United States
Department
of Agriculture

Forest Service

**Rocky Mountain
Research Station**

Research Paper
RMRS-RP-56WWW

November 2005

A Survey of Potential Bald Eagle Nesting Habitat Along the Great Lakes Shoreline

**William W. Bowerman
Teryl G. Grubb
Allen J. Bath
John P. Giesy
D.V. Chip Weseloh**

Bowerman, William W.; Grubb, Teryl G.; Bath, Allen J.; Giesy, John P.; Weseloh, D.V. Chip. 2005. **A survey of potential bald eagle nesting habitat along the Great Lakes shoreline**. Res. Pap. RMRS-RP-56WWW. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 6 p.

Abstract

We used fixed-wing aircraft to survey the entire shoreline and connecting channels of the five Great Lakes to determine potential nesting habitat for bald eagles (*Haliaeetus leucocephalus*) during 1992. Habitat was classified as either good, marginal, or unsuitable, based on six habitat attributes: (a) tree cover, (b) proximity and (c) type/amount of human disturbance, (d) potential foraging habitat/shoreline irregularity, and suitable trees for (e) perching and (f) nesting. Of the 10,596 km of shoreline surveyed, we classified 7,006 km (66%) as potentially suitable (i.e. either good or marginal) nesting habitat. We evaluated classification accuracy by comparing surveyed habitat suitability with locations of currently active nest sites; 97% of the 117 active nests along the Great Lakes in 1992 were located in suitable habitat, 82% in good habitat. Bald eagle nests occurred more often in good habitat and less often in unsuitable habitat than expected ($X^2 > 35.02$, 2 df, $P < 0.001$). Potential nesting habitat existed along the shoreline of all the Great Lakes, but was most abundant along Lakes Huron and Superior and least along Lakes Ontario and Erie. Habitat availability may limit the nesting population of bald eagles along Lake Erie, which has little unoccupied habitat, the most use of marginal habitat, yet the greatest density of nesting eagles in the Great Lakes.

Keywords: aerial survey, bald eagle, *Haliaeetus leucocephalus*, Great Lakes, habitat evaluation, nesting habitat, potential habitat

The Authors

William W. Bowerman, Department of Forestry and Natural Resources, Program of Environmental Toxicology, Clemson University, Clemson, SC.

Teryl G. Grubb, USDA Forest Service, Rocky Mountain Research Station, Flagstaff, AZ.

Allen J. Bath, Department of Zoology, Institute for Environmental Toxicology, Michigan State University, East Lansing, MI.

John P. Giesy, Department of Zoology, Institute for Environmental Toxicology, Michigan Sate University, East Lansing, MI.

D. V. Chip Weseloh, Canadian Wildlife Service, Burlington, Ontario Canada

Rocky Mountain Research Station
Publishing Services

Telephone	(970) 498-1392
FAX	(970) 498-1396
E-mail	rschneider@fs.fed.us
Web site	http://www.fs.fed.us/rm
Mailing Address	Publications Distribution Rocky Mountain Research Station 240 West Prospect Road Fort Collins, CO 80526

A Survey of Potential Bald Eagle Nesting Habitat Along the Great Lakes Shoreline

William W. Bowerman
Teryl G. Grubb
Allen J. Bath
John P. Giesy
D. V. Chip Weseloh

Historically, bald eagles (*Haliaeetus leucocephalus*) nested along the shoreline of all five of the Laurentian Great Lakes (Colborn 1991). The species was extirpated in the 1950's and early 1960's, but has recently returned to successfully nest again along the islands and shorelines of the Great Lakes (Postupalsky 1985). The primary reason for the extirpation was egg shell thinning caused by p,p'-DDE, the aerobic metabolite of DDT. However, prior to the widespread use of DDT after World War II, eagle populations were already declining due to loss of nesting habitat, changes in fish populations, and persecution by humans (Colborn 1991). Although bald eagles have returned to the Great Lakes, in those areas where they are foraging primarily on Great Lakes fish, they still fail to produce young at a level typically associated with a healthy population (Sprunt and others 1973). Concentrations of PCBs and residual p,p'-DDE within addled eggs and plasma of nestling eagles are sufficient to indicate contaminants may be impairing productivity (Bowerman and others 1993).

