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Bald eagles wintering along the Columbia River in southcentral Washington: Factors influencing distribution and characteristics of perch and roost trees

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BALD EAGLES WINTERING ALONG THE COLUMBIA RIVER IN SOUTHCENTRAL WASHINGTON: FACTORS INFLUENCING DISTRIBUTION AND CHARACTERISTICS OF PERCH AND ROOST TREES

By

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ABSTRACT

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Bald Eagles Wintering along the Columbia River in Southcentral Washington: Factors Influencing Distribution and Characteristics of Perch and Roost Trees (58 pp.)

Directors: I. J. Ball and B. Riley McClelland

Bald Eagles (*Haliaeetus leucocephalus*) wintering along the Columbia River in the shrub-steppe ecoregion of southcentral Washington were studied January-March 1986 and October 1986-March 1987. Study objectives were to quantitatively determine the influence of food, perch sites, and human activity on distribution, and to quantify and compare characteristics of perch, roost, and unused trees.

Bald Eagles were nonrandomly distributed in 86 of the 136 1-km segments of the Columbia River between the Tri-Cities and Wanapum Dam. Most eagle observations (504/681 or 74%) occurred on the mid-Hanford Reach (47 river km); 21% were along Priest Rapids Reservoir (28 river km), which was used primarily January-March. Only 35 of 86 km were used frequently ($\bar{x}$ = 20.7 eagles/km); 51 of 86 were used infrequently ($\bar{x}$ = 2.5 eagles/km). Distribution factors in the 86 used km were significantly discriminated from the 50 unused km. Eagle distribution was influenced by human activity (numbers of people, boats, and vehicles) and perch sites (characteristics of islands and riverbanks), but apparently not by the abundance of food [Chinook Salmon (*Oncorhynchus tshawytscha*), American Coots (*Fulica americana*), and waterfowl]. Results of the analysis suggested critical factors were missing, possibly diets, foraging strategies, age-class, social bonding, or historical use-patterns.

Ninety-four percent of the Bald Eagles observed on the mid-Hanford Reach were <300 m from the Columbia River using 10% (217/2241) of the trees >13.0 cm diameter at breast height and 40% (60/152) of the available stands. The same stands were used as both diurnal perches and nocturnal roosts. Only 11 of 69 perch stands had frequent (major) use (70% of perch observations); 3 of 30 roost stands had major, communal use (91% of roost observations). Nearly all tree and stand characteristics were significantly different between used and unused stands, major and minor perches, and major and minor roosts. In general, major perch and roost trees were the tallest, largest in diameter with the most open crowns; they were in the largest, but least dense stands. Additionally, all major perches overlooked consistently used ground perches and primary foraging areas. Most eagles (75%) roosted overnight in 12 of 84 regularly used trees in major roosts; the 12 trees were taller, larger with more open crowns than other trees. Roost stands were larger (area and number of trees) and less dense than all but 1 of the 152 available stands. These stand and tree characteristics of communal roosts may facilitate social interaction among roosting eagles.

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Rex Buck of the Wanapum Tribe lent me a tire iron so I could get home one evening.

Unpublished data or information were freely shared by many biologists: Paul Fielder at Chelan County P.U.D. #1 for Bald Eagle survey data; John Coykendall and Bill Radeke at Columbia National Wildlife Refuge and John Annear at Umatilla National Wildlife Refuge for waterfowl counts; Ron Lavoy at Washington Department of Fisheries for salmon carcass counts; Mike Dell at Grant County P.U.D for dam operations and river flow data, and Eric Anderson at the U.S. Army's Yakima Firing Center for Bald Eagle roosting sites along Priest Rapids Reservoir. I especially thank Al Harmata at Montana State University for enthusiastic discussions about Bald Eagles. At PNL, Dick Fitzner provided previous counts of Bald Eagles, Dennis Dauble and Don Watson shared salmon counts and information, and Les Eberhardt made valuable comments on the study.

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I greatly appreciate the efforts of all people who contributed to my research and professional goals. I consider myself very fortunate to have shared time and space with Bald Eagles.

INTRODUCTION

Washington state has consistently recorded more wintering Bald Eagles (*Haliaeetus leucocephalus*) than any of the other 47 conterminous states: 1126-2509 between 1979 and 1988 (Taylor 1988). Eagles wintering in eastern Washington (22-28%) concentrate along the Columbia River at dam reservoirs or the last "free-flowing" section through the Hanford Reach. Eagles probably move among wintering sites along the Columbia River in response to the changing availability of food; however, human activity and the location of preferred perch trees may also influence distribution (Fielder and Starkey 1987).

In the shrub-steppe ecoregion of southcentral Washington, Bald Eagles winter at two traditional sites: Priest Rapids Reservoir and the Hanford Reach of the Columbia River. Peak counts of 2-10 eagles were noted along Priest Rapids Pool between 1974 and 1984 by Fielder and Starkey (1987). Peak counts along the Hanford Reach have increased from 5 to 34 eagles between 1961-2 and 1984-5 (D. Fitzner, Pacific Northwest Laboratory, pers. comm.). Eagles may be attracted to the Hanford Reach by abundant waterfowl and spawned Chinook Salmon (*Oncorhynchus tshawytscha*), infrequent human activity, and the availability of roost trees (Fitzner and Hanson 1979).

Bald Eagles are federally listed as a threatened species in Washington. Population recovery in southcentral Washington (Columbia River shorelines between the Tri-Cities and Wanapum Dam) may be hindered by loss of perching and roosting habitat, bank erosion and prey decline due to fluctuating water levels, a proposed dam, and human disturbance caused by construction or recreation (U.S. Fish and Wildlife Service 1986). Most perch and roost trees used by eagles in southcentral Washington are senescent, which increases their vulnerability to drought and strong winds. Some trees are also susceptible to bank erosion and damage caused by beavers (*Castor canadensis*) or Great Blue Herons (*Ardea herodias*). Loss of ground perches, increased disturbance by humans, and possible prey declines would result from construction of a hydroelectric dam near Richland, river channelization to accommodate shipping, and/or shoreline acquisition by the U.S. Army's Yakima Firing Center. Although most land along the Columbia River in southcentral Washington is federally owned and public access is prohibited, agricultural and residential development on private land is rapidly invading previously undisturbed shorelines. Recreational activity on the Columbia River itself is expected to continue increasing.

The objectives of this study were as follows:

I. Quantitatively determine the influence of food, perch sites, and human activity on the distribution of Bald Eagles wintering along the Columbia River in southcentral Washington; and

II. Quantify and compare characteristics of unused, perch, and roost trees for Bald Eagles wintering on the Hanford Reach of the Columbia River, Washington

My thesis was written as two professional papers. Chapter I was targeted for the Journal of Raptor Research, and Chapter II for The Northwestern Naturalist.

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CHAPTER I

FACTORS INFLUENCING THE WINTER DISTRIBUTION OF BALD EAGLES ALONG THE COLUMBIA RIVER IN SOUTHCENTRAL WASHINGTON

INTRODUCTION

The distribution of Bald Eagles (*Haliaeetus leucocephalus*) in a wintering area is usually attributed to ephemeral patches of abundant food (Keister 1981, Griffin et al. 1982, Hansen 1986, Fielder and Starkey 1987, Stalmaster 1987). However, human activity and the location of preferred perch trees may also influence distribution (Stalmaster 1976, Steenhof 1976, Keister 1981, Harmata 1984, Fielder and Starkey 1987). When food abundance and human activity are uniformly dispersed, the location of preferred perch trees may be the primary factor influencing eagle distribution (Hansen and Bartelme 1980).

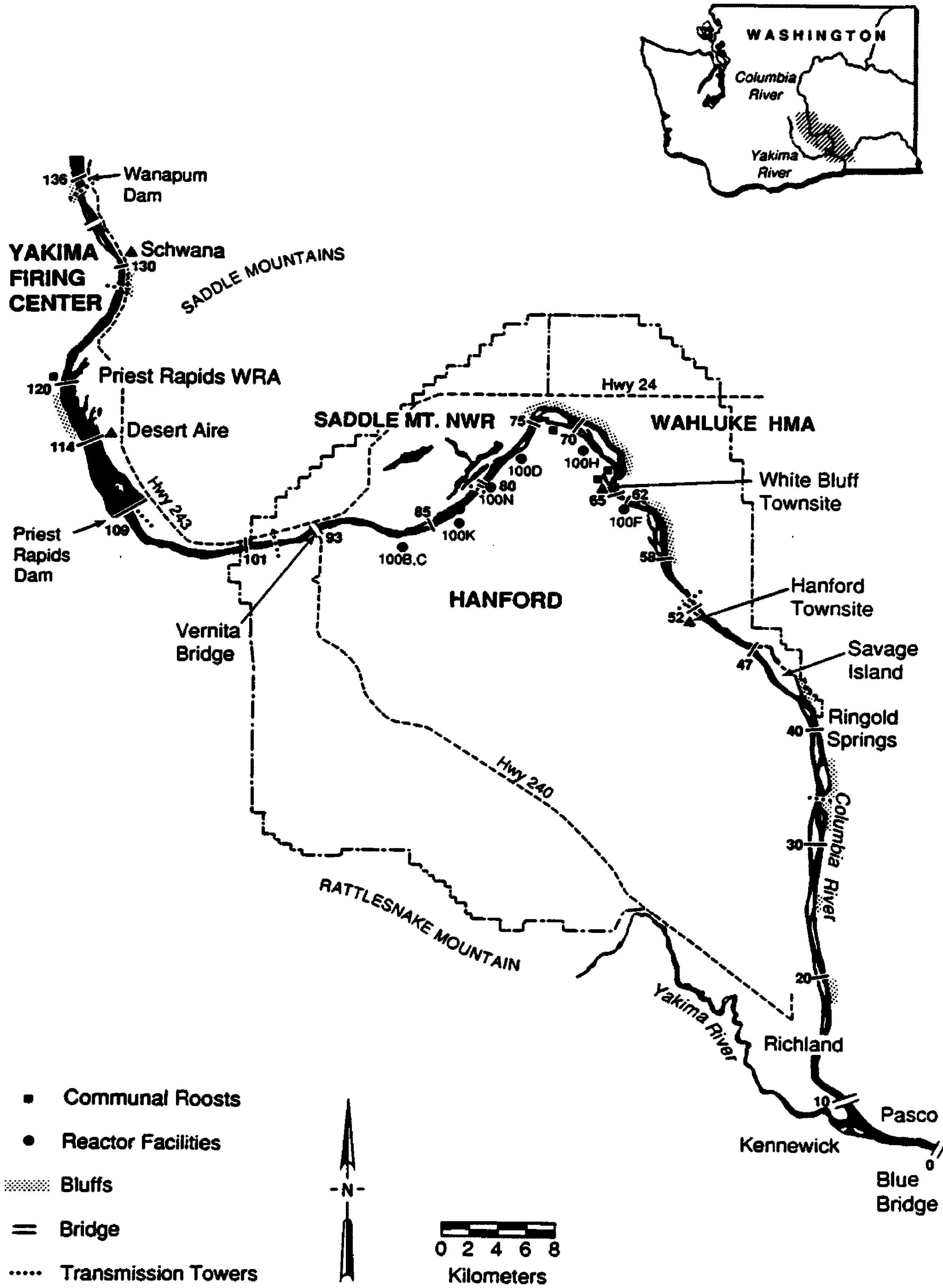
Bald Eagles winter at two traditional sites in the shrub-steppe ecoregion of southcentral Washington: Priest Rapids Pool and the Hanford Reach of the Columbia River. Eagles may be attracted to the Hanford Reach by the abundance of spawned Chinook Salmon (*Oncorhynchus tshawytscha*), wintering waterfowl, infrequent human activity, and the availability of roost trees (Fitzner et al. 1980). My objective was to quantitatively determine the influence of food, perch sites, and human activity on the winter distribution of Bald Eagles along the Columbia River in southcentral Washington.

