brood habitat requires moderate to high water and high soil fertility in areas with a surface area larger than 4 ha. Edge should be maximized with 75% cover and 25% open water. Cover should consist of 55% emergent vegetation, 40% shrubs, and 5% trees and must supply overhead protection and allow horizontal movements of broods. Water must persist through the brood season at a depth up to 2 m, with 75% less than 1 m, and flow less than 1.6 km/h (McGilvrey 1968). Oedogonium and Spirogyra are undesirable because diving ducklings become entangled in these algae types and drown (Stewart 1967b).

Habitat most used by wood ducks are seasonally flooded wetlands, shrub swamps, and wooded swamps (Hawkins and Addy 1966). Impoundments which were flooded areas of timber and swamp shrubs receive the greatest wood duck use (Webster and McGilvrey 1966). Areas which had been cleared before flooding, but where growths of swamp shrubs and soft rush had developed, receive some use. Open water impoundments receive little or no use by broods.

Artificial nest structures may increase wood duck breeding populations. The success of their use depends upon the quality of habitat in which they are placed and how well they are guarded against predators (Webster 1967).

A breeding population, either wild or hand reared, must be present in an area intended for artificial nest structure use. Breeding colonies of wood ducks will not move to a new nesting area from 1.6 km away (Grice and Rogers 1965). Where nest boxes were erected near existing wood duck populations, the birds preferred the nest boxes to natural cavities (Strange et al. 1971). Artificial nest houses which were protected from predators increased wood duck numbers even in areas with abundant natural cavities (Bellrose et al. 1964). Pen-reared wood ducks imprinted to nest boxes in areas where little or no wood duck nesting had been reported returned to those areas to nest (Lane et al. 1968; Doty and Kruse 1972; McGilvrey 1972). Capen et al. (1974) established a breeding population of wood ducks by transplanting wild broods to a previously unused area.

Loafing Habitat

The presence of loafing sites is a psychological need of wood ducks (Webster and McGilvrey 1966). Loafing sites must be at least 45 x 45 cm and 5 to 15 cm above the water. There should be two to five sites per ha, and the sites must be near readily available escape cover. The sites may be formed by piles of debris created by downed timber (Webster and McGilvrey 1966; McGilvrey 1968).

POPULATION TRENDS

The wood duck population was at a dangerously low level in the early 1900's, due to the lack of harvest regulations. The population was allowed to recover after the passage of the Federal Migratory Bird Act in 1918 which gave wood ducks complete protection. A closed season on wood ducks was enacted until 1941, when 15 States allowed them to be taken. The remaining States opened seasons on wood ducks in 1942.

Wood ducks increased to the saturation point of natural nest cavities by 1939, when nest boxes were first used. Birds used 52% of available nest boxes in 1939; use increased to 65% by 1942. Wood ducks suffered a setback in numbers in the early 1950's. As a result, the season on wood ducks was closed in the Mississippi flyway in 1955. A one-duck bag limit was set for wood ducks that year, but the season was closed nationwide again in 1956. It remained closed in some states until 1958, when one wood duck was allowed in the daily bag of Mississippi flyway hunters. The harvest ran under 165,000 until 1963 when 371,000 were taken. The average annual harvest of wood ducks in the Mississippi flyway from 1964 to 1974 was 505,000. The increase in the bag limit to two wood ducks in 1963 partially accounts for the increase in harvest in later years. The increased bag limit also indicates the rapid recovery of the wood duck after the season was closed in 1956.

Wood ducks have been able to sustain an annual kill of 500,000 in the Mississippi flyway and 225,000 in the Atlantic flyway, apparently without jeopardizing its population status. From 1963 to 1974, the wood duck comprised 11% of the duck hunters' bag in the Mississippi flyway and ranked as the second most important duck for 9 years and third for 3 years. The wood duck made up 15% of the duck bag in the Atlantic flyway from 1963 to 1974, ranking second in 4 years and third in 8 years.

The greatest threat to the wood duck population is loss of habitat. The birds have been able to increase in numbers after declines because they can produce large clutches, frequently renest, use dump nesting to increase productivity, and are the only species of North American waterfowl known to successfully raise two broods to flight stage in one season. Also, no other species of waterfowl is capable of expanding into the range and habitat occupied by wood ducks (Bellrose 1976). The wood duck population is in generally excellent condition (Johnsgard 1978). Bellrose (1980) proposed that, due to habitat destruction, the wood duck population may be declining so slightly each year as to be imperceptible in the imprecise population data available.

The California segment of the population of wood ducks began to decline at the turn of the century until protected. The hunting season for wood ducks closed until 1941, when a one-duck limit was set. The major causes for the duck decline were overhunting and habitat destruction brought about by dredging for gold and cutting mature oaks (*Quercus* sp.), willows (*Salix* sp.), and sycamores (*Platanus* sp.). A nest box program was also initiated for the California population (Naylor 1962).

Ontario wood ducks have shown a great increase in numbers over the past 50 years. The population was believed to have increased until the 1960's. The estimated population and harvest decreased during the hunting seasons of 1967-1968 and 1969-1970.

Wood duck production was greater than or equal to deaths from 1954-1963. The mortality rate was 0.82 for immatures and 0.41 for adults. The adult rate rose to 0.56 in 1966, due mainly to hunting harvests.

Effects of Habitat Change

The availability of nesting sites has often been documented as limiting wood duck production. Loss of habitat accompanied the settlement of the U.S., as forests were cleared to rivers' edges; bluffs, swamps and lowlands were drained; and crops were planted (Stearns 1966). Although the wood duck has made a dramatic recovery from critically low numbers, the bird's numbers will never return to the pre-1900 abundance because of swamp drainage and the clearing of bottomland timber (Bellrose 1976). Breeding habitat destruction has been too enormous.

Habitat changes varied in different sections of the U.S. In the southeastern States, wood duck habitat was lost directly or indirectly due to draining, clearing, flood control, pollution, and intensive forest management (Hankla and Carter 1966).

Clearing and draining in the north-central forests led to flooding and silt deposition which scoured logs, debris, and vegetation from the rivers. Presettlement succession of lowland forests was halted by disturbances such as fire, wind, and flood. Succession is now allowed to continue. Rapid changes in forests have resulted from infestations of Dutch elm disease (Stearns 1966).

Perhaps the greatest boon to wood duck production was the introduction of nest boxes. They have increased the breeding populations of wood ducks in many areas. Problems with increased concentrations of breeding wood ducks have been observed, including the concentration of predators, dump nesting, nest abandonment, and competition for nest boxes (interspecific and intraspecific) (Naylor 1962; Grice and Rogers 1965; Jones and Leopold 1967; Haramis 1975). Some nest box programs were a waste of money and effort (Naylor 1962).

Effects of Human Disturbance

Wood ducks are relatively tolerant of human presence, and will nest near houses and human activity. Females may abandon nests if disturbed early in the nesting cycle. Harassment of adults or broods by boaters may affect productivity levels. Human disturbance is generally most detrimental because of man-induced habitat disturbances, e.g., loss of nest sites or drainage of wetlands.

Management

Waterfowl managers have successfully increased the numbers of breeding wood ducks in many areas by erecting artificial nest structures. Bellrose recommended the use of rectangle boxes 30.5 x 38.1 x 60.9 cm with a 7.6 x 10.2 cm elliptical entrance. The entrance should be protected by a metal mask to keep predators from enlarging it by gnawing. The box must contain 10.2 to 12.7 cm of nesting material (sawdust and/or wood shavings). The box should be made of cypress or Wolmanized pressure-treated wood and the mask of galvanized metal. The box should be mounted on live or solid dead trees in shallow water, 1.8 to 4.6 m above the surface (Beshears 1963).

Various devices have been used to deter predators from wood duck nest boxes. In Delaware, boxes with face plates received the most use (54%). Boxes with wooden funnels were used the least, possibly because they received the greatest use by starlings (42%). Half of the boxes with no control devices were used by wood ducks, 33% were occupied by raccoons, and three more showed signs of raccoon use. No boxes with control devices were occupied by raccoons, but signs of attempted entry were found on three with funnels and two with face plates (Handley 1962). At Patuxent and Eastern Neck National Wildlife Refuges in Maryland, McGilvrey and Uhler (1971) observed that starlings used both horizontal and vertical nest boxes, but preferred horizontal ones with 7.6 x 10.2 cm entrance holes. However, increasing the entrance to 7.6 x 27.9 cm deterred starlings and not wood ducks. Openings at both ends deterred both. Wood ducks accepted both horizontal and vertical nest boxes, but preferred vertical ones. Starlings preferred open impoundments to wooded areas; wood ducks showed no preference. Purple martins (*Progne subis*) and great crested flycatchers (*Myiarchus crinitus*) used horizontal nest boxes, but nested after wood ducks, and therefore did not compete with the ducks.

Nest boxes can do more harm than good if predators destroy eggs of wood ducks attracted to the boxes. The boxes must be properly maintained. Durable, predator-proof nest structures placed in carefully selected sites are more productive and worth the extra money and effort. Only a few nest boxes should be erected until acceptance by wood ducks is determined. More boxes can be added as needed to avoid waste. Deep structures mounted as close to vertical as possible or with a slight forward tilt should be used (Webster 1967). Nesting material (sawdust or wood shavings) should be checked and added as needed each year.

Habitat can also be managed to improve wood duck numbers. Mast production can be improved by selective thinning and flooding stands of hardwoods during the dormant season (Brakage 1966). Growing millet provides food for wood ducks in years of poor mast crops. Seasonal flooding of green timber impoundments retarded seedling regeneration, but enhanced the attractiveness and utility of bottomland forests for wood ducks, and allowed maximum use of early appearing invertebrates in vernal pools (Haramis 1975).

The Wood Duck as an Indicator Species

The wood duck may serve as an indicator of good water quality and a healthy wetland ecosystem. The presence of breeding wood ducks may also indicate the presence of mature forests and diverse emergent vegetation, although nonbreeding wood ducks may use wetland areas not suitable as breeding habitat.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in rivers, lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversion for a transport system; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). A problem in many eastern surface mine areas has been the generation of toxic pyrites, causing acidification and sterility of streams and ponds (Spaulding and Ogden 1968). Acid drainage is normally not a problem in the West because alkaline soils cause drainage to be neutral or slightly basic (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas.

Loss of habitat poses the greatest threat to wood duck populations (Bellrose 1976). Surface mining for coal necessitates habitat destruction by removal of overburden and accentuates this threat. Habitat losses due to surface coal mining anticipated to have the greatest negative impact on the wood duck are loss of natural breeding sites, loss of suitable brood habitat, and loss or reduction in food supply. Loss of habitat will result in wood ducks being displaced. Displaced wood ducks will most likely not breed since nesting sites are limited. The loss of nesting sites, brood habitat, or food supply will most likely result in a decrease in the breeding population. Increased use of wetlands for boating or fishing by the increased numbers of people in the vicinity may result in increased duckling mortality through harassment or disturbance, and thus a lowered productivity level.

Increased surface mining could negatively impact wood ducks by expanding into their breeding areas and removing cavity-bearing trees (natural nesting sites) and vegetation essential for brood rearing and food supply. Surface mining could further impact wood ducks if hydrology is significantly affected by deteriorating stream quality, degrading or eliminating aquatic life, lowering the water table, and contaminating aquifers (Rusincovitch 1979). Indirect impacts such as noise and human activity probably would not significantly affect the use of nesting areas by wood ducks (Hein 1962; Leopold 1966; Cunningham 1968) unless human activity included harassment or illegal shooting. The extent of the negative effects of surface coal mining depends on the location and size of the area involved in the mining activity and the time necessary to reclaim the disturbed land.

Most of the wood duck's range (it breeds throughout its range) is located east of the Mississippi River (Fig. 8). Approximately 29% of the nation's surface-minable coal reserves also occur east of the Mississippi River. Much of these coal reserves are in areas classified by Bellrose (1980) as having low or sparse breeding populations; however, large deposits also coincide with medium and high breeding populations along the Mississippi River. The breeding population in the Western States would be proportionally less threatened. In 1977, the U.S. Bureau of Mines considered California's coal deposits insufficient to be included in the reserve base (Rusincovitch 1979). Some of Washington's high and medium wood duck breeding populations occupy areas with surface-minable coal deposits, and a small portion of Oregon's sparse breeding population is located in a surface-minable coal area.

Thick horizontal seams of low sulfur coal beneath large tracts of relatively flat land in the West, i.e., Rocky Mountain and Northern Great Plains regions, have led to the emergence of Western surface mines as the major coal suppliers in the U.S. (Rusincovitch 1979). This area, fortunately, is not in the range of the wood duck. However, Eastern coal producers are still active. For example, the Corn Belt States (Illinois, Indiana, Iowa, Missouri, and Ohio) which contain a portion of the medium and high wood duck breeding population, supplied 21% of the nation's coal production in 1975. Sixty-six percent of this came from surface mines. The wood duck seems to have at least tolerated this surface mining activity because numbers seem to be stable, if not declining at an imperceptible rate (Bellrose 1980; Johnsgard 1978), and are high enough to afford hunters a good harvest (Bellrose 1976).

The nation's constantly increasing demand for energy, plus federally legislated incentives (Powerplant and Industrial Fuels Act of 1978), point toward increased coal production nationwide. The lessened restrictions on high sulfur coal production (1977 Clean Air Act Amendment) add further incentive to the recovery of Eastern coal reserves.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys for breeding and migrating wood ducks should be conducted prior to mining activities to determine the extent of local populations and their habitat use. Establishment of nest boxes in adjoining habitat that will not be affected by mining activities (if available) may allow local breeding hens to become accustomed to nest boxes.

Exploration, Mine Development, and Mining Phase

Exploration activities will have little impact on wood ducks if workers are instructed to avoid nesting and brood-rearing areas whenever possible.

Control of byproducts and runoff may prevent degradation of local water sources. Assuming that woodland streams and wetlands are not disturbed by reduced surface water, contamination, reduced invertebrate abundance, and reduced emergent vegetation, the negative impact of removing cavity-bearing trees might be countered by initiating nest box programs in the affected areas. Since wood ducks usually nest within 0.8 km of permanent water (Grice and Rogers 1965) and seldom farther than 1.6 km (Bellrose 1980), a buffer zone around the habitual nesting and rearing areas could possibly alleviate direct impacts of surface coal mining.

Reclamation Phase

Although the state of the art of reclaiming surface-mined land can potentially allow restoration of disturbed land in 10 to 15 years after mining (Bernard 1979), a considerably longer time is required for trees to reach cavity-bearing size. Creation of wetlands containing emergent vegetation and shrubs, such as buttonbush, in conjunction with a nest box program may provide marginal habitat suitable to support a small population of wood ducks. Planting millet or other grains such as corn and wheat may help to mitigate the loss of mast resources (Brakage 1966; Stewart 1967a; Bellrose 1980). These actions would be costly (construction materials, farming machinery, seed, etc.) and require intensive management efforts (erection and maintenance of nest boxes, maintenance of farm machinery, planting, wood duck censusing, etc.) over an extended period of time.

SUMMARY

The wood duck neared extinction at the turn of the century due to overhunting for sport and commercialization of its plumage. The wood duck population has recovered remarkably well as a result of protection and intensive waterfowl management. The wood duck ranges from southern Canada to the Gulf of Mexico, mostly east of the Mississippi River, with a smaller range along the Pacific coast. The birds normally nest in tree cavities, but they have also shown acceptance of artificial nest structures. Nest boxes must be maintained, sufficiently guarded against predators, and placed near areas of suitable brood habitat. Wood ducks feed on invertebrates, mast, and grain in varying amounts dependent on age and breeding status. Surface mining has apparently not affected the wood duck population so far, but future expansion of Eastern coal mining operations may destroy portions of the wood duck's major breeding habitat. Anticipated negative impacts are loss of brood rearing habitat, loss of nesting habitat, and reduction in food supply. Reclamation of wetlands in conjunction with a nest box program and plantings of grain may provide marginal habitat for wood ducks prior to reestablishment of natural habitat.

REFERENCES

Alexander, H. L., Jr. 1971. Mallard and wood duck brood survival at Remington Farms, Chestertown, Maryland, 1968-1969. Trans. NE Sect. Wildl. Soc., Northeast Fish Wildl. Conf. 28:221-230.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press. Lawrence, KS. 877 pp.

Armbruster, J. 1983. Personal communication. U.S. Fish and Wildlife Service, Western Energy and Land Use Team, 2627 Redwing Rd., Ft. Collins, CO.

Baker, J. L. 1971. Wood duck (Aix sponsa) production from nest boxes and brood studies on the Noxubee National Wildlife Refuge. Ph.D. Thesis, Mississippi State Univ., Mississippi State. 55 pp.

Beckley, O. E. 1965. Wood duck nesting box program. Ten year report. Connecticut Wildl. Conserv. Bull. 11:1-6.

Bellrose, F. C. 1976. The comeback of the wood duck. Wildl. Soc. Bull. 4:107-110.

_____________. 1980. Ducks, geese, and swans of North America. Stackpole Books. Pages 177-194.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers. 1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Manage. 28:661-676.

Bernard, D. P. 1979. Prime farmland disturbance from coal surface mining in the corn belt, 1980-2000. U.S. Dept. Energy, Argonne National Lab. Publ. ES-70. 47 pp.

Beshears, W. W., Jr. 1963. Practice conservation in action, start a wood duck housing project. Alabama Conserv. 33:8-9, 23, 25.

________________. 1965. Alabama wood ducks show strong tendancy toward returning to same nesting, rearing area. Alabama Conserv. 35:11-13.

Bolen, E. G., and B. W. Cain. 1968. Mixed wood duck-tree duck clutch in Texas. Condor 7:389-390.

Bowers, E. F., and F. W. Martin. 1975. Managing wood ducks by population units. Trans. N. Am. Wildl. Nat. Resour. Conf. 40:300-324.

Brakage, C. K. 1966. Management of mast crops for wood ducks. Pages 75-80 in J. B. Trefethen (ed.). Wood duck management and research. Wildl. Manage. Inst.

Capen, D. E., W. J. Crenshaw, and M. W. Coulter. 1974. Establishing breeding populations of wood ducks by relocating wild broods. J. Wildl. Manage. 38:253-256.

Cunningham, E. R. 1968. A three year study of the wood duck on the Yazoo National Wildlife Refuge. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:145-155.

Doty, H. A., and A. D. Kruse. 1972. Techniques for establishing local breeding populations of wood ducks. J. Wildl. Manage. 36:428-435.

Drobney, R. D. 1980. Reproductive bioenergetics of wood ducks. Auk 97:480-490.

Drobney, R. D., and L. H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. J. Wildl. Manage. 43:109-120.

Gilmer, D. S. I. J. Ball, L. M. Cowardin, J. E. Mathisen, and J. E. Riechmann. 1978. Natural cavities used by wood ducks in north-central Minnesota. J. Wildl. Manage. 42:288-298.

Grice, D., and J. P. Rogers. 1965. The wood duck in Massachusetts. Mass. Div. Fish Game, Final Rep. P-R Proj. W-19-R. 96 pp.

Handley, D. E. 1962. Wood duck nest box checks, 1960. Game Res. Ohio 1:76-79.

Hankla, D. J., and V. E. Carter. 1966. Impact of forest management on northern wood duck habitat. Pages 29-36 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

Hansen, H. L. 1966. Silvical characteristics of tree species related to cavities. Pages 64-65 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

Haramis, G. M. 1975. Wood duck (Aix sponsa) ecology and management within the green-timber impoundments at Montezuma National Wildlife Refuge. M.S. Thesis, Cornell Univ., Ithaca, NY. 153 pp.

Hardister, J. P., F. E. Hester, and T. L. Quay. 1966a. Life history and management of the wood duck, Part 1. Wildl. N.C. 30:10-12.

________. 1966b. Life history and management of the wood duck, Part 2. Wildl. N.C. 30:20-23, 30-31.

Hawkins, A. S., and C. E. Addy. 1966. Problems of flyway-wide appraisal of wood duck habitat. Pages 45-51 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

Hein, D. A. 1962. Roosting flight counts as indices to fall wood duck populations in Iowa. M.S. Thesis, Iowa State Univ., Ames. 14 pp.

________. 1965. Wood duck roosting flight phenomena. Ph.D. Thesis, Iowa State Univ., Ames. 203 pp.

Hepp, G. R., and J. D. Hair. 1977. Wood duck brood mobility and utilization of beaver pond habitats. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 31:216-225.

Hester, F. E. 1962. Survival, nesting, and return of adult wood ducks to previously used nest boxes. Proc. Southeastern Assoc. Game Fish Comm. 16:67-70.

Hester, F. E., and T. L. Quay. 1961. A three year study of the fall migration and roosting-flight habits of the wood duck in east-central North Carolina. Proc. Southeastern Assoc. Game Fish Comm. 15:55-60.

Heusmann, H. W. 1975. Several aspects of the nesting biology of yearling wood ducks. J. Wildl. Manage. 39:503-507.

Hocutt, G. E., and R. W. Dimmick. 1971. Summer food habits of juvenile wood ducks in Tennessee. J. Wildl. Manage. 35:296-292.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Johnson, N. F. 1971. Effects of levels of dietary proteins on wood duck growth. J. Wildl. Manage. 35:798-802.

Johnsgard, P. A. 1978. Ducks, geese, and swans of the world. Univ. Nebraska Press. 404 pp.

Jones, R. E., and A. S. Leopold. 1967. Nesting interference in a dense population of wood ducks. J. Wildl. Manage. 31:221-228.

Lane, P. W., G. W. Bond, Jr., and W. H. Julian, Jr. 1968. Wood duck production and transplants on National Wildlife Refuges in the South Atlantic states. Proc. Southeastern Assoc. Game Fish Comm. 22:202-208.

Leopold, F. 1966. Experiences with home-grown wood ducks. Pages 113-123 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

McGilvrey, F. B. 1966. Fall food habits of wood ducks from Lake Marion, South Carolina. J. Wildl. Manage. 30:193-195.

_______________. 1968. A guide to wood duck production habitat requirements. U.S. Bur. Sport Fish. and Wildl. Resour. Publ. 60. 32 pp.

_______________. 1972. Increasing a wood duck nesting population by releases of pen-reared birds. Proc. Southeastern Assoc. Game Fish Comm. 25:202-206.

McGilvrey, F. B., and F. M. Uhler. 1971. A starling-deterrent wood duck nest box. J. Wildl. Manage. 35:793-797.

Moore, R., and T. Mills. 1977. An environmental guide to western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Naylor, A. E. 1962. Wood ducks and nest boxes. California Dept. Fish Game Manage. Leaflet 6. 8 pp.

Rusincovitch, F. 1979. Environmental impact assessment guidelines for new source surface coal mines. EPA-130/6-79-005 U.S. Environ. Protect. Agency, Office of Environ. Review, Washington, DC.

Spaulding, W. M., Jr., and R. Ogden. 1968. Effects of surface mining on the wildlife resources of the United States. U.S. Bur. Sport Fish. Wildl. Resour. Publ. 68, Washington, DC.

Stearns, F. 1966. Present and future status of forests of the north central forests. Pages 5-22 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

Stewart, P. A. 1967a. Disgorging of food by wood ducks. Wilson Bull. 79:339-340.

__________. 1967b. Diving wood duck ducklings entangled in filamentous algae. Condor 69:531.

Strange, T. H., E. R. Cunningham, and J. W. Goertz. 1971. Use of nest boxes by wood ducks in Mississippi. J. Wildl. Manage. 35:786-793.

Webster, C. G. 1967. Improved nest structures for wood ducks. Mod. Game Breeding 3:9-13, 28-36.

Webster, C. G., and F. B. McGilvrey. 1966. Providing brood habitat for wood ducks. Pages 70-74 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

Weier, R. W. 1966. Survey of wood duck nest sites on Mingo Wildlife Refuge. Pages 91-108 in J. B. Trefethen, ed. Wood duck management and research. Wildl. Manage. Inst., Washington, DC.

COOPER'S HAWK (*Accipiter cooperii*)

by

Mark R. Fuller
and
Janet R. Partelow
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The Cooper's hawk (*Accipiter cooperii*) is a raptor of moderate size; males are 385 to 425 mm long and females 435 to 480 mm long (Mueller et al. 1979). The wings are approximately 236 mm and 268 mm in length for males and females, respectively (Marsh and Storer 1981). Males weigh an average of 380 g and females weigh 561 g (Brown and Amadon 1968). The extent of the sexual size dimorphism and differences in measurements associated with age are detailed by Mueller et al. (1981).

The plumage of adult males includes a black crown with gray mantle, back, and upper wing coverts. The plumage of the adult female is similar to the male except that the female has more brown on the back than the male. The tops of the primaries are barred with gray and black, as is the tail, which has three black bands and a white terminal band. The underside of the wings is barred with gray and white, and the underside of the body is whitish and streaked with dusky shafts on the throat. The breast and flanks are marked with irregular bars of rufous brown. The plumage of immature birds up to about 1 year of age includes a brownish back, paler barring on the tail, and many dusky streaks on the underside. The thighs are obscurely streaked with brown.

The cere of adults is greenish-yellow, the bill bluish-black and the legs deep lemon yellow; the soft parts of young birds are paler than those of the adults (Brown and Amadon 1968; Baird et al. 1905; Bent 1937; Meng 1951; Jones 1979). The eye color of nestling Cooper's hawks is gray, changing to yellow, then to light orange in young adults, and gradually to orange-red and, ultimately, red as the birds grow older. The rate of change is more rapid in males (Snyder and Snyder 1974) and can be used to some degree to age birds (Mueller et al. 1981).

Field identification of Cooper's hawks can be difficult because they are intermediate in size between the smaller sharp-shinned hawk and the larger goshawk. Characteristics used to distinguish Cooper's hawks from these two similar species are the relatively longer and more rounded tail of the Cooper's hawk, its shorter wings, and its proportionately larger head (Mueller et al. 1979). Also, the black cap on the head and the white terminal band on the tail are useful as field marks (Clark and Dunne 1979).

In addition to these characteristics, some behavioral patterns exhibited during the breeding season may be useful for identifying Cooper's hawks and locating their nest sites. Displays of soaring, diving, and slow chasing during which the whitish undertail coverts are spread may be observed during courtship flights (Beebe 1974). In addition, vocalizations consisting of 12 to 15 loud "clucks" and "chucks" may be given (the female has a lower voice). Slow circling flights during which the wings are brought over the back, as in the flight of nighthawks, also occur during courtship (Berger 1957; Fitch 1958). Adults may respond to intrusion into their territory or disturbance at the nest site by vocalizing.

An imitation or broadcast of the defensive call or food begging call of Cooper's hawks or the imitation of the hoot of a great horned owl (Miller 1955) has been used to elicit the response of adults, especially late in the breeding cycle (Hennessey 1978). These "defensive" calls of Cooper's hawks are described as a staccato "ca ca ca ca" (Brown and Amadon 1968), "kak kak kak", or "cuck cuck cuck" (Bent 1937). Young birds often emit a food begging call described as "tsee-ar" (Brown and Amadon 1968). Roadside counts conducted in forested habitats in the East detected Cooper's hawks more often after a defense call had been broadcast than by simply looking and listening for birds. The most frequent responses occur prior to the onset of incubation, and after young have hatched (Fuller and Mosher 1981). Adults appear to be most aggressive and vocal during the first week after the young hatch (Janik 1980).

DISTRIBUTION

The breeding range of the Cooper's hawk extends across southern Canada (Smith 1957; Houston 1958; Dekker 1970; Beebe 1974) south through all of the contiguous United States and into northern Mexico (Miller 1955; Brown and Amadon 1968) and includes elevations from sea level to over 2680 m (Phillips et al. 1964; Reynolds 1975) (Fig. 9). Although the breeding range encompasses an extensive area, nesting may occur rarely or not at all in some parts of the range (e.g., Johnson 1965; Skaar 1969; Hubbard 1970; Oberholser 1974; Small 1974; Stewart 1975; Harris 1977).

Birds from the northern one-third to one-half of the breeding range are generally considered migratory, although Cooper's hawks have been observed in the winter in Canada (e.g., Bailey 1914; Beebe 1974) and in the northern States (e.g., Skaar 1969). Birds begin to arrive on wintering areas as early as August and may remain until May (Gullion et al. 1959). Wintering Cooper's hawks are apparently most common in southern States such as Florida (Grimes

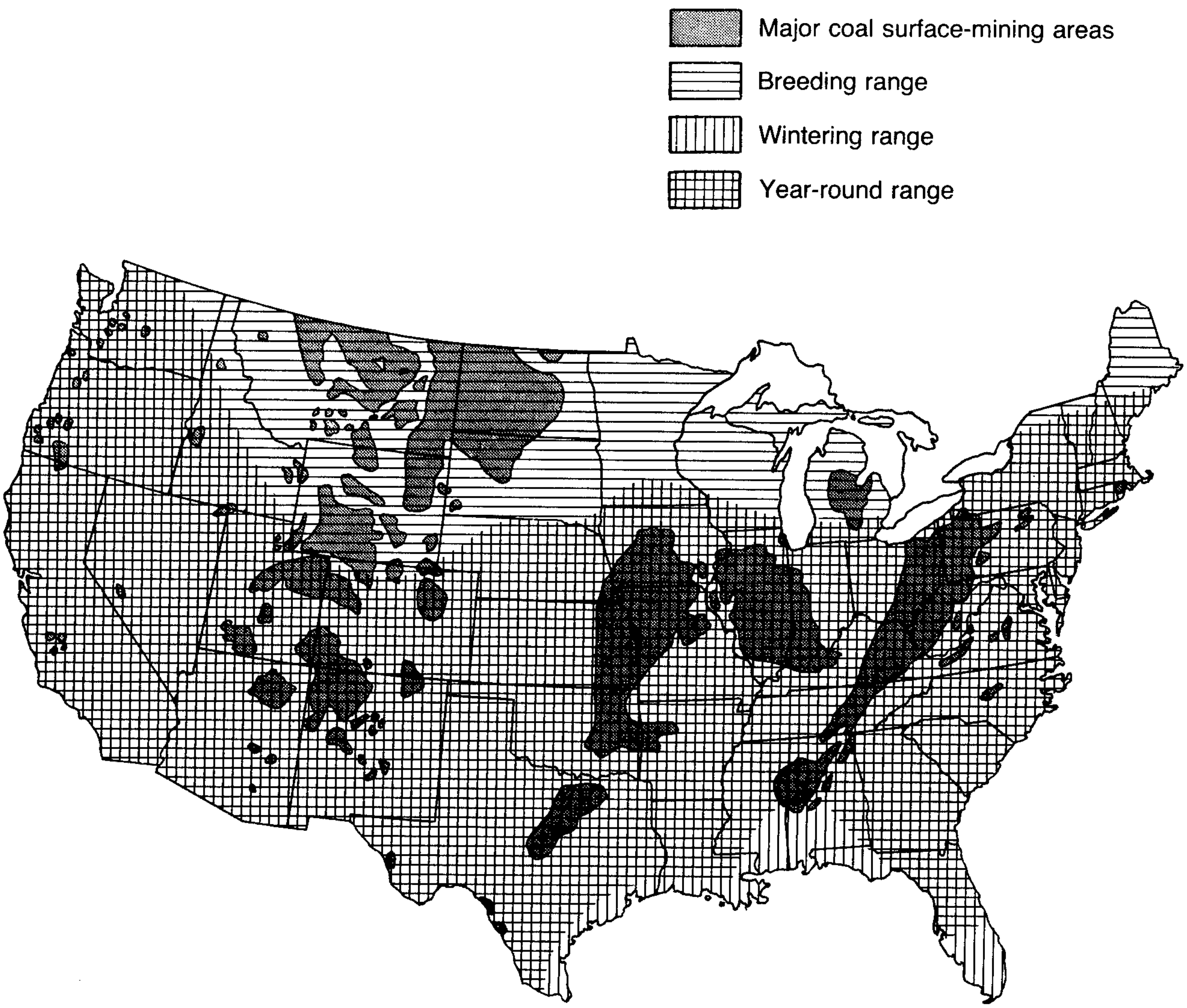


Figure 9. Geographical range of the Cooper's hawk in relation to coal deposits in the United States. After Inkley and Raley (1983).

1944), New Mexico (Bailey 1928), and Arizona (Phillips et al. 1964), but also occur as far south as Costa Rica (Slud 1964) and in Columbia (one record; Brown and Amadon 1968).

Generally, fall migration occurs from late August to early November with birds returning to the breeding areas from late March to mid-April (Bent 1937). Locations of migration routes and concentration areas in eastern North America are documented by Heintzelman (1975). Migration is more dispersed in the western portion of the range (e.g., Guillion et al. 1959; Andrle 1966).

DIET

Most investigations reveal that the majority of the diet of Cooper's hawks is composed of avian prey (Table 3). Small mammals, especially chipmunks (Tamias spp.), are also important as prey items (Pellett 1912; Hamerstrom and Hamerstrom 1951; Meng 1959; Janik 1980; Kennedy 1980; Lee 1981a). Reynolds (1979) characterized Oregon Cooper's hawks as "biomass maximizers" because they captured more animals of a large size than occurred porportionately in the environment (mean weight of prey 135 g). Similarly, males and females "avoided" the smaller categories of prey, preferring medium-sized prey, and females "selected" animals from larger prey categories, in a study by Kennedy (1980).

Cooper's hawks do utilize prey with a wide range of body sizes. Birds in a study in North Dakota and Ontario fed largely on prey weighing from 15 to 116 g (Storer 1966). Species the size of European starlings (Sturnus vulgaris), northern flickers (Colaptes auratus), meadowlarks (Sturnella spp.), and chipmunks are commonly taken (e.g., Meng 1959) and animals as large as ruffed grouse (Bonasa umbellus) and cottontail rabbits (Sylvilagus spp.) may also be included in the diet (Brown and Amadon 1968). The association of size of prey with body size of male and female Cooper's hawks has been investigated by several researchers who concluded that larger females capture larger prey more often than do males (Storer 1966; Reynolds 1972; Snyder and Wiley 1976; Kennedy 1980).

Cooper's hawks usually utilize concealment and surprise to capture prey (Beebe 1974) and hunt in areas providing enough cover in which to "hide", yet open enough to see prey, maneuver, and allow a short pursuit and capture before the prey gains cover. The hawk hunts from a perch or while in flight and pursues prey into bushes or may stalk prey on the ground and attempt to flush potential victims from cover (Bent 1937; Smith 1963; Brown and Amadon 1968). These tactics are often used at forest edges (Meng 1951; Craighead and Craighead 1956), but the hawk also hunts in open understory and among understory shrubs in the forest, or in openings in wet areas (e.g., Brimley 1889). On a few occasions, Cooper's hawks have been observed to strike prey high in the air over open habitat, such as fields (Mead 1963; Clark 1977).

Few data are available concerning the distance over which the hawks will range to obtain prey, but Fitch (1958) observed that males foraged at least 1.2 km from the nest and Brown and Amadon (1968) reported hunting about 3.2 km

Table 3. Food habits of Cooper's hawks (values are percent occurrence).

Locality	Source	Birds	Mammals	Reptiles and Amphibians	Insects	Other	Reference
Range-wide	Stomach	66.8	22.2	8.9	2.1		Snyder and Wiley 1976
Range-wide	Stomach[a]	54.0	15.0			3	May 1935
Range-wide	Stomach[b]	64.0	33.0	10	10		Duncan 1966
New York	Nest	82.0	18.0				Meng 1959
Pennsylvania	Stomach[c]	71.4	28.6				McDowell 1941
Maryland	Nest	30.0	70.0				Janik 1980
Michigan 1942	Nest	87.7	6.8				Craighead and Craighead 1956
Michigan 1948	Nest and tethered young	72.0	11.8				
Michigan	Nest and tethered young	84.4	15.6				Hamerstrom and Hamerstrom 1951
New Mexico/ Arizona	Nest	56.5	29.5	13.9			Snyder and Wiley 1976
Wyoming	Nest and tethered young	73.4	26.5				Craighead and Craighead 1956
Utah	Nest	70.0	30.0				Lee 1981a
California	Nest	26.0					Fitch et al. 1946
Western Oregon	Nest	49.0	53.0	68.0			Reynolds 1979
Eastern Oregon	Nest	72.0	26.0				Reynolds 1979
Washington	Nest	90.4	9.6				Kennedy 1980

[a]Miscellaneous, other vertebrates, and insects combined.

[b]30% of the stomachs were empty.

[c]Proportions of stomachs which contained prey in each category.

from the nest. In a Michigan study, hawks nesting in a forest reserve hunted 0.8 to 1.2 km away on farmlands where they captured abundant house sparrows (*Passer domesticus*) and starlings (Hamerstrom and Hamerstrom 1951).

REPRODUCTION

The peak of spring migration by Cooper's hawks occurs during the last 2 weeks of March (Jones 1979). The exact dates of arrival and departure from breeding areas may be difficult to assess because in many areas migrants or wintering birds may mix with breeding birds. In addition, factors such as latitude, weather, and abundance of prey may influence the arrival of birds on breeding areas. Most courtship and nest building occurs during March and April, although breeding behavior has been recorded as early as February and as late as May (Table 4). Egg laying usually occurs in late April or May. Clutches were started 2 weeks earlier in southern California than in the central part of the State (Asay 1980), and Snyder and Wiley (1976) correlated later egg laying with higher elevation in the Southwest. In years of drought, egg laying may be postponed by a week or so (Asay 1980; Janik 1980). Such was the case in Arizona and New Mexico when, during a dry year, nest building proceeded on schedule but laying did not begin until an influx of migrant birds apparently stimulated the Cooper's hawks to begin their clutches (Snyder and Wiley 1976). Subsequently, the migrants continued north and some hawks failed to lay complete clutches. Clutch size may be a function of habitat quality (Snyder and Snyder 1973). A reduction of small birds in forested habitats may be partly responsible for the decrease in the numbers of Cooper's hawks (Bent 1937).

Clutch size varies from three to six eggs, with four or five being normal (Bent 1937). The duration of incubation averages 30 to 37 days (Meng 1951; Reynolds 1975; Asay 1980). Young birds may remain in the nest as few as 21 days (Asay 1980) or as long as 30 to 32 days (Meng 1951; Reynolds 1975). Fledglings remain near the nest for 10 to 30 days (Fitch et al. 1946; Fitch 1958; Brown and Amadon 1968) at which time they are still dependent on the adults for food. Once they begin hunting on their own, the young continue to remain near the adult's home range for an additional 12 to 30 days (Beebe 1974; Janik 1980). Some indication of dispersal and migration movements are provided by recoveries of birds in Mexico 3 to 5 months after they had been banded in Utah (Eyre and Paul 1973).

Nesting Habitat

Cooper's hawks in the Eastern United States nest in forest associations of deciduous, mixed deciduous and coniferous, or entirely coniferous forest (Baird et al. 1905; Bent 1937; Meng 1951; Price 1941; Hemphill 1966; Titus and Mosher 1981). In the mountainous areas of the West, most nest sites are dominated by conifers (e.g., Bailey and Niedrach 1965; Eyre and Paul 1973; Beebe 1974). The hawks also commonly nest in deciduous stands of riparian habitat (Bailey 1928; Marshall 1957; Ligon 1961; Call 1978), and in more arid woodlands of oak (Asay 1980) and grand mesquite (Brandt 1951).

Table 4. Breeding chronology of Cooper's hawks.

Locality	Arrival	Eggs	Nestling	Fledgling	Depart	References
Florida		1[a] Apr				Grimes 1944
Massachusetts		1 Apr e Jun				Bent 1937
Massachusetts			1 May	e Jul	m Sep	Colburn 1939
Maine	m Apr	e May				Briggs 1904
Maryland/ Pennsylvania	1 Apr	1 Apr 1 May m May 1 Jun	e-1 Jun m Jun	m Jul		Janik 1980, Harlow 1915, and Street 1955
New York	1 Mar	1 Apr			1 Aug	Meng 1951
Ohio/ Indiana	1 Apr e May	1 Apr		Jun Jul		Trautman 1940 and Price 1941
Michigan	1 Mar	1 Apr	1 May e Jun		1 Jul	Craighead and Craighead 1956
Illinois	m Mar				Nov	Ford et al. 1934
Texas		m May				Meitzen 1963
Kansas	e Feb e Apr	m Apr		1 Jul		Fitch 1958 and Johnston 1964
North Dakota		May				Stewart 1975
New Mexico		May				Bailey 1928 and Ligon 1961
Colorado	1 Apr e May	1 May e Jun		1 Jul		Bailey and Niedrach 1965, Stahlecker and Beach 1979
Arizona		1 Apr e Jun				van Rossem 1936, Brandt 1951, Ellis and Depner 1979, and Phillips et al. 1964

Table 4. (concluded)

Locality	Arrival	Eggs	Nestling	Fledgling	Depart	References
Utah	Mar Apr	May			m Jul	Eyre and Paul 1973, and Lee 1981a
Utah, Wyoming, Idaho	1 Apr				m-1 Jul	Hennessey 1978
California		Apr m May	1 May		1 Jun	Fitch et al. 1946, and Asay 1980
Oregon	1 Mar	m May				Reynolds 1975
British Columbia	m Apr e May					Beebe 1974

[a]1 = late, m = mid, e = early

Cooper's hawks generally nest in woodlots of 6 to 8 ha or more (Price 1941; Call 1978), and, in parts of California, in stands containing 6 to 50 trees (Asay 1980). Occasionally, a nest occurs in a smaller wooded area or in isolated trees (Stewart 1975; Asay 1980). Home range sizes of 13 pairs in Michigan ranged from 0.2 to 5.3 km^2 (Craighead and Craighead 1956). Forest edge habitat and water are generally included within the home range of breeding birds. In the Eastern United States, openings in the forested habitat often include agricultural lands (e.g., Price 1941; Hamerstrom and Hamerstrom 1951). Vegetative cover around 31 Cooper's hawk nest sites in Oregon (plot size = 405 ha) consisted of coniferous forest (52%); natural open area (26%); recently logged (15%); savannah (6%); and shrubland (1%) (Moore 1980). For a sample of nests (n = 6) in the central Appalachian Mountains, the distance from nests to water (17 to 407 m) and to a forest opening (16 to 350 m) was not significantly different than the distance from random points to water (35 to 1050 m) or to an opening in the forest canopy (8 to 1110 m) (Titus and Mosher 1981).

Nest sites of Cooper's hawks are often located on the flat part of the terrain in mature forests that have uniform canopies, and in riparian habitats (Jones 1979). Six nest sites in the Appalachian Mountains of Maryland were oriented randomly (Titus and Mosher 1981), but nest sites sampled in Utah (Hennessey 1978) and Oregon (Reynolds 1979; Moore 1980) were all on northern or eastern exposures and all nests were on hillsides with a 0 to 30% slope. Nest trees in an Oregon study were located in cool, relatively humid stands, 50 to 80 years of age, with dense tree growth and canopy closure (Reynolds 1979). The vegetative profile around another sample of Cooper's hawk nests in Oregon contained dense foliage from a height of 3 to 15 m and 77% of the stand was composed of trees less than 16.5 cm diameter at breast height (dbh) (Moore 1980). The average dbh at nest sites in Utah was 15.5 cm, the canopy closure was 84%, and the ground cover was 26% (Hennessey 1978). Cooper's hawk nests in Maryland were located in stands of larger overstory trees, more dense understory, and denser ground cover than were random plots on the study area (Titus and Mosher 1981).

Nest trees in a particular region often include a variety of species (Bent 1937; Brandt 1951; Price 1941; Titus and Mosher 1981) but occasionally may be limited to one or two species. In central and southern California 97% of the nests measured were in live oaks (Asay 1980). The nest is usually in a main crotch or branch of a tree (or braced against a coniferous trunk), and partly concealed by the canopy (e.g., Moore 1980; Titus and Mosher 1981). Nests may be built on squirrel nests, in rubble in the fork of a tree, or they may be incorporated in masses of mistletoe (Moore 1980) or grapevines (Hamerstrom 1972; Schriver, pers. comm.). In California, 45% of the nests studied were old nests that had been rebuilt (Asay 1980), while in Oregon, Reynolds (1975) never observed old nests to be reused. In Oregon, females nesting as 2-year olds never used old nest sites (Moore 1980), but adults do return to nest sites, and may use the same area for several years in succession (Meng 1951; Fitch 1958; Brown and Amadon 1968; Schriver 1969; Reynolds 1975).

Behavioral displays or vocalizations by the adults may aid in locating the nest site. Early in the season aerial courtship displays or birds carrying nesting material may indicate the proximity of a nest. Later, when birds are incubating or caring for young, defensive vocalizations or behavior may be elicited if a conspicuous intruder comes near the nest. The adult may leave the nest quietly if disturbed while incubating (Bent 1937). Feather remains plucked from prey, and a long tail extending beyond the rim of the stick nest (about 71 x 71 x 20 cm) are other indications of a Cooper's hawk nest. If the eggs have hatched, some white down may adhere to the sticks (Brown and Amadon 1968), and white excreta may be visible on the forest floor around the nest (Hemphill 1966).

Eggs (four or five, most commonly) measure about 49.0 x 38.5 mm (n = 62), and are bluish or greenish when fresh, but quickly fade to dirty white with about half the eggs spotted with brown or buff (Bent 1937). Nestlings are first covered with creamy-white down, which is replaced by short silky-white down and the emerging body and flight feathers (Brown and Amadon 1968). A black tip on the end of the tongue and the presence of pads on the underside of the toes aid identification of nestling Cooper's hawks (Janik 1980).

POPULATION TRENDS

During the period around 1900, the Cooper's hawk was considered to be a common forest raptor (Baird et al. 1905; Anderson 1907; Swarth 1914; Trautman 1940). Ridgway (1889) reported that by June, Cooper's hawks outnumbered all other raptors in the woodlands of Illinois, and it was one of the commonest birds of prey before 1920 (Bent 1937). Though some authors considered it common when other raptors had disappeared (May 1935) and more common in the 1940's than in 1910 (Kumlien et al. 1951), a widespread decline in the population size of Cooper's hawks in the Eastern United States began after 1900.

Three times as many Cooper's hawk nests were located before 1920 as after that year (Bent 1937). Trautman (1940) considered them to be uncommon in the summer in Ohio and only 3 pairs were located in 1933 compared to 18 pairs in 1922 and 1924. Cooper's hawks were "less common than formerly" in the Chicago area in 1934 (Ford et al. 1934). Counts of migrants conducted since 1937 in Pennsylvania exhibit a downward trend (Spofford 1969; Snyder et al. 1973). Similarly, numbers of migrants in Maryland decreased 13% from the period of 1951 to 1954 to the period of 1958 to 1961 (Hackman and Henny 1971). Seventeen pairs of Cooper's hawks built nests on a 93 km^2 area in Michigan in 1942 and 1948 (Craighead and Craighead 1956); however, only one active nest was found on the same area during several years of searching in the 1970's and in 1980 (Fuller, Postupalsky, Beske, and F. Craighead, Jr. pers. comm.). An increase in the number of infertile eggs and 2 years of severe winter weather apparently caused a decline which began in the late 1950's in western Pennsylvania and eastern Ohio populations of Cooper's hawks (Schriver 1969). A general decline in the Northeastern United States population was recognized by the late 1960's (Anderson et al. 1968). The most extensive investigation of productivity revealed a significant reduction in the number of banding-age birds from the period 1929-1945 to the period 1949-1967, a 13% decrease in the number of Cooper's hawks between 1941 and 1945, and a 25% loss after 1948 (Henny and Wight 1972). The number of Cooper's hawks seen on Christmas Bird Counts during 1962-1967, compared to 1967-1971, decreased by 5% or more in eight

States and increased in seven States, although more effort to find hawks may bias such results (Brown 1973). Potential errors of identification of Cooper's hawks may occur and result in biased conclusions about population trends (Daniels 1975). More recently, a study incorporating Christmas Bird Counts, migration counts, and results of Breeding Bird Surveys concluded that fewer Cooper's hawks occurred in the Eastern and Central United States from 1967-1974 than from 1948-1966, but in the Eastern region an increasing trend occurred within the period 1967-1974 (U.S. Fish and Wildlife Service 1976).

Present Trends and Status

An evaluation of the number of young banded per nest (approximately 20, Henny pers. comm.) revealed an increase in productivity (from 2.67 during 1949-1967 to 3.36 during 1968-1974) in the Northeastern United States (Braun et al. 1977). Few nests were located in Michigan in the late 1950's and 1960's, but more recent reports suggest an increase in the number of nesting Cooper's hawks there (Postupalsky 1975). The species appears again on the 1981 National Audubon Society's Blue List, but it was noted that the number of hawks may be stable or increasing in some areas (Tate 1981) and in 1982 was included on the National Audubon Society's List of Species of Special Concern (Tate and Tate 1982).

The population status of the Cooper's hawk in various States has prompted a great deal of concern about this raptor. The Cooper's hawk is uncommon in Colorado (Bailey and Niedrach 1965), rare and possibly declining in California (Sierra-Nevada Mountains) (Verner and Boss 1980), less numerous than 15 to 20 years ago in Wisconsin (Hine et al. 1975), rarely breeds in Missouri (Holt et al. 1974), and breeding populations are seriously low in South Carolina (Forsythe and Ezell 1976). In Canada, the species is stable in some areas but declining or of unknown numbers elsewhere (Fyfe 1976). Concern about populations of Cooper's hawks is further reflected by the special protection or recognition it has received by being placed on the "status" lists of numerous states: California - priority 2 list - population declining throughout breeding range (Remsen 1978); Wisconsin - threatened (Hine et al. 1975; 1978 update mimeo); Illinois - endangered (Illinois Department of Conservation 1979); Missouri - endangered (Holt et al. 1974); Michigan - threatened (Michigan Department of Natural Resources 1978); Alabama - of special concern (Boschung 1976); and South Carolina - threatened (Forsythe and Ezell 1976).

Density and Productivity

Few studies have determined the density of Cooper's hawks. An estimated 16 birds occurred on 93 km^2 in south-central Michigan (woodlots dispersed through agricultural lands) (Craighead and Craighead 1956), and 12 ± 10 pairs occurred on 233 km^2 in Dunn County, North Dakota (Postovit 1979). In Douglas fir forests of western Oregon, Reynolds (1975) observed 1 nest/2321 ha occurred during 1 year and 1/1857 ha the next year. Observed densities in ponderosa pine forests of eastern Oregon averaged 1 pair/2200 ha. Spacing of active nests has been reported to be from 1/1.6 km in California (Fitch et al. 1946) and Arizona (riparian habitat) (Brandt 1951; Snyder and Wiley 1976) to 1/1.0 km in Kansas (Fitch 1958) and 1/2.4 km in New York (Meng 1951).

No significant change in clutch sizes (mean = 4.18) of Cooper's hawks was observed in the Northeastern United States and Southeastern Canada during a 20-year period (Henny and Wight 1972). One nest in Saskatchewan contained six young (Gilroy 1955). A nest in Arizona contained seven eggs (Ellis and Depner 1979). Only 7 of 266 clutches in one museum collection contained six eggs. Some birds may renest if a clutch is destroyed (Bent 1937). A female that had been collected during nest building was replaced by another female which subsequently laid eggs (Grant 1957).

Fledglings averaged 2.2 per nest in a study in Michigan (Craighead and Craighead 1956). A sample of 41 recent nests in California averaged 3.8 eggs, 2.8 hatchlings, and 2.0 fledglings; 80% of the nests were successful (Asay 1980). An average of 3.6 young fledged from 4 nests in Washington (Kennedy 1980). Nests in Oregon averaged 3.8 eggs, 2.8 hatchlings, and 2.1 fledglings, with a 68% nest success (78% of the nest failures were in western Oregon) (Reynolds 1975). An average of 1.6 young fledged from all nests sampled (2.6 from successful nests) in Utah (Hennessey 1978); nests averaged 4.0 eggs and 3.3 nestlings (Lee 1981a). Nests in Maryland averaged 3.4 eggs of which 76% hatched and 59% fledged from 4 of 6 nests (Janik 1980).

Productivity is reduced by the loss of eggs, nestlings, and fledglings. Meng (1951) observed young Cooper's hawks in New York were most vulnerable to predation and weather at about 3 weeks of age (when the adult female begins to spend more time away from the nest). Losses in Maryland seemed to occur between banding age and fledging (Janik 1980). In Arizona and New Mexico the most mortality occurred at the end of the breeding cycle due to food stress when the young are still dependent on the adults for food (Snyder and Wiley 1976). The annual loss of first-year birds was estimated as 77.8%, and the loss of adults as 34.0% (Henny and Wight 1972).

Effects of Habitat Changes

Cooper's hawk nests are often observed to be in second growth timber (Schriver 1969) with densely structured habitat (Call 1978) and the presence of "plenty of understory" (Price 1941). Reynolds (1979) observed that the majority of prey brought to the nests of the hawks were species which occupied the ground-shrub and shrub-canopy zones. Recent studies of vegetative characteristics associated with the nests of accipters revealed that Cooper's hawks occupy a relatively well-defined structural habitat; forest habitat beyond this range of structural characteristics usually supports sharp-shinned hawks, goshawks, or other forest inhabiting raptors (Hennessey 1978; Reynolds 1979; Moore 1980; Titus and Mosher 1981). Differences are exhibited between nesting habitats of adults and 2-year old female Cooper's hawks (Moore and Henny in prep.). The young birds nest in an earlier successional stage, incorporate mistletoe less often in the nest structure, fledge fewer young, and have fewer successful nests than females that are at least 3 years old. Most studies of the vegetation associated with raptor use have dealt with the nest site, thus few data are available to suggest the impact of habitat change in other portions of the home range of the birds (Moore 1980) or in the forest in general (Titus and Mosher 1981).

Loss of habitat attributable to succession or an inadequate prey base may be partly responsible for the reduced number of Cooper's hawks (Bent 1937). In addition, the impact of agriculture and residential development are also recognized as threats to Cooper's hawks (Asay 1980).

Effects of Human Disturbance

For many years, human persecution of Cooper's hawks was deliberate and persistent. This species was also known as the "henhawk" or "blue darter", and was the epitome of the "chickenhawk" and thus labeled destructive (vs. beneficial) in relation to agricultural and game management practices (e.g., Fisher 1893; May 1935; Vaughn 1937; McDowell 1941). Persecution by shooting and trapping was an important source of mortality until the 1940's (Bent 1937; Henny and Wight 1972). Shooting and falconry may still adversely impact populations (Snyder 1974). All raptors are presently protected from persecution by national and State laws.

In a study by Moore (1980), human disturbance occurred within a 405-ha circular plot at 28% of the nests sampled in Oregon. Cooper's hawks have often been found nesting within 1.6 km of farmsteads (e.g., Anderson 1907; Craighead and Craighead 1956) and are known to take advantage of the abundance of certain prey species associated with the field-forest edges and outbuildings of agricultural areas (e.g., Hamerstrom and Hamerstrom 1951). A successful nest occurred in the middle of a city (population 2500), and the young hawks could be approached within 4.6 m before they would fly away (Stahlecher and Beach 1979). Subtle but important consequences of nesting near human disturbance may exist. Significantly greater band recoveries from birds that had become accustomed to people have been reported (Snyder and Snyder 1974). Some adults that are exposed to human activity will stay on their nest longer as people approach (Janik 1980) and are less aggressive (Hennessey 1978) than birds not accustomed to human activity. Lee (1981b) observed that a pair of birds nesting near a trail remained on the nest when they could hear people, flushing only when hikers came into view of the nest (Lee 1981b). Losses at two nests in northern Utah were attributed to human disturbance (Hennessey 1978).

Environmental contaminants have been found to reduce the productivity of Cooper's hawks. Following the aerial spraying of the pesticide DDT, increased levels of DDT and DDE (a metabolite of DDT) were detected in the plasma of Cooper's hawks in Oregon (Henny 1977). Correlations occurred between thin eggshells and the presence of high levels of DDE in eggs of those raptors that eat primarily birds (Snyder et al. 1973). A 7.0% decrease in eggshell thickness was measured by Anderson and Hickey (1972). Broken eggs occurred in 11 of 16 clutches in samples from Arizona and New Mexico; the broken shells were 16% thinner than eggs laid prior to 1947 (the beginning of "the pesticide era") (Snyder 1974). Of several raptor species sampled in central New York, Cooper's hawks exhibited the greatest shell thinning (-19.0%) and highest levels of DDE (50.7 and 84.5 ppm) (Lincer and Clark 1978). Other contaminants (e.g., Dieldrin, PCB's, heavy metals) have also been detected in eggs, but the degree to which they pose a threat has not been explored (Snyder et al. 1973).

Management

Recommendations for habitat management that may benefit Cooper's hawks have included promotion of second growth Douglas fir and lodgepole pine forests that are greater than 6 ha in size (Call 1978) and composed primarily of trees 30 to 46 cm dbh, and conservation of riparian habitat (Jones 1979). The legal protection for all raptors and implementation of stricter regulations for the use of pesticides and other potential contaminants have benefited Cooper's hawks.

The Cooper's Hawk as an Indicator Species

Cooper's hawks usually depend on a diversity of prey species, therefore, the continued success of the hawks in an area may provide one means of monitoring the "health" of part of the vertebrate community. Additionally, the susceptibility of Cooper's hawks to accumulation of some pesticides and other pollutants could permit these predators to serve as an indicator species. The continued nesting of the hawks in any area may be a gross gauge of the level of disturbance occurring in that area. The extent to which Cooper's hawks are useful indicators for most of these factors will depend on the data base available for the local area and one's ability to detect the hawks and locate their nests. The special legal status of the species in some States will necessitate intensive surveys for the presence of the hawks and assessment of the impact of proposed mining.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts to Cooper's hawks may occur directly, for instance death by shooting or destruction of a nest, or indirectly, through disturbance that disrupts the normal behavior or by alteration of hunting habitat that in turn has a negative impact on foraging efficiency. The most serious impact would probably occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, possibly resulting in increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population.

Human activity at the nest site during the periods of nest construction or repair, incubation, and nestling care will cause abandonment of the nests or reduced productivity. Coal mining activities undertaken some distance from the nest, or outside the breeding season can also have adverse impacts on raptors. Construction and related activity may displace birds from favored roosts, perches, and hunting habitat. Contaminated water from mining byproducts or runoff, or decreased water supplies due to water diversion may cause a breakdown of the ecological communities on which the raptor relies.

Increased noise levels may deter Cooper's hawks or their prey species from using suitable habitat nearby, though some species become accustomed to noise after a period of adjustment. An increase in dust levels may affect vegetative growth and indirectly cause a decrease in prey populations.

Every effort should be made to avoid disrupting breeding habitat in those States, particularly in the eastern half of the United States, where the Cooper's hawk was observed to have declined in numbers. The extent to which the loss of a number of nest sites on one or more mine leases may threaten the "population" of birds in an area is difficult to assess due to the paucity of data about densities of hawks under various habitat conditions.

For one coal lease (about 24,300 ha), an estimated 8,100 ha would be disturbed by mining over a 27-year period (Lockhart et al. 1980). Assuming that this loss of habitat would be temporary (reclamation efforts should begin on each portion of the 8,100 ha as soon as mining has been completed), and that all of the land was Cooper's hawk breeding habitat, two to four pairs of hawks would be displaced, perhaps for 20 to 40 years (depending on success of reclamation efforts and succession rates). It is unlikely that the temporary loss of pairs from even a dozen lease sites in a State would adversely impact a regional population. The problem for land and wildlife managers will be to account for threats to wildlife not only from mining, but cumulative effects of mining and other developments that alter natural communities.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Cooper's hawk surveys (e.g., Postovit 1979) should be conducted during the premining phase to determine baseline population levels and habitat use of the proposed development area. Data collection may include noting nest site locations, including old stick nests, the type of habitat in which they occur, and food habits. Roadside counts using a defense call to elicit responses during the breeding season will also aid in determining hawk numbers (Fuller pers. comm.). Additional surveys of passerine and mammalian populations may help to delineate the prey base. Cooper's hawk surveys may be conducted for 2 years prior to mining activities to allow for between-year variations.

Exploration, Mine Development, and Mining Phase

The concentration of exploration activities between August and April (the nonbreeding season) will alleviate impacts to local Cooper's hawks. Disturbance conducted during the breeding season will have a lesser impact if concentrated at least 1.2 km from nest sites or out of a direct line-of-sight from the nest. Avoidance of unnecessary disturbance to shrubs and ground cover can minimize impacts to prey populations. Drilling and exploration activities involving little habitat loss and a minimum of human activity should not have a high impact on Cooper's hawk populations. Education of workers and buffer zones around nearby habitat may decrease impacts from harassment and illegal shooting.

If disturbance to, or destruction of, some Cooper's hawk habitat is unavoidable, it is recommended that nests be located, habitat described, and the type and abundance of prey determined. These baseline data can be used during subsequent phases of the mining procedure to mitigate impacts on the hawks and to plan and monitor reclamation.

Habitat destruction in areas involving Cooper's hawk nests will prevent the hawks from renesting in that area. Avoidance of nests until several weeks after the young have fledged will reduce impacts to local nesting birds. Controls on dust and runoff, and avoidance of contamination of water, soil, and air with wastes and by-products, will lessen impacts to surrounding Cooper's hawks and prey populations.

Reclamation Phase

Cooper's hawks generally nest and hunt in woodlands that have a well-developed understory and ground cover and that are dominated by mature trees with a relatively closed canopy. Reclamation should begin immediately after the completion of mining because it will take many years of secondary succession for a community to become suitable for breeding Cooper's hawks. A density and diversity of species similar to that which existed prior to mining will encourage Cooper's hawks to use the reclaimed area.

Habitat for Cooper's hawks can be enhanced by promoting shrubbery in the understory that supports a diversity of avian prey, and trees, shrubs, and grasses that produce seed crops that can be used for food by small mammals. The maintenance of streams and creation of small ponds, forest openings, and forest edge can also benefit Cooper's hawks. Reclamation should be planned so that nesting habitat will be remote from heavy traffic, recreational use, and other sources of disturbance.

SUMMARY

Cooper's hawks should be important to personnel involved in land leases for mining, stripmining, and reclamation of land impacted by mining because: (1) in the eastern half of its breeding range populations of the hawk have undergone dramatic declines and may only recently be producing young at rates necessary for maintaining stable populations; (2) in certain successional stages of forest and in riparian habitats in the Western United States, Cooper's hawks breed regularly and can be useful indicators of human disturbance and disruption of habitat. For no large area (e.g., State, region) does there exist a statistical estimate of the density of the species. No predictions exist regarding the effects of forestry practices (small acreage or commercial), development, and recreation on breeding hawks. Therefore, in the Eastern United States nest sites should be conserved whenever possible. Temporary disruption of breeding areas and displacement of Western Cooper's hawks may not noticeably affect regional populations. Those agencies and companies involved with mining can make useful contributions to our knowledge of, and ability to manage, accipiters by counting breeding birds and monitoring nest site use and productivity. Large scale surveys and sampling of habitats to estimate densities are encouraged.

ACKNOWLEGMENTS

Olendorff and Olendorff's (1968) extensive bibliography provided efficient access to much of the literature prior to the mid 1960's. L. Garrett and staff, C. Kimball and C. Nalley helped assemble the references.

REFERENCES

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press. Lawrence, KS. 877 pp.

Anderson, D. W., and J. J. Hickey. 1972. Eggshell changes in certain North American birds. Proc. Int. Ornith. Cong. 15:514-540.

Anderson, J. M., R. C. Erickson, D. A. Munro, W. R. Spofford, G. C. West, and F. G. Evenden. 1968. Report of committee on conservation. Auk 85:117.

Anderson, R. M. 1907. The birds of Iowa. Proc. of Davenport Acad. Sci. 11:125-417.

Andrle, R. F. 1966. North American migrants in the Sierra De Tuxtla of southern Veracruz, Mexico. Condor 68:177-184.

Asay, C. E. 1980. Habitat, biology, and productivity of Cooper's hawks nesting in the oak woodlands of California. M.S. Thesis. Univ. California, Davis.

Bailey, A. M., and R. J. Niedrach. 1965. Birds of Colorado. Denver Mus. Nat. Hist., Denver, CO.

Bailey, F. M. 1914. Handbook of birds of the Western United States. Houghton Mifflin Co., Boston.

_____________. 1928. Birds of New Mexico. New Mexico Dept. Game Fish.

Baird, S. F., T. M. Brewer, and R. Ridgway. 1905. North American land birds. Vol. III. Little, Brown, and Co., Boston.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia: vultures, hawks, falcons, eagles. Brit. Col. Prov. Mus., Paper 17.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. U.S. Natl. Mus. Bull. 167. 409 pp.

Berger, D. D. 1957. A peculiar type of flight in Cooper's hawks. Wilson Bull. 69:110-111.

Beske, A. Personal communication. U.S. Fish and Wildlife Service, P.O. Box 916, Sheridan, WY 82801.

Boschung, H., ed. 1976. Endangered and threatened plants and animals of Alabama. Alabama Mus. Nat. Hist. Bull. 2.

Brandt, H. 1951. Arizona and its bird life. Bird Res. Found., Cleveland.

Braun, C. E., J. H. Enderson, C. J. Henny, H. Meng, and A. G. Nye, Jr. 1977. Conservation committee report on falconry: effects on raptor populations and management in North America. Wilson Bull. 89:360-369.

Briggs, G. H. 1904. Nesting of Cooper's hawk. Oologist 21:41-42.

Brimley, H. H. 1889. How the Cooper's hawk hunts his prey. Ornithol. and Oologists' Semi-annual 1:32-34.

Brown, W. H. 1973. Winter population trends in the marsh hawk, Cooper's hawk, and sharp-shinned hawks. Am. Birds 27(1):6-7.

Brown, L., and D. Amadon. 1968. Eagles, hawks, and falcons of the world. Part 2. McGraw-Hill Book Co., New York.

Call, M. 1978. Nesting habitats and surveying techniques for common Western raptors. U.S. Bur. Land Manage. Tech. Note TN-316.

Clark, R. J. 1977. Cooper's hawk hunting in the city. Auk 94:142-143.

Clark, W. S., and P. J. Dunne. 1979. Letter to the editor. Am. Birds 33:909.

Colburn, C. G. 1939. Cooper's hawks at Shirley [Mass.]. Bull. Mass. Audubon Soc. 23:4-5.

Craighead, F. C., Jr. Personal communication. Box 156, Moose, WY 83012.

Craighead, J. J., and F. C. Craighead, Jr. 1956. Hawks, owls, and wildlife. Stackpole Co., Harrisburg, PA.

Daniels, G. G. 1975. An inquiry into Christmas bird count accipiter reports. Am. Birds 19:634-637.

Dekker, D. 1970. Migrations of diurnal birds of prey in the Rocky Mountain foothills west of Cochrane, Alberta. Blue-Jay 28:20-24.

Duncan, S. 1966. Analysis of the stomach contents of some Cooper's hawks (Accipiter cooperi). Auk 83:308.

Ellis, D. H., and G. Depner. 1979. A seven-egg clutch for the Cooper's hawk. Condor 81:219-220.

Eyre, L., and D. Paul. 1973. Raptors of Utah. Utah Div. Wildl. Resour. Publ. 73-7. 76 pp.

Fisher, A. K. 1893. The hawks and owls of the United States in their relation to agriculture. U.S. Dept. Agric., Div. Ornithol. and Mammal., Bull. 3.

Fitch, H. S. 1958. Home ranges, territories, and seasonal movements of vertebrates of the natural history reservation. Univ. Kansas Mus. Nat. Hist. 11:63-326.

Fitch, H. S., B. Glading, and V. House. 1946. Observations on Cooper hawk nesting and predation. California Fish Game 32:144-154.

Ford, E. R., C. C. Sanborn, and C. B. Coursen. 1934. Birds of the Chicago region. Chicago Acad. Sci. 5.

Forsythe, D. M., and W. B. Ezell, Jr., eds. 1976. Proc. of the 1st South Carolina Endangered Species Symposium. South Carolina Wildl. Mar. Resour. Dept. and the Citadel. 11 to 12 Nov. 1976. Charleston, SC.

Fuller, M. R. Unpublished data and personal communication. Research Biologist. Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service, Laurel, MD.

Fuller, M. R., and J. A. Mosher. 1981. Methods of detecting and counting raptors: a review. Pages 235-246 in C. J. Ralph and J. M. Scott, eds. Estimating numbers of terrestrial birds. Studies in Avian Biol. 6.

Fyfe, R. W. 1976. Status of Canadian raptor populations. Can. Field-Nat. 90:370-375.

Gilroy, D. 1955. Cooper's hawk nest. Blue Jay 13:20.

Grant, J. 1957. A breeding record of Cooper's hawks in Alberta. Can. Field-Nat. 71:82.

Grimes, S. A. 1944. Birds of Duval Co. (continued). Florida Nat. 17:1-31.

Gullion, G. W., W. M. Pulich, and F. G. Evenden. 1959. Notes on the occurrence of birds in southern Nevada. Condor 61:278-297.

Hackman, C. D., and C. J. Henny. 1971. Hawk migration over White Marsh, Maryland. Chesapeake Sci. 12:137-141.

Hamerstrom, F. 1972. Birds of prey of Wisconsin. Wisconsin Dept. Nat. Resour., Madison.

Hamerstrom, F. N., Jr., and F. Hamerstrom. 1951. Food of young raptors on the Edwin S. George Reserve. Wilson Bull. 63:16-25.

Harlow, R. C. 1915. Cooper's hawk in Pike County Pennsylvania. Oologist 32:25.

Harris, B. K. 1977. Cooper's hawk: third nest record in South Dakota. South Dakota Bird Notes 29:31-32.

Heintzelman, D. S. 1975. Autumn hawk flights: the migrations in Eastern North America. Rutgers Univ. Press, New Brunswick, NJ.

Hemphill, E. 1966. Notes on behavior of nesting Cooper's hawks. Kingbird 16:206-209.

Hennessey, S. P. 1978. Ecological relationships of accipiters in northern Utah - with special emphasis on the effect of human disturbance. M.S. Thesis. Utah State Univ., Logan.

Henny, C. J. Personal communication and unpublished data. Research Biologist. Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service, Pacific Northwest Field Station, Corvallis, OR.

Henny, C. J. 1977. Birds of prey, DDT, and tussock moths in Pacific Northwest. Trans. N. Am. Wildl. Nat. Resour. Conf. 42:397-411.

Henny, C. J., and H. M. Wight. 1972. Population ecology and environmental pollution: red-tailed and Cooper's hawks. Pages 229-250 in Population ecology of migratory birds: A symposium. U.S. Fish Wildl. Serv. Res. Rep. 2.

Hine, R. L., R. F. Nicotera, L. M. Christenson, C. E. Germain, J. B. Hale, H. E. Hettrick, J. T. Addis, and L. A. Posekany. 1975. Endangered animals in Wisconsin: with supplementary lists of threatened animals, animals with watch status, and extirpated animals. Wisconsin Dept. Nat. Resour. mimeo and mimeo update. 10 pp.

Holt, F. T., J. F. Keefe, W. H. Lewis, W. L. Pflieger, and M. H. Sullivan. 1974. Rare and endangered species of Missouri, 1974. Missouri Dept. Conserv. and U.S. Soil Conserv. Serv.

Houston, C. S. 1958. Saskatchewan nesting records of the Cooper's hawk. Blue Jay 16:153-154.

Hubbard, J. P. 1970. Checklist of the birds of New Mexico. New Mexico Ornithol. Soc. Publ. 3.

Illinois Department Conservation. 1979. Endangered and threatened wildlife. Wild. Res. Div., Springfield.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Janik, C. A. 1980. The nesting biology and behavior of woodland raptors in western Maryland. M.S. Thesis. Frostburg State College, Frostburg, MD.

Johnson, N. K. 1965. The breeding avifaunas of the Sheep and Spring Ranges in southern Nevada. Condor 67:92-124.

Johnston, R. F. 1964. The breeding birds of Kansas. Univ. Kansas Publ. Nat. Hist. 12(14):575-655.

Jones, S. 1979. Habitat management series for unique or endangered species: The accipiters-goshawk, Cooper's hawk, sharp-shinned hawk. U.S. Bur. Land Manage. Tech. Note 17. 51 pp.

Kennedy, P. D. 1980. Prey size selection patterns of nesting male and female Cooper's hawks (Accipiter cooperii). M.S. Thesis. Univ. Idaho, Moscow.

Kumlien, L., N. Hollister, and A. W. Schorger. 1951. The birds of Wisconsin. Wisconsin Soc. Ornithol., Inc., Madison.

Lee, J. A. 1981a. Comparative breeding behavior of the goshawk and the Cooper's hawk. M.S. Thesis. Brigham Young Univ., Provo.

____________. 1981b. Habituation to human disturbance in nesting accipiters. Raptor Res. 15:48-52.

Ligon, J. S. 1961. New Mexico birds and where to find them. Univ. New Mexico Press, Albuquerque.

Lincer, J. L., and R. J. Clark. 1978. Organochlorine residues in raptor eggs in the Cayuga Lake Basin, New York. New York Fish Game J. 25(2):121-128.

Lockhart, J. M., D. W. Heath, and C. L. Belitsky. Unpub. (1980). The status of nesting peregrine falcons and other selected raptor species on the Black Butte Mine lease and adjacent lands. 59 pp.

Marsh, R. L., and R. W. Storer. 1981. Correlations of flight-muscle size and body mass in Cooper's hawk: a natural analogue of power training. J. Exp. Biol. 91:363-368.

Marshall, J. T., Jr. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna 32:1-125.

May, J. B. 1935. The hawks of North America. Their field identification and feeding habits. Natl. Assoc. Audubon Soc., New York.

McDowell, R. D. 1941. Cooper's hawk in Pennsylvania. Pennsylvania Game News 12:4.

Mead, R. A. 1963. Cooper hawk attacks pigeon by stooping. Condor 65:167.

Meitzen, T. C. 1963. Additions to the known breeding range of several species in south Texas. Auk 80:368-369.

Meng, H. K. 1951. Cooper's hawk, Accipiter cooperii (Bonaparte). Ph.D. Dissertation. Cornell Univ., Ithaca, NY.

____________. 1959. Food habits of nesting Cooper's hawks and goshawks in New York and Pennsylvania. Wilson Bull. 71:169-174.

Michigan Department of Natural Resources. 1978. Michigan's endangered and threatened species program: 1976-1978. Lansing.

Miller, A. H. 1955. The avifauna of the Sierra Del Carmen of Coahuila, Mexico. Condor 57:154-178.

Moore, K. R.. 1980. An analysis of accipiter nesting habitat in northeastern Oregon. M.S. Thesis. Univ. Idaho, Moscow.

Mueller, H. C., D. D. Berger, and G. Allez. 1979. The identification of North American accipiters. Am. Birds 33:236-240.

____________. 1981. Age, sex, and seasonal differences in size of Cooper's hawks. J. Field Ornithol. 52:112-126.

Oberholser, H. C. 1974. The bird life of Texas. Univ. Texas Press, Austin.

Olendorff, R. R., and S. E. Olendorff. 1968. An extensive bibliography on falconry, eagles, hawks, falcons, and other diurnal birds of prey. Parts 1-4. Copyright, 1968 by R. R. Olendorff.

Pellett, F. C. 1912. Food habits of the red-tailed hawk, Cooper's hawk, and sparrow hawk. Proc. Iowa Acad. Sci. pp. 199-201.

Phillips, A., J. Marshall, and G. Monson. 1964. The birds of Arizona. Univ. Arizona Press, Tucson.

Postovit, H. R. 1979. Population estimates of breeding raptors in North Dakota Badlands. M.S. Thesis. North Dakota State Univ., Fargo.

Postupalsky, S. Personal communication. 1817 Simpson, Apt. 10, Madison, WI 53613.

____________. 1975. Current status of some Michigan raptors. Jack-Pine Warbler 53:76-77.

Price, H. F. 1941. Nests and eggs of the Cooper hawk. Oologist 58:26-27.

Remsen, J. V., Jr. 1978. Bird species of special concern in California. Fed. Aid and Wildl. Restoration Proj. Rep., PRW-54-5-9.

Reynolds, R. T. 1972. Sexual dimorphism in accipiter hawks: a new hypothesis. Condor 74:191-197.

_____________. 1975. Distribution, density, and productivity of three species of accipiter hawks in Oregon. M.S. Thesis. Oregon State Univ., Corvallis.

________________. 1979. Food and habitat partitioning in two groups of co-existing *Accipiter*. Ph.D. Dissertation. Oregon State Univ., Corvallis.

Ridgway, R. 1889. The ornithology of Illinois. Vol. 1. Nat. Hist. Surv. of Illinois.

Schriver, E. C. Personal communication and unpublished data. 153 Parkhill Rd., Boden, PA 15005.

Schriver, E. C., Jr. 1969. The status of Cooper's hawk in western Pennsylvania. Pages 356-359 *in* J. J. Hickey, ed. Peregrine falcon populations: Their biology and decline. Univ. Wisconsin Press, Madison.

Skaar, P. D. 1969. Birds of the Bozeman latilong. Bozeman, MT; P. D. Skaar.

Slud, P. 1964. Birds of Costa Rica. Am. Mus. Nat. Hist. Bull. 128. 430 pp.

Small, A. 1974. The birds of California. Winchester Press, New York.

Smith, H. G. 1963. Notes on behavior of a Cooper's hawk. Wilson Bull. 75:88-89.

Smith, W. J. 1957. Birds of the clay belt of northern Ontario and Quebec. Can. Field-Nat. 71:163-181.

Snyder, H. A., and N. F. R. Snyder. 1974. Increased mortality of Cooper's hawks accustomed to man. Condor 76:215-216.

Snyder, N. 1974. Can the Cooper's hawk survive? Natl. Geog. 145:433-442.

Snyder, N. F. R., and H. A. Snyder. 1973. Experimental study of feeding rates of nesting Cooper's hawks. Condor 75:461-463.

_____________. 1974. Function of eye coloration in North American accipiters. Condor 76:219-222.

Snyder, N. F. R., H. A. Snyder, J. L. Lincer, and R. T. Reynolds. 1973. Organochlorines, heavy metals, and the biology of North American accipiters. Bioscience 23:300-305.

Snyder, N. F. R., and J. W. Wiley. 1976. Sexual size dimorphism in hawks and owls of North America. Ornithol. Monogr. 20.

Spofford, W. R. 1969. Hawk Mountain counts as population indices in north-eastern America. Pages 323-332 *in* J. J. Hickey, ed. Peregrine falcon populations: Their biology and decline. Univ. Wisconsin Press, Madison.

Stahlecker, D. W., and A. Beach. 1979. Successful nesting by Cooper's hawks in an urban environment. Inl. Bird Banding 51:56-57.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Cent. Environ. Stud., Fargo, ND.

Storer, R. W. 1966. Sexual dimorphism and food habits in three North American accipiters. Auk 83:423-436.

Street, P. B. 1955. Birds of the Pocono Mountains, Pennsylvania. Cassinia 41:3-76.

Swarth, H. S. 1914. A distributional list of the birds of Arizona. Cooper Ornithol. Club, Pacific Coast Avifauna 10.

Tate, J., Jr. 1981. The blue list of 1981. Am. Birds 35:3-10.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Titus, K., and J. A. Mosher. 1981. Nest-site habitat selected by woodland hawks in the central Appalachians. Auk 98:270-281.

Trautman, M. B. 1940. The birds of Buckeye Lake, Ohio. Univ. Michigan Mus. Zool. Misc. Publ. 44.

U.S. Fish and Wildlife Service. 1976. Environmental assessment: proposed falconry regulations. U.S. Fish Wildl. Serv., Washington, DC. Mimeo. 51 pp. + vi.

Vaughn, E. A. 1937. Wildlife's public enemy No. 1 (Cooper's hawk). Maryland Conserv. 14:19-20.

van Rossem, A. J. 1936. Notes on birds in relation to the faunal areas of south-central Arizona. Trans. San Diego Soc. Nat. Hist. 8:121-148.

Verner, J., and A. S. Boss, eds. 1980. California wildlife and their habitats: Western Sierra Nevada. U.S. For. Serv., Pac. S.W. For. and Range Exp. Stn., Berkeley, CA.

ZONE-TAILED HAWK (Buteo albonotatus)

by

Mark R. Fuller
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The adult zone-tailed hawk (Buteo albonotatus) has black body plumage, black wing feathers, and when viewed from above or below, usually three white tail bands (only two of which may be visible at a distance); the eyes are dark or reddish brown and the cere, corner of the mouth, and legs and feet are yellow (Brown and Amadon 1968). The downy white plumage of nestlings is replaced by feathers more brown than those of adults, and these brownish feathers have more white along the shafts of the contour feathers, with some white spots visible on the breast and back (Bent 1937). A detailed description of some specimens can be found in Oberholser (1974).

Zone-tailed hawks have been misidentified as common black hawks (Buteogallus anthracinus) in the past (e.g., Bendire 1892; Linton 1908; Bohl and Taylor 1958). Major distinguishing features are the buoyancy of flight and narrow wings in the zone-tailed hawk, and broader wings with the tail barely protruding beyond in the black hawk. Zone-tailed hawks have four emarginated outermost primaries (black hawks have only three) and they appear more slender in the air, having longer wings (wing span 119 to 135 cm, length 47 to 55 cm, May 1935, Snyder and Wiley 1976) than black hawks. Also, zone-tailed hawks have primaries and secondaries on the underwing which are faintly barred and are of lighter color at the trailing edge of the wing. For black hawks a lighter underwing pattern appears only at the end of the wings. Black hawks have only two white tail bands, and from below, only the wide subterminal band is apparent. The call of the zone-tailed hawk is variously described as a feeble scream (Brown and Amadon 1968), a peevish whistle (Bent 1937), or similar to the whistle of a broad-winged hawk (Buteo platypterus) but more piercing and not as highly pitched (Huber 1929). The call of the black hawk is a coarse squawk (Bent 1937) or a series of ascending and descending shrill notes (Glinski pers. comm.). For illustrations of these hawks, consult field guides (e.g., Robbins et al. 1966) and also compare descriptions in Bent (1937) and Brown and Amadon (1968).

Detection and identification of zone-tailed hawks is also complicated by their similarities in appearance and flight behavior to turkey vultures (*Cathartes aura*) (Bent 1937; Willis 1963, 1966; Mueller 1972; Zimmerman 1976). The hawk is smaller, however, and at close range its white tail bands can be seen and its head is feathered and appears larger than the naked head of vultures (Robbins et al. 1966; Brown and Amadon 1968).