Because of the bald eagle's reproductive sensitivity to organochlorine pesticides such as p,p'-DDE and PCBs, this species is a good monitor of environmental quality. Therefore, the International Joint Commission (International Joint Commission 1989) proposed the bald eagle as an ecosystem monitor of Great Lakes water quality. However, in order to fully evaluate effects of organochlorine compounds on nesting eagles, it was first necessary to ascertain the extent of remaining suitable nesting habitat along the Great Lakes shoreline. Therefore, in 1992 we conducted a comprehensive aerial survey of the shoreline of all five Great Lakes and their connecting channels. From this comprehensive aerial survey, we classified and determined the distribution of potential bald eagle nesting habitat along the Great Lakes shoreline. We tested the accuracy of our habitat evaluation by comparing locations of active bald eagle nests (obtained independently of the aerial surveys) with our survey-based habitat classification.

Study Area

The study area included the shorelines, islands, and connecting channels of all five Great Lakes, bounded on the west by the Harbor of Duluth/Superior at the western end of Lake Superior and on the east by the international bridge spanning the St. Lawrence River at Ivy Lea, Ontario. The area within 1.6 km of the United States and Canadian shoreline of the Great Lakes was surveyed (fig. 1). The surface area of the five lakes encompassing the Great Lakes Basin is approximately 754,325 km^2. The elevation of lake levels varies from approximately 183 m at Lake Superior to 75 m above sea level at Lake Ontario (Great Lakes Basin Commission 1975a). Vegetative cover varies across the Great Lakes Basin. Northern spruce-fir forest occurs along the north shore of Lake Superior; major tree species are aspen (*Populus grandidentata, P. tremuloides*), spruce (*Picea mariana, P. glauca*), and balsam fir (*Abies balsamea*). Mixed northern hardwood-pine forest occurs in the central lakes area, comprising the south shore of Lake Superior and northern shores of Lakes Michigan and Huron; dominant species are maple (*Acer rubrum, A. saccharum*), oak (*Quercus rubra, Q. alba*), and pine (*Pinus strobus, P. banksiana, P. resinosa*). Mainly oak forests (*Quercus* spp.) occur along southern Lakes Michigan and Huron, Lake Erie and western Lake Ontario. Mixed forest with species similar to the central lakes occurs along eastern Lake Ontario (Great Lakes Basin Commission 1975a).

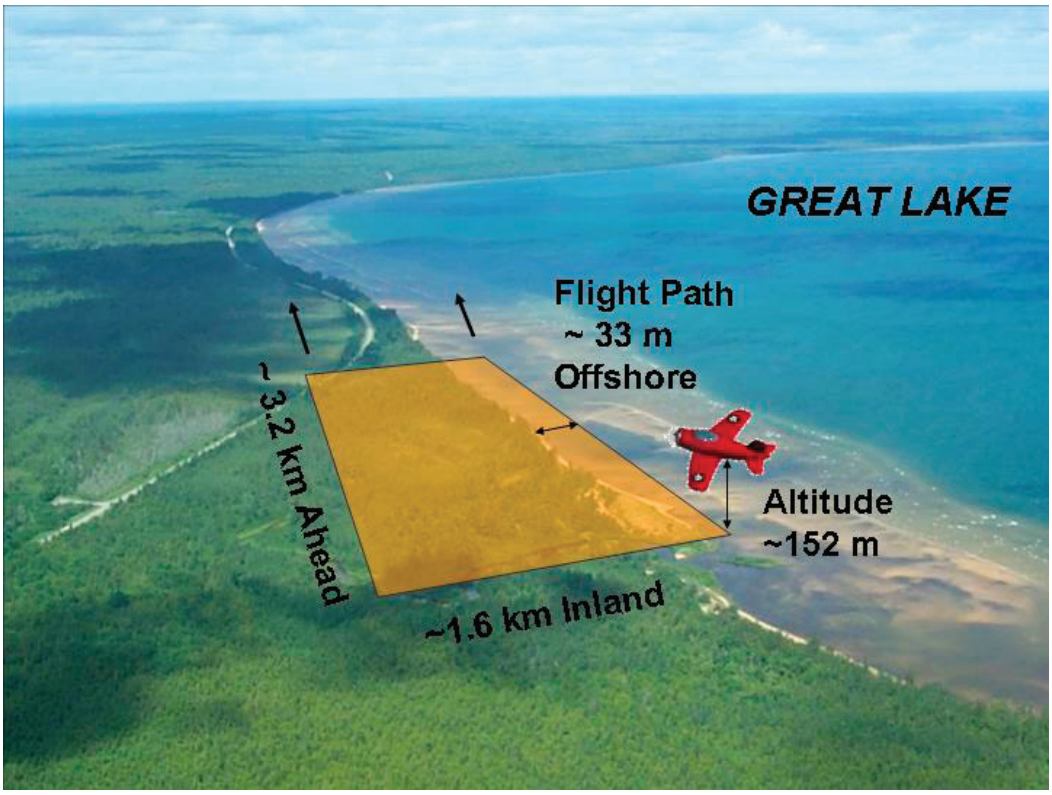

Figure 1—Flight path and altitude above ground level with corresponding moving survey window used during Great Lakes bald eagle nesting habitat survey, 1992.