STUDY AREA

The study area encompassed a 136-km section of the Columbia River between the Tri-Cities (Pasco, Kennewick, and Richland) and Wanapum Dam in southcentral Washington (Fig. 1). This section of the river has two flow regimes: a reservoir upriver from Priest Rapids Dam and a "free-flowing" section downriver. Islands occur as scattered groups. Although 18-171 m bluffs occur in the area, most shorelines and all islands have low relief (1-12 m), and are inundated to various degrees during the daily cycle of power generation at Priest Rapids and other upriver dams. Regularly inundated shorelines are not vegetated, and riparian vegetation is usually sparse. Upland vegetation is shrub-steppe dominated by big sagebrush (*Artemisia tridentata*), bluebunch wheatgrass (*Agropyron spicatum*), and Sandberg's bluegrass (*Poa sandbergii*) (Franklin and Dyrness 1973). Most trees are nonnative and located at inhabited or abandoned farms, towns, and industrial sites.

The Columbia River supports large aggregations of wintering waterfowl (U.S. Fish and Wildlife Service, 1985-

Figure 1. Columbia River study area for Bald Eagles wintering in southcentral Washington. Numbered bars across the Columbia River indicate river kilometer: 1 at the Blue Bridge (Pasco-Kennewick) and 136 at Wanapum Dam.


WASHINGTON
Columbia River
Yakima River
136
Wanapum Dam
YAKIMA FIRING CENTER
Schwana
130
SADDLE MOUNTAINS
120
Priest Rapids WRA
114
Desert Aire
Hwy 243
Priest Rapids Dam
109
101
93
Vernita Bridge
SADDLE MT. NWR
Hwy 24
WAHLUKE HMA
75
70
100D
100H
80
100N
85
100K
100B,C
65
62
100F
White Bluff Townsite
58
HANFORD
52
Hanford Townsite
47
Savage Island
40
Ringold Springs
Hwy 240
Columbia River
30
RATTLESNAKE MOUNTAIN
20
Yakima River
Richland
10
Pasco
Kennewick
0
Blue Bridge
Communal Roosts
Reactor Facilities
Bluffs
Bridge
Transmission Towers
N
0 2 4 6 8
Kilometers

1987 Columbia Basin Waterfowl Counts, unpubl. data) and American Coots (*Fulica americana*). Chinook Salmon (*Oncorhynchus tshawytscha*) spawn naturally in the free-flowing sections of river, primarily at Vernita Bar and near White Bluffs Townsite (Dauble and Watson 1990). Hatchery-reared salmon return to artificial spawning channels located between Vernita Bar and Priest Rapids Dam. The salmon die after spawning, and carcasses are routinely removed from Vernita Bar by a joint-agency team (M. Dell, Public Utility District of Grant County, pers. comm.). However, carcasses downriver from the bar are collected, inventoried, and returned to shorelines where they are readily available to eagles.

Human activity is concentrated at the Tri-Cities, the only major population center (Fig. 1). The small towns of Desert Aire and Schwana are located along Priest Rapids Pool. Public access is prohibited on the federally owned Hanford Site, Yakima Firing Center, and Saddle Mountain National Wildlife Refuge. Human activity on the Hanford Site is confined mostly to reactor or other facilities (Fig. 1), although security and monitoring personnel work along shorelines. Military maneuvers are conducted at the Firing Center. Human activity is intermittent on the agricultural lands between Pasco and Ringold Springs, near Desert Aire, and north of the Yakima Firing Center. Waterfowl hunting (mid-October through mid-January) and sport fishing are common along most shorelines, except between Vernita Bridge and Hanford Townsite where the Columbia River is closed to public recreation 15 October-30 June.

The climate in southcentral Washington is semiarid and winters (November-March) are usually moderate (Stone et al. 1983). Mean annual precipitation is 16.0 cm; snowfall is 3.2 cm. During winter, mean monthly temperatures range between -1.5°C and 7.3°C. The river usually remains ice-free.

METHODS

My study was conducted January-March 1986 and October 1986-April 1987 (1986-7). The Columbia River was mapped into 136 1-km segments (RKMs), each of which included the shoreline area within a 300-m boundary drawn parallel to the river. Five major sections were designated as the Tri-Cities (RKM 1-21), lower Hanford Reach (RKM 22-46), mid-Hanford Reach (RKM 47-92), Vernita (RKM 93-108), and Priest Rapids Pool (RKM 109-136) (see Fig. 1).

Bald Eagles and distribution factors were quantified for each RKM. Food items included accessible salmon carcasses, ducks, Canada Geese (*Branta canadensis*), and coots. Perch sites were characterized by the number of trees ≥13.0 cm diameter at breast height, the area and length of riverbanks and bluffs (a minimum rise of 30 m within 300 horizontal m), and the area and perimeter of islands. Human activity factors were numbers of people, boats, vehicles, small buildings (house-sized or smaller), large buildings, powerline towers, and bridges or dams.

Data Collection

Trees and structures were mapped and counted during a ground survey. Characteristics of islands, riverbanks, and bluffs were measured with a compensating polar planimeter on 7.5-min U.S. Geological Survey maps. All other data were collected during aerial surveys. I mapped and counted eagles, people, boats, vehicles, and salmon carcasses, while a second observer mapped and estimated numbers of ducks, geese, and coots. Eagles were classed as adult (mostly or entirely white heads and tails) or immature, and I noted activity (perched or flying) and perch type (island, riverbank, tree, or bluff). Aerial surveys were conducted at 5-d intervals in a Cessna 172 usually flown at 65 knots and 30 m altitude. Flights started 0.5 h after sunrise and lasted 4 h. Surveys began at the Blue Bridge (RKM 1), followed the eastern shore to Wanapum Dam (RKM 136), and returned along the western shore with one exception: three smaller circles over both shorelines were flown between Hanford Townsite and the 100D area to reduce double counts of eagles. Eagles were also observed daily from the ground.

<u>Data Analysis</u>

Discriminant function analysis (DFA) (SPSSX INC. 1983) was used to segregate factors in used (>0 Bald Eagles) from unused (0 Bald Eagles) RKMs during 1986-7. A DFA case for used RKMs was generated for each eagle observation; only one case/RKM/aerial survey was generated for unused RKMs. The discriminant function was developed using a random selection of cases (50%) and a stepwise entry of variables that maximized the Mahalanobis distance. Variables were retained for analysis when tolerances were <0.10 (Cavallaro et al. 1981), correlations with another variable were <0.50, and univariate probabilities (*P*) were ≤ 0.05 (Edge 1985). The validity of the discriminant function was determined by classifying unselected cases as used or unused RKMs and comparing with *a priori* probabilities (based on sample size).

Tests of independence (*G*) (Sokal and Rohlf 1981) were evaluated with a chi-square distribution (Burington and May 1970) and considered significant at $P \leq 0.05$.

RESULTS

<u>Distribution and Abundance of Bald Eagles</u>

Bald Eagles were observed in the study area from 14 October 1986 to 4 April 1987. A peak count of 60 eagles occurred on 20 December and a minor peak of 46 on 9 February (Fig. 2).

Bald Eagle distribution during 1986-7 was nonrandom: 74% of observations (681) were along the mid-Hanford Reach and 21% along Priest Rapids Pool (Fig. 3). Eagles were sighted at 86 of the 136 RKMs. Frequent sightings (≥5 eagles/RKM, $\bar{x}$ = 20.7) occurred at only 35 of 86 RKMs, whereas infrequent sightings (<5 eagles/RKM, $\bar{x}$ = 2.5) occurred at the remaining RKMs. During early winter (October-December), eagles concentrated at 37 RKMs along the mid-Hanford Reach. After 5 January eagles were also observed consistently along Priest Rapids Pool. Distribution varied by age-class. The overall age ratio (adult:immature) was 43:57 (N = 681), but ratios were 37:63 (N = 505) along the mid-Hanford Reach, 56:44 (N = 145) along Priest Rapids Pool, and 71:29 (N = 31) along the remaining sections. In general, distribution was similar between winters.

Most eagles (92%) were observed perched during aerial surveys: 43% on the ground, 41% on trees, and 8% on bluffs. Ground perches were mainly on islands (63%) rather than riverbanks (37%), but eagles were usually near ($\bar{x}$ = 2.0 m ± 6.9 SD) the river. Eagles were observed on all islands upriver from Ringold Springs. Eagles observed flying (8%) were making short directional flights. Most eagles (736 of 739) and waterfowl were not flushed by our aircraft.

Figure 2. Aerial survey counts of Bald Eagles along the Columbia River in southcentral Washington during the winter of 1986-1987.