DISTRIBUTION

The northern limit of the zone-tailed hawk's range reaches north-central Arizona, southern New Mexico, and southwestern Texas (Fig. 10). The species is rare and local throughout its breeding range which extends through Mexico and Central America into South America (Friedman et al. 1950; Brown and Amadon 1968; de Schauensee 1970). Those hawks breeding in the United States are mostly migratory (Bent 1937), although some winter records exist (e.g., Small 1924; Hubbard 1970).

Early records of observations and collections were summarized by Mearns (1886). In Arizona, nests occur along the lower Colorado River in tributaries of the Big Sandy, Gila, and Salt Rivers and scattered mountains, and a few occur in the Lower and Upper Sonoran Life Zone (Brewster 1883; Swarth 1914; Monson 1947; Phillips et al. 1964; Glinski pers. comm. 1982). From the Arizona border east these hawks breed in the Guadalupe and Capitan Mountains, Gila River Valley, and as far north as Los Alamos in New Mexico (Stevens 1879; Huber 1929; Ligon 1961; Hubbard 1970, 1971). Zone-tailed hawks in Texas breed from sea level to 2,286 m in the southwestern region including the Glass and the Chisos Mountains, Trans Pecos, Rio Grande River, and Edwards Plateau (Brewster 1879; Wauer 1973; Newman 1974; Oberholser 1974). At least 14 sightings exist for southern California, but none of these are breeding records (Grinnell 1909; Grey 1917; Small 1924; Monson 1947; Matteson and Riley 1981).

DIET

The diet of zone-tailed hawks includes lizards, birds, and mammals (Bent 1937; Snyder and Wiley 1976). Huber (1929) observed bird remains in a specimen while Willis (1963) and Swarth (1920) saw zone-tailed hawks with avian prey and Linton (1907) shot a hawk attacking a tame duck. Rock squirrels (*Spermophilus variegatus*) (Cottam 1947) and spotted ground squirrels (*S. spilosoma*) (Zimmerman 1976) have been the object of attacks and chipmunks (*Tamias* spp.) part of the diet (Swarth 1920) of zone-tailed hawks.

REPRODUCTION

Chronology

Zone-tailed hawks arrive at nesting areas as early as mid-March in Texas (Wauer 1973; Oberholser 1974), mid-April in New Mexico (Ligon 1961) and mid to late March in Arizona (Phillips et al. 1964; Glinski pers. comm. 1982). Other than casual winter records, the latest date of observations before migration

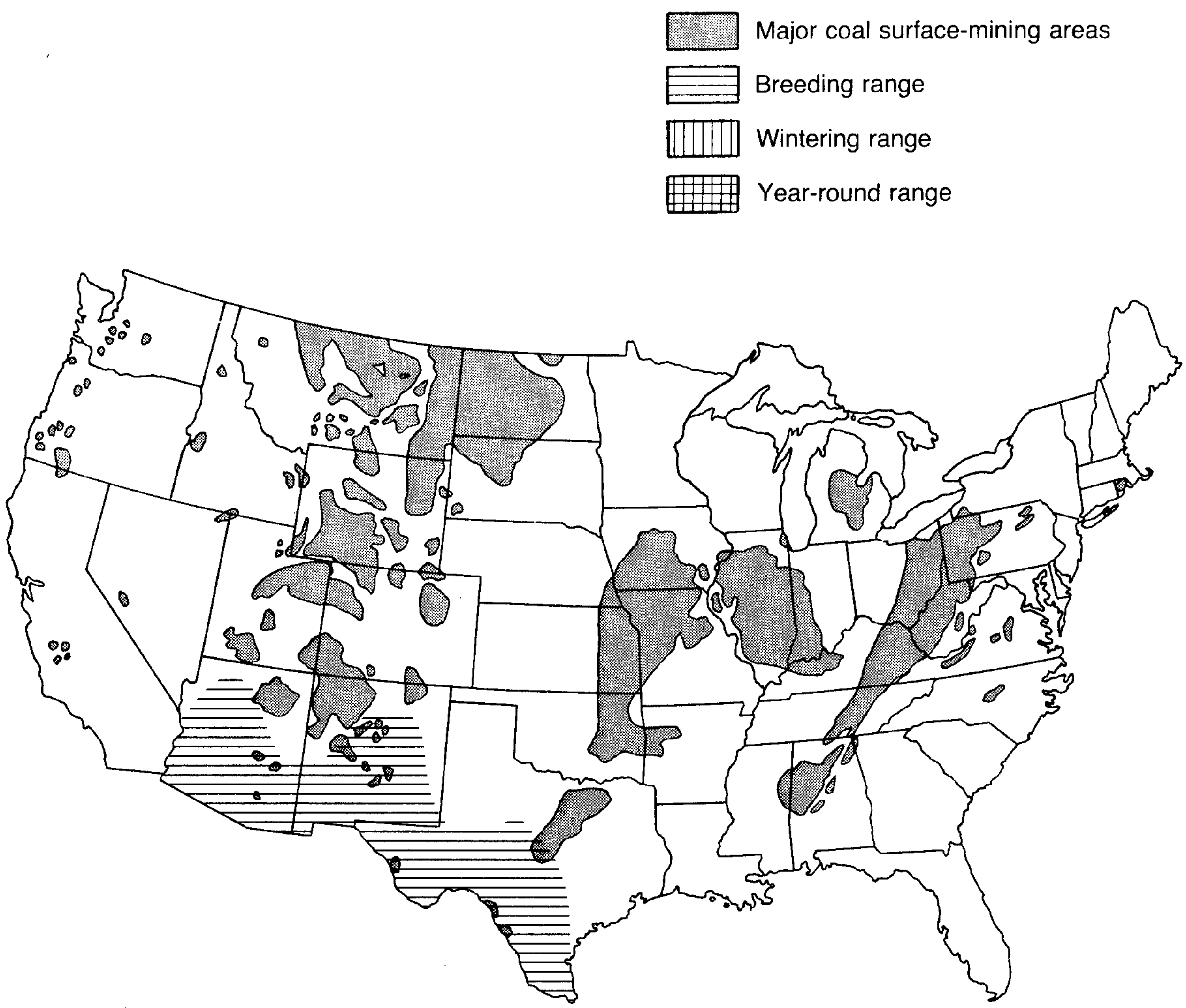


Figure 10. Geographical range of the zone-tailed hawk in relation to major coal deposits in the United States.

appears to be October 2 in Texas (Oberholser 1974). Eggs have been observed as early as March 29 and as late as May 17 in Texas (Brewster 1879; Oberholser 1974). In New Mexico, Huber (1929) collected adults in breeding condition on April 13 and Stevens (1879) collected an egg near hatching on May 28. Egg dates from Arizona occur from April 19 to May 24 (Bendire 1892; Bent 1937; van Rossem 1936). Glinski and Millsap (pers. comm.) believe the nestling stage lasts about 6 weeks. Monson (1947) observed a fledgling on July 13 in Yuma Co., Arizona.

Nesting Habitat

Breeding habitat of the zone-tailed hawk ranges from sea level and near sea level elevation in Texas and along the Lower Colorado River to mountains at 2,743 m (Phillips et al. 1964; Oberholser 1974; Glinski and Millsap pers. comm. 1982). The hawks generally nest within 0.8 km of water (Call 1978), often along streams in riparian woodlands, in broken terrain, canyons, and semi-arid mesa country (Brown and Amadon 1968; Hubbard 1970; Oberholser 1974; Matteson and Riley 1981). Nest structures may be from 7.6 to 30.5 m from the ground and most commonly occur in cottonwoods (e.g., Bendire 1892; Bent 1937; Call 1978). Cypress trees (Brewster 1879), sycamores (Marshall 1957), walnuts, pines (Ligon 1961), ponderosa pines (Matteson and Riley 1981), fir, palo verde (Glinski and Millsap pers. comm.), and oaks (van Rossem 1936; Brandt 1951) are also used as nest trees. The same nest structure may be used in successive years (Brown 1901; Call 1978; Matteson and Riley 1981) and thus may become large and bulky. Some nest areas have a long history (e.g., 70 years) of use (Brown 1901) although after 1 to 3 years of use some sites may be abandoned for a few years before being occupied again (Glinski and Millsap pers. comm.).

Zone-tailed hawks usually lay two (rarely one or three) short, ovate eggs (Bent 1937) which are white or bluish-white and occasionally lightly spotted (Brown and Amadon 1968). The nest is a coarse, sometimes bulky structure, made of large sticks and decorated with bark, moss or most commonly, green leaves (Bendire 1892; Brown and Amadon 1968). When encountered at the nest site, zone-tailed hawks may be aggressive and vocal (Bent 1937).

In western Texas, Matteson and Riley (1981) recorded fledging rates of 1.2 and 1.0 young per nest from two years of data. Productivity was reduced as a result of abandonment, hatch failure, and loss of nestlings.

Hunting Habitat

Zone-tailed hawks range widely into habitats that differ from the site chosen for the nest (Marshall 1957). One of several hunting tactics involves coursing back and forth over an area, in a harrier-like flight, then plunging to capture prey (May 1935; Brown and Amadon 1968; Meeth and Meeth 1978). Hunting flights often occur in rugged terrain, along cliff faces or at forest edges where these hawks apparently utilize updrafts to remain 10 to 20 m above the surface until diving quickly to pursue prey (Willis 1963; Zimmerman 1976). Zone-tailed hawks may also soar higher (i.e., 180 m) and dive toward prey, or may soar over forest canopies, plunging to capture small birds (Willis 1966;

Zimmerman 1976). May (1935) and Marshall (1957) both describe a hover-type flight from which the hawks pursue prey. The degree to which the zone-tailed hawk has evolved behavior and appearance similar to the turkey vulture as an adaptation for prey capture and aerodynamics is being studied (Willis 1963, 1966; Mueller 1972; Zimmerman 1976; Glinski pers. comm.).

ZONE-TAILED HAWK POPULATION TRENDS

Present Levels

The zone-tailed hawk is not a common bird anywhere in its range (e.g., Wauer 1973). Glinski and Millsap (pers. comm.) have records of about 100 nest sites in the United States and estimate the present breeding population may be as many as 200 pairs. Estimates are difficult to make because these birds are rare and local breeders, widely dispersed at nest sites in a variety of habitats including mountainous terrain and remote side canyons (see Porter and White 1977). Oberholser (1974) believed the number of hawks declined throughout the twentieth century.

Effects of Habitat Changes

The alteration of Southwestern U.S. riparian habitats by tree-cutting (Phillips et al. 1964) and overgrazing (Call 1978; Glinski and Millsap pers. comm.), which inhibit regeneration of trees suitable for nesting as well as damaging prey habitat, has affected the nesting distribution of zone-tailed hawks. The extent to which loss of water flow in various drainages, due to agricultural, industrial, and residential use of water, has affected the hawks is unknown.

Effects of Human Disturbance

Increased recreational use of the Edwards Plateau apparently forced zone-tailed hawks from that area of Texas (Oberholser 1974), and recreation along streams and rivers, especially during the critical time of incubation and brooding (i.e., around Memorial Day weekend), probably disrupts nesting (Glinski and Millsap pers. comm.). Human use of canyon habitat may cause nest abandonment with subsequent renesting attempts frequently failing (Call 1978). Shooting of hawks also remains a problem (Zimmerman 1970).

Management

Arizona (1978) and Texas (1979) provide special legal protection for zone-tailed hawks by designating them threatened and protected nongame species, respectively. Habitat management recommendations for the species include elimination of overgrazing and propagation of more natural riparian habitat (Zimmerman 1970; Call 1979). The opening of some dense scrub and forest may benefit the hawks (Glinski and Millsap pers. comm.). Protection from indiscriminate shooters and more careful use of rodenticides may also benefit the species (Zimmerman 1970).

The Zone-Tailed Hawk as an Indicator Species

Zone-tailed hawks will not be useful indicators of impacts caused by mining until more data are gathered about the density and population dynamics of the species, as well as better information about habitat use, especially in hunted areas. Because Texas, New Mexico, and Arizona are at the northern limits of the species' breeding range (Fig. 10) and because it nests in such low densities, the species may never be practical for monitoring disruptions or recoveries of wildlife.

By virtue of their peripheral occurrence and rarity in the United States, and special protection status in Texas and Arizona, zone-tailed hawks must receive extra consideration regarding those activities that could disturb breeding birds.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts to zone-tailed hawks may occur directly, for instance death by shooting or destruction of a nest site, or indirectly through disturbance that disrupts the normal behavior or by alteration of hunting habitat that in turn has a negative impact on foraging efficiency. The species dependence on relatively few nest sites in the U.S. and its association with canyons and riparian habitat suggests that adverse alteration to these sites and areas would pose the most serious threats. The paucity of nests and prolonged use over many decades suggests that the species has little behavioral plasticity for alternative nest situations. Human activity at the nest site during the periods of nest construction or repair, incubation and nestling care will cause abandonment of the nests or reduced productivity. Construction of haul roads or other development causing prolonged activity in the breeding range should be post-poned until some time after young have gained some independence.

Coal mining activities undertaken some distance from the nest, or outside the breeding season can also have adverse impacts on raptors. Construction and related activity may displace birds from favored roosts, perches, and hunting habitat. Contaminated water from mining byproducts or runoff, or decreased water supplies due to water diversion may cause a breakdown of the riparian community on which the raptor relies. Collision with or electrocution from powerlines may be a problem. Thus, mining within 16 km of zone-tailed hawk nests should proceed only in conjunction with mitigation directed to the hawk, and designed to lessen impacts on the canyon land and riparian habitats in general. About 100 nest sites are known historically, but some of these have already been rendered inactive due to disturbance. Pairs of these hawks may not maintain alternate nests within their home ranges, and the use of some sites for more than 70 years suggests each nest is a critical element for the population in the United States.

Activities most likely to disrupt the reproductive behavior of zone-tailed hawks are those involving frequent and prolonged presence in the home range, such as haul road construction. Roadways or spoil pits in the hunting range of a pair may potentially disturb prey species, and thus have a negative impact on the hawk.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Any anticipated mining activity within the range of zone-tailed hawks should be preceded by a survey to determine if the species breeds on or within 16 km of the proposed lease area. Because these rare birds range over relatively large areas it is important to attempt mitigation not only at the nest site but throughout their potential home ranges (up to 16 km from the nest). If these hawks are found on or near lease areas, their presence and productivity may be monitored annually so that protective measures can be taken throughout all phases of mining. Range use, food habits, and productivity levels may be documented for baseline data to compare with data from the mining and reclamation phases. If a nest site(s) is located, impacts may be lessened if mining activities are located away from the nest and home range.

Exploration and Mine Development Phase

During this phase the most effective mitigation can be achieved by eliminating disturbance within 16 km of nest sites, from mid-March to August. The behavior of zone-tailed hawks in various parts of their home ranges and the effects of disturbance on their behavior and productivity have not been studied. These factors have been evaluated to some extent for ferruginous hawks and golden eagles, both of which are relatively wide-ranging species. Depending on the extent of exposure relative to the nest site and the type of disturbance (e.g., line-of-site vision from nest to disturbance vs. heavy vegetation or topography between nest and disturbance), a recommended buffer zone of 0.4 to 3.2 km (with shape correlated to topography and ownership) may be established for activities such as occasionally walking or driving through the home range, or for low levels of noise (White et al. 1979; Sutter and Joness 1981).

Mining Phase

Mitigation during the mining phase includes avoidance of nest sites and use of buffer zones particularly during the breeding season. Dust control measures and control of water contamination or change in water levels will also help to protect nesting birds. Education of workers and strict control of firearms in the region may decrease human harassment.

Reclamation Phase

Every effort should be made to restore the original diversity of vegetation to the area. A mosaic of aquatic areas, woodlands, shrublands, and rocky outcrops and boulders will provide hunting habitat. Planting a variety of shrubs and trees and creating wetland habitats may enhance the area for zone-tailed hawks. Continued monitoring may help to ensure successful reclamation efforts.

SUMMARY

The zone-tailed hawk reaches the northern limits of its breeding range in Texas, New Mexico, and Arizona, where it nests in relatively remote and rugged riparian and canyon habitats. Individuals range widely, hunt in a variety of habitats, and consume prey ranging from fish to medium-sized birds and mammals.

Should mining activity be anticipated within the range of zone-tailed hawks, it is recommended that efforts be made to locate nest sites of the species and conduct mining at least 16 km away from these rare birds. Because so little is known about their ecology, and because breeding pairs are so widely spaced, the zone-tailed hawk should not be viewed as a valuable indicator species.

ACKNOWLEDGMENTS

R. Glinski and B. Millsap kindly provided unpublished information from their current fieldwork. L. Garrett and her staff, C. Kimball, and C. Nalley assisted with obtaining references and publications. J. Partelow helped compile information from the literature and reviewed the manuscript, B. Dowell reviewed the report.

REFERENCES

Bendire, C. E. 1892. Life histories of North American birds. U.S. Nat. Mus. Spec. Bull. 1.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. U.S. Nat. Hist. Bull. 167. 409 pp.

Bohl, W. H., and E. Taylor. 1958. Correction in identification of the zone-tailed hawk as a Mexican black hawk. Condor 60:139.

Brandt, H. 1951. Arizona and its bird life. Bird Res. Found., Cleveland, OH.

Brewster, W. 1879. On the habits and nesting of certain rare birds in Texas. Bull. Nuttall Ornithol. Club 4:80.

__________. 1883. On a collection of birds lately made by Mr. F. Stephens in Arizona. Bull. Nuttall Ornithol. Club 8(1):21-36.

Brown, H. 1901. Band-tailed hawk's nest (Buteo abbreviatus) in Arizona. Auk 18:392-393.

Brown, L., and D. Amadon. 1968. Eagles, hawks, and falcons of the world. Vol. 2. Hamlyn Publ., Feltham, Britain.

Call, M. 1978. Nesting habitats and surveying techniques for common Western raptors. U.S. Bur. Land Manage., Tech. Note 316. Denver Serv. Cent., CO.

Call, M. 1979. Habitat management guides for birds of prey. U.S. Bur. Land Manage., Tech. Rep. T/N338. Denver, CO. 70 pp.

Cottam, C. 1947. Zone-tailed hawk feeds on rock squirrel. Condor 49:210.

de Schauensee, R. M. 1970. Guide to the birds of South America. Livingston Publishing Co., Wynnewood, PA.

Friedman, H., L. Griscom, and R. T. Moore. 1950. Distributional checklist of the birds of Mexico. Cooper Ornithol. Club, Pacific Coast Avifauna 29.

Glinski, R. 1982. Personal communication. 6255 E. Halifax, Mesa, AZ.

Glinski, R., and B. Millsap. 1982. Personal communication. 6255 E. Halifax, Mesa, AZ.

Grey, H. 1917. Zone-tailed hawk at San Diego, California. Condor 19:103.

Grinnell, J. 1909. Zone-tailed hawk in California. Condor 11:69.

Hubbard, J. P. 1970. Check-list of the birds of New Mexico. New Mexico Ornithol. Soc. Publ. 3. 108 pp.

__________. 1971. The summer birds of the Gila Valley, New Mexico. Occas. Pap. Delaware Mus. Nat. Hist. Nemouria 2:1-35.

Huber, W. 1929. Zone-tailed hawk in Lincoln County, New Mexico. Auk 46:544.

Ligon, J. S. 1961. New Mexico birds and where to find them. Univ. New Mexico Press, Albuquerque. 360 pp.

Linton, C. B. 1907. Mexican black hawk in California. Condor 9:110.

__________. 1908. Correction (concerning Buteo abbreviatus). Condor 10:181.

Marshall, J. T., Jr. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna 32:1-125.

Matteson, S. W., and J. O. Riley. 1981. Distribution and reproductive success of zone-tailed hawks in west Texas. Wilson Bull. 93:282-284.

May, J. R. 1935. The hawks of North America. Houghton Mifflin Co., Boston.

Mearns, E. A. 1886. Some birds of Arizona. Auk 3:60-73.

Meeth, P., and K. Meeth. 1978. Zone-tailed hawks Buteo albonotatus in Colombia. Ardea 66(3):121.

Monson, G. 1947. Zone-tailed hawk breeding along Colorado River. Wilson Bull. 59:172.

Mueller, H. C. 1972. Zone-tailed hawk and turkey vulture: mimicry or aerodynamics? Condor 74:221-222.

Newman, G. A. 1974. Recent bird records from the Guadalupe Mountains, Texas, U.S.A. Southwest Nat. 19:1-7.

Oberholser, H. C. 1974. The bird life of Texas. Vol. 1. Univ. Texas Press, Austin.

Phillips, A., J. Marshall, and G. Monson. 1964. The birds of Arizona. Univ. Ariz. Press, Tucson.

Porter, R. D., and C. M. White. 1977. Status of some rare and lesser known hawks in Western United States. Pages 39-57 in R. D. Chancellor, ed. Report of Proc.: World Conference on Birds of Prey, Vienna, 1-3 October 1975. Int. Counc. Bird Preservation: Taylor and Francis, Britain.

Robbins, C. S., B. Bruun, and H. S. Zim. 1966. Birds of North America. Golden Press, NY.

Small, A. 1924. The birds of California. Winchester Press, NY.

Snyder, N. F. R., and J. W. Wiley. 1976. Sexual size dimorphism in hawks and owls of North America. Am. Ornithol. Union, Ornithol. Mono. 20. 96 pp.

Stevens, F. 1879. Nesting of Buteo zonocercus in New Mexico. Bull. Nuttall Ornithol. Club 4:189.

Sutter, G. W., II, and J. L. Joness. 1981. Criteria for golden eagle, ferruginous hawk, and prairie falcon nest site protection. Raptor Res. 15:12-18.

Swarth, H. S. 1914. A distributional list of the birds of Arizona. Cooper Ornith. Club. Pacific Coast Avifauna 10.

_____________. 1920. Birds of the Papago Saguaro National Monument and the neighboring regions. Govt. Printing Off., Washington 1-63.

van Rossem, A. J. 1936. Notes on birds in relation to the faunal areas of south-central Arizona. Trans. San Diego Soc. Nat. Hist. 8:121-148.

Wauer, R. H. 1973. Birds of Big Bend National Park and vicinity. Univ. Texas Press, Austin. 233 pp.

White, C. M., T. Thurow, and J. F. Sullivan. 1979. Effects of controlled disturbance on ferruginous hawks as may occur during geothermal energy development. Pages 777-779 in Trans. Vol. 3, Geothermal Resour. Counc., Davis, CA.

Willis, E. O. 1963. Is the zone-tailed hawk a mimic of the turkey vulture? Condor 65:313-317.

_____________. 1966. A prey capture by the zone-tailed hawk. Condor 68:104-105.

Zimmerman, D. A. Unpub. (1970). Birds and bird habitats on National Forest lands in the Gila River Valley, southwestern New Mexico. Western New Mexico Univ. and Gila Natl. For. Silver City, NM. 42 pp.

_____________. 1976. Comments on feeding habits and vulture-mimicry in the zone-tailed hawk. Condor 78:420-421.

FERRUGINOUS HAWK (*Buteo regalis*)

by

David L. Evans
Northern Prairie Wildlife Research Center
U.S. Fish and Wildlife Service
Jamestown, ND 58401

SPECIES DESCRIPTION

The ferruginous hawk (*Buteo regalis*) is the largest North American buteo. It occurs in light and, less commonly, dark (melanistic) and red (erythristic) color phases. Light phase adults are brownish above, with rufous feather edgings; undersides are whitish, except for the thighs which are rusty-brown (ferruginous) with black barring. The tail is whitish or silvery, often with a reddish or rufous tinge near the end. Juveniles are similar to the adult, with some spotting on the breast and flanks. The thighs are whitish with dark spotting. The tail of juveniles is white at the base and brownish-gray with several indistinct bars on the remaining portion. The eyes of juveniles are yellowish, turning brownish by the first year and eventually to a rich chocolate-brown in older birds (Brown and Amadon 1968). Legs of ferruginous hawks are feathered to the toes. Both juveniles and adults in melanistic and erythristic color phases are characterized by dark brown or rufous plumage on undersides as well as above. Birds with these color phases typically comprise less than 5% of the population in the Western States (Olendorff 1973; Howard 1975; Lokemoen and Duebbert 1976; Blair and Schitoskey 1982). About 30% of the birds are reported to be dark phase in southwestern Saskatchewan (Lokemoen and Duebbert 1976).

DISTRIBUTION

The ferruginous hawk breeds in semi-arid plains and intermountain areas from eastern Washington, southern Alberta, Saskatchewan, Manitoba, and eastern North Dakota south to southern Arizona, New Mexico, and Kansas (Fig. 11). It winters, at low densities, over the central and southern parts of the breeding range and at higher densities in Baja California, and northern Mexico (Weston 1969; American Ornithologists' Union 1983). The primary wintering area appears to be centered in western Texas (Salt 1939; Bock and Lepthien 1976).

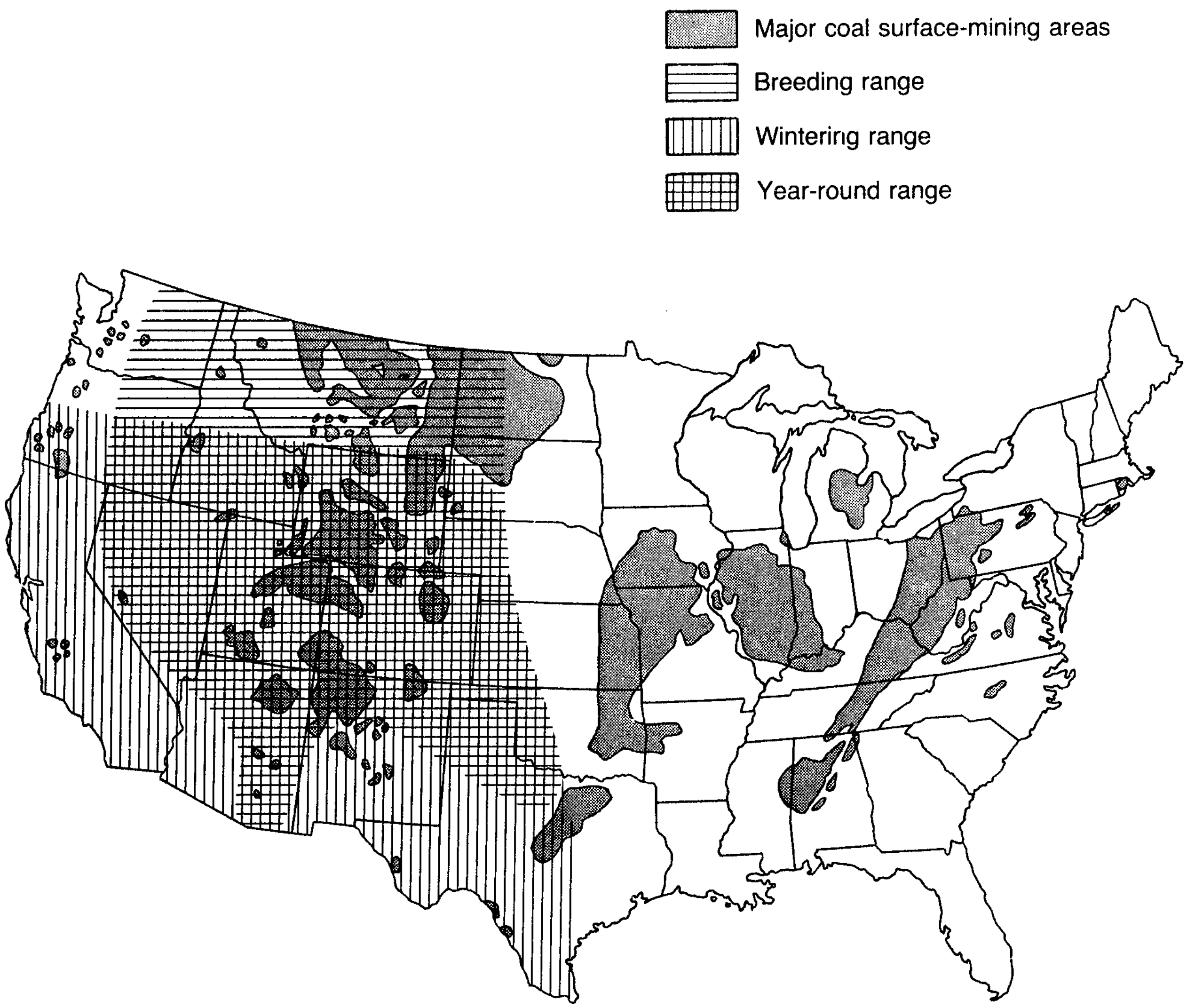


Figure 11. Geographical range of the ferruginous hawk in relation to major coal deposits in the United States. After Inkley and Raley (1983).

DIET

Ferruginous hawks feed primarily on small to medium-sized mammals. Birds, reptiles, and invertebrates form a very small proportion of the total consumed biomass (Snyder and Wiley 1976; Sherrod 1978). The black-tailed jackrabbit (Lepus californicus), when available, may constitute over 90% of the biomass consumed (Weston 1969; Smith and Murphy 1973; Howard and Wolfe 1976; Woffinden and Murphy 1977). The white-tailed jackrabbit (Lepus townsendii) may comprise over half of the diet in northwestern South Dakota (Blair and Schitoskey 1982). The diet in other areas typically centers around various species of ground squirrels (Spermophilus richardsonii, S. townsendii, S. washingtoni, or Ammospermophilus leucurus, depending on the range) and the northern pocket gopher (Thomomys talpoides), with a variety of lagomorphs and other small mammals contributing the remaining prey biomass (Howard and Wolfe 1976; Lokemoen and Duebbert 1976; Fitzner et al. 1977; Schmutz 1977; Wakeley 1978a; Gilmer pers. comm.).

The cover type selected for hunting has not been thoroughly described for the ferruginous hawk. Ferruginous hawks return consistently to hunt areas with little or no vegetative cover, though the areas may have lower prey populations than surrounding areas containing denser cover (Wakeley 1978b). Apparently, many of the food items captured are emigrants from surrounding fields containing better cover. Ferruginous hawks along the Idaho-Utah border inhabit the juniper-sagebrush (Juniperus spp.-Artemisia spp.) ecotone, utilizing the sagebrush community for hunting and junipers for nesting (Powers et al. 1975).

REPRODUCTION

Ferruginous hawks typically return to breeding areas in late February - early March in Colorado and the Great Basin (Weston 1969; Olendorff 1973; Smith and Murphy 1973) and in late March - early April in South Dakota, North Dakota, and Alberta (Lokemoen and Duebbert 1976; Schmutz 1977; Blair and Schitoskey 1982; Gilmer pers. comm.). Courtship and nest building ensue, and egg laying begins some 2 to 5 weeks later. Egg laying occurs in April, the peak time varying with regional and between-year climatic conditions (Weston 1969; Olendorff 1973; Lokemoen and Duebbert 1976; Schmutz 1977).

Incubation lasts 35 to 36 days (Olendorff 1973; Schumtz 1977) and is done primarily by the female. The male provides all food through the incubation and early nestling period and assumes incubation and brooding duties for short periods only. The young no longer require constant attendance after they reach 3 weeks of age and the female may then help provide additional food. The young fledge at 38 to 50 days, males leaving first (weight approximately 1300 g) and females following as long as 10 days later (weight approximately 1800 g) (Schumtz 1977; Gilmer pers. comm.). The young hawks depend on their parents for food for several more weeks (Smith and Murphy 1973; Powers et al. 1975; Woffinden and Murphy 1977; Blair and Schitoskey 1982).

The ferruginous hawk breeds primarily in relatively open areas. Extensive wooded areas and mountainous regions are typically avoided. Ferruginous hawks use a wide variety of nest substrates (Table 5). Nests located in vegetation vary in height from 2 to 3 m in bushes, junipers, or sagebrush (Artemisia tridentata) to 10 to 15 m high in cottonwoods (Populus spp.) or other tall trees (Weston 1969; Call 1978; Gilmer pers. comm.). Ground nests are typically placed on some habitat discontinuity: hillsides; rocky outcrops; low ledges; rockpiles; erosional remnants; low cliffs; buttes; rocky pinnacles; or river cutbanks (Weston 1969; Olendorff 1973; Call 1978; Blair and Schitoskey 1982; Gilmer pers. comm.). Ferruginous hawks also nest on a variety of man-made sites: high voltage transmission line towers; wooden power poles; haystacks; chimneys; windmills; pumping structures; abandoned buildings; sheepherder monuments; rock piles; spoil piles from mine test pits (Call 1978; Gilmer pers. comm.); and artificial nesting platforms (Schmutz 1977; Anderson and Follett 1978; Howard and Hilliard 1980).

POPULATION TRENDS

Population estimates and productivity measurements are not understood for the ferruginous hawk. Fluctuations of local populations, apparently in association with prey cycles and wide dispersion of breeding sites, have precluded an accurate assessment of the overall status of the ferruginous hawk. Most populations are thought to be stable or slowly declining, with habitat loss the most serious threat (Evans 1982). Call (1980) estimated a minimum of 2,810 to 3,590 breeding pairs over the entire range in 1979. The National Audubon Society placed the ferruginous hawk on the Blue List in 1972 (early warning of potentially dangerous, apparently non-cyclic population declines) and in 1982 placed the species on the List of Species of Special Concern (Tate and Tate 1982). Studies in Washington (Fitzner et al. 1977), Colorado (Olendorff 1973), South Dakota (Lokemoen and Duebbert 1976; Blair and Schitoskey 1982), and North Dakota (Gilmer pers. comm.), however, indicate adequate population recruitment rates. Populations in Idaho and Utah were reproducing adequately through the early 1970's (Weston 1969; Smith and Murphy 1973; Howard and Wolfe 1976). Declines in numbers of nesting birds and their productivity occurred after 1972 in Idaho and Utah coincident with a severe decline in black-tailed jackrabbit populations, the major prey species in that region (Howard and Wolfe 1976; Powers and Craig 1976; Woffinden and Murphy 1977). Although these declines are presumably associated with the 'low' phase of the jackrabbit cycle (Howard and Wolfe 1976; Woffinden and Murphy 1977), Powers and Craig (1976) noted that alternative prey (Richardson's ground squirrel) were available in their study area and speculated that increased human activity contributed to ferruginous hawk declines. Productivity in that same area was higher in 1977-79 as rabbit populations increased (White et al. 1979; Thurow et al. 1980). Higher production in ferruginous hawks occurred in local areas where alternative prey species were available (Howard and Wolfe 1976; Woffinden and Murphy 1977; Wakeley 1978b). The relative effects of human disturbance during different periods of prey abundance are little known; the results of White et al. (1979) suggest that nesting adults are more sensitive to disturbance during periods of food stress.

Table 5. Habitats used by ferruginous hawks for nesting.

Study	Habitats (number of nests)
Utah (Smith and Murphy 1978)	Juniper (55) Pinyon Pine (2) Cliffrose (2) Cottonwood (1) Ground (13) Rock Outcrop (1) Cliff (3) Man-made (2)
Idaho-Utah (Howard and Wolfe 1976)	Juniper (92) Ground (3)
Utah (Weston 1969)	Ground (14) Juniper (11) Cliff (1) Cliffrose (1)
Idaho-Utah (Powers and Craig 1976)	
Little Lost River Valley	Juniper (1) Ground (39)
INEL site	Juniper (35)
Washington (Fitzner et al. 1977)	Juniper (5) Black Locust (1) Rock Outcrop (25)
South Dakota (Blair and Schitoskey 1982)	Ground (35)
South Dakota (Lokemoen and Duebbert 1976)	Ground (2) Tree (13) Haystack (2)
Colorado (Olendorff 1973)	Tree (49) Erosional remnant (8) Creek bank (4) Cliff (4) Ground (4) Man-made structure (2)

Estimates of the population of ferruginous hawks in Western coal provinces are not available. Most studies on the ferruginous hawk have been conducted on relatively small areas and have concentrated on breeding biology and prey relationships. Population density and productivity vary considerably between study areas and from year to year (Table 6), presumably due to differences in prey abundance or availability. Ferruginous hawks often occur in localized concentrations where large areas of apparently suitable habitat exist (Powers et al. 1975). It is not known whether this reflects prey abundance, the availability or preference of nest sites, or a traditional use of an area by a reduced, non-expanding population (i.e., young adults returning to their natal area and being recruited into the local population).

Effects of Habitat Changes

Historically, man's alteration of habitat has had both positive and negative effects on the ferruginous hawk. The creation of a variety of new nesting sites (planted trees, high voltage transmission line towers, haystacks) has allowed expansion of some populations into previously uninhabited areas (Olendorff 1973; Gilmer pers. comm.). Agricultural development and other human endeavors, on the other hand, have undoubtedly had negative effects on many populations. Reclamation of overgrazed, shrub-invaded rangeland has reduced nesting and roosting habitat in the intermountain areas of the Western United States (Powers et al. 1975). Cultivated areas appear to be consistently avoided in the West (Weston 1969; Olendorff and Stoddart 1974; Howard and Wolfe 1976; Woffinden and Murphy 1977). Nests, however, commonly occur within or closely adjacent to cultivated areas in the central Dakotas (Lokemoen and Duebbert 1976; Gilmer pers. comm.). These areas supported higher densities of ferruginous hawks with better reproductive performance than did areas west of the Missouri River in North and South Dakota.

Effects of Human Disturbance

Human disturbance during the prelaying, laying, and incubation periods appears to be a critical factor in nest desertion (Fyfe and Olendorff 1976). Field researchers quickly recognized this problem and have restricted nest visits during this critical period (Olendorff 1973; Howard 1975; Powers et al. 1975). The number of desertions resulting from agricultural practices, recreation, etc. is a matter of conjecture but such activities may contribute to declines in some areas. Many ferruginous hawks nest successfully in cultivated areas in central North Dakota (Gilmer pers. comm.) and in southern Idaho (Thurow et al. 1980) but the bird's tolerance to agricultural activities appears to be more limited in other Western States (Olendorff 1973; Olendorff and Stoddart 1974; Powers et al. 1975; Howard and Wolfe 1976; Fitzner et al. 1977).

Illegal shooting constituted a substantial source of mortality in many areas (Salt 1939; Smith and Murphy 1973; Snow 1974; Howard 1975). The shooting of raptors appears to have declined during the last decade as public awareness of nongame importance has increased.

Table 6. Productivity of ferruginous hawks in western North America.

Study	Year	Occupied nests	Occupied nests	Number of young	Young per occupied nest
Utah (Weston 1969)	1967	13	--	8	0.62
	1968	14	--	28	2.00
Utah (Smith and Murphy 1978)	1967	15	10	12	0.80
	1968	28	25	55	1.96
	1969	34	31	90	2.65
	1970	13	7	10	0.77
Utah (Woffinden and Murphy 1977)	1972	16	12	31	1.94
	1973	7	3	7	1.00
	1974	3	3	3	1.00
Utah (Howard and Wolfe 1976)	1972	43	31	59	1.37
	1973	54	26	26	0.48
Washington (Fitzner et al. 1977)	1974	9	3	5	0.56
	1975	12	6	15	1.25
Colo. (Olendorff 1973)	1971	10	7	16	1.60
	1972	6	3	8	1.33
	1970	9	6	11	1.22
	1971	13	11	27	2.08
	1972	31	20	58	1.87
South Dakota (Blair and	1976	18	13	34	1.89
Schitoskey 1982)	1977	17	14	39	2.29
South Dakota (Lokemoen and Duebbert 1976)	1973	16	15	56	1.81
	1974	15	12		
North Dakota (Gilmer pers. comm.)	1976	45	32	112	2.49
	1977	199	125	--	--
	1978	179	131	--	--
	1979	243	185	--	--

Management

Increased emphasis has been placed on the management of populations of ferruginous hawks. A number of agencies have erected artificial nesting platforms in potential and existing nesting areas. In Alberta, 93 nest platforms were erected on a 100 km^2 area in 1975 (Schmutz 1977). Two ferruginous hawk pairs occupied and fledged young from the platforms in 1976. Six of those platforms were used in 1980 by ferruginous and Swainson's hawks (*Buteo swainsoni*) (Fyfe pers. comm.). No data are available for the intervening years. Twenty-four nesting platforms were erected in 1976 in the proposed Birds of Prey National Conservation Area in southwestern Idaho (Howard and Hilliard 1980). From 1977-1980, 10 occupancies and eight successful nests that fledged 22 young were recorded (average of 2.2 young per occupied nest).

New nest support structures were erected on the Comanche National Grassland in southeastern Colorado. The number of nesting pairs on this site increased from 7 to 15 from 1968 to 1978, and productivity increased from 1.8 to 3.1 young fledged per nest (Anderson and Follett 1978). Fencing around trees that may be potential nest sites and that are subject to cattle damage may protect nest sites in areas where the availability of trees may be a limiting factor (Olendorff and Stoddart 1974).

Ferruginous hawks are potentially vulnerable to electrocution when landing and taking off from conventional wood power poles. Miller et al. (1975) provide specifications for the construction of low voltage power lines that will reduce or eliminate the incidence of electrocutions.

Rangeland reclamation projects have reduced nesting and hunting habitat in some areas. Methods of controlling sagebrush and juniper invasion of overgrazed rangeland include chaining, discing, and plowing. Chaining is recommended if such control must occur, with at least 20% of the original vegetation retained as small, scattered islands (Howard and Wolfe 1976). This design will produce optimum ferruginous hawk habitat in 3 to 4 years. Reclaimed areas seeded with crested wheatgrass (*Agropyron cristatum*) produced suitable hunting habitat within 6 to 8 years when native vegetation reinvaded the treated areas.

The Ferruginous Hawk as an Indicator Species

An indicator species is one that has a narrow range of tolerance for environmental change and, as such, may serve as an early warning of excessive disruption to its environment (Graul et al. 1976; Wagner 1977). The ferruginous hawk is sensitive to both human disturbance and changes in prey populations. Both of these factors, associated with surface coal mining, will negatively impact populations of ferruginous hawks. Ferruginous hawks can be adaptable to some aspects of human activity, such as their utilization of man-made nesting sites. The ferruginous hawk, whose breeding range encompasses western coal lands, would thus seem a valuable indicator of the impacts of surface mining and of the success of mitigation efforts.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts to ferruginous hawk populations may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur through destruction of nests and nestlings. Stress from increased human activity and increased noise levels may result in nest abandonment, lowered productivity levels, or abandonment of the entire area. Serious impacts to ferruginous hawks may occur during exploration activities that involve areas larger than the actual mine site and may cause desertion and reduce the number of hawks fledged on the area. Populations may also be affected by the general increase in human activity indirectly associated with the mining process, i.e., recreational activities resulting in general disturbance and nest desertion, indiscriminate shooting of birds, and possible reductions in prey populations through legal hunting.

Habitat loss may result in serious impacts of local ferruginous hawk populations through loss of nest sites and hunting territories. Displaced individuals will be forced to move to other suitable habitat, resulting in overcrowding and increased competition (assuming suitable habitat is already occupied). This displacement and increased competition may result in an ultimate decrease in the population.

Increased dust levels and contaminated water supplies from mining byproducts may cause a decrease in vegetative growth, resulting in lower small mammal populations and thus decreasing local raptor populations. Mortality may also be caused by electrocution or collision with transmission towers and lines.

Impacts to populations of ferruginous hawks may vary considerably among mining areas. On a 240-square mile study area in Sweetwater County, Wyoming, 60% of all ferruginous hawk nests were within 1 km of areas of projected major mine disturbance (Lockhart et al. 1980). Most areas of projected coal development did not appear to have high nesting densities of ferruginous hawks in eastern Montana (Bricco pers. comm.). Population densities were also quite low on a proposed coal development area in Harding County, South Dakota. It is thus difficult to predict, because population densities are so variable, the amount of habitat that could be disrupted by mining activities without adversely impacting the regional populations of ferruginous hawks.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Baseline data on local ferruginous hawk populations are essential to an assessment of mining impacts and success of the implementation of mitigation techniques for those populations (see Kennedy 1980). Population surveys, including a suitable off-mine control area, should be initiated at least 2 years prior to any mine-related activity (Lockhart et al. 1980). An annual census including a survey of all potential nesting sites to determine occupancy and a second survey to determine success and productivity of occupied nest sites will provide information on population levels (Postupalsky 1974). The collection of pellets and documentation of prey items found in nests during the second survey may help identify important local prey species and annual changes in their relative abundance. Sampling procedures should be designed for the specific phase of the yearly cycle being studied.

Exploration and Mine Development Phase

Progress of mine development should be performed with consideration for the annual nesting status of raptors. Scheduling activities to avoid the nesting season of raptors is believed to be a strong measure for mitigation of impacts and may further promote the adaptability of raptors to high disturbance situations. Establishment of buffer zones to protect nest sites will minimize impacts to ferruginous hawks at this critical stage of mine progress. A recommended buffer zone would preclude any human activity 0.8 km from any nest and any construction 1.6 km from any nest (White et al. 1979). Closer disturbances in later phases of the nesting cycle may serve to habituate birds to disturbance (Lockhart et al. 1980, and pers. comm.); the effects of disturbance during the nestling period should be investigated. Relaxing or eliminating buffer zones during the non-breeding season (August through February) will probably not be harmful to ferruginous hawk populations and will aid mineral exploration efforts.

Destruction of existing and potential nest sites will occur during actual mine construction and surface stripping stages of the mining process. Nesting platforms (Call 1979) and the careful routing of high voltage transmission lines (HVTL's) in the vicinity of proposed mining areas may result in the establishment or re-establishment of nesting territories near future reclamation lands. The status of these established territories throughout mining and reclamation phases may serve as a useful indicator of impact severity and mitigation success. Gilmer and Wiehe (1977) reported on nesting success on HVTL towers in North Dakota. Nests established in the types of towers then available had good production but were vulnerable to destruction by high winds. More recently, new HVTL's of the "Minn-Kota" type tower have been constructed. These towers provide an extremely secure site for nest placement and have been utilized heavily by ferruginous hawks (Gilmer pers. comm.). The extra buffer resulting from the high nest placement (approximately 80 ft) may allow ferruginous hawks to utilize mine disturbance areas; "Minn-Kota" type HVTL's should be given high priority in HVTL selection. If tower areas develop into traditional nest sites, modification of current legislation to allow the retention of nesting and perching towers after completion of mining may be appropriate. Towers should also be designed to eliminate risk of electrocution. Roads routed away from nesting areas, powerlines, and HVTL's may help to minimize illegal shooting and general disturbance.

Mining Phase

Disturbance to regional populations of ferruginous hawks will decrease during the mining phase but specific nesting areas may be heavily impacted and some nests will be destroyed. Permanent buffer areas established where feasible, especially near mining boundaries where coal recovery may be economically marginal, will help alleviate impacts. Leaving small islands of ferruginous hawk habitat appears to be an inadequate solution at this time (Tyus and Lockhart 1979; Lockhart et al. 1980). Efforts would be more effective if concentrated on replacing suitable nesting habitat throughout the mining phase. This may be accomplished with use of artificial platforms, tree reclamation, and leaving suitable sections of highwalls (Tyus and Lockhart 1979; cf. Lockhart et al. 1980).

Habitat loss and replacement and resulting losses or replacement of breeding raptors could be quantitatively assessed on an annual basis throughout the life of the mine. Likewise, annual prey abundance both on the mine lease and in control areas could be documented. Long-term data on mine effects are essential for accurate evaluations of overall impact on local raptor populations.

Reclamation Phase

Mine reclamation may be primarily directed toward re-establishment and enhancement of environmental components necessary to support large and diverse raptor populations currently found on the area. Sandstone cliffs, bluffs, rock outcrops, or pinnacles found within the mine area may be preserved to the maximum extent possible regardless of past use by nesting raptors. Reclamation of suitable, geologically sound highwalls may be modified to preserve cliff-like structures for future nesting substrates (requires leniency from current Office of Surface Mining regulations). Reclamation should provide soils, vegetation, and rocky habitats suitable for raptor prey species.

Nesting platforms erected on reclaimed areas, perhaps as many as one per section, will encourage nesting by hawks. Trees planted in suitable areas may provide future nesting sites; fencing around trees in rangeland regions will protect them from damage by cattle. Wooden fence posts for hunting perches (Marion and Ryder 1975; Wakeley 1978c) will enhance the habitat for hawks if installed on 1/4 section corners on sites where natural perches will be unavailable or destroyed.

Mine reclamation may be the most critical factor in the successful mitigation of the impacts of surface mines on the hawk populations. Requirements for producing adequate populations of suitable prey are not well known. McCann (1975), investigated factors that limit or enhance mammal populations on mine reclamation plots in eastern Montana, and observed that cottontails (*Sylvilagus floridanus*) were most abundant soon after mining when sweet clover (*Melilotus officinalis*) was abundant. Ground squirrels and pocket gophers appeared two years after mining, primarily in areas where topsoil was replaced. The distribution of these animals, however, appeared to be limited by a shortage of food and/or cover.

SUMMARY

Western surface coal mining may drastically effect local populations of ferruginous hawks. The hawk is sensitive to disturbance and its populations sometimes fluctuate in a cyclical manner as populations of its principal prey species fluctuate, thus the hawk seems vulnerable to the impacts of habitat change caused by coal surface mining. Recommendations for mitigating and monitoring mine impacts on ferruginous hawks, cited above, may be a reasonable approach to reducing deleterious impacts of coal surface mining on this species. Further research to evaluate the potential severity of mining impacts and the utility of mitigation techniques is also recommended.

ACKNOWLEDGMENTS

Eileen K. Bartels obtained many of the reference materials cited in this report. The following individuals reviewed the report and offered many helpful comments and suggestions: D. S. Gilmer; D. H. Johnson; J. M. Lockhart; R. R. Olendorff; C. M. White; and N. D. Woffinden.

REFERENCES

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Anderson, W. C., and T. M. Follett. 1978. Nest-site management techniques for increasing productivity of grassland raptors. Abstract Proc. 1978 Annual Raptor Research Foundation, Inc. Conference. Allentown, PA.

Blair, C. L., and F. Schitoskey. 1982. Breeding biology and diet of the ferruginous hawk in South Dakota. Wilson Bull. 94(1):46-54.

Bock, C. E., and L. W. Lepthien. 1976. Geographical ecology of the common species of _Buteo_ and _Parabuteo_ wintering in North America. Condor 78(4):554-557.

Bricco, D. 1980. Personal communication. U.S. Bureau of Land Management. Miles City District, MT.

Brown, L., and D. Amadon. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill, New York. 2 vols. 945 pp.

Call, M. W. 1978. Nesting habitats and surveying techniques for common Western raptors. U.S. Bur. Land Manage. Tech. Note TN-316. 115 pp.

__________. 1979. Habitat management guide for birds of prey. U.S. Bur. Land Manage. Tech. Note TN-338. 70 pp.

__________. Unpub. (1980). Nesting habitats and general status of the ferruginous hawk. 6 pp.

Evans, D. L. 1982. Status reports on twelve raptors. U.S. Fish Wildl. Serv. Special Rep. Wildl. 238. 68 pp.

Fitzner, R. E., D. Berry, L. L. Boyd, and C. A. Rieck. 1977. Nesting of ferruginous hawks (Buteo regalis) in Washington 1974-1975. Condor 79(2):245-249.

Fyfe, R. W. 1980. Personal communication. Canadian Wildlife Service, Edmonton, Alberta.

Fyfe, R. W., and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occas. Pap. 23. 17 pp.

Gilmer, D. S. Personal communication. U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Davis, CA.

Gilmer, D. S., and J. M. Wiehe. 1977. Nesting by ferruginous hawks and other raptors on high voltage powerline towers. Prairie Nat. 9(1):1-10.

Graul, W. D., J. Torres, and R. Denney. 1976. A species-ecosystem approach for nongame programs. Wildl. Soc. Bull. 4(2):79:80.

Howard, R. P. 1975. Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho. M.S. Thesis, Utah State Univ., Logan. 60 pp.

Howard, R. P., and M. Hilliard. 1980. Artificial nest structures and grassland raptors. Raptor Res. 14(2):41-45.

Howard, R. P., and M. L. Wolfe. 1976. Range improvement practices and ferruginous hawks. J. Range Manage. 29(1):33-37.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Kennedy, P. L. 1980. Raptor baseline studies in energy developments. Wildl. Soc. Bull. 8(2):129-135.

Lockhart, J. M. 1980. Personal communication. U.S. Fish and Wildlife Service, Region 6, Grand Junction, CO.

Lockhart, J. M., D. W. Heath, and C. L. Belitsky. Unpub. (1980). The status of nesting peregrine falcons and other selected raptor species on the Black Butte Mine lease and adjacent lands. 59 pp.

Lokemoen, J. T., and H. F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. Condor 78(4):464-470.

Marion, W. R., and R. A. Ryder. 1975. Perch site preferences of four diurnal raptors in northeastern Colorado. Condor 77(3):350-352.

McCann, S. A. 1975. The movement and occurrence of small mammals on a reclamation plot. Pages 318-324 in W. F. Clark, ed. Proc. Fort Union Coal Field Symp., April 25-26, 1975. Billings, MT. 706 pp.

Miller, D., E. L. Boeker, R. S. Thorsell, and R. R. Olendorff. 1975. Suggested practices for raptor protection on powerlines. Edison Electric Institute, New York. 21 pp.

Olendorff, R. R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. U.S. IBP Grassland Biome Tech. Rep. 211. 233 pp.

Olendorff, R. R., and J. W. Stoddart, Jr. 1974. The potential for management of raptor populations in Western grasslands. Raptor Res. Rep. 2:47-88.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Raptor Res. Rep. 2:21-31.

Powers, L. R., and H. Craig. 1976. Status of nesting ferruginous hawks in the Little Lost River Valley and vicinity, southeastern Idaho. Murrelet 57(2):46-47.

Powers, L. R., R. P. Howard, and C. H. Trost. 1975. Population status of the ferruginous hawk in southeastern Idaho and northern Utah. Raptor Res. Rep. 3:153-158.

Salt, W. R. 1939. Notes on recoveries of banded ferruginous rough-legged hawks (Buteo regalis). Bird-Banding 10(2):80-84.

Schmutz, J. K. 1977. Relationships between three species of the genus Buteo (Aves) coexisting in the prairie-parkland ecotone of southeastern Alberta. M.S. Thesis, Univ. of Alberta, Calgary. 126 pp.

Sherrod, S. K. 1978. Diets of North American Falconiformes. Raptor Res. 12(3/4):49-121.

Smith, D. G., and J. R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull. Biol. Ser. 18(3):1-76.

______________________________. 1978. Biology of the ferruginous hawk in central Utah. Sociobiology 3(2):79-95.

Snow, C. R. 1974. Habitat management series for unique or endangered species - ferruginous hawk. Rep. 13. U.S. Bur. Land Manage. Tech. Note. 23 pp.

Snyder, N. F. R., and J. W. Wiley. 1976. Sexual size dimorphism in hawks and owls of North America. Ornithol. Mongr. 20. 96 pp.

Tate, J. T., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Thurow, T. L., C. M. White, R. P. Howard, and J. F. Sullivan. 1980. Raptor ecology of Raft River Valley, Idaho. EG & G Idaho, Inc. EGG-2054. 45 pp.

Tyus, H. M., and J. M. Lockhart. 1979. Mitigation and research needs for wildlife of Western surface mined lands. Pages 252-255 in The Mitigation Symposium: a national workshop on mitigating losses of fish and wildlife habitats. Rocky Mountain For. Range Exp. Stn. Gen. Tech. Rep. RM-65. 684 pp.

Wagner, F. H. 1977. Species vs. ecosystem management: concepts and practices. Trans. N. Am. Wildl. Nat. Resour. Conf. 42:14-24.

Wakeley, J. S. 1978a. Activity budgets, energy expenditures, and energy intakes of nesting ferruginous hawks. Auk 95(4):667-676.

____________. 1978b. Factors affecting the use of hunting sites by ferruginous hawks. Condor 80(3):316-326.

____________. 1978c. Hunting methods and factors affecting use by ferruginous hawks. Condor 80(3):327-333.

Weston, J. B. 1969. Nesting ecology of the ferruginous hawk, (Buteo regalis). Brigham Young Univ. Sci. Bull. Biol. Ser. 10(4):25-36.

White, C. M., T. Thurow, and J. F. Sullivan. 1979. Effects of controlled disturbance on ferruginous hawks as may occur during geothermal energy development. Trans. Geothermal Res. Council 3:777-780.

Woffinden, N. D., and J. R. Murphy. 1977. Population dynamics of the ferruginous hawk during a prey decline. Great Basin Nat. 37(4):411-425.

MERLIN (*Falco columbarius*)

by

Dale M. Becker
and
I. J. Ball
Montana Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
Missoula, MT 59812

SPECIES DESCRIPTION

The merlin (*Falco columbarius*), or pigeon hawk, is a small polytypic falcon occurring throughout much of the Northern Hemisphere. Eight races are recognized worldwide (Brown and Amadon 1968). The four North American races include the western merlin (*F. c. bendirei*) of the western taiga; the eastern merlin (*F. c. columbarius*) of the eastern taiga; the black merlin (*F. c. suckleyi*) of the Pacific coastal forests; and the Richardson's merlin (*F. c. richardsonii*) of the parklands and Great Plains (Peters 1926; Temple 1972a).

The merlin is the second smallest falcon in North America, slightly larger than the American kestrel (*Falco sparverius*). Weights range from 150 to 215 g for male merlins to 187 to 255 g for females (Brown and Amadon 1968). Females also exhibit greater wing, tail, and tarsal lengths than males (Temple 1972b).

The adult male merlin exhibits varying intensities of slate blue on the upper back and wings. The tail has broad bands alternating with grey or white. The underside of the tail is slate grey, and the belly and breast is pale rufous, finely streaked with blackish-brown teardrop-shaped spots. The adult female is characterized by dark brown coloration dorsally, streaked with black. Ventrally, the body is white or cream-colored, and is streaked with brown from the throat to the belly. The dark brown tail bands alternate with rufous to cream-colored bands. In both sexes, eye color is dark brown, and the cere, orbital skin, and feet are yellow.

Immature merlins are similar to adult females in coloration and markings. Cere and orbital skin are bluish, while the eyes are dark brown and the feet are yellow.

The most noticeable difference between subspecies is coloration. The description above most closely fits taiga merlins. Black merlins of both sexes are considerably darker on the upper parts than are the taiga birds. Richardson's merlins of both sexes exhibit paler upper parts than the taiga birds.

DISTRIBUTION

Merlins occur in every province in Canada and every State in the continental United States at some time during the year (Trimble 1975) (Fig. 12). The two races of taiga merlins collectively occupy the largest breeding range. Their breeding range extends throughout the boreal forest from Newfoundland to western Alaska, and from treeline south into eastern Washington and Oregon, northern Idaho, northwestern Montana, northern Minnesota, Wisconsin, and Michigan, and New York, Vermont, New Hampshire, and Maine. Most of those birds migrate and winter across the Southern and Western United States, Mexico, Central America, West Indies, and northwestern South America (Temple 1972a).

Black merlins breed in the coastal forests of western British Columbia, Vancouver Island, and many of the coastal islands from southern British Columbia to southern Alaska (Temple 1972b; Beebe 1974). While numerous merlins have been observed in Washington and Oregon during the breeding season, only a few nests have been documented (Anderson pers. comm.). In some areas black merlins may remain in the vicinity of their nesting areas during the winter if weather conditions and prey availability permit. Migration southward through the Western United States and Canada is common and wintering birds occur as far south as central California (Trimble 1975) and as far inland as Colorado (Bailey and Niedrach 1965). Wintering black merlins also occur in Nevada, New Mexico, Utah, Wyoming, Idaho, and Montana.

Richardson's merlins breed throughout most of the prairie provinces and the north-central plains States. Breeding populations exist in Alberta, Saskatchewan, Manitoba, Montana, Wyoming, South Dakota, North Dakota, and Nebraska. Wintering birds occur in parts of the breeding range and south into Utah, Colorado, Kansas, Oklahoma, Texas, New Mexico, Arizona, Nevada, and California (Trimble 1975).

DIET

Merlins prey primarily on small to medium-sized birds. Birds comprise about 80% of the merlin's diet, insects 15%, and mammals 5% (Brown and Amadon 1968). Other studies also indicate a predominance of birds in the merlin's diet (Fox 1964; Johnson and Coble 1967; Oliphant and McTaggart 1977; Hodson 1978; Newton et al. 1978; and Becker in prep.).

Merlins hunt diurnally, and occasionally into twilight. Their attack on prey may be in the form of a direct, very fast dash or a stoop from above (Trimble 1975; Oliphant pers. comm.).

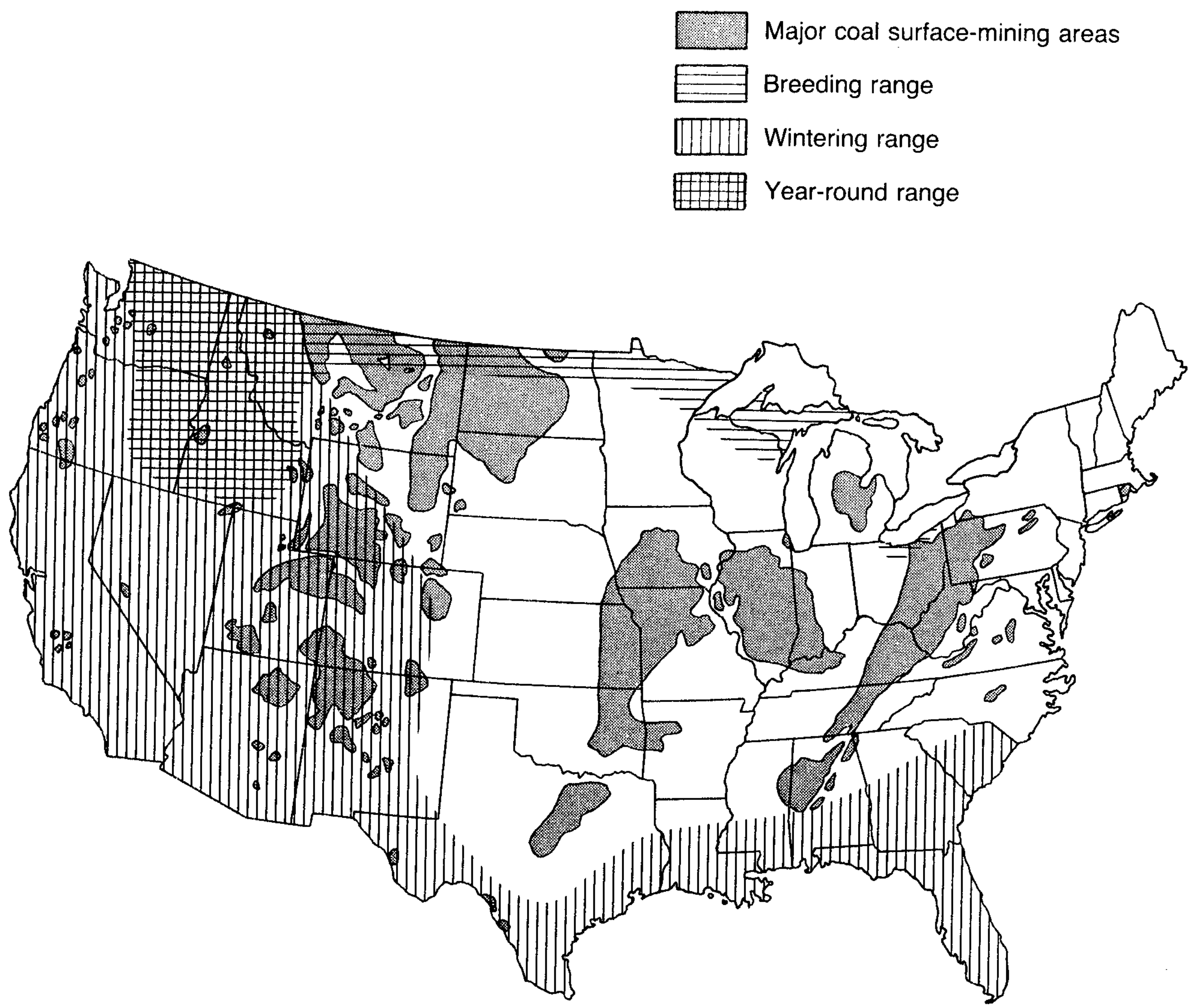


Figure 12. Geographical range of the merlin in relation to major coal deposits in the United States. After Inkley and Raley (1983).

Most intensive studies of prey utilization have indicated that merlins often tend to specialize on one or two prey species. Horned larks (Eremophila alpestris) comprised approximately 50 to 54% of the avian prey taken by merlins on Canadian prairie sites and chestnut-collared longspurs (Calcarius ornatus) comprised 14 to 37% of avian prey items (Fox 1964; Hodson 1978). Approximately 64% of the total number of identified prey items utilized by merlins nesting in an urban environment in Saskatchewan were house sparrows (Passer domesticus) (Oliphant and McTaggart 1977). Meadow pipits (Anthus pratensis) comprised 48% of the avian prey recorded in Northumberland (Newton et al. 1978). In Montana, approximately 92% of 427 prey items recorded consisted of birds, with horned larks (27%), lark buntings (Calamospiza melanocorys) (18%), and vesper sparrows (Pooecetes gramineus) (13%) predominating (Becker in prep.). Differential utilization of prey species is probably dependent upon density, visibility, vulnerability, suitability of hunting habitat, and hunting techniques of the merlins.

Hunting Habitat

In most areas, merlins forage over open prairies or meadows, or along the edges of forest openings. Beebe (1974) saw merlins hunting in edge habitat along major burns, sparsely-treed muskeg, and other open areas. Forest edge is used as hunting habitat in Ontario (Lawrence 1949).

The majority of the prey species utilized by merlins on the Canadian prairies are birds of open grasslands (Fox 1964; Hodson 1976). In eastern Montana, breeding male Richardson's merlins foraged over elongated home ranges of 12.6, 23.1, and 28.1 km^2 (Becker 1982). Hunting habitat included sagebrush/grassland as well as tilled agricultural land. The merlins usually overflew the agricultural land to hunt in natural prairie habitat, partially explaining the large home ranges. Hodson (1978) hypothesized that the use of grazed grassland serves as an advantage to hunting merlins because these areas contain little escape cover for prey species.

REPRODUCTION

Male merlins in the United States and Canada may arrive at breeding areas as early as the latter part of February to early March in the prairie provinces and the northern Great Plains States (Bent 1938; Fox 1964; Becker and Sieg in press). Females usually arrive at nesting areas up to a month after the males.

Upon the arrival of the female, the male begins courtship activities which include vocalization, courtship flights, and food offerings. Calling and displays by the male at potential nest sites aid in attracting females.

Eggs are layed at intervals of approximately 48 hours (Williams and Matteson 1947; Fox 1964; Brown and Amadon 1968; Fox 1971). Clutch size varies from two to seven (Beebe 1974). Normal size of clutches is four or five eggs. Mean clutch size may vary from 4.5 eggs on the Canadian prairie (Fox 1964) to 4.3 eggs in Newfoundland (Temple 1972c), to 4.4 in eastern Montana (Becker and Sieg in press).

Egg laying at southern fringes of the merlin range occurs in early April (Brown and Amadon 1968). A peak laying period occurs during the first half of May for merlins nesting in the prairies of the northern Great Plains (Fox 1964; Oliphant 1974a; Becker and Sieg in press). Table 7 provides information on merlin nesting chronology.

Table 7. Nesting chronology of North American merlins.

Ranges of nesting activities			
Egg laying period	Incubation period	Hatching period	Fledging period
5/20-6/15	5/25-6/20	6/10-7/10	7/20-7/30

Source: Call 1978

The incubation period is 28 to 32 days (Fox 1964; Brown and Amadon 1968). The majority of the incubation is accomplished by the female, although the male occasionally takes part. The male is the primary food provider for the nesting pair during incubation.

Hatching occurs at approximately 2-day intervals, and the female broods the young almost continually for the first 7 to 10 days following hatching. The male remains the primary hunter while the young are in the nest, but the female may make occasional hunting forays near the nest (Becker in prep.).

Fledging occurs when young merlins are 25 to 35 days old. Fledging of nestling merlins in eastern Montana occurred between 25 June and 15 July (Becker and Sieg in press). Call (1978) listed fledging dates ranging from 20 July to 30 July. Following fledging, young birds remain in the vicinity of the nest until they are able to fly well and accompany the adults on hunting forays. The young may remain with the adults for some time following fledging (Fox 1964; Brown and Amadon 1968; Oliphant 1974a).

Mean fledging rates per nest of 2.6 young (Fox 1964) and 3.5 young (Hodson 1976) have been observed for merlins on the Canadian prairie. Becker and Sieg (in press) noted a mean fledging success of 3.3 young per nest in Montana.

Nesting Habitat

Merlins are versatile in the types of nesting habitat utilized. Nesting merlins in the United Kingdom often utilize ground nests in heather cover (Rowan 1921a; Brown 1976; Newton et al. 1978), but ground nesting is uncommon in North America. Most nesting areas in the United States and Canada are characterized by trees near open grasslands, meadows, or forest openings (Becker 1981; Hodson 1976).

Taiga merlins nest in coniferous tree species, such as black spruce (Picea mariana), red spruce (P. rubens), white spruce (P. glauca), white pine (P. strobus), and jack pine (P. banksiana) (Trimble 1975). Nests originally constructed by American crows (Corvus brachyrhynchos) and common ravens (Corvus corax) are usually utilized.

Black merlins nest in Pacific coastal forests near openings. Common nest-tree species are Douglas-fir (Pseudotsuga menziesii), Sitka spruce (Picea sitchensis), western hemlock (Tsuga heterophylla), silver fir (Abies amabalis), and western red cedar (Thuja plicata) (Trimble 1975).

Richardson's merlins nesting in an urban environment in Saskatoon, Saskatchewan, use coniferous trees as nest sites (Oliphant pers. comm.). Merlins in rural parts of Saskatchewan nest in mixed woods along rivers, on islands, and in shelterbelts on the otherwise open prairie (Fox 1964). Deciduous tree species, such as aspen, poplar (Populus spp.), maple (Acer spp.), willow (Salix spp.), and birch (Betula spp.), and conifers, such as white spruce and jack pine, are used as nest trees. Nesting occurs in poplar and box elder (Acer negundo) adjacent to shortgrass prairie (Hodson 1978). Nests in central Montana were located in ponderosa pine (Pinus ponderosa), Douglas fir, and limber pine (Pinus flexilis) stands near open areas (Ellis 1976). Merlin nests described by Becker (1981) in Montana were located in ponderosa pine stands on the slopes of buttes overlooking open prairie. Similar nesting habitat is used by merlins in South Dakota (Whitney et al. 1978), North Dakota (Stewart 1975), Wyoming (Oakleaf pers. comm.), and Nebraska (Lock 1973; Lock and Craig 1975). Old nests of black-billed magpies (Pica pica) and American crows are used throughout much of the species' range.

POPULATION TRENDS

Present Levels

Comprehensive publications on North American merlins are relatively few, and most recent studies have dealt with Richardson's merlins in Saskatchewan, Alberta, and Montana. The most comprehensive population studies are those of Fox (1964, 1971), Hodson (1976), Oliphant and Thompson (1978), and Becker and Sieg (in press). The Canadian Wildlife Service has also conducted productivity surveys of nesting merlins in Alberta for several years.

Reproductive studies conducted during the late 1960's and early 1970's (Fox 1971; Temple 1972c; Fyfe et al. 1976) showed cause for concern about the relationship between low reproductive success in merlins and the effects of organochlorine pesticides. More recent studies (Hodson 1976; Oliphant and Thompson 1978; Becker and Sieg in press) indicate satisfactory reproductive success.

Overall population levels and status of merlins are unknown; most available studies deal only with local populations. Information on a regional scale is lacking. Oliphant (in press) compiled information from a questionnaire mailed to individuals in States and provinces. Richardson's merlins on the northern Great Plains have exhibited generally good reproductive success during 1950-1982 with 3 to 4 young/successful nest. Less information is available on the taiga and black merlins. Taiga merlins exhibited a reproductive success of 2 to 3 young/successful nest and black merlins had 3.5 young/successful nest; sample sizes are small and the population status is not understood for these subspecies.

Effects of Habitat Changes

Merlins are sensitive to habitat changes that decrease hunting habitat or nest sites. The taiga and black merlins inhabit regions with relatively little human impact occurring. The Richardson's merlin inhabits grasslands that are rapidly decreasing. The rapid conversion of large tracts of natural prairie to cultivated agricultural land in many areas of the northern Great Plains may be the most serious threat to merlin habitat on a regional basis. Conversion of native grassland to agriculture decreases the hunting habitat available to merlins (Hodson 1976). Removal of windbreaks decreases the number of nest sites available.

Fire control practices instituted during the past 50 to 60 years may have both positive and negative impacts on merlins. Comparison of historical photographs to current conditions in Richardson's merlin habitat in southeastern Montana revealed some improvements in nesting habitat (Becker unpubl. data). Fire control may help to protect nest trees. However, some previously suitable feeding areas and sparsely-treed nesting areas are probably no longer adequate for those purposes because of heavy encroachment by forests. Controlled burning may help to maintain grassland habitats.

Intensive grazing practices may decrease habitat for prey populations, thus decreasing merlin populations. Intensive logging practices over large areas may remove hunting and nesting habitat for black or taiga merlins.

Effects of Human Disturbance

Individual merlins differ in their tolerance to human disturbance. Like other species of raptors, merlins are most susceptible to nest abandonment if disturbed during incubation. Losses of young may also occur from prolonged disturbance during brood rearing. Richardson's merlins in Saskatoon became habituated to human activities to the extent that they used trees in yards for nesting (Oliphant pers. comm.). Nest defense behavior was much reduced from that seen in more natural nesting areas. During the brood-rearing phase in southeastern Montana, merlins tolerated repeated nest visits for data gathering and nest modifications to facilitate time-lapse photography (Becker unpubl. data).

Conspicuous aerial and vocal nest defense behavior attracts attention and can expose the birds to mortality from shooting (Hodson 1976). Shooting does not appear to be as serious a problem as in the past (Trimble 1975).

Management

Protection of nesting and hunting habitat is the most critical management need for merlins of all subspecies. Management of public lands should focus on retention of grass and shrub plant communities, particularly in those areas adjacent to potential nesting areas. Forestry practices should protect potential nesting trees and small groves of trees throughout grassland areas. Presence of corvid nests denote trees of most urgent concern, though protection should not be limited to these trees. Monitoring reproductive success and pesticide levels, and banding to better define migratory routes and wintering areas, are essential to maintaining a flexible, responsive management program. Information for developing management programs is fair for Richardson's merlins, but inadequate for the taiga and coastal subspecies.

Regional population estimates, or at least trend surveys, constitute an important management need for all subspecies. Similarly, a better understanding of the relationships between corvid populations, their nests, and merlin nest requirements would be extremely useful for all merlin management.

Management information needs on black merlins center on breeding habitat, particularly the impacts of logging practices. Similar information is needed for the taiga subspecies. In addition, much more information is needed about pesticide contamination of the taiga birds on their wintering grounds. Management programs for Richardson's merlins would profit most from an improved knowledge of the impacts of land use on abundance and vulnerability of merlin prey species.

The winter ecology of all merlin subspecies is so poorly understood that the management significance of alterations to winter habitat cannot be assessed.

The Merlin as an Indicator Species

Local Richardson's merlin populations appear to show less year-to-year fluctuations than do raptors that depend heavily on cyclical populations of rodents as a food resource. This aspect of their population ecology improves their suitability as an indicator species. Merlins are obviously tolerant enough of human disturbance that they can pioneer or increase their populations in residential areas where conditions are otherwise suitable (Oliphant 1974a, 1974b). Where breeding merlins are already established and persistent disturbance is subsequently imposed, populations may decrease from increased stress and lowered productivity.

If suitable nesting habitat can be maintained in coal recovery areas, merlins could serve as a useful indicator of the maintenance or recovery of prairie ecosystems, particularly avian communities.

Since merlin nests are often relatively easy to find, breeding and productivity could be monitored to provide considerably more sensitive measures than mere presence or absence.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts on merlins may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining activities if nests and nestlings are destroyed. The most serious impacts would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population. Dust from survey and haul road construction, test drilling, and blasting may adversely affect prey populations. Wastes, byproducts, and increased runoff may contaminate water resources, indirectly impacting prey populations. Collisions with transmission lines may cause injury or death.

Increased noise levels and human presence (especially in formerly remote areas) may prevent merlins from using suitable habitat nearby. Increased human presence may also result in harassment and illegal shooting of merlins.

Populations of merlins are relatively high where nesting and hunting habitat conditions are best (Fox 1964; Ellis 1976; Hodson 1976; Becker and Sieg in press; Armbruster pers. comm.; Oliphant pers. comm.). Any disruption of occupied habitat or shift to more marginal habitat will probably result in a population decline.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys should be initiated during the premining phase to collect baseline data of merlin populations in areas proposed for mining (Kennedy 1980; Lockhart et al. 1980). Data gathered may include numbers of nesting pairs, productivity levels, prey utilization, and habitat utilization.

Additional information for minimizing or mitigating impacts of mining activities on merlins includes: distribution of nests and feeding areas on the proposed development area; home range sizes of merlins nesting in various habitat situations; prey utilization in the different types of habitats utilized; comprehensive description and quantification of nesting habitat; and responses of nesting birds to various types of man-caused disturbances near active nests.

Exploration and Mine Development Phase

Regulations on access to merlin habitat by exploration crews, types of exploration activities proposed, critical periods in the nesting cycle, and ways to minimize disturbance may be discussed with workers to help minimize impacts.

General guidelines and suggestions for minimizing negative impacts during exploration and development follow:

(1) No activities should be allowed within 400 m of active nests from 15 March through 30 July, with any exceptions examined on a case-by-case basis. Where concentrations of nesting pairs are involved, more stringent regulations may be required after consultation with biologists knowledgeable about nesting merlins.

(2) Proposed exceptions to the above guideline should be reviewed individually by a biologist knowledgeable about nesting merlins.

(3) Disturbance-type activities need not be restricted during the remainder of the year when there is no potential for disturbance of breeding activities.

In most cases, actual destruction of merlin nest sites or other habitat will be minimal during the premining and development phases.

Mining Phase

During the mining phase, nesting and hunting habitat of merlins is likely to be seriously disturbed or destroyed. Known active and inactive nests, and lands within 400 m of them, may be bypassed if possible to alleviate impacts. It may be possible to gradually move active nests from the path of mining activities, as has been done successfully with golden eagles (*Aquila chrysaetos*) (Postovit et al. 1982). Such techniques may be useful for merlins, but should not be allowed to detract from activities geared toward natural habitats and populations. If otherwise suitable nesting trees lack abandoned corvid nests, magpie nests could possibly be moved to the site from other areas. Some magpie nests are lined with hardened mud, and these nests are extremely durable.

Lockhart et al. (1980) discussed the inadequacy of maintaining small islands of habitat for individual species of raptors. We can only recommend that the largest possible amount of natural habitat be maintained around nesting areas. Merlins are apparently adaptable enough to overfly unsuitable habitat in order to reach hunting areas. The limits of this adaptability are unknown, and we also do not know whether it will apply to major land surface disruptions.

Dust control, erosion control, and proper disposal of wastes and by-products may prevent deterioration of surrounding habitat. Restriction of firearms on the mining site may alleviate illegal shooting and harassment of merlins.

Reclamation Phase

Diverse natural vegetation, including native grasslands, should be re-established as rapidly as possible after mine closure. Suitable hunting habitat can be re-established much more rapidly than can nesting trees, reinforcing the high priority of saving nesting habitat wherever possible. Establishment of replacement nesting habitat may begin as soon as unavoidable destruction of nesting habitat is planned. Replacement nest trees of the largest feasible size may be transplanted. Existing trees may be fenced to prevent damage by cattle.

SUMMARY

The merlin is a small raptor inhabiting several ecosystems, including open native grassland in the Great Plains region.

Of the four North American subspecies, Richardson's merlins are the most vulnerable to negative impacts from surface mining activities. Any destruction of prime habitat can be expected to cause population declines, with magnitude and duration of the decline as the major unknown factors.

Current regional population levels are poorly known. Mitigation efforts should center on preservation of nesting habitat and rapid re-establishment of nest trees, and diverse prairie vegetation and dependent avifauna.

Impacts to merlins will include loss of habitat, deterioration of remaining habitat, and increased stress from human presence and harassment. Buffer zones around nest sites and restrictions on activities during the breeding season may help to alleviate impacts.

ACKNOWLEDGEMENTS

G. A. Fox, R. W. Fyfe, J. S. Marks, B. W. O'Gara, and L. W. Oliphant provided many useful comments; T. A. Legg, S. K. Kraft, and S. K. Jackson assisted with correspondence, library research, and typing. S. K. Kraft prepared the illustrations. R. R. Olendorff and C. M. Anderson assisted by allowing D.M.B. to search their literature files. Personnel of several State, provincial, and Federal agencies and universities in the United States and Canada provided access to much of the information included herein.

REFERENCES

American Ornithologists' Union. 1983. Chekc-list of North American birds. 6th ed. Allen Press. Lawrence, KS. 877 pp.

Anderson, C. M. 1980. Personal communication. Kirkland, WA.

Armbruster, H. I. 1980. Personal communication. Canadian Wildlife Service, Edmonton, Alberta.

Bailey, A. M., and R. J. Niedrach. 1965. Birds of Colorado. Denver Mus. Nat. Hist., Denver, CO. 885 pp.

Becker, D. M. 1981. A survey of raptors on National Forest land in Carter County, Montana. U.S. For. Serv., Billings, MT. 61 pp.

______________. 1982. Home range and habitat utilization of breeding male Richardson's merlins in southeastern Montana. Paper presented at the Raptor Research Foundation 1974 Annual Meeting. Salt Lake City, UT. November 18-20, 1982.

______________. In prep. Food habits of Richardson's merlins in southeastern Montana.

______________. Unpub. data. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT.

Becker, D. M., and C. H. Sieg. In press. Breeding chronology and reproductive success of Richardson's merlins in southeastern Montana. Raptor Res.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia--Vultures, hawks, falcons, eagles. British Columbia Provincial Mus. Occas. Paper 17. 163 pp.