Methods

A Cessna 172 or 177 fixed-wing aircraft, flying at approximately 200 km/hr at an average altitude of 152 m and 33 m offshore, was used to survey all shoreline (fig. 1). To maximize consistency in habitat evaluation, the third author conducted all aerial surveys. Lakes Erie and Ontario were flown between 2-5 January 1992. Portions of Lakes Huron, Michigan, and, Superior were flown between 23-27 April, with the remaining shoreline completed between 12-14 September (Huron and Superior) and on 28 September (Michigan).

A moving, 3.2-by-1.6-km, survey window encompassing an aerial observer's average field of view, was used to define the approximate area of habitat evaluated for potential bald eagle nesting (fig. 1). Our aerial search image incorporated six habitat attributes: (a) tree cover, (b) proximity and (c) type/amount of human disturbance, (d) potential foraging habitat/shoreline irregularity, and suitable trees for (e) perching and (f) nesting (Grubb and others 2003; table 1). The first two attributes were assessed initially to determine if further evaluation was appropriate. If the thresholds for these attributes were exceeded, habitat evaluation continued. Type/amount of Nearest Human Disturbance was partitioned into three levels to accommodate the influence of varying amounts of human activity on potential habitat. Availability of an adequate prey base along the shoreline was assumed because of proximity to the Great Lakes. Additional foraging habitat, such as marshes, still water, shallow bays, and the increased lake-shore interface of irregular shoreline, were considered to improve forage availability. Habitat was classified as good (all attributes present at optimal levels), marginal (one or more attributes lacking or at suboptimal levels), or unsuitable (insufficient attributes for nesting; see Grubb and others 2003). For some analyses good and marginal were combined into suitable habitat.

A comparison of surveyed habitat suitability classes with actual locations of active bald eagle nests in 1992 provided a test of the accuracy of our nesting habitat assessment. During the aerial survey there was no effort to find, nor any foreknowledge of, current eagle nest locations; only one nest was noted during our survey. We used a Chi-square goodness of fit test to compare our

Table 1—Habitat attributes evaluated in determining good, marginal, and unsuitable potential habitat for nesting bald eagles during an aerial survey of the Great Lakes shoreline in 1992.

1. Tree Cover
>10% forested
2. Proximity Nearest Human Disturbance
>0.8 km from light to moderate human activity (Attributes 3a and 3b), or
>1.6 km from heavy human activity (Attribute 3c)
3. Type/amount Nearest Human Disturbance
a. Light[a] — trails, undeveloped campgrounds, unimproved roads
b. Moderate — buildings, paved roads, small boat docks/launches
c. Heavy — cities, industry, extensive development, marinas
4. Potential Foraging Habitat and/or Shoreline Irregularity
Presence of shallows, bays, marshes, small lakes, and/or
Ratio of total shoreline to linear distance >2.0[b]
5. Potential Perch Trees
Suitable[c] perch trees ≥30 cm diameter at breast height (dbh)
≤0.4 km from potential foraging area
6. Potential Nest Trees
≥3 suitable[d] nest trees
≥61 cm dbh if coniferous or ≥46 cm dbh if deciduous
Dominant (supercanopy) or near edge (of stand, along shore)

[a]Light category also applies when human activity is totally absent.
[b]Total shoreline: Linear distance. Total shoreline includes the Great Lake shore plus that of any islands, bays, marshes, interior lakes, stream or river banks, etc., within the survey window. Linear distance is the length of a straight flight path parallel to shore across the survey window, i.e., 3.2 km (fig. 1).
[c]Suitable perch trees typically have exposed or open branching with good views and accessibility.
[d]Suitable nest trees have accessible, sufficiently large branching and structure at or above canopy height to support an eagle nest.

surveyed habitat classification (or expected nest distribution) with the actual distribution of existing nest sites (Ott 1988). We tested for random distribution by locating all active nest sites between 1988-92, and then comparing the number of nest sites recorded in each habitat class with the expected number, which was determined by multiplying the total number of nests by the percent of linear shoreline in each habitat class. Lake Ontario was not included in these analyses since bald eagles have not nested there since the 1970's (Colborn 1991).

