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Received 4 December 1990.
Accepted 13 August 1992.
Associate Editor: Morrison.

BALD EAGLE HOME RANGE AND HABITAT USE IN THE COLUMBIA RIVER ESTUARY

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Abstract. Little information is available on how areas heavily impacted by humans affect habitat use and home range size of bald eagles (*Haliaeetus leucocephalus*). Thus, we studied home range and seasonal habitat use of bald eagles in the Columbia River estuary (CRE), Oregon and Washington, 1984–86. Aerial and boat surveys of the entire population and intensive observations of 9 breeding pairs were conducted. Most resident pairs were present near their nests year-round. Home range size of resident pairs averaged approximately 22 km^2 for both breeding and nonbreeding periods, and ranged from 6 to 47 km^2 among pairs. Areas of highest use within home ranges averaged <0.5 km^2 (range = 0.1–1.0 km^2), and their locations within home ranges varied between breeding and nonbreeding periods. Resident and nonresident migrant bald eagles in the CRE generally selected remnant stands of old-growth forest near the shoreline for nesting habitat, hunted from perches in mixed-mature conifers and bottomland hardwoods on river islands, and primarily used tidal flats as foraging habitat. We recommend a nesting region approach for managing bald eagles in large geographical areas heavily impacted by humans. This addresses the needs of a number of resident nesting pairs and transient wintering eagles, including the identification of high-use areas and key habitat features important to year-round populations.

J. WILDL. MANAGE. 57(1):19–27

The recovery of endangered wildlife populations is dependent on understanding the habitat requirements necessary for reproduction and survival. Habitat of bald eagles (*Haliaeetus leucocephalus*), particularly old-growth forests and wetlands near coastal and estuarine areas, is threatened by increasing demands for human development and recreational activities (McGarigal et al. 1991, Stalmaster et al. 1985). Information on habitat use by eagles during the breeding period is critical to provide for successful nesting opportunities, and identification of concentration areas and habitats important to nonbreeding eagles is necessary to maintain stable winter populations (U.S. Fish and Wildl. Serv. 1986).

In Oregon, bald eagles begin nesting in March, hatching occurs in April and May, and young may remain near the nest site throughout the summer (Isaacs et al. 1983). Many eagles that breed in western Canada and Alaska migrate to southern areas during winter (Young 1983).

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However, in areas where food is available, adult bald eagles may winter near nests (Sherrod et al. 1976, Frenzel 1984, Swenson et al. 1986). The size and shape of bald eagle territories probably are functions of the availability of food and suitable habitat, proximity of adjacent pairs, and time of year (Stalmaster et al. 1985).

We found little information on the amount of area necessary to satisfy habitat requirements for a pair of breeding bald eagles, particularly in locations of intense human development. The home range of eagle pairs has been estimated roughly by measuring distances between active nests (Grier 1969, Corr 1974). However, a quantitative estimate of home-range size and delineation of high-use areas within the home range are necessary to manage nesting and foraging habitat and provide for recovery of the species (U.S. Fish and Wildl. Serv. 1986). Identifying key habitat features within the home range that may be crucial to longterm site viability also is critical for habitat management. Herein, we describe home-range size, areas of intensive use, and habitat selection of bald eagles in the Columbia River estuary (CRE), an area in Oregon and Washington heavily impacted by human development.

This investigation was conducted under the auspices of the Oregon Cooperative Wildlife Research Unit; Oregon State University, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating. The project was funded by the U.S. Army Corps of Engineers through Contract #DACW57-84-C-0071. Special thanks to D. P. Anderson, G. L. Dorsey, R. W. Frenzel, F. B. Isaacs, K. McGarigal, D. A. Wright, and T. Zimmerman for contributing to the success of this project.

STUDY AREA

Our study area included approximately 800 km^2 of the CRE and adjacent upland habitat, extending from the Pacific Ocean to Longview, Washington (Fig. 1). Clear-cutting has depleted most upland old-growth forests, except for isolated patches of mature timber along a narrow riparian zone. Most upland forest consisted of young to mature Douglas-fir (*Pseudotsuga menziesii*) and young western hemlock (*Tsuga heterophylla*). Mature stands of red alder (*Alnus rubra*) occurred in patches. Remnant old growth has been preserved primarily for known bald eagle nests on private land and in 2 Washington state parks. Diking and landfills have converted much of the previously forested and wetland areas to agricultural lands or small industry.