Bent, A. C. 1938. Life histories of North American birds of prey. Vol. 2. U.S. Natl. Mus. Bull. 170. Washington, DC. pp. 70-90.

Brown, L. H. 1976. British birds of prey. Collins. London. 400 pp.

Brown, L. H., and D. Amadon. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill. New York, NY. 945 pp.

Call, M. W. 1978. Nesting habitats and surveying techniques for common western raptors. U.S. Bur. Land Manage. Tech. Note TN-316. 115 pp.

Ellis, D. H. 1976. First breeding records of merlins in Montana. Condor 78:112-114.

Fox, G. A. 1964. Notes on the Western race of the pigeon hawk. Blue Jay 12:140-147.

__________. 1971. Recent changes in the reproductive success of the pigeon hawk. J. Wildl. Manage. 35:122-128.

Fyfe, R. W., R. W. Risebrough, and W. Walker, II. 1976. Pollutant effects on reproduction of the prairie falcons and merlins of the Canadian prairies. Canadian Field-Nat. 90:346-355.

Hodson, K. A. 1976. The ecology of Richardson's merlins on the Canadian prairies. M.S. Thesis. Univ. British Columbia, Vancouver. 83 pp.

______________. 1978. Prey utilized by merlins nesting in shortgrass prairies of southern Alberta. Can. Field-Nat. 92(1):76-77.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop-Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Johnson, W. I., and J. A. Coble. 1967. Notes on food habits of pigeon hawks. The Jack-Pine Warbler 45:97-98.

Kennedy, P. L. 1980. Raptor baseline studies in energy development. Wildl. Soc. Bull. 8:129-135.

Lawrence, L. D. K. 1949. Notes on nesting pigeon hawks at Pisimi Bay, Ontario. Wilson Bull. 61:13-25.

Lock, R. A. 1973. A second nesting record for merlins in Nebraska. Nebraska Bird Rev. 47:39.

Lock, R. A., and R. Craig. 1975. Merlin nest in Nebraska. Nebraska Bird Rev. 43:78-79.

Lockhart, J. M., D. W. Heath, and C. L. Belitsky. Unpub. (1980). The status of nesting peregrine falcons and other selected raptor species on the Black Butte Coal Mine lease and adjacent lands. U.S. Fish Wildl. Serv., Denver, CO. 59 pp.

Newton, I., E. R. Meek, and B. Little. 1978. Breeding ecology of the merlin in Northumberland. Brit. Birds 71:376-398.

Oakleaf, R. 1980. Personal communication. Wyoming Game and Fish Department. Lander, WY.

Oliphant, L. W. 1974a. Merlins -- the Saskatoon falcons. Blue Jay 32:140-147.

____________. 1974b. Behavior of merlins nesting in an urban environment. Paper presented at the Raptor Research Foundation 1974 Annual Meeting. Univ. Minnesota, St. Paul. November 23-25, 1974.

____________. In press. North American merlin breeding survey. Raptor Res.

____________. Personal communication. Univ. Saskatchewan, Saskatoon, Saskatchewan.

Oliphant, L. W., and S. McTaggart. 1977. Prey utilized by urban merlins. Can. Field-Nat. 91:190-192.

Oliphant, L. W., and W. J. P. Thompson. 1978. Recent breeding success of Richardson's merlins in Saskatchewan. Raptor Res. 12:35-39.

Peters, J. L. 1926. The North American races of _Falco columbarius_. Bull. Essex County Ornithol. Club 8:20-26.

Postovit, H. R., J. W. Grier, J. M. Lockhart, and J. Tate, Jr. 1982. Directed relocation of a golden eagle nest site. J. Wildl. Manage. 46:1045-1048.

Rowan, W. 1921a. Observations on the breeding habits of the merlins. Part I -- General environment. Br. Birds 15:122-129.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College for Environmental Studies. North Dakota State Univ., Fargo. 295 pp.

Temple, S. A. 1972a. Systematics and evolution of the North American merlins. Auk 89:325-338.

____________. 1972b. Sex and age characteristics of North American merlins. Bird-Banding 43:191-196.

____________. 1972c. Chlorinated hydrocarbon residues and reproductive success in eastern North American merlins. Condor 74:105-106.

Trimble, S. A. 1975. Habitat management series for unique or endangered species -- Merlin (*Falco columbarius*). U.S. Bur. Land Manage. Rep. 15. 41 pp.

Whitney, N. R., B. E. Harrell, B. A. Harris, N. Holden, J. W. Johnson, B. J. Rose, and P. F. Springer. 1978. The birds of South Dakota. South Dakota Ornithologists' Union. Vermillion. 311 pp.

Williams, R. B., and C. P. Matteson, Jr. 1947. Wyoming hawks: American merlins or pigeon hawks. Wyoming Wildl. 11(12):21-24.

Dale Becker's current address: #5 Rebecca Ct., Helena, MT 59801.

PRAIRIE FALCON (*Falco mexicanus*)

by

Dale M. Becker
and
I. J. Ball
Montana Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
Missoula, MT 59812

SPECIES DESCRIPTION

The prairie falcon (*Falco mexicanus*) is the most common large falcon in the Western United States, southern portions of British Columbia, Alberta, and Saskatchewan, and northern Mexico. Adult birds range from 38 to 51 cm in length, and wing span averages approximately 107 cm. Weights of 63 prairie falcons averaged 500 to 635 g (554 g) for 15 adult males; 515 to 570 g (539 g) for 5 immature males; 760 to 975 g (863 g) for 31 mature females; and 675 to 925 g (824 g) for 12 immature females (Enderson 1964).

Adult prairie falcons are medium brown dorsally and slightly lighter on the crown than on the back. A pale supra-orbital line extends from the cere to a point above and behind the eye. An indistinct collar of white nearly surrounds the neck, and a dark brown moustache stripe extends along each side of the face below the eye.

When they are new and unworn, the medium brown tail feathers exhibit pale barring, but the central tail feathers are usually unbarred. Eye color is dark brown, and the beak is bluish to black. The cere, legs, and feet are yellow.

Immature prairie falcons are similar to adults in coloration, but may be a darker shade of brown dorsally with more brown breast streaks than adults. The streaking on the flanks is also different from the barred flanks of the adults. The beak is bluish to black, and the eye is dark brown. The cere, legs, and feet are bluish.

Dark brown patches on the undersides of the wings near the body provide a characteristic field mark on prairie falcons viewed from below.

DISTRIBUTION

The prairie falcon nests on cliffs and bluffs in the grassland and desert regions of the United States west of approximately 102° longitude (Fig. 13). Nesting prairie falcons in Canada utilize areas in southern Saskatchewan, central Alberta, and southeastern British Columbia. The breeding range extends southward into Baja California and north-central Mexico (Brown and Amadon 1968; Beebe 1974).

The winter range overlaps much of the breeding range. A survey of band returns from birds banded as nestlings revealed a tendency for eastward movement (Enderson 1964). Occasionally birds move as far east as Missouri and Illinois.

DIET

Prairie falcons often capture prey on the ground. Rodents and ground-dwelling birds comprise a major portion of the diet (Porter et al. 1973). Heavy utilization of one or two key prey species frequently occurs; often, the most important prey species include one bird and one mammal (Enderson 1964; Porter et al. 1973).

A predominance of horned larks (*Eremophila alpestris*) and Richardson's ground squirrels (*Spermophilus richardsonii*) occurs in the prairie falcon's diet in Wyoming, Colorado (Enderson 1964), and western Montana (Leedy 1972). Townsend's ground squirrels (*S. townsendii*) and horned larks are most important in diets of prairie falcons in southwestern Idaho (Ogden and Hornocker 1977). Plains pocket gophers (*Geomys bursarius*) and horned larks are heavily utilized in New Mexico (Platt pers. comm.). Western meadowlarks (*Sturnella neglecta*) and thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) are key prey species in southeastern Montana (Becker 1981a). Numerous additional prey species are utilized to a lesser extent, varying with geographical area.

REPRODUCTION

Webster (1944) noted that male prairie falcons arrived on nesting territories prior to the arrival of females, but Enderson (1964) believed that females usually arrive first.

Following the arrival of both members of the pair at a nesting territory, courtship activities continue for a period of approximately one month. During courtship, both members of the pair may take part in very vocal courtship flights. Nest site selection also occurs during courtship activities (Brown and Amadon 1968). Copulation occurs frequently during the courtship period (Enderson 1964).

Egg laying begins as early as mid-March to mid-April in some areas (Table 8). Clutch size is usually 4 or 5 eggs, but may vary from 2 to 6 (Bent 1938). If the eggs are destroyed, a second clutch may be laid in 2 to 3 weeks

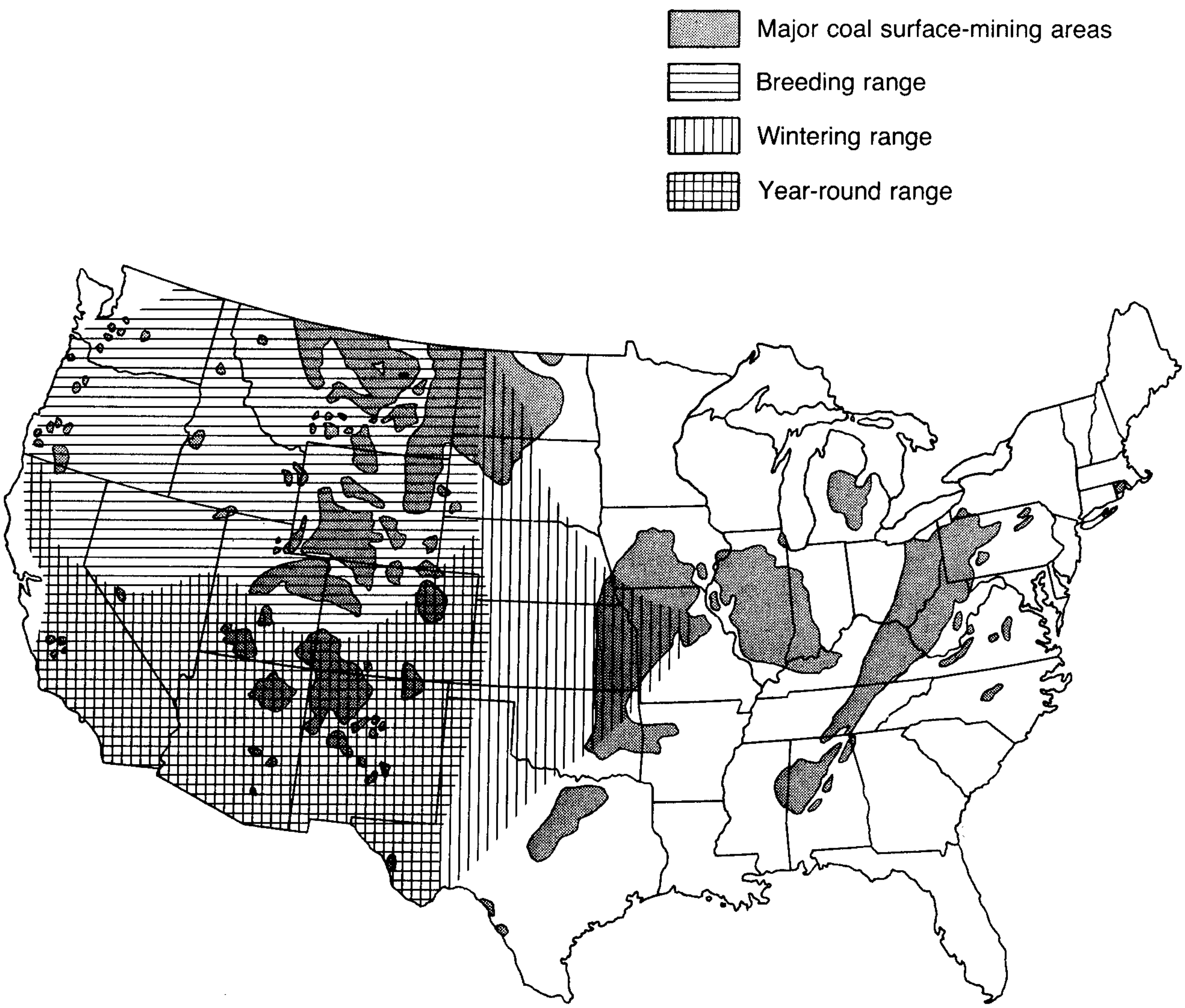


Figure 13. Geographical range of the prairie falcon in relation to coal deposits in the United States.

Table 8. Summary of prairie falcon nesting chronology from various studies.

Study	Location	Ranges of nesting activity periods		
		Egg laying	Hatching	Fledging
Enderson 1962	Colorado	4/12-5/9	5/12-6/8	6/21-7/19
Olendorff 1973a	Colorado	4/12-5/10	5/12-6/10	6/13-6/19
Platt pers. comm.	New Mexico	4/4-4/30	5/4-5/30	6/7-7/3
Denton 1976	Oregon	3/22-5/15	4/22-6/14	6/3-7/15
Ogden and Hornocker 1977	Idaho	4/1-5/8	5/1-6/7	5/9-7/16
U.S. Bureau of Land Management 1979	Idaho	(3/15-5/25)[a]	(4/10-7/1)	(5/28-7/5)
Johnstone 1980	Oregon	4/20-5/17	4/19-6/16	(5/28-7/19)
Becker 1981a	Montana	(4/15-5/18)	(5/14-6/28)	(5/28-7/24)

[a]Dates in parentheses were derived from graphical representations or were considered as approximations when gathered.

(Enderson 1964). During the 29 to 31-day incubation period, the male does nearly all the hunting for the pair. Males incubate the eggs during feeding breaks by the female. After 2 to 3 weeks of brooding and feeding the young, females begin to leave the nest to forage.

Fledging success is usually 3 to 4 fledglings per nest (Table 9). Young prairie falcons fledge at 5 to 6 weeks of age, and usually stay in the vicinity of the nest until they become self-sufficient at hunting. Thereafter, they may remain in the vicinity of the nest or disperse.

Some prairie falcons breed when 1 year old (Webster 1944; Platt 1977), but most probably do not begin breeding until their second year (Enderson 1964). Little is known about the length of sexual activity. Prairie falcons may live as long as 20 years (Enderson 1969); however, the longest known banding recovery is 13 years. Immature mortality is estimated at 74% and average annual adult mortality is 25% (Enderson 1969). The average life expectancy of a prairie falcon is 2.4 years (Shor 1975).

Nesting Habitat

Prairie falcons are specific in their nesting habitat requirements, nesting exclusively in cliff cavities or on ledges. An ideal cliff nest site is one that "...has a sheltered ledge which provides the site for the eggs, has gravel or loose material in it for the falcon to make a 'scrape' or nest depression, and overlooks at least some treeless country for hunting" (Snow 1974). Aeries are usually well-protected from sun and rain. Two or more aeries often exist on each occupied territory, with nesting activities alternating between sites. Throughout much of the eastern part of the prairie falcon's range, sedimentary sandstone cliffs are used for nesting, probably due largely to the eroded cavities that often occur in these formations.

Old nest structures of red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), and common ravens (*Corvus corax*) are sometimes used (Decker and Bowles 1930; Hickman 1972; Platt pers. comm.). Absence of suitable nest sites on cliffs can limit nesting densities (Olendorff 1973b; Oliphant et al. 1976; Fyfe and Armbruster 1977; Call 1979; Crawford 1979).

Sites upon which nests are most often constructed are variable by geographical location. Preferences for southern and eastern aspects are exhibited by prairie falcons in western Montana (Leedy 1972). Southern and southwestern aspects are preferred in southeastern Montana (Becker 1981a). Prairie falcons in southwestern Idaho utilized a variety of aspects for nesting (Ogden and Hornocker 1977). Aspect preferences in particular locations are probably highly dependent upon cliff availability in these areas. The height of the nest site on the cliff is also variable, depending upon locally available sites. Generally, however, nest sites providing some protection from the elements and inaccessibility to predators are suitable, regardless of height.

Table 9. Summary of prairie falcon reproductive performance in various areas. Sample sizes are in parentheses.

Study	Location	Mean clutch size	Mean brood size	Mean fledging success
Enderson 1964	Colorado	4.5(55)	1.9(67)	1.2(67)[a]
Leedy 1972	Montana	4.3(20)	2.4(27)	1.9(58)[a]
				2.9(38)[b]
Edwards 1973	Alberta	4.5(20)	2.5(21)	1.6(24)[b]
Platt pers. comm.	New Mexico	3.2(18)	2.9(18)	-------[c]
Olendorff 1975	Colorado	4.4(24)	3.9(27)	3.4(26)[b]
Denton 1976	Oregon	4.0(30)	3.4(29)	2.5(43)[a]
				3.0(36)[b]
Ogden and Hornocker 1977	Idaho	4.4(68)	3.5(87)	3.1(110)[a]
Lockhart et al. 1977	Montana	-------	-------	3.4(6)[a]
				4.0(6)[b]
U.S. Bureau of Land Management 1979	Idaho	4.5(114)	3.9(118)	3.9(137)[b]
Johnstone 1980	Oregon	4.3(12)	3.8(15)	3.2(21)[a]
Lockhart et al. 1980	Wyoming	-------	-------	3.2(20)[a]
				3.7(17)[b]
Platt 1981	Colorado	-------	-------	2.8(88)[a]
				3.7(67)[b]
Becker 1981a	Montana	4.6(54)	4.2(64)	3.9(64)[a]
				4.5(56)[b]

[a]Mean number of young fledged/breeding attempt.

[b]Mean number of young fledged/successful aerie.

[c]Exact fledging success undetermined.

Observations of hunting prairie falcons and examination of prey items at nests have generally shown open areas (prairies or deserts) to be the most important hunting habitats. Specifics of terrain and habitat selected for hunting differ between individual birds (Harmata et al. 1978), and obviously differ among populations over the diverse range of this species. Hunting flights by adult prairie falcons in Idaho range up to 26 km from the nest. Individual home ranges during the reproductive stage vary from 26 to 142 km^2 (U.S. Bureau of Land Management 1979). In southern California, males hunt up to 23.3 km from nests and females up to 17 km. Home range size varies from 63.8 to 78.3 km^2 in males and from 31.0 to 71.2 km^2 in females (Harmata et al. 1978). In northern California, breeding prairie falcons foraged up to 21 km from the nest and exhibited home ranges of 34 to 389 km^2 (Haak 1982).

POPULATION TRENDS

Prairie falcon populations in North America have been estimated at 5,000 to 6,000 breeding pairs (U.S. Bureau of Land Management 1979). This estimate was based on a questionnaire sent to states, provinces, and Mexico. Precision of estimates probably differs a great deal between regions. Prairie falcons may be expanding their range into areas formerly occupied by peregrine falcons (*Falco peregrinus*) (Porter et al. 1973).

Recent studies of prairie falcons in Washington (Parker 1972), California (Garrett and Mitchell 1973), and Oregon (Denton 1976) indicated declines in some local populations. Studies conducted in Canada (Fyfe and Armbruster 1977) and Colorado (Platt 1981) indicate stable populations, at least on a local basis. Population modeling on prairie falcons of Idaho's Snake River Birds of Prey Area indicated that productivity was slightly above population maintenance levels (U.S. Bureau of Land Management 1979).

Although correlations between pesticide residues and depressed reproductive performance have been documented in the past (Enderson and Berger 1970; Leedy 1972; Enderson and Wrege 1973; Fyfe et al. 1976), more recent studies suggest that this problem is abating. Attempts to document mortality rates of raptors have often been hampered by small sample sizes and low recovery rates.

Based on local population estimates, productivity, and foraging adaptability, the overall population status of prairie falcons tends to be assessed as good. Problem areas almost certainly exist, however, where habitat disruption or excessuve disturbance have caused local declines.

Effects of Habitat Changes

Agricultural impacts on prairie falcon habitat may be either positive or negative. Grazing by livestock may increase densities of certain prey species, particularly ground squirrels. Prey vulnerability may also be increased by grazers removing ground cover. Conversely, the conversion of grasslands or shrublands to cultivated agriculture can be expected to reduce prey densities in most situations. No references in the literature indicate breeding prairie falcons can be supported primarily by tilled agricultural lands.

Prairie falcons are more susceptible to loss of nesting habitat than many species of raptors because they rely completely on cliffs as nest sites. Thus the number of suitable nest sites is limited. Furthermore, suitable nest sites are probably saturated in many areas.

Effects of Human Disturbance

The outcome of human disturbance at or near prairie falcon aeries is dependent upon the nature of the activity, time and duration of the activity, and proximity to the aeries (Harmata et al. 1978). Potential problems associated with disturbance of nesting raptors include desertion; damage to eggs or young by frightened adults; cooling, overheating, and loss of moisture from eggs; chill and heat prostration of nestlings; missed feedings; premature fledging; and increased nest predation (Fyfe and Olendorff 1976). In California, nests that were easily accessible to man had significantly lower productivity than did nests in more remote locations (Boyle 1982).

Like most species of raptors, prairie falcons are least tolerant of disturbance during courtship, egg laying, and incubation (Harmata et al. 1978). Any major disturbance prior to hatching carries a substantial risk of nest abandonment or serious harm to unhatched or newly hatched birds. Human disturbance and improper research techniques may result in desertion and damage to eggs or young (Leedy 1972; Edwards 1973; Fyfe and Olendorff 1976).

Following hatching, prairie falcons are tolerant enough of human disturbance that repeated brief nest visits for study purposes do not usually cause nest abandonment. The effects of prolonged disturbance during the nestling stage have not been formally studied and hence cannot be predicted. Likewise, the likely outcome of disturbance initiated before nesting commences is unknown.

Buffer zones of at least 400 m established around prairie falcon aeries have been suggested to alleviate negative impacts caused by disturbance (Suter and Joness 1979). Adequate size of buffer zones is variable depending upon the nature of anticipated disturbances, and should be determined on a case-by-case basis.

Management

A broad array of techniques for managing raptor populations and habitat have been developed during the past decade (Olendorff et al. 1980). The prairie falcon has been of special interest because of its similarities to the endangered peregrine falcon, and also because of its presence over broad areas of public lands in the West.

Habitat management for prairie falcons and other raptors includes both maintenance of existing habitat (U.S. Bureau of Land Management 1979) and attempts to enhance existing habitat and create new habitat (Fyfe and Armbruster 1977; Call 1979; Olendorff et al. 1980).

Management of habitat in the Snake River Birds of Prey Natural Area in Idaho has focused on preserving both nesting and hunting habitat for several species of resident raptors, while allowing controlled development of other resources (U.S. Bureau of Land Management 1979). In other areas, where natural nest sites are lacking, artificial nesting ledges or cavities have been created (Paul and Steele 1976; Fyfe and Armbruster 1977; Crawford 1979; Boyce et al. 1980; Becker 1981b). The nesting sites can be excavated with hand tools in relatively soft substrates, but must be drilled and blasted on some cliffs. Thus, artificial nesting sites for prairie falcons are relatively time consuming to construct. However, the sites are maintenance free in most situations and remain usable almost indefinitely. In addition, artificial cliff nest sites are less obtrusive and more "natural" in appearance than most other types of artificial structures.

Raptor populations are most likely to be limited by availability of nesting sites or prey (Newton 1979). Obviously, any effective management plan for prairie falcons must provide a balanced approach to the two components. In a long-term perspective, maintenance of adequate hunting habitat will most likely prove more difficult and expensive than will maintenance or provision of nesting sites.

The Prairie Falcon as an Indicator Species

Prairie falcons seem to exhibit a moderate level of inherent sensitivity to human disturbance. Although some would argue that only the most sensitive species should be used as indicators, selection should be based on a spectrum of criteria.

Populations of prairie falcons tend to remain relatively consistent from year to year, which simplifies the detection of long-term trends. Plasticity of prairie falcon prey selection reduces their sensitivity to fluctuations in prey species caused by habitat alteration. Their tendency to prey on both birds and mammals lends an aspect of generality to the value of prairie falcons as indicators of mining impacts. Hence, they are more suitable as an indicator species than are raptors that fluctuate greatly with prey density (Kennedy 1980). Their broad geographical distribution also increases the suitability of prairie falcons as an indicator species over much of the Western United States and the Canadian prairies.

Aeries are traditionally used and often relatively easy to locate, thus facilitating population monitoring. Conversely, most aeries can be reached only by rappelling or checked by helicopter flights. Cliff nesting provides a measure of vertical isolation from disturbance, and also provides nesting birds with a panoramic view of surrounding habitat, including disruptive factors. The net result of these relationships is unknown.

Overall, the prairie falcon is a relatively good prospect for indicator species status, provided that presence and productivity are monitored.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Call (1979) presented a comprehensive list of raptor - mining conflicts. Those associated with habitat changes included destruction of nesting and hunting habitat, inflexibility of mine rehabitation practices, and excessive road construction.

Potential impacts to prairie falcon populations may occur directly, through mortality, or indirectly through increased stress and habitat loss. Direct mortality may occur during construction and mining phases if nests and nestlings are destroyed. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition will result in an ultimate reduction in the breeding population.

Prairie falcons may also potentially be impacted by increased noise and dust levels and contaminated water supplies. More likely these factors could decrease prey populations, indirectly impacting prairie falcons. Increased human disturbance during the breeding season may result in lower productivity levels. Collisions with transmission lines may result in injury or death. Raptors are also subject to illegal shooting and harassment, problems that could increase with increased human presence.

The breeding range of the prairie falcon encompasses most of the known coal deposits in western North America (Fig. 13). It would be relatively easy to calculate the proportion of the breeding range underlain by strippable or total coal deposits, but the usefulness of such calculations is suspect for a number of reasons: (1) Breeding prairie falcons are not distributed evenly over the range, and many local concentrations of nesting birds have yet to be documented; (2) definition of strippable deposits will broaden as mining technology improves and energy costs escalate; and (3) destruction of nesting habitat will impact populations over an area much broader than the area of direct disruption.

Prairie falcons are apparently at equilibrium densities in many parts of their range, thus any reduction in the most limiting resource would be expected to cause a parallel population decline.

Firm population figures on targeted mining areas and on non-coal lands are needed to predict regional population impacts. These data would be time consuming and expensive to gather, but carefully planned use of topographic maps and aerial photographs to locate potential nesting areas (Wilderness Research Institute 1980) may reduce costs to acceptable levels. When population data are available, projection of impacts should be based on the assumptions that each active nesting site to be destroyed or likely to be abandoned will result in the net loss of one breeding pair. The most defensible projection of impacts by destruction of hunting habitat is that regional populations will decrease in direct proportion to the ratio of disturbed to undisturbed hunting habitat. Projections must be interpreted with the understanding that losses of nesting sites can be mitigated, and that loss of hunting habitat may be only temporary.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Prior to and during the premining phase, baseline studies should be initiated (Kennedy 1980). Potential effects of human disturbance should also be assessed (White et. al. in prep.). Minimal site-specific information necessary for adequate mitigation include: (1) Inventory of all potential nesting and hunting habitat in the area of potential disruption; (2) census of breeding populations; (3) survey of prey utilization; and (4) documentation of home range and habitat use. Expenses of these intensive studies will be high for initial mining programs, but much of the information accumulated will be applicable to subsequent situations.

Prior to initiation of exploration and mine development activities (drilling, seismic exploration, surveying, etc.) wildlife biologists and energy exploration personnel should meet for discussions of access, types of exploration activities proposed, critical periods in the nesting cycle, and methods of minimizing disturbance.

Exploration and Mine Development Phase

General guidelines for minimizing negative impacts of exploration and development activities are as follows:

(1) Activities should be restricted within 400 m of active aeries from 1 March through 15 July, with any exceptions examined on a case-by-case basis. Where concentrations of nesting pairs occur, more stringent regulation of activities may be necessary upon consultation with biologists knowledgeable about nesting prairie falcons;

(2) Proposed exceptions to the above guideline should be reviewed by biologists knowledgeable about nesting prairie falcons; and

(3) Activities that have disturbance potential need not be restricted during the remainder of the year when little or no potential for disturbance of breeding activities exist.

Actual destruction of aeries and other important prairie falcon habitat will be minimal during this phase. The major concern is avoiding undue disturbance that might cause abandonment of the aerie by nesting falcons.

As soon as specific plans for mining activities are available, nesting sites at which destruction is unavoidable should be identified. Where cliffs in surrounding areas lack suitable nest sites, alternative artificial sites should be constructed. These sites may be completed at least 1 year before destruction of active aeries. Furthermore, each active aerie destroyed may be replaced by at least four artificial sites. Not all artificial sites will prove acceptable, and nesting prairie falcons commonly shift between adjacent sites. Additional artificial sites should not be constructed where natural sites are dense, as intraspecific strife may result.

Mining Phase

Deterioration or loss of habitat during the mining phase is by far the most serious threat to prairie falcons associated with surface mining. Protection of actual and potential nesting sites and buffer zones within a 400 m radius will minimize impacts to prairie falcons. Where destruction of aeries is unavoidable, such activities conducted in late summer, fall, or winter will prevent destruction of an active nest and allow returning migrants to select other sites.

Scheduling of mining activities to include consideration of raptor nesting chronology will also minimize impacts (Lockhart et al. 1980), though not all conflicts can be avoided while still maintaining efficient mine operation. Retention of suitable highwalls (Lockhart et al. 1980) could provide future nesting sites for prairie falcons and other raptors.

Reclamation Phase

Assuming that nest-site requirements have been met during earlier stages, reclamation efforts can focus on establishment of stable vegetative cover that will support prey populations. Reclamation of hunting habitat should not be tailored to individual raptor species, but rather should promote a diverse community of potential prey and other wildlife species. Following establishment of vegetative cover, livestock grazing programs may be initiated; several of the early programs should include investigation of grazing effects on prey populations and vulnerability.

Roads constructed during any phase of mining should be closed and revegetated when they are no longer needed. Road closures will serve many functions in wildlife mitigation, but are especially critical near actual or potential nesting sites.

SUMMARY

The breeding range of the prairie falcon includes most of the potential coal mining areas of western North America. The best available data suggest that population status is good, but local declines are expected to accompany major disturbance of land surface. Reliable estimates of regional populations and of the proportion existing on coal lands are necessary before regional impacts of proposed mining activities can be projected.

Formulation of mitigation plans is hampered by a number of voids in information. Based on current levels of knowledge, we recommend several measures to minimize negative impacts and to mitigate unavoidable losses. Efforts should be concentrated on preserving or replacing existing nesting sites, rehabilitating mined lands to provide for diverse communities of prey species and other wildlife, avoiding as much disturbance as possible, and accumulating a better base of knowledge about the effects of disturbance and habitat disruption on prairie falcon populations.

ACKNOWLEDGMENTS

S. K. Jackson, S. K. Kraft, and T. A. Legg assisted with correspondence and manuscript preparation. R. R. Olendorff allowed the use of literature in his files. Personnel of several agencies and universities in the United States and Canada provided access to much of the literature reviewed. Review comments were provided by M. W. Call, M. N. Kochert, I. M. Lockhart, B. W. O'Gara, D. Pangowski, S. W. Platt, C. M. White, and R. N. Williams.

REFERENCES

Becker, D. M. 1981a. A survey of raptors on National Forest land in Carter County, Montana. U.S. Forest Serv., Billings, MT. 61 pp.

____________. Unpub. (1981b). Artificial nest site development for prairie falcons in southeastern Montana. U.S. For. Serv., Billings, MT. 8 pp.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia--vultures, hawks, falcons, eagles. British Columbia Provincial Mus. Occas. Pap. 17. 163 pp.

Bent, A. C. 1938. Life histories of North American birds of prey. Vol. II. U.S. Natl. Mus. Bull. Washington, DC. 482 pp.

Boyce, D. A., Jr. 1982. Prairie falcon fledgling productivity in the Mohave Desert, California. M.S. Thesis. Humboldt State Univ., Arcata, CA. 97 pp.

Boyce, D. A., Jr., L. Fisher, W. E. Lehman, B. Hipp, and J. Peterson. 1980. Prairie falcons nest on an artificial ledge. Raptor Res. 14:46-50.

Brown, L. H., and D. Amadon. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill. New York, NY. 945 pp.

Call, M. W. 1979. Habitat management guides for birds of prey. U.S. Bur. Land Manage. Tech. Note TN-338. Denver, CO. 70 pp.

Crawford, J. D. Unpub. (1979). Artificial nesting sites for the management of prairie and peregrine falcon populations in North Dakota. U.S. Bur. Land Manage., Dickinson, ND. 17 pp.

Decker, F. R., and J. H. Bowles. 1930. The prairie falcon in the state of Washington. Auk 47:25-31.

Denton, S. J. 1976. Status of prairie falcons breeding in Oregon. M.S. Thesis. Oregon State Univ., Corvallis. 58 pp.

Edwards, B. F. 1973. A nesting study of a small population of prairie falcons in southern Alberta. Can. Field-Nat. 87:322-324.

Enderson, J. H. 1962. Ecology of the prairie falcon (Falco mexicanus Schlegel) in the central Rocky Mountain region. Ph.D. Thesis. Univ. Wyoming, Laramie. 87 pp.

____________. 1964. A study of the prairie falcon in the central Rocky Mountain region. Auk 81:332-352.

____________. 1969. Peregrine and prairie falcon life tables based on band recovery data. Pages 505-509 in J. J. Hickey, ed. Peregrine falcon populations: their biology and decline. Univ. Wisconsin Press, Madison. 596 pp.

Enderson, J. H., and D. D. Berger. 1970. Pesticides: Eggshell thinning and lowered production of young in prairie falcons. BioScience 20:355-366.

Enderson, J. H., and P. H. Wrege. 1973. DDE residues and eggshell thickness in prairie falcons. J. Wildl. Manage. 37:476-478.

Fyfe, R. W., and H. I. Armbruster. 1977. Raptor research and management in Canada. Pages 282-293 in R. D. Chancellor, ed. World conference on birds of prey: Report of proceedings. Int. Counc. for Bird Preservation.

Fyfe, R. W., and R. R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occas. Pap. 23. 17 pp.

Fyfe, R. W., R. W. Risebrough, and W. Walker II. 1976. Pollutant effects on the reproduction of the prairie falcons and merlins of the Canadian prairies. Can. Field-Nat. 90:346-355.

Garrett, R. L., and D. J. Mitchell. 1973. A study of prairie falcon populations in California. Calif. Dept. Fish Game. Wildl. Manage. Branch Admin. Rep. 73-2. 15 pp.

Haak, B. A. 1982. Foraging ecology of prairie falcons in northern California. M.S. Thesis. Oregon State Univ., Corvallis. 64 pp.

Harmata, A. R., J. E. Durr, and H. Geduldig. 1978. Home range, activity patterns, and habitat use of prairie falcons nesting in the Mohave Desert. U.S. Bur. Land Manage. Rep. Contract YA-512-CT8-43. 89 pp.

Hickman, G. L. 1972. Prairie falcons and red-tailed hawks rearing young in inactive golden eagle nests. Condor 73:490.

Johnstone, R. S. 1980. Nesting ecology and management of the raptors in Harney Basin, Oregon. Draft report. U.S. Bur. Land Manage., Burns, OR.

Kennedy, P. L. 1980. Raptor baseline studies in energy development. Wildl. Soc. Bull. 8:129-135.

Leedy, R. R. 1972. The status of prairie falcons in western Montana: special emphasis on possible effects of chlorinated hydrocarbon insecticides. M.S. Thesis. Univ. Montana, Missoula. 96 pp.

Lockhart, J. M., T. P. McEneaney, and A. L. Harting, Jr. Unpub. (1977). The effects of coal development on the ecology of birds of prey in southeastern Montana and northern Wyoming. U.S. Fish Wildl. Serv., Denver, CO. 31 pp.

Lockhart, M. J., D. W. Heath, and C. L. Belitsky. Unpub. (1980). The status of nesting peregrine falcons and other selected raptor species on the Black Butte Mine lease and adjacent lands. U.S. Fish Wildl. Serv., Denver, CO. 59 pp.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD. 399 pp.

Ogden, V. T., and M. G. Hornocker. 1977. Nesting density and success of prairie falcons in southwestern Idaho. J. Wildl. Manage. 41:1-11.

Olendorff, R. R. 1973a. The ecology of nesting birds of prey of northeastern Colorado. U.S. IBP Grassland Biome Tech. Rep. 211. 233 pp.

_____________. 1973b. Raptorial birds of the U.S.A.E.C. Hanford Reservation, south-central Washington. BNWL-1790, UC-11. Battelle N.W. Lab., Richland, WA. 45 pp.

_____________. 1975. Population status of large raptors in northeastern Colorado--1970-1972. Pages 185-205 in J. R. Murphy, C. M. White, and B. E. Harrell, eds. Population status of raptors: Proceedings of the Conference on Raptor Conservation Techniques. Raptor Res. Rep. 3.

Olendorff, R. R., R. S. Motroni, and M. W. Call. 1980. Raptor management-the state of the art in 1980. U.S. Bur. Land Manage. Tech. Note 345. 56 pp.

Oliphant, L. W., W. J. P. Thompson, T. Donald, and R. Rafuse. 1976. Present status of the prairie falcon in Saskatchewan. Can. Field-Nat. 90:365-368.

Parker, R. C. 1972. Prairie falcon management in Washington State. West. Assoc. Game Fish Comm. Conf. 52-394-408.

Paul, P. J., and J. H. Steele. Unpub. (1976). An evaluation and improvement of cliff nesting habitat for Canada geese and raptors on the Oldman River, Alberta. Can. Wildl. Serv., Edmonton, Alta. 11 pp.

Platt, S. W. 1974. Personal communication. Black Butte Coal Co., Point of Rocks, WY.

____________. 1977. Successful breeding of juvenile prairie falcons in northeast Colorado. Raptor Res. 11:81-82.

____________. 1981. Population dynamics of the prairie falcon in northeastern Colorado. In S. W. Platt. Prairie falcon: Aspects of population dynamics, individual voice identification, marking, and sexual maturity. Ph.D. Dissertation. Brigham Young Univ., Provo, UT.

Porter, R. D., C. M. White, and R. J. Erwin. 1973. The peregrine falcon in Utah, emphasizing ecology and competition with the prairie falcon. Brigham Young Univ., Sci. Bull. 18:1-74.

Shor, W. 1975. Survival rate of wild adult prairie falcons deduced from band recovery data. Raptor Res. 9(3):46-50.

Snow, C. 1974. Habitat management series for unique or endangered species--prairie falcon (Falco mexicanus). Rep. 13. U.S. Bur. Land Manage., Denver, CO. 18 pp.

Suter, G. W., II, and J. L. Joness. 1979. Criteria for golden eagle, ferruginous hawk, and prairie falcon nest site protection. Oak Ridge Natl. Lab. Publ. 1593, Oak Ridge, TN. 14 pp.

U.S. Bureau of Land Management. 1979. Snake River birds of prey special research report to the Secretary of the Interior. U.S. Bur. Land Manage., Boise, ID. 142 pp.

Webster, H., Jr. 1944. A survey of the prairie falcon in Colorado. Auk 61:609-616.

White, C. M., T. L. Thurow, and J. F. Sullivan. In prep. Reproduction of ferruginous hawks exposed to controlled disturbance. Accepted for publication in Condor.

Wilderness Research Institute. 1980. Peregrine falcon nesting habitat survey on U.S. Forest Service lands along the west slope of the Sierra Nevada Mountains. U.S. For. Serv. Rep. Contract 53-91U9-0-80029. 47 pp.

Dale Becker's current address: #5 Rebecca Ct., Helena, MT 59801.

SANDHILL CRANE (*Grus canadensis*)

by

David L. Evans
Eileen K. Bartels
Northern Prairie Wildlife Research Center
U.S. Fish and Wildlife Service
Jamestown, ND 58401

and

Judith Scherpelz Armbruster
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Ft. Collins, CO 80526

SPECIES DESCRIPTION

Two species of cranes occur in North America, the sandhill crane (*Grus canadensis*) and the whooping crane (*G. americana*). Both are sensitive to disturbance and habitat loss and have suffered declines since historic times. The sandhill crane is one of the oldest living avian species, with fossil remains dating back 9 million years (Walkinshaw 1973). The species stands 1.0 to 1.2 m tall with a wingspan of 1.8 to 2.1 m, and is distinctive with its long neck and legs. Adults are gray with a red crown; the plumage is often stained with rust. Immatures are plain brown (Peterson 1980). The whooping crane, a Federally-listed endangered species, is solid white with black primaries and a red crown, and occasionally occurs in sandhill crane flocks.

DISTRIBUTION

Of the six subspecies of sandhill cranes in North America, three nest in or migrate through the Western coal region and may be affected by surface coal mining (Fig. 14). The lesser sandhill crane (*G. c. canadensis*) breeds in northeastern Siberia, Alaska, and northern Canada, and winters in Texas, southeastern Arizona, New Mexico, California, and northern Mexico.

The Canadian sandhill crane (*G. c. rowani*) breeds primarily in the boreal forest regions of the Canadian prairie provinces and winters primarily in coastal Texas and Mexico (Guthery 1972; Braun 1975; Guthery and Lewis 1979).

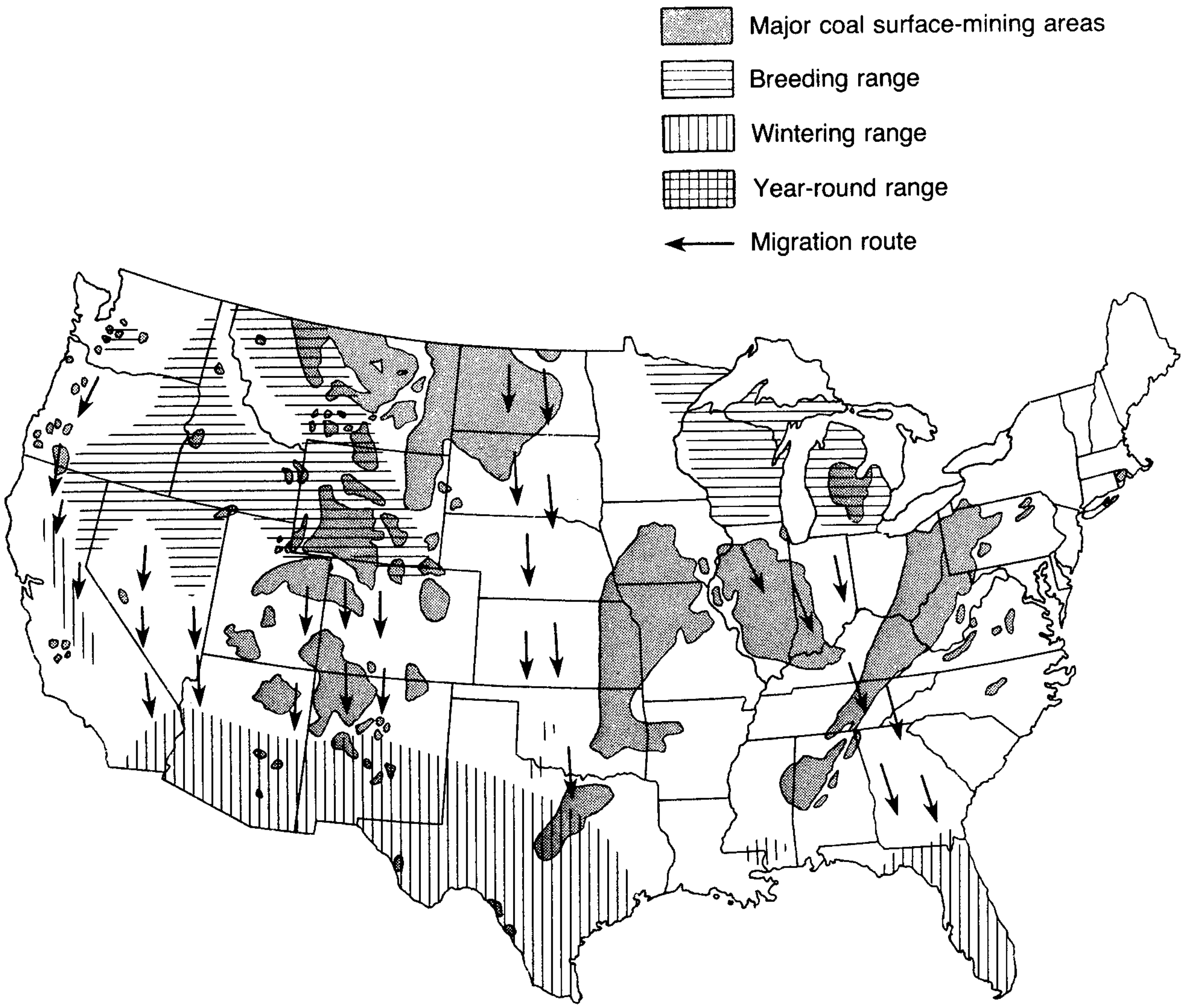


Figure 14. Geographical range of the sandhill crane in relation to major coal deposits in the United States. After Baldwin (1977), Lewis (1977), and National Geographic Society (1983).

The greater sandhill crane (*G. c. tabida*) breeds from approximately 40° N to 50° N in the northern United States and southern Canada from Michigan west to central Oregon (Walkinshaw 1973). Four geographically distinct populations are recognized (Braun 1975; Lewis 1977):

1. Eastern - breeds in Michigan, Minnesota, Wisconsin, and southeastern Manitoba to southwestern Ontario; winters in southern Georgia and Florida.

2. Rocky Mountain - breeds in eastern Idaho, western Wyoming, northeastern Utah, southwestern Montana, and northwestern Colorado; winters in western New Mexico, southeastern Arizona, and northern Mexico. The population at Grays Lake, Idaho, is involved in a foster parenting program with young whooping cranes.

3. Colorado River Valley - breeds in northeastern Nevada and probably south-central Idaho; winters south of Parker, Arizona, and near Brawley, California.

4. Central Valley - breeds in southern Oregon and northeastern California and southern British Columbia; winters in the California Central Valley.

The Florida sandhill crane (*G. c. pratensis*) is a resident subspecies that breeds and winters in north-central Florida and southern Georgia. The Mississippi sandhill crane (*G. c. pulla*) consists of a small population of 40 to 50 birds and is resident in Jackson County, Mississippi (Valentine 1979). The Cuban sandhill crane (*G. c. nesiotes*) is resident and nonmigratory in western Cuba and the Isle of Pines (Walkinshaw 1973).

DIET

Sandhill cranes are omnivorous and opportunistic in their feeding habits. A wide variety of foods have been reported including roots, tubers, seeds, berries, vegetation, invertebrates, amphibians, snakes, eggs, young birds, and small mammals (Hamerstrom 1938; Walkinshaw 1949; Harvey et al. 1968; Littlefield 1976; Mullins and Bizeau 1978). During the summer, the diet tends to include more animal foods. During migration and on wintering areas, grain crops are utilized extensively when available. Crop depredations are sometimes a problem on fall staging areas and on wintering grounds, especially in late harvest years (Munro 1950; Boeker et al. 1961; Buller 1967; Madsen 1967; Stephen 1967; Drewien and Bizeau 1974; Lewis 1977). Usually, feeding occurs on waste grain in harvested fields, primarily wheat, barley, corn, sorghum, and rice (Boeker et al. 1961; Madsen 1967; Stephen 1967; Guthery 1975; Lewis 1979; Reinecke and Krapu 1979). Wintering cranes in southeastern Texas exhibit diminishing feeding on agricultural areas and increased use of native vegetation as the winter progresses (Guthery 1975; Melvin and Temple 1980).

REPRODUCTION

Sandhill cranes nest in a variety of wetland habitat types, including tundra, shallow marshes, and bogs. The essential components of a nesting territory are water, nesting cover, feeding areas, and freedom from human disturbance (Littlefield and Ryder 1968; Lewis 1977). Nesting territories are established early in the spring and are mutually exclusive. Mated pairs typically return to their territory of the previous year. Loud, synchronized unison calls (Walkinshaw 1973) are given by the mated pair during territory establishment, courtship, and, with declining frequency, the remainder of the nesting season. Unmated individuals also give unison calls occasionally, as do mated birds during the non-breeding season. The nest is built in or near water and consists of a mound of emergent vegetation, sticks, grass, and mud; dryland nests are rarely as large as over-water nests. The typical clutch contains two eggs, which hatch asynchronously after about 28 to 31 days of incubation. The young (colts) are able to walk within a day; they are led by their parents to adjacent uplands or meadows to feed during the day and return to wetlands to roost at night (Lewis 1977).

Interchick aggression often results in the death of one sibling in two-chick broods (Littlefield and Ryder 1968). Captive-reared chicks are more aggressive when hungry, so environmental factors may reduce sibling aggression in some years (Quale 1976). Considerable variation occurs in the number of two-chick broods produced from year to year in Alaska (Boise 1976). Observations of two-chick broods indicate that each parent leads one of the siblings, keeping them well separated (Harvey et al. 1968; Littlefield and Ryder 1968). The colts' prefledging diet appears to be predominantly animal matter (Boise 1977; Lewis 1977; Bennett 1978). The young are capable of flight at 10 to 11 weeks and typically remain with their parents until the following nesting season (Walkinshaw 1949).

Roost sites are important for cranes to use at night for resting and preening. Preferred sites include large expanses of shallow water with a soft substrate a distance from a bare shore. Cranes require shallow areas extensive enough for large numbers to roost together, good visibility for predator detection (Soine 1981), and protection from disturbance (especially human) (Armbruster and Farmer 1981).

Staging and Migration Requirements

Habitat requirements during staging and migration include grain food, invertebrate food, loafing areas, and roosting sites (Armbruster and Farmer 1981). Feeding and loafing requirements may be met by grainfields, wet meadows, grasslands, and alfalfa fields. Roosting sites along the Platte River must be free of vegetation, thus occasional high water flows are important to scour sandbars and discourage woody growth.

POPULATION TRENDS

Overall trends indicate sandhill crane populations are stable or increasing. The lesser sandhill crane population was estimated at a minimum of 250,000 to 280,000 in the early 1970's and appeared to be stationary (Braun 1975; Lewis 1977). More recent estimates suggest the population may approach 400,000 to 500,000 birds (U.S. Fish and Wildlife Service 1981). The population of Canadian sandhill cranes is estimated at 54,000 birds (Aldrich 1979). Populations of the greater sandhill crane appear to be stable or increasing. The Eastern population had census results of over 14,000 in 1979 and over 15,000 in 1980 (Lovvorn and Kirkpatrick 1981). The Rocky Mountain population was estimated at 15,000 to 17,000 birds in 1979-1980 and is increasing (Drewien pers. comm.). The Colorado River Valley population is estimated at 1,000 (Drewein et al. 1976); present status is unknown. The Central Valley population appears stable, with about 3,500 birds, plus an additional group of about 300 birds nesting in southern British Columbia.

The sedentary Florida subspecies is stable at about 5,000 birds (Braun 1975; Lewis 1977). Extensive drainage projects and real estate development have been offsetting habitat gains resulting from land clearing for cattle grazing.

The Mississippi sandhill crane numbers 40 to 50 birds (Valentine 1979). The Cuban subspecies population has never been very large; evidence indicates the population of about 200 birds is stable or increasing slowly (Braun 1975; Lewis 1977).

Effects of Habitat Changes

Sandhill cranes are very sensitive to habitat changes that effect nesting, feeding, and roosting areas. Wet meadows along the Platte River have been destroyed by dredging, draining, filling, gravel mining, housing developments, and conversion to agricultural uses (Wallenstrom 1976). Decreased flows in the Platte River allowing vegetation encroachment on sandbars, and developments along the shoreline, have caused cranes to move their staging areas east along the river to the present location. Cranes are very susceptible to collisions with fences and powerlines, and may suffer mortality where fences and powerlines are near feeding or roosting areas (Kauffeld 1981).

Effects of Human Disturbance

Cranes are sensitive to human disturbance, and will avoid habitat that is near human activity. Visual barriers of woody vegetation over 1 m in height may allow cranes to use habitat near a source of disturbance. Table 10 presents types of disturbance resulting in avoidance of cropland, alfalfa and grassland; Table 11 presents disturbance factors affecting use of roost areas. (These are preliminary data developed for a draft model for crane habitat, and may be subject to revisions.) Cranes require at least 25 m of unobstructed view around a roost site (Armbruster and Farmer 1981).

Table 10. Types of disturbances resulting in avoidance of cover types by sandhill cranes and the size of affected areas.

Type of disturbance	Width (m) of affected area[a]	
	Cropland	Alfalfa and grassland
Paved road	100	200
Gravel road	50	100
Private road	10	20
Urban dwelling	200	400
Single dwelling	50	100
Railroad	100	200
Commercial development	200	400
Recreational area	50	100
Highlines	10	20
Bridges	100	200

[a]Width of a band on both sides of a disturbance factor, or the radius around a single point.

Source: Armbruster and Farmer 1981.

Table 11. Types of disturbances influencing use of potential riverine roost sites by sandhill cranes and the size of affected areas.

Type of disturbance	Width (m) of affected area[a]
Paved road	400
Gravel road	200
Private road	40
Urban dwelling	800
Single dwelling	200
Railroad	400
Commercial development	800
Recreational area	200
Highlines	40
Bridges	400

[a]Width of a band on both sides of a disturbance factor, or the radius around a single point.

Source: Armbruster and Farmer 1981.

Typical roost sites in the southern Central Flyway are 1.6 to 4.8 km from the nearest road and a greater distance from the nearest house (Lewis 1976). In central North Dakota, fall roost sites were used within 0.8 km of the nearest road and 1.6 km of the nearest house (U.S. Bureau of Reclamation 1979).

Management

Management of habitat for sandhill cranes includes protection of nesting areas, enhancement of feeding areas, and regulation of flow regimes for roosting habitat. Wet meadows can be managed for food production by controlled burning (Logan et al. 1976), grazing, and haying (Lingle 1981). Flooding meadows and ponds will produce more areas for loafing and roosting (Kauffeld 1981). Removal of fences and powerlines can decrease mortality in areas of high use. Unwanted woody vegetation at roost sites may be removed mechanically (Lingle 1981). Control of river flow regimes may decrease woody vegetation at roost sites and flood adjacent feeding habitats, increasing the habitat value of these areas (Shoemaker et al. 1981).

The Sandhill Crane as an Indicator Species

An indicator species is one that has a narrow range of habitat requirements and responds readily to environmental change. The sandhill crane may serve as an indicator species of wetlands because of its dependence on this habitat type for nesting. Because of the use of the Platte River by large numbers of cranes for staging during migration, the crane may serve as an indicator of the flow of the Platte River. Any decrease in flow of the Platte River from water demands of mining operations may destroy critical roosting areas for sandhill cranes.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include: changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in rivers, lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversion of water for a transport system; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; and increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding, feeding, and roosting areas.

Sandhill cranes may be impacted directly, through mortality, or indirectly, through increased stress and habitat loss. Mortality may occur if nests and nestlings are destroyed during construction and mining activities. The most serious impact would be from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food sources, and nesting and roosting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population.

Changes in flow regimes by a decrease of water in the Platte River would allow vegetation to invade sandbars and render the sites useless as roosting habitat for cranes. Construction of reservoirs, and diversions and groundwater withdrawal for irrigation and municipal uses have caused major hydrologic changes in the Platte River basin, reducing the amount of roosting habitat available for cranes (Hadley and Eschner 1981). Further changes in water resources may have detrimental effects on roosting habitat and wet meadow feeding areas. Because a large majority of the population is concentrated in a relatively small area during staging and migration, any detrimental effects on these areas may have serious impacts on the entire crane population.

Cranes are particularly sensitive to human disturbance, including human presence, noise levels, and any human activities. The increase in human disturbance may deter cranes from using suitable habitat near areas of disturbance.

Transmission lines can be a major source of mortality to cranes. New transmission lines placed in areas of heavy crane use may cause deaths and injuries from collisions (Kauffeld 1981).

Potential Impact Areas

Greater sandhill crane. Two areas containing strippable coal deposits are important breeding or staging areas for the greater sandhill crane (Fig. 15). In Colorado, a breeding population of about 250 birds occurs in Routt County and adjacent portions of Jackson and Moffatt Counties. Up to 325 birds have been observed on local staging areas, primarily on the Yampa and Elk Rivers, in the spring and fall (Bieniasz 1979). The Bear River, Lincoln County, Wyoming, supports up to 2,000 to 3,000 cranes during spring and fall migration and 350 to 450 birds during the breeding season. The Bear River and Routt County population represent about 5% of the known summering cranes in the Rocky Mountain population of greater sandhill cranes (Drewien and Bizeau 1974; Lewis 1977).

Lesser and Canadian sandhill crane. Most lesser and Canadian sandhill cranes migrate through or directly adjacent to the Western coal region (Fig. 15). During fall, large concentrations occur on traditional staging areas in the prairie provinces, Montana, and North Dakota (Buller 1967; Lewis 1977). Cranes remain on central North Dakota staging grounds for periods of up to 7 weeks or longer (Melvin and Temple 1980), utilizing refuges and lakes on public and private land for roosting and feeding on cereal grains in nearby fields (Munro 1950; Madsen 1967; Stephen 1967). These areas presumably are important for premigratory fattening (cf. Lewis 1979), especially for immature birds (Northern Prairie Wildlife Research Center, unpubl. data). Large concentrations also occur south of the northern staging areas but they are not as consistent from year to year and apparently represent short term stopover points during migration (Buller 1967; Melvin and Temple 1980).

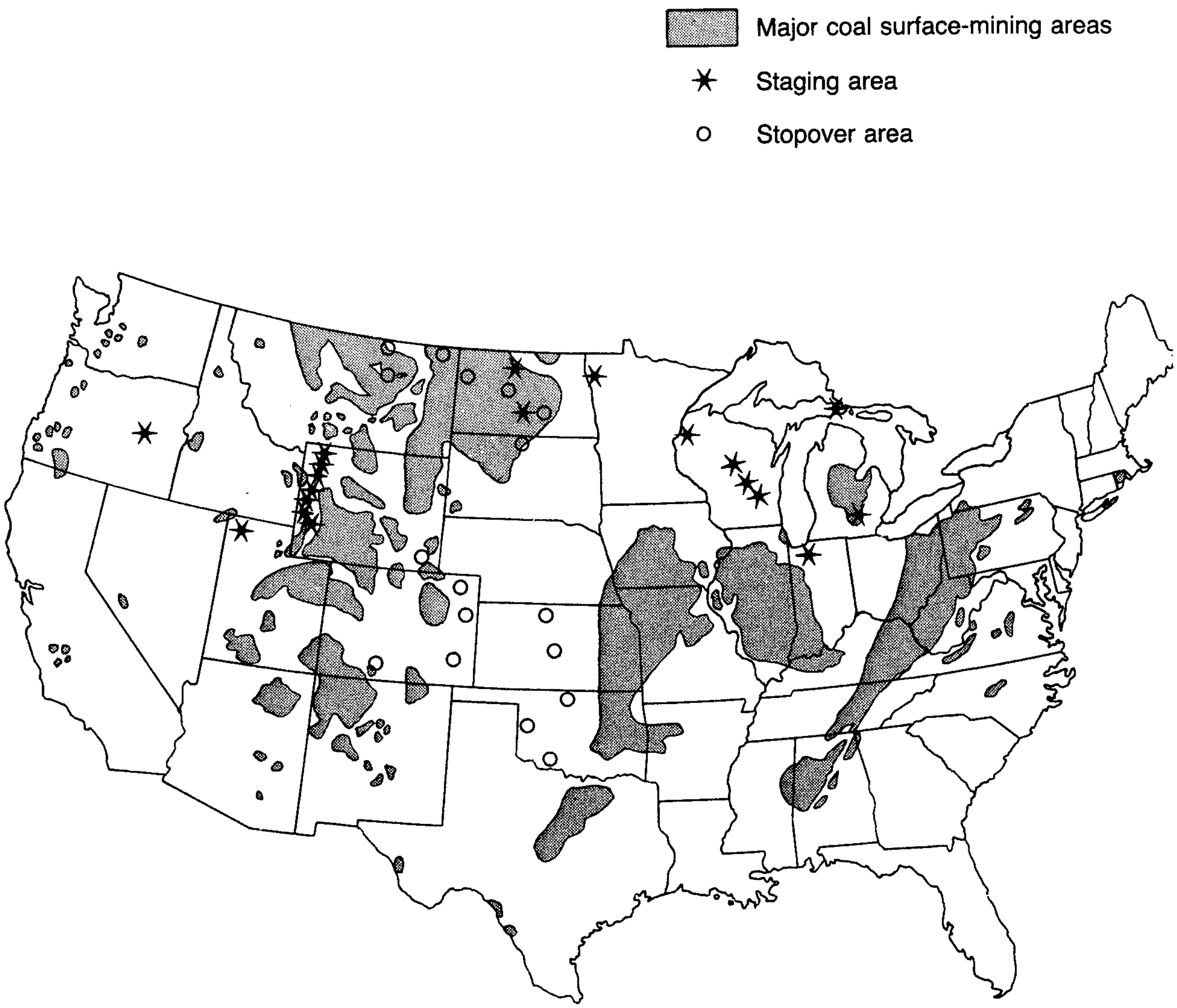


Figure 15. Important staging and migration stopover areas of the sandhill crane. After Buller (1967) and Lewis (1977).

Surface coal mining may potentially affect fall staging areas at Medicine Lake National Wildlife Refuge (NWR), Montana, and in McLean County, North Dakota. These staging areas are used predominantly by the lesser sandhill crane (Johnson and Stewart 1973).

No mining is occurring at the present time (1983) in the vicinity of Medicine Lake NWR, Montana (Bellinger pers. comm.) but some feeding areas may be affected in the future. Up to 10,000 cranes have been observed on the refuge (Buller 1967). In North Dakota, strippable coal reserves occur in south-central McLean County (Bluemle 1977). This coal deposit lies directly southwest of a major crane staging area centered on a line between Lake Audubon NWR and Mercer, North Dakota (U.S. Bureau of Reclamation 1979). Over 21,000 cranes used this staging area in 1979 (U.S. Bureau of Reclamation 1980). As coal development proceeds in McLean County, some feeding areas may be affected. However, the main roosting areas appear to be beyond the boundaries of presently known coal deposits.

During spring migration, most lesser and Canadian sandhill cranes stage along the Platte River, Nebraska (Frith 1976; Lewis 1977; U.S. Fish and Wildlife Service 1981). An estimated 509,000 cranes were censused along the Platte River in March 1982 (Benning pers. comm.). Northward migration from the Platte River to staging areas in Saskatchewan and Manitoba is fairly direct, with few prolonged stops in the Western coal region (Lewis 1977; U.S. Fish and Wildlife Service 1981). During spring, important fall staging areas in the coal region receive relatively little use; migrating cranes appear to be much more opportunistic in selection of roosting and feeding areas than cranes at staging areas (Melvin and Temple 1980; U.S. Bureau of Reclamation 1980).

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Initial surveys have delineated greater sandhill crane breeding and staging areas likely to be affected by coal development (see Potential Impact Areas). Areas of projected coal development should be further monitored to more closely identify traditional nesting and staging areas. In view of the proximity of projected coal development to the important lesser sandhill crane fall staging grounds in McLean County, North Dakota, and at Medicine Lake NWR, fall population surveys should be conducted to better establish the extent of crane utilization of potential mining areas.

Exploration, Mine Development, and Mining Phase

Mitigation may begin during the earliest stages of mining activity. Mine exploration is often conducted over undisturbed areas that are usually larger than areas which may eventually be mined. Scheduling of exploration activities to avoid periods of heavy use by nesting, staging, or migrating cranes in important areas will help alleviate impacts to cranes.

Because of the noise and activity levels associated with exploration and test drilling, a tentative buffer zone for no activity as much as 3.2 km or more around traditional roost sites may be necessary to ensure use of the roost sites during the fall staging period (late July to mid-November) (Buller 1967; Melvin and Temple 1980). An additional buffer, perhaps as great as 6.4 to 8.0 km, with activity restricted to the period from 2 hours after sunrise to 2 hours before sunset, may also be necessary (cf. Lewis 1976).

Exploration activity in the vicinity of nesting areas should be scheduled for the non-breeding season whenever possible. Little is known about how much disturbance cranes will accept without abandoning nests or leaving local habitat; further research on this subject is needed (Lewis 1977). Mine exploration during the breeding season may have to be restricted in a zone of up to 4.8 to 8.0 km from nesting areas to preclude territory abandonment.

Some crane habitat will likely be destroyed during the mining phase. Traditional staging areas appear to be very important to large segments of crane populations; roost sites receiving consistent year to year use are especially critical and, with appropriate buffers, should be preserved. Traditional nesting areas may be preserved whenever possible to help minimize impacts, particularly near mining boundaries where coal recovery may be economically marginal.

Any water diversion or alteration of water resources should be planned to avoid impacting major staging areas.

Reclamation Phase

The possibilities for reclaiming crane nesting habitat are largely unknown but do not appear good. Creation of wetlands and wet meadows may provide nesting and feeding areas. Restoration of stream drainages (where Rocky Mountain sandhill cranes often nest) to the condition necessary for crane reoccupation may be difficult.

In North Dakota, the stated reclamation objective is a return to agricultural production; resumption of cereal grain production may help to assure the continuing availability of feeding sites for cranes on fall staging grounds and migration stopping points.

SUMMARY

Three subspecies of sandhill crane nest in or migrate through the Western coal region. Two major fall staging areas in Montana and North Dakota used by lesser and Canadian sandhill cranes are near areas with strippable coal deposits. Neither area presently has mining activity and impacts in the future are not expected to be great. Changes in water levels along the Platte River from diversions may severely impact the large numbers of cranes using the Platte River during migration. Breeding populations of the greater sandhill crane in Routt County, Colorado, and along the Bear River, Wyoming, occur in areas of anticipated coal development. It is not presently known what proportion of these populations might be affected, which together represent about 5% of the Rocky Mountain population of greater sandhill cranes. This population has been increasing during the past decade. Mitigation measures include protection of important nesting and staging areas, enhancement of wet meadows, creation of wetlands, and continued cultivation of grain crops.

REFERENCES

Aldrich, J. W. 1979. Status of the Canadian sandhill crane. Pages 139-143 in J. C. Lewis, ed. Proc. 1978 Crane Workshop. Natl. Audubon Soc. Colorado State Univ. Print. Serv., Fort Collins.

Armbruster, M. J., and A. H. Farmer. 1981. Draft sandhill crane suitability model. Pages 136-143 in J. C. Lewis, ed. Proc. 1981 Crane Workshop. Natl. Audubon Soc. Tavernier, FL.

Baldwin, J. H. 1977. A comparative study of sandhill crane subspecies. Ph.D. Dissertation. Univ. Wisconsin, Madison. 150 pp.

Bellinger, J. R. Personal communication. Refuge Manager, Medicine Lake National Wildlife Refuge, Montana.

Bennett, A. J. 1978. Ecology and status of greater sandhill cranes in southeastern Wisconsin. M.S. Thesis, Univ. Wisconsin, Stevens Point. 107 pp.

Benning, D. 1983. Personal communication. U.S. Fish and Wildlife Service, 730 Simms Street, Room 456, Golden, CO 80401.

Bieniasz, K. A. 1979. The greater sandhill crane in Routt County, Colorado. Pages 197-203 in J. C. Lewis, ed. Proc. 1978 Crane Workshop. Natl. Audubon Soc. Colorado State Univ., Fort Collins.

Bluemle, J. P. 1977. The face of North Dakota - the geologic story. North Dakota Geogr. Surv. Educational Series 11. 73 pp.

Boeker, E. L., J. W. Aldrich, and W. S. Huey. 1961. Study of experimental sandhill crane hunting season in New Mexico during January 1961. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl. 63. 24 pp.

Boise, C. M. 1976. Breeding biology of the lesser sandhill crane - a preliminary report. Pages 126-129 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc. Oklahoma State Univ. Publ. Print., Stillwater.

__________. 1977. Breeding biology of the lesser sandhill crane *Grus canadensis canadensis* (L.) on the Yukon-Kuskokwim Delta, Alaska. M.S. Thesis, Univ. Alaska, Fairbanks. 79 pp.

Braun, C. E., Chairman. 1975. Conservation committee report on status of sandhill cranes. Wilson Bull. 87:297-302.

Buller, R. J. 1967. Sandhill crane study in the Central Flyway. U.S. Bur. Sport Fish. Wildl. Spec. Sci. Rep. Wildl. 113. 17 pp.

Drewein, R. Personal communication. Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow, ID 83843.

Drewien, R. C., and E. G. Bizeau. 1974. Status and distribution of greater sandhill cranes in the Rocky Mountains. J. Wildl. Manage. 38:720-742.

Drewein, R. C., R. J. Oakleaf, and W. H. Mullins. 1976. The sandhill crane in Nevada. Pages 130-138 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc., Oklahoma State Univ. Publ. Print., Stillwater.

Frith, C. R. 1976. Crane habitat of the Platte River. Pages 151-156 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc. Oklahoma State Univ. Publ. Print., Stillwater.

Guthery, F. S. 1972. Food habits, habitat, distribution, numbers, and subspecies of sandhill cranes wintering in southern Texas. M.S. Thesis, Texas A&M Univ., College Station. 81 pp.

____________. 1975. Food habits of sandhill cranes in southern Texas. J. Wildl. Manage. 39:221-223.

Guthery, F. S., and J. C. Lewis. 1979. Sandhill cranes in coastal counties of southern Texas: taxonomy, distribution, and populations. Pages 121-128 in J. C. Lewis, ed. Proceedings 1978 Crane Workshop. Natl. Audubon Soc. Colorado State Univ. Print. Serv., Fort Collins.

Hadley, R. F., and T. R. Eschner. 1981. Relation of hydrologic and geomorphic changes to wildlife habitat in Platte River Channels, Southcentral Nebraska. Pages 27-32 in J. C. Lewis, ed. Proc. 1981 Crane Workshop. Natl. Audubon Soc. Tavernier, FL.

Hamerstrom, F. N., Jr. 1938. Central Wisconsin crane study. Wilson Bull. 50:175-184.

Harvey, J. M., B. C. Lieff, C. D. Macinnes, and J. P. Prevett. 1968. Observations on behavior of sandhill cranes. Wilson Bull. 80:421-425.

Johnson, D. H., and R. E. Stewart. 1972. The sandhill crane with emphasis on aspects related to North Dakota. Prairie Nat. 4:65-76.

____________. 1973. Racial composition of migrant populations of sandhill cranes in the northern plains states. Wilson Bull. 85:148-162.

Kauffeld, J. 1981. Management of migratory crane habitat on Alamosa and Monte Vista National Wildlife Refuges. Pages 117-121 in J. C. Lewis, ed. Proc. 1981 Crane Workshop. Natl. Audubon Soc. Tavernier, FL.

Lewis, J. C. 1976. Roost habitat and roosting behavior of sandhill cranes in the southern Central Flyway. Pages 93-104 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc. Oklahoma State Univ. Publ. Print., Stillwater.

__________. 1977. Sandhill crane (Grus canadensis). Pages 5-43 in G. C. Sanderson, ed. Management of migratory shore and upland game birds in North America. Int. Assoc. Fish Wildl. Agencies. Washington, DC.

__________. 1979. Taxonomy, food, and feeding habit of sandhill cranes, Platte Valley, Nebraska. Pages 21-27 in J. C. Lewis, ed. Proc. 1978 Crane Workshop. Natl. Audubon Soc. Colorado State Univ., Fort Collins.

Lingle, G. R. 1981. Morman Island Crane Meadows - Protecting habitat for cranes along the Platte River, Nebraska. Pages 17-21 in J. C. Lewis, ed. Proc. 1981 Crane Workshop. Natl. Audubon Soc., Tavernier, FL.

Littlefield, C. D. 1976. Sandhill cranes feeding on ducklings. Wilson Bull. 88:503-504.

Littlefield, C. D., and R. A. Ryder. 1968. Breeding biology of the greater sandhill crane on Malheur National Wildlife Refuge, Oregon. Trans. N. Am. Wildl. Resour. Conf. 33:444-454.

Logan, T. H., R. D. Klataske, and R. J. Wicht. 1976. Preliminary report on the National Audubon Society's management efforts in the Platte River Valley of Nebraska. Pages 144-150 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc., Oklahoma State Univ. Publ. Print., Stillwater.

Lovvorn, J. R., and C. M. Kirkpatrick. 1981. Fall census of eastern greater sandhill cranes. Pages 259-265 in J. C. Lewis, ed. Proc. 1981 Crane Workshop. Natl. Audubon Soc. Tavernier, FL.

Madsen, C. R. 1967. Food and habitat selection by fall migrant sandhill cranes in Kidder County, North Dakota. M.S. Thesis, Michigan State Univ., East Lansing. 60 pp.

Melvin, S. M., and S. A. Temple. Unpub. (1980). Migration ecology and wintering grounds of sandhill cranes from the interlake region of Manitoba. Univ. Wisconsin, Madison. 60 pp.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Mullins, W. H., and E. G. Bizeau. 1978. Summer foods of sandhill cranes in Idaho. Auk 95:175-178.

Munro, D. A. 1950. A study of the economic status of sandhill cranes in Saskatchewan. J. Wildl. Manage. 14:276-284.

National Geographic Society. 1983. Field Guide to the birds of North America. National Geographic Society, Washington, DC. 464 pp.

Northern Prairie Wildlife Research Center. Unpublished data. U.S. Fish and Wildlife Service, Jamestown, ND.

Peterson, R. T. 1980. A field guide to the birds. 4th ed. Houghton Mifflin Co., Boston. 384 pp.

Quale, T. R. 1976. Interchick aggression in sandhill cranes. Pages 263-267 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc. Oklahoma State Univ. Publ. Print., Stillwater.

Reinecke, K. J., and G. L. Krapu. 1979. Spring food habits of sandhill cranes in Nebraska. Pages 13-19 in J. C. Lewis, ed. Proc. 1978 Crane Workshop. Natl. Audubon Soc. Colorado State Univ., Fort Collins.

Shoemaker, T. G., S. L. Ellis, and H. W. Shen. 1981. Development of minimum streamflow recommendations for maintenance of whooping crane habitat on the Niobrara River, Nebraska. Pages 155-174 in J. C. Lewis, ed. Proc. 1981 Crane Workshop. Natl. Audubon Soc. Tavernier, FL.

Soine, P. J. 1981. Roost habitat selection by sandhill cranes in central North Dakota. M.S. Thesis, North Dakota State Univ., Fargo. 31 pp.

Stephen, W. J. D. 1967. Bionomics of the sandhill crane. Can. Wildl. Serv. Rep. 2. 48 pp.

U.S. Bureau of Reclamation. 1979. Whooping crane and sandhill crane studies, 1978. Pages 66-74 in Garrison Diversion Unit Biological Investigations. 1978 Annual Rep.

__________. 1980. Crane surveys. Pages 63-69 in Garrison Diversion Unit Biological Investigations. 1979 Annual Rep.

U.S. Fish and Wildlife Service. 1981. The Platte River ecology study. Northern Prairie Wildlife Research Center. Special Res. Rep. 187 pp.

Valentine, J. M., Jr. 1979. The Mississippi sandhill crane--a status update. Pages 135-138 in J. C. Lewis, ed. Proc. 1978 Crane Workshop. Natl. Audubon Soc. Colorado State Univ., Fort Collins.

Walkinshaw, L. H. 1949. The sandhill cranes. Cranbrook Inst. Sci. Bull. 29. 202 pp.

__________. 1973. Cranes of the world. Winchester Press, New York. 370 pp.

Wallenstrom, R. L. 1976. The Platte River National Wildlife Refuge. Pages 141-143 in J. C. Lewis, ed. Proc. Int. Crane Workshop 1975. Natl. Audubon Soc., Oklahoma State Univ. Publ. Print., Stillwater.

PIPING PLOVER (*Charadrius melodus*)

by

James J. Dinsmore
Animal Ecology Department
124 Science II Building
Iowa State University
Ames, IA 50011

SPECIES DESCRIPTION

The piping plover (*Charadrius melodus*) is a small (17.7 cm long) plover with pale brown upper parts and white undersides. It has a band of white across the forehead extending to behind the eyes and a white ring around the neck. A dark stripe extends across the forehead behind the white band. A black shoulder mark often extends forward to form a full ring across the upper breast. The sexes are similar in color but the dark areas are paler in females. The dark areas are also paler in winter plumage (Palmer 1967).

In summer, the legs and bill are yellow or orange with a black tip on the bill. In winter, the legs and bill are darker in color (Palmer 1967). Males average 54.9 g and females 55.6 g in weight on Long Island (Wilcox 1959) while in Nova Scotia males average 56.2 g and females 55.3 g (Cairns 1977).

DISTRIBUTION

Two subspecies are recognized; both are confined to North America (Fig. 16). The race *C. melodus melodus* breeds on coastal beaches from southeastern Quebec, Newfoundland, and northern New Brunswick south to Virginia and (formerly) North Carolina. Birds from this population winter on the Atlantic Coast from South Carolina to Florida with scattered records on the Gulf Coast and throughout the Bahamas and Greater Antilles (American Ornithologists' Union 1983).

The subspecies *C. m. circumcinctus* nests from south-central Alberta and south-central Manitoba south through eastern Montana, northwestern North Dakota, southeastern South Dakota, to central and eastern Nebraska. Another population of this subspecies breeds along the shores of the Great Lakes. Birds from these two populations winter on coastal beaches of the Gulf of Mexico (American Ornithologists' Union 1957).

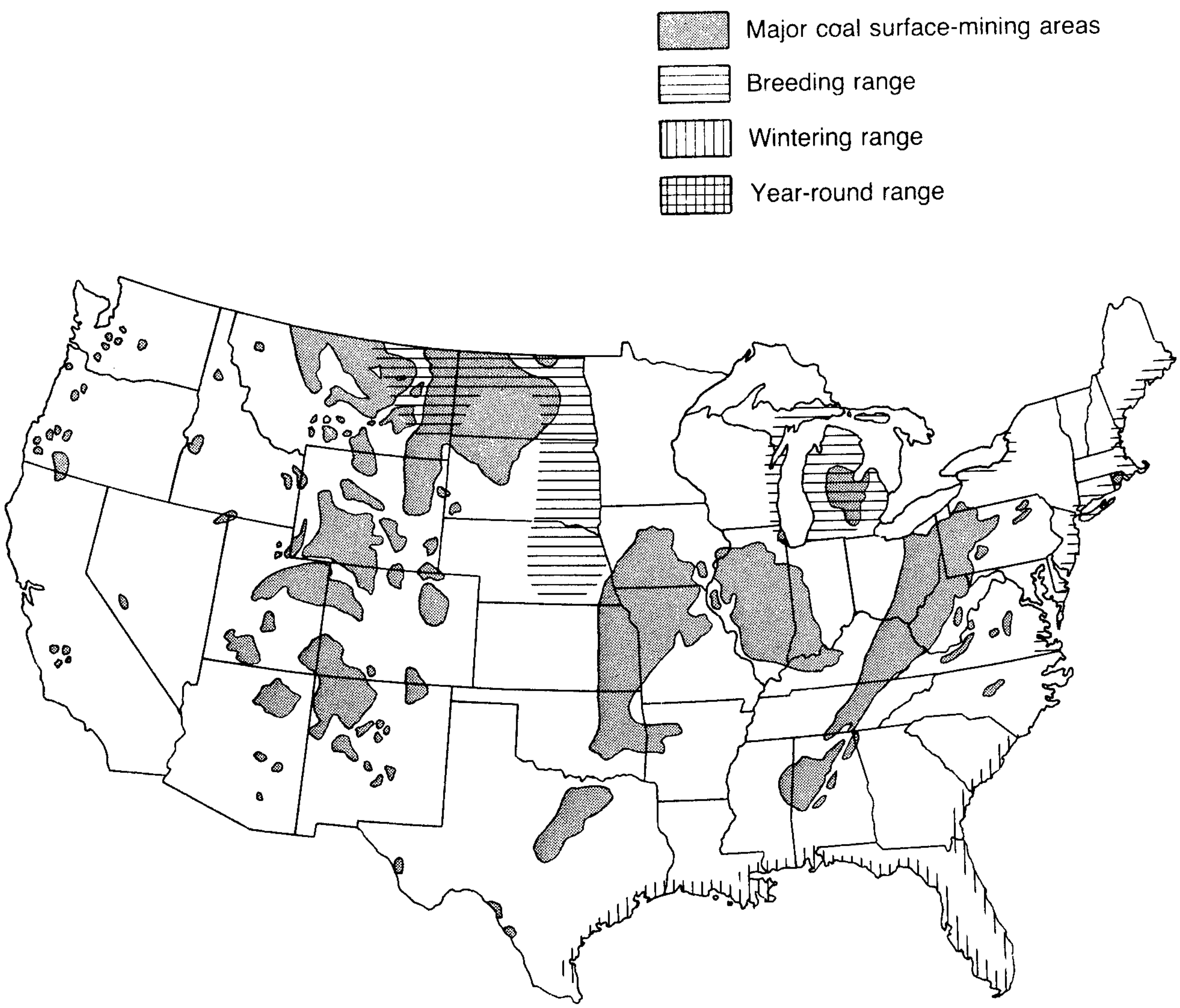


Figure 16. Geographical range of the piping plover in relation to major coal deposits in the United States. After Inkley and Raley (1983).

DIET

Little information is available on food habits. In general, piping plovers eat marine worms, insects, crustaceans, and molluscs (Bent 1929; Quinn and Walden 1966; Palmer 1967; Cairns 1977).

The piping plover nearly always forages on sandy beaches, running a short distance and then stopping to stare at the sand before pecking at an object (Cairns 1977). When staring at the sand, it often tilts the head to one side before reaching to grab the food item (Bent 1929). It often stands on one foot and vibrates the other foot against moist sand before pecking (Nichols 1941; Cairns 1977). Presumably this foot-trembling helps the bird detect a food item. Such birds averaged about 30 pecks per minute (Cairns 1977).

REPRODUCTION

Nesting Phenology

Migrants arrive at the breeding grounds in New York in late March (Wilcox 1959), in Nova Scotia from mid-to late April (Cairns 1977, 1982), and in Michigan in April (Cottrille 1957). Complete clutches have been observed as early as April 26 in New York (Wilcox 1959) and May 7 in southern Michigan (Cottrille 1957). The peak of egg laying in Nova Scotia and Michigan is early to mid-May (Cottrille 1957; Cairns 1977, 1982). Some eggs hatch as early as late May in New York, Nova Scotia, and Michigan but the peak of hatching generally is late May through mid-June (Cottrille 1957; Wilcox 1959; Cairns 1977, 1982). The few eggs hatching in late July probably are from pairs that renested. At Long Point, Lake Erie, eggs were laid in early May and young hatched by late May (Bradstreet et al. 1977).