Results

Potential nesting habitat was found along all five Great Lakes but was more concentrated and contiguous in the northern lakes (Superior, Michigan, and Huron, fig. 2). Lake Superior had good habitat along most of its perimeter. Lakes Michigan and Huron had good or marginal habitat concentrated along their more northern shores. The more populated and industrialized southern portions of Lakes Michigan and Huron, and the areas surrounding Lakes Erie and Ontario, contained fewer and more disjoint regions of suitable habitat. The shoreline of these southernmost lakes was predominantly marginal. Total linear distance of suitable (i.e., good and marginal) habitat varied by lake (table 2) and by governmental jurisdiction (table 3). Of the 10,596 km of shoreline surveyed, 7,006 km (66%) was classified as either good or marginal potential nesting habitat. Only 9% of the suitable habitat was located along Lake Erie (637 of 7006 km, table 2), yet it had a greater density of nesting eagles where they occurred than any of the other lakes.

The 117 active bald eagle nests along the Great Lakes shoreline in 1992 were not evenly distributed: Lake Superior had the most nests followed by Lakes Erie, Huron, and Michigan (table 4). The distribution of nests among habitat suitability classes was not random within ($X^2 > 35.02$, 2 df, $P < 0.001$) nor among lakes ($X^2 = 2970.11$, 2 df, $P < 0.001$). Bald eagle nests occurred more

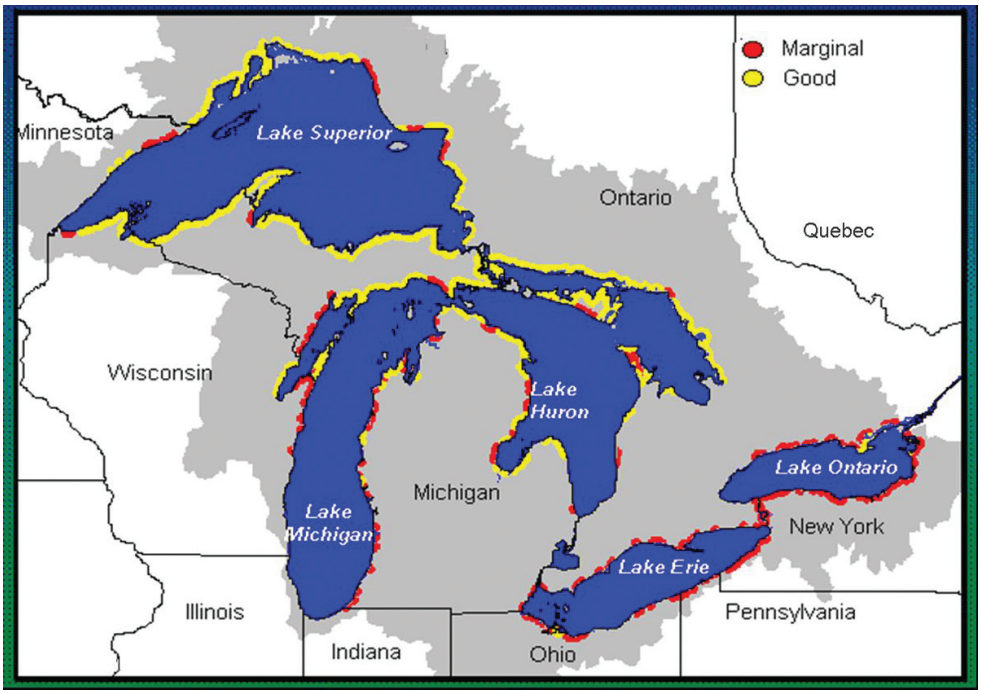

Figure 2—Areas classified as Good or Marginal bald eagle nesting habitat within 1.6 km of the Great Lakes shoreline, 1992. Unshaded areas were classified as unsuitable nesting habitat.

Table 2—Total length (km) and percent (%) by lake and suitability class of potential bald eagle nesting habitat classified into three habitat suitability classes during an aerial survey of the five Great Lakes shoreline in 1992.