Wetlands of the CRE consisted of intertidal mud and sand flats, and brackish and freshwater marshes associated with river islands. Natural islands were dominated by Sitka spruce (*Picea sitchensis*), black cottonwood (*Populus trichocarpa*), red alder, and willow (*Salix* sp.). Vegetation on dredge-material islands of the Columbia River consisted mostly of sedge (*Carex* spp.), creeping bentgrass (*Agrostis alba*), fescue (*Festuca* spp.), red alder, cottonwood, and willow.

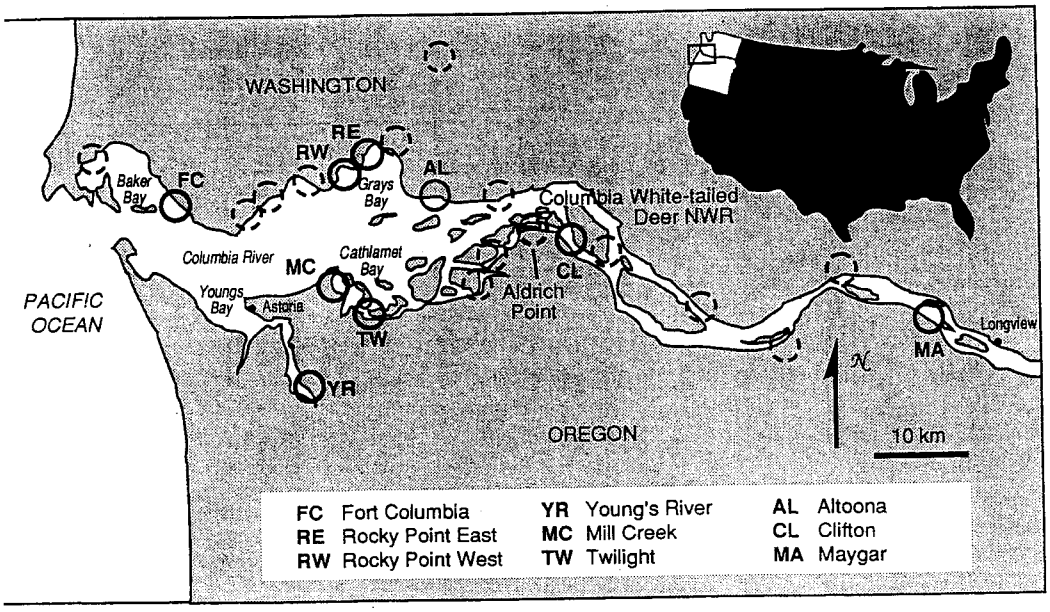
METHODS

Distributional Surveys

We conducted aerial and boat surveys to collect data on distribution and habitat use of bald eagles. Systematic, low-altitude flights by fixed-wing aircraft were conducted once a month from April through November 1985 and twice a month during the winter months of 1985 and 1986. Surveys included all nest sites, intertidal marshes and mudflats, islands, and adjacent uplands within 100 m of the shoreline. We plotted locations of eagles on aerial photographs and recorded perching habitat for each location based on habitat types similar to Franklin and Dyrness (1973). Eagles without completely white head and tail were classified as subadults (Postupalsky 1974).

Resident Adults

We captured 4 adult bald eagles from 4 different nest territories using floating fish on open water (Frenzel and Anthony 1982). We attached 65-g radio transmitters (164.1–164.7 MHz) dorsally on the eagles with a 1-cm-wide teflon ribbon harness. Nine resident pairs of eagles were monitored in 8-hour bouts 4–6 times/month during 1-year periods from July 1984 to April 1986, which comprised 3,845 hours of eagle observation. We scheduled observation bouts to correspond with peak activity periods (e.g., early morning, late afternoon). We were able to locate eagles without transmitters, because resident adults habitually use the same perches within their territories (Stalmaster et al. 1985). We were able to follow eagles continually throughout the bouts because the CRE provided an expansive view for observing birds in flight, and resident pairs rarely flew inland.