The little information available from the Great Plains suggests a similar phenology. Two nests in Nebraska hatched between June 6 and 8 (Pickwell 1925). In Saskatchewan, the breeding season is somewhat later with clutches completed by late May and young present by the second week of June (Renaud et al. 1979). Flightless young were seen there as late as August 10.

In Nova Scotia, some birds leave the nesting area by mid-July and most are gone by mid-August (Cairns 1977). From the nesting area they apparently gradually move south along the coast. In New Jersey, most southbound movement was noted from July 4 to September 5 (Urner and Storer 1949) with October 24 the latest date of migration.

Nests and Nest Sites

The two major requirements of piping plover nesting habitat are a relatively unvegetated area and a sandy substrate. Plovers prefer dry, light-colored sand along the outer shore of coastal areas (Cairns 1977, 1982). The nest is a shallow scrape in the sand, and may be lined with bits of shell or pebbles (Pickwell 1925; Wilcox 1939, 1959; Stiles 1940; Cairns 1977, 1982). It is built on dry open areas of fine sand beaches or in areas of sparse grass cover (Robbins 1919; Pickwell 1925; Wilcox 1939, 1959). Nests often occur on the narrow strip of sand below the foot of the outer dunes and above the high tide line. However, other flat, unvegetated stretches of sand on the protected side of dunes and sandspits may also be utilized when available. Besides sand, fine gravel, small stones, or broken seashells may be scattered across the substrate. In Nova Scotia, 55 of 61 nests (90%) occurred on relatively bare areas of sandpits (Cairns 1977). Nests are nearly always built in the open and not near any conspicuous object such as vegetation or large stones. Nests occur near or under vegetation only when suitable substrate is confined to a narrow strip (Cairns 1977). Piping plovers desert the area when dune areas are invaded by dune grass (Ammophila breviligulata) (Wilcox 1959). Nests on Long Island average about 76 m apart (Wilcox 1939) and in Nova Scotia average 51 to 53 m apart (Cairns 1977, 1982). One pair may dig more than one scrape and perhaps as many as 45 (Taverner and Swales 1907).

In addition to a nesting territory, piping plovers defend a feeding territory of 50 to 100 m of beachfront during the nesting season (Cairns 1977, 1982). Usually this is directly adjacent to the nesting territory and includes the beach-water interface.

Piping plovers along the Great Lakes usually nest on beaches or other open, unvegetated areas, although some may nest on rocky areas (Cottrille 1957; Niemi and Davis 1979). In Saskatchewan, piping plovers usually nest on unvegetated flats near alkaline or salt lakes (Renaud et al. 1979). Piping plovers in North Dakota prefer bare areas composed of gravel, sand, or pebbly mud (Stewart 1975). Some also nest on sandbars in rivers (Stiles 1940; Renaud et al. 1979), although such areas are subject to rapid flooding and vegetation change. Piping plovers will colonize man-made habitats (Renaud et al. 1979) and dredge fill areas (Moser 1940; Switzer 1979).

Clutch Size, Eggs, and Incubation

The eggs are a pale sand gray ground color marked with a few small dark brown or black dots or spots (Bent 1929; Wilcox 1959; Palmer 1967). Most clutches contain three or four eggs (Wilcox 1959; Cairns 1977, 1982; Niemi and Davis 1979). Some of the two- or three-egg clutches may have lost eggs to predation (Wilcox 1959). Eggs are laid at 2-day intervals (Wilcox 1959; Cairns 1977, 1982). Egg measurements average about 24 to 25 mm by 31.5 to 32.5 mm (Bent 1929; Wilcox 1959; Cairns 1977, 1982). Wilcox (1959) observed the last egg in the clutch tends to be the longest and often the widest and heaviest, while Cairns (1977, 1982) observed no such trend. Egg weights averaged 9.6 g (Wilcox 1959).

Both sexes incubate (Wilcox 1959; Cairns 1977, 1982). The incubation period averages 28 days (range 27 to 31 days), starting with the laying of the last egg and extending to the hatching of the last egg (Wilcox 1959; Cairns 1977). Females renest if the first clutch is lost (Wilcox 1959; Cairns 1977). One pair on Long Island renested after a 10-day interval (Wilcox 1959).

Nesting Success

On Long Island from 1937 to 1958, 612 of 668 eggs (91%) in 174 nests hatched, an average of 3.5 young hatching per nest (Wilcox 1959). In Nova

Scotia, 152 of 201 eggs in 51 nests hatched (76%) for an average of 3.0 young per nest (Cairns 1977, 1982). Less information is available on survival to fledging; of 75 young in 26 nests, 29 were presumed to have died (39%), 28 probably fledged (37%), and the fate of the other 18 (24%) was unknown (Cairns 1977, 1982). On one area in Nova Scotia, 1.3 to 2.1 young per pair fledged while in another area 11 to 17 young of 15 pairs fledged (0.7 to 1.1 young per pair) (Cairns 1977, 1982). The major mortality factors are disturbance from recreational use, beach vehicles, dogs, and various predator species, such as Norway rat (Rattus norvegicus), house mouse (Mus musculus), American crow (Corvus brachyrhynchos), red fox (Vulpes vulpes), and opossum (Didelphis virginiana) (Wilcox 1959; Cairns 1977). At least one egg hatched in 12 of 21 nests (57%) on Long Point, Ontario from 1966 to 1975 (Cartar 1976). Nest predation by gulls (Larus sp.) was an important mortality factor in that population.

Growth and Development

The entire clutch generally hatches within four to eight hours, and the young leave the nest as soon as their down is dry, usually within two to three hours. The young weigh an average of 6.8 g at hatching (Wilcox 1959). Both adults care for the brood. The young tend to stay within 100 to 200 m of the nest until they can fly (Wilcox 1959). Adults brood the young until they are three to four weeks old (Wilcox 1959; Cairns 1977), but care decreases with age of the young. Young fledge at four to five weeks of age (Wilcox 1959; Cairns 1977, 1982). The young weigh 12.4 g at 10 days of age, 25.7 g at 21 days, and 29.4 g at 29 days (Wilcox 1959). Thus at the time of fledging, they weigh only a little over half of the adult weight.

Young apparently leave the breeding area soon after fledging. Cairns (1977) noted two that left the breeding beach 32 and 47 days after hatching. No evidence exists of the birds staying in family groups after they leave the breeding area.

Post-Breeding, Migratory, and Wintering Habitat

Little information is available on post-breeding, migratory, and wintering habitat. At fledging, the young move to the beach front and presumably they and the adults utilize that habitat from then until the next breeding season (Cairns 1977). Migrating piping plovers in the mid-Atlantic States are usually observed on outer beaches, especially on wet or water-covered sand (Nichols 1941; Burger et al. 1977). Piping plovers on Lake Erie occurred progressively more often on beach pools and less often on the beach-water interface from spring through October (Bradstreet et al. 1977). Nearly all records of migrating and wintering birds along the Atlantic coast are from outer beaches.

POPULATION TRENDS

Population Structure

Most information on population structure has been developed from studies on Long Island (Wilcox 1959). Between 1937 and 1958, 1,723 piping plovers were banded on Long Island. Forty-seven plovers banded as chicks were later retrapped as adults and had achieved an average minimum age of 3.4 years (males x = 4.4 years, females x = 2.6 years). Thirteen percent of the females and 28% of the males lived five years or longer, with an extreme of 14 years (Wilcox 1962).

Of 288 adults retrapped on nests, only three left their original nesting area to nest in another area and one of those subsequently returned to the area where it had hatched (Wilcox 1959). Wilcox's (1959) data suggest that at least some young return to nest at their natal beach while others disperse to nearby nesting areas. Once piping plovers have nested in an area, there is a strong tendency for them to continue to nest at that area in subsequent years.

Piping plovers apparently change mates between years on a regular basis. Only 39 pairs (of 288 individuals retrapped) were together more than one year; and only two of these remained paired for three years (Wilcox 1959). These pairs moved their nest sites an average of 62 m (range 0 to 350 m) between years. The 120 males that took a new mate moved their nest sites an average of 240 m while 103 females moved theirs an average of 1,243 m.

Population Density

Piping plovers are semi-colonial. Nests on Long Island are usually at least 61 m apart (Wilcox 1959). However, in Nova Scotia, over two years, nests averaged 51 m and 53 m apart with the closest nests only 3 m apart (Cairns 1977, 1982). Thirty pairs occurred on about 120,000 m^2 for a mean territory size of 4,000 m^2 (range 500 to 8,000 m^2) or 2.5 pairs per ha. In addition, all pairs had a feeding territory of 50 to 100 m of beach usually adjacent to the nesting area. Robbins (1919) observed nine pairs on 1.6 ha.

In southern Saskatchewan, 1.3 to 4.6 piping plovers occurred per km of shoreline at Quill Lake (Renaud et al. 1979). In North Dakota, four pairs occurred on 182.8 m of shoreline (21.9 per km) (Rolfe 1900), and eight pairs occurred on the shoreline of a 196-ha lake (Stewart 1975). Individual alkali lakes in prairie pothole regions may support 4 to 30 pairs per km^2 and 3 to 8 pairs per wetland (Godfrey 1950; Stewart 1975). An estimated 2.2 pairs per km^2 and 1 pair per wetland occur on alkali lakes in North Dakota (Kantrud and Stewart unpubl. ms.). The prairie pothole region of North Dakota could support approximately 1400 pairs if water is present in all the basins.

The piping plover has been listed on the National Audubon Society's Blue List since 1973 (Tate and Tate 1982), suggesting that the species may be suffering from a noncyclical population decline. A summary of the population status for each of the three distinct piping plover populations follows.

Atlantic coast. The concensus is that piping plover numbers along the Atlantic coast were alarmingly low around 1900, mainly because of hunting (Bent 1929). Once hunting was banned, the population increased and by the 1930's, an estimated 500 pairs were on Long Island, New York (Wilcox 1939). Since then they have declined again so that Long Island now has only about 80 to 100 pairs, and the entire Atlantic coast population is estimated at about 910 nesting pairs (Cairns and McLaren 1980).

Great Lakes. Less information is available on this population but it may have had an even more precipitous decline. A breeding population at Long Point, Ontario on Lake Erie has declined from an estimated 100 pairs in 1927 and 1928 (Snyder 1931) to only 3 or 4 pairs in 1974 and 1975 (Cartar 1976). Former populations in Ohio, Indiana, and Illinois apparently are gone (Hicks 1938; Russell 1973; Trautman 1977; Tate 1981). A small population still was present on western Lake Superior in 1978 (Niemi and Davis 1979), and 14 pairs were observed in Michigan in 1982 (Tessen 1982). Apparently small numbers persist on Lakes Superior, Huron, and Michigan.

Great Plains. Little information is available on this population. Renaud et al. (1979) estimated Quill Lake in southern Saskatchewan had 350 to 400 adult piping plovers in 1978. Densities there were similar to those reported by Ferry (1910) on the same area in 1909, which suggests the population is stable. Renaud et al. (1979) estimated the Saskatchewan population of piping plovers at about 1000 to 1500 adults, some of which probably were nonbreeders, and suggested there was no evidence of a decline. They also suggested that fair numbers were present in Manitoba. Ten to twenty pairs have nested at Lake of the Woods, Minnesota in recent years (Henderson 1982; Hirsch 1982), and a few pairs nest along the Platte River in Nebraska (Ducey 1982).

Management

The two major considerations for managing piping plover populations involve providing suitable habitat and reducing human interference of the birds on their nesting grounds. The basic habitat requirement of nesting piping plovers is relatively flat, unvegetated land with a sandy substrate near a lake, river, or ocean. Water is critical in providing a feeding area for the birds at the land-water interface. The fact that piping plovers seldom nest on sandy areas away from water further suggests that water is critical. Suitable open, sandy areas occur naturally as early seral stages on dunes and recently formed sandbars and islands. Presumably such areas could be created by burning, cutting vegetation, or using earth moving equipment (see Swickard 1974). Areas might also be formed by drawing down the water level on lakes or reservoirs, by depositing fill material along shorelines, or by creating new islands (e.g., Soots and Parnell 1975).

Effects of Habitat Change

Changes in water levels may impact nesting plovers. Sudden water changes such as flooding or drought can eliminate nesting, reduce food supplies, and leave areas more exposed to predation. Use of large alkali lakes on the prairies for storage of irrigation wastewater could have deleterious effects on piping plover habitat through inundation of shorelines.

Lowered productivity because of increased human disturbance is probably more important as a factor in the current decline of piping plovers than is the availability of habitat (Cairns and McLaren 1980). Several areas which formerly had nesting piping plovers and still have seemingly suitable habitat no longer have nesting piping plovers.

Effects of Human Disturbance

The effects of humans on nesting plovers are somewhat variable. Birds on isolated nests tended to leave them when humans were about 85 m away while birds on nests in heavily used areas tolerated humans as close as 3 m away (Cairns 1977). Successful piping plover nests occurred within 10 m of roads (Niemi and Davis 1979). Piping plovers in Nebraska left their nests when humans were over 91 m away (Pickwell 1925) and on Long Island, adults generally left nests when humans were about 61 m away (Wilcox 1939). However, Bailey (1930) was able to approach a nesting pair close enough to touch the adults.

Piping plovers nesting on an isolated, rarely visited beach fledged 1.3 to 2.1 young per pair while those nesting on a recreational beach fledged 0.7 to 1.1 young per pair (Cairns 1977, 1982).

Disturbance of piping plovers is probably most critical during the nesting season. At that time, disturbance of the adults from their nests, destruction of eggs or young, and harassment of the young all could be harmful. Because piping plover nesting habitat (sandy beaches) is also a favorite area for human recreation, disturbances that would need control include recreational vehicles, loose pets, picnickers, and swimmers. Predation by gulls, crows, foxes, and raccoons (*Procyon lotor*) also may have increased with urbanization of the Atlantic coast (Cairns and McLaren 1980).

The Piping Plover as an Indicator Species

An indicator species is one that has a narrow range of tolerance for environmental change, and thus is one that may serve as an early warning of excessive disruption to its environment (Graul et al. 1976). Piping plovers fit this description well, occurring almost strictly on open, sparsely-vegetated beaches or similar habitats. Their nesting range along the Atlantic coast and the Great Lakes is essentially a narrow band up to several hundred meters wide. On the Great Plains, piping plovers are confined to a narrow band along the shores of lakes and rivers. Evidence indicates that their numbers have declined in recent years, at least in part because of disturbance on the nesting grounds. The largest population now apparently is in the northern Great Plains (Renaud et al. 1979). However, because piping plover habitat generally does not overlap with major areas of coal land, piping plovers will have limited value as an indicator of surface mine impacts in the Great Plains.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts to piping plovers may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining phases if nests and nestlings are destroyed. A more serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (if suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population. The presence of apparently suitable habitat and decreasing plover populations indicate factors in addition to habitat availability may be affecting plover populations.

Increased noise levels may deter piping plovers from using suitable habitat nearby, though some species do become accustomed to noise after a period of adjustment. Contaminated water supplies from mining by-products or increased runoff may be harmful through detrimental effects on prey populations. Increased human presence may reduce nest success by trampling of nests or disruption of nesting activities. Plovers may avoid habitat near mining activities because of increased human presence. Collisions with transmission lines may cause injury or mortality to plovers.

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include: changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in rivers, lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversion for a transport system; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; and increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). A problem in many Eastern surface mine areas has been the generation of toxic pyrites, causing acidification and sterility of streams and ponds (Spaulding and Ogden 1968). Acid drainage is normally not a problem in the West because alkaline soils cause drainage to be neutral or slightly basic (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas.

On the Great Plains, piping plovers occur in areas with limited water supplies and any major demands coal mining might have on these water supplies could affect piping plovers. A possible immediate effect would be the lowering of water levels in nearby lakes or reservoirs. If variation in water levels is carefully controlled and the water levels are restored when the plovers are absent, this action could benefit piping plovers by creating larger areas of suitable flat sandy habitat. However, continued water drawdowns could harm piping plover habitat. Good piping plover habitat is continually being created by the effects of drifting sand, wind erosion, and wave action. Long term drawdowns would gradually allow areas to be permanently vegetated, creating cover unsuitable for piping plovers. In addition, if lakes are drawn down, the gradually decreasing perimeter would mean a decrease in the area of nesting habitat. Drawdowns could also connect islands or isolated sandbars to the mainland, increasing the likelihood of predation on nesting piping plovers. In a complete drawdown, the loss of water in a basin would mean the loss of the food base for piping plovers and their probable abandonment of the area.

In portions of the Great Plains (Iowa, Nebraska, South Dakota), sandbars and islands on the major rivers provide most of the suitable nesting habitat for piping plovers. With the stabilization of much of the Missouri River for flood control and barge traffic, much of this nesting habitat has disappeared and the piping plover has disappeared as a nesting species (e.g., Roosa 1977). Energy development on the Great Plains may lead to proposals to stabilize additional rivers for increased barge traffic. Such proposals should be considered in view of the possible impact this action might have on piping plovers.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys for piping plovers should be conducted in the area of proposed development two years prior to development activities. Baseline data of populations on and off the mine site will provide information on the potential impact of coal mining and the mitigation measures needed.

Exploration, Mine Development, and Mining Phases

Impacts to nesting piping plovers may be lessened if exploration activities are conducted outside of the breeding season, or if nesting concentrations are avoided. Buffer zones of 0.5 km around wetlands may also help to protect nesting birds. Proper containment of wastes and by-products may prevent contamination of water supplies. Temporary water diversions that potentially may change water levels of wetlands will have less impact on nesting piping plovers if diversions occur outside of the breeding season. Placement of transmission lines away from wetlands may decrease injuries or mortality from collisions.

Reclamation Phase

Reclamation of wetlands and creation of new wetlands can be an important mitigation measure for piping plovers. The proper deposition of spoil from coal mines offers the possibility of creating new piping plover nesting habitat, both in areas that formerly had breeding populations and in previously unoccupied areas. To be successful, a spoil area should be fairly flat, sandy, and adjacent to water and, at most, have only a thin vegetative cover. Because revegetating spoil land in the West is difficult, providing a thin cover should be fairly easy and it might be possible to maintain the cover at that stage for a fairly long time. The possible erosion of spoil into water and the presence of any harmful elements in the spoil should be considered before such areas are created. Also it should be recognized that if the spoil land is being used to create a new recreational facility (e.g., a beach), such an area will have limited use by piping plovers unless steps are taken to protect the birds from disturbances during the nesting season.

AREAS OF RESEARCH NEEDS

For a species that, in general, has been so little studied, good information is available on its population structure. The major research need for managing this species is the development of an effective means of monitoring their populations. Monitoring is especially needed on the Great Plains because little is known about this population and it is the largest remaining population. Because piping plovers breed in limited, fairly well-defined areas, it should be possible to obtain close to complete population counts. A statewide random sampling of various habitats in North Dakota (Stewart and Kantrud 1972) recorded only five piping plovers, indicating that a more selective sampling method is needed to be effective.

Another need is further information on productivity and mortality. Little understanding exists about the sources of mortality of piping plovers. Information is needed on how various human recreational activities affect piping plovers and how beach areas can be managed to maximize piping plover productivity while still allowing humans to use the areas (see Buckley and Buckley 1976). If it is possible to reduce human-caused mortality, will it be possible or necessary to take further steps such as predator control to try to increase productivity of piping plovers? For instance, the increase in numbers of gulls along the Atlantic coast (Drury and Kadlec 1974) already has affected several species of birds and may be a factor in the decline of piping plovers. Perhaps a predator control program would be beneficial to piping plovers.

Information is also needed to determine if reclamation of spoil lands, bulldozing vegetation on sandy areas, burning, creating spoil islands, or other steps can create areas that will be colonized by nesting piping plovers. Piping plovers will use spoil land (Moser 1940; Lakela 1946; Switzer 1979; Renaud et al. 1979), but no studies have been conducted to determine what factors in those environments attract piping plovers. This will require monitoring various managed areas within the piping plover nesting range to see if they are utilized and performing controlled experiments to determine which methods are most effective in providing piping plover habitat.

Finally, an important consideration is that piping plovers spend over half of the year away from the nesting grounds. As yet little is known about their specific habitat requirements on the wintering grounds or the impact on piping plovers from increased human development of land along the South Atlantic and Gulf coasts. Further studies of the bird's habitat requirements away from the nesting areas clearly are needed.

SUMMARY

The piping plover is a small plover that breeds on open beaches in the northern Great Plains, around the Great Lakes, and on the mid-Atlantic coast of North America. It feeds on small invertebrates it captures along the water's edge. Most clutches contain four eggs and are laid in a simple scrape on the ground. Adult males and females may live as long as 10 and 11 years, respectively.

Destruction of habitat and changing water levels may adversely impact nesting piping plovers in coal mining areas. Wetland reclamation is an important mitigation measure for this species.

REFERENCES

American Ornithologists' Union. 1957. Check-list of North American birds. 5th edition. The Lord Baltimore Press, Baltimore, MD. 691 pp.

________. 1983. Check-list of North American birds. 6th edition. Allen Press. Lawrence, KS. 877 pp.

Bailey, A. M. 1930. The piper of the dunes. Nat. Hist. 30:627-634.

Bent, A. C. 1929. Life histories of North American shore birds. U.S. Nat. Mus. Bull. 146, 412 pp.

Bradstreet, M. S. W., G. W. Page, and W. G. Johnston. 1977. Shorebirds at Long Point, Lake Erie, 1966-1971: seasonal occurrence, habitat preference, and variation in abundance. Can. Field-Nat. 91:225-236.

Buckley, P. A., and F. G. Buckley. 1976. Guidelines for protection and management of colonially nesting waterbirds. Natl. Park Serv., Boston, MA. 54 pp.

Burger, J. M., A. Howe, D. C. Hahn, and J. Chase. 1977. Effects of tide cycles on habitat selection and habitat partitioning by migrating shorebirds. Auk 94:743-758.

Cairns, W. E. 1977. Breeding biology and behavior of the piping plover (Charadrius melodus) in southern Nova Scotia. M.S. Thesis. Dalhousie Univ., Halifax, N.S. 115 pp.

________. 1982. Biology and behavior of breeding piping plovers. Wilson Bull. 94:531-545.

Cairns, W. E., and I. A. McLaren. 1980. Status of the piping plover on the East Coast of North America. Am. Birds 34:206-208.

Cartar, R. 1976. The status of the piping plover at Long Point, Ontario, 1966-1975. Ont. Field Biol. 30:42-45.

Cottrille, B. D. 1957. Summer distribution of the piping plover in Michigan. Jack-Pine Warbler 35:26-33.

Drury, W. H., and J. A. Kadlec. 1974. The current status of the herring gull population in the northeastern United States. Bird-Banding 45:297-306.

Ducey, J. 1982. The 1982 least tern and piping plover breeding season on the lower Platte River, Nebraska. Nebraska Bird Rev. 50:68-72.

Ferry, J. F. 1910. Birds observed in Saskatchewan during the summer of 1909. Auk 27:185-204.

Godfrey, W. E. 1950. Birds of the Cypress Hills and Flotten Lake Regions, Saskatchewan. Can. Dept. Resour. and Develop., Natl. Parks Branch, Bull. 120, Biol. Ser. 46.

Graul, W. D., J. Torres, and R. Denney. 1976. A species-ecosystem approach for nongame programs. Wildl. Soc. Bull. 4:79-80.

Henderson, C. L. 1982. Minnesota's 1982 nongame wildlife program. Naturalist 33(4):4-8.

Hicks, L. E. 1938. Piping plover taken in central Ohio. Wilson Bull. 50:141.

Hirsch, K. 1982. New colonies in Lake of the Woods. Loon 54:37-39.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Kantrud, H. A., and R. E. Stewart. Unpub. U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, ND 58401.

Lakela, O. 1946. Additional observations on the nesting of piping plovers in Duluth. Flicker 18:11.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Moser, R. A. 1940. The piping plover and least tern nesting in Omaha. Nebr. Bird Rev. 8:92-94.

Nichols, J. T. 1941. On piping plover feeding. Proc. Linn. Soc. NY 52-53:130.

Niemi, G. J., and T. E. Davis. 1979. Notes on the nesting ecology of the piping plover. Loon 51:74-79.

Palmer, R. S. 1967. Piping plover. In Stout, G. D. The shorebirds of North America. The Viking Press, New York. 270 pp.

Pickwell, G. 1925. Some nesting habits of the belted piping plover. Auk 42:326-332.

Quinn, J., and R. Walden. 1966. Notes on the incubation and rearing of the piping plover (*Charadrius melodus*). Aviculture Mag. 72:145-146.

Renaud, W. E., G. J. Wapple, and D. W. Edgett. 1979. The piping plover in Saskatchewan: a status report. Blue Jay 37:90-103.

Robbins, C. A. 1919. A colony of Cape Cod piping plover. Auk 36:351-355.

Rolfe, E. S. 1900. Nesting notes on the waders of the Devils Lake region. Osprey 4:85-87.

Roosa, D. M. 1977. Endangered Iowa birds. Iowa Preserves Board Spec. Rep. 4. 25 pp.

Russell, R. 1973. The extirpation of the piping plover as a breeding species in Illinois and Indiana. Illinois Audubon Bull. 165:46-48.

Snyder, L. L. 1931. A faunal investigation of Long Point and vicinity, Norfolk County, Ontario. III. The birds of Long Point and vicinity. Trans. Royal Can. Inst. 18:139-227.

Soots, R. F., and J. F. Parnell. 1975. Ecological succession of breeding birds in relation to plant succession on dredge islands in North Carolina estuaries. North Carolina Sea Grant Publ. UNC-SG-75-27, Raleigh. 91 pp.

Spaulding, W. M., Jr., and R. Ogden. 1968. Effects of surface mining on the wildlife resources of the United States. U.S. Bur. Sport Fish. Wildl. Resour. Publ. 68, Washington, DC.

Stewart, R. E. 1975. Breeding birds of North Dakota. Fargo, Tri-College Cent. for Environ. Stud. 295.

Stewart, R. E., and H. A. Kantrud. 1972. Population estimates of breeding birds in North Dakota. Auk 89:766-788.

Stiles, B. F. 1940. Nesting of the piping plover in Iowa. Iowa Bird Life 10:48-49.

Swickard, D. K. 1974. An evaluation of two artificial Least Tern nesting sites. California Fish Game 60:88-90.

Switzer, F. A. 1979. Piping plovers use man-made habitat. Blue Jay 37:116.

Tate, J. 1981. The blue list for 1981. Am. Birds 35:3-10.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Taverner, P. A., and B. H. Swales. 1907. The birds of Point Pelee. Wilson Bull. 19:82-99.

Tessen, D. T. 1982. Western Great Lakes region. Am. Birds 36:978-981.

Trautman, M. B. 1977. The Ohio Country from 1750 to 1977 -- a naturalist's view. Ohio Biol. Surv. Biol. Notes 10. 25 pp.

Urner, C. A., and R. W. Storer. 1949. The distribution and abundance of shorebirds on the northern and central New Jersey coast, 1928-1938. Auk 66:177-194.

Wilcox, L. 1939. Notes on the life history of the piping plover. Birds of Long Island 1:3-13.

________. 1959. A twenty year banding study of the piping plover. Auk 76:129-152.

________. 1962. Oldest known shorebird in North America. Eastern Bird-Banding Assoc. News 25:45-46.

MOUNTAIN PLOVER (*Charadrius montanus*)

by

James J. Dinsmore
Animal Ecology Department
124 Science II Building
Iowa State University
Ames, IA 50011

SPECIES DESCRIPTION

The mountain plover (*Charadrius montanus*) inhabits the high dry shortgrass plains east of the Rocky Mountains from southern Canada to northern New Mexico and Texas. The mountain plover is a medium-sized plover about 19.2 cm in length, without the breast band typical of many plovers. The bill is black and the legs are light colored. In the alternate plumage (March through late July or August), the mountain plover has a white chin, a dark line from the eye to the bill, and another black band across the crown back to above the eye. The nape and rest of the cheeks are brown. Most of the rest of the body is light brown above and white below. The basic plumage (August to March) is similar except the black from the eye to the bill and on the crown is missing (Bent 1929; Laun 1957; Palmer 1967). The sexes are alike in coloration. Adults weigh about 107 g (Graul 1973a, b).

DISTRIBUTION

Mountain plovers occur primarily on the arid lands east of the Rocky Mountains (Fig. 17). Mountain plovers nest from southern Alberta, northern Montana, northeastern North Dakota, south through eastern Wyoming, western Nebraska, Colorado, and western Kansas to south and central New Mexico, and western Kansas (American Ornithologists' Union 1983). Most breeding birds are in southeastern Wyoming, and eastern Colorado (Graul and Webster 1976). Nesting reports outside of that area generally refer to small populations or isolated pairs (e.g., Lock 1975; Tolle 1976; Wallis and Wershler 1981). The nesting range spans altitudes of 1,219 to 2,743 m with most found between 1,524 to 2,134 m (Laun 1957). Mountain plovers winter from central California, southern Arizona, and central and southern Texas south into Mexico (Bent 1929; American Ornithologists' Union 1983; Laun 1957).

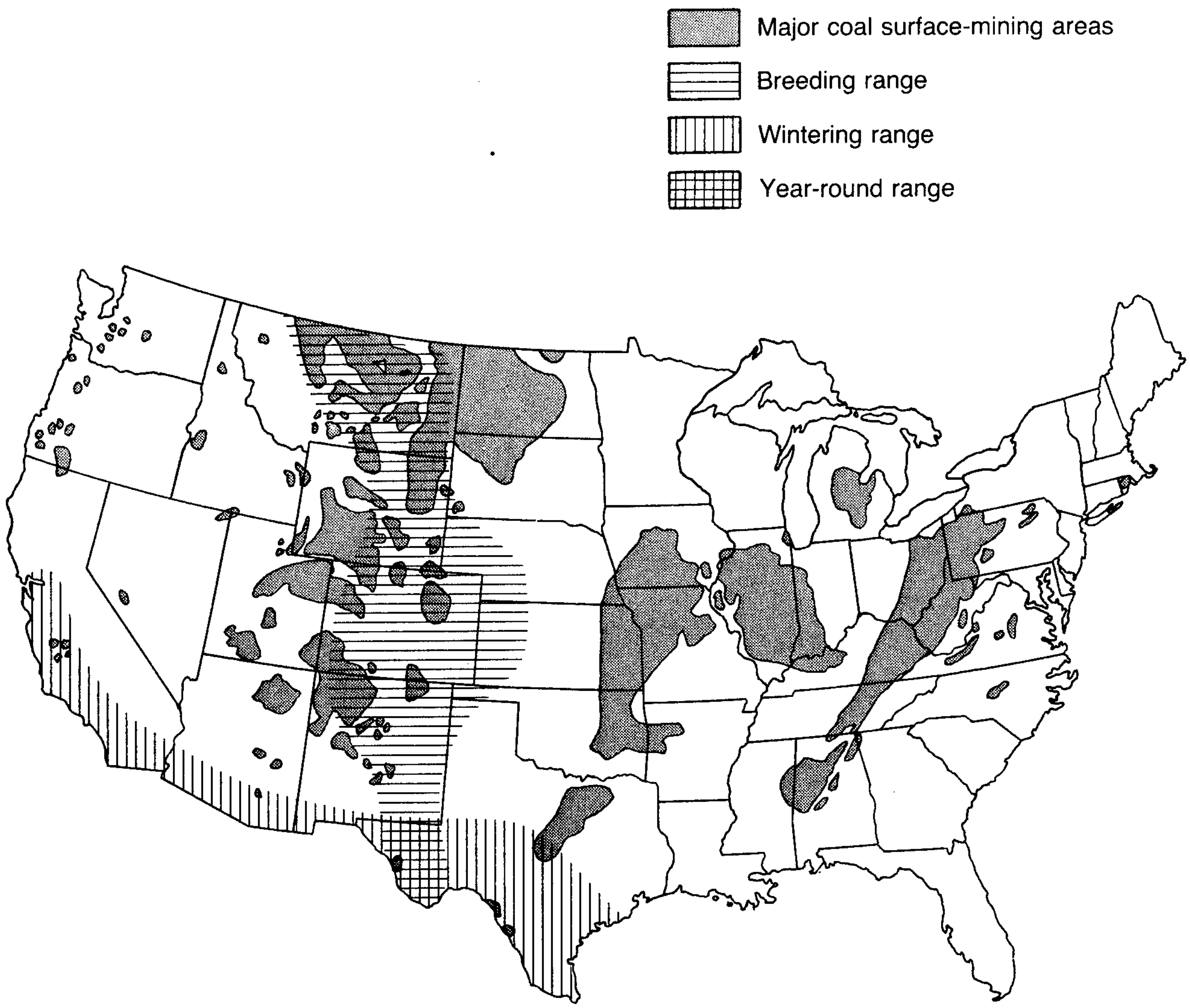


Figure 17. Geographical range of the mountain plover in relation to major coal deposits in the United States. After Inkley and Raley (1983).

DIET

Mountain plovers feed almost strictly on insects, especially grasshoppers, crickets, beetles, and ants (Coues 1874; Dawson 1923; Bent 1929; Stoner 1941; Laun 1957; Baldwin 1971; Graul 1973a). The diet in Colorado is 99.7% arthropods with beetles (60%), grasshoppers and crickets (24.5%), and ants (6.6%) the most important food items (Baldwin 1971). They rarely drink and apparently obtain their water from the food they eat (Laun 1957; Graul 1973a).

Mountain plovers forage much as other plovers do, by running, stopping to peer at the ground, and poking with the bill to grab a prey item (Laun 1957; Graul 1973a; Cogswell 1977).

REPRODUCTION

Mountain plovers generally occur in the shortgrass prairie on the high dry plains. Within that habitat, they occur most often in areas dominated by blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*) (Bradbury 1918; Finzel 1964; Graul 1973a, b, 1975; Graul and Webster 1976). Nests, adults, or young have been located on a mixed grass association dominated by needle-and-thread grass (*Stipa comata*) and blue grama (Finzel 1964), on a midgrass native prairie (Lock 1975), and in a basin sagebrush association (Tolle 1976). A small population occurred on an area dominated by needle-and-thread grass, prairie junegrass (*Koeleria cristata*), and Sandburg bluegrass (*Poa secunda*) (Laun 1957). Two nests in southeastern Alberta were on a heavily grazed winter pasture with a recent burn. The dominant plants were blue grama and threadleaf sedge (*Carex filifolia*) (Wallis and Wershler 1981). More recent studies report mountain plovers nesting in western New Mexico (Hubbard 1978; Johnson and Spicer 1981).

Wintering mountain plovers use open habitats similar to those used during the nesting season (Russell and Lamm 1978). They do not occupy beaches or mudflats but use grassy fields back from the water's edge or barren fields (Coues 1874; Dawson 1923). Along the Texas coast and in interior California, they inhabit dry prairies dominated by short grasses (Grinnell et al. 1918; Laun 1957). They also feed in freshly cultivated fields (McCaskie 1966; Cogswell 1977).

Mountain plovers arrived at the breeding grounds in late March during 3 years in northeastern Colorado (Graul 1973a, 1975). Egg laying began in late April (April 17 in 2 years; April 21 in a third) and the last clutch was begun between June 12 and 15. The peak of clutch initiation was about May 1 to 5. Most clutches hatched in late May through late June and chicks fledged from about early to late July (Graul 1973a). Flocks formed as early as mid-June and generally grew in size through mid-August. By mid-August some birds were leaving the area but plovers were still present as late as September 23.

Other detailed records from southeastern Wyoming document the earliest nesting as March 25 and the 10-year average arrival date as April 13 (McCreary and Mickey 1935). The latest date was August 24 and the average departure date for 7 years was August 16. Other nesting records fit this general outline (Laun 1957; Wallis and Wershler 1981).

A mountain plover nest is a simple scrape on flat ground. Ninety percent of 133 nests were on ground with less than a 2° slope and only one nest was on a greater than 5° slope (Graul 1973a, 1975). Plovers avoid tall vegetation and nest in the open (Bradbury 1918; Graul 1973a, 1975). Nests often occur in areas of buffalo grass and blue grama with scattered cacti and western wheatgrass (Agropyron smithii) (Graul 1973a, 1975). Vegetation in such areas is usually less than 80 mm tall in April and rarely over 100 mm tall later in the summer. Fifty-five percent of 133 nests in Colorado occurred within 30 cm of an old cow manure pile with 19.5% placed against a manure pile (Graul 1973a, 1975). Nests averaged 140 m apart (Graul 1975). Nest sites in Montana were reported as nearly always associated with the grazed shortgrass of prairie dog towns (Knowles et al. 1982).

The scrape is about 11.5 cm in diameter and 1.3 cm deep (Laun 1957). The nest scrape is not lined at the initiation of egg laying but during incubation the adult adds material, most commonly cow manure chips, dry grass rootlets, grass leaves, and lichen (Bradbury 1918; Laun 1957; Graul 1973a, 1975; Wallis and Wershler 1981).

Clutches contain one to four eggs with most nests containing three eggs (Bradbury 1918; Laun 1957; Graul 1973a, b, 1975). Eggs usually are laid at 34 to 48 hour intervals (Graul 1973a, 1975). Most eggs are olive buff to dark olive in ground color and are heavily spotted with brownish black or black (Shufeldt 1913; Bradbury 1918; Bent 1929; Graul 1973a, 1975). A few eggs may be buffy or reddish brown (Graul 1975; Tolle 1976). Eggs average about 38.0 mm by 28.5 mm (Bent 1929; Graul 1973a, 1975). Eggs weigh 13 to 19 g (x = 15.6 g) in the first week of incubation (Graul 1973a, b, 1975).

Incubation begins as soon as the clutch is complete, and attentiveness increases with the nesting cycle (Laun 1957; Graul 1973a, 1975). Attentiveness averaged 58% and 42% over two seasons and was highest at mid-day (Graul 1973a, 1975). The incubation period is from 28 to 31 days (x = 29 days) (Laun 1957; Graul 1973a, 1975). Both sexes incubate (Graul 1973a, 1975).

Incubating mountain plovers generally quietly leave their nest when a human intruder is 50 to 100 m away (Graul 1973a, 1975). If the intruder stays near the nest, the adult usually feigns a broken wing as a distraction display. Distraction displays increase in frequency and duration as the nesting season progresses (Graul 1973a, 1975). If disturbed by another mountain plover, small bird, or ground squirrel, mountain plovers attack with the wings outstretched (Graul 1973a, 1975). Cattle and other large mammals can approach to within about 1 m of a nest before they are attacked (Walker 1955; Graul 1973a, 1975).

In Colorado, 62 of 92 nests hatched young (67%) (Graul 1973a, 1975). The average number of young hatched per successful nest was 2.7. Losses were due to weather, usually hail (11%), predation (15%), or abandonment (7%). A ground squirrel (Spermophilus tridecemlineatus) took an egg from one nest and kit fox (Vulpes macrotis), coyote (Canis latrans), badger (Taxidea taxus), striped skunk (Mephitis mephitis), prairie rattlesnake (Crotalus viridis), and bull snake (Pituophis melanoleucus) were all possible nest predators. Two females were known to renest within 2 weeks of the loss of their first nests (Graul 1973a, 1975). Three of seven nests (43%) in Colorado hatched young (Bailey and Niedrach 1933) and at least 6 of 18 eggs (33%) in six nests in Wyoming hatched (Laun 1957).

Mortality of young is heaviest in the first 3 days of hatching (Graul 1973a, 1975). Sixteen broods of nearly fledged chicks averaged 1.4 chick per brood (56% survival of those that had hatched), but this excluded consideration of broods where all young had been lost. Predation by various hawks and loggerhead shrikes (Lanius ludovicianus), separation from the adult, disease, and lack of food are probably all important mortality factors (Graul 1973a, 1975).

The chicks generally are dry within 3 hours of hatching and leave the nest the day of hatching or the next day (Graul 1973a, 1975). The young are brooded for about 2 weeks (Laun 1957; Graul 1973a, 1975). For the first 3 days, the young tend to move away from the nest site but from then until fledging they remain an average of 300 m from the nest site (Graul 1973a, 1975). Broods are not mixed and invariably are attended by only one adult (Graul 1973a, 1975). At 9 to 14 days, young weigh 18 to 29 g and at 28 to 32 days they weigh more than 53 g (Graul 1973a). Up until 10 to 12 days of age, the young usually crouch if a human approaches. Older chicks usually run away (Graul 1973a, 1975). The young fledge (capable of flying at least 100 m) at about 33 to 34 days (Graul 1973a, 1975).

POPULATION TRENDS

The population structure of mountain plovers is unusual in that each adult commonly incubates a clutch (Graul 1973a, b). Typically the female pairs with a male and he incubates the first clutch. The female then lays a second clutch, either remaining paired with the original male or pairing with a second male. The female usually incubates this second clutch. Such a system accounts for the sighting of only one adult at a nest (e.g., Laun 1957) or with a brood. It also means that each pair has the potential to hatch two full clutches in a relatively brief nesting season. Graul (1973a, b) suggests that this system is an adaptation to an environment where there is great year-to-year fluctuation in food availability as is found on the shortgrass prairie. In a year with high food availability, some females may lay more than two clutches (Graul 1976).

Mountain plovers breed when 1 year old (Graul 1973a). Five of eight adults (63%) returned to the same nesting area in Colorado for two successive years, but only 2 of 229 chicks (1%) were recorded in the same area the following year (Graul 1973a). Several of the adults returned to within 100 m of their previous nest site.

Limited information on local and regional densities of mountain plovers is available. Densities of 6.2 pairs/100 ha were recorded on two flat herbaceous communities in Wyoming (Finzel 1964). Six pairs on 3,857 ha were recorded in Wyoming for a density of 0.3 birds/100 ha (Laun 1957). Neither of these studies recognized the complexities of the mountain plover mating system and the effect that could have on density estimates. Graul (1973a) recorded 22 to 31 ($\bar{x}$ = 26) birds and 27 nests on a 64.8 ha-area for a density of 41.7 nests/100 ha.

Mountain plover densities in northeastern Colorado are estimated at 20 birds/100 ha on good habitat and 10 birds/100 ha on marginal habitat (Graul and Webster 1976). Using these figures, an estimated 20,820 mountain plovers (mean density 6/100 ha) occur on a 3,470 km^2 plot in Colorado and about 214,200 to 319,220 breeding mountain plovers occur in Montana, Wyoming, Colorado, and New Mexico. This excludes some peripheral nesting populations but is the only population estimate available for the species.

Effects of Habitat Changes

Two major threats to mountain plovers are the loss of breeding habitat through cultivation, and the loss of their food base through spraying with various chemicals to control insects (Wiens and Dyer 1975). Flat blue grama - buffalo grass lands often are the first to be converted to cropland and thus lost as habitat for mountain plovers (Graul and Webster 1976). Another threat is that of pitting, an agricultural practice in which a machine digs many shallow 25 x 110 cm holes. Such a practice might retain more soil moisture leading to taller grasses that would be unsuitable as habitat for mountain plovers.

Although grazing is a threat to several other inhabitants of shortgrass rangeland (Wiens and Dyer 1975), grazing is probably beneficial to mountain plovers. Grazing by cattle may help to maintain the open blue grama-buffalo grass community that appears to be optimal habitat for mountain plovers (Klipple and Costello 1960; Hyder et al. 1971). Areas in northeastern Colorado that have good mountain plover nesting habitat commonly are heavily grazed with no adverse effect on the species (Graul 1973a; Graul and Webster 1976). Likewise, a breeding area in Canada was heavily grazed (Wallis and Wershler 1981). Kantrud and Kologiski (1982) observed mountain plovers on heavily grazed land in the northern Great Plains. Presumably cattle now fill the same role in this environment that bison (*Bison bison*) and other large herbivores did in the past. Although nests occasionally may be lost by cows stepping on them, Graul (1973a, 1975) found no evidence of such losses.

Wintering habitat is being severely affected by land use changes, also. Conversion from dryland crops and rangeland to irrigated pasture, fruit trees, and other intensive agricultural uses has been rapid with development of the California Water Project. Residential expansion has replaced most former habitat in the southern California coastal counties.

Effects of Human Disturbance

The mountain plover occupies an environment that currently has a low human population density. The major impact of humans on mountain plovers originally was through hunting and more recently through land use practices.

Several authors noted that mountain plover numbers declined in the early 1900's and suggested that heavy shooting pressure on a species that was easy to shoot was a major factor in its decline (Cooke 1915; Tyler 1916; Dawson 1923). The elimination of mountain plovers as a legal game species has curtailed this threat. Spraying to control insects on rangeland might kill some mountain plovers and also reduce the number of insects which are the major food of mountain plovers (see McEwen et al. 1972).

Management

Burning has potential as a management tool for mountain plovers. Several mountain plover nesting sites in Canada were on burned areas whereas nearby, taller and more densely vegetated unburned areas were not used by the species (Wallis and Wershler 1981).

The Mountain Plover as an Indicator Species

An indicator species is one that has a narrow range of tolerance for environmental change, and thus is one that may serve as an early warning of excessive disruption to its environment (Graul et al. 1976). Mountain plovers fit this description quite well, being confined almost strictly to the shortgrass prairie of North America and especially to areas dominated by blue grama and buffalo grass. Densities drop rapidly outside of northeastern Colorado, the stronghold of this species' range, and many other seemingly suitable areas do not contain the species (Graul and Webster 1976). Because of its rather narrow habitat requirements and because its breeding range broadly overlaps large areas of Western coal land, the mountain plover should be an important indicator of surface mine impacts on the western Great Plains.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Little damage should occur to mountain plovers during the exploration and premining phase. Because of their cryptic coloration, mountain plovers often are missed by humans visiting their territories and would be noted only if the human approached a nest close enough to elicite distraction displays by the bird. Even then, most humans probably would not locate the nest. Mountain plovers do not appear to be excessively skittish or prone to desert their nests. Because their nests are somewhat widely distributed, little potential exists for occasional human visitors to disturb large numbers of mountain plovers during this phase of mine development.

During the mining phase, the major concern would be destruction of nesting habitat by mine development. This effect could be reduced by avoiding mining in areas containing high population densities of mountain plovers. Undoubtedly, some areas suitable for coal development currently contain breeding mountain plovers and such birds would be displaced if mining is undertaken. To a limited extent, such birds might find other, perhaps less suitable nesting habitat elsewhere. The birds do show a trend to return to their previous nest site (Graul 1973a), but presumably they could move to adjacent areas. If suitable nesting habitat is unavailable or already occupied, the stress of overcrowding and increased competition could result in an overall decrease in the breeding population. Increased dust levels or contaminated water resources might degrade the habitat, making it less suitable for plovers.

Of secondary concern would be human disturbance. Increased human populations on the sparsely populated nesting range of mountain plovers would increase the potential for disturbance and disruption of nesting as described above. Because mountain plovers are good tasting, relatively tame, and easy to shoot (Tyler 1916), there is also the potential for illegal shooting of the birds.

An additional concern is that the attraction of humans to the shortgrass prairie for coal mining raises the possibility that some of the people may remain in the area after the mines are closed. This increased human habitation may lead to further agricultural development of the area or other disturbances to non-mined areas, further reducing the habitat available for mountain plovers.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Recent surveys show that the major breeding stronghold of the mountain plover is northeastern Colorado and southeastern Wyoming with much smaller populations elsewhere. The nesting range overlaps areas having major coal resources, and the species will be impacted by loss of habitat during coal development.

During the premining phase, land that potentially could be mined should be surveyed for mountain plovers for 2 years prior to development. If mountain plovers are present, estimates of population densities should be obtained and, if at all possible, used to determine where mines should be developed, and to assist in planning of reclamation efforts.

Exploration, Mine Development and Mining Phases

Exploration and mine development activities conducted outside of the breeding season will help to alleviate impacts to breeding birds. Avoidance of nesting concentrations of mountain plovers on the periphery of the mining site may help to alleviate impacts to those birds. Control of dust levels and erosion and proper disposal of wastes and byproducts may help to prevent degradation of habitat.

Reclamation Phase

The major reclamation step after mining is restoring the overburden and topsoil on mined areas and revegetating the area with suitable shortgrass range plants. The nesting habitat needs of mountain plovers are quite well documented: relatively flat ground with short, sparse vegetative cover. Areas dominated by blue grama and buffalo grass appear to be preferred. A major problem is the difficulty in re-establishing some of the preferred plants, especially blue grama and buffalo grass or some other shortgrass species complex that mountain plovers will accept. Revegetation of mine spoil areas has been studied extensively in the West (May et al. 1971; Hyder et al. 1975; Lang et al. 1975). The most successful species in such areas are various wheatgrasses (Agropyron spp.) and other relatively tall plants (Farmer et al. 1974; DePuit and Dollhopf 1978). Little success has been achieved in establishing blue grama or buffalo grass (Hyder et al. 1971, 1975). As indicated earlier (see Management), grazing and burning may be used to help maintain this habitat once suitable species are established. After re-establishment, the areas should be monitored to follow the progress of the vegetation and any populations of mountain plovers on them.

Areas of Research Needs

Several areas of research are needed for mountain plovers. A major need is the development of a reliable means of monitoring populations. Graul and Webster (1976) gave general population estimates, extrapolating from densities on a small area. A broader-based method whereby numbers can be better monitored and trends in the numbers can be determined is needed. As yet, we have no way of knowing whether the numbers of this species are increasing, declining, or stable.

Another need is a better estimate of productivity. At best we have only a rough idea of the productivity of mountain plovers. Such estimates are difficult to obtain because of the unusual mating system in which each sex generally cares for a clutch of eggs and because of the rapid movement of the young away from their nest. Intensive monitoring of marked birds would be needed to obtain such information.

Along with estimates of productivity, further information on population structure and their life span is needed. As yet we have no idea how long individuals live, how many years they may breed, and what the major sources of mortality are.

As was indicated earlier, another need is development of methods to re-establish stands of blue grama and buffalo grass on reclaimed land. Because these species seem to provide optimal habitat for mountain plovers, we either need to develop means whereby reclaimed land can be revegetated with them or we need to find substitutes that mountain plovers will accept. The latter course will require revegetating suitable flat open plots with various combinations of plants and monitoring their use by mountain plovers over a period of time.

Finally, some attention needs to be given to the habitat needs of mountain plovers on the wintering grounds. Although it is not a bird of beaches, many of the grasslands near the beaches that mountain plovers formerly occupied in southern California, Texas, and elsewhere have been converted to other uses. Clearly these habitat requirements need to be identified as they may be a critical factor in the survival of this species.

SUMMARY

The breeding distribution of the mountain plover has diminished, largely as a result of hunting pressure. Although hunting of the species has been eliminated, its current nesting range centers in northern Colorado, where the range overlaps with areas of potential coal development. To minimize coal mining impacts, mitigation efforts should emphasize avoiding areas of high mountain plover breeding density and careful attention to restoration of shortgrass communities after areas have been mined.

REFERENCES

American Ornithologists' Union. 1983. Check-list of North American birds. 6th edition. Allen Press, Lawrence, KS. 877 pp.

Bailey, A. M., and R. J. Niedrach. 1933. The mountain plovers of the prairies. Nat. Hist. 33:75-80.

Baldwin, P. H. 1971. Diet of the mountain plover at the Pawnee National Grassland, 1970-71. U.S. IBP Grassland Biome Prog. Rep. 134. Colorado State Univ., Fort Collins. 34 pp.

Bent, A. C. 1929. Life histories of North American shore birds. U.S. Natl. Mus. Bull. 146. 412 pp.

Bradbury, W. C. 1918. Notes on the nesting of the mountain plover. Condor 20:157-163.

Cogswell, H. L. 1977. Water birds of California. Berkeley, Univ. Calif. Press. 399 pp.

Cooke, W. W. 1915. Our shorebirds and their future. Yearbook of the Dept. Agric. 1914, pp. 275-294.

Coues, E. 1874. Birds of the northwest. U.S. Geol. Surv. of the Territories Misc. Publ. 3, 791 pp.

Dawson, W. L. 1923. The birds of California. South Moulton Co., San Diego. 2121 pp.

DePuit, E. J., and D. J. Dollhopf. 1978. Revegetation research on coal surface-mined lands at West Decker Mine, Decker, MT: Progress report, 1975. U.S. Agric. Exp. Stn. Rep. 133, 30 pp.

Farmer, E. E., R. W. Brown, B. Z. Richardson, and P. E. Packer. 1974. Revegetation research on the Decker Coal Mine in southeastern Montana. U.S. For. Serv. Res. Pap. INT 162. 12 pp.

Finzel, J. E. 1964. Avian populations of four herbaceous communities in southeastern Wyoming. Condor 66:496-510.

Graul, W. D. 1973a. Breeding adaptations of the mountain plover (Charadrius montanus). Ph.D. Thesis. Univ. Minnesota. 175 pp.

__________. 1973b. Adaptive aspects of the mountain plover social system. Living Bird 12:69-94.

__________. 1975. Breeding biology of the mountain plover. Wilson Bull. 87:6-31.

__________. 1976. Food fluctuations and multiple clutches in the mountain plover. Auk 93:166-167.

Graul, W. D., J. Torres, and R. Denney. 1976. A species-ecosystem approach for nongame programs. Wildl. Soc. Bull. 4:79-80.

Graul, W. D., and L. E. Webster. 1976. Breeding status of the mountain plover. Condor 78:265-267.

Grinnell, J. H., H. Bryant, and T. Storer. 1918. Game birds of California. Univ. California Press. pp. 481-485.

Hubbard, J. P. 1978. The breeding and seasonal status of the mountain plover in New Mexico. New Mexico Ornithol. Soc. Bull. 6(1):2-6.

Hyder, D. N., R. E. Bement, E. E. Remmenga, and D. F. Hervey. 1975. Ecological responses of native plants and guidelines for management of shortgrass range. U.S. Dept. Agric. Tech. Bull. 1503. 87 pp.

Hyder, D. N., A. C. Everson, and R. E. Bement. 1971. Seedling morphology and seedling failures with blue grama. J. Range Manage. 24:287-292.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Johnson, T. B., and R. B. Spicer. 1981. Mountain plovers on the New Mexico-Arizona border. Continental Birdlife 2(3):69-73.

Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. U.S. Fish Wildl. Serv., Wildl. Res. Pap. 15. 33 pp.

Klipple, G. E., and D. F. Costello. 1960. Vegetation and cattle responses to different intensities of grazing on short-grass ranges on the Central Great Plains. U.S. Dept. Agric. Tech. Bull. 1216. 82 pp.

Knowles, C. J., C. J. Stoner, and S. T. Gieb. 1982. Selective use of black-tailed prairie dog towns by mountain plovers. Condor 84(1):71-74.

Lang, R., F. Rauzi, W. Seamands, and G. Howard. 1975. Guidelines for seeding range pasture and disturbed lands. Univ. Wyoming Agric. Exp. Stn. Bull. 621. 11 pp.

Laun, C. H. 1957. A life history study of the mountain plover, Eupoda montana, Townsend, on the Laramie Plains, Albany County, WY. M.S. Thesis, Univ. Wyoming. 67 pp.

Lock, R. A. 1975. Young mountain plover seen in Kimball County. Nebraska Bird Rev. 43:54-56.

May, M., R. Lang, L. Lujan, P. Jacoby, and W. Thompson. 1971. Reclamation of strip mine spoil banks in Wyoming. Univ. Wyoming Agric. Exp. Stn. Res. J. 51. 32 pp.

McCaskie, R. G. 1966. The occurrence of red-throated pipits in California. Auk 83:135-136.

McCreary, O. C., and A. B. Mickey. 1935. Bird migration records from southeastern Wyoming. Wilson Bull. 47:129-157.

McEwen, L. C., C. E. Knittle, and M. L. Richmond. 1972. Wildlife effects from grasshopper insecticides sprayed on short-grass range. J. Range Manage. 25:188-194.

Palmer, R. S. 1967. Mountain plover. Page 270 in Stout, G. D. The shorebirds of North America. New York, The Viking Press.

Russell, S. M., and D. W. Lamm. 1978. Notes on the distribution of birds in Sonora, Mexico. Wilson Bull. 90:123-131.

Shufeldt, R. W. 1913. An introduction to the study of the eggs of the North American Limicolae. Condor 15:138-151.

Stoner, E. A. 1941. Mountain plover in Solano County, CA. Condor 43:158.

Tolle, D. A. 1976. A westward extension in the breeding range of the mountain plover. Wilson Bull. 88:358-359.

Tyler, J. G. 1916. Migration and field notes from Fresno County, CA. Condor 18:167-169.

Walker, L. W. 1955. Mountain plover. Audubon 57:210-212.

Wallis, C. A., and C. R. Wershler. 1981. Status and breeding of mountain plovers (Charadrius montanus) in Canada. Can. Field-Nat. 95:133-136.

Wiens, J. A., and M. I. Dyer. 1975. Rangeland avifaunas: their composition, energetics, and role in the ecosystem. Pages 146-181 in Symposium on management of forest and range habitat for nongame birds. D. R. Smith (Tech. Coord.). U.S. For. Serv. Gen. Tech. Rep. WO-1.

LONG-BILLED CURLEW (*Numenius americanus*)

by

Marshall A. Howe
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The long-billed curlew (*Numenius americanus*) is the largest North American Scolopacid. Curlews breed only in arid grasslands and open, brushy habitats in the western Great Plains and Great Basin. The only other Scolopacids that are sympatric with long-billed curlews are the marbled godwit (*Limosa fedoa*), upland sandpiper (*Bartramia longicauda*), and willet (*Catoptrophorus semipalmatus*). However, these three species prefer taller grass in the moister portions of this region. Curlews are traditionally separated into a northern race (*N. a. parvus*) and a southern race (*N. a. americanus*), although differences between the two races are slight and populations are geographically continuous (American Ornithologists' Union 1957).

Long-billed curlews are very large, conspicuous shorebirds with long, decurved bills. Females are somewhat larger than males. Ridgway (1919) reported a mean wing chord length of 291.3 mm for females and 279.3 mm for males. In a Washington study, female wings averaged 269.0 mm (n = 1), and male wings averaged 265.3 mm (Allen 1980). The difference in bill length is even more pronounced, with females averaging 184 mm and males averaging 145.3 mm in one study (Ridgway 1919) and females averaging 131 mm and males averaging 117.7 mm in another study (Allen 1980). There is a clear geographic variation in size, with northern birds smaller than southern birds. Weights recorded by Allen (1980) for her Washington study were 533.9 g for one female and a mean of 512.7 g for three males.

The adult plumage is a light, pinkish cinnamon overlaid with grayish-brown, bold streaking on the head, neck, and chest. The back is similarly colored but has dark cross-barring in addition to longitudinal streaking, yielding a herringbone pattern. In flight, the dusky, innermost flight feathers contrast sharply with the generally brownish appearance of the rest of the dorsal plumage. Conspicuous bright cinnamon patches on the underside of the wing extend from the body to the bend of the wing. The throat and chin are whitish (Ridgway 1919).

DISTRIBUTION

Long-billed curlews are strictly endemic to North and Central America. They breed in the western Great Plains and Great Basin and winter from the extreme southwestern United States and the Gulf of Mexico south to Guatemala.

The breeding range extends from southern British Columbia, Alberta, Saskatchewan, and Manitoba south to Utah, New Mexico, and Texas (American Ornithologists' Union 1957). West of the Rocky Mountains, curlews breed in southeastern British Columbia (Godfrey 1966), eastern Washington (Yocom 1956), eastern Oregon (Gabrielson and Jewett 1940), northeastern California (Grinnell and Miller 1944), southern Idaho (Burleigh 1972), western Montana (Skaar 1975), Utah (Behle and Perry 1975), and probably Colorado (Kingery and Graul 1978). East of the Rockies, curlews have been reported breeding in southern Alberta, Saskatchewan, southwestern North Dakota (Godfrey 1966; Stewart 1975), Montana (Skaar 1975), western South Dakota (Timken 1969), Wyoming (Oakleaf et al. 1979), Colorado (McCallum et al. 1977), western and north-central Nebraska (Johnsgard 1979), western Kansas (Johnston 1964), northwestern Oklahoma (Sutton 1967), north-central and eastern New Mexico (Ligon 1961), and the Texas panhandle (Oberholser 1974).

Prior to extensive settling and agricultural development, the range of the curlew extended eastward across the Great Plains to Wisconsin and Illinois (Bent 1929). The loss of the eastern portion of this range is generally attributed to increased cultivation (Bent 1929; Sugden 1933). There is some question of the extent of the original Eastern range because of the curlew's preference for arid, shortgrass areas (Jenni pers. comm.).

The winter range of the curlew extends from California, western Nevada, Texas, and Louisiana south to Baja California, Oaxaca, and Guatemala (American Ornithologists' Union 1957). A substantial wintering population occurred on the Atlantic seaboard between South Carolina and Florida before curlews disappeared from the Eastern Plains (Bent 1929). Today, wintering curlews are generally rare east of the Mississippi River.

During migration, flocks of long-billed curlews occur in suitable habitat between the breeding and wintering ranges west of the 100th meridian and in eastern Texas. Figure 18 shows the present breeding and wintering distributions of the curlew.

DIET

Although the long bill of the curlew probably evolved as an adaptation for probing curved burrows of deep-dwelling invertebrates, the curlew is an opportunistic carnivore that feeds on the ground surface, as well as from burrows. Curlews feed primarily by gleaning prey from grasses (Jenni pers. comm.). They also feed by probing into burrows and natural cavities, especially in thick patches of vegetation and near the bases of small forbs and shrubs (Allen 1980).

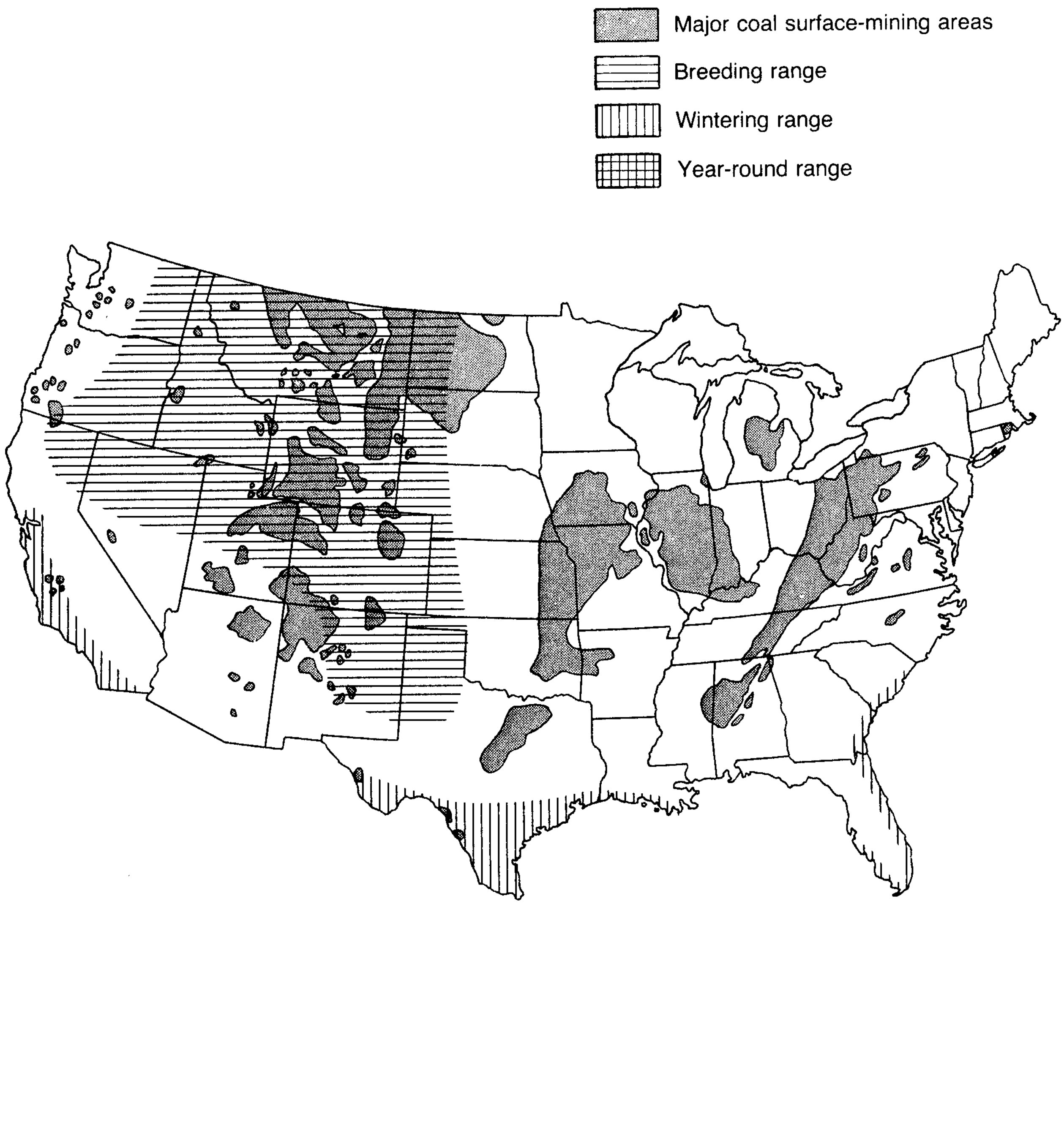


Figure 18. Geographical range of the long-billed curlew in relation to major coal deposits in the United States. After Inkley and Raley (1983).

On the breeding grounds, curlews feed on grasshoppers, crickets, beetles, caterpillars, spiders, flies, and butterflies (Wickersham 1902; Sugden 1933). Carabidae and Tenebrionidae are the families of beetles most commonly eaten by curlews in eastern Washington (Allen 1980). Small vertebrates, including toads (Wickersham 1902) and nestling passerines, such as horned larks (Eremophila alpestris) (Sadler and Maher 1976) and lark buntings (Calamospiza melanocorys) (Timken 1969), are a minor part of the diet. Curlews sometimes leave their territory to feed in irrigated fields early in the nesting season, and chicks have been observed feeding in alfalfa fields (Pampush 1979; Jenni et al. 1982).

Curlews wintering on the coast favor intertidal flats for feeding, although at times they also feed in the grassy portions of salt marshes (Stenzel et al. 1976) and in the surf on outer beaches (Bent 1929). Many curlews winter inland where they feed on shortgrass plains, around pools and sloughs, and on golf courses and airport flats (Oberholser 1974).

The feeding habits of long-billed curlews on wintering grounds have been most intensively studied at Bolinas Lagoon on the central California coast, where curlews feed primarily on intertidal flats at low tide levels (Stenzel et al. 1976). Mud crabs (Hemigrapsus oregonensis) are the primary prey species; ghost shrimp (Callianassa californiensis) and mud shrimp (Upogebia pugettensis) are also eaten in considerable amounts. Curlews usually take these crustaceans from deep burrows by exploratory probing or by waiting motionless until a crustacean appears and then striking. Wintering curlews also feed on snails and periwinkles (Wickersham 1902).

REPRODUCTION

Long-billed curlews arrive on the breeding grounds between late March and mid-April (Bent 1929; Wolfe 1931; Sugden 1933; Sutton 1967; Burleigh 1972; Behle and Perry 1975; Pampush 1979; Allen 1980; Renaud 1980). They arrive earliest in the northwestern part of the range (the third week of March in Oregon; Pampush 1979) and latest in the Canadian prairie provinces (the second and third weeks of April in Alberta and Saskatchewan; Renaud 1980). Curlews that breed successfully in an area will return to breed in that area in subsequent years (Bicak pers. comm.).

Curlews arrive singly or in small flocks. They may establish territories immediately (Allen 1980) or wait for several weeks while the flocks gradually disperse (Forsythe 1970). Both paired and unpaired birds establish territories, with unpaired males defending their territories the most vigorously, especially after nesting has begun (Allen 1980). Territory size in Washington varied from 6 to 8 ha in field and brush habitat to 20 ha in homogeneous grasslands. During the prenesting period, a curlew pair roosts in the territory at night but may leave the territory for several hours during the day to feed in irrigated fields or loaf in undefended areas, such as river islands.

Long-billed curlews are largely restricted to natural shortgrass prairie or rangelands where the vegetation remains about 30 cm in height during the early portions of the breeding season (Jenni et al. 1982). Curlews always select a very open nest site, although the site may be as small as 0.4 ha (Allen 1980). Nesting habitat in Utah includes unvegetated alkali flats (Sugden 1933).

The use of an area by curlews is not related to plant species composition; instead, it is significantly, negatively correlated with the height and vertical coverage of the vegetation (Bicak and Jenni 1981). About 15 ha of rolling topography with short vegetation are required for a curlew pair to establish a nesting territory. Areas of taller vegetation (> 3.0 dm) or frequent small patches (< 0.5 ha) of bunch grasses are also needed to provide escape cover and a source of invertebrates for chicks. Breeding curlews require a buffer zone around nesting territories of similarly suitable habitat. Required vegetation structure is generally provided by shortgrass prairie.

In the western Nebraska sandhills, where curlews are abundant, the dominant association includes grasses of the genera *Bouteloua*, *Stipa*, *Buchloe*, and *Panicum* (Bicak unpub.; Jenni et al. 1982). Cheatgrass-bluegrass (*Bromus-Poa*) associations are the preferred type of vegetation for nesting habitat (Pampush 1979; Allen 1980; Jenni et al. 1982).

Several authors have suggested that curlews prefer nest sites adjacent to sloughs or other water sources (Bent 1929; Sugden 1933; Ligon 1961; McCallum et al. 1977; Johnsgard 1979). McCallum et al. (1977) reported that 26 of 63 curlews found in Baca County, Colorado, were within 91.4 m of a water source. However, curlews will visit water sources up to several kilometers from the nest site during any part of the breeding season (Jenni pers. comm.).

Curlew nests are similar to those of other shorebirds and consist of a shallow scrape on the ground about 130 to 275 mm in diameter and 23 to 66 mm deep (Allen 1980). The nest is lined with pieces of grass and small twigs collected near the nest bowl (Sugden 1933). Egg laying begins the first and second week of April in Washington and Oregon (Pampush 1979; Allen 1980), the last half of April in Utah (Forsythe 1970), and early May in Saskatchewan (Renaud 1980) and Texas (Oberholser 1974).

The typical clutch is four eggs, laid approximately 2 days apart (Forsythe 1970; Allen 1980); Graul (1971) reported three eggs laid during a 4-day period. Both members of the pair incubate the nest, with the female curlew generally incubating during the day and the male at night (Allen 1980). The incubation period from the laying of the last egg through hatching is 27 to 28 days (Graul 1971; Forsythe 1972). Hatching usually occurs over a 5-hour period (Allen 1980). The parents periodically brood the young for approximately the first 2 weeks.

The family remains in the general vicinity of the nest for the first few days after hatching. Some broods continue to stay in or near the nest territory (Allen 1980), while others may move up to several kilometers (Sadler and Maher 1976). The female usually leaves the family when the chicks are 2 to 3 weeks old; the male often remains with the chicks at least until they are able to fly at 41 to 45 days (Allen 1980). The chicks and the attending adult(s) generally leave the original territory about 31 days after hatching and travel up to 2 km per day. Flocks of juveniles and adult males presumably begin to form during this nomadic prefledging period.

A period of flocking precedes the departure of the curlews from the breeding grounds. Departure occurs prior to the hottest part of the summer in most of the breeding range. Flocks form as early as May 25 in Oregon, apparently consisting of birds having aborted nesting attempts and females that had left broods from early hatches (Pampush 1979). Pampush recorded a flock of 380 curlews on June 23 that consisted mostly of adult males; a flock of 130 curlews located on June 30 contained 40% juveniles. Allen (1980) reported flocks of curlews from the beginning of June until July 28 in Washington, although only small numbers of juveniles were present in the July flocks. Even in Saskatchewan, where brooding occurs later than in the Great Basin, curlews are generally not seen after July (Renaud 1980).

POPULATION TRENDS

Although accurate historical population data are not available, long-billed curlew populations have apparently declined since the 1880's due to agriculture and human population pressures (Bent 1929; McCallum et al. 1977; Renaud 1980). Significant amounts of breeding habitat have been altered or destroyed in the last 100 years and continue to be lost with the development of new irrigation techniques. Plans to escalate the mining of coal reserves in parts of the breeding range of the curlew pose further threats to the population.

Estimation of the total current population of curlews is difficult because they are widespread in arid habitats sparsely populated by humans. However, there is no evidence to suggest that curlews are more dense within their present range than they were in the past. Therefore, the range restriction that has occurred over the past 100 years (Sugden 1933) apparently represents an overall population decline of curlews rather than a geographical concentration of existing populations.

The breeding densities of curlews vary greatly from one part of their range to another, and many apparently suitable areas do not contain curlews (McCallum et al. 1977). The Black Canyon Planning Unit in southwestern Idaho supports the densest breeding population of long-billed curlews in the Columbia and northern Great Basins (Pampush 1980) and, therefore, west of the Continental Divide (Bicak et al. 1981). The greatest density recorded is one territorial male/15.7 ha in Idaho (Redmond et al. 1981). Allen (1980) reported territory sizes of 6 to 20 ha in Washington, although the actual breeding pair density was only one pair/69 ha. Territories in southwestern Idaho averaged 14 ha in the most densely populated areas (Redmond et al. 1981). Pampush (1979) reported densities of one nest/23.2 ha in areas of low shrub density and one nest/58.1 ha in areas with moderate shrub density in Oregon. Densities were only one pair/600 to 700 ha on a grassland site in Saskatchewan (Sadler and Maher 1976).

Breeding curlews are territorial and require a minimum amount of land before they will initiate breeding activities. Curlews do not establish territories adjacent to unsuitable habitat; they leave an unoccupied buffer zone that is 300 to 500 m wide (Redmond et al. 1981).

Although Breeding Bird Surveys do not measure absolute densities of species, they may reveal population trends when several years of data are compared. Unpublished analyses of Breeding Bird Survey data since 1967 do not indicate any recent changes in the population of curlews (Robbins pers. comm.). However, conclusions about recent trends in the entire curlew population should not be based on Breeding Bird Survey data because relatively few survey routes cover areas inhabited by long-billed curlews.

Effects of Habitat Changes

Grass culms and vertical and horizontal stem density are important proximate factors that limit habitat utilization by curlews (Pampush 1980). Disturbances such as grazing, plowing, or fire that enhance the invasion of weedy herbaceous plants or shrubs can be expected to affect curlew habitat utilization patterns. Shrub invasion, in particular, may result in the elimination of breeding pairs from an area that previously had low shrub coverage.

Cultivation of prairie grassland has been the major source of the loss of long-billed curlews from the eastern portion of their former range. Extensive cultivation is usually incompatible with curlew breeding habitat, although curlew nests have been found in fields of young barley (Pampush 1979), and agricultural lands are sometimes used as feeding sites by curlews. The loss of habitat may become an even more serious problem with the increased use of center pivot irrigation on previously untilled land in the Western plains. In Oregon, 30,000 acres of curlew nesting habitat are believed lost to cultivation annually (Allen 1980). In some areas, such as eastern Washington, homestead farms have reverted back to natural prairie or been converted to grazing land, and curlews have reoccupied these areas (Yocom 1956).

Curlews use short vegetation more than taller vegetation and appear to be one of the few species that can benefit from livestock grazing (Bicak et al. 1981). Because curlews require short vegetation as nesting habitat, any grazing regime that reduces vegetative height and density to minimum values at the beginning of the breeding season is beneficial. Grazing regimes need to consider the year-to-year variation in climatic factors and vegetation to be equally beneficial for curlews in all years.

In the Black Canyon Planning Unit in Idaho, both sheep and cattle grazing were beneficial to curlews (Bicak et al. 1981). Sheep grazing appeared to be more beneficial than cattle grazing because of the stocking rate of sheep and their habit of grazing in a broad front rather than along established paths like cattle. Grazing should have a minimum direct influence on the curlews and should occur prior to nesting when it is most beneficial.

Grazing cattle are often frightened off by incubating curlews flushing suddenly from the nest (Sugden 1933), although excessive grazing pressure presents more risk to nests. Sheep are a greater problem to nesting curlews because of their gregariousness and their lack of response to flushing birds. In a north-central Oregon study area, two curlew nests exposed to sheep grazing were trampled and five others abandoned (Pampush 1979). Curlews in western South Dakota nested in fields grazed by cattle but avoided those grazed by sheep (Timken 1969).

Although cultivation and grazing are the two biggest man-induced habitat changes that affect curlews, the growth of towns and cities has also appropriated much breeding habitat (Jenni et al. 1982). In addition, surface mining and ancillary activities can be an important cause of local habitat changes.

Curlews are probably well adapted to natural short term habitat changes, such as those resulting from rainfall cycles, although years of unusually heavy rainfall (Jenni et al. 1982) or severe drought (Ligon 1961) may inhibit breeding. Fire may make brush areas suitable for curlews for the first year but these sites may rapidly become undesirable if there is much precipitation and no grazing (Jenni et al. 1982). If breeding habitat is changed and nesting is precluded, it is not known where the displaced birds go, or if they ever return to the area (Bicak pers. comm.).

Effects of Human Disturbance

Human activity in breeding areas can have a significant impact on curlew breeding success. An incubating curlew normally sits tightly on the nest when first approached until the human is quite close to the nest. However, once flushed, an incubating bird may remain away from the nest for as long as an hour with some risk to the eggs from exposure during this time. Curlews are likely to return to the nest more quickly during extreme temperatures unless human activity persists in the immediate vicinity.

The major direct human threats to breeding curlews are illegal shooting and disturbance by off-road vehicles. Nine curlews were found shot in May and June during a 3-year U.S. Bureau of Land Management study in Idaho (Jenni et al. 1982). Although the extent of this problem is not known, curlews can be conspicuous targets even at considerable distances. The open habitats used by curlews are often attractive to owners of off-road vehicles, resulting in nest abandonment or destruction and chick mortality. Nest abandonment is most likely to occur prior to incubation. Damage to vegetation resulting from off-road vehicle use and subsequent erosion potentially have even greater impacts on curlews because they can result in habitat that is unsuitable for curlews for a long period of time. Curlews avoid areas that receive heavy off-road vehicle use (Jenni et al. 1982). Chemical control of grasshoppers reduces the quality of habitat for curlews and may cause secondary poisoning.

Other human influences, such as injury to curlews from contact with discarded debris, flying into wire fences or telephone lines (Allen 1980), and collection of eggs by sheepherders for food in some areas (Pampush 1979), probably do not exert a significant impact on the population.

Management

A sound management program is dependent on effective census techniques, so that population trends can be detected and monitored. The Finnish line transect method of censusing appears to be the most effective technique for long-billed curlews, with the results approximating actual breeding densities (Redmond et al. 1981). Because curlews nest in physiognomically similar habitats throughout their range, this census technique is probably applicable anywhere.

Management plans for curlews should be aimed at preventing undesirable habitat changes in areas currently used by curlews. Controlled burning and grazing may be useful in creating additional suitable habitat. The physical structure of the habitat is more critical to its suitability than plant species composition (Bicak pers. comm.). Low-profile vegetation is required for nesting. However, adults with chicks and chicks during the premigratory phase require different habitat than breeding adults, and habitat management must consider these changing needs to be successful.

The potential of areas for curlew breeding can be enhanced by restricting or eliminating off-road vehicle use, especially during the nesting season. Eliminating debris piles, which can attract predators and shooters, should also enhance breeding success.

The Long-Billed Curlew as an Indicator Species

Although the curlew is not as stenotopic as some prairie birds, it is dependent on arid, open land where grass height does not exceed 30 cm during the early breeding season (Jenni et al. 1982). Curlews prefer range that is not in very good condition by most range scientists' standards. Environmental conditions that result in taller grasses, increased vegetation density, or increased topographic diversity on a localized level will likely result in a decline in curlew populations. The range reduction of the curlew in this century is evidence of the inability of this species to adapt to habitat changes. Therefore, long-billed curlew populations should be reasonably good indicators of the condition of various shortgrass ecosystems in the Western United States.

Some surface mining of coal in the Western plains will undoubtedly occur in curlew breeding areas. Recolonization of these areas by curlews after reclamation would indicate successful restoration of topographic and vegetative features. If curlews are fairly common in the vicinity but do not recolonize reclaimed sites, significant alterations from the original habitat structure should be suspected.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Most of the direct and indirect impacts of coal mining occur during exploration and mine development. Exploration normally involves a much larger area than the specific mine sites that are ultimately developed (Moore and Mills 1977), and the greatest number of curlews are potentially impacted at this time. The significance of this impact depends on many factors, including the number of drilling sites, the amount of land surface disruption from drilling and building of access roads, the frequency of visits, and, especially, the timing of exploration activities.

Curlews will not nest at the mine excavation site proper, and birds displaced by excavation activities will not renest that year. Whether or not curlews find suitable nest sites in adjacent areas in subsequent years depends on several factors, including the existing curlew nesting densities in those areas. Displaced curlews will probably be subjected to overcrowding and increased stress, most likely resulting in an overall reduction in the breeding population.

Additional impacts to curlews during the mining phase can result from excessive blasting, deposition of airborne dirt particles, or altered water drainage patterns. Blasting will probably not be an important factor in the Great Plains because coal deposits are close to the surface. The impact of deposition of airborne dirt is unknown but it may affect insect use of vegetation as a food source, thereby lowering the prey base for curlews. Collisions with transmission lines may cause injury or death.

The effects of altering the underground water system can be serious and can extend well beyond the mine site. For example, lowering the water table may have a long term effect on vegetation density and composition. Routing pumped water to low areas may result in vegetation growth that is attractive to birds and predators, but is unacceptable habitat for curlews. Alkalization of the water table due to leached minerals from overburden materials can have long term impacts on vegetation (Moore and Mills 1977), although these impacts may be subtle and difficult to detect.

Long-billed curlew populations have declined significantly due to habitat loss. Therefore, every effort should be made to preserve current nesting habitat in its natural state. Any level of habitat disruption will risk further losses to an already dwindling population. There are no adequate estimates of the total curlew population, and curlews are not evenly distributed within their habitat. Therefore, it is impossible to accurately predict the magnitude of the population loss that would result from habitat destruction over a broad area. In addition, if breeding habitat is altered to the point that it is unsuitable for nesting, the curlews will leave the area and it is unknown where they might go or if they would ever return (Bicak pers. comm.).