	Habitat Suitability Class			
Great Lake	**Good km (%)**	**Marginal km (%)**	**Unsuitable km (%)**	**Lake Totals km (%)**
Superior	2,186 (76)	186 (7)	487 (17)	2,859 (27)
Michigan	624 (33)	353 (18)	942 (49)	1,919 (18)
Huron	1,975 (65)	319 (11)	744 (24)	3,038 (29)
Erie	94 (7)	543 (40)	707 (53)	1,344 (13)
Ontario	112 (8)	614 (43)	710 (49)	1,436 (13)
Class Totals	4,991 (47)	2,015 (19)	3,590 (34)	10,596 (100)

Table 3—Total length (km) and percent (%) by political jurisdiction and suitability class of potential bald eagle nesting habitat classified into three habitat suitability classes during an aerial survey of the five Great Lakes shoreline in 1992.

	Habitat Suitability Class			
Jurisdiction	**Good km (%)**	**Marginal km (%)**	**Unsuitable km (%)**	**Jurisdiction Totals km (%)**
Michigan	1,837 (60)	427 (14)	774 (26)	3,038 (29)
Wisconsin	545 (52)	89 (8)	421 (40)	1,055 (10)
Minnesota	171 (45)	74 (20)	134 (35)	379 (4)
Ohio	20 (5)	140 (37)	216 (58)	376 (4)
Illinois	0 (0)	0 (0)	87(100)	87 (<1)
Indiana	0 (0)	0 (0)	69(100)	69 (<1)
Pennsylvania	0 (0)	43 (51)	41 (49)	84 (<1)
New York	47 (7)	331 (51)	275 (42)	653 (6)
United States Subtotal	2,620 (46)	1,104 (19)	2,017 (35)	5,741 (54)
Ontario, Canada	2,371 (49)	911 (19)	1,573 (32)	4,855 (46)
Class Totals	4,991 (47)	2,015 (19)	3,590 (34)	10,596 (100)

Table 4—Frequency of active bald eagle nests by lake and suitability class for potential bald eagle nesting habitat classified into three habitat suitability classes during an aerial survey of the five Great Lakes shoreline in 1992.

	Habitat Suitability Class			
Great Lake	**Good Nests (%)**	**Marginal Nests (%)**	**Unsuitable Nests (%)**	**Lake Totals Nests (%)**
Superior	59 (98)	1 (2)	0 (0)	60 (51)
Michigan	7 (88)	1 (12)	0 (0)	8 (7)
Huron	23 (92)	2 (8)	0 (0)	25 (21)
Erie	7 (29)	13 (54)	4 (17)	24 (21)
Ontario	0 (0)	0 (0)	0 (0)	0 (0)
Class Totals	96 (82)	17 (15)	4 (3)	117 (100)

often in good habitat and less often in unsuitable habitat than expected. For all lakes except Lake Erie, nests were located within marginal habitat at a lesser proportion than expected. Ninety-seven percent of the 1992 active nests along the Great Lakes occurred in suitable habitat, and 82% were located in good habitat. The majority (93 of 113, 82%) of the nesting areas identified in suitable (i.e., good or marginal) nesting habitat were along the three northern lakes (table 4). The only nest sites located in unsuitable habitat were along Lake Erie. All four sites were single nest trees or small woodlots in large marshes with no forest cover.

Discussion

During our survey, we only evaluated physical habitat attributes that could be discerned from a moving aircraft. The attributes outlined in table 1 had to be estimated. Forage was assumed to be available throughout the Great Lakes. The foraging attributes we assessed from the air identified secondary foraging habitat characteristics which would tend to increase prey availability near the potential nesting habitat. However, no direct measure of foraging availability was determined nor are the data necessary to analyze potential availability of fish forage in all of the survey areas available.

Nesting raptors are delimited by whichever is more scarce, availability of food or nest sites (Newton 1979). Lake Erie's primary productivity and aggressive management of human presence near nests may compensate for its apparent lack of good habitat. The greater forage productivity of Lake Erie in comparison to the northern lakes (Great Lakes Basin Commission 1975b) may increase the potential for successful nesting in otherwise marginal habitat (Hansen 1987). Primary productivity is greatest in the western basin of Lake Erie (Great Lakes Basin Commission 1975c), where the majority (21 of 31) of active nests in 1993 and subsequent years have been located. Human disturbance, which decreased habitat quality, was also greater along the Lake Erie shoreline than along the other lakes. Yet, the large number of nesting areas within this marginal habitat may be partially explained by the aggressive management strategies of the Ohio Department of Natural Resources and Ontario Ministry of Natural Resources which include cooperative management plans with private landowners, monitoring nest sites with volunteers, and maintaining 400-m human exclusionary zones during the nesting season (Grier and others 1983).