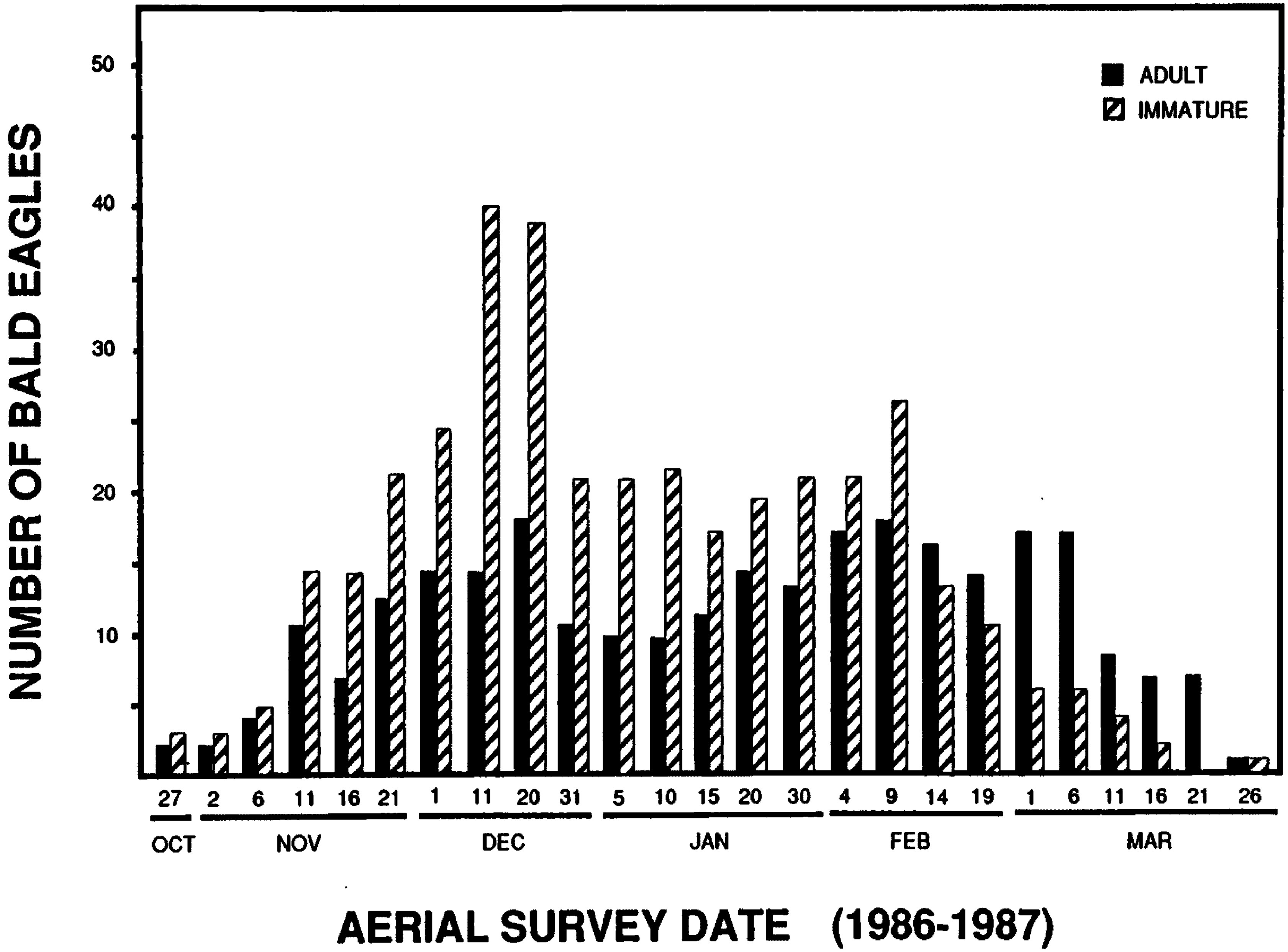
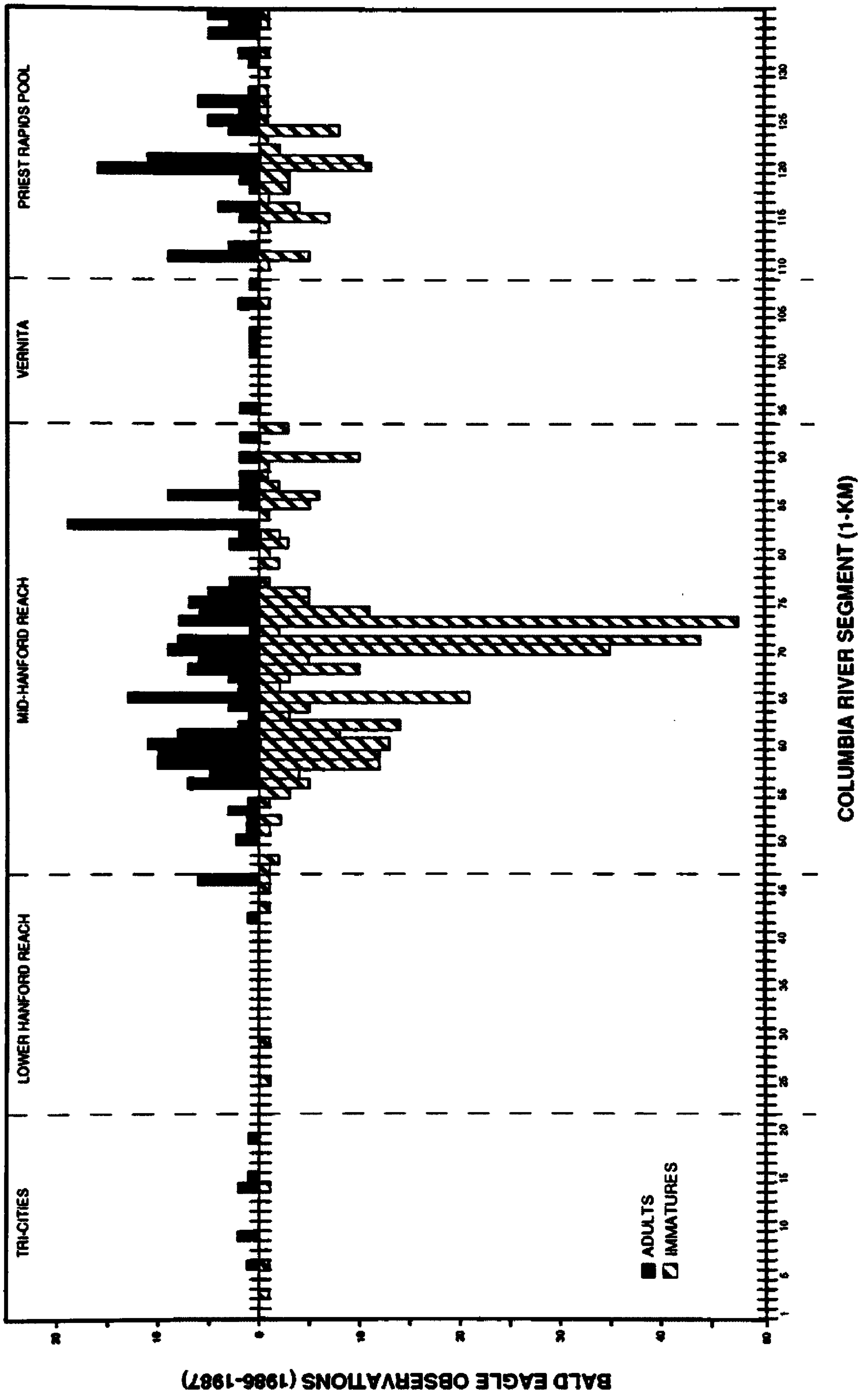

ADULT
IMMATURE
NUMBER OF BALD EAGLES
50
40
30
20
10
27
2
6
11
16
21
1
11
20
31
5
10
15
20
30
4
9
14
19
1
6
11
16
21
26
OCT
NOV
DEC
JAN
FEB
MAR
AERIAL SURVEY DATE (1986-1987)

Figure 3. Bald Eagle observations (*N* = 681) during the winter of 1986-1987 by 1-km segments of the Columbia River between the Tri-Cities and Wanapum Dam, Washington.


TRI-CITIES
LOWER HANFORD REACH
MID-HANFORD REACH
VERNITA
PRIEST RAPIDS POOL
ADULTS
IMMATURES
COLUMBIA RIVER SEGMENT (1-KM)
BALD EAGLE OBSERVATIONS (1986-1987)

During all field work of both winters, I rarely observed soaring (nine instances) or perching on artificial structures (two instances).

Factors Influencing Distribution

Used RKMs were univariately distinguished ($P < 0.03$) from unused RKMs by human activity factors (except large buildings) and perch characteristics (except bluffs) (Table 1). Used RKMs had fewer trees, boats, vehicles, people, medium buildings, powerline towers, and bridges or dams. Used RKMs also had smaller islands and more convoluted riverbank shorelines that resulted in larger areas.

The abundance of food did not differ ($P > 0.22$) between used and unused RKMs, even though prey distributions shifted among RKMs and populations declined through winter. Salmon carcasses were most abundant during early winter from mid-November to 5 January. Decomposing salmon carcasses downriver from Ringold blended with shorelines, and were probably undercounted. Waterfowl, observed along all sections of the river, were most abundant before 20 January; thereafter, mean numbers/RKM/aerial survey declined from 143.0 to 17.1 ducks and from 17.1 to 3.4 geese. Coots were abundant through mid-March along the Tri-Cities, lower Hanford Reach, and Priest Rapids Pool sections. Weak correlations ($r < 0.39$, $P < 0.00001$) were detected only

Table 1. Results of discriminant function analysis for segregation of distribution factors in 86 used and 50 unused 1-km river segments (RKM) by Bald Eagles wintering along the Columbia River: $\bar{x}$ ± SD, univariate probabilities (*P*), and standardized canonical coefficients (Coef). *N* cases = 824 used and 418 unused.

	Used RKM	Unused RKM	*P*	Coef
		VARIABLES INCLUDED IN DFA		
deciduous trees (N)	99.3 ± 147.8	224.1 ± 342.8	<0.001	0.610
island perimeter (m)	770.3 ± 1214.9	1318.1 ± 1584.1	<0.001	0.375
riverbank length (m)	2393.6 ± 840.5	2118.2 ± 454.9	<0.001	-0.362
vehicles (N)	1.8 ± 8.5	10.1 ± 38.2	<0.001	0.342
powerline towers (N)	0.6 ± 2.5	0.9 ± 3.3	<0.001	0.299
boats (N)	0.1 ± 0.4	0.5 ± 3.0	<0.001	0.288
humans (N)	0.5 ± 2.4	0.8 ± 1.9	<0.001	0.170
small buildings (N)	7.4 ± 25.5	16.4 ± 27.1	<0.001	
bridges and dams (N)	0.1 ± 0.3	0.1 ± 0.3	<0.029	
		VARIABLES OMITTED FROM DFA: >0.5 CORRELATION WITH ANOTHER VARIABLE		
coniferous trees (N)	8.8 ± 34.2	35.9 ± 69.8	<0.001	
island area (m^2)	79.8 ± 154.5	118.2 ± 151.6	<0.001	
riverbank area (m^2)	668.2 ± 209.3	595.6 ± 132.6	<0.001	
		VARIABLES OMITTED FROM DFA: *P* > 0.05		
large buildings (N)	0.7 ± 2.8	0.9 ± 2.3	>0.069	
salmon carcasses (N)	0.6 ± 4.1	0.9 ± 6.2	>0.218	
bluff area (m^2)	24.0 ± 45.4	25.3 ± 43.3	>0.623	
ducks (N)	68.2 ± 246.4	75.2 ± 238.9	>0.632	
geese (N)	9.7 ± 57.5	8.5 ± 42.0	>0.698	
coots (N)	11.3 ± 56.1	11.9 ± 38.6	>0.832	
bluff length (m)	223.2 ± 431.8	219.5 ± 383.1	>0.882	

between numbers of immature eagles and salmon carcasses or ducks.