Site-specific studies of the immediate and long term effects of coal mining on long-billed curlews are needed. Accurate estimates of existing curlew nesting populations are required in all site-specific studies to provide baseline data to which subsequent populations can be compared. Population monitoring should continue throughout the mining and reclamation phases. The ultimate impact of the mining activity will be determined by the degree to which curlews repopulate the reclaimed prairie and adjacent areas. Information on the extent of the area of impact of various mining activities and on the recolonization success of reclaimed land are important considerations in developing guidelines for later mining operations. The impact of mining activities on local curlew populations should be a major consideration in deciding whether or not to develop potential mine sites.

Secondary impacts of coal mining on curlew populations, such as the effect of habitat fragmentation, should also be considered during the site-specific evaluation. If habitat fragmentation, resulting from mining or other development activity, leaves patches of prairie below the minimal acceptable size for curlews, use by curlews may be precluded despite optimal habitat structure within the patches. It should be remembered that many species of birds have minimal area requirements for suitable habitat that greatly exceeds individual territory size (Bond 1957). Therefore, if scattered mining activities are anticipated within an area of similar curlew densities, the resulting impacts on curlews should be considered in terms of the loss of continous prairie habitat.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Conflicts between coal surface mining and curlew populations are most likely to occur in Montana, North Dakota, and Wyoming (Fig. 18). Local surveys will be needed to determine whether or not specific mining operations will impact curlew populations.

Premining Phase

Curlew populations should be censused for at least 2 years prior to exploratory drilling to ensure against the possibility of censusing an atypical breeding density in any 1 year. Curlews should be censused during the peak of incubation; i.e., when most birds have laid their eggs but before hatching has started (between late April and mid-May). A Finnish line transect census method (Redmond et al. 1981) may be used before the excavation site is selected. This census method yields reasonably accurate estimates of breeding pair densities (Redmond et al. 1981). Once the mining site has been selected, a more precise census method, such as spot mapping, may be used on the site and for a 1 km radius area around the site if curlew densities are high (Redmond et al. 1981). Comparison of the results of the two census methods yields a conversion factor that can be applied to the results of the Finnish line transect to extrapolate actual densities. Several similar sites of equal size outside the exploration area may also be censused as control areas. Censuses may be repeated during the peak of the chick growth phase to determine if the distribution of birds changed significantly at this time. For example, the selected mine site might be a relatively poor nesting area but a critical feeding area for broods.

Exploration, Mine Development, and Mining Phase

Ideally, exploratory activities should be scheduled between September and March, when curlews are generally absent from the area. The impact on curlews may be negligible when exploration is scheduled while the curlews are absent and drilling sites and access roads are reclaimed before the curlews return in the spring. Repeated disturbance during the nesting season, however, may result in nest desertion and egg and chick mortality (Jenni et al. 1982).

It is important to continue censuses during the exploration, mine development, and mining phase so that the magnitude of the impact in peripheral areas can be determined by comparison with the control areas. Impacts in peripheral areas can be reduced by minimizing the number of haul roads; restricting human activity on the roads, at the mine, and in the immediate vicinity of buildings; and discouraging recreational use of surrounding prairie areas. Dust control measures and proper disposal of wastes and byproducts may alleviate impacts to vegetation and water resources.

Reclamation Phase

Reclamation of mined land should begin as soon as possible, while mining is still occurring. Early reclamation efforts reduce the length of time that curlews are excluded from the mining area and provide early analyses of reclamation success that can lead to improved techniques for future reclamation efforts. The results from careful monitoring of reclamation efforts at similar sites can also be used when developing the final reclamation plan for a mine site.

The goal of mined land reclamation should be to restore the original topography and vegetation. This necessitates the careful removal and storage of the topsoil during the early stages of excavation. Because nutrients are often leached from topsoil during storage (Moore and Mills 1977), fertilization will probably be necessary.

It is ideal to reseed reclaimed mining operations with native plants. However, any plant association reseeded on a reclaimed area may attract curlews as long as the grasses are short and relatively homogeneous or can be managed and maintained within the curlew's range of tolerance (Bicak pers. comm.). Reclaimed shortgrass prairie areas are sometimes reseeded with wheatgrasses (*Agropyron* spp.) because they become established quickly and provide good livestock pastures. However, wheatgrasses are a minor component of natural shortgrass prairies and the resultant vegetative structure generally is unsuitable for curlews and other shortgrass species. Reseeding annual grasslands that curlews are currently using for breeding with crested wheatgrass will probably result in the curlews abandoning the area (Pampush 1980). If maintaining curlew habitat is an important objective in reseeding operations, species or mixes should be used that result in vegetation of minimum height and density.

Curlew censuses and studies of revegetation patterns should be conducted for several years after reclamation. Reclamation techniques that are found to result in the most rapid recovery of both the prairie and curlew populations should be applied to future surface mine reclamation activities.

SUMMARY

Long-billed curlews are conspicuous shorebirds that are widespread in the Western Plains and Great Basin areas. Curlew populations have declined as a result of the appropriation of prairie habitat for agriculture and other land use modifications. The long-billed curlew is a sensitive native species that may be jeopardized by land use changes unless there is enlightened future management (Pampush 1980). Many proposed surface mine developments will impact local populations to varying degrees. The total population of long-billed curlews and the minimum viable population are unknown, and no projections of allowable habitat disruption can be made at this time. Accurate censuses of curlews need to be made before and during mining operations and after reclamation to determine the short and long term impacts on curlew populations and their ultimate recovery potential. Human disturbance factors associated with mining may have a greater effect on curlews than on songbirds and other less sensitive species.

ACKNOWLEDGMENTS

Alan Sands, U.S. Bureau of Land Management, Boise, Idaho, provided portions of the manuscript by Jenni et al. prior to its publication. Mark Agricola prepared the preliminary figures.

REFERENCES

Allen, J. N. 1980. The ecology and behavior of the long-billed curlew in southeastern Washington. Wildl. Monogr. 73:1-67.

American Ornithologists' Union. 1957. Checklist of North American birds. 5th ed. Lord Baltimore Press, Baltimore. 691 pp.

____________. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Behle, W. H., and M. L. Perry. 1975. Utah birds. Utah Mus. Nat. Hist., Salt Lake City.

Bent, A. C. 1929. Life histories of North American shorebirds. Part 2. U.S. Nat'l. Mus. Bull. 146:1-412.

Bicak, T. K., and D. A. Jenni. 1981. Habitat requirements of long-billed curlews (*Numenius americanus*): Vegetative characteristics. Abstract of paper presented at 1981 meeting of the American Ornithologists' Union. 24-27 August 1981, Edmonton, Alberta.

Bicak, T. K., R. L. Redmond, and D. A. Jenni. 1981. Effects of grazing on long-billed curlew (*Numenius americanus*) breeding behavior and ecology in southwestern Idaho. Pages 74-85 *in* Proceedings of the Wildlife-Livestock Relationships Symposium. For., Wildl., Range Exp. Stn., Univ. Idaho, Moscow.

Bicak, T. K. Unpublished manuscript and personal communication. Dept. Zool., Univ. Montana, Missoula.

Bond, R. R. 1957. Ecological distribution of breeding birds in the upland forests of southern Wisconsin. Ecol. Monogr. 27:351-384.

Burleigh, T. D. 1972. Birds of Idaho. Caxton Printers, Caldwell, ID.

Forsythe, D. M. 1970. Vocalizations of the long-billed curlew. Condor 72:213-224.

____________. 1972. Observations of the nesting biology of the long-billed curlew. Great Basin Nat. 32:88-90.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis.

Godfrey, W. E. 1966. The birds of Canada. Natl. Mus. Canada Bull. 203 (Biol. Ser. 73):1-428.

Graul, W. D. 1971. Observations at a long-billed curlew nest. Auk 88:182-184.

Grinnell, J., and A. H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna 26:1-608.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Jenni, D. A., R. L. Redmond, and T. K. Bicak. 1982. Behavioral ecology and habitat relationships of long-billed curlews in western Idaho. U.S. Bur. Land Manage., Boise, ID.

Jenni, D. A. Personal communication. Dept. Zool., Univ. Montana, Missoula.

Johnsgard, P. A. 1979. Birds of the Great Plains. Univ. Nebraska Press, Lincoln.

Johnston, R. F. 1964. The breeding birds of Kansas. Univ. Kansas Publ. Mus. Nat. Hist. 12:575-655.

Kingery, H. E., and W. D. Graul. 1978. Colorado bird distribution latilong study. Colorado Field Ornithol. and Colorado Div. Wildl., Denver.

Ligon, J. S. 1961. New Mexico birds. Univ. New Mexico Press, Albuquerque.

McCallum, D. A., W. D. Graul, and R. Zaccagnini. 1977. The breeding status of the long-billed curlew in Colorado. Auk 94:599-601.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Oakleaf, B., H. Downing, B. Raynes, M. Raynes, and O. Scott. 1979. Wyoming avian atlas. Working draft. Wyoming Game Fish Dept. 68 pp.

Oberholser, H. C. 1974. The bird life of Texas. Univ. Texas Press, Austin.

Pampush, G. J. Unpub. (1979). Breeding ecology of the long-billed curlew (Numenius americanus) in northcentral Oregon. U.S. Fish Wildl. Serv. Coop. Res. Unit, Corvallis, OR.

Pampush, G. J. 1980. Status report on the long-billed curlew in the Columbia and northern Great Basins. U.S. Fish Wildl. Serv. Rep., Portland, OR.

Redmond, R. L., T. K. Bicak, and D. A. Jenni. 1981. An evaluation of breeding season census techniques for long-billed curlews (Numenius americanus). Stud. in Avian Biol. 6:197-201.

Renaud, W. E. 1980. The long-billed curlew in Saskatchewan: status and distribution. Blue Jay 38:221-237.

Ridgway, R. 1919. The birds of North and Middle America. U.S. Natl. Mus. Bull. 50:390-395.

Robbins, C. S. Unpublished data and personal communication. Patuxent Wildlife Research Center, U.S. Fish Wildl. Serv. Laurel, MD.

Sadler, D. A. R., and W. J. Maher. 1976. Notes of the long-billed curlew in Saskatchewan. Auk. 93:382-384.

Skaar, P. D. 1975. Montana bird distribution. P. D. Skaar, Bozeman, MT.

Stenzel, L. E., H. R. Huber, and G. W. Page. 1976. Feeding behavior and diet of the long-billed curlew and willet. Wilson Bull. 88:314-332.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Center Environ. Studies, Fargo, ND.

Sugden, J. W. 1933. Range restrictions of the long-billed curlew. Condor 35:3-9.

Sutton, G. M. 1967. Oklahoma birds. Univ. Oklahoma Press, Norman.

Timken, R. L. 1969. Notes on the long-billed curlew. Auk 86:750-751.

Wickersham, C. W. 1902. Sickle-billed curlew. Auk 19:353-356.

Wolfe, L. R. 1931. The breeding Limicolae of Utah. Condor 33:49-59.

Yocom, C. F. 1956. Re-establishment of breeding populations of long-billed curlews in Washington. Wilson Bull. 68:228-231.

INTERIOR LEAST TERN (*Sterna antillarum athalassos*)

by

R. Michael Erwin
Patuxtent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The least tern (*Sterna antillarum*) is the smallest of the tern subfamily Sterninae (family Laridae). Once considered conspecific with the Old World species *Sterna albifrons*, the least tern is now considered a separate species with three subspecies in North America (American Ornithologists' Union 1983). The interior race (*S. a. athalassos*), the focus of this report, is relatively restricted in its distribution primarily to the Mississippi River and its tributaries with a few disjunct nesting sites elsewhere. The California least tern (*S. a. browni*) summers along the southern California-Baja coast, and the Eastern least tern (*S. a. antillarum*) occurs along the Atlantic and Gulf coasts.

The least tern is 20 to 22.5 cm in length and weighs about 60 g (Marples and Marples 1934). Like the other closely-related *Sterna* species, the least tern has a black pileum during the breeding season, the mantle and wings are light gray, and underparts are white. Diagnostic field marks for the species are the white forehead, bright yellow black-tipped bill, and yellow legs (Bent 1921; Peterson 1947). In winter plumage, the bill is black and the occiput and nape are brownish black (Bent 1921). Before the adult postnuptial molt in July or August, the young birds are distinguishable from the adults primarily by the buffy color of the forehead and crown and the mottled condition of the wing coverts (Bent 1921).

Some question exists regarding the separation of the subspecies *S. a. athalassos* and *S. a. antillarum*. Preliminary electrophoretic examinations show no distinguishable differences between the two subspecies (Thompson pers. comm.). The status in Texas is uncertain, because both *S. a. athalassos* and *S. a. antillarum* both occur in the State, and cannot always be differentiated.

DISTRIBUTION

The interior race breeds (or formerly bred) primarily along the Mississippi River and its major tributaries such as the Missouri (and its tributaries, the Platte, the Niobrara, and the Cheyenne Rivers), the Ohio, the Arkansas, and the Red Rivers (and its tributaries including the Sheyenne River) (Hardy 1957; Downing 1980) (Fig. 19). A disjunct nesting population also breeds on the Pecos River at Bitter Lake National Wildlife Refuge (NWR) in eastern New Mexico. The least tern winters from Louisiana south into the Caribbean and throughout South America (Bent 1921).

The other races of the least tern in North America are coastal. The California least tern, on the U.S. Department of the Interior's list of endangered species, nests from Monterey County, California south to Baja California, Mexico (Massey 1974). The East and Gulf coast race is distributed from the Texas coast to Maine.

DIET

The least tern is principally piscivorous, feeding in shallow water of rivers, streams, and impoundments. The river shiner (*Notropis blennius*) is the dominant prey item for the interior race (Hardy 1957). Other small fish in interior rivers may include gizzard shads (*Dorosoma cepedianum*), sunfish (*Lepomis* spp.), and suckers (*Ictiobus* spp.). At Salt Plains NWR, river shiners, killifish (Cyprinodontidae), and mosquito fish (Poeciliidae) are eaten (Grover 1979). In coastal areas, least terns eat mollusks, annelids, and small crustacea in addition to fish but these prey are apparently not available in the interior river systems (Hardy 1957; Cramp et al. 1974).

Least terns generally feed close to their nesting colonies (Lack 1968; Erwin 1978a), usually within about 1 km. Like other *Sterna* terns, they typically plunge-dive for small fish, usually in shallow waters near land (Bent 1921; Marples and Marples 1934; Hardy 1957). They feed in rivers, sloughs, pools, and pits behind levees along the Mississippi River (Ganier 1930; Hardy 1957). On one occasion at least, field feeding on insect larvae was observed (McDaniel and McDaniel 1963), similar to the behavior of tractor-following laughing gulls (*Larus atricilla*).

REPRODUCTION

Chronology

The least tern is one of the earliest tern species to arrive at breeding grounds in spring, appearing in the lower Mississippi drainage from about mid-April onward (Hardy 1957), on the Platte River about late May, and on the Upper Missouri June 1-5 (Faanes pers. comm.). Migration routes follow the Red, Arkansas, and Missouri Rivers.

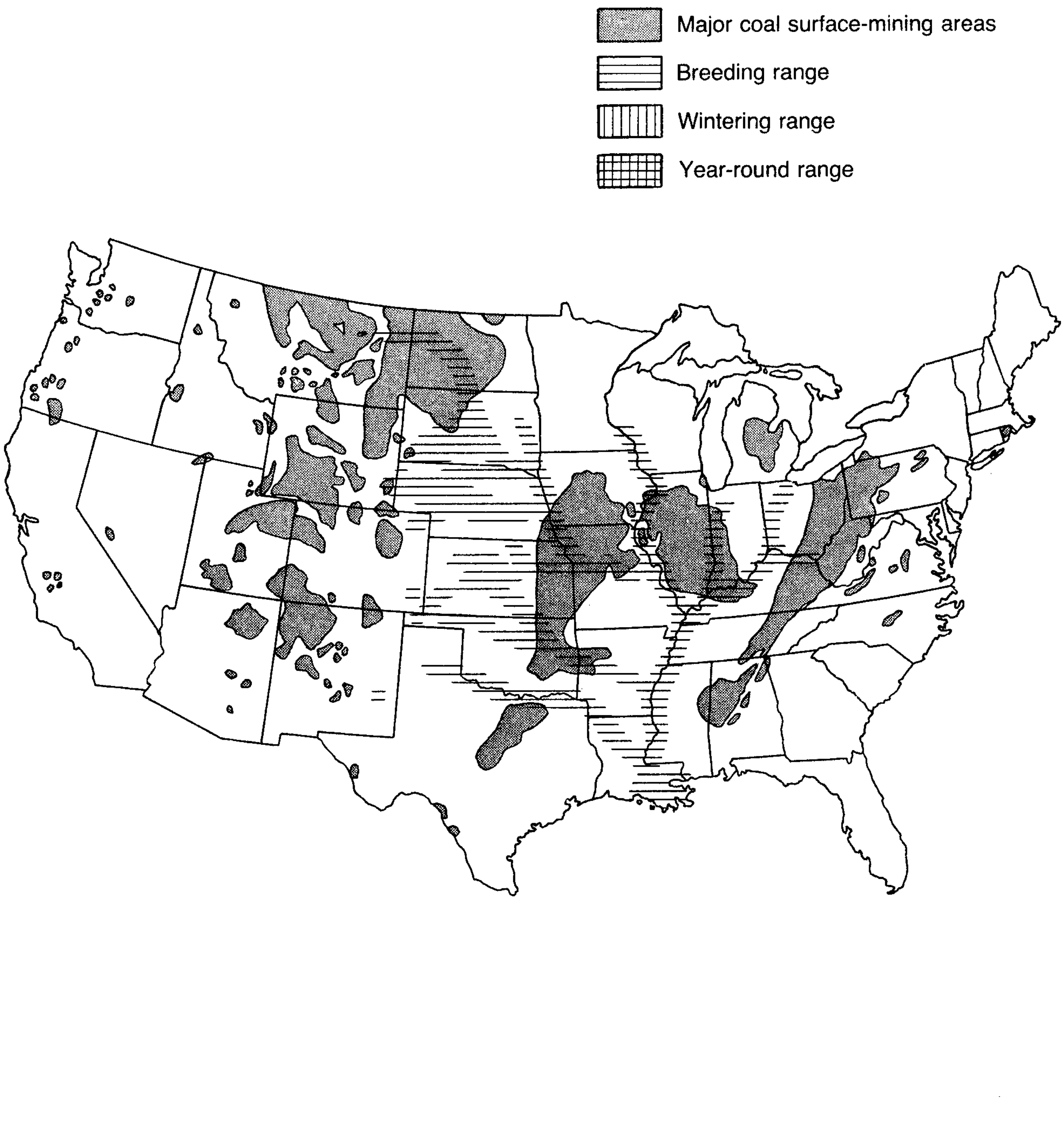


Figure 19. Geographical range of the interior least tern in relation to major coal deposits in the United States. After Inkley and Raley (1983) and Ducey (1981).

Courtship occurs during a 2- to 3-week period after arrival at the nesting grounds (Massey 1974) and egg laying may be underway usually by late May in most areas (Bent 1921; Blodget 1978a, b), although an Ohio River colony did not nest until early June (Hardy 1957). Nesting occurs mid-to-late June in Nebraska and South Dakota (Anderson pers. comm.).

The nest consists of a scrape in the sand placed near driftwood or debris, and often lined with small pebbles (Ducey 1981). Normally, a clutch of two or three eggs is laid (Bent 1921; Marples and Marples 1934; Hardy 1957) with single eggs occasionally occurring. At the Bell Island, Ohio River colony (Hardy 1957), three-egg clutches predominated and, in Iowa, most nests contained three eggs (Stiles 1939). However, at several locations in Tennessee and Mississippi, two-egg clutches were the mode (Hardy 1957). Thus, both between-colony and between-year variation in clutch size occurs for this species.

Both sexes incubate the eggs but females often contribute more than 80% to the effort (Hardy 1957; Davis 1968; Massey 1974). Reports of the incubation period vary from 14 to 16 days (Bent 1921) to 19 to 24 days in Massachusetts (Hagar 1937), and 17 to 18 days at an Omaha, Nebraska colony (Moser 1940; Blodget 1978a). Eggs usually hatch on consecutive days.

After hatching, both members of the pair feed the young small fish. The chicks are very mobile after only a few days, travelling some distance from the nest scrape. At approximately 20 days of age, chicks are capable of flight (Hardy 1957). Like most other terns, the young continue to be fed by their parents during late summer and early fall (Ganier 1930; Marples and Marples 1934).

Nesting Habitat

Habitat requirements include sandbars, favorable water levels, and a nearby food source (Hardy 1957). Least terns nest in extremely open terrain along bodies of water throughout the United States. Along the coast, terns nest in small colonies of usually 20 to 50 pairs, with some colonies exceeding 100 pairs (Downing 1973; Erwin 1978a, 1979). They nest on beaches along the mainland and on barrier islands, and now more commonly on man-made habitats such as dredge and construction fill sites (Downing 1973; Erwin 1979) and occasionally on roof tops in several southern regions (Fisk 1975; Thompson and Forsythe 1979). In the interior of the United States, the terns nest most commonly on sandbars along major rivers with broad expanses and braided channels (Ganier 1930; Hardy 1957; Holt et al. 1974; Downing 1980). Not all sandbars are equally suitable, however. The optimal nesting substrate in a river system consists of high, vegetation-free bars, that are well-isolated from the mainland. Isolation and avoidance of vegetation reduce the incidence of mammalian predation. The other major source of mortality is flooding, thus higher bars are preferred. Nonriverine habitats include salt flats, salt marshes, sandy beaches at off-river sandpits, dredged sand piles, and mud or sand flats at the upper reaches of reservoirs (Ducey 1981).

The least tern is notorious for shifting its colony sites both within and between seasons (Nisbet 1973; Erwin 1978b). This phenomenon probably relates to the high risk of predation and human disturbance encountered by the species (Erwin 1978b; Downing 1980).

POPULATION TRENDS

Present Levels

In 1975, Downing (1980) conducted a partial survey of the interior nesting population, covering approximately 3,200 km of rivers from Texas to Nebraska and Tennessee. Figure 20 and Table 12 show recent colony locations.

Downing (1980) reported a total estimate of 1,250 birds but only 616 were actually seen. He gives little justification, however, for why he doubled the number seen to arrive at his estimate, other than to say that "ground checks of many areas were made ..." (p. 209). Erwin (1979) found a very high correlation between the numbers estimated from the air and the number of nests counted on the ground along the Atlantic Coast in 1976-77. Thus, the actual population in the interior may be about 600 pairs or 1,200 adults, essentially in agreement with Downing's estimate.

The strongholds of the breeding population are in Nebraska along the Platte and Niobrara Rivers, the Salt Plains area of Oklahoma, and along the Upper Mississippi in the 150-mile stretch of river between Cairo, Illinois and Osceola, Arkansas. In this latter area, 11 colonies occur, containing half of the total interior population.

Other important areas include the Missouri River in Nebraska and the Cheyenne and Missouri Rivers in South Dakota (Anderson pers. comm.). The interior population may also include about 150 birds in Kansas, 350 in Nebraska, and at least 100 in South Dakota. Good potential habitat in both North and South Dakota has never been surveyed.

Distribution beyond the Mississippi drainage area includes the Pecos River, New Mexico, colony. In 1980, a peak of 17 birds was recorded (Anderson pers. comm.).

A new nesting area is located in eastern Colorado where new reservoirs have made habitat available (Kingery 1980). The first nesting record for the Lamar, Colorado, area was in 1978 (Kingery 1978).

Because region-wide censuses were not conducted before 1975, the status of the entire interior race is uncertain. The propensity of this species for relocating its colonies within and between years makes the least tern appear to be unstable. Yet it may be this tendency that permits the species to persist despite the hazards of predators, flooding, and other disturbances.

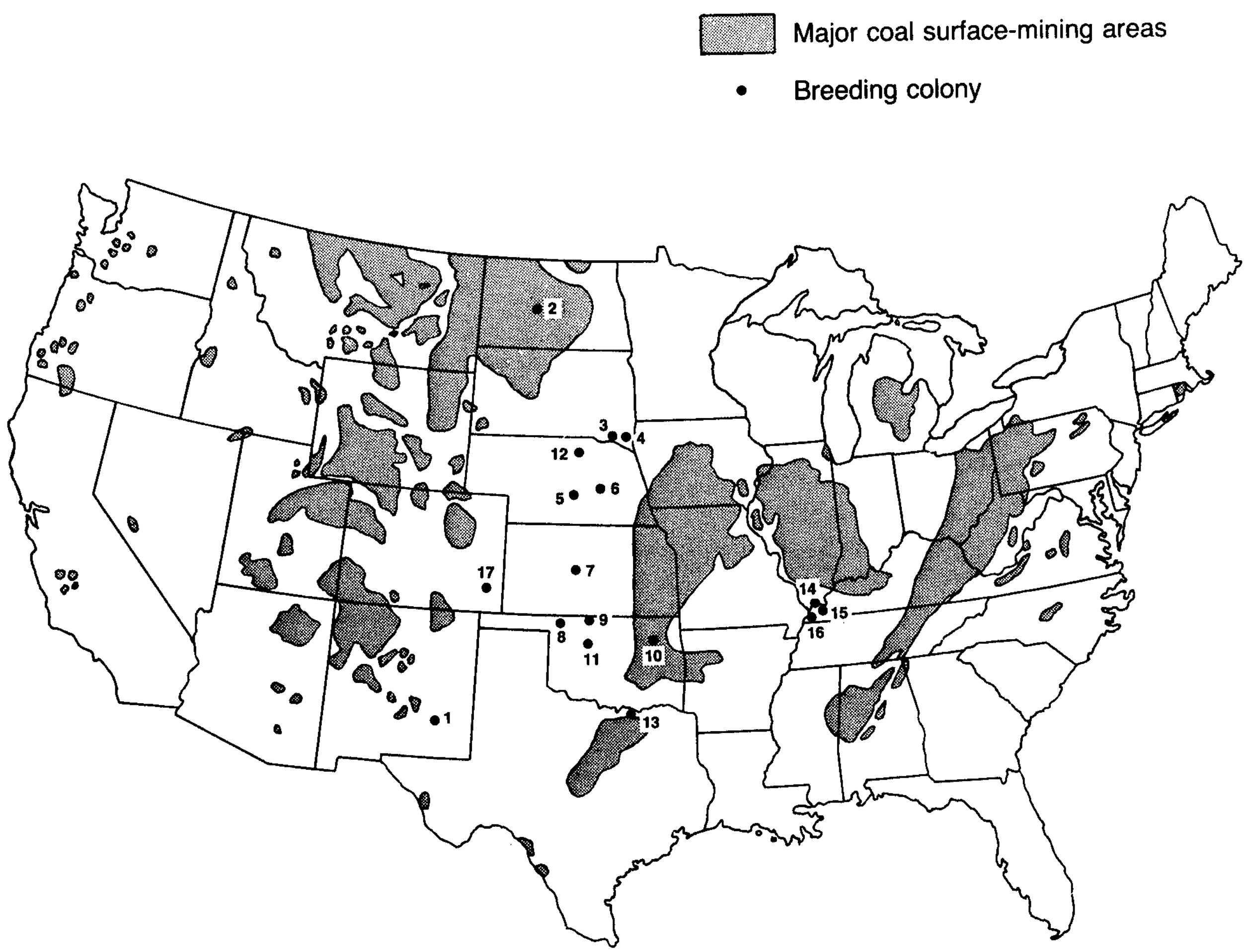


Figure 20. Recent breeding colony locations of the interior least tern in the United States. Numbers refer to colonies listed in Table 12.

Table 12. Recent[1] colony locations and nesting populations of the interior least tern.

Location	Map Number[2]	Breeding Population	Year	Source[3]
New Mexico				
Bitter Lake National Wildlife Refuge	1	20 adults	1974	Downing 1980
		5+ nests	1979	AB
		17 adults	1980	Anderson (pers. comm.)
North Dakota				
Garrison Dam Oahe Reservoir Missouri River	2	111 adults (10 colonies)	1979	AB
South Dakota				
Yankton	3	6 adults	1975	CBR
Vermillion	4	6 adults	1975	CBR
Missouri River (50 mile segment below Yankton)	NA	35 adults (5 colonies)	1975	Downing 1980
Nebraska				
Lexington	5	4 pairs (2 colonies)	1980	C. Faanes (pers. comm.)
Grand Island	6	17 pairs (2 colonies)	1980	C. Faanes (pers. comm.)
Platte River	NA	80 birds	1975	Downing 1980
Niobrara River	12	85 adults (6 colonies on lower 100 miles)	1975	Downing 1980
Kansas				
Quivera National Wildlife Refuge	7	10-20 birds	1975	Downing 1980
		unknown	1979	AB
Oklahoma				
Edith Salt Plains and Cimarron River	8	40 birds	1975	Downing 1980
Great Salt Plains Nat'l. Wildlife Refuge	9	80 pairs	1977	Grover 1979
		135 pairs	1978	
Tulsa area	10	active colony	1979	AB
Canadian River, Taloga to Newcastle	11	2 birds	1975	Downing 1980

Table 12. (concluded)

Location	Map Number[2]	Breeding Population	Year	Source[3]
Texas				
Red River-Spanish Fort and Hagerman Nat'l. Wildlife Refuge	13	15 birds	1975	Downing 1980
Kentucky				
Columbus	14	7 birds	1975	CBR
Oakland	15	7 birds	1975	CBR
Hickman	16	21 birds (2 colonies)	1975	CBR
Colorado				
Lamar	17	4 adults	1978	AB
		7 birds	1980	AB
Blue Lake	17	6 adults	1979	AB

[1]Information from 1974 to 1980.

[2]Refer to Figure 20.

[3]Codes: AB = American Birds (Nesting Season); CBR = Data from the Colonial Bird Register, Laboratory of Ornithology.

Effects of Habitat Changes

Tern nesting habitat along rivers is often in a dynamic ecosystem where sandbars may be deposited by high floodwaters or changed in size and shape by waves and currents. Fluctuating water levels may destroy nests during the breeding season, or provide predators access to colonies. Channelization of major rivers has removed sandbars and decreased available habitat for least tern nesting, causing terns to move to unchannelized portions of the rivers. The extensive channelization activities along the Missouri and Mississippi Rivers have removed much of the historical nesting habitat (Ducey 1981).

Dam construction decreases flow in rivers, causing nesting areas to be subject to vegetation encroachment, and precluding nesting by least terns (Ducey 1981). Dam construction may result in newly exposed sandbars, providing new habitat for tern colonies.

Man-induced habitat changes have provided many new colony sites for the least tern (Kingery 1980). Islands and other new sites created by dredge deposition from waterway dredging or from construction fill are often colonized by the terns (Jernigan 1977; Soots and Landin 1979; Erwin 1979). Building roofs are occasionally used in the South (Fisk 1975; Thompson and Forsythe 1979). Habitat use by nesting least terns can thus be relatively diverse compared to other related seabirds. However, the need for a bare substrate, either sand, gravel, pebble, or shell, is paramount.

The use of artificial habitats has increased primarily where disturbance by man has resulted in loss or degradation of natural habitats (Blindell 1975; Fisk 1975). Intensive development and recreational use of beaches (Blodget 1978b) has removed former nesting sites, especially along the Atlantic and Gulf Coasts. Studies are needed to evaluate the relative reproductive performance of least terns in man-modified versus natural habitat types. Although factors other than vehicular and human disturbance (e.g., predation, weather) were the most important sources of mortality in Massachusetts (Blodget 1978a, b), in Great Britain the opposite is true with the little tern (*Sterna albifrons*) (Cramp et al. 1974).

Effects of Human Disturbance

Least terns are sensitive to human disturbance. The beaches and sandbars used by tern breeding colonies attract human use in the form of vehicular and recreational activities, and agricultural activities, such as cattle use and farm machinery (Ducey 1981). Human disturbance may affect nesting terns through direct disruption of nests and birds, and through encroachment of nesting habitat. This disturbance may result in destruction of eggs and lowered productivity levels.

An increased demand for recreational areas in the future is likely to cause increased disruption to least tern nesting activity.

Management

Management recommendations for the least tern focus on maintenance of nesting and feeding habitat and protection from human disturbance. Annual spring surveys for least terns should be conducted in areas of known colonies and also in areas where suitable habitat exists (Ducey 1981). Colonies should be monitored for signs of disturbance or vegetation encroachment. River sandbars can be maintained for nesting by chemical or mechanical control of vegetation, and protection from current action with rip rap or other similar methods. Regulation of instream flow can provide suitable aquatic habitat to support fish populations, and suitable flows to avoid inundation of nesting colonies. Salt flats should be provided with freshwater inflows for terns to nest successfully (Grover 1979). Signs and fencing around colonies may help to protect nesting areas from human disturbance (Buckley and Buckley 1976). Local conservation groups may be used to conduct surveys and monitor colonies (Ducey 1981). Electric fencing may be used to protect colonies from predators.

Recent studies along the Platte River included a survey of the interior least tern, its habitat use, and the recommendation that unvegetated sandbars and adequate water supplies be available to ensure a breeding population (Faanes and Krapu pers. comm.).

The Least Tern as an Indicator Species

An indicator species is one which is sensitive to environmental change, i.e., the population size, age structure, or behavior reflect a change in one or more potentially limiting environmental factors. The least tern often nests in areas susceptible to human activity and may persist there despite low success (Massey 1974; Blodget 1978a, b; Galli 1978, 1979); therefore this species may be a poor indicator of some forms of human disturbance. In fact, it may be attracted to a disturbed area by recent construction (Massey 1974; Kingery 1980). Disappearance of a least tern colony from a historically used area may indicate excessive human disturbance, vegetation encroachment, or deterioration of fish populations.

The least tern is on the National Audubon Society's Blue List, indicating that a noncyclic population decline is occurring for the species (Tate and Tate 1982). The California subspecies is included on the U.S. Department of the Interior endangered species list; data suggest that interior least tern populations are lower than numbers of the California least tern (American Ornithologists' Union 1975).

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts of coal mining on interior least terns may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur if nests and nestlings are destroyed during construction and mining activities. Increased stress may occur through human disturbance, increased noise and dust, and degradation of habitat. Loss of habitat is potentially the most serious impact.

Most large-scale surface mining activities are expected to be water-intensive ventures. Alterations in water resources may include: changes in water distribution and water quality as a result of land contour change and seepage; reduction in water levels in rivers, lakes, ponds, and marshes as a result of diversion, mine dewatering, deep well pumping, or diversion for water transport systems; contamination of water resources from accidental leaks and spills of industrial liquids, pesticides, or herbicides used in mining and reclamation activities; contamination with toxic chemicals from leaching or runoff from overburden, waste rock, and ore storage piles; and increased sedimentation and turbidity from increased runoff or erosion (Moore and Mills 1977). These changes in water resources will result in habitat loss from the destruction or degradation of breeding and feeding areas.

Land contour changes, such as filling and excavating, may potentially have a positive impact on nesting least terns, especially in areas near rivers where natural, open sandbars are limited in number and new sandbars are created.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys should be conducted on major river stretches in areas close to and remote from prospective mining areas for 2 to 3 years before beginning a project. A literature search for historical nesting sites may also indicate areas to be surveyed. Several visits to active colonies from May through August can document within-season shifts in colony sites and to determine gross reproductive success. Collection of prey items found in the colonies could be useful to indicate the fish species found in the local river system.

Exploration and Mine Development Phase

Mitigation should be considered during the initial exploratory phase. Because exploration would presumably entail activities relatively remote from river channels, this phase would be expected to have no effect on least terns.

In mine development, important decisions need to be made concerning water sources and diversion. If impoundments are created near the mine, the effect could be positive. New nesting of least terns in eastern Colorado has been attributed to the creation of new reservoirs (Kingery 1980). However, if water is diverted from nearby rivers such as the upper Missouri in the Dakotas, the effect on the associated fish and wildlife may be detrimental over a large area.

Mining Phase

The mining phase is probably the most important phase to the least tern because it is at this time that habitat is being altered, fill sites used, and water levels lowered and water quality reduced.

If development is planned for areas where least terns occur, the impact of the extraction will be minimized if water is diverted from reservoirs, impoundments, or lakes rather than free-flowing rivers. If rivers must be diverted, sufficient water volume must be maintained in the river bed that, during the summer months, a minimal flow is maintained sufficient to support fish populations.

Potential mining sites where water quality and isolated sandbars should be maintained to support terns are along the upper Missouri River in North Dakota below the Garrison Dam and along the Mississippi River in the southern extreme of Illinois (south of Cairo). These stretches are important for terns because they provide isolated open bars for nesting. In other parts of these rivers alteration by dams, riprapping, etc. has modified the riverbeds drastically. Water levels should be monitored carefully in these areas to ensure an adequate supply for fish populations and to provide isolated bars. High levels result in bar submergence, while low levels lead to land bridges between the river banks and the bars, causing mammalian predation.

Restricted access to nearby tern colonies may protect nests from human disturbance. Protection of water resources from wastes and erosion may prevent contamination of aquatic ecosystems.

Reclamation Phase

The major aspect of reclamation of a mining site to benefit least terns is the degree to which drainage is restored to the original condition. Drainages near major tributaries designed to decrease erosion may prevent turbidity problems.

The prevention of vegetation encroachment on sand-gravel areas near water bodies is an effective way to provide potential nesting areas for least terns and other ground nesters such as plovers.

Providing open, low piles of sandy material isolated from shore, and at least 1 m higher than the water level, is highly attractive to nesting least terns. Further, if fencing of some of these areas can be encouraged, mammalian predation on the tern colony could be reduced.

SUMMARY

Western surface coal mining may have relatively little impact on the least tern. Most maps of coal distribution indicate little mining potential near any of the major tributaries of the Mississippi River where the majority of the tern population is centered. Where development does occur, least terns are often attracted to the area because of the availability of sand and/or gravel piles which are used for nesting.

The chief detriment to the least tern would be a water diversion of several major tributaries of the Mississippi River to major energy facilities in the Montana-Dakota-Wyoming region. Reduced water flow especially in spring and summer would severely affect fish populations which would, in turn, be harmful to nesting terns at a time when food demand is at a peak. Dependence upon lakes and reservoirs rather than free-flowing rivers would help reduce the potential for impact on terns.

ACKNOWLEDGMENTS

I am grateful to C. Kimball for assistance in the preparation of the bibliography, to R. Clapp for generously providing a bibliography he had compiled on least terns as part of a report for the Biological Services Program, and to K. Hall for assistance in typing.

REFERENCES

American Ornithologists' Union. 1975. Report of the committee on conservation. Auk 92(4, suppl.):1B-16B.

____________. 1983. Check-list of North American birds. 6th ed. Allen Press, Inc., Lawrence, KS. 877 pp.

Anderson, M. Personal communication. U.S. Fish and Wildlife Service, Pierre, SD.

Bent, A. C. 1921. Life histories of North American gulls and terns. U.S. Natl. Mus. Bull. 113.

Blindell, R. M. 1975. Protection at little tern colonies. British Birds 68(6):250-251.

Blodget, B. 1978a. The effect of off-road vehicles on least terns and other shorebirds. M.S. Thesis, Univ. Massachusetts, Amherst. 76 pp.

____________. 1978b. The effect of off-road vehicles on least terns and other shorebirds. U.S. Natl. Park Serv. Coop. Res. Unit Rep. 26.

Buckley, P., and F. Buckley. 1976. Guidelines for the protection and management of colonially nesting waterbirds. Natl. Park Serv., No. Atlantic Regional Office, Boston, MA.

Cramp, J., W. R. P. Bourne, D. Saunders. 1974. The seabirds of Britain and Ireland. Taplinger Publishing Co., Inc., NY. 287 pp.

Davis, M. E. 1968. Nesting behavior of the least tern (*Sterna albifrons*). M.A. Thesis, Univ. California, Los Angeles. 72 pp.

Downing, R. L. 1973. A preliminary nesting survey of least terns and black skimmers in the East. Am. Birds 27:946-949.

____________. 1980. Survey of interior least tern nesting populations. Am. Birds 34(2):209-211.

Ducey, J. E. Unpub. (1981). Interior least tern (Sterna albifrons athalassos). U.S. Fish Wildl. Serv., Pierre, SD.

Erwin, R. M. 1978a. Coloniality in terns: the role of social feeding. Condor 80:211-215.

____________. 1978b. Population and colony site dynamics in selected Massachusetts waterbirds. Proc. Colonial Waterbird Group 1:19-25.

____________. 1979. Coastal waterbird colonies: Cape Elizabeth, Maine to Virginia, 1977. U.S. Fish Wildl. Serv. FWS/OBS-79/10.

Faanes, C. Personal communication. Northern Prairie Wildlife Research Center, U.S. Fish and Wildlife Service, Jamestown, ND.

Faanes, C., and G. Krapu. Personal communication. Northern Prairie Wildlife Research Center, U.S. Fish and Wildlife Service, Jamestown, ND.

Fisk, E. J. 1975. Least tern: beleagured, opportunistic, and roof-nesting. Am. Birds 29:15-16.

Galli, J. 1978. The colonial waterbirds of New Jersey--summer 1978. Annu. Rep. Div. Fish, Game Wildl., New Jersey Dept. of Environ. Protection, Trenton.

____________. 1979. 1979 aerial colony nesting waterbird survey for New Jersey. Annu. Rep. Div. Fish, Game Wildl., New Jersey Dept. of Environ. Protection, Trenton.

Ganier, A. F. 1930. Breeding of the least tern on the Mississippi River. Wilson Bull. 42:103-107.

Grover, P. B., Jr. 1979. Habitat requirements of Charadriiform birds nesting on salt flats at Salt Plains NWR. M.S. Thesis, Oklahoma State Univ., Stillwater.

Hagar, J. A. 1937. Least tern studies--1935 and 1936. Bull. Mass. Audubon Soc. 21(4):5-8.

Hardy, J. W. 1957. The least tern in the Mississippi valley. Michigan State Univ. Publ. Mus. Biol. Ser. 1(1):1-60.

Holt, F. T., J. F. Keefe, W. H. Lewis, W. L. Pflieger, and M. H. Sullivan. 1974. Rare and endangered species of Missouri, 1974. Missouri Dept. Conserv. and U.S. Soil Conserv. Serv.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution map prepared from American Ornithologists' Union (1983).

Jernigan, L. S., Jr. 1977. Comparison of least tern (Sterna albifrons antillarum) population size and nesting habitat on barrier and dredge islands in the North Carolina coastal zone. M.S. Thesis, North Carolina State Univ., Raleigh. 51 pp.

Kingery, H. 1978. Mountain west region. Am. Birds 32:1190-1194.

Kingery, H. 1980. Mountain west region. Am. Birds 34.

Lack, D. 1968. Ecological adaptations for breeding in birds. Chapman and Hall. London. 409 pp.

Marples, G., and A. Marples. 1934. Sea terns or sea swallows. London, Country Life Press, London. 227 pp.

Massey, B. W. 1974. Breeding biology of the California least tern (Sterna albifrons browni). Proc. Linnaean Soc. NY 72:1-24.

McDaniel, B., and S. McDaniel. 1963. Feeding of least terns over land. Auk 80:544.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04.

Moser, R. A. 1940. The piping plover and least tern nesting in Omaha. Nebraska Bird Rev. 8:92-94.

Nisbet, I. C. T. 1973. Terns in Massachusetts: present numbers and historical changes. Bird-Banding 44:27-55.

Peterson, R. T. 1947. A field guide to the birds. Boston, Houghton Mifflin Co.

Soots, R., Jr., and M. Landin. 1979. Development and management of avian habitat on dredged material islands. U.S. Army Eng. Waterways Exp. Tech. Rep. D5-78-18.

Stiles, B. F. 1939. The least tern in Iowa. Iowa Birdlife 9:19-21.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Thompson, S. M., and D. M. Forsythe. 1979. A comparison of least tern reproductive success in natural and artificial nesting sites. Bull. South Carolina Acad. Sci. 41:74. [Abstract only.]

Thompson, B. 1982. Personal communication. Nongame Program Leader, Texas Parks and Wildlife Department, Austin, TX.

BURROWING OWL (*Athene cunicularia*)

by

Jeffrey S. Marks and I. J. Ball
Montana Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
Missoula, MT 59812

SPECIES DESCRIPTION

The burrowing owl ranks eleventh in size among the 18 owl species in North America north of Mexico (Karalus and Eckert 1974). Burrowing owls are unique among North American strigiforms in that males average slightly larger than females in both weight and wing length. Average weight of 46 burrowing owls (31 males, 15 females) was 156 grams (Earhart and Johnson 1970).

The burrowing owl has a brown dorsum which is spotted and barred with white and buff. The venter is buffy, barred with brown. The wings and tail are brown with light bars (Grossman and Hamlet 1964; Zarn 1974). The white throat patches and eyebrows are used in displays (Thomsen 1971; Martin 1973). Burrowing owls have bright yellow eyes and lack ear tufts. Their long legs are sparsely feathered.

Adult females tend to be darker than males and more strongly barred on the venter (Thomsen 1971; Butts 1973; Martin 1973). Thomsen (1971) and Butts (1973) had difficulty in discerning plumage differences between sexes in museum specimens. The paler plumage of males is apparently due to fading, as the males spend relatively more time outside the burrow during daylight (Martin 1973). Posture differences exist between sexes (Thomsen 1971). Females generally perch in a more horizontal position than males. In the hand during the nesting season, females can be separated from males by the presence of a brood patch (Martin 1973).

DISTRIBUTION

The Western subspecies of burrowing owl (*A. c. hypugaea*) breeds from southern Manitoba across southern Canada to central British Columbia. The eastern border of its range lies along a line drawn between western Minnesota and southwestern Louisiana; the southern limit is uncertain but lies somewhere in central Mexico (American Ornithologists' Union 1983) (Fig. 21). Although

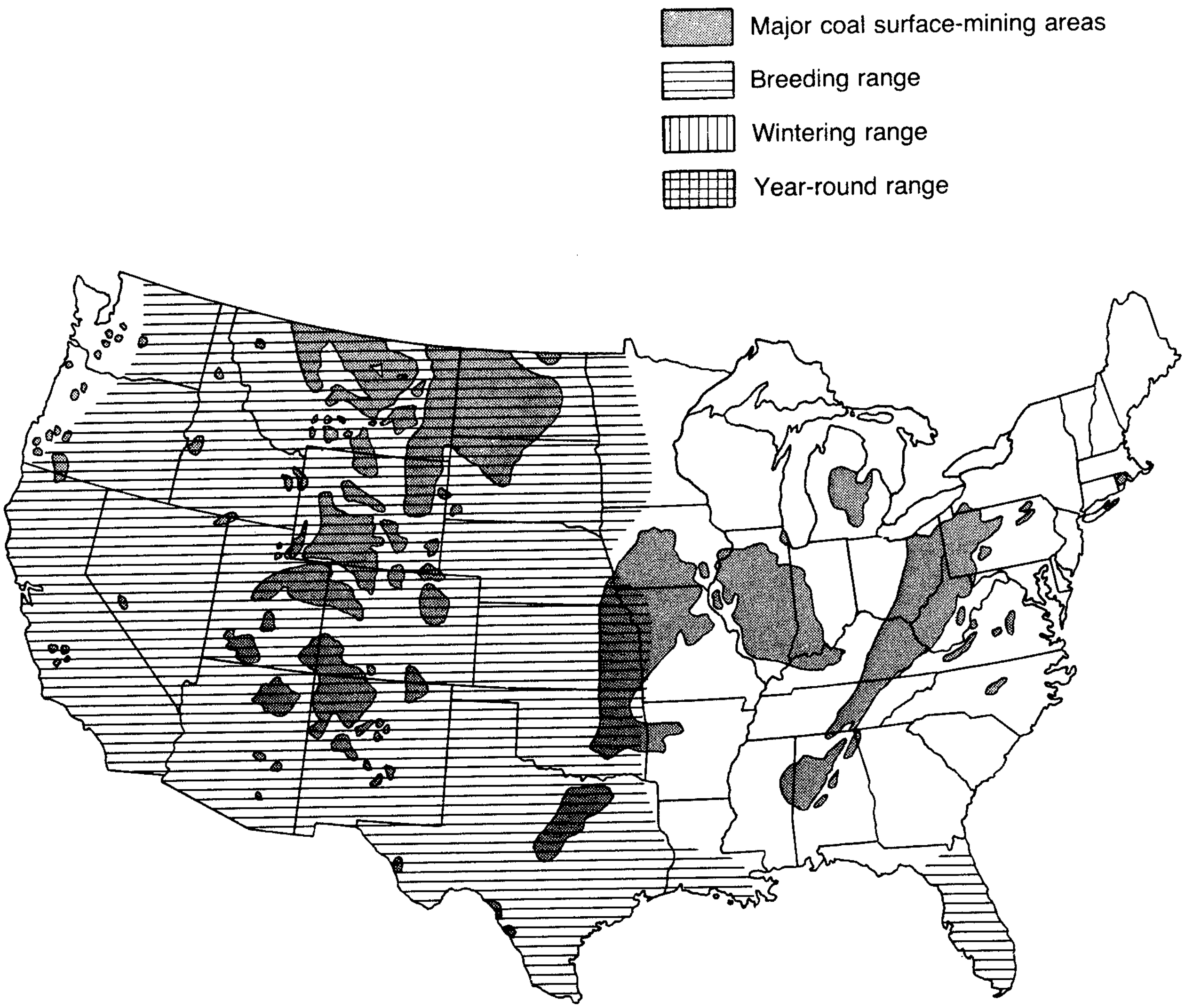


Figure 21. Geographical range of the western burrowing owl in relation to major coal deposits in the United States. After Inkley and Raley (1983).

burrowing owls are migratory in much of the United States, winter records exist as far north as Washington (Alcorn 1941; LaFave 1960). Banding studies indicate some South Dakota burrowing owls winter in Texas and Oklahoma (Brenckle 1936). Burrowing owls in Oklahoma (Butts 1973) and in New Mexico (Martin 1973) were absent from their breeding areas in winter. Marked owls in California were present on the breeding grounds year-round (Coulombe 1971; Thomsen 1971); immigrants also appeared during the breeding season (Coulombe 1971).

DIET

Burrowing owls prey extensively on invertebrates (Grant 1965; Maser et al. 1971; Smith and Murphy 1973a; Marti 1974; Gleason 1978; Gleason and Craig 1979). Most of the invertebrates identified in burrowing owl pellets were insects from the Orders Coleoptera, Dermoptera, and Orthoptera. Burrowing owls also capture a variety of small mammals, and although insects may be the most numerous prey, mammals generally contribute the most biomass (Smith and Murphy 1973a; Marti 1974; Gleason 1978; Gleason and Craig 1979). Small mammals are important burrowing owl prey (Errington and Bennett 1935; Longhurst 1942; Maser et al. 1971; and Thomsen 1971). Small rodents commonly found in burrowing owl pellets include voles (*Microtus* spp. and *Lagurus curtatus*), deer mice (*Peromyscus* spp.), harvest mice (*Reithrodontomys* spp.), pocket mice (*Perognathus* spp.), and kangaroo rats (*Dipodomys* spp.). Jackrabbits (*Lepus* spp.) are probably taken as carrion (Thomsen 1971; Smith and Murphy 1973a; Marti 1974). Burrowing owls also feed on ground squirrel (*Spermophilus tereticaudus*) carrion (Coulombe 1971).

Although birds are seldom recorded in burrowing owl diets, Neff (1941) collected 64 wings of nestling black terns (*Chlidonias niger*) and 16 wings of juvenile tricolored blackbirds (*Agelaius tricolor*) at the entrance of an active owl burrow near a marsh.

Burrowing owls occasionally capture reptiles (Coulombe 1971; Maser et al. 1971; Smith and Murphy 1973a; Marti 1974). Amphibians in burrowing owl diets include spadefoot toad (*Scaphiopus* spp.) (Sperry 1941; Bond 1942), Great Plains toad (*Bufo cognatus*), Pacific treefrog (*Hyla regilla*) (Coulombe 1971), and California newt (*Taricha torosa*) (Stoner 1932).

Burrowing owls catch some of their prey in daylight. They have poorer vision in low light than barn owls (*Tyto alba*), great horned owls (*Bubo virginianus*), and long-eared owls (*Asio otus*) (Marti 1974). Although they may not be as well-adapted for prey capture in darkness as other North American owls, noctural activity does occur (Best 1969; Coulombe 1971; Thomsen 1971; Butts 1973; Gleason and Craig 1979). The most intensive foraging activity occurs just after sunset and before sunrise (Coulombe 1971; Martin 1973). Burrowing owls exhibit seasonal variation in diet (Errington and Bennett 1935; Best 1969; Maser et al. 1971; Butts 1973; Marti 1974; Ross 1974). A shift from diurnal activity in summer to nocturnal activity in winter is probably related to changes in prey availability (Best 1969; Butts 1973). The ability of burrowing owls to shift activity periods, feed on a wide variety of prey species, and exhibit seasonal variation in diet indicate that they are opportunistic predators.

REPRODUCTION

The timing of arrival of burrowing owls on the breeding grounds varies geographically. In New Mexico, owls arrive from mid-March to early April (Martin 1973). Burrowing owls in Minnesota arrive in mid- to late April (Grant 1965). Courtship begins soon after arrival at the breeding site, and in some instances burrowing owls may arrive as pairs (Martin 1973). In a nonmigratory population near Oakland, California, pair formation began in early December (Thomsen 1971).

The burrow is the center of activity and provides the key to the ecology of burrowing owls (Coulombe 1971). Burrowing owls are strongly dependent on burrows constructed by badgers (*Taxidea taxus*) and rodents. Although evidence indicates one burrowing owl pair may have constructed a burrow, digging activities are typically limited to renovation of mammal burrows (Thomsen 1971).

Egg laying occurs from late March to early May. Data from museum and egg collections average 6.48 eggs/clutch (N = 439) (Murray 1976); the largest clutch was 11 eggs. Incubation does not begin until the clutch is nearly complete (Henny and Blus 1981) and lasts about 4 weeks (Zarn 1974; Henny and Blus 1981); only the female develops a brood patch (Howell 1964; Martin 1973). The male supplies the female with food during incubation and brooding (Thomsen 1971; Butts 1973; Martin 1973), and probably participates little, if any, in incubation.

The young emerge from the burrow when about 2 weeks old, and can fly at 6 weeks (Zarn 1974). The highest fledging success reported was 4.9 young per pair in New Mexico (Table 13). The young continue to receive food from the parents for several weeks after first flight. Young burrowing owls first forage independent of their parents in August in New Mexico (Martin 1973) and September in California (Thomsen 1971).

Habitat Use

Good burrowing owl habitat must be open, have short vegetation, and contain an abundance of burrows. Throughout their range, burrowing owls are birds of open country. The Florida subspecies (*A. c. floridana*) has expanded its range northward in response to extensive clearing of forest lands for agriculture (Ligon 1963; Courser 1979).

Table 13. Reproductive performance by burrowing owls in the United States.

Location	No. breeding pairs	No. young/pair	Source
Texas	56	3.6	Ross (1974)
New Mexico	15	4.9	Martin (1973)
California			
1965	9	4.4	Thomsen (1971)
1966	15	3.4	Thomsen (1971)
California	11	2.0	Vincenty (1974)
Oklahoma	54	4.7	Butts (1973)
Idaho	27	3.6	Gleason (1978)

Short vegetation is another conspicuous feature of burrowing owl habitat (Best 1969; Butts 1973). Burrowing owls used grassland tracts within 5 days after the tracts had been burned (Higgins and Kirsch pers. comm. 1980) and used severely overgrazed land in New Mexico (Ramirez pers. comm. 1980). Short vegetation may increase prey availability, enhance predator detection by the owls, and may attract burrowing rodents that provide nest sites for burrowing owls.

The third and most important component of burrowing owl habitat is the burrow. Coulombe (1971) states that "the distribution of burrowing owls coincides with the occurrence of colonial burrowing rodents, and local occurrences of these birds appear to be governed more by the suitability of burrow sites than by any other single factor."

In the Western United States, prairie dogs (Cynomys spp.) and ground squirrels (Spermophilus spp.) are the most important sources of burrowing owl nest sites. Burrowing owls in southeastern Idaho nest in badger burrows (Gleason 1978). Burrowing owls in southwestern New Mexico nest exclusively in kangaroo rat (Dipodomys spectabilis) burrows (Best 1969). Burrowing owls have also been observed in the burrows of marmots (Marmota spp.), skunks (Mephitis spp.), and nine-banded armadillos (Dasypus novemcinctus) (Bent 1938).

Burrowing owl use of abandoned prairie dog towns is minimal, and active dog towns are the primary habitat for the owls (Butts 1973). One obvious reason for this is that burrows may cave in as they deteriorate in the absence of burrowing mammals to maintain them. It is also possible that burrowing owls in active mammal colonies are less vulnerable to predation if they can respond to mammalian alarm calls. Prairie dogs trim vegetation within their colonies, presumably to improve visibility (Knowles pers. comm. 1981); the resulting decrease in vegetation height may enhance active colonies for burrowing owl use. Although burrowing owls often exhibit an affinity for active mammal colonies, they are not restricted to them. In southwestern Idaho burrowing owls usually nest in abandoned badger burrows, often far from active ground squirrel colonies (Marks pers. comm. 1981). Gleason (1978) observed burrowing owls nesting in cavities in basalt outcroppings.

POPULATION TRENDS

The U.S. Fish and Wildlife Service (1973) lists the burrowing owl as "status undetermined." The burrowing owl was a charter member of the National Audubon Society's "Blue List" of bird species exhibiting noncyclic population declines (Arbib 1971) and in 1982 was moved to the list of Species of Special Concern (Tate and Tate 1982). The Canadian Wildlife Service (1981) has placed the burrowing owl on the "threatened" list, which identifies species likely to become endangered in Canada if factors affecting their vulnerability are not reversed.

No overall estimates of burrowing owl populations exist for the United States, but their numbers clearly are decreasing in many areas (Zarn 1974). Little density information exists because of censusing problems (Gleason 1978); existing density figures do not accurately reflect burrowing owl status because of the clumping of owls in association with colonies of burrowing mammals (Zarn 1974).

Burrowing owl breeding densities in the United States range from one pair per 58 km^2 in Idaho to one pair per 0.0013 km^2 in Texas (Table 14). The highest densities are in active ground squirrel and prairie dog colonies. Most researchers have probably chosen the densest populations available for study purposes, so the resultant figures cannot be extrapolated to broad geographical areas.

Effects of Habitat Changes

Any habitat alterations that effect openness, vegetation height, and burrow availability have the potential to influence burrowing owl populations. Of these three components, vegetation height and burrow availability are the most critical. Burrowing owls in the West probably do not suffer for lack of open habitat, but the creation of open habitat is clearly responsible for the burrowing owl's northward range expansion in Florida. Burrowing owls stop using canal banks for nesting when the vegetation grows above the canal tops or becomes moderately dense along the banks (Coulombe 1971). Increased growth of vegetation due to reduced grazing pressure results in decreased use by

Table 14. Density estimates for burrowing owls in the United States.[a]

Location	Pairs/km^2	Burrow	Source
Texas	1/.0013	Prairie dog	Ross (1974)
Oklahoma			
Within colonies	1/.05	Prairie dog	Butts (1973)
Outside colonies	1/50	Badger	Butts (1973)
California			
Imperial Valley	1/.26	Ground squirrel	Coulombe (1971)
Oakland	1/.04	Ground squirrel	Thomsen (1971)
Utah	1/52	Badger	Smith and Murphy (1973b)
Colorado	1/38	Prairie dog	Olendorff (1973)
Idaho			
Native range	1/58	Badger, basalt	Gleason (1978)
Agriculture	1/23	Badger	Gleason (1978)

[a]Source: Gleason (1978).

burrowing owls (Butts 1973). The control of shrubs may improve burrowing owl habitat. Moderate to heavy shrub cover contributes to the low density of burrowing owls (Gleason 1978).

Burrow availability is the primary factor controlling distribution of burrowing owls. Loss of burrows results from agricultural development, road construction, housing developments, and the eradication of burrowing mammal populations. Prairie dog burrows deteriorate within 3 months to 3 years following disappearance of the mammals (Butts 1973; Ross 1974).

There is little information concerning the effects of habitat changes on burrowing owl prey populations. In a California burrowing owl population food did not appear to be a limiting factor (Coulombe 1971). Burrowing owls hunt over cultivated fields adjacent to nest sites. The cultivated land may contain "certain important prey items" in greater numbers than uncultivated land (Butts 1973).

Effects of Human Disturbance

Burrowing owls nest on the outskirts of cities (Abbott 1930), at airports (Thomsen 1971), and along well-used roads and highways (Coulombe 1971). The potential for human disturbance is great because the owls perch conspicuously near their nests and often allow close approach. Some burrowing owls in Oklahoma exhibited gunshot wounds (Butts 1973). Because prairie dogs and ground squirrels are used for target practice throughout the West, burrowing owls undoubtedly suffer some mortality from indiscriminant shooting. Two burrowing owl nests were destroyed when they were covered during construction of a parking lot (Vincenty 1974). A third nest was destroyed when motorcyclists ran over the burrow. Burrowing owls that nest along highways are vulnerable to passing automobiles.

Poisoning ground squirrel and prairie dog colonies not only degrades burrowing owl habitat by decreasing burrow availability, it may poison the owls as well. Burrowing owls have suffered in some areas from consumption of rodenticides (Tyler 1968; Butts 1973; Coulombe pers. comm. in Zarn 1974).

Management

Every effort should be made to preserve colonies of burrowing mammals that contain nesting burrowing owls. The following management recommendations have been paraphrased from Butts (1973), and although they are directed specifically to prairie dogs, most could also be applied to other burrowing mammals.

1. Prairie dog towns containing high concentrations of burrowing owls must be protected. Possible means of preservation include:

    a. The purchase of dog towns or at least an easement by a State or Federal government agency or by private conservation groups; and

b. Payments to landowners to compensate for damages inflicted by prairie dogs. An agreement to maintain dog towns at a fixed size could be included with the above measures. This could be accomplished by periodic control of prairie dogs along portions of the colony periphery not used by burrowing owls.

2. Refuge dog towns should be established on public land at regular intervals within the range of the burrowing owl. At the very least, dog towns should be established on national wildlife refuges and national grasslands.

3. Dog towns scheduled for poisoning campaigns should be thoroughly searched during the spring and summer to identify areas of burrowing owl use.

4. Poisoning of dog towns with treated grain should be restricted to winter months to minimize adverse effects on burrowing owls. If the dog towns must be poisoned during spring and summer, the poisoning should be restricted to fumigation of burrows unoccupied by burrowing owls.

5. Use of rodenticides should be restricted to those with low secondary toxicity to raptors.

6. Managers should develop an education program to emphasize the values of burrowing owls. Such a program is of greatest importance in areas where burrowing mammals are regularly shot for sport (Zarn 1974).

The artificial burrow is a promising management technique for burrowing owls. Collins and Landry (1977) have been very successful attracting owls to artificial nest structures. In one situation, a burrowing owl laid eggs in an artificial burrow 2 days after the burrow was installed. The artificial burrows developed by Collins and Landry are easy to install and inexpensive. The use of artificial burrows can be an important part of reintroduction efforts in areas where burrowing owl nesting habitat has been cultivated, or in areas where burrowing mammals have been exterminated. Anderson (1979) conducted a successful hacking experiment using an artificial burrow. Artificial burrows can be made with a removable top, thus allowing researchers to study burrowing owl breeding biology without destroying the nests. Henny and Blus (1981) have collected information on laying rates, incubation behavior and movements of young burrowing owls that would have been unobtainable if the owls had not nested in artificial burrows.

The Burrowing Owl as an Indicator Species

Burrowing owls are relatively tolerant of passive human disturbance, such as increased traffic or construction noise. Hence they are unlikely to serve as a valuable indicator species for monitoring the effects of general disturbance that accompanies surface mining activities.

Conversely, burrowing owls could probably serve as an adequate indicator of the success of reclamation efforts in establishing soil profiles that can support burrows, although the presence of burrowing mammals themselves would probably be easier to document and quantify.

The obvious preference of burrowing owls for open areas with low vegetation dictates caution in using this species as an indicator of success in land reclamation efforts: land with the inherent capability to produce vegetation too dense for burrowing owls might become suitable for them after a relatively unsuccessful reclamation effort. The complete dependence of burrowing owls on existing burrows complicates interpretation of the presence or absence of the species. This reliance could, however, be used to advantage in a monitoring program. We believe that the major situation in which burrowing owls would serve as an important indicator species would be where natural burrows are relatively scarce but habitat conditions are otherwise suitable. In this situation a route of artificial burrows could be established, with occupancy, clutch size, hatching success and fledging success monitored on and adjacent to mining areas before and after mining and reclamation. Reproductive success of burrowing owls would provide a sensitive measure of the re-establishment of invertebrate and small mammal fauna. Such a system could cover a broader spectrum of prey species if American kestrel (Falco sparverius) nest boxes were installed along the same route.

Disadvantages to an artificial nest burrow/box approach include the initial expense of installation and the fact that only part of the habitat requirements of the birds (i.e., food abundance and availability) would be monitored. However, the unmeasured component (natural burrows or cavities) is relatively easily monitored. Furthermore, the proposed system would allow the investigator to control a number of variables that can seldom be dealt with adequately in field studies: nest site availability, spacing between nests, nest site quality, and detectability of nest sites in differing habitats. Monitoring an artificial nest site route would be relatively fast (hence economical); and personnel changes would have little effect on continuity of data, in sharp contrast to any program that depends upon a field worker finding natural nests. Reproductive performance data, easily obtained from artificial nest sites but very time consuming or impossible to obtain from natural nests, provide infinitely more insight into population and ecosystem welfare than does mere presence or absence of breeding pairs.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts on burrowing owls may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining activities if nests and nestlings are destroyed. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population.

Increased human presence may impact burrowing owls through illegal shooting and harassment. An increase in dust levels from construction and mining activities and haul roads may have detrimental effects on vegetation, indirectly impacting burrowing owls through prey populations dependent on vegetation for food and cover. Deterioration of water supplies through increased runoff or mining wastes and byproducts may harm burrowing owls if ingested, or may have deleterious impacts on prey populations.

Most vertebrates tend to maintain populations at or near the capacity of the environment to support them. In raptors, this capacity is usually set by either food supplies or nest sites (Newton 1979). Thus, any environmental perturbation impairing the supply of an essential resource that is not superabundant will cause a decline in the population level. Depending upon the local situation, these essential resources for burrowing owls are most likely to be burrows and/or food supply. It seems likely that any activity having a measurable negative impact upon these resources will have a parallel negative impact on burrowing owl populations.

The most serious obstacle to projecting overall population impacts is the nearly complete lack of burrowing owl population data on and adjacent to coal lands and in secure portions of burrowing owl range. Considering the difficulties of surveying burrowing owls, it seems unlikely that broadscale population data are obtainable under any reasonably forseeable funding situation.

Information is needed on the relative proportion of the burrowing owl population that is on or adjacent to coal lands and the length of time required for successful reclamation of burrowing owl habitat.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Little information exists concerning mitigation for burrowing owls. Burrowing owls have readily accepted artificial burrows (Collins and Landry 1977; Henny and Blus 1981) but the acceptance of artificial or natural burrows by owls transplanted from burrows destroyed by surface mining has not been proven. The amount of disturbance from mining activities that burrowing owls will tolerate before nest desertion is unknown, as is the success with which colonies of burrowing mammals can become established on reclaimed lands. The following recommendations have not been tested and must be considered tentative. Sound mitigation procedures will be developed only after extensive testing and continued monitoring of burrowing owl populations on and away from areas of coal surface mining.

Premining Phase

Baseline information should be collected before beginning any mine-related activity (Thompson 1978; Kennedy 1980). Control areas away from mining sites should be chosen and monitored concurrently with the collection of baseline data on proposed mine sites. Survey information collected may include the number of burrowing owls present during the nesting season, including information on breeding attempts; information on hunting activity and habitat use; reaction of owls to man-caused disturbances; pellet collections throughout the nesting season to identify shifts in prey species composition during the breeding cycle; description of causes of mortality and nest failure; description of the nest burrow and surrounding habitat; and monitoring of prey populations (insects and small rodents).

Exploration and Development Phase

Exploration and development of mining facilities conducted during the nonbreeding period will result in the least impact to owls. Education of exploration crews and encouragement to avoid unnecessary activities near the locations of nest burrows and burrowing mammal colonies may alleviate disturbances during the breeding season.

Impacts may be lessened if roads and other facilities are constructed away from burrowing owl nests and not placed through colonies of burrowing mammals if alternate routes are available. If it appears that active nest burrows will be destroyed during exploration, relocation of the owls into natural or artificial burrows may minimize disturbances. Burrowing owls may be easily captured at occupied nest sites using medium-sized Havahart or Tomahawk live traps (Coulombe 1970; Martin 1971; Ferguson and Jorgensen 1981).

Mining Phase

The greatest disruption to burrowing owl habitat will occur during the mining process. Lockhart et al. (1980) urge that mine development be performed with consideration for the annual nesting cycle of raptors. They state that "Scheduling activities to facilitate nesting success of raptors is believed to be a strong measure for mitigation of impacts and may further promote the adaptability of raptors to high disturbance situations." In cases where destruction of burrowing owl nests is unavoidable, ample time to allow for relocating all owl nests will help to alleviate impacts. This includes time for construction of artificial burrows if no natural sites are available.

An important mitigation measure includes avoiding the destruction of mammal colonies containing a concentration of nesting burrowing owls. Buffer zones prohibiting mining activity may be set up on the colony periphery to minimize impacts. Increased impacts may be avoided if the colonies containing nesting concentrations of burrowing owls are not surrounded by lands disturbed by mining activity. Land managers should strive to preserve as much land as possible around areas of high burrowing owl concentration.

Dust control measures, such as paving roads, control of runoff, and proper disposal of byproducts and wastes, may prevent deterioration of surrounding habitat. Fencing or buffer zones around nearby colonies, and education of workers, may prevent impacts from harassment or illegal shooting.

Reclamation Phase

The recolonization of surface-mined lands by burrowing owls will be the most important measure of mitigation success. To ensure continued burrowing owl use, reclamation efforts should be directed to the enhancement of reclaimed lands for burrowing mammals. Such reclamation measures provide the soil type and vegetation most suitable to burrowing mammals. Thus, restoration of the land to a natural state should favor prey populations.

Reestablishment of burrowing owl populations will be helped if artificial burrows are constructed on reclaimed lands as well as lands adjacent to mining operations. All roads no longer needed can be converted to a natural state to reduce access to burrowing owl nest sites. Reclaimed lands should be monitored annually for burrowing owl occupancy. Ideally, occupied burrows should be observed for reproductive success and food habits. An inventory of burrowing mammals should also be conducted annually. Continued monitoring of control sites is essential in elucidating the impacts of surface mining and the success of mitigation efforts.

SUMMARY

Burrowing owl numbers have declined in recent years in the Western United States, and much of the Western coal deposits are located in areas inhabited by burrowing owls. The principal factor limiting burrowing owl numbers is nest site availability. The widespread eradication of colonial burrowing mammals and the conversion of native range into agriculture are largely responsible for the decrease in burrowing owl nest sites. Surface mining of coal poses a serious threat to Western burrowing owl populations because of the potential for reduction of suitable nest burrows and disruption of prey populations. Mitigation recommendations contained in this report include reestablishment of burrowing mammal habitat and use of artificial nests.

ACKNOWLEDGMENTS

D. M. Becker assisted in all phases of report preparation. Dennis J. Martin and Carl D. Marti commented on an earlier draft. We also acknowledge the many agency and university biologists who provided access to pertinent information.

REFERENCES

Abbott, C. G. 1930. Urban burrowing owls. Auk 47:564-565.

Alcorn, G. D. 1941. The western burrowing owl in Grays Harbor County, Washington. Murrelet 22:57-58.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th edition. Allen Press, Lawrence, KS. 877 pp.

Anderson, J. W. 1979. The burrowing owl in Sacramento. Bull. Sacramento Zool. Soc. 16:9-12.

Arbib, R. 1971. The blue list for 1972. Am. Birds 25:948-949.

Bent, A. C. 1938. Life histories of North American birds of prey (Part 2). U.S. Natl. Mus. Bull. 170. 482 pp.

Best, T. R. 1969. Habitat, annual cycle, and food of burrowing owls in southwestern New Mexico. M.S. Thesis. New Mexico State Univ., Las Cruces. 34 pp.

Bond, R. M. 1942. Food of the burrowing owl in western Nevada. Condor 44:183.

Brenckle, J. F. 1936. The migration of the western burrowing owl (Speotyto cunicularia hypugaea). Bird-Banding 7:166-168.

Butts, K. O. 1973. Life history and habitat requirements of burrowing owls in western Oklahoma. M.S. Thesis. Oklahoma State Univ., Stillwater. 188 pp.

Canadian Wildlife Service. 1981. Canadian endangered species.

Collins, C. T., and R. E. Landry. 1977. Artificial nest burrows for burrowing owls. N. Am. Bird Bander 2:151-154.

Coulombe, H. N. 1970. Physiological and physical aspects of temperature regulation in the burrowing owl (Speotyto cunicularia). Compar. Biochem. Physiol. 35:307-337.

______. 1971. Behavior and population ecology of the burrowing owl (Speotyto cunicularia) in the imperial valley of California. Condor 73:162-176.

Courser, W. D. 1979. Continued breeding range expansion of the burrowing owl in Florida. Am. Birds 33:143-144.

Earhart, C. M., and N. K. Johnson. 1970. Size dimorphism and food habits of North American owls. Condor 72:251-264.

Errington, P. L., and L. J. Bennett. 1935. Food habits of burrowing owls in northwestern Iowa. Wilson Bull. 47:125-128.

Ferguson, H. L., and P. D. Jorgensen. 1981. An efficient trapping technique for burrowing owls. N. Am. Bird Bander 6:149-150.

Gleason, R. S. 1978. Aspects of the breeding biology of burrowing owls in southeastern Idaho. M.S. Thesis. Univ. Idaho, Moscow. 47 pp.

Gleason, R. S., and T. H. Craig. 1979. Food habits of burrowing owls in southeastern Idaho. Great Basin Nat. 39:274-276.

Grant, R. S. 1965. The burrowing owl in Minnesota. Loon 37:2-17.

Grossman, M. S., and J. Hamlet. 1964. Birds of prey of the world. Bonanza Books, New York. 496 pp.

Henny, C. J., and L. J. Blus. 1981. Artificial burrows provide new insight into burrowing owl nesting biology. Raptor Res. 15(3):82-85.

Higgins, K. F., and L. M. Kirsch. 1980. Personal communication. U.S. Fish Wildl. Serv., Northern Prairie Wildl. Res. Cent., Woodworth, ND.

Howell, T. R. 1964. Notes on incubation and nestling temperatures and behavior of captive owls. Wilson Bull. 76:28-36.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Karalus, K. E., and A. W. Eckert. 1974. The owls of North America. Doubleday and Co., Garden City, NJ, New York, NY. 278 pp.

Kennedy, P. L. 1980. Raptor baseline studies in energy development. Wildl. Soc. Bull. 8:129-135.

Knowles, C. 1981. Personal communication. Ph.D. candidate, Zoology Department, Univ. Montana, Missoula.

LaFave, L. D. 1960. A burrowing owl wintering in eastern Washington. Murrelet 41:29.

Ligon, J. D. 1963. Breeding range expansion of the burrowing owl in Florida. Auk 80:367-368.

Lockhart, J. M., D. W. Heath, and C. L. Belitsky. Unpub. (1980). The status of nesting peregrine falcons and other selected raptor species on the Black Butte Mine lease and adjacent lands. U.S. Fish Wildl. Serv., Denver, CO. 59 pp.

Longhurst, W. M. 1942. The summer food of the burrowing owl in Costilla County, Colorado. Condor 44:281-282.

Marks, J. S. 1981. Personal communication. Montana Coop. Wildl. Res. Unit, U.S. Fish Wildl. Serv., Missoula.

Marti, C. D. 1974. Feeding ecology of four sympatric owls. Condor 76:45-61.

Martin, D. J. 1971. A trapping technique for burrowing owls. Bird-Banding 42:46.

____________. 1973. Selected aspects of burrowing owl ecology and behavior. Condor 75:446-456.

Maser, C., E. W. Hammer, and S. H. Anderson. 1971. Food habits of the burrowing owl in central Oregon. Northwest Sci. 45:19-26.

Murray, G. A. 1976. Geographic variation in the clutch sizes of seven owl species. Auk 93:602-613.

Neff, J. A. 1941. A note on the food of burrowing owls. Condor 43:197-198.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD. 399 pp.

Olendorff, R. R. 1973. The ecology of nesting birds of prey of northeastern Colorado. U.S. IBP Grassland Biome Tech. Rep. 211. 233 pp.

Ramirez, P., Jr. 1980. Personal communication. U.S. Fish and Wildlife Service, Ecological Services, Corpus Christi, TX.

Ross, P. V. 1974. Ecology and behavior of a dense colony of burrowing owls in the Texas Panhandle. M.S. Thesis. West Texas State Univ., Canyon. 62 pp.

Smith, D. G., and J. R. Murphy. 1973a. Late summer food habits of adult burrowing owls in central Utah. Raptor Res. 7:112-115.

______________. 1973b. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young Univ. Sci. Bull. Ser. 18:1-76.

Sperry, C. S. 1941. Burrowing owls eat spadefoot toads. Wilson Bull. 53:45.

Stoner, E. A. 1932. Notes on the western burrowing owl. Condor 34:228-229.

Tate, J. Jr., and D. J. Tate. 1982. The blue list for 1982. American Birds 36(2):126-135.

Thompson, L. S. 1978. Circle West Wildlife Baseline Study. Tech. Rep. 2. Energy Div., Montana Dept. Nat. Resour. and Conserv. 305 pp.

Thomsen, L. 1971. Behavior and ecology of burrowing owls on the Oakland Municipal Airport. Condor 73:177-192.

Tyler, J. D. 1968. Distribution and associates of the black-tailed prairie dog in Oklahoma. Ph.D. Dissertation. Univ. Oklahoma, Norman. 85 pp.

U.S. Fish and Wildlife Service. 1973. Threatened wildlife of the United States. Resour. Publ. 114.

Vincenty, J. A., III. 1974. A study of factors affecting nesting raptor populations in urban areas, Sacramento County, California-1974. California Dept. Fish Game, Wildl. Manage. Branch Admin. Rep. 74-5. 21 pp.

Zarn, M. 1974. Habitat management series for unique or endangered species-burrowing owl. U.S. Bur. Land Manage. Rep. 11, Tech. Note TN-250. 25 pp.

SPOTTED OWL (*Strix occidentalis*)

by

Eric D. Forsman
Oregon Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
Oregon State University
Corvallis, Oregon

SPECIES DESCRIPTION

The spotted owl (*Strix occidentalis*) is a medium-sized nocturnal owl that inhabits the mountains of the Western United States and Mexico. It is chunky and round-headed with a wingspan of about 102 cm and a body length of about 48 cm (Dawson 1909; Earhart and Johnson 1970; Walker 1974). Adults are dark brown with white spots on the back of the head and neck; the breast and abdomen are brown, barred with irregular rows of tawny-white blotches. The irises are dark brown, appearing black at any distance beyond a few meters. There are three subspecies which differ physically primarily in the darkness of their plumage and the amount of white spotting. The northern spotted owl (*S. o. caurina*) is the darkest race, the California spotted owl (*S. o. occidentalis*) is intermediate, and the Mexican spotted owl (*S. o. lucida*) is the palest race (Xantus 1859; Merriam 1898; Nelson 1903; Swarth 1915; Bent 1938). Some authors have suggested that *S. o. caurina* and *S. o. occidentalis* should be considered one subspecies (Oberholser 1915); in the checklist of the American Ornithologist's Union (1957), however, *caurina* and *occidentalis* are listed as separate subspecies.

The only other forest owl with which the spotted owl might be confused is the barred owl (*Strix varia*). The two species are similar in size, but the barred owl is grayish brown on the back and head and has vertical streaks of grayish brown on the breast and abdomen rather than the pattern of brown and white blotches that characterizes the spotted owl. At present, the barred owl co-occurs with the spotted owl only in British Columbia and Washington, but it is gradually expanding its range to include areas historically occupied by the spotted owl (Taylor and Forsman 1976).

Aside from its appearance, the most distinguishing characteristic of the spotted owl is its lack of fear of man. Spotted owls will usually allow human observers to approach within 2 to 5 m before they fly away. Some collectors have killed spotted owls by simply walking up to them and striking them with sticks (Bailey 1923; Ligon 1926). Females will sometimes remain on the nest until they are lifted off (Peyton 1909, 1910).

DISTRIBUTION

The spotted owl occurs in mountainous areas along the Western coast of North America, from southwestern British Columbia south to southern California (Bent 1938; Gabrielson and Jewett 1940; Jewett et al. 1953; Guiguet 1970; Forsman 1976; Gould 1977) (Fig. 22). It also occurs in the high mountains of eastern Arizona and New Mexico north to southern Utah and central Colorado, and east to the Guadalupe Mountains of western Texas (Bailey 1928; Phillips et al. 1964; Bailey and Niedrach 1965; Oberholser 1974; Craig and Webb 1980). South of the United States border, local populations apparently exist in the Sierra Madre Mountains at least as far south as Mount Tancitaro in the state of Michoacan (Nelson 1903; Friedman et al. 1950).

There are two records of spotted owls from Glacier National Park, Montana (Weydemeyer 1927; Hoffman et al. 1959). However, Wright (1977) reported that the record of Hoffman et al. (1959) was an error; the bird that was photographed was a barred owl, not a spotted owl. Shea (1974) did not observe spotted owls in Glacier National Park, but found the barred owl a common, permanent resident there. Weydemeyer's (1927) report was not documented by specimens or photographs and is questionable.

In all areas where it occurs, the spotted owl is a permanent resident (Bent 1938). Pairs can usually be found in the same areas year after year as long as suitable habitat is present (Peyton 1910; Bent 1938; Forsman 1976).