The identification and protection of historic nesting areas should also be incorporated into management of potential nesting habitat on all the Great Lakes. Bald eagles have reoccupied historical nesting habitat along five lakes; yet land management decisions that could either decrease forested areas or increase human disturbance could reduce the potential for reoccupation. Most of the recently occupied nesting areas along the lakes are far from human presence. Loss of historic or recently occupied habitats not only decreases the recovery potential for eagles within the Great Lakes ecosystem, but it also could lessen the bald eagle's importance as an ecosystem monitor of Great Lakes water quality by precluding the species' presence in large areas of the basin.

The primary management challenges in the Great Lakes region are 1) to protect the remaining shorelines of the Great Lakes from large-scale changes that would render these areas less suitable for nesting bald eagles, 2) to initiate land management practices that will foster improvement or addition of potential nesting habitat along Great Lakes shorelines, and 3) to preserve sufficiently large tracts of nesting habitat along the shores of Lake Erie to maintain the current nesting population of bald eagles.

Acknowledgments

Financial support was provided by the Great Lakes Protection Fund, Canadian Wildlife Service, Ontario Ministry of Natural Resources, and the Michigan Department of Natural Resources, Nongame Wildlife Fund. E. Addison, P. Hunter, J. Robinson, M. Shieldcastle, J. Weinrich, and D. Weseloh provided invaluable support and assistance in facilitating our multi-jurisdictional survey. W. Haliday expertly piloted our aerial survey. We thank C. Fetter for the Great Lake illustration. S. Bursain, J. Sikarski, S. Winterstein, and M. Zabik reviewed the original manuscript.

References

Colborn, T. 1991. Epidemiology of Great Lakes bald eagles. Journal of Toxicology and Environmental Health 33:395-453.

Bowerman, W. W., D. A. Best, J. P. Giesy, T. J. Kubiak, and J.G. Sikarskie. 1993. The influence of environmental contaminants on bald eagle populations in the Laurentian Great Lakes, North America. IV World Conference on Birds of Prey, Berlin.

Great Lakes Basin Commission. 1975a. Report: Great Lakes Basin Framework Study. Public Information Office, Great Lakes Basin Commission, Ann Arbor, Michigan.

Great Lakes Basin Commission. 1975b. Report: Great Lakes Basin Framework Study. Appendix 4 Limnology of Lakes and Embayments. Public Information Office, Great Lakes Basin Commission, Ann Arbor, Michigan.

Great Lakes Basin Commission. 1975c. Report: Great Lakes Basin Framework Study. Appendix 8 Fish. Public Information Office, Great Lakes Basin Commission, Ann Arbor, Michigan.

Grier, J. W., J. B. Elder, F. J. Gramlich, N. F. Green, J. V. Kussman, J. E. Mathisen, and J. P. Mattsson. 1983. Northern states bald eagle recovery plan. U. S. Fish & Wildlife Service, Washington, D.C.

Grubb, T. G., W. W. Bowerman, J. A. Bath J. P. Giesy and D. V. Weseloh. 2003. Evaluating Great Lakes bald eagle nesting habitat with Bayesian inference. Res. Pap. RMRS-RP-45. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 10 p.

Hansen, A. J. 1987. Regulation of bald eagle reproductive rates in southeast Alaska. Ecology 68(5): 1387-1392.

International Joint Commission. 1989. Proceedings of the expert consultation meeting on bald eagles. International Joint Commission, Windsor, Ontario.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota. 397 pp.

Ott, L. 1988. An introduction to statistical methods and data analysis, Third Edition. PWS-Kent Publishing Company, Boston, Massachusetts.

Postupalsky, S. 1985. The bald eagles return. Natural History 87:62-63.

Sprunt, A., IV, W. B. Robertson, S. Postupalsky, R. J. Hensel, C. E. Knoder, and F. J. Ligas. 1973. Comparative productivity of six bald eagle populations. Transactions North American Wildlife and Natural Resources Conference 38:96-106.

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Research Locations

Flagstaff, Arizona
Fort Collins, Colorado*
Boise, Idaho
Moscow, Idaho
Bozeman, Montana
Missoula, Montana
Reno, Nevada
Albuquerque, New Mexico
Rapid City, South Dakota
Logan, Utah
Ogden, Utah
Provo, Utah

*Station Headquarters, Natural Resources Research Center,
2150 Centre Avenue, Building A, Fort Collins, CO 80526