DFA segregated ($F = 0.87$, df = 7,2342, $P < 0.0001$) used from unused RKMs. Discriminating variables were boats, vehicles, medium structures, towers, riverbank length, island perimeter, and deciduous trees. DFA correctly classified 96% of the unselected cases as used (*a priori* probability = 0.69), but only 22% as unused (*a priori* probability = 0.31). The discriminant function was moderately linear ($r = 0.36$).

DISCUSSION

Bald Eagle distribution in a wintering area is usually attributed to ephemeral patches of abundant food (Hansen 1986, Stalmaster 1987). However, along the Columbia River in southcentral Washington, eagles were not associated with all patches of abundant salmon carcasses, waterfowl, or coots. Bald Eagle distribution was apparently influenced by human activity and perch sites. Human activity is commonly suggested as a factor affecting distribution (Stalmaster 1976, Steenhof 1976, Fielder and Starkey 1987), but characteristics of ground perches have not been considered. I could not determine the influence of preferred perch trees on eagle distribution (Hansen and Bartelme 1980) because both food and human activity were not uniformly dispersed.

Human Activity

Most Bald Eagles wintered at sites with relatively infrequent human activity. Bald Eagles habituate to routine human activity (Stalmaster 1976, McClelland et al. 1982, Harmata 1984), and may have tolerated the presence of security, environmental, and fisheries personnel on the mid-Hanford Reach. My incidental observations of eagle responses to these personnel indicated that eagles flushed from trees usually reperched on the same tree, and eagles flushed from the ground perched on nearby trees or bluffs.

More human activity occurred along Priest Rapids Pool than along the mid-Hanford Reach. Eagles encountered more vehicular traffic along the pool due to the proximity of a highway, but Stalmaster (1976) and Harmata (1984) noted that eagles generally tolerate moving vehicles. In contrast to eagle responses to human activity on the mid-Hanford Reach, eagles along Priest Rapids Pool temporarily abandoned preferred sites when disturbed by human activity such as army maneuvers.

By selecting secure sites, Bald Eagles minimize disturbance from humans (Stalmaster 1987) and promote foraging efficiency. Knight and Knight (1986) found that more eagles fed on the ground at sites with infrequent disturbance; at sites where the intrusion potential was high (or near vegetation), eagles increased vigilance (head raises/min and total scanning time). Avoidance flights can interrupt feeding from 30 min (Skagen 1980) to 2 h (Stalmaster 1976), and increase energy expenditure (Stalmaster and Gessaman 1984). Bald Eagles may tolerate relatively more human activity when food abundance decreases (Stalmaster 1976, Skagen 1980).

Perch Sites

Bald Eagles may perch at different sites within a wintering area for foraging, feeding, loafing, or roosting (Stalmaster 1976, Fischer 1982), or sheltering from severe weather (Steenhof 1976, Fischer 1982, Griffin et al. 1982). However, in southcentral Washington eagles were observed at the same perch sites during both winters, throughout the day, and during all weather conditions. The relatively mild winters in southcentral Washington may not elicit sheltering responses by eagles. Night roosts (Fig. 1) were located near four of the centrally located complexes.

Specific sites used by eagles were a cluster of closely spaced perches (perch complex). The principal perches within a perch complex were rocks (usually the same rock) on island margins or riverbank peninsulas; these shorelines were flat and not vegetated. Eagles perched on the ground throughout the day. Trees occurred at most complexes, but eagles consistently perched on relatively few trees. Eagles also perched on steep bluffs above complexes, possibly because long-range views were enhanced. All complexes were along shoals where the largest area of riverbed was exposed by the daily decreases in river flows.

<u>Food</u>

Bald Eagles fed on salmon carcasses, ducks, and coots. Large-mammal carrion was usually not available; only one instance of feeding on a mule deer (*Odocoileus hemionus*) carcass was observed. Eagles were not seen foraging on dead or stunned fish immediately below Wanapum or Priest Rapids Dam, unlike observations at Grand Coulee Dam (Wood 1980). Most eagles remained at the same perch complexes after salmon carcasses were consumed. Fitzner et al. (1980) suggested that wounded waterfowl may provide food for eagles after salmon carcasses are depleted. But during this study, waterfowl counts declined rapidly, while eagle counts remained relatively stable.

Scavenging of other aquatic prey by Bald Eagles was probably a prevalent foraging strategy. Scavenging at perch complexes would help explain fidelity to areas along shoals, infrequent soaring, and weak or insignificant correlations with foods. I identified the following food remains at eagle perch-trees: freshwater clams (Pelecypoda), crayfish (*Pacifasticus leniusculus*), salmon, ducks, geese, and Ring-necked Pheasant (*Phasianus colchicus*). Becker et al. (1981) identified crayfish and 14 species of fish stranded and exposed among the sloughs and islands of the Hanford Reach during low river levels.

Age-related Distribution

Adult territoriality during winter (Harmata 1984) and age-related foraging strategies may explain some distributional patterns. At several perch complexes, adults (probably paired) were observed consistently, but neither territorial defense (see Sherrod et al. 1976) nor perch defense (see Harmata 1984) were noted. More adults than immatures were observed capturing ducks and coots. Adults may be more successful at capturing live prey than immatures because of their increased maneuverability (Harmata 1984, Hansen 1986) and skill (Harmata 1984, Bennetts 1986). Bennetts (1986) found that the distribution of Bald Eagles along MacDonald Creek in Glacier National Park could be explained by age-related differences in foraging strategies.

Relative sensitivity to human activity among age-classes is not consistent (Stalmaster 1987). In my study area, adults were associated with more human activity than immatures. Adults may minimize risks by site familiarity developed over successive winters (Harmata 1984), early recognition of danger (Knight and Knight 1983, Harmata 1984), and increased vigilance (Knight and Knight 1986).

Discriminant Function Analysis

Classification functions are not always possible, even when two groups are significantly discriminated, because statistical assumptions are violated or critical information is missing (Johnson and Wichern 1982). My data violated the assumptions of normal distribution and equal covariance matrices, although Johnson (1981) considered DFA relatively insensitive to these violations. Function development was hampered by zero values, which were not entirely correctable by transformations (J. Simpson, Pacific Northwest Laboratory, pers. comm.).

Predictive failure for only unused RKMs suggested that critical data were missing. Distribution may also be related to historical use-patterns, diets, communal behavior during winter (Young 1983, Stalmaster 1987), or attraction to feeding conspecifics (Knight and Knight 1983). Thus, the winter distribution of Bald Eagles in southcentral Washington appeared to be influenced by age-related and social factors in addition to human activity and perch characteristics.

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CHAPTER II

CHARACTERISTICS OF PERCH AND ROOST TREES USED BY BALD EAGLES WINTERING ON THE HANFORD REACH OF THE COLUMBIA RIVER, WASHINGTON

INTRODUCTION

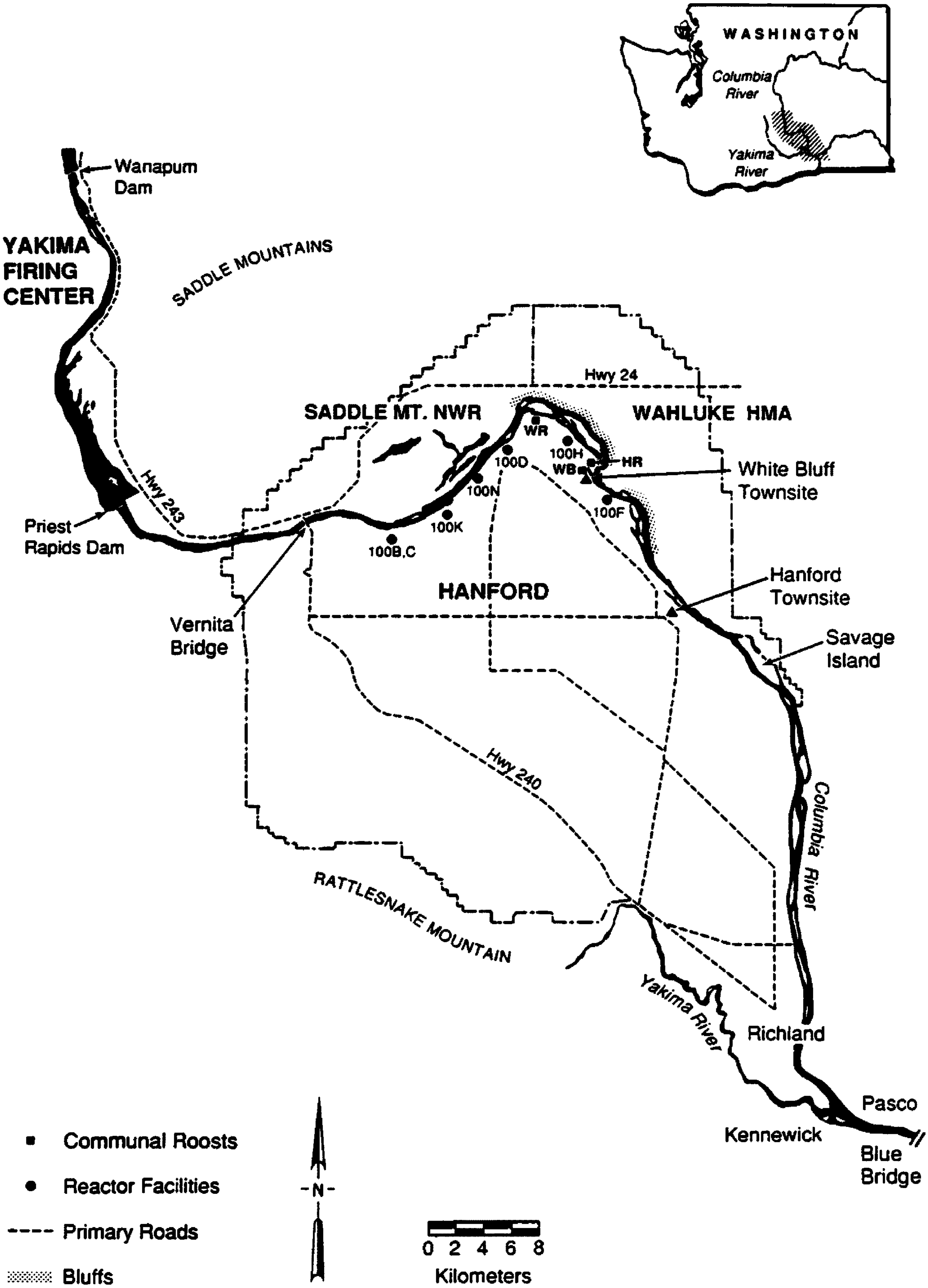
Bald Eagles (*Haliaeetus leucocephalus*) wintering on the Hanford Reach of the Columbia River in the shrub-steppe ecoregion of southcentral Washington use nonnative trees for perching and roosting. The Hanford Reach is a traditional wintering area (Fitzner and Hansen 1979), but characteristics of trees have not been quantified. The loss of perching and roosting habitat in southcentral Washington is listed as a primary threat to the recovery of Bald Eagles from a threatened status (U.S. Fish and Wildlife 1986). My objective was to quantify and compare characteristics of perch, roost, and unused trees for Bald Eagles wintering on the Hanford Reach.