DIET

The diet of the spotted owl includes a variety of small mammals, birds and insects, and an occasional reptile or amphibian (Richardson 1906; Daggett 1913; Dawson 1923; Balmer 1924; Ligon 1926; Huey 1932; Bent 1938; Marshall 1942, 1957; Johnson and Russell 1962; Smith 1963; Maser 1965; Earhart and Johnson 1970; Forsman 1976; Beebe and Schonewald 1977). In Oregon, where the diet has been studied in the greatest detail, the northern flying squirrel (*Glaucomys sabrinus*) was the most common animal in the diet in the *Tsuga heterophylla* (western hemlock) Zone and the dusky-footed woodrat (*Neotoma fuscipes*) was the most common animal in the diet in the Mixed Confier and Mixed Evergreen Zones (Forsman 1976, 1980, 1981) [vegetative zones follow Franklin and Dyrness (1973)].

Small numbers of pellets collected by Marshall (1942) and Smith (1963) indicated that the flying squirrel is also a common animal in the diet of spotted owls in British Columbia and portions of the Sierra Nevada Mountains of California. In the southwestern United States and Mexico, various species of woodrats appear to comprise the nucleus of the diet, but insects are also heavily utilized during the summer (Ligon 1926; Huey 1932; Marshall 1957; Kertell 1978; Forsman unpub.). Spotted owl pellets collected in Utah contained

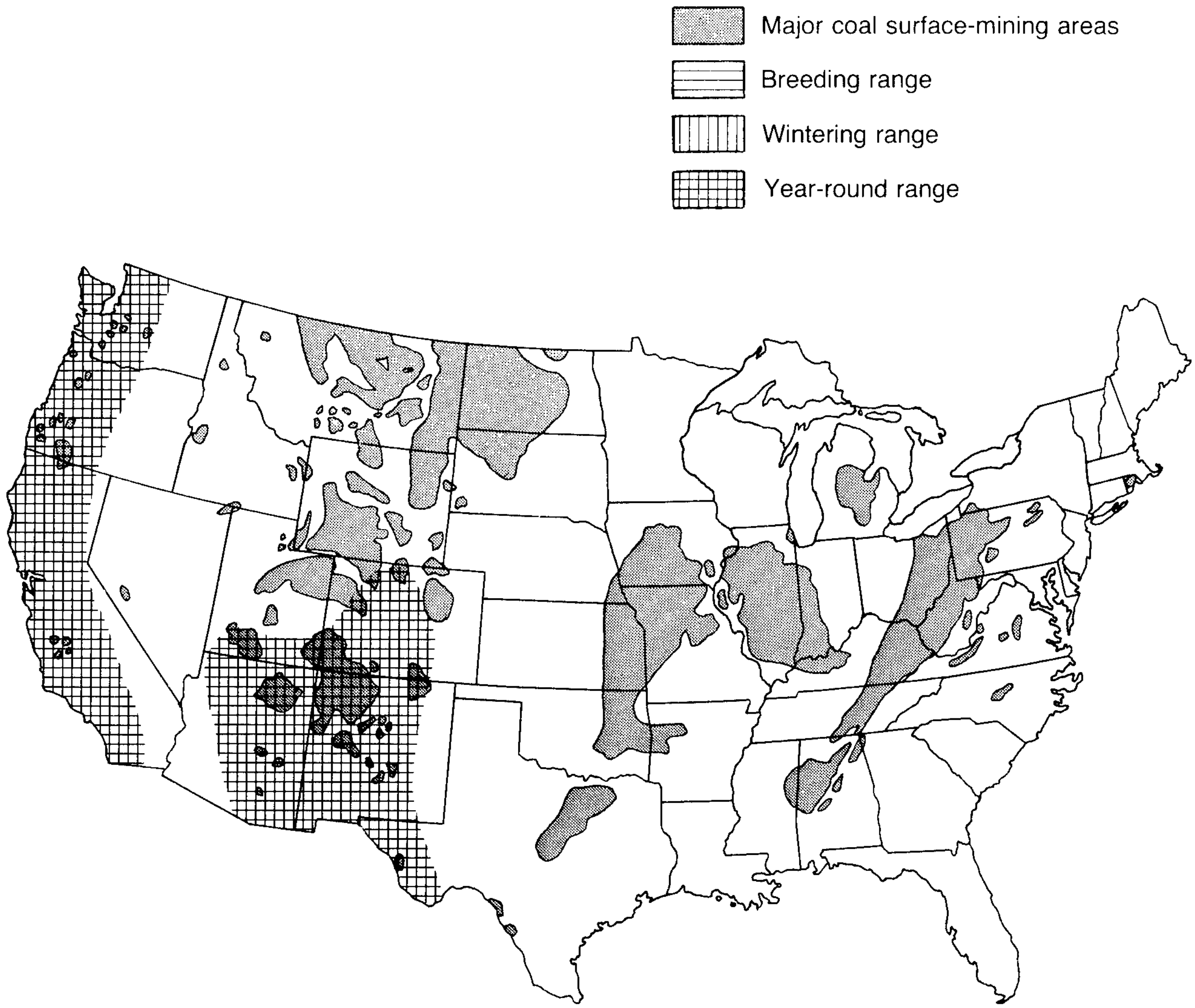


Figure 22. Geographical range of the spotted owl in relation to major coal deposits in the United States. After Inkley and Raley (1983).

predominantly woodrats along with mice (Peromyscus spp.), a pallid bat (Antrozous pallidus), and various species of Orthoptera and Arachnida (scorpion) (Wagner et al. 1982).

A report by Michael (1933) that spotted owls fed on muskmellon seeds, eggshells, and other human garbage was probably erroneous; I believe Michael mistook the feces of an omnivorous mammal for spotted owl pellets. Unfortunately, some reviewers (e.g., Bent 1938) have accepted Michael's report uncritically, and others have even embellished it. For instance, Karalus and Eckert (1974), offering no evidence of their own, reported that spotted owls were "fond of various forms of offal and garbage", and were seen most frequently near picnic garbage dumps. Analyses of over 4,000 spotted owl prey items in Oregon revealed no evidence that spotted owls ever fed on human garbage (Forsman 1976, 1980, 1981, unpub.).

A study of 14 radio-tagged spotted owls in Oregon indicated that they strongly preferred old-growth forests for foraging and generally avoided recent clear-cuts and second-growth forests younger than 25 years old (Forsman 1980, 1981). The owls may have avoided recent clear-cuts and young second-growth because their preferred prey (flying squirrel) was absent from such areas (Forsman 1980, 1981).

Foraging areas utilized by spotted owls in Oregon ranged from 549 to 3,390 ha (Forsman 1980, 1981); most foraging areas were between 920 and 1,400 ha. Marshall (1942) estimated that spotted owl foraging areas covered about 518 ha; his estimate was probably low compared with the data from Oregon because he had no way of following the owls at night except by listening to their calls.

In the southwestern United States and southern California, spotted owls apparently forage in areas where cliffs and steep-walled canyons are associated with pine-oak woodlands or spruce-fir forests (Swarth 1904; Dickey 1914; Ligon 1926; Brandt 1951; Marshall 1957).

REPRODUCTION

Spotted owls occupy the same foraging areas throughout the year. In February or March, the male and female on each territory begin to roost together near the traditional nest site (Forsman 1976, 1980).

In northern California and the Pacific Northwest, spotted owls roost primarily in dense forests where they can avoid exposure to high temperatures during the summer and wet weather during winter (Barrows and Barrows 1978; Forsman 1976, 1980, 1981). In Oregon, old-growth forests were strongly preferred for roosting, and mature forests were preferred over second-growth forests, apparently because older forests provide better protection from high temperatures and rainfall than do young forests (Forsman 1980, 1981). Old-growth forest includes a closed-canopy forest having trees over 200 years old at densities of 8/ha or greater (Forsman 1976). These forests usually include snags, decadent trees, and an abundance of cavities. Old-growth trees are commonly 178 to 228 cm dbh. Mature refers to trees or forest 100 to 200 years old, and second-growth refers to trees or forest under 100 years old. In the Southwest, spotted owls also use forests for roosting. However, in mountainous areas where vegetation is sparse, they also roost in caves or narrow defiles in cliffs where they can avoid exposure to high diurnal temperatures (Ligon 1926; Oberholser 1974; Kertell 1978; Forsman, unpub.).

Spotted owls nest in cavities or platforms in trees or in caves or ledges in rock cliffs (Bendire 1882; Dunn 1901; Dickey 1914; Ligon 1926; Bent 1938; Forsman 1976, 1980). Very rarely, nests may be located on the ground (Norris 1886; Lillie 1891). The use of caves and cliffs for nests is confined largely to the southern portion of the range. Of 47 nests examined in Oregon, 30 (64%) were in large cavities in old-growth trees and the rest were in various types of platforms in mature or old-growth trees. All of the platform-type nests had either been constructed by other raptor species in previous years or had formed naturally when falling debris was trapped on top of thick clumps of limbs. None of the owls constructed its own nest. Statements by Bendire (1882, 1892) that spotted owls built their own nests do not appear to be based on observation.

In the Southwest and southern California, spotted owls nest in forested canyons where steep cliffs, caves, and dense trees provide protection from high diurnal temperatures (Peyton 1910; Ligon 1926; Marshall 1957).

In northern California and the Pacific Northwest, dense coniferous forests are preferred for nesting, especially old-growth stands where a multi-layered forest canopy is present (Smith 1963; Forsman 1976, 1980, 1981). Nests are frequently, but not always, located within a few hundred meters of water (Peyton 1910; Forsman 1976).

Scattered observations in southern Utah indicate spotted owls are nesting in the State, although no information is available on numbers or breeding densities (Marti pers. comm.). Narrow, cool canyons are used for roosting and nesting; no information is available on foraging habitat in this area. Habitat surrounding these canyons usually consists of pinyon-juniper and areas of scattered trees.

Soon after they begin to roost together, adults begin to display and copulate in the vicinity of the nest each evening (Forsman 1976). Eggs are laid between March 1 and April 19, with most clutches initiated the last 10 days in March or the first week in April (Bent 1938; Forsman 1976). The average clutch size is two, but clutches of three are not uncommon. Clutches or broods of four are rare (Bendire 1892; Dunn 1901). Incubation and brooding are done entirely by the female. Incubation lasts approximately 32 days (Forsman 1976). From the time that incubation begins until the young are approximately 2 weeks old, the male provides all of the food for the female and young. Thereafter, the female begins to assist the male in foraging for the young (Forsman 1980). The young leave the nest when they are approximately 34 to 36 days old. Zarn (1974) may have been misinformed when he stated that spotted owls left the nest when only 7 days old. When they leave the nest, young spotted owls are very weak fliers, and frequently end up on the ground (Forsman 1976; Miller 1974). This generally is not a serious situation because the owlets are excellent climbers and can regain elevated perches by climbing up tree trunks or sloping logs (Beebe and Schonewald 1977; Forsman 1976). At least one observer who was unaware of the climbing ability of young spotted owls has suggested that adult spotted owls carried their young to elevated perches (Dickey 1914).

After leaving the nest in May or June, young spotted owls are fed by their parents until August or September (Forsman 1976, 1980). During this period, the young remain within the parental territory. The young become completely independent and leave the parental territories in September or October (Forsman 1980).

POPULATION TRENDS

Although recent surveys by Gould (1974, 1977), Forsman (1976, 1980, 1981), and others have indicated that the spotted owl is fairly common in some areas, it is generally believed that populations are declining in northern California and the Pacific Northwest as a result of habitat loss (Gould 1974, 1977; Forsman 1976; Forsman et al. 1977; Postovit 1979).

In Oregon and California, pairs of spotted owls are generally spaced 2.5 to 5.0 km apart in areas where suitable forest habitat is present (Marshall 1942; Gould 1974; Forsman 1976, 1980). Total populations are not known for these areas, but in Oregon over 600 pairs were located between 1970 and 1978 as a result of intensive census work by many different individuals (Forsman unpub.). I estimate that approximately half of the habitat that is suitable for spotted owls in Oregon has been searched for spotted owls in the past decade, so the total population is probably around 1,200 pairs. Gould (1977) reported 317 pairs located in California between 1974 and 1977, but did not make a population estimate for the state. Populations in Washington, Oregon, and northern California are declining as old-growth forests are harvested and replaced with young second-growth forests (Gould 1974; Forsman 1976, 1981; Forsman et al. 1977).

Spotted owl populations in the scattered mountain ranges of the Southwest are apparently small compared to populations in Oregon, Washington, and California (Swarth 1904; Phillips et al. 1964; Bailey and Niedrach 1965; Craig and Webb 1980). However, no concentrated effort has been made to census spotted owls in any of the mountains of the Southwest or Mexico, so it is possible that populations in those areas are larger than believed. Population trends in the Southwest are unknown. Historical records of spotted owls occur as far north as northern Colorado (Webb 1982). Recent observations record spotted owls in Mesa Verde National Park, Colorado (Webb 1982); and Zion National Park (Kertell 1977), Canyonlands National Monument (Webb 1982), and Capitol Reef National Park (Marti pers. comm.), all in southern Utah.

Effects of Habitat Changes

In northern California and the Pacific Northwest, old-growth forests are gradually being eliminated and replaced with intensively managed, second-growth forests. The harvest of old-growth forests removes the nest trees and roost areas utilized by spotted owls and also eliminates or greatly reduces their preferred prey species for many years after harvest (Forsman 1980, 1981). As a result, spotted owl populations in the northern portion of the species' range continue to decline (Forsman 1976, 1981, unpub.). In the Southwest, any habitat change that removes cliffs and caves used for nesting, or the forest areas around the nest sites used for foraging, would probably prevent spotted owls from nesting there.

Effects of Human Disturbance

Spotted owls are relatively tolerant of human presence, such as researchers or bird watchers, and use habitat with logging roads. Recreational activities, such as rock climbers, could potentially cause owls to abandon nest sites from repeated disturbances. Human presence that included large numbers of people, noise, and habitat disruption might deter spotted owls from using nearby habitat.

Shooting and other forms of vandalism are not a serious problem with the spotted owl because it is nocturnal and difficult to detect during the day. During the last 10 years in Oregon, I have heard of only one spotted owl that was injured by vandals (Pinto pers. comm.).

Management

The subspecies of the spotted owl appear to use widely different habitat types. In the Pacific Northwest, old-growth forests are important. In the Southwest, narrow canyons are used for nesting. Both habitats are important in their abilities to provide a cool environment for thermoregulation. Very little research has been conducted on spotted owls outside of the Pacific Northwest. Thus, management practices benefiting the subspecies *S. o. lucida* are speculative at best.

Between 1972 and the present, management of the spotted owl has become a major concern in the Pacific Northwest, where the owl is most threatened by habitat loss. In this region, an interagency wildlife committee of biologists from the U.S. Forest Service, U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, and State game agencies has been working since 1973 to develop a management plan for the spotted owl on commercial forest lands. In the most recent revision of the spotted owl management plan for Oregon and Washington (Oregon and Washington Interagency Wildlife Committee 1980), the interagency committee recommended that at least 405 ha of old-growth forest be maintained within a 2.4 km radius of nest sites utilized by spotted owls. This recommendation was based on radiotelemetry studies in Oregon in which it was found that most pairs of spotted owls utilized at least 405 ha of old-growth forest for foraging (Forsman 1980, 1981).

Full implementation of the management plan proposed by the Oregon and Washington Interagency Wildlife Committee has been delayed, pending additional research. I anticipate that similar management plans for spotted owls will eventually be initiated in northern California. Anyone wishing to correspond with members of the Oregon and Washington Interagency Wildlife Committee about spotted owl management should contact the Director of the Oregon Department of Fish and Wildlife, Portland, Oregon.

Where it is not possible to retain large areas of old-growth forest for spotted owls, the next best approach is to retain patches of dense old-growth around nest areas and principal roost areas (Gould 1974; Forsman 1976). This method may not work in all cases, but if it is occasionally successful it is certainly better than no management at all.

Any management for spotted owls that involves the retention of old-growth forests on commercial forest lands will considerably reduce wood production. It is doubtful, therefore, that more than a minimal effort will be made to protect spotted owls on commercial forest lands in Washington, Oregon, or northern California. Substantial declines in spotted owl populations should be expected in these areas during the next century.

The Spotted Owl as an Indicator Species

The spotted owl may serve as an indicator species in the Pacific Northwest because of its dependence on large tracts of old growth and mature forests. The species cannot be used as an indicator species in the Southwest because its habitat requirements are uncertain and its distribution appears to be scattered.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts of surface mining on spotted owls may occur through mortality, habitat loss, or increased stress. Mortality may occur if nests and nestlings are destroyed during construction and mining activities. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available. The ability of spotted owls to adopt new territories is unknown. The displacement may result in an ultimate reduction in the breeding population.

Increased noise levels may deter spotted owls from using suitable habitat, especially because vocalizations are important in communication. An increase in dust levels, increased erosion, and wastes and byproducts contaminating water sources may have detrimental effects on prey populations, or deter spotted owls from using suitable habitat. Increased human presence may result in harassment of birds, illegal shooting, or abandonment of nests.

Within the range of the spotted owl, the only major coal formations are in New Mexico, Colorado, Arizona, and Utah (Fig. 22). If surface mining is conducted in rugged mountains or canyonlands in the latter areas, the mined areas would be permanently eliminated as spotted owl habitat. The terrain would be leveled and the steep-walled canyons, cliffs, and caves that the owls require would be destroyed.

Underground mining of coal, such as is planned in southern Oregon, may have a small impact on spotted owl populations, primarily because of the construction of roads and above-ground support facilities. These impacts could be minimized by routing roads away from areas where spotted owls are known to occur. At worst, however, I do not expect that underground coal mining will have more than a minor effect on spotted owl populations, simply because the amount of deep coal deposits within the range of the spotted owl is small (Fig. 22).

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys should be conducted during the premining phase to determine the presence and location of spotted owls on the area proposed for development. The use of taped spotted owl calls and spotlights during the breeding season may assist in location of nests and territories. Areas searched should include narrow canyons and cliffs providing cooler microclimates, and the surrounding habitats. If possible, information should be collected on numbers and locations of owls, habitat use, prey utilization, and productivity levels.

Exploration, Mine Development, and Mining Phase

Avoidance of canyons with nesting spotted owls and establishment of a buffer zone of 405 ha within a 2.4 km radius of nest sites will help to alleviate impacts. Exploration activities should have minimal impacts on spotted owls if nests and territories are avoided. Control of dust and erosion, and proper disposal of wastes and byproducts, may prevent deterioration of adjacent habitat.

Reclamation Phase

Reclamation of spotted owl habitat is difficult because cliffs and canyons cannot be replaced, and foraging requirements are unknown. Establishment of native vegetation similar to premining communities may provide habitat for prey species.

SUMMARY

The spotted owl is an uncommon owl inhabiting old-growth forests of the Pacific Northwest and narrow, cool canyons of the Southwest. The diet includes flying squirrels, woodrats, and other small mammals. Nests are built in cavities or on platforms in trees in the Northwest, and in caves or crevices in canyons in the Southwest. Little information is available on habitat use and population size in the Southwest; numbers are low and distribution is uncertain. Impacts of mining on spotted owls are expected to be minimal in the Northwest. Impacts may be serious in the Southwest if canyons containing nesting spotted owls are destroyed.

REFERENCES

American Ornithologists' Union. 1957. Checklist of North American birds. Lord Baltimore Press, Baltimore, MD. Pages 285-286.

____________. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Bailey, A. M., and R. J. Niedrach. 1965. Birds of Colorado. Denver Mus. Nat. Hist., Denver, CO. Vol. I:432.

Bailey, F. M. 1923. Birds recorded from the Santa Rita Mountains in southern Arizona. Pacific Coast Avifauna 15:18.

____________. 1928. Birds of New Mexico. New Mexico Dept. Game Fish. Pages 330-332.

Balmer, A. 1924. (Untitled field report). Murrelet 5(1):13.

Barrows, C., and K. Barrows. 1978. Roost characteristics and behavioral thermoregulation in the spotted owl. Western Birds 9(1):1-8.

Beebe, G. D., and J. Schonewald. 1977. Spotted owls near Palomarin. Point Reyes Bird Observatory 43:6-7.

Bendire, C. E. 1882. The spotted owl. Ornithol. Oologist 7:99.

____________. 1892. Life histories of North American birds. U.S. Natl. Mus. Special Bull. 1:343-344.

Bent, A. C. 1938. Life histories of North American birds of prey. Part 2. Smithsonian Inst., U.S. Natl. Mus. Bull. 170:202-213.

Brandt, H. 1951. Arizona and its bird life. The Bird Research Foundation, Cleveland, OH. Pages 553, 589, 653-654.

Craig, G. R., and B. Webb. 1980. Population surveys of small owls. Colorado Div. Wildl., Wildl. Res. Rep., Part 2:195-207.

Daggett, F. S. 1913. Another instance of cannibalism in the spotted owl. Condor 15(1):40-41.

Dawson, W. L. 1909. The birds of Washington. Occidental Publishing Co., Seattle, WA. Vol. 2:465-467.

____________. 1923. The birds of California. South Moulton Co., San Diego, Los Angeles, and San Francisco. Vol. 3:1090-1096.

Dickey, D. R. 1914. The nesting of the spotted owl. Condor 16(5):193-202.

Dunn, H. H. 1901. The spotted owl (*Syrnium occidentale*). Oologist 18(11):165-167.

Earhart, C. N., and N. K. Johnson. 1970. Size dimorphism and food habits of North American owls. Condor 72(3):251-264.

Forsman, E. D. 1976. A preliminary investigation of the spotted owl in Oregon. M.S. Thesis. Oregon State Univ. 127 pp.

____________. 1980. Habitat utilization by spotted owls in the westcentral Cascades of Oregon. Ph.D. Thesis. Oregon State Univ. 95 pp.

____________. 1981. Habitat utilization by spotted owls on the Eugene District of the Bureau of Land Management. Unpubl. Tech. Rept., Bur. Land Manage., Portland, OR. 63 pp.

____________. Unpublished data. Corvallis, Oregon.

Forsman, E. D., E. C. Meslow, and M. J. Strub. 1977. Spotted owl abundance in young versus old-growth forests, Oregon. Wildl. Soc. Bull. 5(2):43-47.

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. U.S. For. Serv. Gen. Tech. Rep. PNW-8. 417 pp.

Friedman, H., L. Griscom, and R. T. Moore. 1950. Distributional check-list of the birds of Mexico. Part 1. Pacific Coast Avifauna 29:148.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis. p. 348.

Gould, G. I., Jr. Unpub. (1974). The status of the spotted owl in California. California Dept. Fish Game, Sacramento. (56 pp.)

____________. 1977. Distribution of the spotted owl in California. Western Birds 8(4):131-146.

Guiguet, C. J. 1970. Birds of British Columbia: (7) Owls. British Columbia Prov. Mus. Handb. 18:38-41.

Hoffman, R. S., R. L. Hand, and P. L. Wright. 1959. Recent bird records from western Montana. Condor 61(2):147-151.

Huey, L. M. 1932. Note on the food of an Arizona spotted owl. Condor 34(2):100-101.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Jewett, S. G., W. P. Taylor, W. T. Shaw, and J. W. Aldrich. 1953. Birds of Washington State. Univ. of Washington Press, Seattle. Pages 364-365.

Johnson, N. K., and W. C. Russell. 1962. Distributional data on certain owls in western Great Basin. Condor 64(6):513-514.

Karalus, K. E., and A. W. Eckert. 1974. The owls of North America. Doubleday and Co., Inc., Garden City, NY.

Kertell, D. 1977. The spotted owl at Zion National Park, Utah. Western Birds 8(4):147-150.

Ligon, J. S. 1926. Habits of the spotted owl (Syrnium occidentale). Auk 43(4):421-429.

Lillie, H. C. 1891. An April's outing. Oologist 8(10):200-202.

Marshall, J. T., Jr. 1942. Food and habitat of the spotted owl. Condor 44(2):66-67.

__________. 1957. Birds of pine-oak woodland in southern Arizona and adjacent Mexico. Pacific Coast Avifauna 32.

Marti, C. D. 1983. Personal communication. Department of Zoology, Weber State College, Ogden, UT.

Maser, C. 1965. Spotted owl preys on dusky three [sic] mice. Murrelet 46(3):46.

Merriam, C. H. 1898. Syrnium occidentale caurinum, a new owl from the Puget Sound region. Auk 15(1):39-40.

Michael, C. W. 1933. The California spotted owl in Yosemite Valley, CA. Condor 35(5):202-203.

Miller, G. M. 1974. Grace M. Miller on spotted owls. Pages 130-147 in L. W. Walker. The book of owls. Alfred A. Knopf, Inc., NY.

Nelson, E. W. 1903. Descriptions of new birds from southern Mexico. Proc. Biol. Soc. Washington, DC. 16:151-160.

Norris, J. P. 1886. Nesting of the spotted owl. Ornithol. and Oologist 11(9):142.

Oberholser, H. C. 1915. Critical notes on the subspecies of the spotted owl (Strix occidentalis) (Xantus). Proc. U.S. Natl. Mus. 49(2106):251-257.

__________. 1974. The bird life of Texas. Univ. Texas Press, Austin. Vol. 1:457-458.

Oregon and Washington Interagency Wildlife Committee. 1980. Spotted owl management plan for Oregon and Washington. Oregon Dept. Fish Wildl., Portland.

Peyton, L. 1909. From California. Oologist 26(6):93-94.

__________. 1910. Nesting of the spotted owl in northeastern Los Angeles County, CA. Condor 12(4):122-123.

Phillips, A. R., J. T. Marshall, and G. Monson. 1964. The birds of Arizona. Univ. of Arizona Press, Tucson. 212 pp.

Pinto, C. Personal communication.

Postovit, H. 1979. A survey of the spotted owl (Strix occidentalis) in northwestern Washington. Natl. Forest Products Assoc., Washington, DC. 15 pp.

Richardson, C. H., Jr. 1906. Cannibalism in owls. Condor 8(2):57.

Shea, D. S. 1974. Barred owl records in western Montana. Condor 76(2):222.

Smith, C. C. 1963. First breeding record of the spotted owl in British Columbia. Condor 65(5):440.

Swarth, H. S. 1904. Birds of the Huachuca Mountains, Arizona. Pacific Coast Avifauna 4:8.

__________. 1915. The status of the Arizona spotted owl. Condor 17(1):15-19.

Taylor, A. L., and E. D. Forsman. 1976. Recent range extensions of the barred owl in western North America, including the first records for Oregon. Condor 78(4):560-561.

Wagner, P. W., C. D. Marti, and T. C. Boner. 1982. Food of the spotted owl in Utah. Raptor Res. 16(1):27-28.

Walker, L. W. 1974. The book of owls. Alfred A. Knopf, Inc., New York 128-151.

Webb, B. E. 1982. Distribution and nesting requirements of montane forest owls in Colorado. M.A. Thesis, Univ. Colorado, Boulder.

Weydemeyer, W. 1927. Some new birds from western Montana. Condor 29(3):159.

Wright, P. L. 1977. Further bird records from western Montana. Condor 78(3):418-420.

Xantus, J. 1859. Catalogue of birds collected in the vicinity of Fort Tejon, CA, with a description of a new species of Syrnium. Proc. Phil. Acad. Nat. Sci. 1859:189-193.

Zarn, M. 1974. Habitat management series for unique or endangered species. Report 10. Spotted owl (Strix occidentalis). U.S. Bur. Land Manage., Denver Serv. Cent., Denver, CO.

LEWIS WOODPECKER (*Melanerpes lewis*)

by

Gary M. Koehler
Idaho Cooperative Wildlife
Research Unit
U.S. Fish and Wildlife Service
University of Idaho, Moscow 83843

SPECIES DESCRIPTION

The Lewis' woodpecker (*Melanerpes lewis*) is well-adapted for hawking flying insects and poorly adapted for excavating in tree boles. It is the most specialized of North American woodpeckers in the capture of flying insects (Bock 1970). It has wings proportionally larger than any other woodpecker, with a body length of 27 cm and a wing length of 16.5 cm (Jackman and Scott 1975; Jewett et al. 1953).

It does not excavate nesting cavities like most other woodpeckers because it lacks the heavy bill and the appropriate muscular structure characteristic of excavators. The sexes are similar in coloration. They have irridescent greenish-black backs and a gray collar. The throat and chest are gray, the belly rose, and the face is red to dull crimson.

DISTRIBUTION

The Lewis' woodpecker is widely distributed throughout the western half of the United States (Fig. 23). Its breeding range is from southern British Columbia, southwestern Alberta, and Montana, to south-central California, central Arizona, and southern New Mexico, and extends from the West Coast to southwestern South Dakota, northwestern Nebraska, and eastern Colorado (American Ornithologists' Union 1983; Bock 1970).

The winter range extends from northern Oregon and southern British Columbia to northern Baja California, northern Sonora, southern Arizona, southern New Mexico, western Texas to central Colorado, and south-central Nebraska (Bock 1970). It is listed as a casual in Saskatchewan, southern Manitoba, Minnesota, Wisconsin, southern Ontario, Illinois, Missouri, Arkansas, and central Texas (American Ornithologist's Union 1983), and as an accidental in Rhode Island (Bull 1974) and Massachusetts (American Ornithologists' Union 1983).

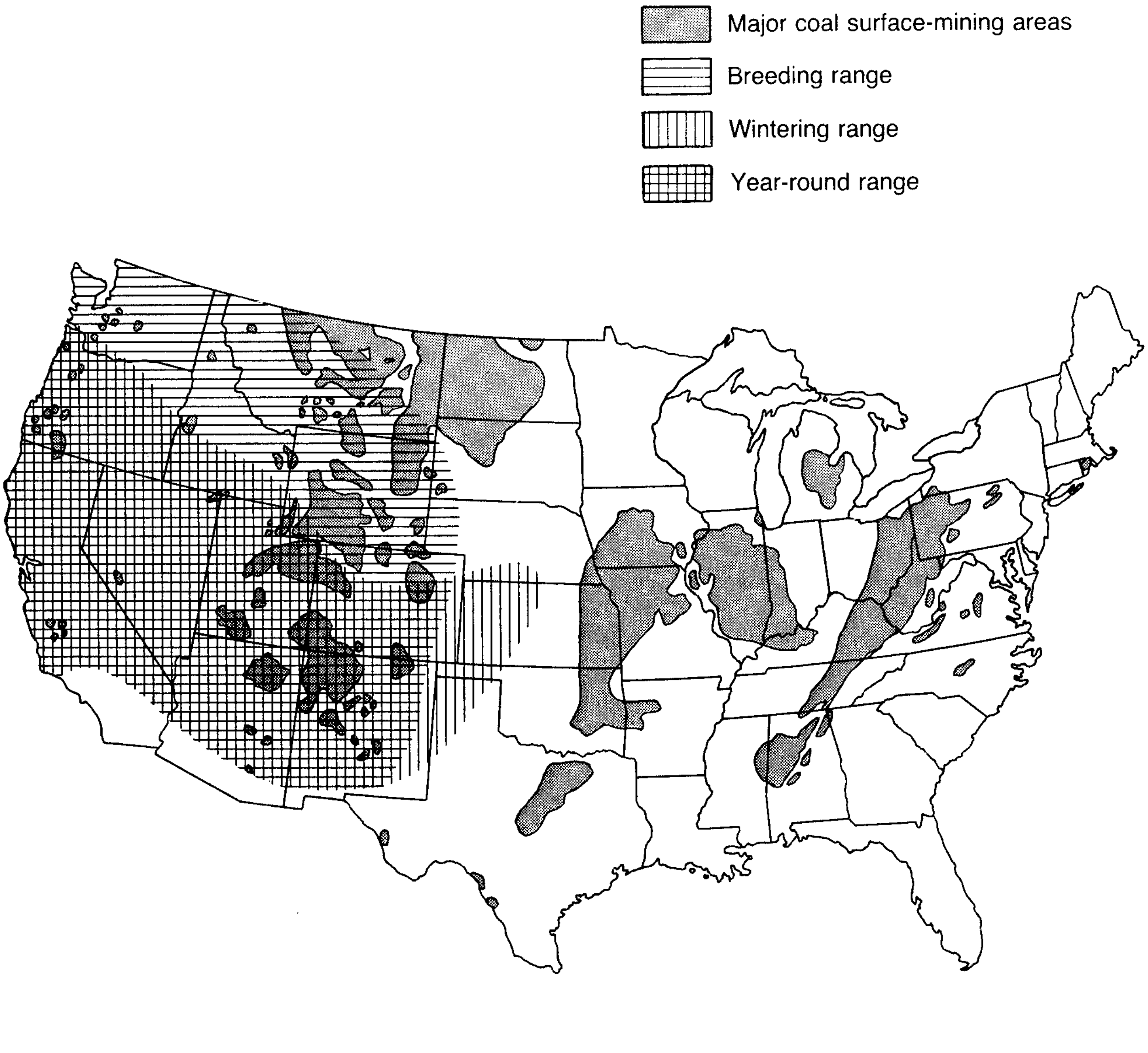


Figure 23. Geographical range of the Lewis' woodpecker in relation to major coal deposits in the United States. After Inkley and Raley (1983).

The range of the Lewis' woodpecker overlaps that of the red-headed woodpecker (Melanerpes erythrocephalus) in central Montana, eastern Wyoming, Colorado, and New Mexico (Scott and Patton 1975).

Although widely distributed over the West, the Lewis' woodpecker is only locally common where habitat and food are adequate. Its winter range and migration routes are determined by food availability. If food is abundant on the breeding range, it will not migrate, but if food is limited it will migrate to the nearest food source. In Colorado, for example, the species may move to lower elevations, whereas in Montana and Idaho it may migrate to Oregon and California (Bock 1970).

DIET

Lewis' woodpeckers are versatile foragers that eat a variety of food items. The diet may include 37% animal matter and 62% vegetable matter (Beal 1911). Only 7% of the yearly diet in Utah was animal matter, with the summer diet containing up to 23% animal matter (Snow 1941).

Acorns may comprise up to 34% of the vegetable matter in the diet (Beal 1911). In Utah, the winter diet may be 47% acorns (Snow 1941). Other vegetable items in the diet list are corn (Zea mays), pine (Pinus spp.) seeds, domestic fruits, and wild fruits and berries, including serviceberry (Amelanchier spp.), hawthorn (Crataegus spp.), dogwood (Cornus spp.), elderberry (Sambucus spp.), poison oak (Rhus spp.), strawberry (Fragaria spp.), raspberry (Rubus spp.), juniper (Juniperus spp.), prune (Prunus spp.), chokecherry (Prunus spp.), and mulberry (Morus spp.) (Beal 1911; Sherwood 1927; Jewett et al. 1953; Bock 1970; Maser and Gashwiler 1977). Sherwood (1927) observed snail and bird egg remains at a food storage site.

A large portion of the diet in oak (Quercus spp.) habitat during winter and fall consists of acorns and much time is spent storing acorns. The Lewis' woodpecker does not excavate holes for storing mast as does the acorn woodpecker (Melanerpes formicivorus), but uses natural crevices or cracks in power poles, dead trees, and bark of oak trees (Bock 1970). Corn may also be stored in cracks in utility poles (Law 1929) and cottonwoods (Populus spp.) (Hadow 1973). Food stores are defended against intruders, including other species of birds as well as other Lewis' woodpeckers (Bock et al. 1971).

Oak woodlands and commercial nut orchards are preferred habitats during the winter (Bock 1970). Snags, utility poles, fence posts, and trees are used for storing food, perching, and scanning while on the winter range.

Insects eaten by Lewis' woodpeckers include beetles of various species, grasshoppers, crickets, ants, various species of flies, and insect larvae (Beal 1911; Sherwood 1927; Snow 1941; Bock 1970). Insects are the preferred food in plains and foothill regions (Hadow 1973). Lewis' woodpeckers in California are attracted to areas with abundant grasshoppers (Williams 1905). Wood-boring insects rarely occur in the diet because these woodpeckers are weak excavators (Martin et al. 1951; Bock et al. 1971).

The Lewis' woodpecker is well-adapted for catching airborn insects. These woodpeckers feed on winged carpenter ants and emerging diptera in a manner similar to swallows, flycatchers, and bluebirds (Bock 1970). Scanning or looking for flying insects is an important behavioral attribute for hunting insects. Lewis' woodpeckers spend about 66% of their insect-hawking time scanning. They scan from prominent perches on low stumps, fence posts, and the tops of tall trees using isolated and conspicuous perches that afford a clear view of the surrounding areas. Seventy-two percent of the perches used by Lewis' woodpeckers were dead trees, power poles, and fence posts; the remainder were live trees (Bock 1970).

The insect-hunting behavior of Lewis' woodpeckers requires savannah or park-like areas with snags, fence posts, utility poles, or dead trees for perching. Preference for perching on low stumps or tall trees depends on the types of insects being hunted (Jackman 1974). Shrubs are an important component of good feeding habitat because shrubs provide habitat for insects. Lewis' woodpeckers are year-round residents among the agricultural areas of southeastern Colorado where they hawk for insects over open fields (Bock et al. 1971).

Lewis' woodpeckers may also feed on the ground in a manner similar to that of the northern flicker (Colaptes auratus) or they may forage among shrubs for larvae, beetles, and tent caterpillars (Bock 1970). They often search for insects, particularly ants, by probing into crevices on limbs and trunks of trees.

In pine forests the hawking of flying insects accounts for 58% of foraging time, while feeding on the ground and in shrubs accounts for 32%, and gleaning the remaining 10% of foraging time (Bock 1970). Forty-six percent of foraging time in oak woodland communities is spent hawking insects, 26% is spent feeding on the ground and in shrubs, 18% is spent in gleaning, and 11% in storing acorns. Lewis' woodpeckers foraging in oak and orchard woodlands during the winter may spend 71% of their foraging time hawking insects and 13% gleaning (Bock 1970).

The omnivorous diet and varied foraging behavior of the Lewis' woodpecker allow this bird to utilize a variety of habitats for feeding. Foraging habitat includes grass/forb communities, shrub/seedling forest communities, and young, old, and mature forests that vary in age from 40 years to more than 160 years. Marsh communities, riparian and deciduous forests, and ecotones in ponderosa pine forests are also used (Snow 1941; Thomas et al. 1979b).

REPRODUCTION

Lewis' woodpeckers nest during May, June, and July, and rarely as late as September (Jewett et al. 1953). Nesting may begin 3 to 4 weeks earlier in lowland habitats than in mountainous regions (Bock 1970). It is believed that Lewis' woodpeckers pair for life. They lay 5 to 9 eggs, with 6 or 7 most common (Bent 1964) and both the male and female incubate. Incubation takes 12 to 16 days (Johnsgard 1979), and the nestlings fledge at 21 to 34 days of age (Bent 1964; Bock 1970).

This woodpecker often nests in small colonies (Currier 1928; Bock 1970). The feeding territory, which averages about 6 ha (Jackman 1974), is not defended; the immediate nest site is defended (Bock 1970).

Lewis' woodpeckers will nest either in existing cavities or use decayed tree trunks and limbs which are easy to excavate. Existing cavities are preferred because this species is not well-adapted for excavating (Bock 1970; Harrison 1979). Thomas et al. (1979a) observed a preference for nesting in trees that are in an advanced (stage 7) state of decomposition. A variety of tree species is used for nesting: willow (Salix spp.), poplar (Populus spp.), boxelder (Acer negundo), dead ponderosa pine (Pinus ponderosa), dead oak, hollow limbs of live oak, and hollow sections of living pine (Bent 1964; Bock 1970).

Nest trees are generally large and have broken tops (Bent 1964). They are taller than 9 m and the diameter at breast height (dbh) is larger than 30 cm (Bent 1964; Bull 1978). The average height of nest cavities above ground in California was 7.3 m, with a range of 3 to 12 m (Bock 1970); and in the Pacific Northwest ranged from 1.5 to 51.8 m above ground (Jackman and Scott 1975).

The Lewis' woodpecker requires open habitat for nesting because of their insect-hunting behavior. Preferred habitat is savannah or park-like with a brushy understory such as old burns, bottomlands along rivers, or habitats with a mature cottonwood overstory and shrub understory (Bock et al. 1971). Logged and burned areas are used if an adequate number of trees or snags are left for nesting and perching and if there is a brushy understory for foraging. Most use in burned areas occurs when shrubs have become established, usually about 10 years after a fire (Bock 1970). Dense sapling stands do not provide good habitat (Bock 1970).

Thirty-four of 36 nests in southeastern Colorado were located in agricultural areas (Bock et al. 1971). The Lewis' woodpecker in Washington uses the ponderosa pine transition zone, tall cottonwoods along streams, borders of clearings, and burned areas (Jewett et al. 1953). The woodpecker nests in juniper forests in Oregon (Maser and Gashwiler 1977) and in boreal forests and burned areas in Idaho (Levy 1962). Breeding habitat includes riparian woodlands, open pine forests, and orchards in New Mexico (Hubbard 1970). Nesting habitat in the Great Plains includes coniferous and deciduous forests, edges of pine forests, burned areas, orchards, and pinon-juniper (Pinus edulis-Juniperus spp.) woodlands (Johnsgard 1979).

A variety of habitats are used in the Blue Mountains of Oregon, including riparian deciduous forests, ponderosa pine, mixed conifer forests, and marsh areas (Thomas et al. 1979b). Successional stages used for nesting include grass/forb communities, shrub/seedling stands less than 10 years old, young forests 40 to 79 years old, and mature and old-growth forests 80 years old and older. Understory shrubs in ponderosa pine habitats where nesting occurred include sagebrush (Artemisia spp.), golden currant (Ribes aureum), rabbit brush (Chrysothamnus spp.), and bitter brush (Purshia tridentata) (Jackman 1974).

Lewis' woodpeckers nest at elevations up to 2000 m in Arizona (Bock 1970) and to 2600 m in Colorado (Bent 1964).

POPULATION TRENDS

The Lewis' woodpecker was listed on the National Audubon Society Blue List as common, widespread in occurrence, but substantially reduced in numbers either regionally or throughout its range (Arbib 1979) and in 1982 was listed as a Species of Special Concern (Tate and Tate 1982). The species is only moderately adaptable to changes in breeding habitat, selecting only a few types of forest communities for nesting (Thomas et al. 1976).

The Lewis' woodpecker is associated with only two or three plant communities and successional stages in the ponderosa pine forest of the Blue Mountains of the Pacific Northwest and is a sensitive environmental indicator of habitat alteration in the ponderosa pine community (Diem and Zeveloff 1980). Thomas et al. (1979b) assigned a low adaptability and versatility value to the Lewis' woodpecker because of its restrictive habitat requirements, and the U.S. Forest Service has classified it as a species of special interest.

Effects of Habitat Changes and Human Disturbance

The Lewis' woodpecker is a highly evolved insect forager and is well-adapted for feeding in open park-like areas. Open savannah-like habitats are required for both breeding and wintering. Other important habitat components include snags or trees which are used for perching and food storage, rotten snags for nesting, and shrubby understory for hunting. Oak forests are utilized during the winter as a source of mast. Impacts that adversely affect these components would be detrimental to this species.

Impacts which alter stream flows and adversely affect riparian habitat, i.e., damming, deep well pumping, and stream channelization, are detrimental activities. Woodcutting, as well as intensive cattle grazing and intensive farming, may also have detrimental effects.

Lewis' woodpeckers become greatly agitated by prolonged human interference at or near their nest sites (Bock 1970). This interference may occasionally cause the birds to desert their nests.

Human activities may also have positive effects. Practices which produce open habitat with an understory of shrubs or lush forbs may benefit these woodpeckers; examples include forest thinning, selective logging, selective use of herbicides, low-intensity controlled fires, and controlled grazing. The Lewis' woodpecker uses orchards but may damage fruit and nut crops (Beal 1911; Bock 1970).

Management

Management to favor Lewis' woodpeckers may involve: allowing forest fires to burn and shrubs to grow; preventing overgrazing, which is detrimental to the shrub understory; maintaining oak groves for winter habitat; retaining standing snags and dead trees for nests, perching, roosting, and food storage; and leaving dying trees, trees that are distorted by wind and disease, and dead trees with broken tops (Jackman and Scott 1975).

The size of management units for Lewis' woodpeckers should reflect a feeding territory size of 6.1 ha (Bull et al. 1980).

A snag density of 249 snags/100 ha is required to maintain the maximum breeding population in ponderosa pine forests while 199 snags/100 ha would provide snags for 80% of the maximum population, and 50 snags/100 ha would provide breeding habitat for only 20% of the maximum population that could occur in ponderosa pine habitats (Thomas et al. 1979a).

Decayed snags or trees with decayed limbs or existing cavities are required for nesting. Snags, trees, utility poles, and fence posts with existing crevices are required for storing food on the winter range. Snags which show signs of decay or have conks and broken tops should be retained (Bull et al. 1980). The minimum dbh of snags should be 30.5 cm with a minimum height of 9.1 m (Bull et al. 1980).

A mixed coniferous forest managed on a 240-year rotation will provide adequate nesting habitat. Logged areas will be used for nesting and feeding habitat only if snags are left for nesting and perching and shrubs are left for foraging. Herbicides used to control shrub growth prevent formation of good habitat for Lewis' woodpeckers (Jackman 1974).

The Lewis' Woodpecker as an Indicator Species

The Lewis' woodpecker is listed as a "Migratory Bird of High Federal Interest" for the Uinta-Southwestern Utah Coal Production Region in Utah and Colorado and the Powder River Coal Production Region of Montana and Wyoming (BLM Instruction Memorandum No. 80-126 and No. 80-41). It is listed because of its value as an indicator species, and its regional decline in population or a susceptibility for population decline, and vulnerability to long-term impacts from human activity. Federal lands which are high priority habitat for birds of high Federal interest may be considered unsuitable for all or certain stipulated methods of coal mining (Criterion No. 14 of 43 CFR 3461.1). The Lewis' woodpecker is also on the National Audubon Society List of Species of Special Concern because of its regional population decline (Tate and Tate 1982). It is considered a valuable indicator of habitat disruption in the ponderosa pine and riparian communities, because of the limited number of habitats used for nesting (Diem and Zeveloff 1980).

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts on Lewis' woodpeckers may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining activities if nests and nestlings are destroyed. The most serious impacts would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population. Dust from survey and haul road construction, test drilling, and blasting may result in negative impacts on breeding birds and insect prey populations. The woodpecker is very sensitive to disturbance and may abandon nests if human activity, noise, and blast shock waves become intolerable.

The construction of support facilities, transmission lines, water supply, and waste disposal facilities will also destroy habitat or result in indirect threats to Lewis' woodpeckers. Electrical transmission lines pose a collision hazard to all avifauna (Moore and Mills 1977), and migrating flocks of Lewis' woodpeckers may be vulnerable to collisions with power lines. Water supply contamination and development may alter stream flow and aquifer levels and adversely affect riparian habitats critical for breeding and wintering in arid regions and lowland areas.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Many of the impacts of surface coal mining on Lewis' woodpeckers may be effectively mitigated during the premining and mining phase. Reclaimed lands may provide adequate habitat in a relatively short time if proper reclamation procedures are initiated.

Recommendations for mitigation can be formulated from literature on the biology and ecology of the woodpecker. Many of the impacts from mining on the bird are unknown or speculative. It is thus important to monitor populations in mining areas to determine and, where possible, avert any negative impacts. Information is needed on the effects of mining activity on riparian habitat and the effects of blasting, dust, and increased human activity on the nesting behavior of the woodpecker and on its insect prey base.

Premining Phase

Lewis' woodpeckers are unevenly distributed throughout their range because of their specific habitat requirements. The bird can be sensitive to habitat alterations because of its specialized hunting behavior and nesting requirements. Their populations should be monitored closely when the bird occurs in areas of mining activity. Censuses should be conducted during both breeding seasons and winter periods for at least the 2 years prior to mine developement to determine actual use of an area. If habitat appears adequate, but woodpeckers are absent, the areas should be treated as potential habitat.

Suitable mitigation areas may be provided by enhancing unused forest areas if habitat will be destroyed during the mining operation. Habitat enhancement might involve selective burning or thinning to promote snags and proliferation of brush. Snags may be produced artificially by frill girdling followed by innoculation of the trees with a decay fungus. Density of snags should approach 2.49/ha. Snags with a dbh of 30.5 cm and height of 9.1 m will provide adequate nesting and roosting cavities.

Riparian habitats are important breeding areas for Lewis' woodpeckers at lower elevations and in arid regions. Water quality and quantity should also be monitored closely throughout the mining operation so that subtle changes do not occur that cause damage to riparian areas.

Migration routes should be considered when planning placement of electrical transmission lines.

Sanctuaries should be established in riparian habitats and forested areas to preserve local populations. The sanctuaries should be at least 6 ha in area and they should be connected by corridors of suitable habitat. Such sanctuaries should be protected from woodcutting and from disturbances during nesting seasons.

Exploration, Mine Development, and Mining Phase

Road building and surface mining have similar adverse impacts due to noise, blasting tremors, dust, and destruction of habitat. Allaire (1978) suggested a buffer zone of at least 100 m should separate the active mine from the breeding grounds if a mining operation is next to environmentally critical areas where "Blue List" or endangered species occur. He also suggested that birds may become accustomed to blasting if blasting is conducted on a regular daily or weekly schedule. Blasting on calm days or days when the dust will not blow into forest habitat will have a lessened impact on woodpeckers. Spoil piles and hauling roads may be constructed in a way to minimize the effects of dust. Paving roads, covering conveyor belts, and mulching wind-erodable areas may be effective in dust reduction (Moore and Mills 1977). The impacts of dust on insect populations could be monitored during the entire mining operation to determine impacts to woodpecker prey populations. Control of runoff and proper disposal of wastes and mining byproducts may prevent deterioration of water resources. Placement of transmission lines to avoid heavy woodpecker use areas and migration pathways may alleviate effects of collisions.

Reclamation Phase

Populations of Lewis' woodpeckers may respond favorably to the early phases of reclamation, because this species uses early successional forest communities and grass-forb habitats for feeding. A favorable response is dependent, however, on providing good habitat early in the reclamation phase. This requires planting shrubs as well as grasses and forbs.

Key understory species for reclamation in the ponderosa pine community include sagebrush, golden currant, rabbit brush, and bitter brush (Jackman 1974). Junipers and fruit or nut trees are recommended for planting, particularly in areas of winter habitat.

Lewis' woodpeckers need fence posts, low stumps, power poles, snags, or dead trees for perching and scanning for flying insects. Posts and poles with a variety of heights should be placed on reclaimed sites because the height of perches used by the bird is dependent on the species of insect being hunted (Jackman 1974). The perches must be isolated and conspicuous, affording a clear view of surrounding areas (Bock 1970). These posts can also be used by the woodpecker for the storage of food.

Snags should be left or non-creosoted poles should be placed on reclaimed sites for nesting. These should retain existing cavities or be in such a state of decay that cavities may be easily excavated by these woodpeckers. Snags or poles should have a minimum dbh of 30.5 cm and a minimum height of 9.1 m (Bull et al. 1980). A snag density of 249 snags/100 ha will provide nesting, roosting, perching, scanning, and food storage requirements.

SUMMARY

The Lewis' woodpecker inhabits a variety of forest types in the Western United States. However, these habitats must provide for hawking for insects in open areas and storing mast for winter. This woodpecker also requires existing cavities in snags or decayed trees for nesting. For these reasons it is sensitive to environmental changes. Lewis' woodpeckers may be vulnerable to coal mining impacts through habitat loss, dust, increased noise and human activity, transmission lines, and water supply contamination. Mitigation measures include enhancement of surrounding habitat, encouragement of snag development, dust control measures, and protection of water resources.

ACKNOWLEDGMENTS

W. C. Fischer and B. R. McClelland's cooperation is greatly appreciated for providing many of the references cited in this report. E. G. Bizeau, M. G. Hornocker, and M. Koehler reviewed this manuscript and provided many helpful suggestions.

REFERENCES

Allaire, P. N. 1978. Effects of avian populations adjacent to an active strip-mine site. Pages 232-240 <u>in</u> Proc. symp.: Surface mining and fish/wildlife needs in the Eastern United States. U.S. Fish Wildl. Serv. FWS/OBS-78/81.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Arbib, R. 1979. The blue list for 1980. Am. Birds 36(6):830.

Beal, F. E. L. 1911. Foods of the woodpeckers of the United States. U.S. Biol. Surv. Bull. 37. 64 pp.

Bent, A. C. 1964. Life histories of North American woodpeckers. Dover Publishing Co., Inc., New York. 334 pp.

Bock, C. E. 1970. The ecology and behavior of the Lewis' woodpecker (Asyndesmus lewis). Univ. Calif. Publ. in Zool. 92:1-100. Univ. California Press, Berkeley and Los Angeles.

Bock, C. E., H. H. Hadow, and P. Somers. 1971. Relations between Lewis' and red-headed woodpeckers in southeastern Colorado. Wilson Bull. (83)3:237-248.

Bull, E. L. 1978. Specialized habitat requirements of birds: snag management, old growth and riparian habitat. Pages 74-81 in R. M. DeGraaf, ed. Proc. workshop: Nongame bird management in the coniferous forests of Western United States. U.S. For. Serv. Gen. Tech. Rep. PNW-64. 100 pp.

Bull, E. L., A. D. Twombly, and T. M. Quigley. 1980. Perpetuating snags in managed mixed conifer forests of the Blue Mountains, Oregon. Pages 325-336 in R. M. DeGraaf, ed. Proc. workshop: Management of Western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86.

Bull, J. 1974. Birds of New York state. Doubleday/Natural History Press, Garden City, NY. 655 pp.

Currier, E. S. 1928. Lewis' woodpeckers nesting in colonies. Condor 30:356.

Diem, K. L., and S. I. Zeveloff. 1980. Ponderosa pine bird communities. Pages 170-197 in R. M. DeGraaf, ed. Proc. workshop: Management of Western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86.

Hadow, H. H. 1973. Winter ecology of migrant and resident Lewis' woodpeckers in southeastern Colorado. Condor 75(2):210-224.

Harrison, H. H. 1979. A field guide to Western birds' nests. Houghton Mifflin Co., Boston. 259 pp.

Hubbard, J. P. 1970. Check-list of the birds of New Mexico. New Mexico Ornith. Soc. Publ. 3. 103 pp.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Jackman, S. M. 1974. Woodpeckers of the Pacific Northwest; their characteristics and their role in the forests. M.S. Thesis, Oregon State Univ., Corvallis. 147 pp.

Jackman, S. M., and J. M. Scott. 1975. Literature review of twenty-three selected forest birds of the Pacific Northwest. U.S. For. Serv., Region 6. Portland, OR. 382 pp.

Jewett, S. G., W. P. Taylor, W. T. Shaw, and J. W. Aldrich. 1953. Birds of Washington state. Univ. Washington Press, Seattle. 767 pp.

Johnsgard, P. A. 1979. Birds of the Great Plains. Univ. Nebraska Press, Lincoln. 539 pp.

Law, J. E. 1929. Another Lewis' woodpecker stores acorns. Condor 31:233-238.

Levy, S. H. 1962. Additional summer southern Idaho bird notes. Murrelet 43(1):10-14.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits. Dover Publishing Co., Inc., New York. 500 pp.

Maser, C., and J. S. Gashwiler. 1977. Interrelationships of wildlife and western juniper. Pages 37-82 in Proc.: Western juniper ecology and management. U.S. For. Serv. Gen. Tech. Rep. PNW-74.

Moore, R, and T. Mills. 1977. An environmental guide to Western surface mining. Part two: Impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04. 407 pp.

Scott, V. E., and D. R. Patton. 1975. Cavity nesting birds of Arizona and New Mexico forests. U.S. For. Serv. Gen. Tech. Rep. RM-10. 52 pp.

Sherwood, W. E. 1927. Feeding habits of Lewis' woodpecker. Condor 29:171.

Snow, R. B. 1941. A natural history of the Lewis' woodpecker *Asyndesmus lewis* (Gray). M.S. Thesis, Utah State Univ., Logan.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Thomas, J. W., R. J. Miller, H. Black, J. E. Rodiek, and C. Maser. 1976. Guidelines for maintaining and enhancing wildlife habitat in forest management in the Blue Mountains of Oregon and Washington. Trans. North Am. Wildl. Conf. 41:452-476.

Thomas, J. W., R. G. Anderson, C. Maser, and E. L. Bull. 1979a. Snags. Pages 60-77 in J. W. Thomas, ed. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. U.S. For. Serv. Handb. 533.

Thomas, J. W., R. J. Miller, C. Maser, R. G. Anderson, and B. E. Carter. 1979b. Plant communities and successional stages. Pages 23-39 in J. W. Thomas, ed. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. U.S. For. Serv. Handb. 533.

Williams, J. J. 1905. Notes on the Lewis' woodpecker. Condor 7:56.

RED-HEADED WOODPECKER (*Melanerpes erythrocephalus*)

by

Gary M. Koehler
Idaho Cooperative Wildlife
Research Unit
U.S. Fish and Wildlife Service
University of Idaho
Moscow, ID 83843

SPECIES DESCRIPTION

The red-headed woodpecker (*Melanerpes erythrocephalus*) is an easy bird to identify. Both sexes have a red head; black back, tail, and wings; and white breast, belly, rump, and secondary wing feathers.

DISTRIBUTION

The red-headed woodpecker occurs over much of the United States east of the Rocky Mountains (Fig. 24). It ranges from southern Saskatchewan, southern Manitoba, western Ontario, and southern New Hampshire to the Gulf Coast. Its western range includes central Montana, eastern Wyoming, eastern Colorado, central New Mexico, and central Texas; and its eastern range extends from the Hudson Valley through Delaware to southern Florida. It is abundant in the midwestern oak and corn regions (Bock and Lepthien 1975), but occurs as a casual in southern British Columbia, southern Alberta, central Saskatchewan, Idaho, Arizona, and the Florida Keys (American Ornithologists' Union 1983). In the northern portion of its range, it generally migrates to available food supplies and in the south is considered a permanent resident (Harrison 1975).

DIET

The red-headed woodpecker feeds on a variety of items. The diet may vary from 50% animal matter and 47% vegetable matter (Bent 1964) to 33.8% animal matter and 66.2% vegetable matter (n = 443 throughout the range) (Beal 1911).

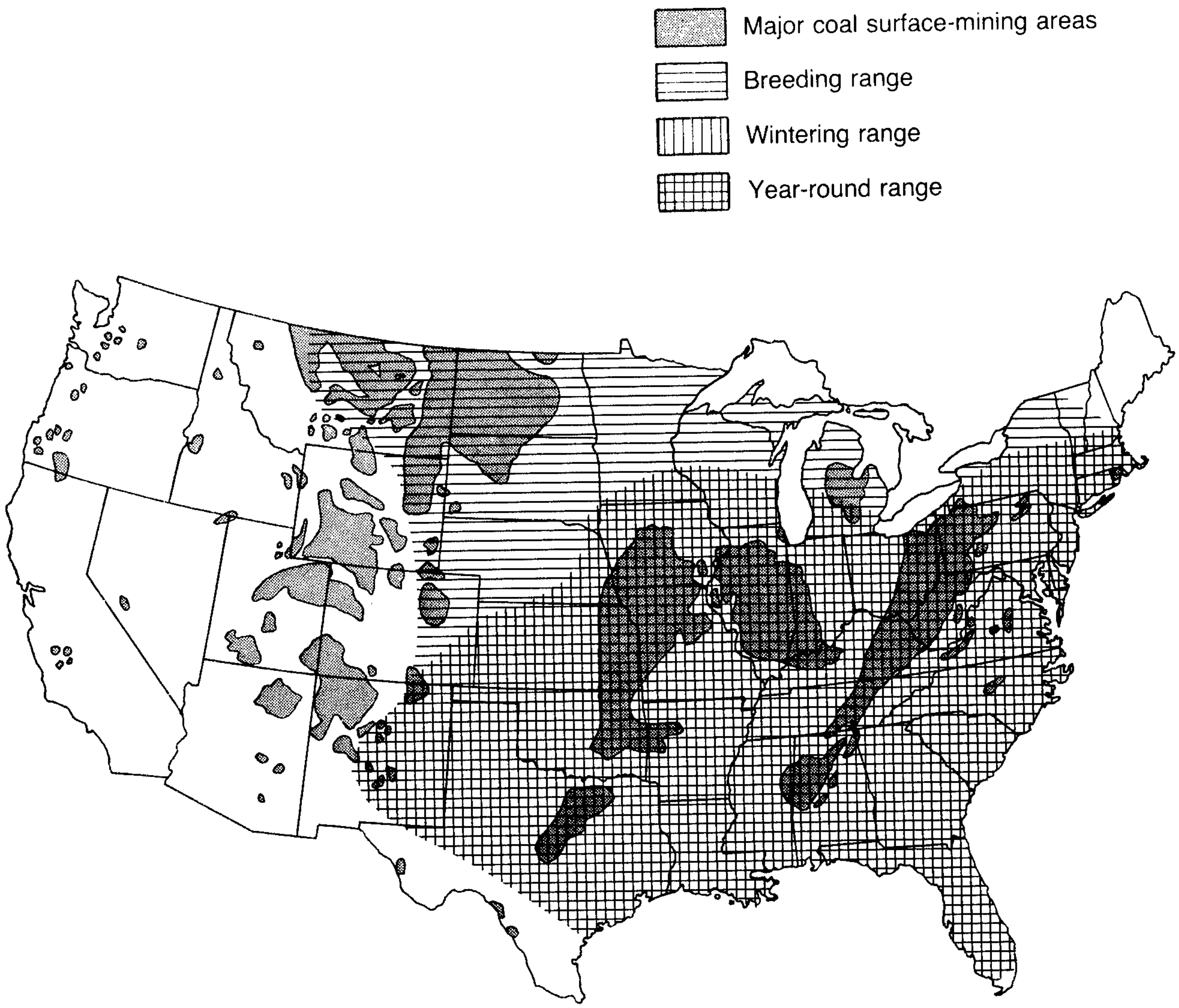


Figure 24. Geographical range of the red-headed woodpecker in relation to major coal deposits in the United States. After Inkley and Raley (1983).

The spring and summer diet consists of flying insects that the woodpeckers capture by hawking or feeding on the ground (Williams 1975). Grasshoppers form an important part of the woodpecker's diet, about 21% in Montana, Iowa, and South Dakota (Beal 1911). Beetles may constitute 19% of the diet and ants 5%. Red-headed woodpeckers also eat eggs and young of other birds (Beal 1911; Pearson 1936; Bent 1964). Other animal matter in the diet includes wasps, crickets, and moth pupa (Kilham 1958a; Williams and Batzli 1979).

Mast (mostly acorns) and grain are the major food during fall and winter (Beal 1911; Reller 1972; Williams and Batzli 1979), with beechnuts (Fagus) and acorns comprising up to 55% of the diet (Beal 1911). In central Illinois, mast occurred in the diet at a relative frequency of 51.6% and corn occurred 41.8%; the species feeds on corn more commonly when mast production is low (Williams and Batzli 1979). Other vegetable matter eaten includes chokecherries, blackberries (Prunus spp.), cambium, poison ivy (Toxicodendron radicans), tree sap, grass seeds, dogwood berries (Cornus spp.), huckleberries (Ericaceae), strawberries (Fragaria spp.), grapes (Vitis spp.), and apples (Prunus spp.) (Beal 1911; Kilham 1958a; Bent 1964; Williams and Batzli 1979). The woodpeckers have been observed feeding mulberries (Morus spp.) to their young (Jackson 1976).

Foraging Behavior and Habitat

Red-headed woodpeckers hawk for flying insects during midday when insects are most active (Reller 1972). Scanning for flying insects is an important part of this type of hunting behavior. They scan from perches on snags, utility poles, or fence posts (Bent 1964; Williams 1975; Conner 1978). They also feed on the ground by gleaning insects from trunks and limbs of trees (Willson 1970; Bock et al. 1971; Reller 1972; Williams 1975). Red-headed woodpeckers in Iowa spend 69% of the time foraging on dead trees (Gamboa and Brown 1976). Their choice of foraging methods may depend on the type of prey available, i.e., they seldom glean for insects in Florida (Moskovits 1978), but commonly glean in Illinois (Willson 1970; Reller 1972). They rarely excavate for insects (Kirby 1980).

Their distribution in winter is dependent on the availability of mast, the major winter food. If there is an absence of mast on the northern breeding range they may migrate to areas with oak (Quercus spp.) or hickory (Carya spp.) forests (Graber and Graber 1963; Moskovits 1978). Migration to winter areas occurs during late summer or early fall. They may remain on the winter range from September through May in Maryland (Kilham 1958b).

From September through November, almost all activity is concentrated on the gathering and storage of mast (Moskovits 1978). They feed from their stores the remainder of the winter (Kilham 1958a). They establish well-defined winter territories (Kilham 1958b; Reller 1972) which are approximately 0.1 ha in size in the northeastern and north-central United States (Evans and Conner 1979) and 0.8 to 1.2 ha in Louisiana (MacRoberts 1975). In contrast to the breeding season when most foraging is confined to their nesting territory (Williams 1975), the winter territory is used for food storage only. They may forage up to 100 m from the territory (Moskovits 1978). The feeding territory in Florida is about 1.0 ha. The winter feeding territory is not defended in that several woodpeckers may feed from the same tree (Kilham 1958a). However, the woodpeckers guard the stores against all other birds (Kilham 1958b; Reller 1972).

Red-headed woodpeckers store their food in existing cracks and crevices in dead tree trunks, loose bark, dead stubs, dead branches of living trees, railroad ties, fence posts, and utility poles (Beal 1911; Kilham 1958a; MacRoberts 1975; Moskovits 1978). They prevent other birds from robbing stores by storing their acorns over a wide portion of the territory, wedging acorns tightly into cracks, and sealing off stores by hammering slivers of wood over the stored mast (Kilham 1958a). Besides mast, they may store corn kernels (Zea mays), cherry drupes, insects, and grass seeds (Hay 1887; Kilham 1958a; Williams and Batzli 1979).

In winter, red-headed woodpeckers require open vegetation for easy defense of the stores and an abundant supply of acorns (Moskovits 1978). Open habitat is also important in spring and summer for their insect-hawking behavior. Open country, old burns, roadside trees, and parks generally provide adequate habitat (Pearson 1936; Harrison 1979).

Preferred feeding habitat in Illinois includes forests of oak, hickory, and maple (Acer spp.) (Willson 1970; Reller 1972; Williams 1975; Williams and Batzli 1979). Red-headed woodpeckers occur in pine/pole and pine/saw timber habitats in Texas (Dickson and Segelquist 1979). They are attracted to flooded riparian areas (Yeager 1955) and beaver (Castor canadensis) ponds (Lochmiller 1979) where snags are abundant. They are common in deciduous forests adjacent to agricultural land in Illinois (Williams and Batzli 1979), but uncommon in the heavily wooded regions of northern Minnesota (Green and Janssen 1975). They are also common in farming areas and towns which have replaced these heavily wooded areas.

Suitable roosting trees are a prerequisite for good winter habitat. Each woodpecker requires at least one dead tree or snag for roosting (Kilham 1958b; Evans and Conner 1979). Roost trees average 50 cm diameter at breast height (dbh) and 12 m in height (Evans and Conner 1979).

Red-headed woodpeckers are sometimes criticized for excavating on and damaging utility poles and fence posts (Beal 1911; Bent 1964; Dennis 1964), damaging fruit and grain crops (Beal 1911; Bent 1964), and eating eggs and young of other birds (Pearson 1936).

REPRODUCTION

Nesting Chronology

Nesting begins from early April to early June depending on the location. In Kentucky, red-headed woodpeckers may start nesting in early May and continue through August (Mengel 1965). They may have two or three broods per season (Rumsey 1970). In Illinois, 3 of 15 pairs were observed to have two broods (Willson 1970).

The male does all the excavation of the nest cavity (Kilham 1977). Four to seven eggs (an average of five eggs) are laid per clutch (Harrison 1979). Both male and female take part in incubation which requires 13 to 14 days (Bent 1964). Fledging success in Illinois may be zero to three young per nest (Kendeigh 1952). After about 25 days the fledglings are chased away by the parents and the second clutch begins. This may be mid-July in Illinois (Reller 1972).

Nesting Habitat

Red-headed woodpeckers prefer to nest in open areas with abundant dead trees or snags (Bent 1964; Harrison 1979). Snags provide 88% of the nest trees in Iowa (Stauffer and Best 1980) and also serve as roosting, mast storing, drumming, and perching sites for red-headed woodpeckers. Density estimates of breeding red-headed woodpeckers in Iowa were 10.7 individuals per ha in savannah-like habitat, 5.9 in upland woodland, 5.8 in floodplain woodland, 4.2 in scrub habitat, 2.5 in wooded edge, and 0.6 in herbaceous habitat (Stauffer and Best 1980). Savannah-like habitat is preferred in Illinois with shrub-grown areas next in preference (Graber and Graber 1963). Nesting habitat may also include old burns, roadside trees, and parks (Pearson 1936; Harrison 1979); beaver ponds in New York (Bull 1974); riparian habitat in southeastern Colorado (Bock et al. 1971), New Mexico (Hubbard 1970), and the Great Plains (Tubbs 1980); moist bottomlands in the South (Dickson 1978); forest edge in Illinois (Johnston 1947); old shelterbelt plantings in North Dakota (Cassel and Wiehe 1980); open areas in Kansas (Jackson 1976); old mature woodlots with low tree density in Virginia (Conner and Adkisson 1977); xeric forest stands in southern Illinois (Bond 1957); and northern hardwood, aspen-birch, and oak habitats in northeastern and north-central United States (Evans and Conner 1979).

In Virginia, red-headed woodpeckers prefer to nest in old mature woodlots that have live trees with a large basal area, a tall canopy, a low density of stems, and an open understory (Conner 1976). They prefer to nest relatively high above the ground in large trees. The average age of nest trees in this study was 228.1 years.

Nesting habitat in Iowa has a high snag density and snag dbh ranging between 51 and 75 cm (Stauffer and Best 1980). Nests in Illinois range from 7 to 20 m above ground and are located on the southern or western side of the trees (Reller 1972). Although red-headed woodpeckers may prefer to nest in large trees, they may use smaller-sized and younger trees in the southern pine forests (Conner 1978).

Red-headed woodpeckers prefer to nest in dead trees or snags, soft snags being most preferred (Stauffer and Best 1980). Live trees may be used to a lesser extent. Woodpeckers use a wide variety of tree species, utility poles, fence posts, and similar structures for nesting (Bent 1964). Utility poles are often used in the Great Plains region where trees are scarce (Dennis 1964). In the southeastern United States red-headed woodpeckers may use abandoned red-cockaded woodpecker (*Picoides borealis*) nest cavities (Baker 1971).

Nesting territories in the north-central and northeastern United States are about 4 ha (Evans and Conner 1979).

POPULATION TRENDS

The red-headed woodpecker has declined in numbers since the mid-1800s and was placed on the National Audubon Society's Blue List (Arbib 1979); in 1982 it was listed as a Species of Special Concern (Tate and Tate 1982). It is not considered threatened or endangered but its population should be monitored closely. Red-headed woodpecker populations have declined at the rate of 3% per year in the Eastern States and provinces (Robbins and Erskine 1975). Population figures during a 1907-09 census in Illinois are seven times greater than during a 1957-58 census (Graber and Graber 1963). A population decline has occurred during recent years in Kentucky (Mengel 1965). Populations have also declined in New Mexico (Hubbard 1970) and North Dakota (Stewart 1975).

Starlings are a major factor contributing to the decline of the red-headed woodpecker (Graber and Graber 1963; Mengel 1965; Reller 1972; Robbins and Erskine 1975; Harrison 1975; Imhof 1976; Short 1979). Starlings, because of their numbers and aggressive nature, are able to evict red-headed woodpeckers from their roosting or nesting cavities.

Red-headed woodpeckers are attracted to creosoted utility poles for nesting despite the resultant nesting failures (Mengel 1965; Rumsey 1970; Harrison 1979). They are also attracted to roadways where they feed on insects and grain along the roadside. Their lack of fear and slow take-off make them particularly vulnerable to traffic mortality. Such mortality has contributed to their decline in many areas (Bent 1964; Mengel 1965).

Effects of Habitat Changes

Silvicultural practices such as short rotations that prevent trees from maturing, producing mast, or attaining the necessary size for nesting and cutting of snags can cause a reduction in habitat for these birds. Short rotation silviculture also prevents decay and heart rot which is necessary for nest and roost cavity excavation (Conner 1978).

Activities detrimental to riparian areas have adverse impacts on these woodpeckers. These activities include reducing stream flows due to damming, deep well pumping, and reservoir construction; reducing riparian woodlots to narrow strips; overgrazing of riparian areas; and intensive farming practices (Stauffer and Best 1980; Tubbs 1980).

Although some habitat alterations may be detrimental, other types of alterations may be beneficial to red-headed woodpecker populations. Stauffer and Best (1980) predicted that populations may increase in closed-canopy riparian woodlands if the canopy, shrubs, and saplings are thinned. Red-headed woodpeckers are attracted to areas with dead or dying trees, such as flooded riparian forest (Yeager 1955; Lochmiller 1979). Spectacular concentrations may be attracted to snags and herbaceous ground cover in areas sprayed with herbicides (Hardin and Evans 1977).

Red-headed woodpeckers are considered to be relatively tolerant of habitat alteration as indicated by the wide variety of habitats used for nesting. Their use of utility poles and fence posts for nesting, roosting, perching, and storing food indicates they are relatively adaptable to habitat alterations. Their range extension into New Mexico may be partly due to the available nesting sites provided by telephone poles along railroads (Leopold 1919).

Effects of Human Disturbance

Red-headed woodpeckers are apparently tolerant of a moderate level of human presence, as indicated by the use of habitat in parks and agricultural and suburban areas. Presumably, repeated disturbances at the nest site during the breeding season may cause nest abandonment or lowered productivity. Human disturbance is likely to have the greatest impact in its effect on habitat changes.

Management

The red-headed woodpecker is a primary cavity nester (excavates its own nest cavities) and provides nest cavities for secondary cavity-nesting birds and mammals (those that are unable to excavate holes). Red-headed woodpeckers may help in the biological control of pest insects and weed seeds. They should be considered in management activities because of their esthetic and ecological values.

Snags are important to red-headed woodpeckers for nesting, roosting, perching, drumming, and food storage. Evans and Conner (1979) calculated the number of snags necessary to maintain various densities of red-headed woodpeckers on breeding and wintering ranges. In order to maintain 80 to 100% of the maximum breeding population, 160 to 200 snags per 40 ha are required; 80 to 120 snags per 40 ha are required to maintain 40 to 60% of the maximum density. For optimum use, snags should be 40 to 60 cm dbh, 9 to 21 m tall, and uniformly distributed over the area (Evans and Conner 1979). Live or dying trees should be maintained for snag recruitment (McClelland and Frissel 1975).

Snags may be artificially induced by injecting trees with a silvicide or frill girdling and inoculating the tree with a heart rot fungus. A silvicide should be used that would not inhibit rot or harm wildlife and other plants (Conner 1978).

Artificially producing snags not only provides the necessary nesting, roosting, and food-storing sites, it also contributes to the thinning of the stand, usually a habitat improvement measure for red-headed woodpeckers. Controlling the understory shrubs in mature forests will create a park-like condition which is beneficial to the species (Evans 1978).

The Red-headed Woodpecker as an Indicator Species

An indicator species is one that has a narrow range of tolerance for environmental change, and may serve as an early warning of excessive disruption to its environment. The red-headed woodpecker is specific in its requirements for nesting cavities, and may serve as an indicator species for the presence of snags and cavity-forming trees in regions without manmade influences, such as fence posts or utility poles. Because the species is able to exploit a variety of habitat types, it is not a good indicator species for any one specific habitat type. The red-headed woodpecker was listed on the National Audubon Society Blue List due to its decline in numbers (Arbib 1979) and in 1982 was moved to the list of Species of Special Concern (Tate and Tate 1982).

POTENTIAL IMPACTS OF SURFACE COAL MINING

The most serious impact of coal surface mining is the destruction of habitat. Loss of habitat will result in displacement of red-headed woodpeckers to surrounding habitat. These individuals will be subjected to increased competition and overcrowding (assuming suitable habitat is already occupied), resulting in lowered productivity, and an ultimate decrease in the breeding population. Other impacts associated with mining may result from noise, dust, blasting tremors, increased human activity, traffic mortality, and competition with starlings for nest sites. Collisions with transmission lines may cause injury or mortality.

In the Great Plains and Rocky Mountain regions, riparian areas are limited and are critical habitat for these woodpeckers. Deep-well pumping may alter the aquifer, which may in turn have negative effects on riparian areas. Stream impoundments that alter flows will adversely affect habitat. Woodcutting removes the required snags, a serious impact near urban areas.

The increase in access roads and vehicle traffic associated with mining activity may pose special threats to red-headed woodpeckers because of a high vulnerability to traffic mortality. Dust from roads and other mining activities may provide additional problems to nesting woodpeckers by coating vegetation and thus decreasing local insect populations, an important food source.

Development of mining support facilities such as residential and administrative areas provide conditions attractive to starlings. Increased starling populations may result in increased competition with red-headed woodpeckers for nest sites. Power and telephone lines constructed with creosoted poles attract nesting red-headed woodpeckers but result in nest failures.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Prior to mine development the mining areas should be censused for red-headed woodpeckers and their habitat should be delineated. Unoccupied wooded sections should be treated as potential mitigation areas, particularly if existing habitat for red-headed woodpeckers will be disrupted during the mining process. However, it is important to ascertain why these areas are unoccupied before utilizing them in the mitigation process. They may be unoccupied because they are unsuitable habitat.

Planning should allow for the protection and maintenance of breeding and wintering habitat. This may mean establishing sanctuaries. Woodcutting should be prohibited in such areas to protect snags. Maintenance of oak groves should receive special consideration in winter areas.

Management units should reflect the size of winter and breeding territories, 4 ha and 1 ha, respectively (Moskovits 1978; Evans and Conner 1979). In addition, areas should be large enough to insulate populations from mining disturbances. A 100 m wide buffer zone between active mine sites and breeding grounds is recommended to minimize effects of noise, blasting tremors, and dust (Allaire 1978). Habitat should not exist as small islands, but should be connected with corridors of suitable habitat.

Forested areas not used by woodpeckers can be managed to encourage use. Red-headed woodpeckers' tolerance for habitat alteration indicates that such mitigation procedures may be successful. The success of relocation should be determined before mining begins. Thinning may improve closed canopy forests by increasing the growth rate of trees, thus providing for the large diameter trees required for nesting. Thinning should encourage snag development and allow for snag recruitment. Stands may be thinned mechanically or with the use of selected silvicides. A density of 67.3 stems per ha and an average basal area of live trees of 25.5 m^2 per ha are recommended (Conner 1976). Snags 40 to 60 cm dbh and 9 to 21 m tall are adequate for nest sites.

About 160 to 200 snags per ha are required to provide good breeding and winter habitat for red-headed woodpeckers (Evans and Conner 1979). Snags should be uniformly distributed for optimum use. The shrubby understory may have to be controlled to provide for the preferred savannah-like habitat (Evans 1978).

Exploration, Mine Development, and Mining Phase

During the exploration, mine development, and mining phase, woodpecker populations and habitat should be continually monitored to detect any impacts due to mining activity.

In lowland and arid regions, riparian areas are critical for red-headed woodpeckers. The quantity and quality of water may be monitored closely to detect any subtle changes and avert any impacts.

Dust that may adversely affect breeding populations can be minimized by paving roads, covering conveyer belts, and mulching wind-erodable areas (Moore and Mills 1977). Placing roads and spoil piles at a distance from nesting habitat will minimize dust on breeding habitat. Blasting and drilling conducted on calm days or days when the wind will not carry dust to breeding grounds may also alleviate impacts (Allaire 1978).

Impacts of noise and blasting tremors can be minimized by blasting on regular daily or weekly schedules, thus allowing birds to become accustomed to the disturbances and perhaps cause less nest abandonment (Allaire 1978).

Reduced speed zones posted along roadways where red-headed woodpeckers are particularly susceptible to traffic mortality may reduce impacts (Burleigh 1958). Roadway design and mechanical devices to discourage woodpecker use may be an effective means of reducing mortality. Placing noncreosoted poles along electrical transmission corridors will provide alternative nest sites; using metal utility poles will eliminate the problem of nesting failures in creosoted poles. Placement of transmission lines outside of migration pathways may decrease injury and mortality from collisions.

Reclamation Phase

Red-headed woodpeckers will use reclaimed mining lands as succession progresses and the vegetative structure becomes more complex (Brewer 1958; Pentecost and Stupka 1979). Success in reclaiming mined lands for woodpecker use is partly dependent on steps taken to enhance the progression of plant succession.

Woodpeckers nested in the late shrub successional stage approximately 40 years after strip mining on lands in Illinois (Karr 1968). Areas mined in 1900 and 1910 were also used for nesting. However, re-establishing red-headed woodpecker populations on disturbed lands requires time for succession to progress and snags to be produced. Succession is dependent, in part, on the manner in which the areas are mined and the mitigation and reclamation programs implemented.

Their tolerance for habitat alteration and alternate nesting sites indicates that the red-headed woodpecker may be a valuable indicator species for judging the success of mitigation programs.

Reclamation requires planting grasses and mast-producing tree seedlings. These seedlings should be planted in a temporal sequence to provide for replacement of nest trees (Conner 1976). Since red-headed woodpeckers will use utility poles and fence posts for nesting, food storage, and roosting, placing noncreosoted poles 40 to 60 cm dbh and 9 to 21 m tall on the reclaimed land may be effective substitutes for snags until natural snags become established. The density of these poles and posts should approach 200 per 40 ha. Red-headed woodpeckers apparently do not use bird houses for nesting; therefore they are not recommended (Harrison 1979).

SUMMARY

The red-headed woodpecker needs mast-producing forests during the winter and savannah-like communities during the breeding season. Snags are important components of both types of habitat. Surface mining may have negative impacts on these woodpeckers by destroying wooded and riparian communities; increasing the numbers of starlings competing for nesting sites; increasing mortality along roadways; and disturbing nesting birds by the dust, noise, blasting, and activity associated with mining. Many of these impacts can be reduced by improving habitat in adjacent areas, and closely monitoring woodpecker populations and the environmental changes associated with mining activity. Reclaimed

lands may provide adequate feeding and nesting habitat in a relatively short time. This is accomplished by planting grasses and trees and erecting non-creosoted posts and poles to be used for perching, nesting, and food storing.