. 1. Columbia River study area with circled locations of bald eagle territories, 1986. Solid circles denote resident pairs that re intensively monitored in our study.

We observed the eagles from an outboard otorboat or a truck, depending on site accesility. Locations of perches and foraging atmpts were plotted on 1:12,000 aerial photoaphs and transposed onto 1:24,000 USGS pographic maps for determination of Univerl Transverse Mercator (UTM) coordinates. dditional data recorded included weather, tide vel, habitat type, and species of perch tree.

ata Analysis

We partitioned locational data of resident eaes into breeding (Mar–Aug) and nonbreeding ep–Feb) periods to depict home range variion throughout the year. Locations for both ale and female of each pair were pooled beuse their use of home range was similar in evious studies in this area (J. W. Watson and . G. Anthony, Oreg. State Univ., unpubl. data). ome ranges were estimated by the harmonic ean method (Dixon and Chapman 1980) using e computer program MCPAAL (Stuwe and lowhowiak 1986). We excluded consecutive lentical locations from the analysis to reduce e possibility of dependent observations (Swiart and Slade 1985).

We defined home range as the area that inluded 95% of all locational data of a pair of esident eagles. We defined the territory as the rea(s) within the home range actively defended from conspecifics and used for nesting and foraging. High-use areas were specific areas within the territory that included key habitat features such as nest trees, favored hunting perches, and foraging areas. For example, the Rocky Point East pair defended from conspecifics the area within the 75% harmonic mean contour (the territory), although they used all the area within the 95% contour (the home-range boundary). The 50 and 25% contours (high-use areas) included key hunting perches, foraging areas, and the nest tree (Fig. 2).

Habitat selection was based on perch locations. Although birds may perch in 1 habitat while using another (e.g., hunting mudflats while perching in riparian habitat), accessibility to prey is largely dependent on available perches. Furthermore, perch habitat may be required for other important functions, such as territorial advertisement and display for potential mates (Fraser 1981). We compared eagle perch locations to random points located on aerial photographs, following the procedure by Marcum and Loftsgaarden (1980). The 95% harmonic mean contour was used to delineate available habitats for resident pairs, and all the area covered during aerial surveys was considered available for the entire population (territorial residents and migrants during the winter). For the entire population, we partitioned data from ae-

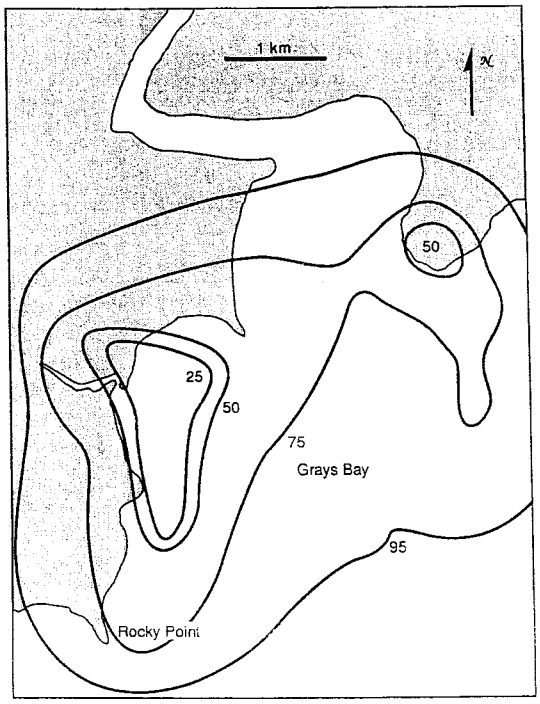


Fig. 2. Home range of the Rocky Point East resident pair of bald eagles, Columbia River estuary. Contours (25–95) delineate areas of decreasing intensity of use for the nonbreeding period, 1985–86.

Table 1. Mean size of home ranges (km²) of resident bald eagles on the Columbia River estuary, 1984–86.

Period[b]	n	Harmonic contours mean[a] 25	50	75	95	Shoreline length (km)
Breeding	9	0.4	1.3	4.5	21.7	5.6
Nonbreeding	9	0.3	1.1	3.5	21.5	6.5
Total mean	9	0.3	1.1	4.0	21.6	6.1

[a] Areas based on percentages of the utilization distribution (25–95) according to Dixon and Chapman (1980).
[b] Breeding period and nonbreeding periods were March–August and September–February, respectively.

rial surveys into low and high tide periods because available habitat was influenced by tide level. Simultaneous confidence intervals were constructed using the Bonferroni approach (Mendenhall 1971) to determine habitat selection. We analyzed habitat-use data using Chi-square goodness-of-fit and contingency tables. The level of significance used in all tests was 0.05.

RESULTS

There were 22 occupied bald eagle territories on the CRE during the period of study; 10 of 14 territories were occupied along the Oregon shoreline, and all 12 territories were occupied along the Washington side of the river (Fig. 1).

Home Range Size of Resident Pairs

Mean home range size (measured within the 95% contour) of eagle pairs (n = 9) was 21.7 and 21.5 km² for the breeding and nonbreeding periods, respectively (Table 1). There was considerable variability between pairs and time periods (range = 5.9–47.3 km²); 4 pairs had larger home ranges during the breeding period, but 4 other pairs used larger areas during the nonbreeding period. Areas of highest use within the home range (measured within the 25% contour) averaged 0.4 and 0.3 km² (range = 0.1–1.0 km²) for the breeding and nonbreeding periods, respectively. Intermediate high-use areas (50–75% contours) were also similar in size year-round (Table 1). Non-resident adults were not observed within the 25% contour of a resident's home range; when territorial defense was observed, it usually conformed to the 50 or 75% contours. Mean shoreline length within home ranges was 5.6 km (SE = 1.95; range = 3.2–8.7 km) during the breeding period and 6.5 km (SE = 1.15; range = 5.1–8.3 km) during the nonbreeding period.

Locations of high-use areas varied with season and year, depending on the pair. Some pairs utilized high-use areas near the nest year-round; whereas others utilized more distant perches and foraging areas during the nonbreeding period. Use of an alternate nest (i.e., a nest tree different from the previous year) also resulted in annual shifts in high-use areas. For example, when the Altoona pair moved their breeding activities to a different nest tree from 1985 to 1986, there was a corresponding shift of utilization contours within their home range west along the shoreline and in their foraging area on the adjacent river island.

Observation of resident pairs indicated that most birds remained near their nest territories year-round. However, resident adults were occasionally absent during the summer 1985. This may be attributed to our inability to locate some eagles during aerial surveys, but temporary excursions from the home range were documented by 3 of the 4 resident eagles equipped with transmitters. These absences were generally <2 weeks and associated with the exploitation of seasonal foraging opportunities (e.g., migratory waterfowl and spawning salmonids) during late

Table 2. Selection of perching habitat by resident bald eagles (n = 9 pairs) observed during breeding (n = 1,987 observations) and nonbreeding (n = 1,584) seasons, Columbia River estuary, 1984–86.

Habitat	Breeding (proportion)				Nonbreeding (proportion)			
	Exp.	Obs.	90% SCI[a]	Sig.[b]	Exp.	Obs.	90% SCI	Sig.
Old-growth conifer	0.02	0.07	−0.07, −0.03	1	0.03	0.09	−0.08, −0.04	1
O-G conifer/broadleaf	0.02	0.27	−0.28, −0.22	1	0.02	0.21	−0.22, −0.16	1
Mature conifer	0.01	0.01	−0.01, 0.01	2	0.01	0.09	−0.10, −0.06	1
Mature conifer/broadleaf	0.20	0.30	−0.14, −0.06	1	0.29	0.38	−0.13, −0.05	1
Young conifer/broadleaf	0.14	0.01	0.11, 0.15	3	0.25	0.00	0.23, 0.27	3
Bottomland broadleaf	0.02	0.04	−0.03, 0.01	1	0.03	0.01	−0.03, 0.01	2
Upland broadleaf	0.01	0.01	−0.01, 0.01	2	0.01	0.01	−0.01, 0.01	2
Tidal flat	0.30	0.23	0.03, 0.11	3	0.06	0.12	−0.09, −0.03	1
Tidal marsh	0.05	0.02	0.01, 0.04	3	0.05	0.02	0.01, 0.05	3
Clear-cut	0.04	0.00	0.03, 0.05	3	0.05	0.00	0.04, 0.06	3
Shrub	0.04	0.02	0.01, 0.03	3	0.04	0.02	0.01, 0.03	3
Herbaceous	0.08	0.00	0.06, 0.10	3	0.09	0.00	0.08, 0.09	3
Pasture	0.03	0.01	0.01, 0.03	3	0.03	0.01	0.01, 0.03	3
Residential	0.01	0.00	0.00, 0.02	2	0.01	0.00	0.00, 0.02	2
Other[c]	0.02	0.01	0.00, 0.02	2	0.03	0.01	0.01, 0.03	3
All	0.99	1.01			1.00	0.99		

[a] Simultaneous confidence interval for difference in expected and observed proportions.
[b] Significance; 1 = use greater than expected, end points of confidence interval negative; 2 = use as expected, confidence interval contains zero; 3 = use less than expected, end points of confidence interval positive; Marcum and Loftsgaarden 1980.
[c] Habitats comprising <1% of use and availability; includes dry sand, commercial, and industrial areas.

summer and autumn. However, 1 female moved 50 km north of the study area following an unsuccessful nesting attempt in 1985. Her radio signal was not relocated until late winter 1986, but she had been replaced by another adult female at the nest territory.

Distribution and Habitat Selection

The distribution of the eagle population was similar year-round and concentrated in an area from approximately Grays and Cathlamet Bays upstream to the Columbia White-tailed Deer National Wildlife Refuge (Fig. 1). We counted 67% (n = 862) of the total eagle observations from surveys in this area that comprised only 36% (287 km^2) of the study area. Twelve resident pairs of adults (57% of active nest territories) also were located in this area (χ^2 = 3.14, 0.05 < P < 0.10). Mean minimum distance between active nests (1984–86) was 4.7 km (SE = 3.0, n = 17) in this area; whereas mean distance was 7.1 km (SE = 4.4, n = 41) for the entire study area.

Resident Adults.—Eagle nest territories on the CRE were adjacent to the river, and all nest trees were within 1.6 km of water. Territories were in mixed-mature and old-growth Douglas-fir/western hemlock forests. Ninety-four percent of the nest trees were alive; species used were Sitka spruce (n = 17), Douglas-fir (n = 14), western hemlock (n = 2), and cottonwood (n = 2). Nests generally were constructed on stout branches within 8 m of the top of dominant trees. Twenty (77%) territories, including unoccupied historic sites, contained >1 nest tree; use of alternate nests occurred at 14 (54%) active sites during the 3 years of study.

Habitat selection was determined from 3,571 perch locations recorded during observation bouts. Perch habitats were not used according to their availability during the breeding (χ^2 = 1,223.1, P < 0.001) and nonbreeding (χ^2 = 1,326.3, P < 0.001) seasons (Table 2). Old growth, mixed-mature stands, and bottomland broadleaf habitats on river islands were selected during the breeding period. Tidal flats did not appear to be selected, perhaps due to their high availability during spring and summer. However, use of tidal flats for perching was high, exceeded only by mature and old-growth forest where nesting activities were centered. Tidal marshes were infrequently used for perching, but eagles often were observed hunting in flight in this habitat. During the nonbreeding period, tidal flats and mature and old-growth forests were selected. Home ranges of resident bald eagles did not include highly developed areas (commercial, residential, and industrial).

Total Population.—Habitat use by all eagles along the CRE was determined from 1,109 perch locations recorded during aerial and boat surveys. Habitats were not used in proportion to

Table 3. Selection of perching habitat by resident and nonresident bald eagles observed at high (n = 376 observations) and low (n = 733) tides, Columbia River estuary, 1984–86.

Habitat	High tide (proportion)				Low tide (proportion)			
	Exp.	Obs.	90% SCI[a]	Sig.[b]	Exp.	Obs.	90% SCI	Sig.
Old-growth conifer	0.01	0.07	−0.08, −0.02	1	0.01	0.05	−0.06, −0.02	1
O-G conifer/broadleaf	0.02	0.16	−0.18, −0.08	1	0.01	0.10	−0.12, −0.06	1
Mature conifer	0.01	0.15	−0.18, −0.08	1	0.02	0.09	−0.10, −0.04	1
Bottomland broadleaf	0.08	0.15	−0.11, −0.01	1	0.05	0.13	−0.12, −0.04	1
Mature conifer/broadleaf	0.20	0.18	−0.05, 0.09	2	0.12	0.10	−0.02, 0.06	2
Young conifer/broadleaf	0.03	0.01	0.00, 0.05	2	0.02	0.02	−0.02, 0.02	2
Dry sand	0.01	0.02	−0.03, 0.01	2	0.02	0.03	−0.03, 0.01	2
Tidal flat	0.03	0.03	−0.03, 0.03	2	0.41	0.23	0.13, 0.25	3
Tidal marsh	0.16	0.05	0.06, 0.05	3	0.10	0.10	−0.03, 0.05	2
Shrub	0.14	0.05	0.04, 0.14	3	0.09	0.06	0.00, 0.06	2
Herbaceous	0.11	0.02	0.05, 0.13	3	0.07	0.01	0.04, 0.08	3
Other[c]	0.19	0.11	0.02, 0.14	3	0.08	0.09	−0.04, 0.02	2
All	0.99	1.00			1.00	1.01		

[a] Simultaneous confidence interval for difference in expected and observed proportions.
[b] Significance; 1 = use greater than expected, end points of confidence interval negative; 2 = use as expected, confidence interval contains zero; 3 = use less than expected, end points of confidence interval positive; Marcum and Loftsgaarden 1980.
[c] Habitats that contained fewer than 5 eagle locations; includes young conifer, upland broadleaf, clearcuts, residential, commercial, and industrial areas.

their availability during low (χ^2 = 284.7, P < 0.001) and high (χ^2 = 301.0, P < 0.001) tides (Table 3). Selected habitats during low and high tides included mature conifer and old-growth forests, which were used for nesting and hunting from shoreline perches. Bottomland broadleaf trees on river islands were used for hunting perches during both low and high tides. Although tidal flats were used less than their availability during low tide, actual use (proportion of total observations) was greater than for habitats that were selected (Fig. 3).

DISCUSSION

Home Range of Resident Pairs

The area used by breeding pairs may vary between geographic locations, depending on time of year, population density, regional differences in food availability, juxtaposition of neighboring pairs, and habitat suitability (Newton 1979:41–42). In the CRE, mean home-range size of 22 km² (radius = 2.6 km) and minimum distance between active nests of 7.1 km is larger than that previously reported for bald eagles. Frenzel (1984) reported mean home-range size of approximately 6.6 km² and mean distance between active nests of 3.2 km for bald eagles nesting on Upper Klamath Lake in southcentral Oregon. Gerrard et al. (1983) found home ranges of 10–15 km² on freshwater lakes in Saskatchewan.

In northcentral Minnesota, Mahaffy and Frenzel (1987) found that a territorial response to eagle decoys was elicited at 0.6 km from the nesting pair. This is within our estimates of defended high-use areas (50% contour) of 0.2–4.2 km². Because of differences in methods, the size of defended areas found in our study cannot be compared with territories of earlier studies, which reported an average radius of 1.6–2.0 km (Corr 1974) or territory size of 1.5–6.0 km² (Gerrard et al. 1983).

Distribution and Habitat Selection

The selection of breeding sites and the distribution of bald eagles on the wintering grounds is largely affected by the availability of prey (Swensen et al. 1986, Watson et al. 1991, Young 1983). The area of highest use in this study (Grays Bay to the Columbia White-tailed Deer National Wildlife Refuge; Fig. 1) was physically and biologically the most diverse area of the CRE, characterized by shallow water and abundant intertidal marshes. Watson et al. (1991) identified scavenging and foraging in water <4 m deep as important foraging techniques by eagles. Scavenging may be particularly important for subadults that are less successful predators and depend on carrion more than adults (Sherrod et al. 1976, Stalmaster and Gessaman 1984).

A common characteristic of eagle high-use areas in the CRE was shoreline habitat with large perch trees that offered an unobstructed view of foraging areas. Physical characteristics of shoreline habitat such as trees with stout

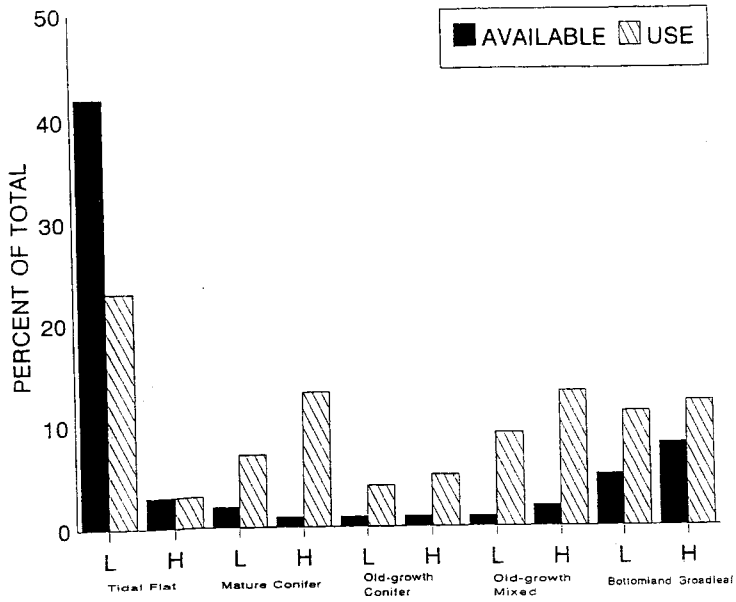


Fig. 3. Percent habitat availability of, and use by, resident and nonresident bald eagles during low (L) and high (H) tide, Columbia River estuary, 1984–86.

branches and open structure seemed more important than tree species. These tree characteristics were typical of riparian zones that provided snags and decadent trees with large, high limbs. Our findings are consistent with other studies that found visibility and proximity to food critical in perch selection (Stalmaster 1976, Swenson et al. 1986). Lower perches were used in open areas if food was abundant. Use of pilings and ground-perching was common in the CRE. Knight et al. (1979) reported that eagles will perch on open ground when food is available.

We identified 3 habitat types important to eagles. Old-growth and mature stands of conifers were selected for nesting by resident pairs and used for foraging, roosting, and perching by the entire population. Most territories in the CRE were located in remnant patches of riparian old growth. Mean height and DBH of nest trees were consistent with those found in western Oregon and typify old-growth structure selected by bald eagles (Anthony and Isaacs 1989). Livingston et al. (1990) found bald eagle nests in Maine were negatively associated with timber harvests, and clear-cut practices were detrimental to eagle habitat use. Mean productivity of bald eagles in Oregon was lower at sites altered by logging compared with unaltered sites (Anthony and Isaacs 1989). Bottomland hardwood habitat, consisting primarily of black cottonwoods on river islands, was used extensively for hunting perches by the entire eagle population in the CRE, and by resident adults during the breeding period. Two breeding pairs used this habitat for nesting. Tidal flats, typically hunted from island and shoreline perches, were the principal foraging habitat for bald eagles in the CRE. They were selected by resident adults during the nonbreeding period but appeared to be avoided during the breeding period. This apparent avoidance resulted from lower-than-average low tides prevalent during the breeding period, which greatly increased the availability of tidal flats. However, use of tidal flats was greater than that of selected habitats (e.g., old growth and bottomland broadleaf). Watson et al. (1991) reported a higher frequency of predation attempts during low tide in the CRE due to increased foraging opportunities associated with shallow water over tidal flats.

MANAGEMENT IMPLICATIONS

Management of bald eagles is challenging due to the dynamic nature of the animal and the effect of human activity on its behavior and habitat. Areas of greatest use within the home range of nesting pairs may vary between seasons

and years, and habitats that provide essential life requisites (tidal flats, riparian areas, and old growth) have been adversely affected by human activity in the past. Only careful planning by land and resource managers can provide for the future welfare of bald eagles.

Achieving the recovery goal of increasing the number of nesting pairs in the 7-state Pacific recovery area will require the protection of existing habitat for breeding and wintering eagles, and recovering habitat lost due to human development and modification (U.S. Fish and Wildl. Serv. 1986). In areas such as the CRE, where eagles are year-round residents, eagle habitat may be best managed as a nesting region (Stalmaster et al. 1985). This consists of planning for all territorial pairs within a geographic area to ensure adequate habitat for present and future populations. This may be accomplished through the preparation of site-specific management plans for existing territories, based on observations of individual pairs (Mathisen et al. 1977, this study). Characteristics of high-use areas identify features of importance and provide criteria for managers to restore habitat for future use. Ascertaining the typical home range size within the region will assist managers in planning for additional pairs. Data from our study suggest the home range size (22 km^2) that may be required by future pairs of breeding eagles in the CRE.

Few old-growth forests remain in the conterminous United States; this habitat has been eliminated along most of the CRE and other parts of the Pacific Northwest. Most private land along the CRE is clear-cut or in early seral stages and was rarely used by eagles in our study. Long-term management of upland habitat should include timber practices that will both achieve economic objectives and maintain suitable habitat for eagles (i.e., old growth). When preparing nest site management plans, wildlife easements or other incentives may encourage landowners to exercise responsible timber harvest practices.

Tidal flats were used heavily by bald eagles in our study. Dredging and filling activities should be discouraged near known nest territories, or if dredging is necessary, restricted to times of low eagle activity. Deposition of dredge material may positively affect eagle habitat if placement can increase existing tidal flats, thereby enhancing foraging opportunities. Delineation of high-use areas in the region can promote cooperative planning by resource managers.

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Received 30 April 1991.
Accepted 13 July 1992.
Associate Editor: Mannan.

CALL-RESPONSE SURVEYS FOR MONITORING BREEDING WATERBIRDS

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Abstract: We broadcast vocalizations of pied-billed grebe (*Podilymbus podiceps*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), Virginia rail (*Rallus limicola*), and sora (*Porzana carolina*) to derive a standardized method to monitor breeding populations of these secretive waterbirds. Broadcast of tape-recorded calls at 60 wetlands in Maine improved species detectability by 93–1, 320% over passive observation. Detection rates at wetlands where target species were known to occur ranged between 0.56 (least bittern) and 0.86 (pied-billed grebe) per survey visit. Three visits to a wetland were adequate to determine the presence or absence of all species with 90% certainty. Least bitterns, soras, and Virginia rails were detected primarily within 50 m of observers; pied-billed grebes and American bitterns were detected up to 500 m distant. Most responses were aural. Responsiveness of each species varied nonsystematically in relation to seasonal chronology, time of day, wind, precipitation, and cloud cover. Single, annual surveys at a stratified random sample of wetlands (i.e., waterbird "miniroutes") can generate sufficient encounter rates for these species to monitor population trends.

J. WILDL. MANAGE. 57(1):27–34

Secretive waterbirds vocalize infrequently and their habitats are localized and inaccessible to most observers (Bystrak 1981). Consequently, they are undersampled by all large-scale, call-count surveys used to monitor trends of bird populations in North America (Butcher 1989). Anecdotal evidence of declines in numbers of pied-billed grebe, American bittern, and least bittern (Tate 1986), and uncertainty about the status of these species (Gibbs and Melvin 1992*a,b,c*), has highlighted the need to develop monitoring programs for such species. Broadcast

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