STUDY AREA

The study area encompassed a 45-km segment of the Columbia River between Savage Island and Vernita Bridge in southcentral Washington (Fig. 1). Native vegetation has been described by Franklin and Dyrness (1973). The riparian zone is generally herbaceous, although shrubby trees, such as willow (*Salix* spp.), Rocky Mountain juniper (*Juniperus scopulorum*), and mulberry (*Morus* spp.) occur sporadically. Most trees are deciduous ornamental or fruit trees that were planted in isolated stands away from the river at now abandoned homesteads and the townsites of Hanford and White Bluffs (Fig. 1). Tree maintenance and irrigation ended when the government purchased the Hanford Site in 1943 (Rickard and Watson 1985).

Public access is prohibited on the federally owned Hanford Site and Saddle Mountain National Wildlife Refuge; most human activity along these shorelines is concentrated at nuclear reactor facilities (Fig. 1). All reactors, except 100N, are deactivated. Public recreation and intermittent cattle grazing occur along shorelines of the state managed Wahluke Habitat Management Area. The Columbia River, between Hanford Townsite and Vernita Bridge, is closed to waterfowl hunting and sport fishing 15 October-30 June.

Figure 1. Study area (Savage Island to Vernita Bridge) for Bald Eagles on the Hanford Reach of the Columbia River during the winters of 1986 and 1986-1987.



WASHINGTON
Columbia River
Yakima River
Wanapum Dam
YAKIMA FIRING CENTER
SADDLE MOUNTAINS
Hwy 24
SADDLE MT. NWR
WAHLUKE HMA
WR
100H
100D
WB
HR
White Bluff Townsite
100N
100F
100K
Hwy 243
Priest Rapids Dam
100B,C
HANFORD
Hanford Townsite
Vernita Bridge
Savage Island
Hwy 240
Columbia River
RATTLESNAKE MOUNTAIN
Yakima River
Richland
Pasco
Kennewick
Blue Bridge
Communal Roosts
Reactor Facilities
Primary Roads
Bluffs
N
0 2 4 6 8
Kilometers

METHODS

Tree Use

Bald Eagles were observed January-March 1986 and October 1986-April 1987. Perch trees (diurnal use) were identified during ground surveys (4 of every 5 d) and aerial surveys (1 of every 5 d). Aerial surveys were conducted along shorelines in a Cessna 172 flying at 65 knots and 30 m altitude. Traditional roosts (Fitzner and Hanson 1979) and new roost sites were located during ground and aerial surveys. Roost trees (nocturnal use) were identified during late-evening ground surveys (2 of every 5 d) and during behavioral observations at 3 roosts (3 of every 5 d). I classified stands based on time of use and total eagle observations: 1-19 as minor perches, 20-128 as major perches, 1-88 as minor roosts, and 695-931 as major (communal) roosts.

Tree Characteristics

Trees were defined as woody stems >3.0 cm diameter at breast height (dbh). Trees ≥13.0 cm dbh were considered available for eagle use. Stands were >1 tree with every tree <50 m from another. All trees <300 m from the Columbia River or ≥300 m and used by eagles were numbered and mapped by stand. Tree characteristics included stand, structural, locational, and human activity variables (Table 1). Stand area was calculated from the paced length and width. Stand

Table 1. Variables used to characterize used and unused trees by Bald Eagles on the Hanford Reach during the winters of 1986 and 1986-1987.

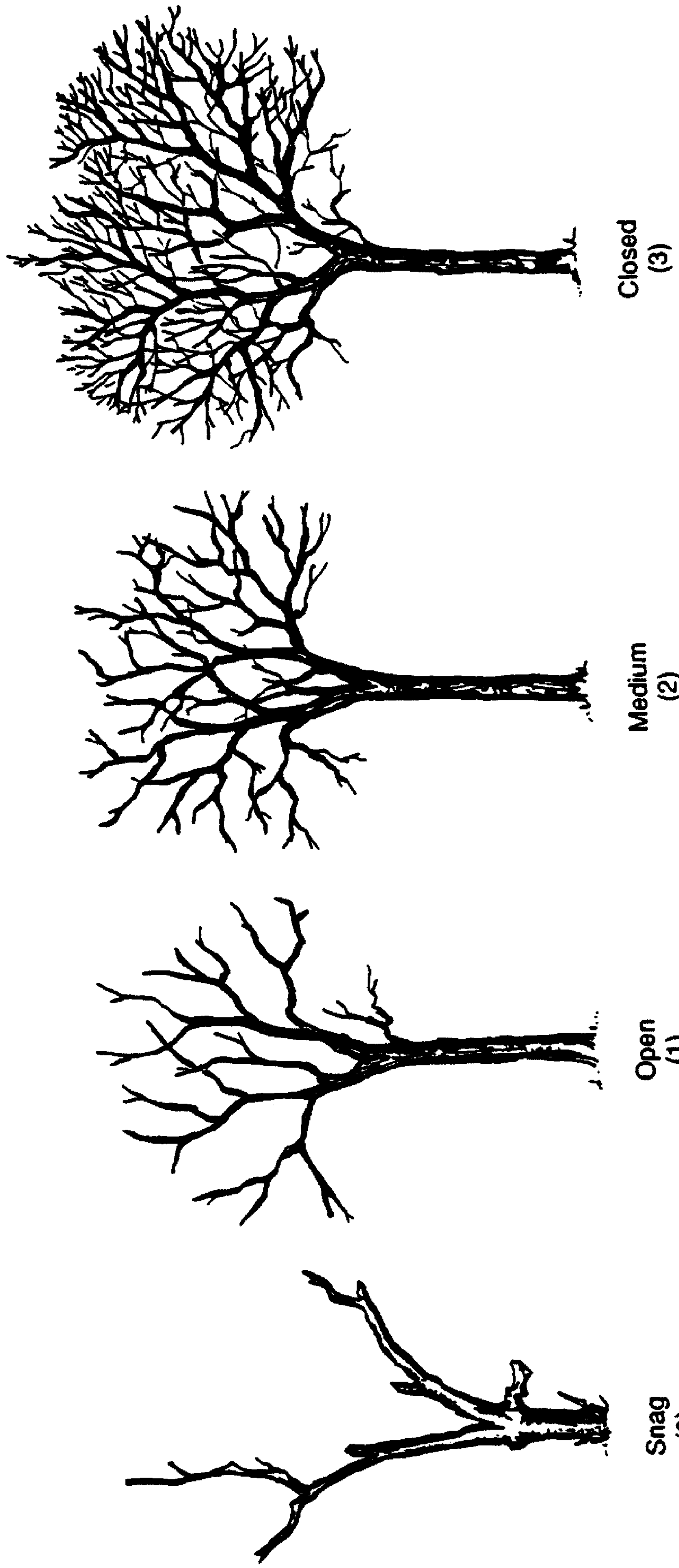
Variable	Description
STAND	
area	stand area (ha)
total trees	total trees >3.0 cm dbh (N)
density	stand density (N trees/ha)
bearing	stand bearing of long axis (0-180° az)
TREE	
height	height (m)
dbh	diameter at breast height-largest bole (cm)
N trees/25 m^2	total trees within 25 m^2 of a used tree
species	species:
	1 Siberian elm (*Ulmus pumila*)
	2 black locust (*Robinia pseudoacacia*)
	3 cottonwood (*Populus* spp.)
	4 white poplar (*P. alba*)
	5 fruit (*Prunus* spp.)
	6 mulberry (*Morus* spp.)
	7 Lombardy poplar (*P. nigra* var. *italica*)
	8 other
status	status:
	10 100% live
	20 75% live
	30 50% live
	40 25% live
	50 0% live
crown	crown closure (Fig. 2):
	0 snag
	1 open
	2 medium
	3 closed
DISTANCE FROM TREE TO	
river	the Columbia River (m)
building	nearest building (m)
prim road	nearest primary road (m)
sec road	nearest secondary road (m)

bearing was the long axis of the stand and determined with a hand-held compass. Tree height was measured with a clinometer. Dbh of the largest bole was measured with a diameter tape. Tree species and status (percent living) were identified after full leaf-out, but crown closure was determined for bare branches during winter (Fig. 2). A primary road was defined as having >100 vehicles/day. Distances from a tree to the river or a secondary road were paced; distances to a building or a primary road were measured on 7.5-min U.S. Geological Survey maps.

Data Analysis

Discriminant function analysis (DFA) (SPSSX INC. 1983) was used to segregate characteristics for the following classifications of trees: 1) used trees in used stands from the tallest tree in unused stands <300 m from the river, 2) used from unused trees in all used stands, 3) major from minor perch stands, and 4) major from minor roost stands. The discriminant function was developed using a random selection of 70% of trees (cases). Variables were retained for analysis when univariate probabilities were <0.05 (Edge 1985), correlations with other variables were <0.50, and tolerances were <0.10 (Cavallaro et al. 1981). Variables were entered stepwise to maximize the Mahalanobis distance. Validity of the discriminant function was based on linearity ($r > 0.60$) and correct classification of the unselected

Figure 2. Crown closure (code) of deciduous trees on the Hanford Reach of the Columbia River.


Closed
(3)
Medium
(2)
Open
(1)
Snag
(0)

cases at >25% over *a priori* probabilities (app) based on sample size.

Paired *t*-tests (*t*) were calculated according to Ott (1984). Tests of independence and goodness of fit (*G*) were adjusted by Williams' correction (Sokal and Rohlf 1981) and evaluated with a chi-square distribution (Burington and May 1970). Analyses of actual and expected eagle distributions and tree use were determined by the Bonferroni method (Byers and Steinhorst 1984). Significance was at $P < 0.05$.

RESULTS

Abundance and Distribution of Bald Eagles

I observed Bald Eagles in the study area 2 January-24 March 1986 and 14 October 1986-4 April 1987. A peak count of 60 eagles was recorded on the 20 December 1986 aerial survey, and a secondary peak of 46 eagles on 9 February 1987. During aerial surveys, 92% of the eagles observed (342) were perched: 49% in trees, 42% on the ground, and 9% on bluffs. Perching on artificial structures was observed on only 2 occasions during both winters. The distribution of eagles perched in trees differed ($G = 10.82$, df = 2, $P = 0.007$) from the distribution of eagles overall when evaluated for 3 Columbia River sections. More eagles (84%) than expected (77%) were perched in trees along the mid-reach (100F islands to 100D), but fewer (11%) than expected (17%) were perched along west reach (100N to Vernita Bridge). Distributions were similar (4% perched in trees and 6% overall) along east reach (Savage Island to 100F islands). Aerial counts were similar ($t = 1.03$, df = 37, $P > 0.10$) to roost counts during every 5-d period.

<u>Tree Use</u>

Bald Eagles <300 m from the Columbia River (94%) were observed using 10% (217/2241) of the available trees and 40% (60/152) of the available stands. Eagles ≥300 m from the river (6%) were observed using 21 trees in 14 stands. Overall, 129 trees in 11 major perch stands accounted for 70% of perch observations (782), and 104 trees in 58 minor stands accounted for 30%. Eighty-four trees in the 3 major (communal) roosts accounted for 91% of all roost observations (2739); 81 trees in 27 minor stands accounted for 9%. Of the 84 trees in major roosts, 12 were considered primary (75% of observations) and 28 were secondary (14% of observations). Eagles were not observed staging before flying to roosts. Stands were not used exclusively as either perches or roosts. The 3 major roosts were also major perches, and 6 minor roosts were also major perches. Sixteen stands were both minor roosts and minor perches.

Tree use in relation to availability differed ($P < 0.001$) among the 3 Columbia River sections and between the north and south shoreline. Eagles used more trees (80%)

than expected (71%) along mid-reach, more (10%) than expected (2%) along west reach, but fewer (10%) than expected (26%) along east reach ($P < 0.05$). Eagles used more trees (99%) than expected (65%) on south shorelines, and fewer (1%) than expected (35%) along north shorelines ($P < 0.05$).

Tree Characteristics

Most tree characteristics, except stand bearing ($P > 0.77$), differed univariately ($P < 0.05$) between used and unused stands, major and minor perch stands, and major and minor roost stands (Table 2). Additionally, a notable progression of stand and tree (and to a lesser extent, distance) characteristics were detected from minor perches, to minor roosts, to major perches, to major roosts, to primary roost trees.

Stands and trees/25 m^2. On average, stands used by eagles were larger (area and number of trees), but less dense than unused stands. Major perch stands were twice as large, but one-third as dense as all used stands. The 3 major roosts were the largest and least dense of all but 1 of the 152 available stands. Although density decreased from unused to used stands and from minor to major stands, used trees in major stands had more neighboring trees/25 m^2.

Heights and diameters. Used trees were on average taller with larger diameters than the tallest trees in

Table 2. Characteristics ($\bar{x}$ ± SD) of used and unused trees and stands by Bald Eagles on the Hanford Reach during the winters of 1986 and 1986-1987.

Variable	Stands <300 M from the River			Perch Stands			Roost Stands		
	Unused		Used	Minor Use		Major Use	Minor Use		Major Use
STANDS									
area-ha	0.3±0.6	*	0.6±0.9	0.4±0.7	**	1.2±1.1	0.4±0.7	*	2.2±0.5
total trees-N	21.2±31.2	*	50.2±84.6	34.0±69.0	**	111.5±98.8	36.5±52.9	*	195.3±93.0
density-t/ha	1070.7±2225.4		544.4±1369.9	609.5±1587.2		155.4±148.4	565.0±1207.6		100.4±72.4
TREES									
height-m	9.3±5.2	**	13.8±5.7	11.8±4.8	**	15.0±5.7	12.3±3.4	**	17.4±5.5
dbh-cm	46.7±36.1	*	63.8±29.3	61.4±31.1		64.0±27.7	64.0±28.1		71.1±28.7
trees/25 m^2	2.4±5.0	**	7.9±7.7	4.4±4.7	**	9.9±8.5	7.1±6.9	*	10.3±8.6
species-code	3.5±2.6	*	2.7±1.6	2.9±2.1	*	2.5±1.1	2.7±1.8		2.8±1.2
status-code	23.2±15.4	**	33.7±14.1	32.0±15.2		34.4±12.9	38.0±12.3	*	33.8±13.2
crown-code	2.2±0.7	**	1.6±0.6	1.6±0.7		1.6±0.5	1.4±0.6	*	1.7±0.5
DISTANCE TO									
river-m	118.1±101.6	**	74.8±58.7	211.2±473.5	*	97.3±114.8	195.8±449.3		101.9±52.5
building-m	1404.7±1199.5	*	1059.1±1003.6	1423.7±1166.3	**	827.0±735.0	946.5±868.2		755.1±639.1
prim road-m	2059.8±1102.1	**	2458.7±1007.5	2043.8±1027.0	**	2639.7±1002.8	2291.8±1087.3	*	2787.1±893.0
sec road-m	192.3±301.3	**	78.0±178.2	137.0±248.4	*	34.3±38.1	45.4±72.0		36.9±28.3

* Univariate $P < 0.05$
** Univariate $P < 0.001$

unused stands. Within a used stand, used trees were generally taller (13.3 m ± 5.4 SD) with larger diameters (61.6 cm ± 29.4 SD) than unused trees (height = 6.4 m ± 3.7 SD, dbh = 17.3 cm ± 16.1 SD) ($F = 0.54$, df = 1,283, $P < 0.001$). Heights and diameters increased from minor perch to primary roost trees (Table 3).

Species, status, and crown closure. Tree use in relation to availability differed for species ($G = 84.43$, df = 6, $P < 0.001$), status ($G = 82.98$, df = 4, $P < 0.001$), and crown closure ($G = 32.94$, df = 3, $P < 0.001$) (Table 4). Eagles used cottonwood, 25-75% live, and open-crowned trees more than expected; eagles used white poplar, 100% live, and medium-crowned trees less than expected ($P < 0.05$). Observed and expected use was similar ($P > 0.05$) for all other categories of species, status, and crown closure.

Species composition of used trees was 88% Siberian elm, black locust, cottonwood, or white poplar compared to 52% for the tallest trees in unused stands. Sixty-six percent of the used trees were partially dead, and 91% had medium to open crowns; only 36% of the tallest trees in unused stands were partially dead, and 53% had medium to open crowns. In major perch stands, trees were primarily (76%) black locust or cottonwood, 75% were partially dead, and 99% had medium to open crowns. In major roost stands, eagles used the

Table 3. Height and diameter of trees used nonexclusively for perching and roosting by Bald Eagles on the Hanford Reach during the winters of 1986 and 1986-1987.

Tree Use	*N*	Height (m)		Diameter (cm)	
		$\bar{x}$ ± SD	Range	$\bar{x}$ ± SD	Range
Primary roost trees	12	20.7 ± 5.7	12.8-30.8	85.5 ± 30.3	33.5-128.3
Secondary roost trees	28	18.4 ± 5.4	9.1-26.8	76.4 ± 23.8	38.3-130.0
3 Major roost stands	84	17.4 ± 5.5	4.0-30.8	71.1 ± 28.7	9.8-143.4
11 Major perch stands	129	15.0 ± 5.7	4.0-30.8	64.0 ± 27.7	9.8-143.4
27 Minor roost stands	81	12.3 ± 3.4	6.1-22.9	64.0 ± 28.1	23.5-154.9
58 Minor perch stands	104	11.8 ± 4.8	3.7-25.0	61.4 ± 31.1	12.8-154.9
All used trees	238	13.5 ± 5.5	3.7-30.8	62.8 ± 28.9	9.8-154.9

Table 4. Results of tree use (238) in relation to availability (3811) for Bald Eagles on the Hanford Reach during the winters of 1986 and 1986-1987.

	Expected Frequency	Observed Frequency	95% Simultaneous Confidence Interval	
		TREE SPECIES		
Siberian elm	0.174	0.168	0.103	0.233
Black locust	0.424	0.471	0.384	0.558
Cottonwood	0.026	0.118	0.062	0.174*
White poplar	0.200	0.122	0.065	0.179*
Fruit	0.119	0.029	-0.000	0.059*
Mulberry and Lombardy Poplar	0.022	0.013	-0.007	0.032
Other	0.035	0.080	0.033	0.127
		TREE STATUS		
100% Live	0.360	0.145	0.086	0.204*
75% Live	0.148	0.239	0.167	0.310*
50% Live	0.113	0.196	0.129	0.262*
25% Live	0.126	0.234	0.163	0.305*
0% Live	0.252	0.187	0.122	0.253
		CROWN CLOSURE		
Snag	0.009	0.017	-0.004	0.038
Open	0.244	0.410	0.330	0.489*
Medium	0.681	0.526	0.445	0.607*
Closed	0.065	0.047	0.013	0.082

* $P < 0.05$

predominant species: either black locust, cottonwood, or white poplar. Most (81-92%) primary and secondary roost trees were partially dead, and all had medium to open crowns.

Distance to the Columbia River. Overall, used trees were closer to the Columbia River than unused trees. Minor stands were approximately twice as far from the river as major stands. Major perch trees ranged 0-260 m from the river, and major roost trees ranged 7-204 m.

Distance to buildings, primary roads, and secondary roads. Trees in all used and major stands were closer to buildings and secondary roads than trees in unused and minor stands. Major perch and roost stands ranged 11-3428 m from the nearest building and 2-232 m from the nearest secondary road. Mean distances to the nearest primary road were farther for all used stands than for unused stands; however, major stands were closer than minor stands. Major stands varied between 76-4197 m from a primary road.

Discriminant Function Analysis

Used and unused stands <300 m from the Columbia River. DFA segregated characteristics of 60 used from 92 unused stands ($F = 0.49$, df = 7,204, $P < 0.0001$). Variables predicting membership were total trees, density, status, height, species, and distances to the river and a secondary road. The function was linear ($r = 0.71$) and correctly classified 93% of unselected cases as used (app = 71%), and 68% as unused (app = 23%).

Used and unused trees in used stands. In the 74 used stands, 238 used trees were segregated ($F = 0.54$, df = 1,283, $P < 0.0001$) from 3797 unused trees by dbh alone. The discriminant function was linear ($r = 0.68$) and correctly classified 86% of unselected cases as used (app = 52%), and 88% as unused (app = 48%).

Major and minor perch stands. DFA segregated ($F = 0.47$, df = 2,162, $P < 0.0001$) characteristics of the 11 major from the 58 minor perch stands. Only area and trees/25 m^2 were needed to predict group membership. The function was linear ($r = 0.73$) and correctly classified 72% of unselected cases as major (app = 56%), and 83% as minor (app = 44%).

Major and minor roost stands. DFA segregated 3 major from 27 minor roost stands ($F = 0.38$, df = 5,114, $P < 0.0001$). Group membership was predicted by area, total trees, height, trees/25 m^2, and status. The function was linear ($r = 0.79$) and correctly classified 95% of unselected cases as major (app = 54%), and 82% as minor (app = 46%).

DISCUSSION

Tree Use

Bald Eagles usually roost and perch at different sites (Stalmaster 1987). Most eagles wintering in grassland or shrub habitats roost communally on nearby forested mountains (Joseph 1977, Keister 1981, Isaacs and Anthony 1987). Near the Hanford Reach, Rattlesnake and Gable Mountains are treeless. Eagles may also use different perch trees for feeding, loafing, or sheltering from harsh weather (Steenhof 1976, Joseph 1977, Fischer 1982). In contrast, most Bald Eagles on the Hanford Reach used the same few trees during both winters, throughout the winter, and throughout the day. Eagles foraged from and fed in major roosts; thus, communal roosts were not solely refuges for nonfeeding eagles (Hansen 1979, Keister 1981).

Tree use was apparently not influenced by routine human activity. Some major perch sites were near deactivated reactor facilities, and all but one were accessible by a secondary road. Hanford personnel drove through and stopped near a major perch and roost stand during regular security patrols. Eagles observed at minor roosts near primary roads (including one used nightly) were not flushed by heavy traffic. Bald Eagles may habituate to routine human activity and constantly moving traffic (Stalmaster 1976, Harmata 1984). Those eagles flushed from perch or roost trees by Hanford personnel usually returned to the same tree. Eagles may have avoided the Wahluke shorelines where human activity was sporadic.

Perch Trees

Most Bald Eagles on the Hanford Reach perched in tall, open-crowned trees with large diameters. Although snags (100% dead trees) were used in proportion to their availability, many other trees had suitable crowns because at least one side was dead. Additionally, some crown openings were enlarged by eagles removing small branches. Bald Eagles may select large open-crowned trees or snags to support their weight, allow easy access, and provide wide-ranging views (Stalmaster 1987). The availability of suitable perch trees may in part influence eagle distribution in a wintering area (Servheen 1975, Hansen and Bartelme 1980, Fielder and Starkey 1986). However, eagles on the Hanford Reach did not use all of the trees with suitable structural characteristics; these were usually on north shorelines or away from primary foraging areas.

All major perch trees overlooked consistently used ground perches and primary foraging areas along the Columbia River. The availability of suitable ground perches on islands and riverbanks (used throughout the day) influenced the distribution of eagles along the Columbia River in southcentral Washington (Chapter 1). When ground perches were inundated by high river levels, tree perching was more common. Eagles may have improved sightings for chinook salmon (*Oncorhynchus tshawytscha*) carcasses, waterfowl, or other aquatic prey by perching in south shoreline trees, thereby facing north and reducing sun glare off the river. Furthermore, tree perches are warmer than ground perches (Stalmaster and Gessaman 1984, Hansen 1986), and eagles on the Hanford Reach may have perched in trees during colder weather.

Minor stands were, in general, farther from the Columbia River and primary foraging areas than major stands. Selection of minor perches may have been related to secluded eating sites (Fischer 1982, Bennetts 1986), additional foraging opportunities, resting sites during local or migrational movements, or early roosting.

Roost Trees

Communal roost trees on the Hanford Reach were structurally and locationally (distance to river) similar to other coniferous and deciduous roosts in the Pacific Northwest (see Keister 1981, Anthony et al. 1982, Crenshaw 1985), and elsewhere in the United States (see Steenhof 1976, Harmata 1984, Haines 1986). Most Bald Eagles roost at one of several communal roosts in a wintering area, although some eagles may roost alone or in small groups (Keister 1981, Harmata 1984, Crenshaw 1985).

Roost selection by Bald Eagles is thought to be most related to structural characteristics of trees because of similarities throughout the winter range (Stalmaster 1987). Roost trees are usually taller and larger than perch trees (Steenhof 1976, Wood 1980, Crenshaw 1985), and taller than other trees in a roost stand (Stalmaster 1987). Taller and larger roost trees, like perch trees, may allow ease of access, wide-ranging views (Hansen et al. 1980, Haines 1986, Stalmaster 1987), and strong upper branches to support the weight of eagles (Hansen 1979).

Roost selection may also be associated with proximity to feeding areas (Steenhof 1976, Keister 1981, Harmata 1984), favorable microclimates (Hansen et al. 1980, Stalmaster and Gessaman 1984), and security from human activity (Hansen et al. 1980, Harmata 1984). However, these selection factors seemed unlikely on the Hanford Reach. Major roosts were within 6 km of each other, and all were centrally located among primary foraging grounds. Use of a particular roost was apparently not influenced by human activity or weather conditions, although winters are relatively mild in southcentral Washington.

Structural characteristics of roost trees and stands have not been related to the roost behavior of Bald Eagles. At communal roosts on the Hanford Reach, nearly all eagles flew from any regularly used tree into a primary or secondary tree. Flights also resulted from frequent interaction among eagles such as displacements, flushing, footing, and wing raising. Injury-free interaction was probably enhanced by views of other eagles from the tallest trees, and adequate flight space in the relatively open stands. A maximum number of suitable trees were available in the largest stands; primary and secondary roost trees were frequently within 25 m^2. Additionally, the tallest trees and largest stands may have advertised roost location, which has previously been attributed to staging or soaring over roosts (Hansen 1979). Communal roosts are thought to provide a setting for social interaction among Bald Eagles, but this function is poorly understood (Young 1983, Crenshaw 1985).

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APPENDICES

Appendix A. **Aerial survey counts of Bald Eagles in southcentral Washington during the winters of 1986 and 1986-1987.**

Date	Time (Pacific Standard)	Bald Eagles Adults	Immatures	Total
14 JAN 1986	1310-1625	15	26	41
19 JAN 1986	0800-1100	14	12	26
22 JAN 1986	1100-1400	10	19	29
29 JAN 1986	0800-1400	13	18	31
4 FEB 1986	1100-1400	10	17	27
10 FEB 1986	0800-1100	13	13	26
18 FEB 1986	1100-1400	9	17	26
21 FEB 1986	0800-1100	22	14	36
26 FEB 1986	1100-1400	9	5	14
1 MAR 1986	0800-1100	14	7	21
6 MAR 1986	1100-1400	12	5	17
10 MAR 1986	0800-1100	10	4	14
14 MAR 1986	1100-1400	8	4	12
19 MAR 1986	0800-1100	6	2	8
TOTAL		165	163	328
27 OCT 1986	0700-1030	2	3	5
2 NOV 1986	0915-1350	2	3	5
6 NOV 1986	0715-1020	4	5	9
11 NOV 1986	0830-1200	11	15	26
16 NOV 1986	0746-1045	7	15	22
21 NOV 1986	0730-1130	13	22	35
1 DEC 1986	0753-1120	15	25	40
6 DEC 1986	0800-1050	13	34	47*
11 DEC 1986	0800-1130	15	41	56
17 DEC 1986	0800-0940	8	3	11*
20 DEC 1986	0800-1130	20	40	60
31 DEC 1986	0815-1130	11	22	33
5 JAN 1987	0815-1120	10	22	32
10 JAN 1987	0815-1200	10	23	33
15 JAN 1987	0800-1130	12	19	31
20 JAN 1987	0800-1145	15	21	36
30 JAN 1987	0800-1145	14	22	36
4 FEB 1987	0745-1130	18	22	40
9 FEB 1987	0920-1230	19	27	46
14 FEB 1987	0745-1115	17	14	31
19 FEB 1987	0730-1045	15	11	26

Appendix A. Continued.

Date	Time (Pacific Standard)	Bald Eagles Adults	Bald Eagles Immatures	Bald Eagles Total
1 MAR 1987	0715-1030	18	6	24
6 MAR 1987	0700-1050	18	6	24
11 MAR 1987	0645-1030	9	4	13
16 MAR 1987	0645-1030	7	2	9
21 MAR 1987	0700-1010	7	0	7
26 MAR 1987	0630-1030	1	1	2
TOTAL		311	428	739

* Incomplete

Appendix B. Roost survey counts of Bald Eagles on the Hanford Reach of the Columbia River in southcentral Washington during the winters of 1986 and 1986-1987.

Date	Bald Eagles			
	Adults	Immatures	Unaged	Total
8 JAN 1986	0	0	32	32
13 JAN 1986	3	10	9	22
14 JAN 1986	0	0	33	33
16 JAN 1986	3	4	12	19
20 JAN 1986	7	15	0	22
23 JAN 1986	5	22	1	28
26 JAN 1986	9	16	0	25
28 JAN 1986	8	12	2	22
3 FEB 1986	4	20	2	26
4 FEB 1986	12	20	5	37
5 FEB 1986	7	19	0	26
9 FEB 1986	4	12	0	16
10 FEB 1986	4	22	1	27
13 FEB 1986	5	17	0	22
17 FEB 1986	8	16	1	25
19 FEB 1986	5	15	0	20
21 FEB 1986	9	12	0	21
23 FEB 1986	11	13	1	25
25 FEB 1986	4	8	3	15
3 MAR 1986	6	8	0	14
7 MAR 1986	2	4	0	6
10 MAR 1986	3	3	0	6
12 MAR 1986	2	0	0	2
14 MAR 1986	1	0	0	1
17 MAR 1986	4	0	0	4
TOTAL	126	268	102	496
20 OCT 1986	1	1	1	3
23 OCT 1986	2	2	0	4
24 OCT 1986	2	5	0	7
27 OCT 1986	1	1	2	4
29 OCT 1986	1	2	0	3
31 OCT 1986	0	4	0	4
2 NOV 1986	3	3	0	6
5 NOV 1986	2	8	0	10
6 NOV 1986	4	2	0	6
10 NOV 1986	4	5	0	9
11 NOV 1986	3	6	0	9

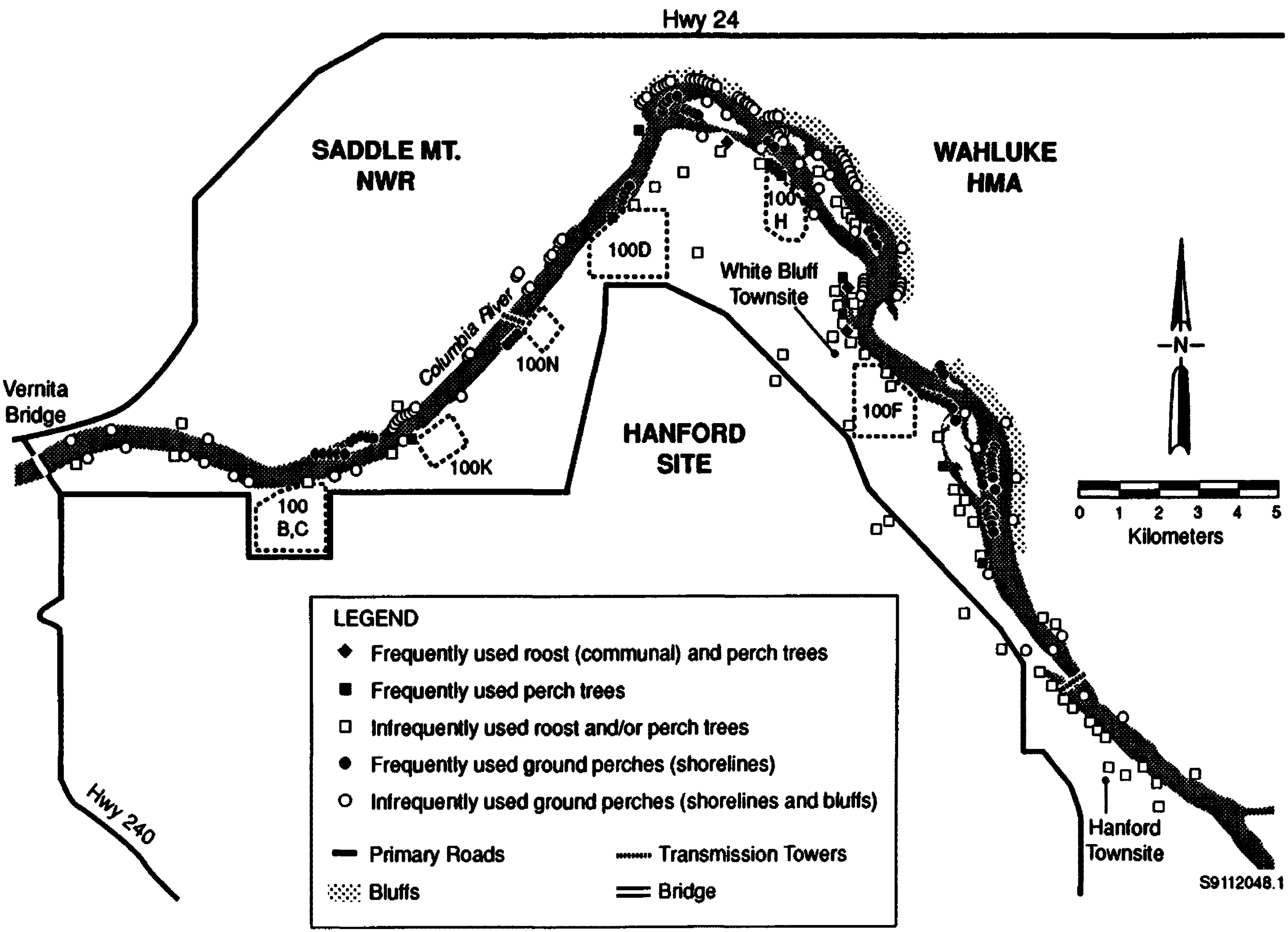
Appendix B. Continued

Date	Bald Eagles Adults	Immatures	Unaged	Total
15 NOV 1986	5	18	3	26
20 NOV 1986	10	20	2	32
21 NOV 1986	8	20	4	32
30 NOV 1986	7	21	10	38
1 DEC 1986	12	18	7	37
5 DEC 1986	13	33	1	47
6 DEC 1986	9	39	4	52
10 DEC 1986	8	45	4	57
11 DEC 1986	12	30	1	43
15 DEC 1986	11	42	1	54
17 DEC 1986	17	37	1	55
19 DEC 1986	13	42	4	59
20 DEC 1986	16	43	3	62
30 DEC 1986	8	36	4	48
31 DEC 1986	10	32	1	43
4 JAN 1987	10	33	0	43
5 JAN 1987	9	37	1	47
9 JAN 1987	6	21	0	27
10 JAN 1987	8	22	1	31
14 JAN 1987	3	18	1	22
15 JAN 1987	6	17	2	25
19 JAN 1987	6	17	4	27
20 JAN 1987	7	16	4	27
24 JAN 1987	8	19	1	28
29 JAN 1987	6	18	1	25
30 JAN 1987	7	22	0	29
3 FEB 1987	5	17	6	28
4 FEB 1987	7	17	4	28
8 FEB 1987	5	14	4	23
9 FEB 1987	10	17	0	27
13 FEB 1987	4	9	9	22
18 FEB 1987	4	9	2	15
19 FEB 1987	5	7	3	15
23 FEB 1987	5	7	1	13
28 FEB 1987	6	4	0	10
1 MAR 1987	5	4	0	9
5 MAR 1987	5	4	1	10
6 MAR 1987	6	6	0	12
10 MAR 1987	4	3	0	7
11 MAR 1987	3	2	2	7
15 MAR 1987	3	3	0	6

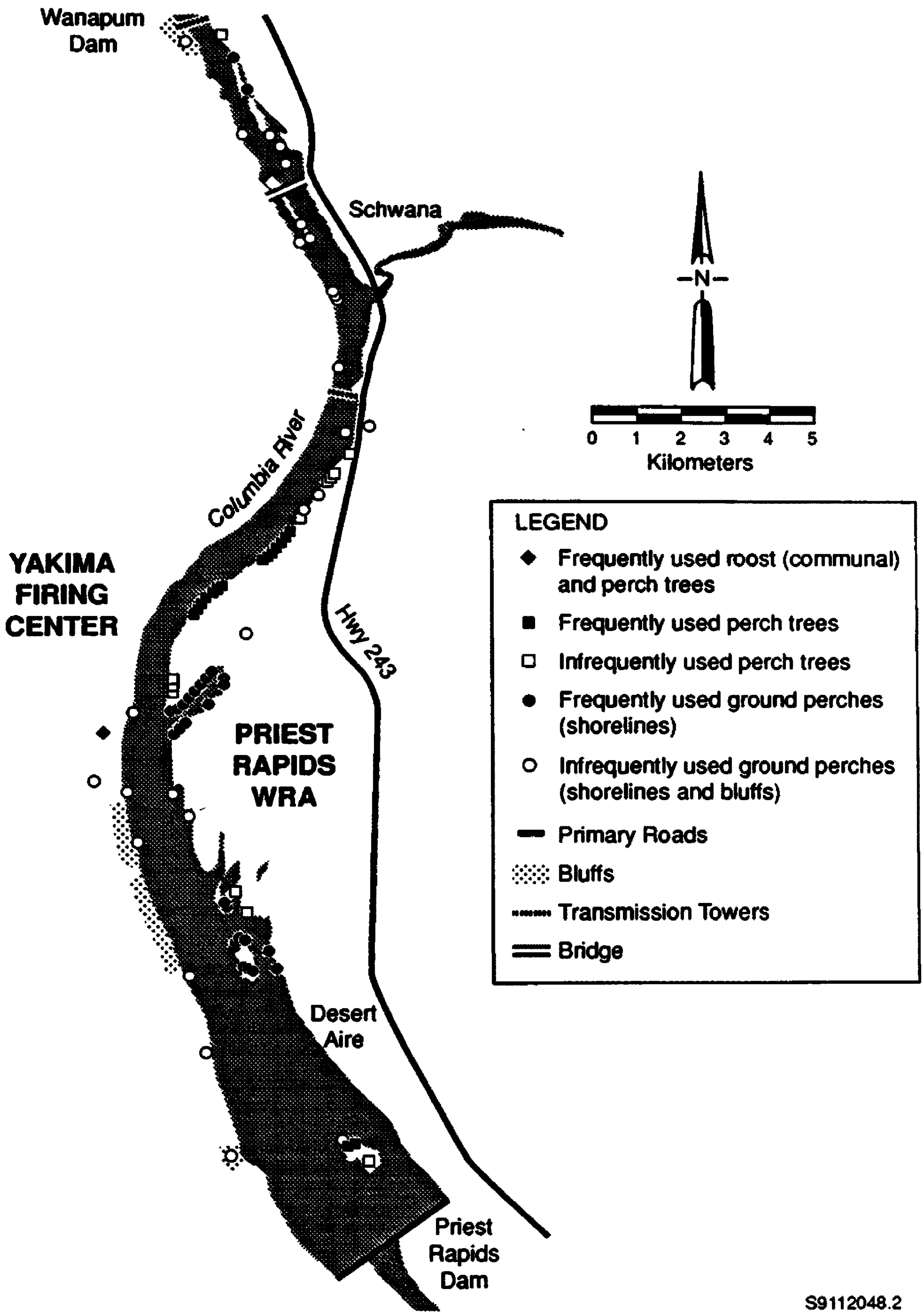
Appendix B. Continued

Date	Bald Eagles Adults	Immatures	Unaged	Total
16 MAR 1987	3	2	0	5
20 MAR 1987	3	0	0	3
21 MAR 1987	4	1	1	6
25 MAR 1987	1	1	0	2
26 MAR 1987	0	0	0	0
27 MAR 1987	0	0	0	0
28 MAR 1987	0	0	2	2
30 MAR 1987	1	1	0	2
31 MAR 1987	2	1	0	3
4 APR 1987	1	0	0	1
TOTAL	350	884	103	1337

Appendix C. Bald Eagle use areas along the Hanford Reach of the Columbia River during the winters of 1986 and 1986-1987. Use area classifications were based on aerial survey observations (741) as follows: 109/351 (31%) on frequently used roost (communal) and perch trees, 131/351 (37%) on frequently used perch trees, 111/351 (32%) on infrequently used roost and/or perch trees, 239/390 (61%) on frequently used ground perches (shorelines), and 151/390 (39%) on infrequently used ground perches (shorelines and bluffs).


Hwy 24
SADDLE MT.
NWR
WAHLUKE
HMA
Columbia River
100D
100
H
White Bluff
Townsite
100N
Vernita
Bridge
100K
HANFORD
SITE
100F
100
B,C
N
0 1 2 3 4 5
Kilometers
Hwy 240
Hanford
Townsite
S9112048.1
LEGEND
Frequently used roost (communal) and perch trees
Frequently used perch trees
Infrequently used roost and/or perch trees
Frequently used ground perches (shorelines)
Infrequently used ground perches (shorelines and bluffs)
Primary Roads
Transmission Towers
Bluffs
Bridge

Appendix D. Bald Eagle use areas along Priest Rapids Reservoir on the Columbia River during the winters of 1986 and 1986-1987. Use area classifications were based on aerial survey observations (214) as follows: 25/105 (24%) on frequently used roost (communal) and perch trees, 62/105 (59%) on frequently used perch trees, 18/105 (17%) on infrequently used perch trees, 57/109 (52%) on frequently used ground perches (shorelines), and 52/109 (48%) on infrequently used ground perches (shorelines and bluffs).


Wanapum Dam
Schwana
Columbia River
YAKIMA FIRING CENTER
Hwy 243
PRIEST RAPIDS WRA
Desert Aire
Priest Rapids Dam
N
0 1 2 3 4 5
Kilometers
LEGEND
Frequently used roost (communal) and perch trees
Frequently used perch trees
Infrequently used perch trees
Frequently used ground perches (shorelines)
Infrequently used ground perches (shorelines and bluffs)
Primary Roads
Bluffs
Transmission Towers
Bridge
S9112048.2