ACKNOWLEDGMENTS

W. C. Fischer and B. R. McClelland's cooperation is greatly appreciated for providing many of the references cited in this report. E. G. Bizeau, M. G. Hornocker, and M. Koehler reviewed this manuscript and provided many helpful suggestions.

REFERENCES

Allaire, P. N. 1978. Effects of avian populations adjacent to an active strip-mine site. Pages 232-240 in Proc. symp.: Surface mining and fish/wildlife needs in the Eastern United States. U.S. Fish Wildl. Serv., FWS/OBS-78/81.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Arbib, R. 1979. The blue list for 1980. Am. Birds 36(6):830.

Baker, W. W. 1971. Progress report on life history studies in the red-cockaded woodpecker at Tall Timber Research Station. Pages 44-59 in Proc. symp.: The ecology and management of the red-cockaded woodpecker. U.S. Bur. Sport Fish Wildl.

Beal, F. E. L. 1911. Foods of the woodpeckers of the United States. U.S. Dept. Agri. Biol. Surv. Bull. 37. 64 pp.

Bent, A. C. 1964. Life histories of North American woodpeckers. Dover Publishing Co., Inc., NY. 334 pp.

Bock, C. E., H. H. Hadow, and P. Somers. 1971. Relations between Lewis' and red-headed woodpeckers in southeastern Colorado. Wilson Bull. 83(3):237-248.

Bock, C. E., and L. W. Lepthien. 1975. A Christmas count analysis of woodpecker abundance in the United States. Wilson Bull. 87(3):355-366.

Bond, R. R. 1957. Ecological distribution of breeding birds in the upland forest of southern Wisconsin. Ecol. Monogr. 27(4):351-384.

Brewer, R. 1958. Breeding-bird populations of strip-mined land in Perry County, Illinois. Ecology 39(3):543-545.

Bull, J. 1974. Birds of New York state. Doubleday Nat. Hist. Press, Garden City, NY. 655 pp.

Burleigh, T. D. 1958. Georgia birds. Univ. Oklahoma Press, Norman. 746 pp.

Cassel, J. F., and J. M. Wiehe. 1980. Uses of shelterbelts by birds. Pages 78-87 in R. M. DeGraaf and W. G. Tilghman, eds. Proc. workshop: Management of Western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. 535 pp.

Conner, R. N. 1976. Nesting habitat for red-headed woodpeckers in southwestern Virginia. Bird-Banding 47(1):40-43.

__________. 1978. Snag management for cavity nesting birds. Pages 120-128 in R. M. DeGraaf and K. E. Evans, eds. Proc. workshop: Management of Southern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

Conner, R. N., and C. S. Adkisson. 1977. Principal component analysis of woodpecker nesting habitat. Wilson Bull. 89(1):122-129.

Dennis, J. V. 1964. Woodpecker damage to utility poles: with special reference to the role of territory and resonance. Bird-Banding 35(4):225-253.

Dickson, J. G. 1978. Forest bird communities of the bottomland hardwoods. Pages 66-73 in R. M. DeGraaf and K. E. Evans, eds. Proc. workshop: Management of Southern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

Dickson, J. G., and C. A. Segelquist. 1979. Breeding bird populations in pine/hardwood forest in Texas. J. Wildl. Manage. 43(2):549-555.

Evans, K. E. 1978. Oak-pine and oak-hickory forest bird communities and management options. Pages 76-89 in R. M. DeGraaf and K. E. Evans, eds. Proc. workshop: Management of Southern forest for nongame birds. U.S. For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

Evans, K. E., and R. N. Conner. 1979. Snag management. Pages 214-225 in R. M. DeGraaf and K. E. Evans, eds. Proc. workshop: Management of north central and northeastern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. NC-51. 268 pp.

Gamboa, G. J., and K. M. Brown. 1976. Comparative foraging behavior of six sympatric woodpecker species. Proc. Iowa Acad. Sci. 82(3-4):179-181.

Graber, R. R., and J. W. Graber. 1963. A comparative study of bird populations in Illinois, 1906-1909 and 1956-1958. Ill. Nat. Hist. Surv. Bull. 28(3). 528 pp.

Green, J. C., and R. B. and Janssen. 1975. Minnesota birds: where, when, and how many. Univ. Minnesota Press, Minneapolis. 217 pp.

Hardin, K., and K. E. Evans. 1977. Cavity nesting bird habitat in the oak-hickory forest, a review. U.S. For. Serv. Gen. Tech. Rep. NC-30. 22 pp.

Harrison, H. H. 1975. A field guide to birds' nests. Houghton Mifflin Co., Boston. 257 pp.

__________. 1979. A field guide to Western birds' nests. Houghton Mifflin Co., Boston. 279 pp.

Hay, O. P. 1887. The red-headed woodpecker a hoarder. Auk 4:193-196.

Hubbard, J. P. 1970. Checklist of the birds of New Mexico. New Mexico Ornithol. Soc. Publ. 3. 103 pp.

Imhof, T. A. 1976. Alabama birds. Univ. Alabama Press, Birmingham. 445 pp.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Jackson, J. A. 1976. A comparison of some aspects of the breeding ecology of red-headed and red-bellied woodpeckers in Kansas. Condor 78(1):67-76.

Johnston, V. R. 1947. Breeding birds of the forest edge in Illinois. Condor 49(2):45-53.

Karr, J. R. 1968. Habitat and avian diversity on strip mined land in east central Illinois. Condor 70:348-357.

Kendeigh, C. S. 1952. Parental care and its evolution in birds. Ill. Biol. Monogr. 22:1-356.

Kilham, L. 1958a. Sealed-in winter stores of red-headed woodpeckers. Wilson Bull. 70(2):107-113.

__________. 1958b. Territorial behavior of wintering red-headed woodpeckers. Wilson Bull. 70(4):347-358.

__________. 1977. Early breeding season behavior of red-headed woodpeckers. Auk 94(2):231-239.

Kirby, V. C. 1980. An adaptive modification in the ribs of woodpeckers and piculets (Picidae). Auk 97:521-532.

Leopold, A. 1919. A breeding record for the red-headed woodpecker in New Mexico. Condor 21:173-174.

Lochmiller, R. L. 1979. Use of beaver ponds by woodpecker in winter. J. Wildl. Manage. 43(1):263-266.

MacRoberts, M. H. 1975. Food storage and winter territory in red-headed woodpeckers in northwestern Louisiana. Auk 92(2):382-385.

McClelland, B. R., and S. S. Frissell. 1975. Identifying forest snags useful for hole-nesting birds. J. For. 73(7):414-417.

Mengel, R. M. 1965. The birds of Kentucky. Am. Ornithol. Union, Ornithol. Monogr. 3. 581 pp.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining, Part two: impacts, mitigation and monitoring. U.S. Fish Wildl. Serv., FWS/OBS-78/04. 407 pp.

Moskovits, D. 1978. Winter territorial and foraging behavior of red-headed woodpeckers in Florida. Wilson Bull. 90(4):521-535.

Pearson, T. G., ed. 1936. Birds of America. Garden City Publishing Co., Inc., Garden City, NY. 289 pp.

Pentecost, E. D., and R. C. Stupka. 1979. Wildlife investigations at a coal refuse reclamation site in southern Illinois. Pages 107-118 in Surface mining and fish/wildlife needs in the Eastern United States. Addendum Symp. Proc. U.S. Fish Wildl. Serv. FWS/OBS-78/81A.

Reller, A. W. 1972. Aspects of behavioral ecology of red-headed and red-bellied woodpeckers. Am. Midl. Nat. 88(2):270-290.

Robbins, C. S., and A. J. Erskine. 1975. Population trends of nongame birds in North America. Trans. N. Am. Wildl. Nat. Resour. Conf. 40:288-293.

Rumsey, R. L. 1970. Woodpecker nest failures in creosoted utility poles. Auk 87(2):367-369.

Short, L. L. 1979. Burdens of the picid hole-excavating habit. Wilson Bull. 91(1):16-28.

Stauffer, D. F., and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44(1):1-15.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Cent. for Environ. Studies, North Dakota State Univ., Fargo. 295 pp.

Tate, J. Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

Tubbs, A. A. 1980. Riparian bird communities of the Great Plains. Pages 419-433 in R. M. DeGraaf and W. G. Tilghman, eds. Proc. workshop: Management of Western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. 835 pp.

Williams, J. B. 1975. Habitat utilization by four species of woodpeckers in central Illinois woodland. Am. Midl. Nat. 93(2):354-367.

Williams, J. B., and G. O. Batzli. 1979. Winter diet of a bark-foraging guild of birds. Wilson Bull. 91(1):126-131.

Willson, M. F. 1970. Foraging behavior of some winter birds of deciduous woods. Condor 72:169-174.

Yeager, L. E. 1955. Two woodpecker populations in relation to environmental change. Condor 57(3):148-153.

PILEATED WOODPECKER (*Dryocopus pileatus*)

by

Gary M. Koehler
Idaho Cooperative Wildlife Research Unit
U.S. Fish and Wildlife Service
University of Idaho
Moscow, ID 83843

SPECIES DESCRIPTION

The pileated woodpecker (*Dryocopus pileatus*) is the largest woodpecker in the United States, with the exception of the possibly extinct ivory billed woodpecker (*Campephilus principalis*). The pileated is about 36 cm in length or about the size of the common crow. It has a long, powerful bill and is well-adapted for excavating cavities. The male is brownish or grayish black. The top of the occipital crest and malar strip are bright red. The female is colored similarly except for a brownish or grayish black malar strip. The chin, wing coverts, and a wide strip on the side of the head of both sexes are white.

DISTRIBUTION

The pileated woodpecker occurs in two widely separated populations in the United States (Fig. 25). A Western population occurs from central California to Washington and east to western Montana. An Eastern population extends from eastern North Dakota, through Minnesota, and eastern portions of Iowa, Missouri, Kansas, Oklahoma, and Texas, and includes most areas east of the Mississippi (American Ornithologists' Union 1983). It is common in the moist forests of the Mississippi Valley, the Southeast and the Northwest (Bock and Lepthien 1975), rare in the Rocky Mountain states (Harrison 1979), and may be considered absent in the Southwest (Beal 1911) where reported sightings are considered as accidental (Phillips et al. 1964) or questionable (Hubbard 1970). It is also considered rare in Minnesota (Green and Janssen 1975).

DIET

Pileated woodpeckers feed on both animal and vegetable matter. The diet varies from 75% animal and 25% vegetable matter in New York (Hoyt 1957) to 73%

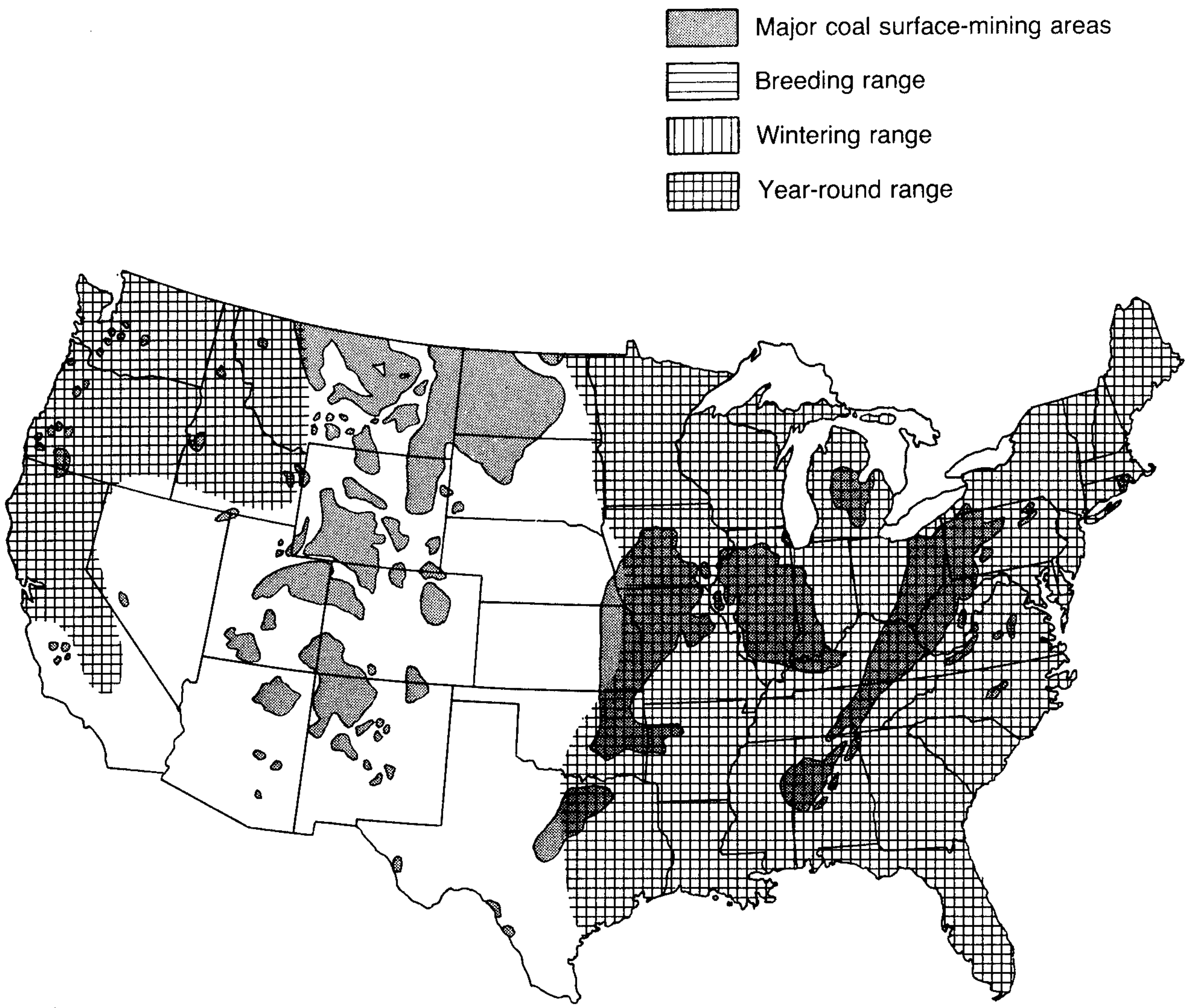


Figure 25. Geographical range of the pileated woodpecker in relation to major coal deposits in the United States. After Inkley and Raley (1983).

animal and 27% vegetable matter throughout the United States (Beal 1911) to 83% animal and 17% vegetable matter in Wisconsin (Becker 1942).

Carpenter ants are the predominant item in the diet. Ants may comprise 40% of stomach contents, with up to 2,600 ants occurring in one stomach (Beal 1911). In Wisconsin, ants comprised 60% stomach contents (Becker 1942). In pileated woodpeckers from throughout the United States, Beal (1911) reported that beetles, mostly in the larval stage, comprised 22% of stomach contents, and another 10% consisted of flies, grasshoppers, caterpillars, and other insects. Insect pupa and termites also occur in the diet (Hoyt 1957; Bent 1964; Kilham 1976).

Carpenter ants and larvae of various wood boring beetles occur in the winter diet; wood boring beetles, young ants, and other species of beetles are eaten during the spring; and ants, grubs, moths, mosquitoes, and flies are eaten during the summer (Hoyt 1957).

The fruit and seeds of dogwood (Cornus spp.), holly (Ilex spp.), poison ivy (Toxicodendron radicans), hackberry (Celtis spp.), sour gum (Nyssa spp.), tupelo gum (Nyssa sylvatica), poison sumac (Rhus vernix), dwarf sumac (Rhus spp.), oak (Quercus spp.), pecan hickory (Carya illinoensis), wild grape (Vitis spp.), Virginia creeper (Parthenocissus quinquefolia), persimmon (Diospyros spp.), and wild cherry (Prunus spp.) are important items of vegetation in the diet (Beal 1911; Hoyt 1957; Bent 1964). Ants that are regurgitated by the adult are the main food of young woodpeckers (Hoyt 1957).

Pileated woodpeckers in Louisiana spent 77% of their feeding time digging or excavating and 23% scaling (Tanner 1942). The woodpeckers excavate decayed, moist trees infected with carpenter ants (Conner et al. 1975). They prefer Douglas fir (Pseudotsuga menziessi) trees as feeding sites in Montana, but also used western larch (Larix occidentalis), red cedar (Juniperus virginiana), and lodgepole pine (Pinus contorta) (McClelland 1979). Douglas fir are preferred in western Oregon (Mannan et al. 1980) and Douglas fir and western larch are selected over ponderosa pine (P. ponderosa) in northeastern Oregon (Bull and Meslow 1977). Lodgepole pine and grand fir (Abies spp.) are used to a lesser extent as feeding sites in northeastern Oregon (Bull and Meslow 1977). Pileated woodpeckers select dead or down material and feed on tree species in the order of their abundance in the deciduous forests of Iowa (Downing 1970).

Preferred feeding sites include logs and snags without limbs or bark (that would inhibit their movements) and natural stumps as opposed to cut stumps (Bull and Meslow 1977; Bull 1981). Forty-four percent of 152 sites used for foraging in northeastern Oregon were snags, 42% were logs, and 14% were stumps (Bull and Meslow 1977). The pileated woodpecker prefers low stumps and lower portions of snags and trees in Montana (McClelland 1979). It feeds on dead and down material during the spring, summer, and autumn in Oregon and on standing material during the winter (Bull 1981). Trees and logs with diameters greater than 17.8 cm are selected (Bull and Meslow 1977). Large diameter trees have more heart wood, providing a more favorable microclimate and a higher density of carpenter ants and wood boring beetles (Bull 1981).

Snags used for foraging in western Oregon have an average diameter at breast height (dbh) of 103 cm (range 20 to 185 cm) and a mean height of 30.4 m (range 5.2 to 64.8 m). Hard snags in stage one deterioration phase account for 13% of the use; stage two hard snags are used 35% of the time; stage three snags with sloughed, decayed sapwood are used 29% of the time; stage four snags with sloughed sapwood and no sound wood are not used, but stage five snags are used 23% of the time. Twenty-three percent of all snags are remnants from previous wildfires or clearcutting operations (Mannan et al. 1980).

Habitats preferred by pileated woodpeckers are generally mature dense forest stands with abundant snags and dead and down woody material. The woodpeckers prefer dense mixed stands of grand fir and Douglas fir in the Pacific Northwest (Bull and Meslow 1977). They use larch stands and white pine/larch stands in Montana (Weydemeyer and Weydemeyer 1928; McClelland 1979) and oak/hickory stands in Virginia (Ryder and Ryder 1976).

Woodpeckers in Montana rarely feed in small clearcuts or open areas, but feed in selection and shelterwood cuts (McClelland 1979). Pileated woodpeckers in Virginia used 1-year old clearcuts 1% of the observation time, 5-year old clearcuts 7% of the time, 12-year old clearcuts 3% of the time, and mature forest 10% of the observation time (Conner and Crawford 1974).

The woodpecker uses second growth forests for feeding if older and larger diameter trees are present. A significant amount of use occurs in second growth Oregon forests that are 61 to 199 years old (Wight 1974). Woodpeckers use pine forests with saw timber-sized trees in east Texas (Dickson and Segelquist 1977) and second growth forests in Missouri (Eifrig 1927).

The size of the feeding territory may vary in various regions depending on the abundance of food and the number of feeding sites available. The feeding territory is 40 ha in Louisiana (Tanner 1942) and 70 ha in Florida and Georgia (Kilham 1976). Territories are 130 to 243 ha in Oregon (Bull and Meslow 1977) and 200 to 400 ha in Montana (McClelland 1979). The larger territories in Montana may contain clearcuts and developed areas.

Winter habitat in oak/hickory forests in Virginia may support 4 birds per 40 ha (Ryder and Ryder 1976). Excellent cover in Wisconsin will support 6 birds per 250 ha (Becker 1942). Hoyt (1957) rarely observed more than one pair per woodlot in New York.

REPRODUCTION

Pileated woodpeckers form permanent pair bonds and maintain breeding territories year after year. They are nonmigratory and remain on their breeding territory during the winter.

Breeding occurs from April through July. The male excavates a new nest cavity each breeding season with the female helping in the selection of the nest site. Old nesting cavities may be used for roosting, but are not used for nesting. Copulation generally occurs in March (Hoyt 1941; Kilham 1959). Two to five eggs are laid, with an average of 3 to 4 (Tanner 1942). Both the male and female incubate the eggs. The eggs hatch after 18 days and the young fledge after 22 to 26 days (Hoyt 1944). Pileated woodpeckers may fledge the last week in June in Oregon (Bull 1981) compared to late April in Florida (Truslow 1970). Parents teach young to search bark for insects (Hoyt 1957). At the end of the summer the young leave the parents and the nesting territory.

The pileated woodpecker often uses the same nest trees in successive years though a new nest cavity is excavated each year. McClelland (1977) recorded an average of 2.6 nest holes per nest tree, and Kilham (1959) noted 11 nest holes in a single tree. Nests must be protected from predators and weather and therefore are often located on the under side of a leaning tree (Bull 1975) or on the leeward side (Conner 1975). Woodpeckers excavate nesting cavities in live or dead trees, but dead trees are preferred. In the Western United States, they prefer nesting in decayed but sound trees (Bull 1975; Miller and Miller 1980) with broken tops (Bull 1975; McClelland et al. 1979). Nest snags in the Eastern United States often have broken tops and are infected with a decay fungus (Conner et al. 1976). Decayed snags are soft and easy to excavate (Conner 1975).

A large diameter is an important requirement for a nest tree (Table 15). Larger diameter trees are needed to provide an adequate-sized cavity for the bird; a large excavation may weaken a smaller diameter tree (Truslow 1967). The dbh of nest trees ranged between 70 and 80 cm in the West (Bull and Meslow 1977; McClelland 1979; Mannan et al. 1980) and averaged about 55 cm in the East (Conner et al. 1975). A minimum dbh for a nest tree is approximately 50 cm (Thomas et al. 1979a).

Nests are excavated in snags 20 to 30 m tall (Conner et al. 1975; Bull and Meslow 1977; McClelland 1979) with cavities located 10 to 15 m from the ground (Conner et al. 1975; Bull and Meslow 1977; McClelland 1979; Mannan et al. 1980).

Nest trees must be in the old or mature age class to provide the proper dbh and height. Age of nest trees averaged 143.5 years in Virginia (Conner and Adkission 1976) and greater than 200 years in Montana (McClelland 1977).

A great variety of tree species are used for nesting. Western larch and ponderosa pine are the preferred species in Oregon and Montana (Weydemeyer and Weydemeyer 1928; Bull and Meslow 1977; McClelland 1979), but numerous tree species are used in the Eastern deciduous forests (Nolan 1959; Bent 1964; Conner et al. 1976). Woodpeckers also occasionally nest in utility poles (Schemnitz 1964; Truslow 1967).

The primary characteristics of nesting habitat are old growth, densely stocked stands with high snag density in riparian or mesic communities (Table 16).

Stand age is often described as being mature, old growth, climax, virgin, or decadent (Kendeigh 1948; Adams and Barrett 1976; McClelland 1979; Thomas et al. 1979a; Marcot 1980) with ages ranging from 100 to greater than 200 years (Mannan et al. 1980). Pileated woodpeckers do nest in second growth stands

Table 15. Pileated woodpecker nest tree characteristics.

Study area	Tree species	Age	Average DBH (range)	Height	Diameter at cavity	Height to cavity	Tree condition	Study reference
Western Oregon	Douglas-fir Western hemlock		78 cm (46-172)			15.0 m (7-24.1)		Mannan et al. 1980
Northeastern Oregon	Ponderosa pine Western larch		76.2 cm (58.99)	21.0 m (11.9-36.9)		13.1 m (7-18.9)	Broken top	Bull and Meslow 1977; Bull 1975; Bull et al. 1980; Thomas et al. 1976; Miller and Miller 1980; Miller et al. 1979
			76 cm				Sound dry wood	
			50 cm	28.0 m				
			50.8 cm			9.5 m	64% sound wood	
Montana	Western larch Ponderosa pine Black cottonwood	Old growth	74.9 cm (39-119)	28.0 m (12.2-47.2)		15.2 m (5.5-29.9)	65% broken top	McClelland 1979 McClelland et al. 1979
Southeastern Virginia		100-180	(35-85)		(30.45)	(5-17)	Dead or live	Conner 1978 Conner and Adkisson 1976
			54.6 cm (33-91)	20.3 m (10.7-36.6)	37.9 cm (30-51)	13.6 m (9.1-19.2)		Conner et al. 1975
		143.5	(30-60)				Broken top	
	Deciduous trees		50 cm	9 m	43.75 cm	(3-23)		Bent 1964

Table 16. Pileated woodpecker nesting habitat characteristics.

Study area	Overstory type	Stand age	density (basal area)	Stem density	Canopy height	Study reference
Western Oregon	Douglas fir	110-200 yr.				Mannan et al. 1980
Northeastern Oregon	Ponderosa pine Mixed conifer White fir Grand fir	80-159 yr. 160+ yr.	75% canopy cover, dense forest	494 stem/ha High stem density 0.32 snags/ha	25m	Jackman 1974 Bull 1975 Thomas et al. 1976, 1979a Edgerton and Thomas 1978 Bull et al. 1980
Montana	Western larch Douglas fir	Old growth	25.1 m /ha			McClelland 1979 McClelland et al. 1979
Northeastern United States	Oak/hickory Mixed deciduous and conifer	Second growth	Dense stand			Hardin and Evans 1977 Evans and Conner 1979
California		Decadent stand	Dense canopy			Marcot 1980
Michigan	Beech/maple/pine	Climax				Kendeigh 1948
Ohio/Indiana	Beech/maple	Virgin				Adams and Barrett 1976
Virginia	Oak/hickory		27.1 m /ha 31.5 m /ha	475.3 stem/ha Greatest density	24.2 m	Conner et al. 1975 Conner and Adkisson 1976

(Weydemeyer and Weydemeyer 1928; Wight 1974; Evans 1978), but such stands have to be old enough to provide snags in the proper stage of decay and size for nesting. Pileated woodpeckers are becoming common in the Eastern United States as second growth forests mature.

Mesic stands that are densely stocked and riparian communities provide the fast growing conditions necessary for producing large diameter trees (McClelland et al. 1979; Thomas et al. 1979b; Marcot 1980). Such habitats provide numerous snags for nesting, roosting, and feeding. Four snags are required in each territory to provide nesting and roosting habitat in the north-central and northeastern United States (Evans and Conner 1979). A density of 0.32 snags/ha is required to provide three cavities per territory for nesting and roosting habitat in Oregon (Bull et al. 1980).

Forest communities used for nesting include loblolly pine (Pinus taeda) in Georgia (Kilham 1979), bald cypress (Taxodium distichum) swamps in South Carolina (Sprunt and Chamberlain 1970), oak/hickory (Quercus/Carya) in Virginia (Conner et al. 1975), beech/maple (Fagus/Acer) in Ohio and Indiana (Adams and Barrett 1976), lowland hardwood/oak/pine (Pinus) in the northeastern United States (Evans and Conner 1979), cedar/balsam fir (Juniperus)/(Abies balsamen) bogs and beech/maple in Michigan (Kendeigh 1948), American elm/ash/basswood (Ulmus americana)/(Fraxinus)/(Tilia heterophylla) in North Dakota (Stewart 1975), Douglas fir/western larch in Montana (Weydemeyer and Weydemeyer 1928; McClelland 1979), and ponderosa pine, mixed conifer, and Douglas fir in Oregon (Bull 1978; Mannan et al. 1980).

Pileated woodpeckers tend to avoid nesting in selectively cut beech/maple stands (Adams and Barrett 1976), preferring to nest far from cleared areas (Conner and Adkisson 1976). They tend to avoid nesting in snags occurring in early successional forest stages in the Pacific Northwest (Thomas et al. 1976), but may use later successional stages (Wight 1974).

Nesting territories in the Western United States ranged from 100 to 200 ha in area (Jackman 1974; McClelland 1979; Marcot 1980). Territories averaged about 70 ha in the northern and northeastern United States (Evans and Conner 1979). There may be 4 to 12 breeding males/km^2 in the dense forest of Louisiana and eastern Texas (Dickson 1978).

POPULATION TRENDS

Populations of pileated woodpeckers decreased during the early 1900's due to market hunting (Beal 1911; Hoyt 1941, 1957) and the destruction of old growth forest habitat (Burleigh 1958; Imhof 1976). Woodpecker populations have increased since the early decades of the century and have become common in cypress swamps of Georgia (Burleigh 1958) and South Carolina (Sprunt and Chamberlain 1970) as well as other regions. The woodpecker has adapted to second growth forests in Alabama where it is often sighted near houses (Imhof 1976) and it often occurs in city parks in New York (Bull 1974).

The pileated woodpecker is useful in controlling insects and in excavating cavities for secondary cavity nesters (Bull 1978). It is an important indicator species because of its sensitivity to habitat alteration (McClelland 1977; Cannut and Poppino 1978).

Effects of Habitat Changes

Timber harvesting eliminates necessary habitat components for pileated woodpeckers (Jackman and Scott 1975; Sanderson et al. 1980). Logging of virgin forests may have been a primary reason for the woodpecker's demise in the East during the late 19th century (Hoyt 1941), for they rarely feed or nest in or near clearcut areas (Conner and Crawford 1974; Conner and Adkisson 1977). The late successional stages of second growth forest are used for nesting if they contain decayed trees and large diameter snags (Eifrig 1927; Brooks 1934; Hoyt 1941). The woodpecker may become attracted to areas flooded by beaver and forage on the abundant snags (Lochmiller 1979), but they tend to avoid areas treated with fire to reduce litter and understory (Kilgore 1971).

Effects of Human Disturbance

The woodpecker's response to disturbances depends on the type of disturbance and its intensity. A decrease in numbers of woodpeckers occurred in areas adjacent to operating coal strip mines (Allaire 1978). After operation was discontinued the number of woodpeckers increased, apparently in response to the decreased blasting tremors, noise, and dust.

Pileated woodpeckers may become accustomed to lesser degrees of disturbances. For example, they often nest close to human habitation (Eifrig 1927; Hoyt 1941; Jackman and Scott 1975) and may not abandon nest sites if accustomed to the presence of visitors (Brooks 1934; Bent 1964; Hoyt 1957; Truslow 1967). They may also use man-made structures such as utility poles, for feeding and nesting (Hoyt 1957; Bent 1964; Dennis 1964; Schemnitz 1964; Truslow 1967), but nests in creosoted poles are often unsuccessful (Rumsey 1970).

Management

Different regions may require different programs for managing the habitat of pileated woodpeckers because territory size and habitat characteristics may vary. A snag density must be maintained which will satisfy the requirements for roosting, nesting, and feeding. Nineteen to 24 snags/40 ha must be maintained in the North-central and Northeastern United States to maintain 80% to 100% of the maximum breeding population and 10 snags/40 ha are required (Evans and Conner 1979) to maintain 40% of the maximum population. Eleven to 15 snags/40 ha are required in the Blue Mountains to maintain a breeding population that is 70% to 100% of maximum. Six snags/40 ha are required to maintain a self-sustaining population, which is 40% of the maximum population (Bull 1978).

The difference in snag requirements between the two regions may be due to differences in territory size, 70 ha in the East (Evans and Conner 1979) and 130 to 243 ha in the Pacific Northwest (Bull and Meslow 1977). A territory of 40 ha, as in Louisiana (Tanner 1942), may require an even greater snag density.

Snags should be 45 to 65 cm dbh and 12 to 21 m tall to provide adequate nest habitat (Evans and Conner 1979; Thomas et al. 1979a; Mannan et al. 1980).

Planning is needed for snag recruitment. Dying trees, trees with heart rot or insect infestations, distorted shapes, or wind breakage, and trees with dead tops should be maintained (Jackman and Scott 1975). Snags can be artificially created by frill girdling or using a silvicide and then inoculating the tree with a heart rot fungus (Conner 1978). Nest boxes will not provide an effective substitute for snags (Mannan et al. 1980).

The size of management units should consider the size of the territory of this woodpecker. Management units should be at least 128 ha in northeastern Oregon (Bull and Meslow 1977) and 200 to 400 ha in Montana (McClelland 1979). The larger areas are required where portions of the range are clearcut or developed. Such areas must provide 200 ha of suitable feeding habitat with snags and logs and 20 to 40 ha of old growth larch and ponderosa pine for present and future nesting habitat. Patches of timber older than 100 years should be retained, interspersed among areas of young intensively managed timber (Mannan et al. 1980). These patches may be 12 ha in size (Bull and Meslow 1977). McClelland et al. (1979) emphasized the need for leaving connecting corridors between islands of timber. Corridors approximately 90 m in width should be maintained along streams (Conner 1973; McClelland 1979; Mannan et al. 1980).

Selected timber harvest may be compatible or even enhance habitat for pileated woodpeckers, while clearcutting may be detrimental to the species. Precommercial thinning can increase the growth rate of trees, enhancing nest tree production (Evans and Conner 1979; Hall and Thomas 1979).

Climax forests in the West should be managed to favor larch, Douglas fir, and ponderosa pine (Hall 1980). Silvicultural practices must be on a rotation period, perhaps 100 to 300 years long, to continually provide snags and decayed tree boles (Jackman and Scott 1975; Conner 1978; Hall 1980). Some large trees and snags should be left for nest sites in areas that are harvested (Mannan et al. 1980).

Pileated Woodpecker as an Indicator Species

An indicator species is one that has narrow habitat requirements and whose populations are sensitive to habitat change. These woodpeckers may serve as a valuable indicator of the long term effects of man-caused disturbances on the mature forest community because of their sensitivity to habitat alteration.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts on pileated woodpecker populations may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining operations if nests and nestlings are destroyed. The most serious impact will be from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition will result in an ultimate reduction in the breeding population.

Surface mining may cause a long-term negative impact on pileated woodpeckers by removing old growth forests and may cause a short-term negative impact on populations nesting in areas adjacent to mine sites. Blasting tremors, noise, and dust may have caused decreased numbers of nesting woodpeckers near coal strip mine areas in Kentucky (Allaire 1978). Additional impacts may result from the increased access and increased human populations associated with mining. These impacts may include cutting snags for firewood, disrupting nesting birds, and shooting birds.

Water supply development, ground water pumping, and reservoir construction may adversely impact riparian habitats. The negative impacts of power line construction associated with mine development include removal of habitat along power line corridors, failure of nests in creosoted utility poles, and collisions of birds with power lines.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

The most effective means for mitigating impacts of coal surface mines for the pileated woodpecker is to provide optimum habitat in adjacent forest stands.

A premining census of birds should be conducted. If the area has pileated woodpeckers, then all existing and potential habitat, as well as individual territories, may be inventoried and plotted on a map. Territory size will vary with regions so that the size and location of territories are important considerations in prescribing management programs.

Adjacent forest areas may be improved as woodpecker habitat by selective thinning. Thinning will increase the growth rate of trees which will favor the production of nest trees. Thinning debris should be cleaned up and not permitted to cover stumps and downed logs.

The production of snags using silvicides or frill girdling and the inoculation of the tree with a decay fungus may be necessary if enough natural snags are not available (Conner 1978). A density of 15 to 24 snags/40 ha is required for a territory size of 70 to 120 ha (Bull 1978; Evans and Conner 1979). Snags at least 50 cm dbh may provide potential nest sites.

Protection of areas with pileated woodpeckers near mine sites will allow young birds to disperse into recently enhanced areas. Undisturbed forest corridors at least 90 m wide connecting the protected areas with the enhanced areas will encourage dispersal and use of new areas.

Exploration, Mine Development, and Mining Phase

Road building and surface mining may have negative effects on woodpeckers due to noise, blasting tremors, dust, and destruction of habitat. Blasting conducted on a regular daily or weekly schedule may allow birds to become accustomed to the disturbance (Allaire 1978). Blasting conducted on windless days or days when the dust will not blow into forest habitat will help to protect forest vegetation from high dust levels. Selective placement of spoil piles and hauling roads will minimize the effects of dust on breeding and feeding areas. Paving roads, covering conveyor belts, and mulching wind-erodable areas may also help in reducing dust (Moore and Mills 1977).

Protection of woodpecker territories and a buffer zone of at least 100 m between territories and active mine sites and avoidance of territories during the breeding season may alleviate impacts (Allaire 1978).

If portions of a territory are to be destroyed during the mining operation, maintenance of an old growth component of at least 20 to 40 ha will ensure the existence of suitable habitat (McClelland 1979). Protection of stands near the nest site, especially during the nesting season, may prevent loss of birds from lowered productivity.

Reclamation Phase

Reclamation of pileated woodpecker habitat may require 100 to 300 years for development of mature trees. Reclamation may initially involve planting grasses and forbs to stabilize the soils and later planting shrubs and tree seedlings to initiate forest regeneration. Disturbed sites should be reclaimed for other wildlife species and for stabilizing soils. Eventually they may provide habitat for pileated woodpeckers. The long time required for habitat development on reclaimed lands stresses the importance of enhancing adjacent forest sites.

SUMMARY

Pileated woodpeckers inhabit old growth and older second growth forests in the Eastern and Western U.S. They feed on insects, fruits, and seeds. Nests are in cavities in large diameter trees. Intensive logging has decreased pileated woodpecker populations in the past. Management practices include maintenance of a snag density of 11 to 24/40 ha. Impacts of coal mining include habitat loss and deterioration, and increased stress from high noise and dust levels. Mitigation should concentrate on enhancement of adjacent forests, since reclamation may require 100 to 300 years.

ACKNOWLEDGMENTS

I appreciate the cooperation of W. C. Fischer and B. R. McClelland in providing many of the references cited in this report. E. G. Bizeau, M. G. Hornocker, and M. M. Koehler reviewed this manuscript and provided many helpful suggestions.

REFERENCES

Adams, D. L., and G. W. Barrett. 1976. Stress effects on bird-species diversity within mature forest ecosystems. Am. Midl. Nat. 96:179-194.

Allaire, P. N. 1978. Effects of avian populations adjacent to an active strip-mine site. Pages 232-240 _in_ Proc. symp: Surface mining and fish/ wildlife needs in the Eastern United States. U.S. Fish Wildl. Serv. FWS/OBS-78/81.

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Beal, F. E. L. 1911. Foods of the woodpeckers of the United States. U.S. Dept. Agric., Biol. Surv. Bull. 37. 64 pp.

Becker, G. C. 1942. Notes on the pileated woodpecker in Wisconsin. Passenger Pigeon IV (4,5,6):29-34.

Bent, A. C. 1964. Life histories of North American woodpeckers. Dover Publishing Co., Inc., New York. 334 pp.

Bock, C. E., and L. W. Lepthien. 1975. A Christmas count analysis of woodpecker abundance in the United States. Wilson Bull. 87(3):344-366.

Brooks, M. 1934. Some traits of the northern pileated woodpecker. Bird-Lore 36(6):347-351.

Bull, E. L. 1975. Habitat utilization of the pileated woodpecker, Blue Mountains, Oregon. M.S. Thesis, Oregon State Univ., Corvallis. 58 pp.

____________. 1978. Specialized habitat requirements of birds, snag management, old growth and riparian habitat. Pages 74-81 _in_ R. M. DeGraaf, ed. Proc. workshop: Nongame bird management in coniferous forests of the Western United States. U.S. For. Serv. Gen. Tech. Rep. PNW-64. 100 pp.

____________. 1981. How woodpeckers select and partition their habitat in northeastern Oregon. Ph.D. Dissertation, Univ. Idaho, Moscow. 99 pp.

Bull, E. L., and E. C. Meslow. 1977. Habitat requirements of the pileated woodpecker in northeastern Oregon. J. For. 75(6):335-337.

Bull, E. L., A. D. Twombly, and T. M. Quigley. 1980. Perpetuating snags in managed mixed conifer forests of the Blue Mountains, Oregon. Pages 325-336 in R. M. DeGraaf, ed. Proc. workshop: Nongame bird management in coniferous forests of the Western United States. U.S. For. Serv. Gen. Tech. Rep. PNW-64. 100 pp.

Bull, J. 1974. Birds of New York State. Doubleday/Natural History Press. Garden City, NY. 655 pp.

Burleigh, T. D. 1958. Georgia birds. Univ. Oklahoma Press, Norman. 746 pp.

Canutt, P. R., and J. H. Poppino. 1978. Accounting for nongame bird habitat in land use planning. Pages 83-89 in R. M. DeGraaf, ed. Proc. workshop. Nongame bird habitat management in coniferous forests of the Western United States. U.S. For. Serv. Gen. Tech. Rep. PNW-64. 100 pp.

Conner, R. N. 1973. Woodpecker utilization of cut and uncut woodlands. M.S. Thesis, Virginia Polytech. Inst. and State Univ., Blacksburg. 82 pp.

____________. 1975. Orientations of entrances to woodpecker nest cavities. Auk 92(2):371-374.

____________. 1978. Snag management for cavity nesting birds. Pages 120-128 in R. M. DeGraaf, ed. Proc. workshop: Management of Southern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

Conner, R. N., and C. S. Adkisson. 1976. Discriminant function analysis: A possible aid in determining the impact of forest management on woodpecker nesting habitat. For. Sci. 22(2):122-127.

____________. 1977. Principal component analysis of woodpecker nesting habitat. Wilson Bull. 89(1):122-129.

Conner, R. N., and H. S. Crawford. 1974. Woodpecker foraging in Appalachian clearcuts. J. Forestry 72(9):564-566.

Conner, R. N., R. G. Hooper, H. S. Crawford, and H. S. Mosley. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39(1):144-150.

Conner, R. N., O. K. Miller, Jr., and C. S. Adkisson. 1976. Woodpecker dependence on trees infected by fungal heart rots. Wilson Bull. 88(4):575-581.

Dennis, J. V. 1964. Woodpecker damage to utility poles: with special reference to the role of territory and resonance. Bird-Banding 35(4):225-253.

Dickson, J. G. 1978. Forest bird communities of the bottomland hardwoods. Pages 66-73 in R. M. DeGraaf, ed. Proc. workshop: Management of Southern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

Dickson, J. G., and C. A. Segelquist. 1977. Winter bird populations in pine and pine-hardwood forest stands in east Texas. Proc. Annu. Conf. Southeast Assoc. Fish Wildl. Agencies 31:134-137.

Downing, G. R. 1970. The winter habits of the northern pileated woodpecker in Iowa. Iowa Bird Life 10(3):43-46.

Edgerton, P. J., and J. W. Thomas. 1978. Silviculture options and habitat values in coniferous forests. Pages 56-65 in R. M. DeGraaf, ed. Proc. workshop: Nongame bird habitat management in coniferous forests of the Western United States. U.S. For. Serv. Gen. Tech. Rep. PNW-64. 100 pp.

Eifrig, C. W. G. 1927. Some notes on pileated woodpeckers. Wilson Bull. 39:174-175.

Evans, K. E. 1978. Oak-pine and oak-hickory forest bird communities and management options. Pages 76-89 in R. M. DeGraaf, ed. Proc. workshop: Management of Southern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

Evans, K. E., and R. N. Conner. 1979. Snag management. Pages 214-225 in R. M. DeGraaf, ed. Proc. workshop: Management of North-central and Northeastern forests for nongame birds. U.S. For. Serv. Gen. Tech. Rep. NC-51. 268 pp.

Green, J. C., and R. B. Janssen. 1975. Minnesota birds: where, when, and how many. Univ. Minnesota Press. 217 pp.

Hall, F. C. 1980. Western forest types and avian management practices. Pages 27-37 in R. M. DeGraaf, ed. Proc. workshop: Management of Western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. 535 pp.

Hall, F. C., and J. W. Thomas. 1979. Silvicultural options. Pages 128-147 in J. W. Thomas, ed. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. U.S. For. Serv. Handbook 533. Publ. by Wildl. Manage. Inst. and U.S. Dept. Agric., Bur. Land Manage.

Hardin, K. I., and K. E. Evans. 1977. Cavity nesting bird habitat in the oak-hickory forest, a review. U.S. For. Serv. Gen. Tech. Rep. NC-30. 22 pp.

Harrison, H. H. 1979. A field guide to Western birds' nests. Houghton Mifflin Co., Boston. 259 pp.

Hoyt, J. S. Y. 1941. Through the year with pileated woodpeckers. Audubon 43(6):525-528.

____________. 1944. Preliminary notes of the development of nesting pileated woodpeckers. Auk 61:376-384.

Hoyt, S. F. 1957. The ecology of the pileated woodpecker. Ecology 38(2):246-256.

Hubbard, J. P. 1970. Checklist of the birds of New Mexico. New Mexico Ornith. Soc. Publ. 3. 103 pp.

Imhof, T. A. 1976. Alabama birds. 2nd ed. Univ. Alabama Press, Birmingham. 445 pp.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Jackman, S. M. 1974. Woodpeckers of the Pacific Northwest; their characteristics and their role in the forests. M.S. Thesis, Oregon State Univ., Corvallis. 147 pp.

Jackman, S. M., and J. M. Scott. 1975. Literature review of twenty-three selected forest birds of the Pacific Northwest. U.S. For. Serv. Region 6, Portland, OR. 382 pp.

Kendeigh, S. C. 1948. Bird populations and biotic communities in northern lower Michigan. Ecology 29(1):101-114.

Kilgore, B. 1971. Response of breeding bird populations to habitat changes in a giant sequoia forest. Am. Midl. Nat. 85:135-152.

Kilham, L. 1959. Behavior and methods of communications of pileated woodpeckers. Condor 61(6):377-387.

__________. 1976. Winter foraging associated behavior of pileated woodpeckers in Georgia and Florida. Auk 93(1):15-24.

__________. 1979. Courtship and the pair-bond of pileated woodpeckers. Auk 96(3):587-594.

Lochmiller, R. L. 1979. Use of beaver ponds by woodpecker in winter. J. Wildl. Manage. 43(1):263-266.

Mannan, R. W., E. C. Meslow, and H. M. Wight. 1980. Use of snags by birds in Douglas-fir forests, western Oregon. J. Wildl. Manage. 44(4):787-797.

Marcot, B. G. 1980. Use of a habitat/niche model for old growth management: a preliminary discussion. Pages 390-402 _in_ R. M. DeGraaf, ed. Proc. workshop: Management of Western forest and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. 535 pp.

McClelland, B. R. 1977. Relationships between hole-nesting birds, forest snags, and decay in western larch-Douglas fir forests of the northern Rocky Mountains. Ph.D. Dissertation, Univ. Montana, Missoula. 517 pp.

____________. 1979. The pileated woodpecker in forests of the northern Rocky Mountains. Pages 283-299 in J. Dickson, R. N. Conner, R. R. Fleet, J. C. Kroll, and J. A. Jackson, eds. The role of insectivorous birds in forest ecosystems. Acad. Press, Inc., New York.

McClelland, B. R., S. S. Frissell, W. C. Fischer, and C. H. Halvorson. 1979. Habitat management for hole-nesting birds in forests of western larch and Douglas-fir. J. For. 77(8):480-483.

Miller, E., and D. R. Miller. 1980. Snag use by birds. Pages 337-356 in R. M. DeGraaf, ed. Proc. workshop: Management of Western forests and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. 565 pp.

Miller, E., A. D. Partridge, and E. L. Bull. 1979. The relationship of primary cavity nesters and decay. Trans. Northeast Sect. Wildl. Soc. 36:60-68.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: Impacts, mitigation and monitoring. U.S. Fish Wildl. Serv. FWS/OBS-78/04.

Nolan, V., Jr. 1959. Pileated woodpecker attacks pilot black snake at tree cavity. Wilson Bull. 71(4):381-382.

Phillips, A., J. Marshall, and G. Monson. 1964. The birds of Arizona. Univ. Arizona Press, Tucson. 212 pp.

Rumsey, R. L. 1970. Woodpecker nest failure in creosoted utility poles. Auk 87(2):367-369.

Ryder, R. A., and A. Ryder, eds. 1976. Twenty-ninth winter bird-population study. Am. Birds 30(6):1040-1075.

Sanderson, H. R., E. L. Bull, and P. J. Edgerton. 1980. Bird communities in mixed conifer forests of the interior Northwest. Pages 224-237 in R. M. DeGraaf and N. G. Tilghman, eds. Proc. workshop: Management of Western forest and grasslands for nongame birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. 535 pp.

Schemnitz, S. D. 1964. Nesting association of pileated woodpecker and yellow-shafted flicker in a utility pole. Wilson Bull. 76(1):95.

Sprunt, A., Jr., and E. B. Chamberlain. 1970. South Carolina bird life. Univ. South Carolina Press, Columbia. 655 pp.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Center for Environ. Studies, North Dakota State Univ., Fargo. 295 pp.

Tanner, J. T. 1942. The ivory-billed woodpecker. New York Natl. Audubon Soc. Res. Pap. 1, New York. 111 pp.

Thomas, J. W., R. J. Miller, H. Black, J. E. Rodiek, and C. Maser. 1976. Guidelines for maintaining and enhancing wildlife habitat in forest management in the Blue Mountains of Oregon and Washington. Trans. North Am. Wildl. Nat. Resour. Conf. 41:452-476.

Thomas, J. W., G. Anderson, C. Maser, and E. L. Bull. 1979a. Snags. Pages 60-77 in J. W. Thomas, ed. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. U.S. For. Serv. Handb. 533. 512 pp.

Thomas, J. W., R. J. Miller, C. Maser, R. G. Anderson, and B. E. Carter. 1979b. Plant communities and successional stages. Pages 23-39 in J. W. Thomas, ed. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. U.S. For. Serv. Handb. 533. 512 pp.

Truslow, F. K. 1967. Egg-carrying by a pileated woodpecker. Living Bird 6:227-236.

______________. 1970. Pileated in a pine tree. Audubon 72(2):8-13.

Weydemeyer, W., and D. Weydemeyer. 1928. The woodpeckers of Lincoln County, Montana. Condor 30:339-346.

Wight, H. M. 1974. Nongame wildlife and forest management. Pages 27-38 in H. Black, ed. Wildlife and forest management in the Pacific Northwest. Oregon State Sch. For., Corvallis.

LOGGERHEAD SHRIKE (*Lanius ludovicianus*)

by

Danny Bystrak
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

Loggerhead shrike (*Lanius ludovicianus*) is a medium-sized passerine with a plain gray dorsum and a paler gray to white ventrum. Wings and tail are black with white markings. A narrow black patch extends from behind the eye to the bill, forming a "mask" pattern. The seven North American subspecies are virtually identical, differing only in degree of overall paleness (Miller 1931).

DISTRIBUTION

The American Ornithologists' Union Checklist (1957) considers seven subspecies of the loggerhead shrike north of the Mexican border. The subspecies *L. l. migrans* occurs from the Appalachians west to the Great Plains, south to northern Louisiana, and north to the northern limit of the species range in southern Canada; *L. l. ludovicianus* occurs in the Southeast, from Virginia to Louisiana; *L. l. excubitoroides* occurs in the Great Plains from Alberta south to Texas; *L. l. sonoriensis* occurs in the arid southwest from California to West Texas; and the range of *L. l. gambeli* extends from British Columbia south throughout the Rocky Mountain and Great Basin area, and west to the Pacific coast (Bent 1950; Cameron 1970). Two subspecies of this shrike (*L. l. anthony* and *L. l. mearnsi*) are restricted to the Channel Islands of southern California (Johnson 1972).

Winter range includes Washington, Oregon, California, southern Nevada, northern Arizona and New Mexico, and the southern half of the breeding range. Figure 26 illustrates the geographical distribution in the United States.

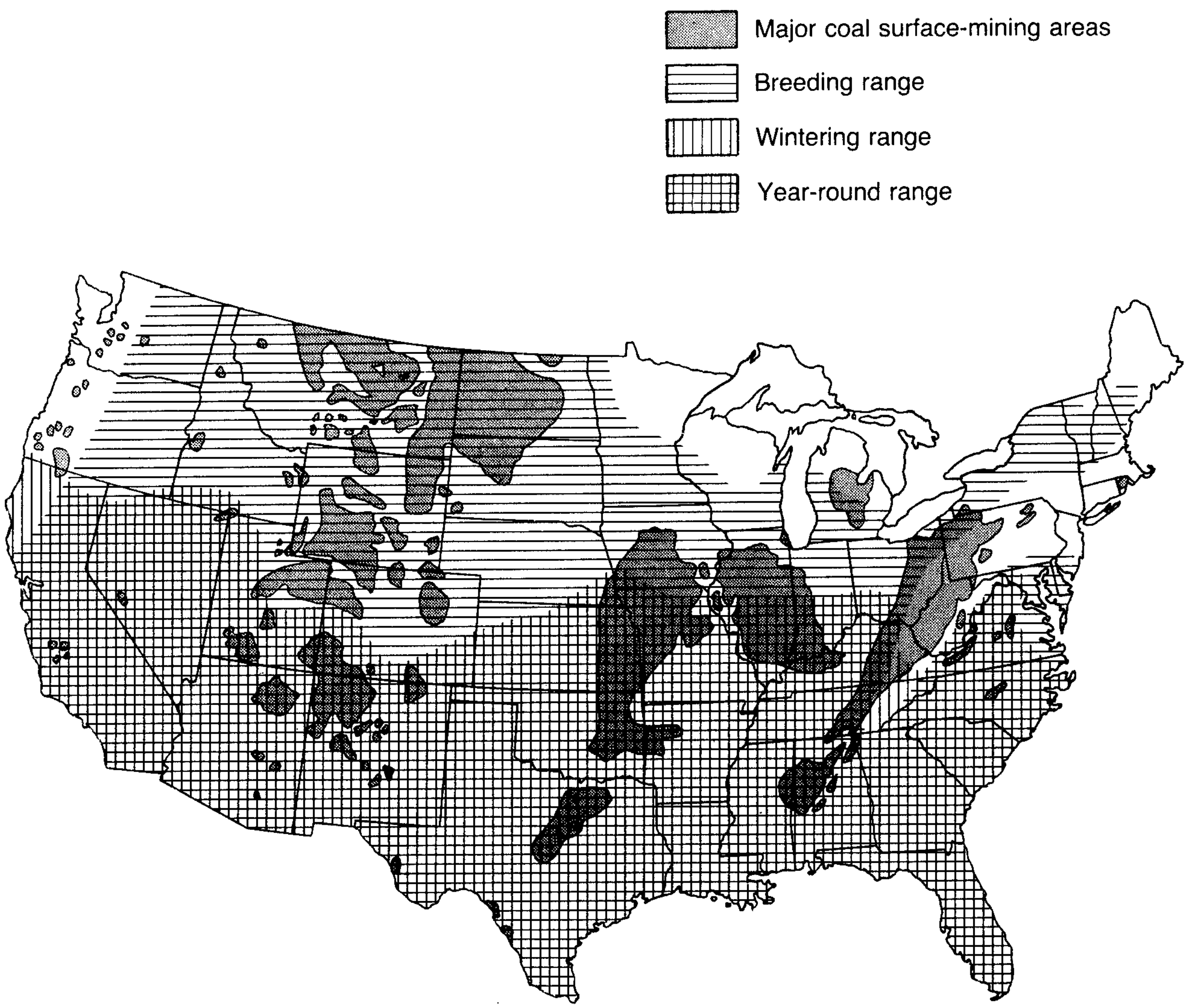


Figure 26. Geographical range of the loggerhead shrike in relation to major coal deposits in the United States.

DIET

Loggerhead shrikes are obligatory carnivores and highly predatory, spending much time sitting and watching for prey (Judd 1898; Knowlton and Harmston 1944). The attack is usually from a perch or occasionally from a hovering position. Although prey are predominantly insects, small vertebrates, especially mice, are taken regularly (Graber et al. 1973). Occasionally larger prey approaching the size of the shrike are selected, i.e., snakes (Chapman and Casto 1972) or birds (Wayne 1921). During the breeding season a preponderance of beetles occurs in the diet (Craig 1978). In 31 specimens collected in southern Illinois during April, 63% of the diet was beetles, mostly Carabids and Scarabaeids (Graber et al. 1973).

A peculiar habit of the shrike is the caching of food items, usually by impaling on a thorn or barbed wire or wedging in a forked branch (Black 1976). The purpose of this caching is not well understood, primarily because of the infrequency of reported cases of shrikes returning to eat cached items (Watson 1910). Applegate (1977) observed a female feeding herself and her nestling primarily from impaled food cached by the male. He suggests that this could be a method of conserving the female's energy during this crucial time. Thorns and forks are also used to hold prey items in place while a shrike is eating (Brown 1971). This is necessary because the species' feet are not raptorial, making it difficult for the bird to hold the prey while eating it. Because the feet lack talons, the actual killing of prey is done with the beak.

A shrike was observed feeding on scraps left behind by marsh (*Circus cyaneus*) and rough-legged (*Buteo lagopus*) hawks, suggesting that shrikes can also be scavengers (Anderson 1976).

Open country is required foraging habitat because the shrike's keen vision is its main hunting facility. A favored hunting habitat is pastureland. The presence of livestock feces in pastures is probably important in attracting beetles, considering the high percentage of Carabid and Scarabaeid beetles in the diet. In addition, abundant grasshoppers in pastureland provide an important food source. Cultivated land does not usually produce much food for shrikes. However, shrikes have been observed following tractors and catching prey items turned up during plowing (Graber et al. 1973).

REPRODUCTION

The loggerhead shrike nests very early (Smith 1969). In the deep South birds are often paired by late January (Bent 1950). Most individuals are nesting by mid-April as far north as Illinois (Cory 1909; Graber et al. 1973). Evidence is strong that shrikes are single-brooded, and most records of late nesting appear to be renesting attempts following an initial nest failure. Bent (1950) contradicts this and suggests that in the South two and often three broods are normal.

After a brief courtship, both members of the pair proceed to construct the nest which is large and bulky, resembling a thrasher's nest (Graber et al. 1973). Nests are completed in approximately 8 to 10 days and the eggs incubated for 16 to 17 days with a similar nestling period (Graber et al. 1973; Porter et al. 1975). Clutch size is usually six eggs, with reported means of 5 to 7 (Graber et al. 1973) and 6.39 (Porter et al. 1975).

The shrike has an unusually high nesting success rate for a passerine. Success rates vary from 80% in southeastern Illinois, and 71% in central Illinois (Graber et al. 1973), to a high of 82% on the shortgrass prairie (Porter et al. 1975).

Shrikes prefer open country for nesting, usually in proximity to their hunting areas. Because the nest is large and bulky and usually built before vegetation has exhibited much leaf growth, the nest is placed near the center of a tree or bush that offers some protection; evergreens are a common choice. Over most of the eastern part of the range, Osage orange (Maclura pomifera), rose (Rosa sp.), common live oak (Quercus virginiana), and eastern red cedar (Juniperus virginiana) offer preferred nest sites. In Mississippi, orchard trees and hawthorn (Crataegus spp.) bushes in open pasture are preferred nest sites (Stockard 1905) while in Colorado, trees with thorns are chosen first, and degree of cover is more important than tree species (Porter et al. 1975). The nest is usually placed about 3.0 to 5.4 m above the ground (Bent 1950).

POPULATION TRENDS

Loggerhead shrikes are suffering a marked decline in population numbers. Virtually all papers dealing with the species in the past 40 years mention a decline (Eifrig 1919; Hess 1910; Erdman 1970; French and French 1977; Morrison 1981; Tate and Tate 1982). As early as 1910 local declines in population were being reported (Hess 1910). The National Audubon Society's Blue List has included the shrike since the List's beginning in 1972 (Tate and Tate 1982), and the North American Breeding Bird Survey shows a significant decline in all three regions of North America (U.S. Fish and Wildlife Service unpub. data). Christmas Bird Count results also indicate a serious decline in numbers in many areas (French and French 1977; Morrison 1981).

As is typical for a declining species, the areas most severely affected appear to be at the periphery of the range. States in which the decline has been most drastic fall primarily within the range of the subspecies L. l. migrans.

The reason for the decline of the shrike is unknown. Because much of the food of the shrike is high in the food chain, pesticides may possibly be a factor, as in raptors. However, observed eggshell thinning due to DDE has not been viewed as a cause for population decline (Morrison 1979; Anderson and Duzan 1978; and Klaas et al. 1974). Therefore, a combination of factors is probably contributing to the decline of the shrike. In much of the East, its decline is probably to be viewed as a return to more natural population levels in response to various factors covered in the following section on habitat change (Palmer 1898). In the West, populations will probably continue to decline below historic levels as a result of habitat change and level off at a point commensurate with the level of ultimate habitat change.

Effects of Habitat Changes

In most of the eastern part of the range, preferred shrike habitat was not available before extensive settlement. Clearing of the original forest provided the necessary open country. In most of the West, the drier climate is less conducive to forest cover, and thus results in an abundance of shrike habitat.

It is extremely likely that loggerhead shrikes increased dramatically in the East as more forest was cleared and replaced by agriculture. However, in more recent times, three common and widespread changes have occurred in the East that have reduced the amount of habitat available for shrikes. In many parts of the East an increase in urbanized acreage has eliminated much shrike habitat. A related factor is an increase in forested land as zoning in urbanized areas renders agriculture impractical. The third and perhaps most significant impact is a trend toward "clean" agriculture. As the small, self-sufficient farms become less common, and monocultural practices increase, brush, hedgerows, windbreaks and pastureland disappear. As mentioned earlier, cultivated land lacking these features offers very little suitable habitat to shrikes. In Missouri, the presence of pastureland is crucial, and a loss of this habitat type is correlated with a commensurate decline in shrike populations (Kridelbaugh pers. comm.).

In the arid West, where natural habitats are more suitable for shrikes, the main deleterious effects are urbanization and clean agriculture including irrigation of many arid areas that are currently well suited to shrikes. An increase in center-pivot irrigation is taking its toll also. Shelterbelts and windbreaks, often the only areas affording nest sites, are usually destroyed to accommodate this rapidly increasing agricultural practice.

Effects of Human Disturbance

A bird so closely associated with agricultural areas is, as expected, largely unaffected by human disturbance except for cases of direct disruption of the nest. The California subspecies is extremely shy during nest building and will cease nest construction if approached within 55 m (Bent 1950). If required habitat is left intact, normal human activities are very unlikely to affect shrikes. This is supported by the fact that the best place for sighting shrikes is on telephone wires, even along major highways. Shrikes will use suburban areas, provided sufficient nesting and feeding habitat are available. Streets with considerable traffic are not a deterrent to shrike use (Bent 1950) and nests have been observed on Dulles International Airport grounds (Clark 1970).

Management

Management of loggerhead shrikes is difficult because over much of its range the bird occurs primarily on private land. Habitat management for shrikes would probably be beneficial to a wide variety of species.

Proper shrike management includes leaving or encouraging dense brushy hedgerows for nesting, and providing a mix of agricultural habitats. Availability of pastureland near nesting sites seems to be important to ensure a supply of Carabid and Scarabaeid beetles during the nesting season. However, these management options would require change from the current agricultural practices of monoculture and clean farming and, therefore, few opportunities exist to implement management alternatives.

The Loggerhead Shrike as an Indicator Species

An indicator species should be stenotypic and, as such, serve as an early warning of excessive human disruption of its environment. Disruptions may be either direct or secondary environmental responses to human activities. The fact that the loggerhead shrike has demonstrated a considerable population decline suggests a narrow range of tolerance, thus qualifying it as an indicator species. This contention is strengthened by the fact that several species are sharing its habitat and range and are not declining. Unfortunately, the factors to which shrikes are sensitive are not known.

Shrikes are a good indicator of surface mining effects because destruction of required habitat would result quickly in a corresponding population decline. This species should also respond quickly to proper reclamation techniques (Spaulding and Ogden 1968). In the early phases of reforestation in the East, properly reclaimed surface mines could be valuable shrike habitat. In the West, shrikes exemplify the need to reclaim surface mines with diverse cover types.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts on loggerhead shrike populations may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining phases if nests and nestlings are destroyed. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population.

Increased human activity may disrupt nesting activities and result in lowered productivity in local populations. An increase in dust levels from construction, mining, and haul roads may decrease vegetative growth, resulting in a decrease in prey populations. Contaminated water supplies from mining byproducts or increased runoff may be harmful to shrikes through direct ingestion, or indirectly through detrimental effects on vegetative growth and prey populations.

Because shrikes do not require large territories and are highly tolerant of human activities, destruction of adjacent habitat not required by shrikes can probably be extensive without affecting nesting shrikes. Comparison of known coal deposits with the shrike range shows extensive areas of overlap, therefore, some habitat disruption will be unavoidable. Considering traditional reclamation practices using grasses, habitat destruction could be widely disruptive to shrike populations.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Surveys of loggerhead shrike populations should be conducted for 2 years prior to mining activities on the mine site and the surrounding area. Baseline data collected should include determination of the size of the shrike population and assessment of the factors influencing the presence of prey items; delineation and evaluation of nesting habitat; and analysis of the shrike population habitat requirements for use in planning effective reclamation.

Exploration, Mine Development, and Mining Phase

Human disturbance and habitat loss will probably have minimal impacts during exploration because of the dispersed nature of the activities. Impacts to nesting birds may be alleviated if activities and subsequent reclamation are conducted outside of the breeding season.

Dust control measures such as paving roads may lessen impacts to surrounding populations. Proper disposal of wastes and by-products and control of runoff will protect water supplies from contamination.

Reclamation Phase

Reclamation of loggerhead shrike habitat may involve establishment of native species including grasses and forbs in open areas and trees and shrubs for nesting and feeding sites. A diversity of habitat types will encourage nesting birds and their prey populations. Successful reclamation activities conducted concurrently with mining may provide habitat for displaced shrikes in a relatively short period of time.

SUMMARY

The loggerhead shrike occurs throughout non-forested regions of the United States and southern Canada. The shrike is primarily carnivorous, feeding on insects and other small animals. The species has shown a continent-wide decline in numbers for several decades, primarily in the

periphery of the range. Population levels appear to be more stable in areas of greater abundance.

Accelerated development of coal resources throughout the United States will probably impact this species. Two of the five major subspecies of loggerhead shrike are vulnerable to habitat alterations created by surface mining. Research is needed to determine the most effective reclamation techniques to enhance shrike populations, including determination of the shrike's ecological requirements. This information will also be valuable for assessing the reason(s) for the shrike population decline. Reclamation is the most important factor in mitigating the effects of surface mining on this species. Establishment of open areas and a diversity of habitats including hedgerows and brushy borders will encourage loggerhead shrike nesting.

REFERENCES

American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. Lord Baltimore Press, Baltimore, MD. 691 pp.

____________. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Anderson, R. M. 1976. Shrikes feed on prey remains left by hawks. Condor 78(2):269.

Anderson, W. L., and R. E. Duzan. 1978. DDE residues and egg shell thinning in loggerhead shrikes. Wilson Bull. 90(2):215-220.

Applegate, R. D. 1977. Possible ecological role of food caches of loggerhead shrike. Auk 94(2):391-392.

Bent, A. C. 1950. Life histories of North American wagtails, shrikes, vireos, and their allies. U.S. Natl. Mus. Bull. 197. 411 pp.

Black, J. H. 1976. The lined snake as food for birds. Bull. Oklahoma Ornithol. Soc. 9(3):17-18.

Brown, W. H. 1971. A loggerhead shrike observation. Iowa Bird Life 41 (2):59.

Cameron, A. W. 1970. Loggerhead shrike breeding in Nova Scotia. Can. Field-Nat. 84:182-183.

Chapman, B. R., and S. D. Casto. 1972. Additional vertebrate prey of the loggerhead shrike. Wilson Bull. 84(4):496-497.

Clark, W. S. 1970. Loggerhead shrike breeding in northern Virginia. Atl. Nat. 25(3):133.

Cory, C. B. 1909. The birds of Illinois and Wisconsin. Field Mus. Nat. Hist. (9):131.

Craig, R. B. 1978. An analysis of the predatory behavior of the loggerhead shrike. Auk 95(2):221-234.

Eifrig, C. W. G. 1919. Birds of the Chicago area. Auk 36:523.

Erdman, T. C. 1970. Current migrant shrike status in Wisconsin. Passenger Pigeon 32:144-150.

French, J., and L. French. 1977. A winter loggerhead shrike. Loon 49 (2):106-107.

Graber, R. R., J. W. Graber, and E. L. Kirk. 1973. Illinois Birds: Laniidae. Illinois Nat. Hist. Surv. Biol. Notes 93. 18 pp.

Hess, I. E. 1910. One hundred breeding birds of an Illinois ten-mile radius. Auk 37(1):19-32.

Johnson, N. K. 1972. Origin and differentiation of the avifauna of the Channel Islands, California. Condor 74(3):295-315.

Judd, S. D. 1898. The food of shrikes. U.S. Dept. Agric. Div. Biol. Surv. Bull. 9:15-26.

Klaas, E. E., H. M. Ohlendorf, and R. G. Heath. 1974. Avian egg shell thickness variability and sampling. Wilson Bull. 86(2):156-164.

Knowlton, G F., and F. C. Harmston. 1944. Food of white-rumped shrikes. Auk 61:642-643.

Miller, A. H. 1931. Systematic revision and natural history of the American shrike. Univ. California Publ. Zool. 38:11-242.

Kridelbaugh, A. L. 1981. Personal communication. Missouri Cooperative Wildlife Research Unit, University of Missouri, Columbia, MO.

Morrison, M. L. 1979. Loggerhead shrike egg shell thickness in California and Florida. Wilson Bull. 91(3):468-469.

______________. 1981. Population trends of the loggerhead shrike in the United States. Am. Birds 35(4):754-757.

Palmer, W. 1898. Our small Eastern shrikes. Auk 15:244-258.

Porter, D. K., M. A. Strong, J. B. Giezentanner, and R. A. Ryder. 1975. Nest ecology, productivity, and growth of the loggerhead shrike on the shortgrass prairie. Southwest Nat. 19(4):429-436.

Smith, C. R. 1969. Loggerhead shrike nesting in Carter County. Migrant 40(4):86.

Spaulding, W. M., Jr., and R. D. Ogden. 1968. Effects of surface mining on the fish and wildlife resources of the United States. U.S. Bur. Sport Fish. and Wildl. Resource Publ. 68:1-51.

Stockard, C. R. 1905. Nesting habits of birds in Mississippi. Auk 22 (3):273-288.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

U.S. Fish and Wildlife Service. Breeding bird survey. Unpublished data. Washington, DC.

Watson, J. R. 1910. The impaling instinct in shrikes. Auk 27:459.

Wayne, A. T. 1921. The loggerhead shrike seen killing a large bird. Auk 38:279-280.

DICKCISSEL (*Spiza americana*)

by

David L. Evans and Eileen K. Bartels
Northern Prairie Wildlife Research Center
U.S. Fish and Wildlife Service
Jamestown, ND 58401

SPECIES DESCRIPTION

The dickcissel (*Spiza americana*) is an abundant breeding bird of the mid- and tallgrass prairie region, breeding principally in hayfields, weedy roadsides and fencerows, and ungrazed prairie. Dickcissels average 15 to 17 cm from tip of bill to tip of tail. The male is suggestive of a small meadowlark with a yellow breast and black bib but has a heavy bill and a chestnut wing patch. During the breeding season, the brightly colored males are especially conspicuous as they sing from elevated perches within their territories. The female resembles a female house sparrow but is paler, has a much whiter stripe over the eye, a touch of yellow on the breast, and a bluish bill (Peterson 1947).

DISTRIBUTION

The breeding range of the dickcissel extends from southern Ontario through the interior of the United States, east to the Appalachian Mountains, west to the Rocky Mountains, and south from Texas to Georgia (Hurley and Franks 1976; Peterson 1980) (Fig. 27). Dickcissels are sporadic and irruptive beyond the periphery of this range, being abundant in some years and scarce or nonexistent in many years (Taber 1947; Aldrich 1948; Emlen and Wiens 1965; Wiens and Emlen 1966; Gross 1968; Robbins and Van Velzen 1969; Stewart 1975). Dickcissels winter from southeastern Mexico south to central Columbia, southern Venezuela, British Guiana, French Guiana, and Trinidad (Gross 1968).

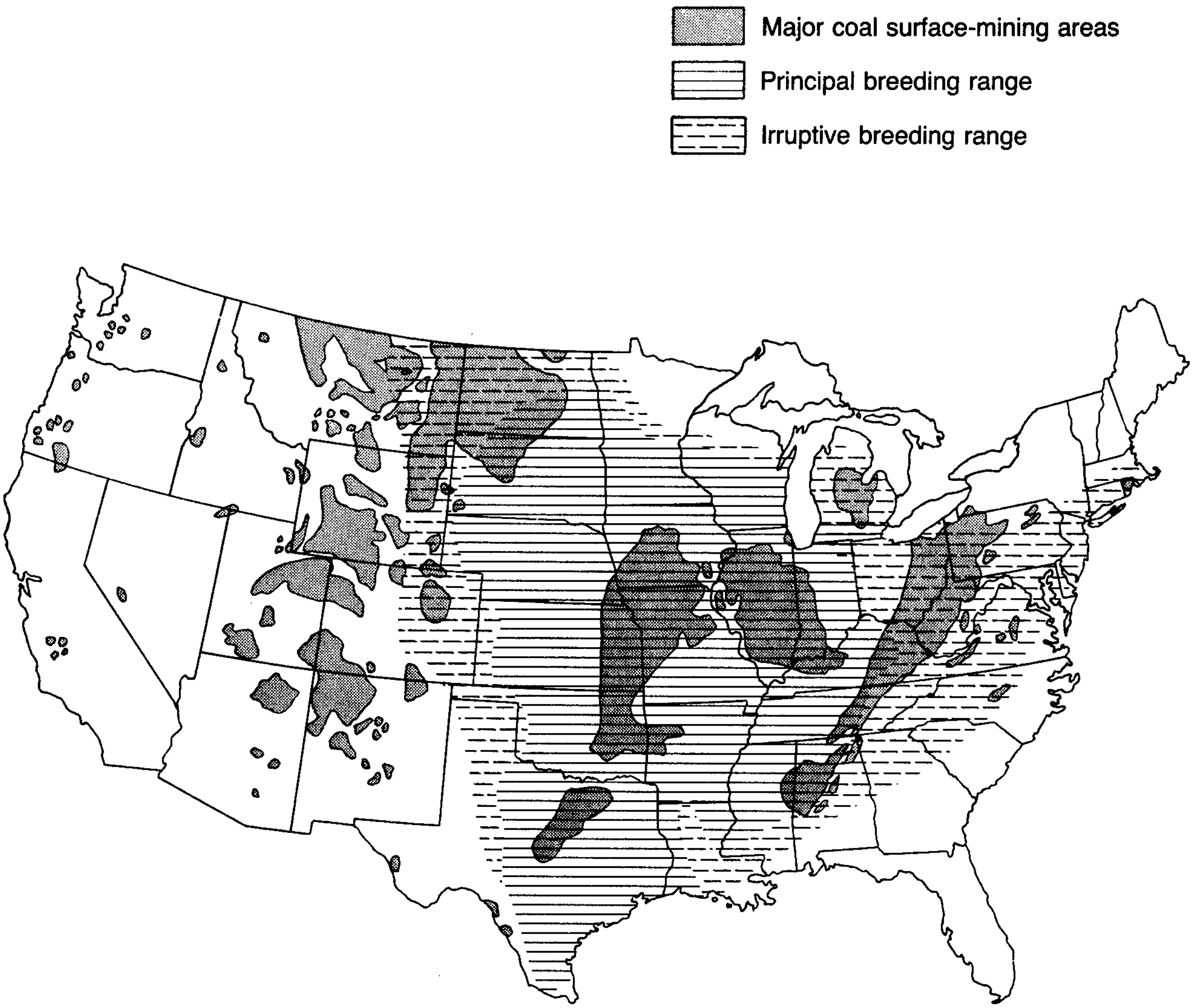


Figure 27. Breeding range of the dickcissel in relation to major coal deposits in the United States. Sources: principal breeding range - Hurley and Franks (1976); irruptive breeding range - Aldrich (1948).

DIET

Dickcissels are primarily granivorous on their wintering grounds, eating sorghum, rice, and native grass and weed seeds (Fretwell and Shane 1975). Insects, especially grasshoppers, replace a large portion of the seed diet during the nesting season (Overmire 1963; Gross 1968). Nestlings are fed insects, chiefly grasshoppers and lepidopterous caterpillars (Fretwell 1967; Gross 1968). In late summer, as migration approaches, weed seeds and waste grain become more important in the diet (Gross 1968).

REPRODUCTION

The dickcissel typically nests in disturbed (subseral) habitats (Zimmerman 1971). Nesting habitat is selected for both density and height of vegetation. Density of territorial males is correlated with increased volume of grasses and forbs. Scattered forbs, woody vegetation, or other structures (e.g, fence posts, telephone lines) must also be present; these are used as song perches (Zimmerman 1971). Disturbed grassland communities where forbs predominate and fields of alfalfa, clover, and timothy are preferred (Fretwell 1967; Gross 1968; Hurley and Franks 1976). Grazing of preferred habitat may result in as much as a 50% reduction in nesting population density but appears to have little effect on nesting success (Overmire 1963).

Dickcissels are polygamous; a male may mate with as many as eight females in a season (Fretwell 1977). The frequency of polygamy and average number of females per male is greater in oldfields than in grasslands (Zimmerman 1971). This appears to be a function of the vegetation, which is more heterogeneous in oldfields thus providing the potential for sequestering more nesting sites (Zimmerman 1982). Males with poor territories attract few or no mates (Zimmerman 1966; Fretwell 1977). Polygamous males typically spend about a week in courtship with one female at a time. Once the female has built the nest, which usually is on or near the ground, another female may be courted (Zimmerman 1966). The female assumes all responsibilities of incubation and raising the young (Zimmerman 1966; Gross 1968; Fretwell 1977). Incubation lasts 11 days (Long et al. 1965) and the nestlings fledge in 8 to 10 days (Gross 1968). Once the nestlings are several days old, no longer requiring constant attention, the female often forages beyond her male's territory (Zimmerman 1966). After fledging, the young birds wander from the territory; one bird 8 to 10 days postfledging was observed a mile from its nest (Gross 1921).

Overall nest survival rates are similar in the two primary nesting habitats (prairies, oldfields). However, survival is higher in oldfields during the nest-building and egg-laying periods while during the incubation and brooding phases it is higher in prairies. This is due to the greater impact of brown-headed cowbird (*Molothrus ater*) nest parasitism in the prairie, which leads to nest abandonment, and the higher incidence of predation in the oldfield (Zimmerman 1982).

POPULATION TRENDS

Effects of Habitat Changes

Since 1800, the breeding range of the dickcissel has expanded, then receded as a result of lumbering, urbanization, and agricultural practices (Hurley and Franks 1976). The breeding range prior to colonization of North America was probably confined to the tallgrass prairie. Settlement of the East and Midwest was accompanied by deforestation and creation of artificial "barrens" in the form of agricultural fields. The hay and grain crops and field-edge brushy growth provided nesting habitat for the dickcissel. Dickcissels regularly bred in the Atlantic coastal States until 1850, then populations began to decline. Two factors may account for this decline. Alfalfa was introduced and became an important crop in the East and Midwest in the latter part of the 19th century. While alfalfa may be well-suited to the needs of the dickcissel, alfalfa harvesting practices which occur during the dickcissel breeding period destroy many nests. In addition, spreading urbanization in the East and Midwest eliminated much of the suitable nesting habitat.

Fretwell (1977) discussed the breeding success of dickcissel populations and postulated that northern populations may be endangered because of a conversion of the food resource in the winter range from small, native grass and weed seeds to cultivated plants with larger seeds. He found evidence of increased survival in northern males, due to increased sorghum and rice plantings on the wintering grounds. However, northern females are smaller than northern males, and are less able to use these grains, thus their survival is not as high. Breeding success is adversely affected by reduced sex ratio and concomitant low female densities; the problem is compounded by increased cowbird parasitism at low female nesting densities. Nesting success north of Oklahoma ranged from 0% to 25% (Hergenrader 1962; Von Steen 1965; Zimmerman 1971). The Oklahoma-Texas dickcissels, on the other hand, are smaller and both sexes apparently feed on native grass and weed seeds. There is no evidence of distorted sex ratios (Fretwell 1977) and breeding success ranges from 30% to 50% (Overmire 1962; Wiens 1963; Fretwell et al. 1974). Grazing and herbicide treatments which reduce vegetative cover can also result in significant reductions in nesting density.

Effects of Human Disturbance

Aside from the grazing and agricultural activities discussed above, human activity does not seem to have any significant impact on dickcissel populations.

Management

Management plans for dickcissels should be aimed at increasing heterogeneity of breeding habitat. Since dickcissels typically nest in disturbed habitats, breeding habitat may be increased by allowing agricultural fields to progress through oldfield stages of secondary succession. Encouragement of brushy field borders and hedgerows and avoidance of clean farming practices will also provide more nesting habitat for dickcissels.

The Dickcissel as an Indicator Species

An indicator species is one having specific habitat requirements with a narrow range of tolerance to habitat change. Because the dickcissel is dependent on prairies and oldfields, it may serve as an indicator species of these habitats. However, the tendency of the species to experience irruptions of numbers on the periphery of the range renders the utility of indicator species status impractical outside the core of the breeding range. Because Western coal deposits are generally outside of the core of the breeding range, the dickcissel should not be considered an indicator species for impacts of coal mining.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts on dickcissel populations may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining phases if nests and nestlings are destroyed. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population.

Increased noise levels may deter dickcissels from using suitable habitat nearby, though some species do become accustomed to noise after a period of adjustment. An increase in dust levels from construction and mining activities and haul roads may decrease vegetative growth resulting in a decrease in food supplies. Contaminated water supplies from byproducts or increased runoff may be harmful to dickcissels through direct ingestion, or indirectly through detrimental effects on vegetative growth. Increased human presence may reduce nest success by trampling of nests or disruption of nesting activities. Collisions with transmission lines may cause injury or mortality.

Although sporadic irruptions of breeding dickcissels into the northern Great Plains and Appalachian coal regions do occur, the breeding habitat in these areas is marginal and dickcissels are rare or absent for intervals of up to 10 or more years (Bailey and Niedrach 1965; Sealy 1971; Skaar 1975; Stewart 1975; Kingery and Graul 1978; Johnsgard 1980). Mining activities in these areas should have little impact on overall dickcissel populations.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Premining Phase

Existing dickcissel populations may be censused in areas of proposed mine development. Studies including breeding bird censuses and data collection on nesting success and habitat use for 2 years prior to mining can demonstrate the importance of the area to dickcissels.

Exploration, Mine Development, and Mining Phases

Conducting activities outside of the breeding season may eliminate impacts to nesting birds.

Construction resulting in unavoidable habitat loss conducted outside of the breeding season will prevent nesting birds from being impacted. Dust and erosion control, and proper disposal of wastes and byproducts, can protect nearby dickcissel populations from degradation of habitat. Placement of transmission lines outside of major migration pathways may lessen injury and mortality from collisions.

Reclamation Phase

Reclamation of dickcissel habitat should include establishment of native species, brushy borders, and encouragement of existing agricultural fields to proceed through secondary succession (Blankespoor 1980). Temporary habitat may be established using hay and grain crops that are harvested after the dickcissel breeding season.

SUMMARY

Dickcissels are an abundant breeding bird of the mid- and tallgrass prairie region, breeding principally in hayfields, weedy roadsides and fencerows, and ungrazed prairies. Their breeding range expanded to the East coast as a result of settlement of lands and concomitant deforestation and agricultural practices prior to 1850. The breeding range declined subsequently as a result of urbanization and changing agricultural practices. In areas where mining disrupts primary breeding habitat, mitigation activities should focus on prairie restoration and allowing agricultural fields to proceed through the early stages of secondary succession.

REFERENCES

Aldrich, J. W. 1948. The breeding distribution of the dickcissel. Audubon Field Notes 2:12-13.

Bailey, A. M., and R. J. Niedrach. 1965. Birds of Colorado. Vol. II. Denver Mus. Nat. Hist., Denver, CO. 895 pp.

Blankespoor, G. W. 1980. Prairie restoration: effects on nongame birds. J. Wildl. Manage. 44(3):667-672.

Emlen, J. T., and J. A. Wiens. 1965. The dickcissel invasion of 1964 in southern Wisconsin. Passenger Pigeon 27:51-59.

Evans, A. K., E. W. Uhleman, and P. A. Eby. 1978. Atlas of Western surface-mined lands: coal, uranium, and phosphate. U.S. Fish Wildl. Serv. FWS/OBS-78/20. 302 pp.

Fretwell, S. 1967. Nesting success of dickcissels breeding in North Carolina. Chat 31:85-88.

__________. 1977. Is the dickcissel a threatened species? Am. Birds 31:923-932.

Fretwell, S., M. Francis, and T. Shane. 1974. Dickcissels nesting in Mesquite, TX. Bull. Tex. Ornithol. Soc. 7:5-6.

Fretwell, S., and T. Shane. 1975. Ecotypic variation in feeding habits of dickcissels on their wintering grounds. Eastern Bird Banding Assoc. News 38:125-128.

Gross, A. O. 1921. The dickcissel (Spiza americana) of the Illinois prairies. Auk 38:1-26, 163-184.

__________. 1968. Dickcissel. Pages 158-191 in Austin, O. L., Jr. Life histories of North American cardinals, grosbeaks, buntings, towhees, sparrows, and allies. Part 1. U.S. Natl. Mus. Bull. 237. 602 pp.

Hergenrader, G. L. 1962. The incidence of nest parasitism by the brown-headed cowbird (Molothrus ater) on roadside nesting birds in Nebraska. Auk 79:85-88.

Hurley, R. J., and E. C. Franks. 1976. Changes in the breeding ranges of two grassland birds. Auk 93:108-115.

Johnsgard, P. A. 1980. A preliminary list of birds of Nebraska and adjacent plains states (Pub. by author). 119 pp.

Kingery, H. E., and W. D. Graul. 1978. Colorado bird distribution latilong study. Colo. Div. Wildl., Denver. 58 pp.

Long, C. A., C. F. Long, J. Knops, and D. H. Matulionis. 1965. Reproduction in the dickcissel. Wilson Bull. 77:251-256.

Overmire, T. G. 1962. Nesting of the dickcissel in Oklahoma. Auk 79:115-116.

__________. 1963. The effects of grazing upon habitat utilization of the dickcissel (Spiza americana) and Bell's vireo (Vireo bellii) in north central Oklahoma. Ph.D. Thesis, Oklahoma State Univ., Stillwater. 65 pp.

Peterson, R. T. 1947. A field guide to the birds. Houghton Mifflin Co., Boston. 290 pp.

__________. 1980. A field guide to the birds. 4th edition. Houghton Mifflin Co., Boston. 384 pp.

Robbins, C. S., and W. T. Van Velzen. 1969. The breeding bird survey, 1967 and 1968. U.S. Fish Wildl. Serv., Spec. Sci. Rep. Wildl. 124. 107 pp.

Sealy, S. G. 1971. The irregular occurrences of the dickcissels in Alberta, Manitoba, and Saskatchewan. Blue Jay 29:12-16.

Skaar, P. D. 1975. Montana bird distribution, preliminary mapping by latilong. (Pub. by author). 56 pp.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-college Center for Environmental Studies. Fargo, ND. 295 pp.

Taber, R. C. 1947. The dickcissel in Wisconsin. Passenger Pigeon 9:39-46.

Von Steen, D. A. 1965. A study of nesting dickcissels in Nebraska. Neb. Bird Rev. 33:22-24.

Wiens, J. A. 1963. Aspects of cowbird parasitism in southern Oklahoma. Wilson Bull. 75:130-139.

Wiens, J. A., and J. T. Emlen. 1966. Post-invasion status of the dickcissel in southern Wisconsin. Passenger Pigeon 28:63-69.

Zimmerman, J. L. 1966. Polygamy in the dickcissel. Auk 83:534-546.

_______________. 1971. The territory and its density dependent effect in *Spiza americana*. Auk 88:591-612.

_______________. 1982. Nesting success of dickcissels (*Spiza americana*) in preferred and less preferred habitats. Auk 99:292-298.

BACHMAN'S SPARROW (*Aimophila aestivalis*)

by

Danny Bystrak
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The Bachman's sparrow (*Aimophila aestivalis*) is a nondescript, small, reddish-brown passerine with an unstreaked breast and a faint grayish superciliary line. Sexes are similar in all three subspecies (*A. a. aestivalis*, *A. a. bachmani*, and *A. a. illinoensis*). The bill is typical of the finches, being conical in shape. The nominate race is described as "above gray, broadly streaked with chestnut-brown, the feathers of the back with blackish central spots; tail dusky with broad gray edgings, the middle pair of rectrices gray with a median stripe of dusky; edge of wing light yellow; sides of head (including superciliary stripe) and neck smoke gray or dull ash gray, the latter streaked with chestnut or dark chestnut-brown; a narrow chestnut or chestnut-brown postocular stripe; chin and throat very pale dull grayish; or buffy grayish white, deepening on chest, sides, and flanks into pale grayish buffy..., the flank sometimes streaked with brown; a dusky submalar streak sometimes present, but usually absent; maxilla dusky, mandible pale; iris brown, legs and feet very pale brownish buffy or dull straw color. The tail is longer, distinguishing it from other similar species found in the same habitat" (Ridgway 1901). The three subspecies are essentially identical in plumage except for an increase in the buffy and rusty colors in *bachmani* and even more so in *illinoensis* (Bent et al. 1968).

The Bachman's sparrow is a solitary species whose habits are secretive in the extreme. Pittman (1960) describes a pursuit that ended in finding the bird in a gopher tortoise burrow, 1.2 m back and 0.6 m underground. The beautiful and varied song of this sparrow perhaps prevents it from going completely unnoticed. Detection is difficult in the winter when the bird is not singing. Despite the influx of wintering birds from the northern portion of the range, the bird remains undetected by all but the most diligent searchers. In recent years, the highest counts recorded on any North American Christmas Bird Count have rarely been over seven individuals. Annual high counts range from 3 to 15 with an exceptional 37 one year. In the winter it is easiest to find them by their call notes in the evening at a roost (Bent et al. 1968). Singing, breeding males are quick to become quiet and hide when approached. The secretive behavior of the sparrows apparently starts at fledging. An account by Nolan (Bent et al. 1968) describes a brood that showed no fear of him until they were fully feathered, at which time his approach caused them to fly and exhibit the typical concealment behavior of adults.

DISTRIBUTION

The Bachman's sparrow breeds in the Eastern and Southern United States: Aimophila aestivalis illinoensis breeds from Indiana, southwest to eastern Texas; A. a. bachmani breeds from Pennsylvania and Maryland south to Mississippi and Georgia; and A. a. aestivalis breeds from southern South Carolina to most of peninsular Florida (American Ornithologists' Union 1957; Bent et al. 1968) (Fig. 28). The breeding range of the Bachman's sparrow has not been stable over the past century. Around the turn of the century, as the last virgin pine forests of the Southeast were cut, this sparrow staged an almost explosive population increase (Bent et al. 1968). Prior to cutting the virgin forests, it was common only around cities and towns where disturbed habitat occurred. As more habitat became available, the range of the Bachman's sparrow expanded and populations increased throughout the Eastern States. Tennessee, Kentucky, West Virginia, Ohio, and Pennsylvania all experienced influxes of the species. Populations were also encountered in limestone glades of the Missouri Ozarks in the mid 1970's (Hardin et al. 1982). In West Virginia, Bachman's sparrows occurred at elevations as high as 3000 feet (Brooks 1938). Another expansion occurred east of the Alleghenies, taking them into the panhandle of West Virginia and central Maryland. Much concern has been expressed in recent years over an apparent withdrawal from much of the breeding range. It is possible that this contraction of range is no more than a return to the original range after the population explosion of the early 1900's.

DIET

Very little is known about the diet of the Bachman's sparrow. Virtually all of its feeding is conducted on the ground (Meanley 1959), which, in combination with its shy habits, makes observation of feeding difficult. The contents of ten stomachs of the bachmani subspecies from Alabama contained 58% animal matter, consisting of 9.3% leaf beetles, 23.1% other beetles, 12% bugs, and 5.7% orthoptera, with some snails, spiders and millipedes (Howell 1924). The vegetable portion of the diet was seeds of grasses, sedges, wood sorrel and Indian strawberry. The contents of eight stomachs of the aestivalis subspecies were very similar, but with orthoptera predominating (Howell 1932). Pine seeds were also present among the vegetable matter. Its extreme secretive behavior has prevented observation of feeding except for the taking of an occasional large insect (Bent et al. 1968).

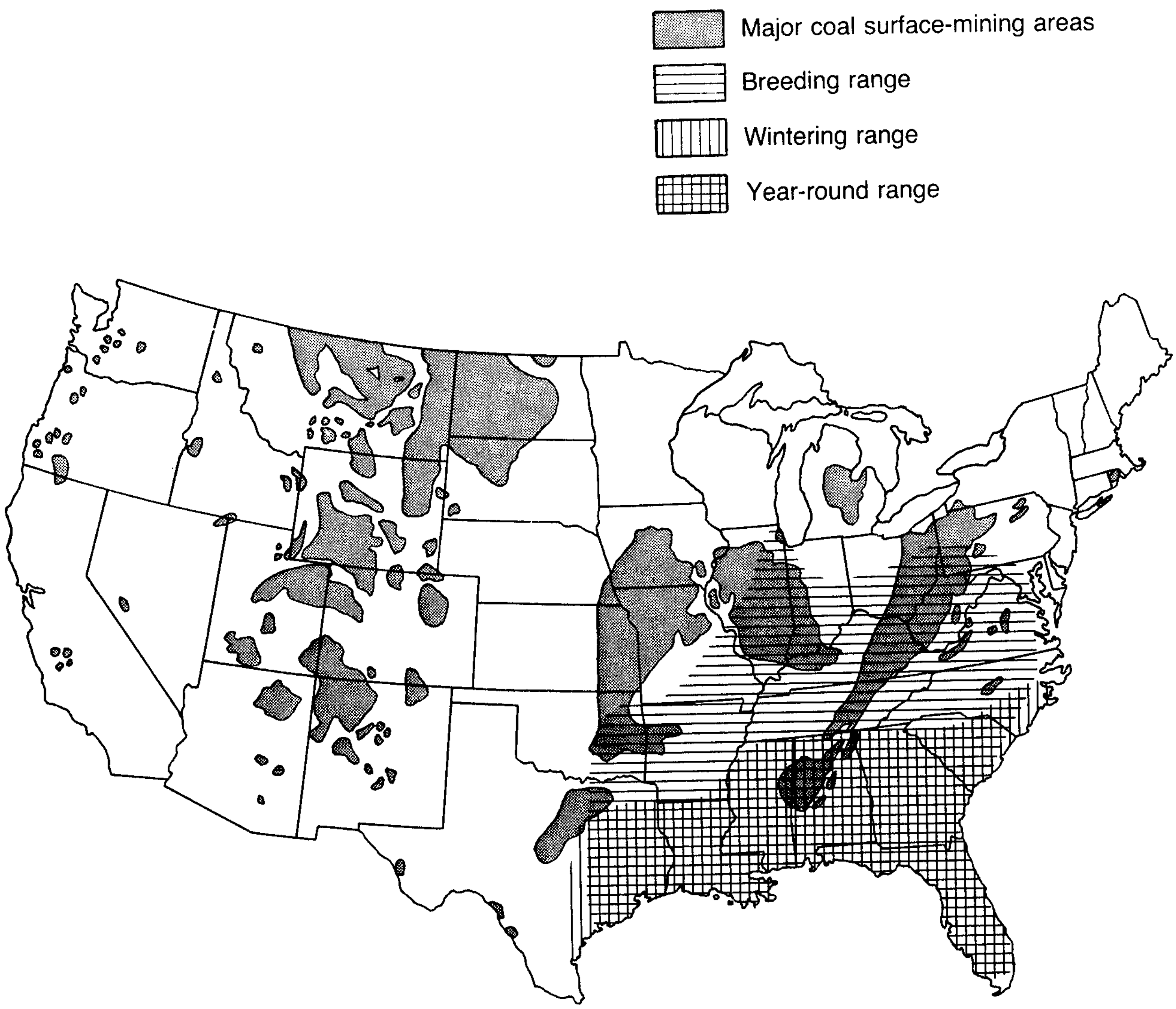


Figure 28. Geographical range of the Bachman's sparrow in relation to major coal deposits in the United States. After Inkley and Raley (1983).

REPRODUCTION

Bachman's sparrow is a permanent resident over a large part of its range and in such areas the beginning of the breeding season is marked by singing of resident birds. This often occurs as early as late February. A 2-month period occurs between first song and nesting in Louisiana (Meanley 1959). Presumably, during this interval, northern birds begin to migrate back to their breeding grounds. They are so secretive, however, that few data are available on migratory movement. At the northern end of the range most birds return to breeding areas by April 22 (Bent et al. 1968). The chronology of nesting is, thus, a function of latitude. As northern birds are establishing territories, southern birds already have full clutches of eggs.

The reproductive cycle is typical of passerines; males sing from a pine bough, oak branch or brush pile, 10 to 50 feet from the ground (Meanley 1959), to attract a mate and defend a territory. Singing is primarily in the early morning and late afternoon, and often during midday. Territories are usually sparsely situated, possibly one pair per two acres in optimum habitat (Meanley 1959). The nest is always on the ground and can be either open or domed. At least two broods, and up to three (Sprunt and Chamberlain 1949), are attempted as demonstrated by an extremely long song period, usually extending into late August or early September.

A typical clutch contains three to five white, unspotted eggs. Incubation of a nest with four eggs in Louisiana began after the third egg was laid; incubation required 14 days (Meanley 1959). At this nest, both parents assisted in feeding the young.

In the more northern parts of the range, abandoned fields, field borders, and overgrown, dry, eroded slopes are the habitats used for breeding. The preference for flat country is not prevalent in the North, as most sites are near the tops of slopes in gullies covered with shrubs, particularly blackberry bushes (*Rubus* spp.) (Bent et al. 1968). Preferred habitat in Indiana is that shared by blue-winged (*Vermivora pinus*) and prairie warblers (*Dendroica discolor*): oldfields predominated by broomsedge (*Andropogon* spp.), dewberry (*Rubus* spp.), cinquefoil (*Potentilla* spp.) and similar plants (Bent et al. 1968). Cedar (*Juniperus virginiana*) glades are favored habitats in the Missouri Ozarks (Hardin et al. 1982).

Over most of the South, Bachman's sparrows prefer flat, open pine (*Pinus* spp.) woods with an understory of various species of scrub oaks (*Quercus* spp.), grasses, and scattered low bushes. In Florida, preferred habitat consists of open pine woods within an understory of some palmetto. Appropriate habitat was not common in the deep South until the original dense pine forests were cut, opening up most of the South to this species. In central Louisiana, the practice of clear or partial cutting followed by direct seeding or planting provides optimum habitat, especially when seed trees and brush piles are left to provide singing perches, escape cover, and nest sites (Meanley 1959).

Preferred winter habitat is similar to nesting habitat, except for some winter movement from open woods to broomsedge fields and scrub oak.

POPULATION TRENDS

At present, Bachman's sparrow is not considered a common species in any part of its range. It is rare, restricted to only a few known sites in the northern part of its range, and is on the threatened and endangered species lists of several States in that region. In Georgia, it is declining drastically (Dorsey 1976). Areas of greatest abundance as determined from Breeding Bird Survey data, are central Louisiana, coastal Mississippi, the central panhandle of Flordia and an area from southeastern Georgia through north-central peninsular Florida (U.S. Fish and Wildlife Service unpublished data). Although Breeding Bird Survey data are not sensitive enough to determine trends for so scarce a species, popular sentiment strongly indicates a downward trend. This is reflected by the fact that Bachman's sparrow has occurred on the "Blue List" published by American Birds for 11 years (Tate and Tate 1982).

Reasons for this decline are not known, but some speculation has been offered. Pesticides possibly may have played a part, but more likely habitat change is responsible (Dorsey 1976). Changes in farming practices and increased efforts to stop wildfires are possible contributors. Another reason for the declining numbers may be an increase in rodents that prey on eggs and nestlings concurrent with decreasing raptor populations. However, other ground-nesting birds in the same area have not suffered similar decreases. The drastic increase in population levels following logging at the turn of the century illustrates the effect of habitat on Bachman's sparrow numbers. Much of the cleared land has returned to a forested condition (especially in Ohio, West Virginia, Indiana and Kentucky) or is converted to clean agriculture (especially in Illinois), so appropriate habitat has become increasingly scarce. It is very likely that the Bachman's sparrow is returning to its original range and population levels.

Effects of Habitat Changes

Since Bachman's sparrow is primarily a species of mid-succession habitats, habitat change is an important factor influencing its abundance and distribution. Both man-made and natural changes can affect good Bachman's sparrow habitat positively or negatively. Logging has been a positive factor in producing Bachman's sparrow habitat because few natural eastern climax habitats provide the brushy structure required. The elimination of the brushy structure by clean farming practices or natural forest succession will result in decreased numbers of Bachman's sparrows.

Effects of Human Disturbance

Direct human disturbance is not a serious negative factor affecting Bachman's sparrow unless the disturbance is prolonged. Like any other species, excessive disturbance in the vicinity of a nest site will result in failure. Direct impact would be mostly unintentional with a species as small and secretive as the Bachman's sparrow.

Management

Bachman's sparrow management is a subject in need of more research. Because the Bachman's sparrow is an open nester, artificial nesting structures are not appropriate, leaving habitat management as the only possible technique to increase Bachman's sparrow populations. Its preference for mid-succession habitats does not facilitate management in areas of large scale habitat destruction such as logged, strip-mined or burned areas. However, because of the need for mid-succession habitat, management practices would most likely be temporary unless a complex management scheme involving large areas is employed. This sort of management is probably only useful in States at the periphery of the range, because the species does not qualify for Federal endangered species status. Because direct tree seeding or planting after logging seems to provide temporary optimum habitat in the South, suitable habitat will probably remain available in the core of the range. If, despite continued presence of appropriate habitat, the species continues to decline, a closer look at its biology will be necessary to attempt any form of effective management.

The Bachman's Sparrow as an Indicator Species

An indicator species is one that has a narrow range of tolerance for environmental change and, as such, may serve as an early warning of excessive human disruption of its environment. Such disruptions can be either the direct result of human activities or secondary environmental responses to such activities. The Bachman's sparrow certainly has a narrow range of tolerance, but because it prefers mid-succession habitats, it may be difficult to use as an indicator species. Because its preferred habitat is likely to always be available, it is probable that it would only be useful as an indicator of available habitat or of more insidious environmental changes such as in pesticide levels.

In specific reference to surface mining, Bachman's sparrow could be a valuable indicator of reclamation techniques. If an area of suitable habitat is destroyed, it could quickly be returned to acceptable condition by seeding or planting of pine trees rather than planting grass species. In the East, where most surface mining is likely to be in wooded areas, this would also mean a faster return to previous conditions.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Impacts to Bachman's sparrow populations may occur directly, through mortality, or indirectly through increased stress and habitat loss. Direct mortality may occur during construction and mining phases if nests and nestlings are destroyed. The most serious impact would occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition will result in an ultimate reduction in the breeding population.

Increased noise levels may deter Bachman's sparrows from using suitable habitat near the development area, though some species do become accustomed to noise after a period of adjustment. An increase in dust levels from construction and haul roads may cause a decrease in vegetative growth and insect populations, resulting in a decrease in food supplies. Contaminated water supplies from by-products or increased runoff may be harmful through direct ingestion, or indirectly through detrimental effects on vegetative growth. Increased human presence may reduce nest success by trampling nests or disruption of nesting activities. Collisions with transmission lines may cause injury or death.

Comparison of the map of the Bachman's sparrow range with known coal deposits (Fig. 28) shows very little overlap; Illinois is the only area where overlap appears widespread. In 16 years of Breeding Bird Survey coverage, no Bachman's sparrows have been reported in Illinois and the State Department of Conservation recognizes the species as endangered. It is unlikely that coal mining in Illinois will have a serious impact on the Bachman's sparrow, but unfortunate coincidence could extirpate it if it is present. Surface mining actually has the potential of enhancing the Bachman's sparrow population in Illinois, if reclamation is conducted in a manner favorable to the species, and mining is not directly responsible for destruction of existing nesting areas.

Other areas of overlap of the two maps are similar. Alabama, Arkansas, and Georgia recognize the Bachman's sparrow as an endangered or threatened species. In the remaining States with overlap, the species occurs in extremely low numbers, probably because of paucity of appropriate habitat.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Only recently has concern been expressed for proper post-mining reclamation and virtually none has been species specific. As recently as 1978, the first efforts to consider any fish and wildlife values during reclamation were initiated by the Eastern Energy and Land Use Team of the U.S. Fish and Wildlife Service.

Premining Phase

Because the Bachman's sparrow is so secretive, any mitigation of mining impact on them should require surveys of the area for 2 years prior to mining activities. Such surveys should be conducted during the peak of the breeding season, since detection of Bachman's sparrows at any other time is virtually impossible. In States where the species is extremely rare, an intensive effort should be made to locate any breeding populations.

Exploration and Mine Development Phase

If Bachman's sparrows are present on a proposed mine site, plans should be initiated to minimize impact. Exploration activities will not have a serious impact on Bachman's sparrows if areas of known occurrence are avoided.

Exploration activities will have a minimal impact on Bachman's sparrows if conducted September to March, outside the breeding season. Activities conducted during the breeding season will have the least impact if nesting concentrations are avoided.

Mining Phase

Nothing is known of the extent to which a Bachman's sparrow nesting site can be isolated by mining activities and still not be abandoned by the sparrows. If known sites are exploited last (if at all) while properly reclaimed areas reach the proper stage to attract the breeding birds potential impacts may be alleviated. If the birds move to reclaimed areas, original sites can probably be mined with no deleterious effect to the local population. If no movement occurs, avoidance of the breeding areas would alleviate impacts to the local population.

Impacts of increased dust levels may be alleviated by dust control measures such as paving roads and watering potential dust sites. Contamination of water supplies may be prevented by control of runoff from the mine site and appropriate disposal of waste products. Placement of transmission lines to avoid migration pathways may lessen injuries and deaths from collisions.

Reclamation Phase

As with most any species of wildlife, the key to the continued presence of Bachman's sparrows on mine sites lies in the reclamation phase. It is important to remember, however, that in areas of extreme scarceness, this will only be effective in conjunction with proper treatment during the two earlier phases. If the only one or two pairs in an area are eliminated during mining, the chances of reestablishment during reclamation will be reduced severely or eliminated.

Reclamation activities designed to develop the area into brushy successional stages could eventually provide habitat suitable for reinvasion by Bachman's sparrows. Planting a mixture of grasses, shrubs, and trees may enhance reclamation efforts.

SUMMARY

Eastern surface coal mining has the potential for severe impact on Bachman's sparrow populations in the small areas of overlap between the breeding range of the species and known recoverable coal deposits. Current population levels are not well known except as crudely defined by the Breeding Bird Survey. The main centers of abundance are safe from coal mining disruption, and the areas of concern are in very low-density portions of the breeding range. Mitigation efforts mentioned above apply primarily to States in which the species is extremely rare. This is actually one of few scarce or declining species whose population could increase due to surface mining, if proper measures are taken during the mining and reclamation phases.

REFERENCES

American Ornithologists' Union. 1957. Checklist of North American birds. 5th ed. Lord Baltimore Press. Baltimore, MD. 691 pp.

____________. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Bent, A. C., and collaborators. 1968. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. U.S. Natl. Mus. Bull. 237, Part 2:630-1248. Smithsonian Institution Press.

Brooks, M. 1938. Bachman's sparrow in the north-central portion of its range. Wilson Bull. 50(2):86-109.

Dorsey, G. A. 1976. Bachman's sparrow: songs and behavior. Oriole 41:52-56.

Hardin, K. I., T. S. Baskett, and K. E. Evans. 1982. Habitat of Bachman's sparrows breeding on Missouri glades. Wilson Bull. 24(2):208-212.

Howell, A. H. 1924. Birds of Alabama. Brown Print. Montgomery, AL. 384 pp.

Howell, A. H. 1932. Florida bird life. Florida Dept. Game Freshwater Fish.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Meanley, B. 1959. Notes on Bachman's sparrow in central Louisiana. Auk 76:232-234.

Pittman, J. A., Jr. 1960. Bachman's sparrow hiding in a burrow. Auk 77:80.

Ridgeway, R. 1901. Birds of North and Middle America. U.S. Natl. Mus. Bull. 50.

Sprunt, A. Jr., and E. B. Chamberlain. 1949. South Carolina bird life. 1st ed. Univ. South Carolina Press. Columbia.

Tate, J., Jr., and D. J. Tate. 1982. The blue list for 1982. Am. Birds 36(2):126-135.

U.S. Fish and Wildlife Service. Unpublished data. Breeding Bird Survey. U.S. Fish Wildl. Serv., Migratory Bird Program, Washington, DC.

BREWER'S SPARROW (*Spizella breweri*)

by

Deanna K. Dawson
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

The Brewer's sparrow (*Spizella breweri*) is a small fringillid common in open, brushy habitats in western North America. It is one of the smallest of the North American sparrows. The length (tip of bill to tip of tail) of the adult male averages 11.4 cm (Robbins et al. 1966) and weights of adult birds range from 10 to 12 gm (Ohmart and Smith 1970).

Adult Brewer's sparrows are grayish-brown in color, with black streaking on the back of the neck, back, head, and scapulars (Paine 1968). The side of the head and under parts are unstreaked. The tail is long and notched, and there is an indistinct wing bar of buffy white. Juvenal plumage is similar to the adult, but there may be streaking on the chest, and the streaks on the head and back may be less distinct. Adults resemble clay-colored sparrows (*Spizella pallida*) and juvenile chipping sparrows (*Spizella passerina*) although the crown in these other species is browner with a pale median line.

The song of the Brewer's sparrow is a long-sustained sequence of trills and stops. Territorial males are vociferous and often engage in flock trilling, particularly at dawn and at dusk (Paine 1968). Individuals can be heard throughout the day and occasionally at night.

The species is relatively inconspicuous during the breeding season even in habitats where it is common, because of its drab coloration and wary behavior. The birds fly into bushes at any provocation (Paine 1968) and keep close to shelter when feeding.

In contrast, the birds are easy to observe and are social in migration and on the wintering grounds, forming flocks with other fringillids. The Brewer's sparrow, along with three other species of fringillids, comprise about 90% of the individuals present in a typical winter flock (50 to 200 birds) in the Mohave Desert (Cody 1971). Such flocks may serve to reduce the risk of predation or to increase feeding efficiency.

DISTRIBUTION

Two subspecies of the Brewer's sparrow are recognized (American Ornithologists' Union 1957). *Spizella breweri breweri* breeds in open, brushy habitat from northwestern and interior British Columbia, west-central and southern Alberta, and southwestern Saskatchewan and southwestern North Dakota to eastern and southern California, southern Nevada, central Arizona, and northwestern New Mexico, central and southwestern Colorado, and eastern and southwestern Kansas (Fig. 29) (American Ornithologists' Union 1983). The breeding range extends as far east as southwestern North Dakota, southwestern South Dakota, and northwestern Nebraska, and as far west as the Cascade Range in Washington and Oregon and into eastern California. This subspecies is closely associated with sagebrush (*Artemisia* spp.) communities and may occur within this vegetation type through a wide range of elevations (Paine 1968). The winter range extends from southern California, Nevada, Arizona, New Mexico, and west-central Texas south to southern Baja California and Mexico.

S. b. taverneri, formerly known as the timberline sparrow, is typically associated with high-elevation scrub habitat in southwestern Yukon, northwestern and central British Columbia, and west-central Alberta south to southeastern British Columbia and southwestern Alberta (American Ornithologists' Union 1957). Although migrants have been taken in Arizona, New Mexico, and western Texas, little is known about the winter range of *S. b. taverneri*. The present paper will consider only *Spizella breweri breweri*, whose breeding range overlaps vast energy reserves in western North America.

DIET

The diet of the Brewer's sparrow varies throughout the year. The species feeds almost entirely on insects and their larvae during late spring and early summer. The alfalfa weevil (*Phytonomus poticus*) comprised 43 to 65% of the food volume in the stomach contents of 46 Brewer's sparrows collected during the summer months (Paine 1968). Coleopterans (beetles) comprised 57% of the total volume of food in the gizzards of nine birds from central Montana in June (Best 1972); Hemipterans were an important food item in birds collected in July (20% vs 5% in June, n = 8). The percentage of plant materials (primarily grass and weed seeds) increased from June to July (8 to 17% in an undisturbed study plot). Brewer's sparrows consume increasingly more plant materials in late summer and fall. Fifty-three percent of autumn foods and 90% of winter foods in one study were plant material (Paine 1968).

The Brewer's sparrow has an extremely low water requirement and is able to maintain body weight on salinities equaling that of sea water (Ohmart and Smith 1970). The species, which occupies arid habitats both on its breeding and wintering grounds, apparently satisfies its daily water requirement through food intake.

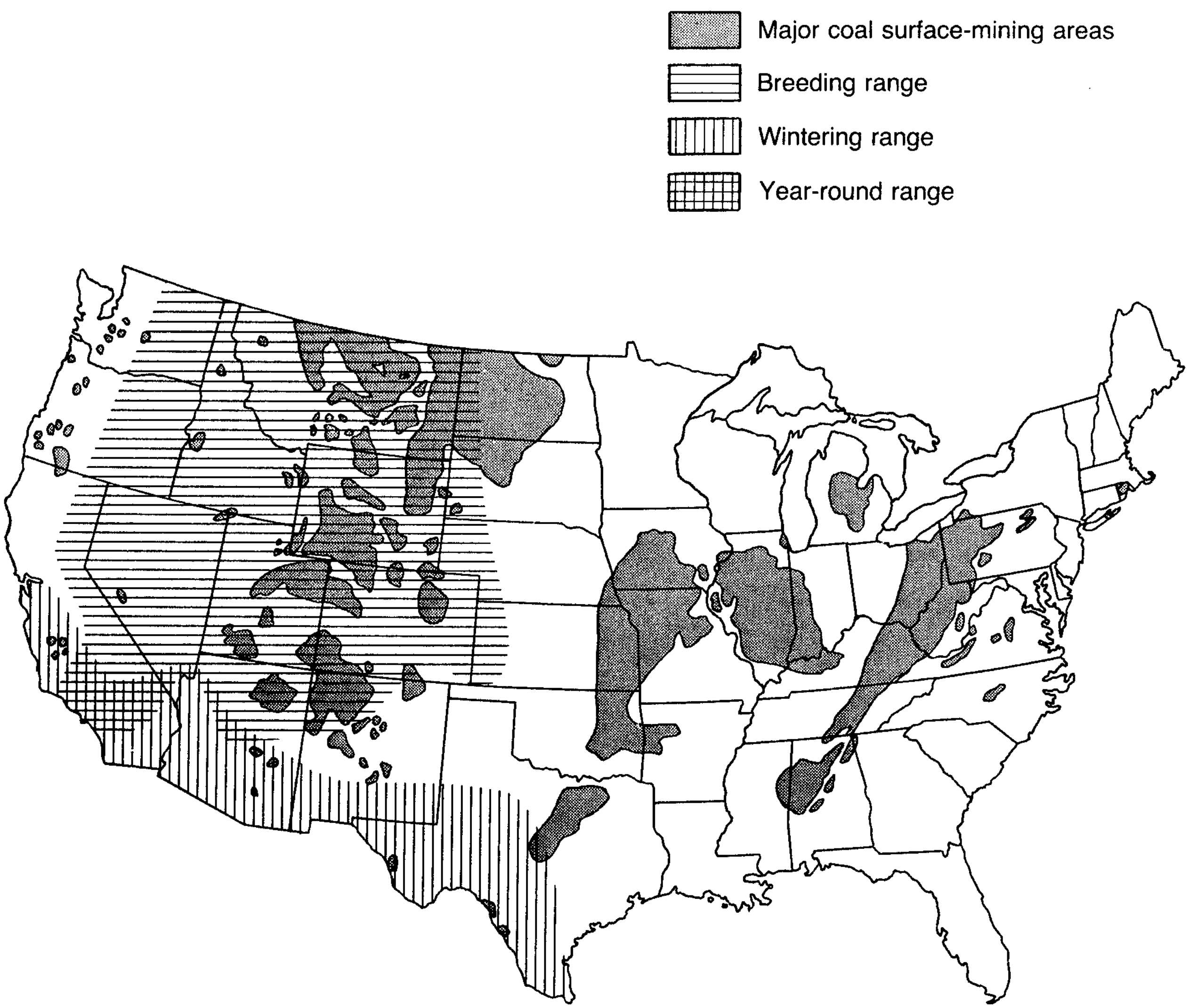


Figure 29. Geographical range of Brewer's sparrow in relation to major coal deposits in the United States. After Inkley and Raley (1983) and C. S. Robbins.

REPRODUCTION

Brewer's sparrows have been observed on the breeding grounds as early as April 24 in north-central Colorado (Porter and Ryder 1974). The establishment of territories and the initiation of nesting may vary considerably from year to year, depending on climatic conditions. Nesting was observed from early May through July on the Colorado study area during 1969-1972, with peaks varying from late-May (1971), mid- to late-June (1970, 1972), to mid-July (1969). A low percentage of Brewer's sparrows mated and nested successfully in sagebrush habitats in southeastern Idaho; only 7 of 30 birds (23%) that established territories nested in the study area (Reynolds 1981). The success rate may be correlated with, or controlled by, the number of sage sparrows (*Amphispiza belli*) and sage thrashers (*Oreoscoptes montanus*) nesting within the area, since nest site requirements of all species were similar and Brewer's sparrows nested about 10 days later than the other species.

Clutch size ranges from two to five eggs, with the usual number being three or four. The incubation period is 11 days and the nestling period is 9 days (Reynolds 1981). The percent of nests that successfully fledged at least one young ranged from 12.5% (n = 8) and 14% (n = 7) in Idaho to 41.2% (n = 15) in Colorado (Porter and Ryder 1974) and 100% (n = 2) in Nevada (Hill 1980). The mean number of young fledged per nest ranged from 0.5 (±1.2, n = 6) in Idaho (Reynolds 1981) to 1.38 in Colorado, where 3.14 fledgings occurred per successful nest (n = 7; Porter and Ryder 1974). Nest failures were attributed to abandonment caused by parasitism by brown-headed cowbirds (*Molothrus ater*) (Rich 1978; Reynolds 1981) and to predation by the loggerhead shrike (*Lanius ludovicianus*) (Reynolds 1979) and possibly by snakes, chipmunks (*Tamias* spp.), or weasels (*Mustela* spp.).

Nesting Habitat

The Brewer's sparrow has often been considered an obligate of the sagebrush (*Artemisia* spp.) type (Wilson Ornithological Society Conservation Committee 1976). The species has also been found to be a common nester in prairie habitats (Wing 1949; Gietzentanner 1970; Porter and Ryder 1974), although all nests in these habitats were located in shrubs, sometimes other than sagebrush. Brewer's sparrows showed no significant positive correlation with either habitat physiognomy or coverage by particular shrub species, in a study of shrubsteppe bird-habitat associations (Wiens and Rotenberry 1981), but were negatively correlated with coverages of spiny hopsage (*Grayia spinosa*) and bud sagebrush (*Artemisia spinescens*), both spiny shrubs.

Several studies (Best 1972; Schroeder and Sturges 1975; Rich 1980; Reynolds 1981) have focused on the nesting of the Brewer's sparrow in sagebrush habitats. Data on nest-shrub characteristics and nest placement are summarized in Table 17. Sage sparrows and sage thrashers nest in sage of the same height as the Brewer's sparrows, but each species nests at a different height within the sage (Rich 1980). Brewer's sparrow nests are approximately 8 cm in diameter and 4 cm deep, and are placed in the outer branches of the sage (Reynolds 1981).

Table 17. Nest-shrub characteristics and nest placement of the Brewer's sparrow.

Study	Location	N	Sagebrush height (cm)	Nest height (cm)
Best 1972	Montana	40	28.0 - 63.5	16.5 (8.9 - 24.1)
Schroeder and Sturges 1975	Wyoming	7	49.9 (31.5 - 67.0)	20.3 (11.5 - 31.0)
Rich 1980	Idaho	27	66.9 ± 11.3	28.2 ± 7.7
Reynolds 1981	Idaho	7	65 ± 9	25 ± 8

POPULATION TRENDS

Brewer's sparrows, sage thrashers, and sage sparrows are the most abundant bird species breeding in the sagebrush type. No regional estimates of the populations of Brewer's sparrows are available. Local densities (pairs per 40 ha) ranged from 12.5 to 50 in sagebrush-grassland habitat in central Montana (Feist 1968, Best 1972), to 46.8 in a prairie tract in southeastern Washington (Wing 1949), to 60 to 64 in sagebrush habitat in southeastern Idaho (Rich 1978, Reynolds 1979).

Effects of Habitat Changes and Human Disturbance

No evidence suggests that regional populations of the Brewer's sparrow are declining. Local populations, however, can be adversely affected by habitat change. Sagebrush has been considered by many land managers to have little value, so large acreages have been converted to grassland or cropland by public land management agencies and private landowners. An estimated 10% of the sagebrush rangelands in the West has been altered (Wilson Ornithological Society Conservation Committee 1976) although the pace of sagebrush control has recently slowed. The use of rangeland for livestock grazing has no effect on Brewer's sparrows and other species nesting in sagebrush; however, no nests of these species occurred in a former sagebrush range converted to grassland (Reynolds and Trost 1981). A total (spray) kill of sagebrush resulted in a significant (54%) reduction in the number of breeding pairs of Brewer's sparrows, whereas no notable change in breeding pairs resulted from a limited kill of sagebrush (Best 1972). Herbicide spray (2,4-D) apparently did not reduce nest success during the year of application in southeastern Wyoming (Schroeder and Sturges 1975). However, the use by Brewer's sparrows of a sprayed sagebrush stand one and two years after spraying was 67% and 99% lower than use of an unsprayed stand, and no nests were found in the sprayed stand. In addition to the direct impact of habitat change, the intrusion of grazing lands into sagebrush makes the breeding birds of the sagebrush type more vulnerable to parasitism by the brown-headed cowbird (Rich 1978). The Brewer's sparrow is wary and easily disturbed during the breeding season (Paine 1968).

Management

Preservation of sagebrush and other brushy vegetation types appears to be the best strategy for maintaining populations of Brewer's sparrows. Conversion and fragmentation of sagebrush range not only reduce the availability of preferred nesting habitat, but make the Brewer's sparrow and other species more susceptible to cowbird parasitism.

The Brewer's Sparrow as an Indicator Species

Many of the known recoverable coal reserves in the Western United States lie within the breeding and wintering range of the Brewer's sparrow (Fig. 29). The Brewer's sparrow should serve as a valuable indicator of the impact of surface-mining operations because the species is sensitive to habitat change and because its population, if undisturbed, remains relatively stable from year to year.

POTENTIAL IMPACTS OF SURFACE COAL MINING

Potential impacts to Brewer's sparrows may occur directly, through mortality, or indirectly, through increased stress and habitat loss. Direct mortality may occur during construction and mining activities if nests and nestlings are destroyed. The most serious impact may occur from habitat loss. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition may result in an ultimate reduction in the breeding population.

Increased noise levels may deter Brewer's sparrows from using suitable habitat nearby, though some species become accustomed to noise after a period of adjustment. An increase in dust levels from construction and mining activities and haul roads may decrease vegetative growth, possibly resulting in a decrease in both plants and insects available for food. Contaminated water supplied from mining byproducts or increased runoff may impact Brewer's sparrows indirectly through detrimental effects on vegetative growth. Increased human disturbance may result in lowered productivity or nest abandonment. Collisions with transmission lines may cause injury and mortality.

Little is known concerning post-breeding season and winter habitat use by the Brewer's sparrow. Apparently the species is less restricted in its habitat requirements and thus less vulnerable to disturbance than during the breeding season.

Populations of Brewer's sparrows are affected locally by changes in the nesting habitat (Best 1972; Schroeder and Sturges 1975; Reynolds and Trost 1981). Both large- and small-scale surface mining will have a detrimental effect on populations if operations are developed within the sagebrush type. The concerns thus become the proportion of the total population that will be affected by mineral resource development, the duration of the disruption, and the likelihood that mine sites will be recolonized by Brewer's sparrows following reclamation.

Regional estimates of populations of Brewer's sparrows within the Western coal areas are not available. Data on densities from locales distributed throughout the region are, however, available in the literature (e.g., Wing 1949; Feist 1968; Porter and Ryder 1974; and Breeding Bird Censuses reported in Audubon Field Notes and American Birds). In addition, the results of Breeding Bird Surveys conducted within the region provide useful information on long-term population trends. These data coupled with approximation of the acreage of sagebrush-dominated rangeland (much of which is administered by the Bureau of Land Management, U.S. Department of the Interior, and the Forest Service, U.S. Department of Agriculture), can be extrapolated to a rough estimate of regional populations. The acreage of suitable breeding habitat coinciding with strippable coal deposits can likewise be calculated from available figures or aerial photos. The impact of surface mining can be projected as the proportion of suitable breeding habitat and thus the proportion of the total regional population that will be disturbed.

The time period when nesting habitat is lost will vary from site to site, depending on the duration of the mining activity. Whether the loss is temporary or permanent will depend on the success of the reclamation of strip-mined lands.

The methods outlined above will yield an estimate of the impact of surface mining on regional populations of Brewer's sparrows as a direct result of habitat loss. The effects of indirect, off-site disturbances are more difficult to predict. Construction of transportation and energy distribution networks and the influx of people into what are now relatively unsettled regions are inevitable and may prove to be a greater disturbance than the actual mine site activities. Field research should be conducted on and adjacent to mine sites to monitor the response of populations of Brewer's sparrows and other avian species to these indirect, off-site disturbances. These local studies should be carried out before development of coal deposits is begun on a large scale.

RECOMMENDATIONS FOR MITIGATION OF MINING IMPACTS

Recommendations for mitigating the impacts of surface-mining activities should focus on minimizing habitat loss and disturbances which reduce nest productivity, because populations of the sparrow are not threatened or known to be declining. These recommendations should be re-evaluated and refined as additional information becomes available.

Premining Phase

Baseline data should be gathered on avian populations before any mining activity is initiated because the development of coal resources could potentially modify large areas of the western States. The proposed mine site and adjacent areas should be surveyed to determine location and extent of suitable breeding habitat. Study plots should be established at and adjacent to selected mine sites and in control areas in similar habitat unlikely to be affected by the disturbance. Field studies should be initiated at least 2 years prior to any mine exploration and development to provide the best assessment of the impacts of mining-related activities on avian communities. Censuses of breeding populations should be conducted annually through the first few years of mine activity. Data on nest productivity (hatching and fledging success) and on causes of mortality and nest failure should be collected, since these variables are probably the best measure of the impacts of human and off-site disturbances.

Exploration, Mine Development, and Mining Phases

Destruction of breeding habitat for Brewer's sparrows and other avian species is inevitable at many proposed mine sites. The negative impacts of mining-related disturbances on these species can be minimized by restricting or curtailing mine exploration and development activities during the breeding season.

Dust control measures, such as paving roads, control of runoff, and proper disposal of byproducts will alleviate impacts to vegetative growth. Placement of transmission lines to avoid major migration pathways may help to lessen injuries and mortality from collisions.

Reclamation Phase

Reclamation of surface-mined lands will be critical to the successful mitigation of mine impacts. Low mean precipitation and humidity, extreme fluctuations in temperature, poorly developed soil, and other environmental variables may make revegetation of mine spoils extremely slow and difficult. Site stabilization, mulching, fertilizing, irrigating, and restricting access by herbivores and humans can reduce the time required to reach natural equilibrium. Land managers and coal company personnel, long dubious of the worth of sagebrush and other scrub species, may also need to be convinced of the value in re-establishing native vegetation over the more economically desirable grasses. Roads constructed during mining operations should be closed and revegetated to discourage recreational use of recovering habitats.

Monitoring of avian use of established study plots and reclaimed areas is essential to determine the impacts of surface mining and the success of mitigation efforts. The recolonization of reclaimed lands by Brewer's sparrows and other species will be the most important measure of mitigation success.

SUMMARY

Many of the known recoverable coal reserves in the Western United States occur within the breeding and wintering range of the Brewer's sparrow. Although the species is common throughout much of its breeding range, local and regional populations may be adversely affected due to mining-related disturbances and habitat loss. The species may serve as a valuable indicator of the impacts of surface-mining activities because it is restricted primarily to the sagebrush type during the breeding season and is known to be sensitive to habitat change.

Recommendations for mitigating impacts focus on minimizing disturbance during the breeding season and re-establishing preferred native vegetation on mined sites. Monitoring populations on and adjacent to mine sites will give a better understanding of the effects of disturbance and the success of mitigation efforts.

REFERENCES

American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. Lord Baltimore Press. Baltimore, MD. 691 pp.

____________. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawerence, KS. 877 pp.

Best, L. B. 1972. First year effects of sagebrush control on two sparrows. J. Wildl. Manage. 36(2):534-544.

Cody, M. L. 1971. Finch flocks in the Mohave Desert. Theor. Population Biol. 2(2):142-158.

Feist, F. G. 1968. Breeding-bird populations in sagebrush-grassland habitat in central Montana. Audubon Field Notes 22:691-695.

Giezentanner, J. B. 1970. Avian distribution and population fluctuations on the shortgrass prairie of north central Colorado. M.S. Thesis, Colorado State Univ., Ft. Collins. 113 pp.

Hill, H. O. 1980. Breeding birds in a desert scrub community in southern Nevada. Southwest Nat. 25(2):173-180.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Ohmart, R. D., and E. L. Smith. 1970. Use of sodium chloride solutions by the Brewer's sparrow and tree sparrow. Auk 87(2):329-341.

Paine, R. T. 1968. Brewer's sparrow. Pages 1208-1217 in O. L. Austin, Jr., ed. Life histories of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies. U.S. Natl. Mus. Bull 237 (Part 2).

Porter, D. K., and R. A. Ryder. 1974. Avian density and productivity studies and analysis on the Pawnee site in 1972. U.S. Inter. Biol. Program, Grassland Biome Rep. 252. March.

Reynolds, T. D. 1979. The impact of loggerhead shrikes on nesting birds in a sagebrush environment. Auk 96(4):798-800.

____________. 1981. Nesting of the sage thrasher, sage sparrow, and Brewer's sparrow in southeastern Idaho. Condor 83:61-64.

Reynolds, T. D., and C. H. Trost. 1981. Grazing, crested wheatgrass, and bird populations in southeastern Idaho. Northwest Sci. 55:225-234.

Rich, T. 1978. Cowbird parasitism of sage and Brewer's sparrows. Condor 80(3):348.

____________. 1980. Nest placement in sage thrashers, sage sparrows and Brewer's sparrows. Wilson Bull. 92(3):362-368.

Robbins, C. S. Personal communication. Patuxent Wildlife Research Center, Laurel, MD.

Robbins, C. S., B. Brunn, and H. S. Zim. 1966. Birds of North America. Golden Press, NY. 340 pp.

Schroeder, M. H., and D. L. Sturges. 1975. The effect on the Brewer's sparrow of spraying big sagebrush. J. Range Manage. 28(4):294-297.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrub steppe environments. Ecol. Monogr. 51:21-41.

Wilson Ornithological Society Conservation Committee. 1976. Conservation committee report on effects of alteration of sagebrush communities on the associated avifauna. Wilson Bull. 88(1):165-171.

Wing, L. 1949. Breeding birds of Virgin Palouse Prairie. Auk. 66:38-41.

MCCOWN'S LONGSPUR (Calcarius mccownii)

by

Marshall A. Howe
Patuxent Wildlife Research Center
U.S. Fish and Wildlife Service
Laurel, MD 20708

SPECIES DESCRIPTION

McCown's longspur (Calcarius mccownii) is a small, ground-dwelling finch endemic to the shortgrass prairies of the northern United States and southern Canada, migrating to the Southwestern United States and northern Mexico. Its breeding range is limited and less extensive than formerly, but the species is locally abundant. Its preferred habitat is regularly grazed shortgrass, where it breeds most often in association with horned larks (Eremophila alpestris), mountain plovers (Charadrius montanus), and chestnut-collared longspurs (Calcarius ornatus) (Kantrud pers. comm.).

During the breeding season, McCown's longspurs are strongly sexually dimorphic. At this season the male has a black forehead and a black streak extending back from the base of the bill. A large crescent-shaped patch on the upper breast is also black. The crown is pale brownish gray, blending into a brownish back streaked with dusky. The tail, very conspicuous in flight, is largely white, contrasting sharply with the black tip and brown central feathers. The wings are grayish with a chestnut patch on the lesser and middle coverts. The lower breast and belly are dusky white (Ridgway 1901).

The female is brown with blackish streaks above and buffy white below. The tips of the middle wing coverts are buffy, producing a conspicuous wing-bar. Broad brown streaks extend backward from the eye and down from near the base of the bill, both streaks contrasting with the pale buffy color of the sides of the face (Ridgway 1901).

Male wing lengths average 91.4 mm and bills 11.9 mm. Females are slightly smaller, with wings of 84.3 mm and bills of 11.2 mm (Ridgway 1901). Males are slightly heavier than females. Males in a Saskatchewan population averaged 26.3 g ($n = 33$) while females averaged 25.4 g (Maher 1970). Sixteen Colorado females averaged 25.8 g (Howe, unpublished data).

DISTRIBUTION

The McCown's longspur breeds mostly in shortgrass prairie from southern Alberta and Saskatchewan south through western North Dakota, Montana, and Wyoming to north-central Colorado and northwestern Nebraska (Godfrey 1966; American Ornithologists' Union 1983). It has not nested in South Dakota since 1949 (Johnsgard 1979). It is widespread east of the Rockies in Montana (Skaar 1980). In Wyoming it breeds most commonly in the southeast, less frequently in other parts of the eastern half of the State (Kantrud 1982; Oakleaf et al. 1982). In North Dakota it is locally common in the extreme west, where it often breeds in small grain stubble, but formerly was much more abundant and ranged to well-drained prairie in the northeast (Stewart 1975). In Colorado it nests only in the vicinity of Weld County (Kingery and Graul 1978). At one time the species nested in southwestern Minnesota (American Ornithologists' Union 1983). The primary wintering area is from central Arizona, southern New Mexico, southeastern Colorado (casually), west-central Kansas, central Oklahoma south to western and south-central Texas, northeastern Sonora, Chihuahua, and northern Durango (American Ornithologists' Union 1983). According to Kingery and Graul (1978), however, it does not winter in Colorado. The breeding and wintering ranges of McCown's longspur in the United States are shown in Figure 30.

DIET

During the breeding season, McCown's longspurs are primarily insectivorous. In 24 digestive tracts of adults from Colorado (Baldwin 1970), 78% of the mass of ingested food was animal material and 22% plant material (mainly seeds). Of the animal material, 27% of the dry weight was acridid grasshoppers, and an additional 36% members of the families Formicidae, Curculionidae, and Tenebrionidae. Feeding occurs throughout the day, accounting for 29 to 32% of the diurnal activity budget (Creighton 1974). Although most insects are taken on the ground, about 30% are taken in the air, and a small proportion is gleaned from forbs (Creighton 1974).

The young are fed insects exclusively; acridid grasshoppers comprise the majority of the prey (Dubois 1937; Mickey 1943; Felske 1971; Creighton 1974; Howe, unpublished data). In Colorado, 37% of the insect mass fed to young was Coleopteran beetles and an additional 15% was composed of Diptera, Hymenoptera, and Lepidoptera (Creighton 1974). Moths are an important food item in Wyoming (Mickey 1943). The insect fauna on shortgrass prairies varies from year to year, probably as a function of precipitation, so diet might be expected to vary accordingly.

REPRODUCTION

McCown's longspurs return to breeding areas at low elevations in southeastern Wyoming by the first week of April (Mickey 1943; Finzel 1964), to Montana sites by the middle of April (Dubois 1935), and to Alberta by early May (Sadler and Myres 1976). Males are the first to arrive, followed by

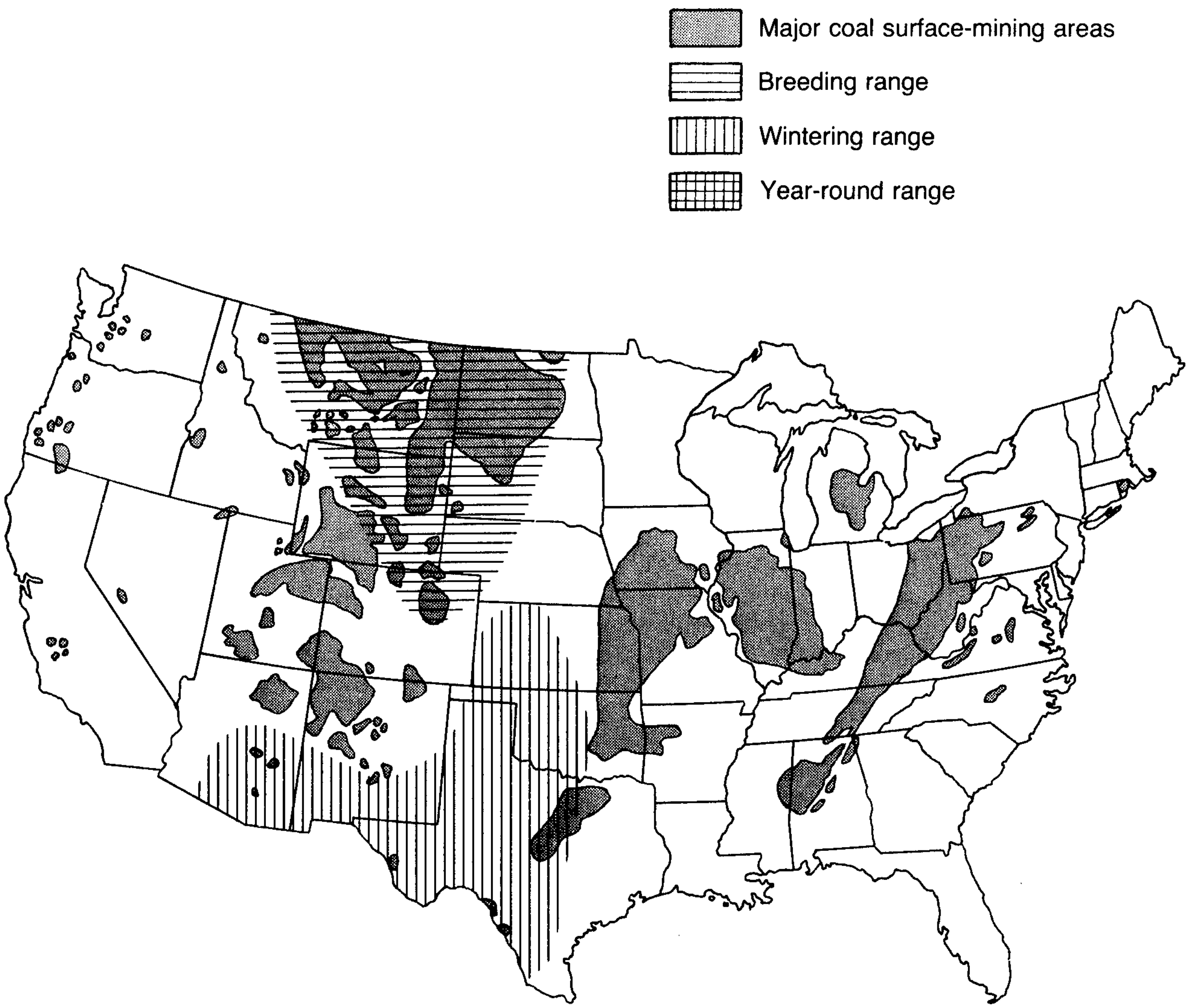


Figure 30. Geographical range of the McCown's longspur in relation to major coal deposits in the United States. After Inkley and Raley (1983).

females by the third week of April in southeastern Wyoming (Mickey 1943). In dry years birds may remain in flocks until mid-May (Finzel 1964), but normally males establish territories by the end of April. Egg-laying commences in early May in most areas or as early as the end of April in Colorado (Creighton 1974). Most clutches are completed by the week of May 16 in Colorado and between May 11 and 21 in Montana (Dubois 1935). Birds are typically double-brooded (Mickey 1943) and nests are sometimes initiated as late as early July (Dubois 1935; Creighton 1974). Average clutch size varies between 3 and 3.5 (Mickey 1943; Ryder 1972; Creighton 1974).

The incubation period is 12 days (Mickey 1943; Creighton 1974). Young leave the nest between 8 and 11 days after hatching, most typically at 10-10.5 days (Mickey 1943; Creighton 1974; Howe, unpub. data). Parents attend the young for at least 2 weeks after fledging, during which period the female may begin a second clutch (Howe, unpub. data). Extrapolating from late nest-initiation dates, parents may be attending fledged young as late as the second week of August. In early August birds begin to flock and roam outside of the immediate breeding area (Finzel 1964). Departure from the breeding range is gradual and birds may be found well into October.

Although McCown's longspurs show a strong preference for true shortgrass prairie, they sometimes nest in other arid habitats characterized by short, sparse vegetation. They also are known to nest in sagebrush-grassland (Kantrud 1982; Oakleaf et al. 1982), small grain stubble (Stewart 1975), and heavily grazed mixed-grass prairie (Maher 1970). In northeastern North Dakota they formerly nested on sparsely vegetated, well-drained sections of mixed-grass prairie (Stewart 1975).

Within typical shortgrass (Buchloe, Bouteloua, Stipa) habitats, McCown's longspurs seem to prefer sites with large amounts of exposed soil. The average longspur territory in Colorado contained 23% bare soil interspersed with blue grama grass (Bouteloua gracilis) and pricklypear cactus (Opuntia polyacantha) (Creighton 1974). McCown's longspurs in Colorado avoided areas containing greater than 11% mid-grasses. A preference for sparse, low vegetation may explain many authors' impressions that McCown's longspur densities are greatest atop knolls and rises, where the soil is apt to hold less moisture (Dubois 1935; Giezentanner 1970; Creighton 1974). Felske (1971) noted the same phenomenon and felt that the earlier snow melt in spring on hilltops enables the ground to warm faster, resulting in earlier feeding opportunities.

The nest is a hollowed out scrape in the ground, approximately flush with the ground surface and lined with grasses. Nest depths average 5 cm and the inside diameter about 6 cm (Dubois 1935; Mickey 1943). Nests are often constructed adjacent to discontinuities, such as grass tufts, forbs, or piles of cow feces.

All feeding takes place within the territory until fledging, when the territory structure breaks down (Howe unpub. data). Occasionally birds fly long distances from the territory, but the function of these flights is unknown (Mickey 1943). At a Colorado site, many birds left their territories periodically to drink at a nearby cattle tank (Howe unpub. data). Outside of the breeding season, similar arid habitats are used for feeding.

POPULATION TRENDS

The present population of McCown's longspurs is unknown and cannot be estimated accurately, because the full breeding range is imprecisely known, and within the range birds are not evenly distributed. In Colorado (Howe, unpublished data), Wyoming (Mickey 1943), North Dakota (Stewart 1975), Saskatchewan (Felske 1971), and probably elsewhere, breeding birds occur in clumps, leaving many seemingly suitable areas unoccupied.

Furthermore, density varies widely from one nesting population to another. Nesting densities of longspurs in southern Wyoming were 126 pairs/100 ha at an altitude of 1,950 m and 59 to 84 pairs/100 ha at 2,286 m (Finzel 1964). A population in Weld County, Colorado, had a density of 107 pairs/100 ha (Howe unpublished data). Breeding pair densities (per 100 ha) range from 36.1 in Saskatchewan (Maher 1970), 14.4 and 19.3 in Colorado (Ryder 1972), to a maximum of 67.9, also in Colorado (Porter 1973). A comparison of several sampling techniques for estimating breeding density concluded that the spot-mapping method yields results most comparable to actual densities (Porter 1973). This technique accounted for 85 to 89% of the nests located after intensive searches.

Effects of Habitat Changes

Populations have undoubtedly declined in some parts of the original range because of agricultural expansion in the early part of the twentieth century. Range restrictions occurred in North Dakota (Stewart 1975) and breeding birds have been eliminated from South Dakota (Johnsgard 1979). In the Western plains, where agricultural development has been less intensive, it is not clear if populations have declined. The introduction of center-pivot irrigation systems will potentially permit cultivation of shortgrass prairie now occupied by McCown's longspur. Any activity that increases the proportion of mid-grasses to short grasses, and any conversion of natural prairie to cultivated land, will adversely affect longspurs and probably eliminate most from the immediate vicinity.

Mid-grass prairie can be attractive to McCown's longspurs when it is grazed, but the degree of grazing required seems to vary by region and soil type (Kantrud and Kologiski 1982). In Saskatchewan this species breeds only in grazed mid-grass habitats (Maher 1970). Although these areas may have been grazed historically by buffalo, it is possible that longspurs have expanded their range locally in response to domestic cattle grazing.

Effects of Human Disturbance

Except for agricultural development or other forms of land modification, no evidence exists indicating human presence is a significant adverse influence on breeding McCown's longspurs. Severe local disturbances that result in unintentional disfiguration of the landscape (e.g., off-road vehicle activity) undoubtedly would have an impact. But, where they occur, longspurs seem to tolerate the presence of isolated human habitations and moderate activity levels. They are well adapted to the presence of ungulates and thrive on grazed, arid land. Intensive sheep grazing, however, would probably result in considerable nest trampling. Frequent activity in nesting areas and repeated nest visitations by biologists do not typically induce desertion.

Management

While there have been no attempts to actively manage habitat for McCown's longspurs, the most effective management technique in the natural range is likely to be the preservation of preferred habitat. Maintenance of small-grain stubble might provide some acceptable habitat, but successful reproduction on such sites would depend on timing of agricultural operations. Mid-grass prairie within or bordering the range of McCown's longspur might be made attractive by intensive cattle grazing. The degree to which McCown's longspurs are sensitive to fragmentation of their habitat (e.g., how large do tracts of suitable habitat have to be to attract longspurs?) is not known. They reach their highest densities, however, in broad, expansive stretches of arid prairie. "Natural" experiments, from which their sensitivity to fragmentation can be assessed, probably exist at many sites within their range. Intensive censusing of different sized tracts in such areas would be a very fruitful line of research.

McCown's Longspur as an Indicator Species

An indicator species is one that occurs within a narrow habitat spectrum and whose populations are sensitive to habitat changes. Changes in the population of an indicator species may be a signal that significant changes in components of its habitat are occurring. McCown's longspur, though widely distributed, is largely restricted to arid shortgrass prairie (or grazed mid-grasses) and drops out where the proportion of mid-grasses exceeds 11% (Creighton 1974). It may be unusually sensitive to minute changes in the complex of soil, vegetation, and climate (Felske 1971). Because it is reasonably common within this rather limited habitat type, McCown's longspur should be an excellent indicator of changes in shortgrass prairie. Hence, reoccupation of reclaimed surface-mined land by McCown's longspurs should be evidence of successful restoration of topography and vegetation physiognomy. Furthermore, monitoring of longspur populations on the periphery of a surface mining site over a period of years may yield evidence of subtle habitat changes, such as those that may result from altered drainage patterns or water chemistry.

IMPACTS OF COAL MINING ON MCCOWN'S LONGSPURS

Activities associated with surface mining are not likely to severely affect McCown's longspur except where the land surface is actually destroyed by construction of access roads or the mining operation itself. Passerine birds (small songbirds) are generally more tolerant of human activity than larger species, such as raptors or curlews. However, the fragmenting effect of mining on patches of natural prairie or, as mentioned above, altered drainage or water quality could exert an influence beyond the immediate mining site.

During the development stage, longspurs will obviously be eliminated from excavation sites. Whether these birds will be able to relocate will depend upon breeding densities in surrounding areas and upon the timing of the excavation. Excavation during the breeding season will almost certainly prevent affected longspurs from breeding successfully during that year. Populations on the periphery of the mining site may or may not be adversely influenced.

Habitat loss will result in impacts to McCown's longspurs through direct mortality, and increased stress and indirect mortality from displacement. Direct mortality may occur during construction and mining operations if nests and nestlings are destroyed. Displaced individuals will be forced to move to surrounding habitat, if available, resulting in overcrowding and increased competition for food resources and nesting sites (assuming suitable habitat is already occupied). The displacement and increased competition will most likely result in an ultimate reduction in the breeding population.

Further impacts might be anticipated during the mining phase, if water pumping is sufficient to change the level of the water table or if drainage systems result in excessive vegetation growth downslope from the mine. Vegetation changes, if they occur at all, may happen rapidly or over a period of years, depending on the severity of disruption to the natural subterranean water regime. Chemical changes (primarily alkalization) in aquifers, resulting from leaching of the removed overburden, could eventually influence vegetation growth (Moore and Mills 1977).

Excessive blasting during the mining phase might exert peripheral effects on longspurs. However, blasting is not normally an important activity in the Western plains where coal reserves lie close to the surface (Moore and Mills 1977).

Information is lacking on the site-specific impact at the periphery of active mining zones and the patterns of recolonization on reclamation sites. Studies are needed on the effects of mining on McCown's longspurs in large and small tracts of prairie. That is, will reduction of a prairie patch from 10 km^2 to 5 km^2 (for example) by a mining operation exert more of a peripheral impact on longspurs than a similar mining operation in a 100-km^2 prairie patch? If a minimal area for attracting longspurs exists, the former example might result in a greater impact on longspur populations. If such a difference is found, better predictions could be made on the degree of impact at future mining sites.

RECOMMENDATIONS FOR MCCOWN'S LONGSPUR MITIGATION

The most likely areas where exploitable coal reserves will be sympatric with McCown's longspur populations are Montana, western North Dakota, and perhaps isolated areas in central and eastern Wyoming.

Premining Phase

As with any impact assessment program, evaluating the effects of surface mining on McCown's longspur populations requires baseline data on population density before any activity takes place. If lead time is great enough, censuses should be conducted in mid-May (or closer to 20 May near the Canadian border) for the two breeding seasons prior to exploration and development. Breeding density or activity may vary considerably between average years and years of abnormally high or low precipitation (Felske 1971; Howe, unpublished data). Censusing over two years would minimize the risk of documenting an atypical nesting situation in any one year. The most effective census technique for relatively small areas is spot-mapping (Porter 1973). This procedure should be followed both on the future site of the mine and for a distance of at least 1 km beyond the anticipated limits of the mine and its ancillary operations. Other passerine birds detected during the censuses should also be plotted, as this will require little additional time. If cause exists to expect significant impact on water drainage patterns or changes in water chemistry, the census area should be expanded to include the potentially affected area.

Spot-mapping is time consuming and generally impractical for coverage of areas greater than 100 ha in open country. Its results, however, approximate actual breeding pair densities, so the technique is necessary on the future excavation site proper. To census areas beyond a 100-ha core, the Finnish line transect method should be used (Merikallio 1958). Although this technique yields only information on relative densities between sites, large areas can be censused fairly efficiently. If a Finnish transect is conducted in an area of known density (determined by spot-mapping), a conversion factor can be calculated. Using this factor, results of Finnish transects in other areas can be converted to estimates of breeding densities. This method should be used throughout the entire area slated for exploration. Several sites of equal size outside the exploration area should also be censused in this way to serve as controls.

Exploration and Mine Development Phase

This is the stage in which most of the direct impacts on McCown's longspur will occur. Because exploration will normally take place over a larger area than that ultimately chosen for excavation (Moore and Mills 1977) the broadest areal impact on longspurs may occur at this time. The magnitude of impact of exploratory drilling can be minimized if such operations are conducted between August and March. If both exploratory operations and effective reclamation can be completed during this period, there may be few or no adverse effects. If exploratory operations result in little alteration of the ground surface, impacts may be negligible even if work is conducted between March and August.

Transect censuses on the periphery of the mining site and in the control areas should continue annually throughout this and subsequent stages so that the timing and magnitude of any population changes can be carefully documented. These censuses are best conducted during early morning hours. If it is possible to curtail noisy operations during the periods in which censuses are being conducted near mine sites, this should be done. The effectiveness of the censuses is a function of both visual and aural detection of the birds. Peripheral effects on breeding longspurs can be kept to a minimum if the number of access and haul roads is minimized and if traffic and human activity are restricted to these roads, the mine, and the immediate vicinity of buildings.

Mining Phase

Continued censusing during the mining phase will enable a distinction to be made between general impact on longspurs in all directions from the mine and directional impact. Population declines in a particular direction from the mine may correlate with the location of haul roads, utility lines, or drainage viaducts.

If feasible, reclamation should be initiated during the active mining phase as local sites are depleted of coal. In addition to reducing the time over which mined areas are unusable by longspurs, this practice will permit monitoring of reclamation success even as mining continues. Reclamation techniques may thus be improved along the way, before the entire area is eventually reclaimed.

Reclamation Phase

The goal of reclamation should be duplication, as much as possible, of the original topography, vegetation composition, and physiognomy. Careful removal of topsoil in the development stage will help ensure re-establishment of the original vegetation. However, during storage of topsoil, evaporation slows the already slow decay process that returns nutrients to the soil (Moore and Mills 1977). Therefore, fertilization of the topsoil will probably be necessary after it is reapplied to reclaimed sites.

Unfortunately, reseeding of many native grasses is often unsuccessful. Because of this, the vegetation on reclaimed sites is often up to 50% introduced species, compared with 20% in natural prairie (Moore and Mills 1977). To ensure that the resulting vegetation is compatible with longspur use, care should be taken to seed only with shortgrass rather than the wheatgrasses (*Agropyron* spp.) that are often used. Excessive growth of wheatgrass and other mid-grasses will discourage colonization by longspurs. Ideally, several different reseeding programs should be attempted on different parts of the reclaimed site and prairie regeneration studied over a period of several years. Plant ecologists should be consulted in the design of these programs. The most successful of the programs can then be applied in future reclamation efforts in similar habitats.

Censuses should continue for 3 years after reclamation, or less if longspurs quickly achieve premining nesting densities. Results of these monitoring programs should be considered in planning future surface mining operations.

SUMMARY

Western surface coal mining will likely have local impacts on breeding populations of McCown's longspurs, particularly in Montana and perhaps in Wyoming and North Dakota. The major effect will be elimination of these birds where the natural prairie is destroyed. Longspurs and other songbirds are probably not as sensitive to human activity as some larger species, such as raptors. Therefore, impacts on the periphery of the mining operations are apt to be minimal. Nonetheless, careful census programs should be carried out

before, during, and after drilling and excavation to document any changes in longspur populations. Changes could result from factors such as altered subterranean water regimes, sensitivity to blasting, or reduction of the size of a prairie patch below the minimum level acceptable to longspurs. When possible, exploratory drilling should be conducted outside of the longspur breeding season. Reclamation efforts should be geared toward duplication of premining topography and vegetation, to ensure re-establishment of longspur habitat and food needs.

REFERENCES

American Ornithologists' Union. 1983. Check-list of North American birds. 6th ed. Allen Press, Lawrence, KS. 877 pp.

Baldwin, P. H. 1970. The feeding regime of granivorous birds in shortgrass prairie in Colorado. Pages 237-247 in S. C. Kendeigh and J. Pinowski, eds. Productivity, population dynamics, and systematics of granivorous birds. Int. Biol. Prog., The Hague.

Creighton, P. D. 1974. Habitat exploitation by an avian ground-foraging guild. Ph.D. Dissert., Colorado State Univ., Ft. Collins. 139 pp.

Dubois, A. D. 1935. Nests of horned larks and longspurs on a Montana prairie. Condor 37:56-72.

__________. 1937. The McCown's longspurs of a Montana prairie. Condor 39:233-238.

Felske, B. E. 1971. The population dynamics and productivity of McCown's longspur at Matador, Saskatchewan. M.S. Dissert., Univ. of Saskatchewan.

Finzel, J. E. 1964. Avian populations of four herbaceous communities in southeastern Wyoming. Condor 66:496-510.

Giezentanner, J. G. 1970. Avian distribution and population fluctuations on the shortgrass prairie of northcentral Colorado. U.S. Intern. Biol. Prog. Grassland Biome Tech. Rep. 62:1-113.

Godfrey, W. E. 1966. The birds of Canada. Nat. Mus. Canada Bull. 203, Biological Series 73. Ottawa. 428 pp.

Howe, M. A. Unpublished data. Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service, Laurel, MD 20708.

Inkley, D. B., and C. M. Raley. 1983. Wyoming Coop. Fish. Wildl. Res. Unit, Laramie. Distribution maps prepared from American Ornithologists' Union (1983).

Johnsgard, P. A. 1979. Birds of the Great Plains. Univ. Nebraska Press, Lincoln.

Kantrud, H. A. 1982. Personal communication. Northern Prairie Wildlife Research Center, U.S. Fish and Wildlife Service, Jamestown, ND.

____________. 1982. Maps of distribution and abundance of selected species of birds on uncultivated native upland grasslands and shrubsteppe in the Northern Great Plains. U.S. Fish Wildl. Serv. FWS/OBS-82/31. 31 pp.

Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the Northern Great Plains. U.S. Fish Wildl. Serv., Wildl. Res. Rep. 15. 33 pp.

Kingery, H. E., and W. D. Graul. 1978. Colorado bird distribution latilong study. Colo. Field Ornithologists and Colo. Div. Wildl., Denver.

Maher, W. J. 1970. Growth of ground-nesting birds at Matador, Saskatchewan, Canada. Pages 85-102 in S. C. Kendeigh and J. Pinowski, eds. Productivity, population dynamics, and systematics of granivorous birds. Int. Biol. Prog., The Hague, Netherlands.

Merikallio, E. 1958. Finnish birds - their distribution and numbers. Fauna Fennica 5:1-181.

Mickey, F. W. 1943. Breeding habits of McCown's longspur. Auk 60:181-209.

Moore, R., and T. Mills. 1977. An environmental guide to Western surface mining. Part two: impacts, mitigation, and monitoring. U.S. Fish Wildl. Serv., FWS/OBS-78/04. 407 pp.

Oakleaf, B., H. Downing, B. Raynes, M. Raynes, and O. Scott. 1982. Wyoming avian altas. Wyo. Game Fish Dept. and Bighorn Audubon Soc. 87 pp.

Porter, D. K. 1973. Accuracy in censusing breeding passerines on the shortgrass prairie. M.S. Dissert., Colorado State Univ., Ft. Collins. 107 pp.

Ridgway, R. 1901. The birds of North and Middle America. U.S. Nat. Mus. Bull. 50:1-715.

Ryder, R. A. 1972. Avian population studies on the Pawnee site. U.S. Intern. Biol. Prog. Grassland Biome Tech. Rep. 171:1-62.

Sadler, T. A., and M. T. Myres. 1976. Alberta birds, 1961-1970. Prov. Mus. Alberta (Nat. Hist. Sect.) Occ. Pap. 1:1-314.

Skaar, P. D. 1980. Montana bird distribution. P. D. Skaar, Bozeman, Montana.

Stewart, R. E. 1975. Breeding birds of North Dakota. Tri-College Cent. Environ. Studies, Fargo.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. FWS/OBS-83/35	2.	3. Recipient's Accession No.
4. Title and Subtitle: Impacts of coal surface mining on 25 migratory bird species of high Federal interest			5. Report Date: December 1983
			6.
7. Author(s)			8. Performing Organization Rept. No.
9. Performing Organization Name and Address	Western Energy and Land Use Team U.S. Fish and Wildlife Service Creekside One Building 2627 Redwing Road Fort Collins, CO 80526-2899		10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address	Western Energy and Land Use Team Division of Biological Services Research and Development Fish and Wildlife Service Washington, DC 20240		13. Type of Report & Period Covered
			14.

15. Supplementary Notes

Judith S. Armbruster, ed.

16. Abstract (Limit: 200 words)

Potential impacts of coal surface mining on 25 migratory bird species of high Federal interest are examined. Information presented is the result of literature searches on migratory bird species and coal surface mining operations. Each species account includes a discussion on distribution, life history, habitat requirements, population status, effects of habitat changes and human disturbance, and management techniques. Information on potential impacts and recommendations for mitigation measures is included, along with general suggestions for the reclamation of wildlife habitat. This document is designed for use by biologists in conducting a preliminary assessment of the potential impacts of a particular coal surface mining project on selected species of migratory birds of high Federal interest present in the area during some part of the year.

17. Document Analysis a. Descriptors

Birds
Coal mining
Surface mining
Wildlife

b. Identifiers/Open-Ended Terms

Migratory birds
Coal surface mining
Habitat

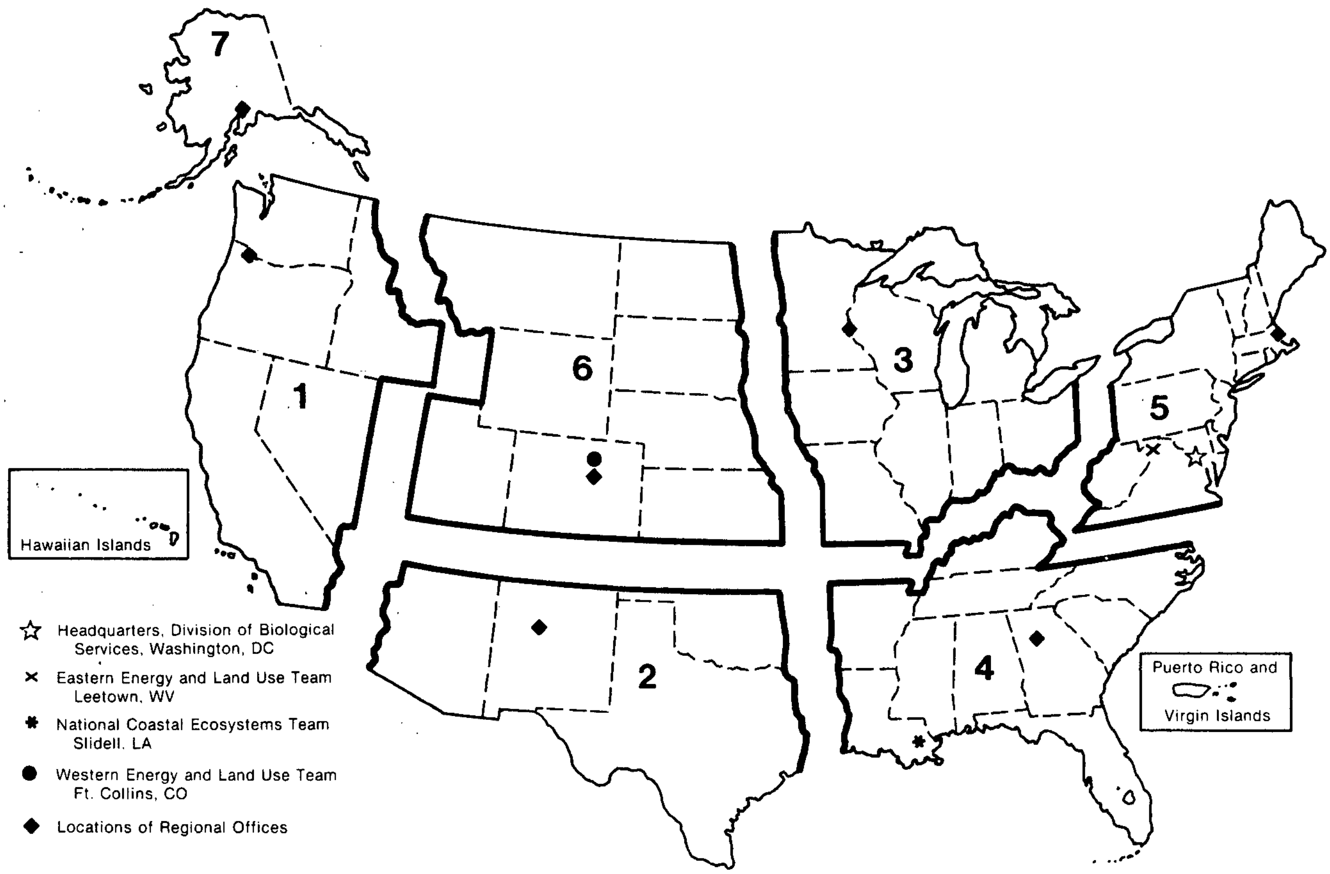
c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	Unclassified	348
	20. Security Class (This Page): Unclassified	22. Price

(See ANSI-Z39.18) See Instructions on Reverse

☆ U.S. Government Printing Office 1984 - 777-777/9150 Reg. 8

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce



REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE