BALD EAGLES (Haliaeetus leucocephalus) NESTING IN OREGON AND ALONG THE LOWER COLUMBIA RIVER, 1978-2007

Final Report

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ABSTRACT

We surveyed the breeding population of bald eagles (*Haliaeetus leucocephalus*) in Oregon and along the lower Columbia River from 1978–2007. Surveys were conducted annually by aircraft, boat, and/or afoot from 1 February–31 August to determine occupancy and productivity of breeding areas. We divided the study area into ten watersheds based on Recovery Plan management zones. Overall, the minimum size of the breeding population increased from 66 occupied breeding areas in 1978 (65 in Oregon and 1 in Washington) to 553 in 2007 (496 in Oregon and 57 in Washington). Population growth rate (r) was exponential for all areas combined, but varied among the nine watersheds from 0.048 for the Deschutes to 0.147 for the Willamette. The average increase in the breeding population was 0.073 or a 7.3% increase per year for the study area. At the beginning of the study, the breeding population was located primarily in the Deschutes, Klamath, Pacific, and Columbia watersheds with dispersed breeding areas elsewhere. By the end of the study, the population was concentrated in those four areas plus the Willamette, Rogue, and Umpqua watersheds, and additional breeding areas were dispersed throughout most of the state except for the Owyhee watershed of southeast Oregon. We documented breeding phenology over the 30-year period and discovered an approximately five-day advance in the egg-laying period for breeding areas west of the Cascades, which may have been a result of warmer late-winter and spring temperatures in the region during the latter part of the study.

Nesting success, productivity (number of young produced per occupied breeding area), and brood size increased significantly from 1978–2007, and productivity was correlated positively with breeding success over the 30 years of the study. Overall,

average annual productivity was >1.0 young per occupied breeding area during the last decade of the study, which was indicative of a healthy population. However, productivity on segment 2 of the lower Columbia River (river miles 13–31 or km 21–50) was low throughout the study indicating that the effects of environmental contaminants still persist in that area. Reduced productivity with increasing population indicated that breeding populations at Odell Lake and the west side of Upper Klamath Lake were at or near carrying capacity. Overall, our data suggest that the breeding population of the study area has the potential to double or triple in the future based on the amount of shoreline habitat present and assuming unchanged environmental conditions.

Recoveries of bald eagles banded as nestlings in Oregon (n = 22) provided a longevity record for the study area of 26-years-3-months and indicated that subadults moved further from natal areas than adults (438 km vs. 153 km or 272 mi vs. 95 mi, respectively). Seven banded nestlings that were recovered as adults during the breeding season were 59 km (37 mi) on average from their natal areas, providing evidence of natal philopatry. Encounters in the study area with marked bald eagles from outside Oregon were common (n = at least 62), involved eagles from 6 western states and Mexico, occurred throughout Oregon (20 or 22 of 36 counties), and were concentrated in Klamath, Lake, and Deschutes counties (53%). Movements of resident and non-resident bald eagles that utilized the study area delineated a complex web of overlapping ranges extending from northwestern Mexico to Alaska and northwestern Canada and included Oregon, Washington, Idaho, Montana, Wyoming, Utah, Nevada, California, and Arizona.

The breeding population (n = 553) was associated with estuaries (31%), rivers (22%), reservoirs (21%), and natural lakes (15%), and 90% of occupied breeding areas were within 3,200 m (2 mi) of shorelines. Breeding areas were distributed bi-modally relative to elevation because of concentrations at rivers and estuaries at low elevations west of the Cascades and at lakes or reservoirs at higher elevations east of the Cascades. Productivity decreased with increasing elevation. Although that correlation was weak overall (r = -0.111), it was prominent on the west slope of the Cascade Mountains. Lower productivity at high elevations likely was due to severe weather in some years that resulted in cold and wet conditions during egg-laying and incubation periods. We also found that low productivity coincided with mate changes (0.36 young per occupied breeding area) and establishment of new territories (0.29 young per occupied breeding area), which indicated that inexperience of first-time breeders was a likely reason for failure of nesting attempts. Our analysis of nesting success within breeding areas indicated that successful nesting attempts were followed by successes 69% of the time (n = 4,498) and that failed attempts followed failures 47% of the time (n = 2,793).

Primary nest tree species were Douglas-fir (*Pseudotsuga menziesii*), Sitka spruce (*Picea sitchensis*), and black cottonwood (*Populus trichocarpa*) west of the Cascades, and ponderosa pine (*Pinus ponderosa*) and Douglas-fir east of the Cascades. In general, nest trees used by bald eagles in the study area were the dominant individuals in forest stands located near water bodies with an abundant food supply and some degree of isolation from human activity, although there were notable exceptions to this latter generality. The cumulative number of bald eagle nest trees within breeding areas increased with time ($r = 0.928$, $p < 0.01$) from approximately one the first year a breeding area was known to approximately five after 30 years. Nest and nest tree "survival" averaged 97% per year over 28 years, and 16% of nest trees discovered in 1978 still held nests in 2007. We observed use of bald eagle nests by seven other avian species: red-tailed hawk (*Buteo jamaicensis*), osprey (*Pandion haliaetus*), great horned owl (*Bubo virginianus*), peregrine falcon (*Falco peregrinus*), Canada goose (*Branta canadensis*), common raven (*Corvus corax*), and golden eagle (*Aquila chrysaetos*), with most use by Canada goose.

We provided several recommendations for monitoring and documenting nesting and wintering populations, managing nest trees and forests within breeding areas, and future research topics for bald eagles in Oregon and the Pacific Northwest. Our primary recommendations were: 1) implement a more intensive nest monitoring plan for Oregon than is provided by the nation-wide, post-delisting monitoring plan of the U.S. Fish & Wildlife Service, 2) develop a centralized data base and tracking system for breeding and wintering locations and results of nest and winter monitoring, 3) manage for and conserve nesting habitat, especially the preservation of existing nest trees and management of forest stands to replace nest trees, following the approaches established when the species was listed under the Endangered Species Act, 4) continue periodic research on the effects of contaminants on nesting bald eagles on the lower Columbia River, 5) study movements and survival of resident bald eagles, 6) coordinate research and management with other western states, Mexico, and Canada, and 7) monitor nesting phenology for evidence of long-term change.

INTRODUCTION

Bald eagles (*Haliaeetus leucocephalus*) are long-lived (Stalmaster 1987:22, U.S. Geological Survey 2010a) and exhibit strong nest-site and mate fidelity (Jenkins and Jackman 1993). Once breeding areas have been located, size, reproductive parameters, and nest-site characteristics of breeding populations can be determined with surveys that use established techniques and terminology (Postupalsky 1974, 1983; Steenhof 1987). Surveys conducted since 1963 documented increased size (App. 1) and expanded distribution (App. 2) of the breeding population in the contiguous United States. Those findings were major factors in the decision to remove the bald eagle from the federal list of threatened and endangered species (U.S. Department of the Interior 2007).

The bald eagle is one of the most studied North American birds and has been the topic of thousands of popular and scientific articles (Lincer et al. 1979, Buehler 2000:29, U.S. Geological Survey 2009). In-depth information on biology, behavior, habitat use, natural history, and recovery efforts is available on the species throughout much of its geographic range (e.g., Herrick 1934, Bent 1937:321-349, Stalmaster 1987, Gerrard and Bortolotti 1988, Palmer et al. 1988:187-237, Beans 1996, Buehler 2000, Wheeler 2003:120-146). Recovery plans for five regions of the contiguous United States (U.S. Fish and Wildlife Service 1986:1) contain information on their status, protection, management, and recovery (U.S. Department of the Interior 2007), but this information is not readily available to the scientific community or the public.

The Pacific States Bald Eagle Recovery Plan listed recovery goals and outlined steps needed to achieve those goals in Washington, Oregon, California, Nevada, Idaho, Montana, and Wyoming (U.S. Fish and Wildlife Service 1986). In addition, the Working Implementation Plan for Bald Eagle Recovery supplemented the recovery plan by providing specific guidance for achieving recovery goals in Oregon and Washington (Bald Eagle Working Team for Oregon and Washington 1990). Natural history, status, and management of bald eagles in the state of Washington have been researched and documented (Stinson et al. 2007). The species' status in Washington was changed from "state threatened" to "state sensitive" on 11 January 2008 because of federal delisting, reduced threats, and increased size of the nesting population in the state (Washington Department of Fish and Wildlife 2009). For Oregon, Woodcock (1902:34), Gabrielson and Jewett (1940:195), Marshall (1969:11), Anderson (1971), Opp (1980), Smith (1991), and Isaacs and Anthony (2003) wrote accounts on the species. Oregon's first breeding bird atlas documented generalized nesting distribution from 1995 to 1999 (Adamus et al. 2001).

Bald eagles are native to North America where have existed for at least one million years (Stalmaster 1987:5). They have coexisted with humans in the Pacific Northwest for at least the last 10,000-14,000 years (Bishop 2003:232). Fossilized bones from bald eagles have been found in California, Oregon, Nebraska, New Mexico, and Florida at sites dating back to the Pleistocene (Howard 1932:45). Direct evidence of the prehistoric occurrence of the species in Oregon comes from 29,000±-year-old (late-Pleistocene) fossils collected at Fossil Lake in Christmas Lake Valley (Shufeldt 1913, Howard 1946, Allison 1966), remains collected at an ~8,000-year-old midden along the Columbia River near The Dalles, OR (Miller 1957), and 5,000–6,000-year-old bones excavated from an archeological site at Lower Klamath Lake in northern California

(Grayson 1976). At the Columbia River site, bald eagles were the second most abundant species represented in bone samples; gulls (*Larus* sp.) were first and California condors (*Gymnogyps californianus*) were third (Miller 1957).

Historically, reports of bald eagles in Oregon prior to 1969 were mostly anecdotal. Lewis and Clark reported bald eagles at the mouth of the Columbia River in November 1805 and January 1806 (Gabrielson and Jewett 1940:196). David Douglas observed, shot, and ate bald eagles while exploring the lower Columbia River in 1825 and 1826 (Nisbet 2009:38, 55, 60 & 69). John K. Townsend, a pioneering naturalist who explored the lower Columbia River from 1834 to 1836, observed that the bald eagle was one of the commonest year-round resident bird species (Jobanek and Marshall 1992:4). Other historical anecdotes indicated that the bald eagle was abundant along the lower Columbia River in the late 1800s (Stinson et al. 2007:20). Woodcock (1902:34) reported the species from Yaquina Bay (10 pairs resident), Tillamook County (rare resident), Scio (rare resident), Elkton (uncommon breeder), Columbia River (common, especially at the mouth), Klamath Lake (especially numerous), Haines (common resident), Beaverton (not common), and Corvallis (nesting along the Willamette River). Observations of the species were documented from the mid-to-late 1800s for the Columbia and Willamette rivers (common), Klamath Lakes (abundant), and Fort Klamath (common breeding species) (Gabrielson and Jewett 1940:196). Gabrielson and Jewett (1940:196) concluded that bald eagles had become uncommon in Oregon by 1935, except along the coast, Columbia River, and at Klamath Lake. They listed additional records of individual eagles from, "... lakes of the Wallowa Mountains, the Deschutes River and lakes about its headwaters, Harney Valley, Lake County, and the headwaters of the Umpqua River."

In the first attempt to quantify the abundance of bald eagles in Oregon, Marshall (1969:11) reviewed the species' status in the late 1960s and concluded that there had been little change in distribution since the 1930s. He listed 41 known and possible nesting sites and reported that population size was unknown because all of the sites had not been surveyed in the same year. The first systematic bald eagle nest surveys in Oregon were local efforts on the Deschutes National Forest (Shull 1978) and in the Klamath Basin (Anderson 1985) beginning in 1970 and 1971, respectively. In 1972, the Wildlife Services Division, Bureau of Sport Fisheries and Wildlife (BSFW) Region 1, (now U.S. Fish and Wildlife Service Region 1) conducted surveys and compiled observations on nesting bald eagles in the state (U.S. Fish and Wildlife Service, unpublished data, Portland, Oregon, USA). The first account on the size, distribution and productivity of bald eagles nesting in Oregon was for 1978 and 1979 (Opp 1980) and was based on preliminary data contained in our annual reports (Isaacs and Anthony 1980). Our first publication on the species (Isaacs et al. 1983), concluded that most of the increase in the size of the nesting population from 1978–1982 was the result of increased survey effort rather than a population increase. We also concluded that productivity in Oregon was similar to stable populations in other states and recommended continued monitoring because of an apparent downward trend in productivity.

The bald eagle was listed as threatened in Oregon under the federal Endangered Species Act (ESA) in 1978 (U.S. Department of the Interior 1978) and under the Oregon

ESA in 1987 (Marshall et al. 1996). As a result, bald eagles have been studied extensively in Oregon since 1978 (Isaacs and Anthony 2003). Nest site characteristics, habitat management, effects of human activity, causes of nesting failure, home range and habitat use, food habits, time budgets, winter habits and communal roosting, roost site characteristics, energetics of communal roosting, population estimation, environmental contaminants, midwinter population counts during 1979–1983 and 1988–2007, and the nesting population have all been topics of study (see App. 3 for references). Even though the bald eagle was removed from the federal list of threatened species in 2007 (U.S. Department of the Interior 2007), it was still categorized as threatened in the state of Oregon as of 29 October 2010 (Oregon Department of Fish and Wildlife 2010a).

The primary objectives of our study were to: 1) estimate the size of the breeding population, 2) describe the distribution of breeding pairs, 3) determine nesting phenology, and 4) document productivity for different ecological regions (watersheds) . Results of our surveys initially were compiled in annual reports (Isaacs and Anthony 2008) and used by resource managers to comply with local, state, and federal regulations for protection of threatened and endangered species and their habitat. The purpose of this report is to describe the status of the breeding population of bald eagles in Oregon and along the lower Columbia River from 1978–2007. Herein, we summarize results of 30 years of surveys and document the exponential increase in the breeding population. Because the density of breeding areas was high in some areas, we predicted that we would observe depressed productivity and little population growth in those areas during the latter years of the study. We also present results on other characteristics of the breeding population, breeding areas, nests, and nest trees. Finally, we provide our thoughts on management implications, including future monitoring and habitat conservation that we believe are important for conservation of the species after delisting at both the state and federal levels.

STUDY AREA

Boundaries

Our study area was the state of Oregon and the Washington side of the Columbia River (Fig. 1). Oregon is midway between the equator and North Pole on the west coast of North America. The state is roughly rectangular in shape, approximately 620 km (385 mi) at its widest point east to west and approximately 476 km (296 mi) at its widest point north to south, and includes approximately 248,644 km^2 (96,002 mi^2) of land and approximately 2,924 km^2 (1,129 mi^2) of surface water (Oregon Blue Book 2009). The Columbia River and latitude 46° N form the northern border between the states of Oregon and Washington; the east boundary between Oregon and Idaho is the Snake River and a north-south line approximately 2.4 km (1.5 mi) west of longitude 117° W; the south boundary between Oregon and Nevada and California closely follows latitude 42° N; and the west side of the state is bounded by the Pacific Ocean at approximately longitude 124° W. Elevations range from sea level at the Pacific Ocean to 3,424 m (11,234 ft) above sea level at the top of Mount Hood in the Cascade Mountains (elevations from State of Oregon 1:500,000 scale topographic map, U.S. Geological Survey, Reston Colorado, USA).

Topography

Volcanic mountains divide the state north to south so that roughly 1/3 of the land area is west of the crest and 2/3 is east of the crest of the Cascade Mountains. Most of the landscape west of the Cascade crest is <914 m (3000 ft) elevation, while nearly all of the landscape east of the Cascades is >914 m (3000 ft) above sea level (Loy et al. 2001:119). Other major mountain ranges are the Coast Range and Siskiyou mountains west of the Cascades; and the Blue, Wallowa, Ochoco, and Warner mountains, and Steens Mountain and Hart Mountain east of the Cascades.

Climate

Oregon climate generally is maritime west of the Cascades and continental east of the Cascades. Consequently, west-side weather usually is warmer and wetter than that east of the Cascades. This pattern is modified by mountain ranges that affect local weather; precipitation increases and temperature decreases with elevation, and air masses that cross the Cascades bring maritime conditions to the east side or continental weather to the west side (Franklin and Dyrness 1973:38–43, Taylor and Hannan 1999:2–9). Weather in nine climate zones was described for the state of Oregon (Taylor and Bartlett 1993a–i). Mean annual precipitation ranged from 127–310 cm (50–122 in) in the Coastal Zone (Taylor and Bartlett 1993a) to 20–33 cm (8–13 in) in the Southeast Zone (Taylor and Bartlett 1993i). Highest monthly precipitation occurred in December and lowest precipitation in July, statewide. August was the warmest month west of the Cascades; July was warmest east. High mean maximum monthly temperature ranged from 26° C (79° F) in the Coastal Zone (Taylor and Bartlett 1993a) to 36° C (97° F) in the Southeast Zone (Taylor and Bartlett 1993i). The coldest month throughout Oregon was January. Low mean minimum monthly temperature ranged from -13° C (9° F) in the Northeast Zone (Taylor and Bartlett 1993h) to 2° C (36° F) in the Coastal Zone (Taylor and Bartlett 1993a). Current climate change predictions suggest that average temperature will rise, weather patterns will shift, severe storms and drought will increase, and average snow packs will shrink (Oregon Department of Energy 2009).

Habitat Diversity

The combination of size, location, landform, and climate within the state resulted in a high diversity of wildlife habitats in Oregon. The four major biomes of the world: arctic-alpine, desert, grassland, and forest occur in the state (Marshall et al. 2003). Ten distinct ecological regions were identified for Oregon (Loy et al. 2001:174), 70 vegetation and land cover types have been recognized (Loy et al. 2001:176), and 27 general wildlife habitat types have been mapped (Loy et al. 2001:187). As a result of the large variety of habitats, Oregon is home to nearly 800 vertebrate species of freshwater fishes and wildlife (Puchy and Marshall 1993), including abundant big game, upland game birds, waterfowl, and furbearing animals that are hunted or trapped (Oregon Department of Fish and Wildlife 2010b). Another 124 species of bony and cartilaginous saltwater fishes occur in the Pacific Ocean from the high tide line to a depth of 55 m (180 ft), an area that approximates Oregon's 4.8 km (3 mi) of ocean territory (Oregon Department of Fish and Wildlife 2006:27, 31, and App. J). In addition, domestic livestock are abundant and occur throughout the state (U.S. Department of Agriculture 2009).

Land Ownership and Forests

Land ownership in Oregon was 44% private, 25% U.S. Bureau of Land Management (BLM), 25% U.S. Forest Service (USFS), and 6% state, local, and other federal government (Loy et al. 2001:84). Bald eagles nest (Anthony and Isaacs 1989) and roost communally (Anthony et al. 1982) in forested habitats, so the amount and kind of forested lands in the state is important. Franklin and Dyrness (1973) described the vegetation of Oregon and Washington. Forestland covered nearly half (48.4%) of Oregon, and the primary forestland managers were USFS (47%), private land owners (35%), and BLM (12%). The remaining 6% of forested lands was managed by Oregon Department of Forestry (3%) and other federal, state, and local agencies (3%) (Oregon Forest Resources Institute 2009). Dominant tree species in forests varied by latitude, longitude, elevation, precipitation, temperature, and soil type. Western Oregon forests were dominated by Douglas-fir (*Pseudotsuga menziesii*), Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), grand fir (*Abies grandis*), red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and Oregon white oak (*Quercus garryana*). In contrast, eastern Oregon forests were dominated by ponderosa pine (*Pinus ponderosa*), Douglas-fir, lodgepole pine (*Pinus contorta*), sugar pine (*Pinus lambertiana*), incense-cedar (*Libocedrus decurrens*), white fir (*Abies concolor*), Shasta red fir (*Abies magnifica*), Englemann spruce (*Picea engelmannii*), mountain hemlock (*Tsuga mertensiana*), western larch (*Larix occidentalis*), western white pine (*Pinus monticola*), and western juniper (*Juniperus occidentalis*). Black cottonwood (*Populus trichocarpa*) was dominant in some riparian areas on both sides of the Cascades (Franklin and Dyrness 1973).

Shoreline

Bald eagles typically nest, roost, and hunt near or over major bodies of water so the amount of shoreline is a crude measure of the amount of habitat available to the species in the state. Oregon has an abundance of ocean, estuary, bay, lake, reservoir, and river shoreline. The Pacific Ocean forms the western boundary of the state with approximately 515 km (320 mi) of coastline and 1,853 offshore rocks, reefs, and islands (U.S. Fish and Wildlife Service 2009a). The coastline also includes 22 major estuaries (Oregon Coast Atlas 2009) with shoreline that is not measured as coastline or accounted for in river length measurements. The Columbia River forms 497 km (309 mi) of the northern border between Oregon and Washington, and over half of the eastern border of Oregon is delineated by 370 km (230 mi) of the Snake River and associated reservoirs. In western Oregon, minor tributaries of the Columbia (145 km or 90 mi), the Willamette (1,530 km or 951 mi), Umpqua (700 km or 435 mi), and Rogue rivers (401 km or 249 mi); and several other coastal rivers that flow into the Pacific Ocean (1,191 km or 740 mi) total 3,967 km (2,465 mi) of river shoreline. East of the Cascades, river lengths were not designated or were incomplete on U.S. Geological Survey (USGS) topographic maps for Middle Fork John Day, Wenaha, Lostine, Powder, Burnt, Malheur, Owyhee, Donner and Blitzen, Silvies, Chewaucan, Sycan, Williamson, Sprague, and Lost rivers. River lengths were mapped for the Hood (19 km or 12 mi), Umatilla (79 km or 49 mi), Deschutes and its major tributaries (801 km or 498 mi), Klamath (32 km or 20 mi), most of the John Day basin (558 km or 347 mi), the Grande Ronde (354 km or 220 mi), and the Imnaha (79 km or 49 mi), resulting in an incomplete total of 1,923 km (1,195 mi) of river length for eastern Oregon (river lengths from U.S.

Geological Survey 7.5 minute quadrangle topographic maps, U.S. Geological Survey, Reston, Colorado, USA).

Oregon has >6,000 lakes, reservoirs, ponds, marshes, and sloughs. There are >1,400 named lakes, and >60 reservoirs larger than 6.2 cubic hectometers (5,000 acre-feet) (Johnson et al. 1985:1). A total of 202 lakes ≥20 hectares (50 acres) and reservoirs ≥40 hectares (100 acres) occur in the state (Johnson et al. 1985:6).Shoreline length reported for 200 water bodies was 1,362 km (846 mi) for 95 lakes and reservoirs west of the crest of the Cascades, and 1,909 km (1,186 mi) for 105 in eastern Oregon (Johnson et al. 1985). A total of 10,543 km (6,551 mi) of rivers; ocean, freshwater lake and reservoir shoreline mostly occurs within 1.6 km (1 mi) of forest, thus it represents abundant potential nesting habitat for bald eagles.

Recovery Zones and Watersheds

The Pacific States Bald Eagle Recovery Plan delineated 47 recovery zones in Washington, Oregon, California, Nevada, Idaho, Montana, and Wyoming based on physiographic features, seasonal use by eagles, major land uses, and land ownership (U.S. Fish and Wildlife Service 1986:28-29). Eleven recovery zones were designated for Oregon and the Washington side of the Columbia River (U.S. Fish and Wildlife Service 1986:29). We modified the 11 recovery zones into 10 “watersheds”, which we used for analyses in this report (Fig 1). Recovery zone 16 was incorporated into zone 37 because the original boundary between zones 16 and 37 in Oregon arbitrarily divided the Owyhee Basin (U.S. Fish and Wildlife Service 1986:29). The boundary between zones 12 and 13 was adjusted so that 13 included all of the Umpqua River basin, and we included most of the Sandy River in zone 12 rather than zone 10 to be consistent with other major rivers flowing into the Columbia River. Name changes from recovery zone to watershed were: 9-Blue Mountains was renamed “Northeast”, 10-Columbia River was shortened to “Columbia”, 11-High Cascades was renamed “Deschutes”, 12-Willamette Basin was shortened to “Willamette”, 13-Oregon Coast and Umpqua Basin was renamed “Pacific”, 14-Snake River Canyon was shortened to “Snake”, 21-Harney Basin and Warner Mountains was shortened to “Harney”, 22-Klamath Basin became “Klamath”, 23-California/Oregon Coast was renamed “Rogue”, and 37-Great Basin was renamed “Owyhee” (Fig. 1).

Seven of ten watersheds were shared with neighboring states. The Northeast and Columbia watersheds included land in Washington; the Snake watershed was shared with Idaho and Washington; the Harney, Klamath and Rogue watersheds were shared with California; and the Owyhee watershed included most of Nevada and a small portion of northeastern California (Fig. 1). The Deschutes, Willamette and Pacific watersheds were entirely within the state of Oregon (Fig. 1). The Columbia was the only shared watershed where breeding areas in both states were included in our study area because the Columbia River corridor provided habitat for many nesting pairs, some breeding areas included portions of both states, and we monitored or coordinated monitoring of breeding areas on the Washington side of the river from 1996–2007. In addition, there have been concerns about the effects of environmental contaminants on the Columbia River subpopulation (Anthony et al. 1993, Buck et al. 2005). Watersheds were further subdivided into smaller areas (App. 4) for some analyses.

METHODS

Terminology

Our terminology and data summary methods were based on the definitions of Postupalsky (1974, 1983) who recommended standard terminology for describing status of nests and breeding areas, and criteria for calculating reproductive success. The basic reproductive unit for bald eagles is a breeding pair. The area used by a breeding pair for nesting and raising young has been referred to several ways: "territory", "breeding territory", "nesting territory", "breeding area", "nesting area", 'breeding site", "nest site", and "site" in different publications. The term "territory" implies an exclusively defended space within a species' home range (Lincoln and Boxshall 1990:377) and assumes occupancy. We did not determine defended spaces or home ranges for breeding pairs in our study area; however, home ranges were described for two breeding areas at Upper Klamath Lake (Frenzel 1988) and ten breeding areas on the lower Columbia River (Garrett et al. 1988, 1993). We used "breeding area", "nest site", or "site" interchangeably to describe the area with a bald eagle nest that was used or assumed to have been used by one breeding pair of bald eagles for nesting. We did not use the term "territory" except where appropriate by definition.

A bald eagle breeding area can have one or more nests. In rare instances, there may not be a nest present if the only nest fell apart or was destroyed, and a new nest had not been built. When there are multiple nests within a breeding area, they are referred to as "alternate" nests (Postupalsky 1983). In our study area, all the nests but one were in trees (n = 1,646); consequently, alternate nests were in the same tree or in different trees, so multiple nest trees within a breeding area were referred to as “alternate nest trees”. We classified nest trees as alternate in annual reports when another nest tree in the breeding area held a nest where there was evidence of eggs during a breeding season. The term alternate was applied on an annual basis, so a nest tree that was an alternate one year may have been used for egg laying in another year. This distinction is important because resource managers sometimes assume a nest tree has less importance if it was classified as an alternate. We considered all nest trees within a breeding area as equally important habitat components regardless of history of use by eagles because nest trees can be used for several years, vacated for one or more years, then used again.

Definition of the term "occupied breeding area” and criteria used to determine the number of young produced at occupied breeding areas are open to interpretations which can bias results of nest surveys. The term "occupied" has been applied in different ways by different authors, but it is usually refers to cases where nest trees were associated with pairs of adults (Postupalsky 1983). However, it often was difficult to determine the number of adults in a breeding area when nest checks were brief and few in number or when adults were away from the nest (Postupalsky 1983, Steenhof 1987). Consequently, we classified breeding areas as occupied based on the presence of one adult at or near a nest, and had six primary reasons for doing so: 1) many nest checks were brief, often less than one minute during air surveys, 2) some breeding areas were observed only twice during the nesting season, although follow-up visits usually were conducted when prior observations were inconclusive, 3) poor access and rugged terrain hampered ground searches for adults, 4) air searches for adults were time consuming, expensive, and dangerous in rugged terrain, 5) evidence of recent nest use was difficult to assess from the ground, especially by inexperienced observers, and from the air when nests were within the canopy of a live tree, and 6) only one adult often was observed, even at sites where young were in the nest. Consequently, the number of occupied sites in our study may have included a small portion of breeding areas with single, unpaired adults, so our estimates of population size may be biased slightly high, and nesting success and productivity may be biased slightly low in comparison to other published literature.

Ideally, nesting success and productivity are based on the number of young raised to fledging (Steenhof 1987); however, there can be difficulty in determining how many young fledge when surveys involve only two visits per breeding area per year (Postupalsky 1983, Steenhof 1987). Consequently, Postupalsky (1983) recommended counting young when adults are no longer brooding consistently and young are large and partly-to-fully feathered. We determined the number of feathered nestlings rather than the number of fledglings. Occasionally, downy nestlings were present during the last scheduled visit to a site. When this happened, we included the downy chicks in the number of young produced or made a final determination of the number of young at a later date with additional monitoring.

Protocol

We monitored the nesting population of bald eagles in Oregon and along the Washington side of the Columbia River annually for 30 years (1978–2007). The 1978 survey was conducted by Marianne Fierstine, graduate student at Oregon State University, and the second author based on lists of known and suspected nest sites compiled from agency files and provided by persons monitoring local populations.

Subsequently, we conducted annual surveys with help from cooperating resource managers and volunteers. Each annual survey began with the list of breeding areas compiled the previous year. We attempted to monitor all breeding areas listed the previous year, find new nests, and confirm and catalog new nests reported by others annually.

Isaacs et al. (1983) described methods used to initiate the project and conduct surveys from 1978–1982. Long-term continuity and consistency were maintained throughout the study because we coordinated the project and conducted field work during all years. The authors and others employed to work on this or related projects made most of the observations at nest sites early in the study (e.g., 87% of 620 observations in 1980). Our proportion of observations declined to 30% in 2007 (n = 2,388) as the number of nest sites increased and we relied more on experienced cooperators in order to expand survey coverage and complete the survey on time. For example, 341 people contributed to the survey in 2007 vs. ~35 in 1978. The annual number of observations at nest sites increased from 292 in 1978 to 2,388 in 2007. Observations from 1971–1977 were provided by experienced cooperators that monitored breeding areas prior to this study and were included in our data set if they contained useful data on breeding areas confirmed and monitored during this study.

Ninety-two percent of 31,870 observations cataloged for 1971–2007 occurred from 1 March through 31 July (App. 5). The average number of observations per breeding area surveyed was 3.6 (n = 9,281 breeding areas surveyed), which was higher than the minimum of two visits per breeding area per year recommended for monitoring nesting bald eagles (Postupalsky 1974, 1983, Steenhof 1987:161). Additional visits were needed to determine status at some sites, and some sites were checked more than necessary during one or more breeding seasons for management purposes, convenience, or because of observer interest.

We attempted to monitor the entire nesting population annually rather than survey a representative sample because we often were asked about the breeding status at nests by resource managers or landowners who needed the information to comply with federal (U.S. Department of the Interior 1978) and state ESA regulations (Oregon Department of Fish and Wildlife 1997), Oregon Forest Practices Rules (Oregon Department of Forestry 1997), or Washington Bald Eagle Protection Rules (Stinson et al. 2007:71, 77). We could not predict which nest trees would be involved in land management activities in a given year, so we wanted to know the location and condition of nest trees, and nesting status at as many breeding areas as possible annually. As the nesting population increased, we were forced to modify our methods in order to complete surveys on time. Survey schedules, use of experienced volunteers and biologists from other organizations, areas covered by air and ground surveys, record keeping systems, ways of collecting reports from cooperators, and annual data summary methods were adapted to fulfill our objectives.

History of nest tree use, nesting success, and productivity were recorded by nest tree and breeding area (Isaacs and Anthony 2008). Nest trees received unique numbers in chronological order as they were confirmed and cataloged in order to facilitate accurate and consistent record keeping. Breeding areas and nest trees also were named, usually after local geographical features. Names were the primary site identifiers used in field notes and communications with cooperators. Names of breeding area were useful in managing the survey, while breeding area and nest tree numbers were essential for managing the data over many years.

The survey protocol for checking nests from land or water (App. 6) was provided to cooperators annually, early in the nesting season (~mid February). Cooperators were asked to provide details on their observations rather than their interpretation of the data. This enabled us to review observations and keep interpretations consistent and resulted in an archive of original observations (Postupalsky 1983) that future researchers may find useful. We encouraged observers to report the breeding area name, survey date, observer name and their contact information, survey method (ground, boat, fixed-wing aircraft, helicopter), nest tree number if there was evidence of eggs, eagle use of nest [e.g., new material, nest building behavior, eagle in incubating posture, etc.], number of adults observed, number of nestlings observed, and plumage status of nestlings. Plumage status was categorized as: downy (0 to ~4 wk); partly feathered (~4 to ~7.5 wk); feathered (~7.5+ wk); and fledged, through year 2001. After 2001, we requested that observers age nestlings using plumage classes described by Carpenter (1990) (App. 7). In addition, we asked for details on nest and nest tree condition, age of other eagles observed, behavior of all eagles observed, and any other observations pertinent to bald eagle ecology. Nest site names and nest tree numbers were from the most recent annual report (Isaacs and Anthony 2008). Cooperators were asked to provide accurate maps or global positioning system (GPS) coordinates and datum for nest trees that had not been documented previously. We recorded similar eagle and nest tree information in field notes when checking nests from land or water, and we searched for and mapped new nests during ground and aerial surveys.

Aerial surveys of most of the study area were conducted in fixed-wing aircraft (Cessna 172, 180, or 185) from 1978–1989. For safety reasons, helicopters (Bell 206B and Bell 206L) were used from 1990–2007 for portions of the study area. Air surveys usually were flown twice per breeding season. The first, or “occupancy” survey was timed to coincide with incubation, and the second, or “productivity” survey was timed to count nestlings before fledging. In general, we followed the guidelines of Watson (1993), who recommended moving approaches rather than hovering, staying >60 m (200 ft) from nests and eagles, and keeping time at nests to <10 seconds. We followed those recommendations as much as possible to keep any disturbances as a minimum. Aerial surveys were conducted by a pilot and 1-5 (usually 1-3) observers. The number of observers varied with aircraft size and personnel available. All passengers observed nests by eye or with binoculars, counted the number of eagles and searched for nests.

Air survey coverage varied by year (App. 8). Initially, most nests were checked by air then follow-up visits were made on the ground. As the nesting population increased and the distribution of breeding areas widened, we used air surveys to check areas with large concentrations of nests or difficult access (e.g. lower Columbia River), while ground surveys were used to visit sites not checked by air and to follow-up on inconclusive aerial surveys. Aerial surveys by helicopter were the most efficient method of monitoring, especially where access was difficult or many breeding areas were close together.

Timing of aerial and ground surveys initially was based on similar surveys conducted in Washington (Grubb et al. 1975), then was modified slightly to fit nesting chronology in Oregon (Isaacs et al. 1983). Occupancy surveys (App. 8) were flown circa

1 April when most breeding pairs were incubating. Productivity surveys were flown close to 1 June when many nestlings were feathered and before fledging began. Field notes were hand written or recorded on a digital voice recorder then transcribed. Information recorded included: time of day, breeding area name, nest tree number, number and age of eagles observed, nest status, plumage development of nestlings, locations of previously undocumented nest trees, and other pertinent information. When a digital voice recorder was used by the primary observer, another observer wrote brief notes on breeding area status as a back-up in case of voice recorder failure.

Data Management and Analyses

Data management was an essential intermediate step between data collection during field work and publishing annual reports. Year-to-year data management was also important and was complicated by changing technologies (e.g., note cards to personal computer spreadsheets for record keeping, etc.), refinements in definitions and protocol of monitoring, increasing eagle population, and the increasing number and wide range of experience of contributing observers.

Information from each observation at a breeding area became one record of a spreadsheet. If a breeding area was checked more than once in a day, the observations were combined into one record that best described the status of the site on that day. When sorted by breeding area number then date, the records were used to track survey progress and characterize nesting success and productivity at the end of the breeding season. Each record had 12 primary fields and additional fields for recording observer names and affiliations (App. 9).

At the end of each nesting season, observation records provided nesting status and productivity for each breeding area. Codes for status and productivity from the observation that described the outcome of nesting attempts were transferred from the observation spreadsheet to the outcome spreadsheet, which contained one record per breeding area. Each record had fields for the year the breeding area was confirmed, geographic area based on recovery zone, breeding area number, breeding area name, and each year from 1971 to 2007. Number of occupied breeding areas or years occupied, nesting success, and number of young produced per occupied breeding area with known outcome or per year occupied (App. 10) were the primary statistics used to compare occupancy and productivity among years, breeding areas, watersheds, and other subpopulations.

Annual reports described nest tree locations and nesting histories, and summarized population and productivity data (Isaacs and Anthony 2008). For each nest tree, we listed county, location (township, range, section, quarter section), recovery zone, site number, nest tree number, nest tree name, landowner, and history of use by year. Private landowners, federal and state agencies, Oregon Natural Heritage Information Center (2009), and private consultants used the annual report as a reference for information on breeding areas and their locations for Oregon.

Population Size

The number of occupied breeding areas reported annually was our minimum estimate of the size of the breeding population. The minimum number of individuals in the breeding population was estimated as two times the number of occupied breeding areas, assuming two breeding-age eagles per breeding area. Estimates were minimums because we did not know the locations of all occupied breeding areas and the population of individual bald eagles included non-breeding adults and subadults that were not counted. We also computed the percent of breeding areas that were occupied and population growth rates for comparisons between watersheds and other subgroups. Population growth rates were calculated using the formula $r = [\log(N_t / N_0)] / t$, where r was the annual rate of growth, N_t was the population at time t (2007), N_0 was the initial population size (1978 unless indicated otherwise), and t was the number of years (Caswell 2000). Population growth and occupancy by watershed were analyzed with linear regression and simple Chi-square tests, respectively.

Juveniles, subadults, near adults and non-breeding adults, collectively called non-breeders, comprised another segment of the population during the breeding season. Non-breeding eagles can be classified into one of six plumages (McCollough 1989): (1) Juvenal - 1/2 year, (2) Basic I - 1 1/2 year, (3) Basic II - 2 1/2 year, (4) Basic III - 3 1/2 year, (5) Basic IV - 4 1/2 year, and (6) Definitive (Adult). Distinguishing plumage classes often was impossible in the field because of short observation time during aerial surveys, poor light conditions, poor visibility, and non-breeding adults could not be distinguished from breeding adults. Instead, we classified non-adult eagles into different categories based on the circumstances of the observation. The broadest groupings were subadult and adult, where subadults were any bird not in adult plumage (McCollough 1989: categories 1-4 or 5). Narrower groupings were possible when juveniles (McCollough 1989: categories 1 or 2) or near adults (McCollough 1989: categories 4 or 5) could be distinguished from other subadults (McCollough 1989: categories 2-4). McCollough (1989:6) found that some individuals as old as 8 1/2 years had dark feathers in their head plumage; consequently, we could have categorized some adults as near adults based on that characteristic. To avoid classifying adults as near adults and keep observer bias to a minimum, we limited the analysis of the relative abundance of non-adult bald eagles to McCollough's (1989) Juvenal and Basic I-III plumaged birds, which were recorded by the first author during field work from the ground. Those four plumage classes were grouped as subadults, and the relationship of the number of subadults observed per breeding area (y) with respect to year of survey (x) was analyzed with linear regression.

Distribution

Distribution of breeding areas was based on locations of nest trees and history of use by eagles. Nest tree locations were marked originally on 7.5' quadrangle USGS topographic maps. When Global Positioning Systems (GPS) became available, locations of new nest trees were based on GPS coordinates collected at or above nest trees with handheld or aircraft mounted GPS units. Locations of nest trees that were inaccessible and not surveyed by air were estimated by triangulation from known observation points.

One or more nest trees known or assumed to be used by one breeding pair of bald eagles for nesting during one or more breeding seasons were considered to be within one breeding area. Distances between nest trees within breeding areas were determined using NAD27 Continental U.S. Universal Transverse Mercator coordinates (UTMs) for each nest tree and the Pythagorean Theorem. The location of the first nest tree discovered in each breeding area was mapped to show the distribution of breeding areas on the study area and within watersheds. Changes in distribution over time were depicted by maps of occupied breeding areas at 10-year intervals. Changes in distribution by watershed and location west or east of the Cascade Mountains were analyzed with simple Chi-square tests on frequencies from 1978–2007.

Nesting Phenology

Nesting phenology was based on earliest and latest dates reported or calculated for incubation, hatching, and fledging. An incubation period of ±35 days, fledging at 8-14 weeks, and post-fledging care followed by dispersal at 2–11 weeks were based on Buehler (2000:17–19). More details on nesting phenology were derived from observations. Records with known dates were divided into successful or failed breeding attempts based on the outcomes of annual surveys.

Records from successful nesting attempts were grouped into five-day periods from 1 January through 2 September and 30-day periods from 3 September through 31 December because the number of observations was small for the latter time period. Records from failed nesting attempts were grouped similarly, except the five-day periods ended on 3 August and 30-day periods began on 4 August. Records from 29 February were included in the 25 February through 1 March period. If there was more than one record for a breeding area in the same year within a 5-day or 30-day period, only one record for that period was used. If status was the same for all the repeat records, then status for the first record was used. If the status was different, then the record with the most advanced nesting status was used. For example, “two breeding-age eagles and a nest” were more advanced or definitive than “possibly occupied - not enough information to be certain”.

Records for nesting successes and failures were summarized as occupied, having evidence of eggs, having eaglets, or eagles undetected, and the proportion of observations for each of these categories was calculated and graphed for each 5-day and 30-day period. Those results were used to compare breeding status between successful and failed nesting attempts, time periods (e.g., 1971–1992 vs. 2003–2007), and regions (e.g., west of the crest of the Cascade Mountains vs. east of the crest) for successful nesting attempts. The proportion of occupied sites where eagles or eaglets were not detected also was compared by 5-day and 30-day periods for successes and failures.

Timing of nestling development was derived from records of successful nesting attempts by calculating proportions of records by four plumage categories for five-day periods from 11 April–8 August. Three of the categories were based on the seven plumage stages for nestlings described by Carpenter (1990) (App. 7): downy (stages 1a-2), partly feathered (stages 3a and 3b), and feathered (stages 3c and 3d). The fourth category, fledged, consisted of eaglets that had flown from the nest tree at least once.

Productivity

Nesting success and productivity have been used routinely to assess reproductive success of bald eagles (Stalmaster 1987: 132–143). Both parameters require determining if breeding pairs succeed or fail to raise young. Nesting success and productivity of the population were based on the number of occupied breeding areas where outcomes of breeding attempts were known. Likewise, nesting success and productivity for individual breeding areas were based on the number of years of occupation with known outcome. Nesting success occurred when young were hatched and known or assumed to have survived to fledging, and was expressed as a proportion of total occupied breeding areas with known outcome that raised at least one young.

We measured productivity as the number of young produced per occupied breeding area and brood size as the number of young produced per successful breeding attempt. Young per occupied breeding area included all occupied sites with known outcome, and young per successful breeding area excluded all failed nesting attempts. Corresponding statistics for individual breeding areas were young produced per years occupied with known outcome and young produced per years successful.

Abandoned Breeding Areas

During each breeding season there were breeding areas that were not occupied. Some were designated “unoccupied” when the survey protocol was met, while others were classified as “occupation unknown” because of inadequate timing and/or number of visits. We selected the breeding areas that were not occupied in 2007 and quantified their monitoring history prior to 2007. Breeding areas that were monitored to protocol and classified as unoccupied for ≥1 year after they were last occupied, potentially were abandoned. However, breeding areas classified as unoccupied one year often were occupied the next. Consequently, we used the probability that a breeding area would remain unoccupied to develop criteria for classifying a breeding area as abandoned.

Aquatic Features Associated with Breeding Areas

Each breeding area was grouped into one of seven categories based on the nearest water body where the adults most likely hunted. Most sites fit into one of six categories: estuary, natural lake, marsh, ocean, reservoir, or river. Breeding areas where the primary hunting area was uncertain or unknown were combined into a seventh category called “atypical”. Rate of population growth, breeding area occupation, and productivity were calculated and compared among these categories. Simple Chi-square tests were used to evaluate changes in population size, and differences in occupancy and nesting success.

Band Returns and Marked Eagles

From 1979–1983, 143 nestling bald eagles from the Klamath and Deschutes watersheds were banded with standard USFWS leg bands, and auxiliary leg bands and/or patagial wing markers were attached to some (Frenzel 1984). In 1986, an additional 14 nestlings from the Columbia watershed were banded with USFWS leg bands (Garrett et al 1988:88). Subsequently, we received reports on individuals from those banding efforts that were found dead or injured and reported to us or the Bird Banding Laboratory, U. S. Geological Survey, Laurel, Maryland. Those reports enabled us to determine age at death based on hatching on 1 April of the year banded, and provided encounter locations for each recovered resident eagle. We determined the distance from the banding location to the encounter location by measuring the straight-line distance between those points on U.S. Geological Survey, 7.5-minute-quadrangle, topographic maps, or from Google Earth satellite imagery (Google 2010). Age at death and distance from banding location to encounter location were compared between resident adults (≥5 years old) and subadults (<5 years old), and distances for encounters during the breeding season (February-August) were compared to distances for encounters outside the breeding season (September-January) within and between age classes.

Bald eagles from other western U.S. states, Canada, and Mexico, variously were banded, color-marked, and/or equipped for satellite and/or conventional telemetry by other researchers (e.g., McClelland et al. 1994:12, Linthicum et al. 2007). We referred to those birds as non-residents when they were reported in Oregon. We collected reports of marked resident and non-resident eagles that were encountered on our study area, opportunistically (App. 12). Origin, encounter date, age class (subadult or adult), encounter location, marker type, and condition and status were recorded for each bird reported. Month of encounter, encounter location, age, and origin were summarized for non-residents, and origins were compared with recovery locations of banded residents.

Columbia River Segments

The Columbia River was divided into seven segments for some analyses based on ecological attributes:

Segment 1 - River miles 0–13 (0–21 km) extended from the Columbia River mouth at the Pacific Ocean to the Astoria-Megler Bridge. Hunting opportunities for bald eagles were not limited to the Columbia River and Baker Bay because of the coast-ocean interface, proximity to Willapa Bay in Washington; lakes on the Clatsop Plains; and the Skipanon, Lewis & Clark, and Young's rivers; and Young's Bay in Oregon. This segment had strong tidal influence with extensive mudflats exposed at low tide and few permanent islands. River width was approximately 5–8 km (3.1–5.0 mi).

Segment 2 - River miles 13–31 (21–50 km) included the Astoria-Megler Bridge to Aldrich Point, OR, and much of Lewis & Clark National Wildlife Refuge (NWR) in Washington. Hunting areas for eagles primarily were the Columbia River, and Cathlamet and Grays bays. This segment also had strong tidal influence and extensive mudflats. Permanent islands with narrow channels and sloughs were a prominent feature of this river stretch especially along the Oregon shore upstream from Tongue Point. River width was mostly approximately 6–15 km (3.7–9.3 mi), but narrowed to approximately 3.5 km (2.2 mi) at the upstream end.

Segment 3 - River miles 31–47 (50–76 km) included Aldrich Point to the upstream end of Puget Island and the upstream end of Lewis & Clark NWR and Julia Butler Hansen NWR. The Columbia River was the primary hunting area for eagles. This stretch was the upper end of saltwater influence. Large permanent islands with narrow channels and sloughs predominated, and river channels were approximately 0.5–3.5 km (0.3–2.2 mi) wide.

Segment 4 - River miles 47–86 (76–138 km) included the upstream end of Puget Island to the downstream end of Sauvie Island including the confluence of the Cowlitz River. Hunting opportunities for eagles included the river channel and narrow channels and sloughs associated with islands and lowlands along the river. The main river channel was approximately 0.75–2.0 km (0.5–1.2 mi) wide.

Segment 5 - River miles 86–106 (138–171 km) included the downstream end of Sauvie Island to near the Interstate 5 bridge between Portland, Oregon and Vancouver, Washington. Hunting areas included the river channel, Ridgefield NWR, Sauvie Island Wildlife Management Area, Multnomah Channel, Vancouver Lake, and the confluences of the Lewis and Willamette rivers. The Columbia River channel was relatively narrow, approximately 0.5–1 km (0.3–0.6 mi), and uniform in width in this segment.

Segment 6 - River miles 106–146 (171–235 km) included the Interstate 5 bridge to Bonneville Dam, which was the upstream end of tidal influence. Hunting opportunities primarily were along the Columbia River including islands and riverside lowlands with sloughs and narrow channels. Steigerwald Lake, Franz Lake, and Pierce Island NWRs and the confluence of the Sandy River were within this segment. River width was approximately 0.25–2.0 km (0.16–1.2 mi).

Segment 7 - River miles 146–309 (235–497 km) included Bonneville Dam to where the river flows out of Washington. This segment consisted of four large reservoirs formed by Bonneville, The Dalles, John Day, and McNary dams; Lake Bonneville or Bonneville Reservoir, Lake Celilo, Lake Umatilla, and Lake Wallula, respectively, and included Umatilla NWR. The reservoirs generally were wide and deep with few islands. Several major rivers entered the Columbia in this segment and formed shallow deltas. Natural and manmade lakes and ponds, fish hatcheries, and dam tailraces provided additional hunting opportunities. River width ranged from 0.2–4.8 km (0.1–3.0 mi).

Previous research (Anthony et al. 1993, Buck et al. 2005) and annual survey results (Isaacs and Anthony 2008) indicated that nesting success and productivity varied along the Columbia River. We compared those parameters by state, river segment and river mile by simple Chi-square tests on frequencies to quantify the differences and locate individual and groups of breeding areas with low productivity. The relationship of productivity (y) to river mile (x) was tested with linear regression.

Density of Breeding Areas

Density of breeding areas was calculated to investigate any evidence of density dependent effects on productivity. Seven water bodies with similar nesting habitats, similar and shared hunting areas, and nesting populations with ≥5 occupied breeding areas were selected for this investigation. The seven water bodies fitting those criteria were: 1) Columbia River estuary - Pacific Ocean to river mile 146 below Bonneville Dam, 2) Odell Lake, 3) Crane Prairie and Wickiup reservoirs, 4) Lake Billy Chinook, 5) Willamette River - Columbia River confluence to river mile 185 in Eugene, 6) Umpqua River - Pacific Ocean to river mile 120 in Roseburg, and 7) Upper Klamath and Agency lakes. The Upper Klamath and Agency lakes region was further subdivided into two areas, 7a) Spence Mountain-Eagle Ridge (west side of Upper Klamath Lake) and 7b) Upper Klamath and Agency lakes excluding Spence Mountain-Eagle Ridge.

Nesting density was based on the number of breeding areas per length of shoreline or river. Reservoir and lake shoreline lengths were adopted from Johnson et al. (1985), and river lengths were from USGS 7.5 minute quadrangle topographic maps (U.S. Geological Survey, Reston, Colorado, USA). Shoreline length of the Columbia River estuary was estimated by tripling the river mile length because most of the estuary was wide enough for breeding areas to occur on opposing shorelines; and islands, bays, channels and sloughs were common along some stretches of river. Shoreline length of Spence Mountain-Eagle Ridge was determined by direct measurement on USGS 7.5 minute quadrangle topographic maps (U.S. Geological Survey, Reston, Colorado, USA). Length of shorelines or rivers was divided by number of occupied breeding areas for each year there were ≥5 occupied breeding areas. This served as an index to density of breeding populations in these areas. Rate of population growth, shoreline or river length per occupied breeding area, and productivity were used to evaluate the potential for density-dependent affects by water body. The relationship of productivity (dependent variable) to length of shoreline per occupied breeding area (independent variable) for each water body was evaluated with linear regression.

Distance from Water and Elevation of Breeding Areas

Distances from breeding areas to associated water bodies were determined from 7.5' quadrangle USGS topographic maps based on the location of the most recently used nest tree from the 2007 survey. Distance from water was the horizontal, straight-line distance from the nest tree to the edge of the closest mean high water line of the nearest permanent body of water. Breeding areas that were associated with permanent aquatic habitats that were known or assumed to be the primary hunting areas of breeding pairs were classified as “typical”. Distance from water was not determined for breeding areas where the primary aquatic hunting areas were unknown or suitable aquatic habitat was not evident on maps or from ground surveys. Aquatic hunting areas for these sites were assumed to be distant, dispersed, intermittent, or nonexistent, and these breeding areas were classified as ”atypical”.

Elevations of breeding areas were determined from 7.5' quadrangle USGS topographic maps based on the location of the most recently used nest tree from the 2007 survey. Elevation was the distance above sea level of the land surface at the base of the nest tree. Occupancy rates and productivity of breeding areas were compared by elevation statewide, and within and between regions. The Mann-Whitney U-test was used to test distance from water of breeding areas east vs. west of the Cascades, and the relationship of productivity (dependent variable) to distance from water (independent variable) by watershed was determined with linear regression.

Historical Breeding Population

We created a simple hypothetical model of size of the breeding population before 1978 by utilizing a circa 1800 estimate of the number of breeding areas based on the following assumptions: 1) the prehistoric nesting population was at carrying capacity, 2) the initial number of breeding areas was roughly equal to our circa 1800 estimate, 3) there was a continuous decline in occupied breeding areas from the early 1800s to the 1970s due to shooting, poisoning, trapping, habitat loss, and prey depletion that corresponded with exploration, settlement, and development by white European and American immigrants and their descendants, and 4) environmental pollutants and pesticides introduced after World War II interfered with reproduction and increased the rate of mortality and population decline in affected areas.

We estimated the number of breeding areas that might have been found in Oregon and along the lower Columbia River circa 1800 based on our knowledge of nesting habitat, eagle population density in 2007, and local information on home range size (Frenzel 1988, Garrett et al. 1988, 1993). Circles approximately 3.2 km (2 mi) in diameter representing breeding areas (1 circle = 1 breeding area) were drawn on a 1:500,000 scale USGS topographic map of Oregon. Circles nearly touched in areas where we found the densest breeding populations (e.g., Columbia River below Bonneville Dam, coastal estuaries, Pacific coast headlands near seabird colonies, Upper Klamath Lake, Odell Lake) resulting in breeding area centers approximately 3.2 km (2 mi) apart. Circle centers were approximately 6.4 km (4 mi) apart along lower stretches of major rivers (e.g., Columbia, Umpqua, Rogue, Willamette rivers) and became progressively further apart as river size decreased upstream. Natural lakes that apparently did not have fish populations prior to 1800 (e.g., Waldo Lake, Crater Lake, East Lake, Paulina Lake), reservoirs built since 1800 (e.g., Dorena, Cottage Grove, Fall Creek, Unity, Phillips, Fern Ridge, etc.), and islands in the Columbia River that probably did not exist or lacked large trees because of seasonal flooding were not included in the estimate. Circles were counted to produce a minimum estimate of the number of breeding pairs. This minimum estimate was doubled to produce a maximum estimate because breeding areas in some regions in 2007 were closer than 1/2 the distances used to estimate the circa 1800 distribution of breeding areas.

Mate Changes at Breeding Areas

Mate changes within breeding pairs were impossible to detect with our survey methods when eagles in adult plumage may have replaced those in the same plumage. However, mate changes most likely occurred when eagles in subadult or near-adult plumage were observed engaged in breeding behavior at a breeding area where both individuals were in adult plumage the previous year. We recognized the possibility that eagles in subadult or near-adult plumage may have been experienced breeders and retained pre-definitive plumage characteristics as described by McCullough (1989); consequently, we minimized that possibility by limiting the analysis to breeding areas where breeding pairs in adult plumage were reported earlier in the nesting season of, or the year before, the apparent mate change, or where the new mate was obviously in a subadult or near-adult plumage. The first year that a subadult or near-adult eagle was observed in a breeding area was considered the year of the mate change. Productivity was calculated for five years before the mate change, the year of the change, and five years after the change, then the frequencies of each were compared among years by simple Chi-square test.

Nest Building and Copulation

Observations of nest building and copulation were taken from field notes and reports, grouped by month and nesting outcome, and used as relative indicators of those behaviors. Nest building, nest repair, and nest adornment, collectively were referred to as nest building because it was difficult to distinguish those activities in the field or from second-hand reports. Simple Chi-square tests were used to quantify and compare monthly differences in the frequency of nest building and copulation.

Nest Trees, Nests, Gaps in Use, and Nest Tree Changes

Type (coniferous or deciduous), species, and condition (alive or dead) were recorded for many nest trees. Nest tree types were compared between years and watersheds. Nest tree species not reported previously (Anthony and Isaacs 1989) were documented, and nest tree condition when nests were built was quantified. The relationships between nest tree condition and nest presence, and eagle productivity were examined by comparing productivity from five years before to five years after nest trees died.

Histories of nest tree use for breeding by bald eagles (Isaacs and Anthony 2008) were used to quantify use and loss of nests and nest trees within breeding areas. Cumulative number of nest trees per breeding area, status of nests and nest trees, number of nest trees existing per breeding area, gaps in use of nest trees and breeding areas, and gaps in presence of nests in trees were used to show the dynamics of use and reuse of nest trees. Minimum nest longevity was determined from nests with no gaps in presence in the nest tree and that no longer existed in 2007. Nest survival was estimated from the percentage of nest trees discovered each year of the project that still held nests in 2007.

Changes in use of nest trees between years and within breeding areas occurred when bald eagles occupying a breeding area moved their center of breeding activity from a nest in one tree to a nest in another tree. Nests were considered to be the center of breeding activity when the nesting outcome for the year included evidence of eggs (adult in incubating position, egg(s) or nestlings). Consequently, a change in nest tree was assumed to have occurred when the nest tree with evidence of eggs changed between years.

Changes in use of nest trees occurred from one year to the next or over longer periods of time (≥2 years) depending on when evidence of eggs was reported. All nest tree changes were used to quantify frequency of change for the population and within breeding areas. The relationship of nest occupancy and productivity (dependent variables) to frequency of nest tree changes (explanatory variable) within breeding areas was examined with linear regression. Changes in consecutive years were analyzed to investigate year-to-year differences in nesting success and productivity around nest tree changes with and without nest loss. Number of successful breeding attempts and number of young produced before and after nest changes with and without nest loss were compared with simple Chi-Square tests.

New Breeding Areas

New breeding areas were documented each year; however, the years that breeding areas were first established usually were unknown. We reviewed nest tree histories for new breeding areas where the first nest tree reportedly was built since the previous nesting season and assumed that those breeding areas were established that year. Productivity and nesting success were calculated and compared with simple Chi-

Square test for the year the first nest was reported and the following five years for all new breeding areas combined.

Other Species and Bald Eagle Nests

We recorded instances of other species associated with and using bald eagle nests either by building nests that eagles subsequently used or by using nests originally built by eagles. Species, occurrence, circumstances, and unusual events were summarized and described.

Ownership of Nest Trees

Ownership of land where nest trees occurred was determined from various maps showing boundaries between public and private lands. Private landowners were not identified specifically, so they were grouped into a single category. Nest trees on public land were located on land managed by local, state, and federal agencies. The public agencies responsible for managing the land with nest trees were identified. Ownership was summarized by nest tree and by breeding area for watersheds and by state. Breeding areas with more than one nest tree and more than one landowner were classified as “multiple” ownership. Population growth, occupancy rates, and productivity were compared between private and public landowners. Mann-Whitney U-tests were used to compare reproductive success by elevation of public versus private breeding areas east and west of the Cascades. Student’s t-test was used to compare productivity between public and private ownerships, and Simple Chi-square tests on frequencies were used to evaluate number of successful breeding attempts and number of young on private and public lands.

Population Size by Month

There were no year-round statewide inventories of bald eagles in Oregon. Consequently, we could not estimate monthly population size numerically. Instead, we modeled relative abundance by month based on other direct and indirect evidence, which included our knowledge of nesting and wintering populations, timing of movements of marked individuals to and from the state, observations from people who watched breeding areas year-round, and reports from Oregon Birds OnLine (OBOL, an e-mail discussion list server about bird watching in Oregon sponsored by Oregon Field Ornithologists http://www.oregonbirds.org/ 3 November 2010). Reports of bald eagles for Oregon posted on OBOL were counted and averaged by month for 1996-2001 and 2007 to portray relative abundance by month from a birder's perspective.

The model population was comprised of two groups: residents, eagles fledged from nests in Oregon and along lower Columbia River and non-residents, eagles fledged from nests in other western states, Mexico, or Canada. The resident population included nestlings, juveniles, subadults, and adults; non-residents were juveniles, subadults, and adults. Population sizes of residents and non-residents were adjusted monthly relative to the January population size based on the following assumptions: 1) roughly half the Oregon population was resident and half non-resident in early January; 2) the population of non-residents was highest in February or early March; 3) the non-resident population was lowest in June, when non-resident eagles were at breeding areas outside the study area; 4) the resident population increased by approximately 50% with hatching of nestlings during March, April, and May; 5) non-resident eagles that nested north of Oregon left later in the spring and arrived later in the fall than non-resident eagles that nested south of Oregon; 6) non-resident adults tended to leave earlier than non-resident juveniles and subadults; 7) approximately half the residents were present year-round and half left the study area in late summer and early fall; and 8) most residents that left the study area had returned by early January.

Year-To-Year Nesting Outcomes

One outcome of a breeding attempt was assigned to each breeding area for each year the breeding area was surveyed from 1971–2007 (Isaacs and Anthony 2008). Six outcomes were definitive: 1) 3 = successful with three young, 2) 2 = successful with two young, 3) 1 = successful with one young, 4) OCEF = occupied with evidence of eggs and failed, 5) OC2F = occupied by two breeding-age eagles without evidence of eggs and failed, and 6) OC1F = occupied by at least one breeding-age eagle without evidence of eggs and failed (Apps. 13, 14A & 14B). A seventh category designated as "Other" included all undetermined and unoccupied outcomes (Apps. 13, 14A & 14B).

Results of breeding attempts for consecutive years within breeding areas were grouped into year-Y and year-Y+1 pairs. Proportions were calculated for each of the seven possible Y+1 results (outcomes) for each year-Y group. Results were tabulated by year-Y group to show how distribution and proportion of year-Y+1 results were related to the corresponding year-Y results. Broad categories of success and failure were evaluated by combining the three categories of nesting success (3, 2, and 1) and the three categories of nesting failure (OCEF, OC2F, and OC1F). Proportions were calculated for success followed by success, success followed by failure, failure followed by success and failure followed by failure; and frequencies were compared with simple

Chi-square test. Finally, frequencies of year-Y+1 results for the six definitive outcome categories were compared by simple Chi-square test.

RESULTS

Population Size

The number of breeding areas surveyed and occupied in Oregon and along the lower Columbia River increased 602 and 738%, respectively, from 1978–2007 (Fig. 2). The number of occupied breeding areas, which was our minimum population estimate for the study area, increased from 66 to 553 breeding pairs (65 to 496 in Oregon and 1 to 57 in Washington) over the 30-year period (Table 1). There was an exponential increase in the breeding population (Fig. 2, $y = 77.927e^{0.0684}x$, $r = 0.995$, $p < 0.01$), which represented an average annual growth rate of 0.073 or 7.3% per year (Table 2). This increase was due to the addition of new breeding areas ($r = 0.813$, $p < 0.01$, Fig. 3A) and the increase in the percent of breeding areas that were occupied ($r = 0.831$, $p < 0.01$, Fig. 3B). For example, there were 85 occupied breeding areas in 1979 including 15 that previously were undocumented, and 76% of total breeding areas (n = 112 surveyed) were occupied. In contrast, 553 occupied breeding areas were found in 2007 including 31 that were previously undocumented, and 88% of all breeding areas surveyed were occupied (n = 632).

Breeding populations increased in all watersheds; however, the rate of increase varied from 0.048–0.147 with the largest increases in the Columbia and Willamette watersheds (Table 2, Fig. 4, App. 15). Watersheds with <10 occupied breeding areas at the beginning of the study (e.g. Willamette and Columbia) exhibited higher growth rates than those with ≥10 breeding areas (e.g., Klamath and Deschutes). There was a negative correlation between the rate of population growth and the initial population size among watersheds (r = -0.761, p = 0.018, Fig. 5). The proportion of breeding areas occupied ranged from 71% in the Northeast watershed to 92% in the Rogue watershed and averaged 86% for the study area (Table 3, App. 16). Percent of breeding areas occupied varied significantly among watersheds (X^2 = 15.739, 8 df, p = 0.047) because of the low occupancy rates in the Columbia and Northeast regions (Fig. 6).

The minimum number of individual bald eagles in the breeding population at the start of the nesting season was assumed to be the number of occupied breeding areas multiplied by two breeding age birds for each breeding area. Therefore, the minimum size of the breeding population in 2007 was estimated to be 1,106 breeding-age individuals based on 553 occupied breeding areas (Table 1). In addition to the breeding population, non-breeding adults and subadults (including juveniles) were recorded. The proportion of subadults in the sample increased during the study from 0.08–0.22 (r = 0.659, p < 0.01, Fig. 7) indicating an increase in that segment of the population. However, there was considerable annual variation in the proportion of subadults observed in the population. In 2007, 75 subadults were observed at 209 breeding areas by the first author, resulting in an estimate of 0.359 subadults per breeding area. That proportion of subadults at the 634 breeding areas resulted in an estimate of 227 subadults in the population during the 2007 season. As a result, our estimate of the minimum population on the study area during the 2007 nesting season was 1,333 bald eagles, excluding an unknown number of non-breeding adults and the 2007 cohort of 576 nestlings.

Distribution

The distribution of occupied breeding areas in the study area expanded as the breeding population increased. Annual changes were small; however, changes in distribution were more apparent when examined at ten-year intervals (Figs. 8A-D). In 1978, 101 breeding areas were concentrated around Upper Klamath Lake, Crane Prairie and Wickiup reservoirs, and the lower Columbia River with scattered sites along the Pacific coast (Fig. 8A). Ten years later (1987), 192 breeding areas were located in the four areas listed above with additional sites along the Umpqua River, at reservoirs on the west side of the Cascade Mountains, along the lower Rogue River, the upper Rogue River Basin, and around Lake Billy Chinook on the lower Deschutes River (Fig. 8B). In 1987, only one breeding area was known for northeastern Oregon, and there were none known along the main stem of the Willamette River from Eugene to Portland (Fig. 8B).

From 1987-1997, the number of breeding areas increased to 371 as the population continued to grow in the areas mentioned above, and new regions were added as breeding areas were found above Bonneville Dam on the Columbia River, along the main stem of the Willamette River, and in central Oregon (Fig. 8C). By 2007, there were 662 breeding areas distributed similar to the pattern of 1997. Local populations increased within and around the regions mentioned above, and the subpopulations that appeared to be distinct in 1978 (Upper Klamath Lake, Crane Prairie and Wickiup reservoirs, lower Columbia River, and Pacific coast) apparently were connected by breeding areas that were established along major drainages between regions (Fig. 8D). Population growth and range expansion during 1997-2007 especially were evident along the Willamette and Columbia rivers (Fig. 8D). The discovery of breeding areas in arid southcentral Oregon (i.e., Flat Top in 1997 and Squaw Ridge in 2007 in the Fort Rock Valley) and the first successful nesting on a manmade structure at Smith Lake in Portland during 2004 were examples of new breeding areas in non-traditional habitat.

There was an uneven distribution of breeding areas among the watersheds. In 1978, 6 of 10 watersheds had occupied breeding areas, and 97% (n = 66) were located in the Klamath (36%), Deschutes (27%), Pacific (23%), and Columbia (11%) watersheds (Fig. 9). In 1987, 7 of 10 watersheds contained occupied breeding areas and 92% (n = 160) were located in the same four areas: Klamath (37%), Pacific (23%), Deschutes (17%), and Columbia (15%) (App.17). Even though breeding populations increased in all four areas from 1978-1987, the order of abundance changed because the proportion of occupied breeding areas declined in the Deschutes while the Columbia proportion of the population increased and Klamath and Pacific proportions were similar (App. 17).

Distribution of occupied breeding areas by watershed changed considerably from 1987–2007. By 1997, 8 of 10 watersheds had occupied breeding areas, and 83% (n = 311) were found in the Klamath (31%), Columbia (19%), Pacific (18%), and Deschutes (15%) watersheds, the most populated regions from previous decades. The order of abundance changed because the proportion of occupied breeding areas increased in the Columbia and decreased in the other three watersheds. The increased proportion of occupied breeding areas in the Willamette (9%) and Rogue (5%) watersheds resulted in 97% of occupied breeding areas (n = 311) being distributed over 6 of 8 watersheds in

1997 (App. 17). In 2007, occupied breeding areas were located in 9 of 10 watersheds; the six most populated areas contained 96% of occupied breeding areas (n = 553); and Columbia surpassed Klamath as the most populated watershed. Distribution of occupied breeding areas in order of abundance by watershed in 2007 was Columbia (25%), Klamath (23%), Pacific (17%), Deschutes (13%), Willamette (13%), Rogue (5%), Snake and Harney (<1% each), and Owyhee (0%)(Fig. 9, App. 17).

Locations of occupied breeding areas at the beginning of the study and at ten-year intervals (Figs. 8A-D) indicated that the distribution of bald eagle breeding areas both expanded around existing local populations and widened as nest sites were discovered in other areas. There were significant differences in population increases among watersheds (X^2 = 708.978, 5 df, p < 0.01), with the Columbia, Willamette, and Rogue increasing the most and the Pacific, Deschutes and Klamath increasing less than other watersheds (Table 2, Fig. 9). In addition, there was a broader geographic change in distribution (X^2 = 116.334, 1df, p <0.01) (Fig. 8), which was caused by higher population growth rates for watersheds west of the crest of the Cascade Mountains, especially the Columbia and Willamette watersheds (Table 2). The result was a change from 36% of occupied breeding areas west and 64% east of the Cascade crest in 1978 (n = 66) to 58% west of the crest and 42% east in 2007 (n = 553) (Fig. 9).

Nesting Phenology

Nesting phenology for bald eagles breeding in the study area was defined by earliest and latest reported dates of incubation, hatching, and fledging for breeding areas with successful nesting (Fig. 10, App. 18). Earliest incubation date was 9 February at Fernhill Wetlands, Washington County, in 2003 and latest incubation start date was approximately 1 May at Killin Wetlands/ Banks, Washington County, during 2006. Earliest hatching was 20 March at Fernhill Wetlands in 2002 and latest hatching was approximately 4 June at Killin Wetlands/ Banks in 2006. Earliest fledging was 4 June at Birch Creek, Malheur County in 2004 and latest fledging was 20 August at Killin Wetlands/ Banks in 2006. The earliest and latest dates of incubation, hatching, and fledging were rare events (Fig. 10) that did not represent the typical nesting phenology exhibited by the majority of the population.

We summarized nesting status separately for successful and failed breeding attempts to compare and contrast day-to-day changes in breeding phenology between the groups (Fig. 10, App. 19). Occupation of breeding areas and evidence of eggs in nests were similar for both successful and failed breeding attempts through early March. Evidence of eggs in nests by observations of incubation behavior was most prevalent between 27 March and 10 April for both successful and failed breeding attempts. Although timing of maximum evidence of eggs was the same for both groups, the proportion of breeding areas with evidence of eggs was higher at successful (83%, n = 2,434) than at failed (41%, n = 1,786) breeding attempts during that 15-day period. Early hatching began in the last half of March, and eaglets were present during most observations through the remainder of the nesting season at successful breeding areas (Fig. 10). Eaglets were present at 91% of the successful breeding areas (n = 6,838) from 26 May–19 July and declined thereafter (Fig. 10).

At breeding areas that failed, evidence of eggs declined after 10 April, and reports of eaglets or other evidence of eggs were rare by late May and comprised only 4.5% of observations (n = 3,691) from 26 May–19 July (App. 19). Presence of one or two adult eagles (41%) and no eagles detected (55%) were the primary status reports for breeding areas that failed during that period (App. 19). Finally, the proportion of breeding areas where adult eagles or eaglets were observed was similar for successful and failed breeding areas post-nesting and during the early breeding season (3 September-16 March, Fig. 11).

Observations of nestlings at successful breeding areas indicated that all eaglets were downy from first hatching in mid-March to 15 April (Fig. 12). The proportion of downy young declined after 15 April as observations of partly feathered and feathered chicks increased (Fig. 12). Observations of partly feathered young were highest during 16–20 May, and the proportion of feathered chicks peaked during 20–29 June (Fig. 12). Earliest fledging was observed in early June, and fledged young increased as observations of feathered nestlings declined through July and early August (Fig. 12).

The proportion of breeding areas with evidence of eggs (pOCE) for 11 five-day periods between 7 March and 30 April was derived from n = 5,912 observations that were distributed normally around 1–5 April (Fig. 10). We used these data to analyze regional and temporal differences in timing of egg-laying in nesting phenology. Distributions of pOCE for breeding areas East and West of the Cascade Mountains for 1971–2007 were similar and highest for both regions during 1–5 April (Fig. 13A). Distributions of pOCE for 1971–1992 (22 years, n = 1,519) and 2003–2007 (5 years, n = 1,918) indicated that nesting phenology advanced by five days between these time periods (Fig 13B). The highest pOCE for 1971–1992 occurred during 6–10 April, while the peak of pOCE was 1–5 Apr for 2003–2007, and the parallel trends indicated that the advance was uniform for the 11 five-day periods (Fig. 13B). Comparisons of pOCE for

1971–1992 and 2003–2007 within the East (Fig. 13C) and West (Fig. 13D) regions indicated that the advanced phenology was the result of changes in the West region (Fig. 13D) and not the East region.

Productivity

Results of nest surveys were used to calculate nesting success and productivity by breeding area, watershed (Table 3) and year (Table 1) (Apps. 20 & 21A-E). Although there was variability among years, nesting success increased significantly from 1978 to 2007 ($r = 0.501$, $p < 0.01$, Fig. 14A). In addition, annual productivity ($r = 0.628$, $p < 0.01$) and brood size ($r = 0.547$, $p < 0.01$) increased during the study (Fig. 14B). There was a high positive correlation ($r = 0.915$, $p < 0.01$) between the number of young produced per occupied breeding area (productivity) and nesting success for the 30 years of surveys (Fig. 15), indicating that either of those statistics could be used for regional and temporal comparisons and for evaluating the potential effects of other parameters (e.g., elevation, distance from water, etc.) on nesting success or productivity. We chose to use data from breeding areas with ≥5 years of occupation as a minimum criteria for analyses because productivity data from breeding areas with <5 years of occupation were not normally distributed and use of breeding areas with ≥10 years of data eliminated 48% of the breeding areas (n = 654) from analyses (App. 22).

Eighty-six percent of breeding areas surveyed from 1978–2007 (n = 9,250) were occupied, and nesting success was determined for 97% of nesting attempts (n = 7,966). Thirty-eight percent of nesting attempts failed and 62% were successful in producing young (n = 7,696) during the study. For failed breeding attempts (n = 2,953), 46% had evidence of eggs, 35% had two breeding-age eagles and no evidence of eggs, and 19%

had one breeding-age eagle and no evidence of eggs (App. 13). Successful breeding attempts (n = 4,743) had either downy (4%) or feathered or fledged (96%) young. The number of young per successful breeding attempt (brood size) ranged from one to three. One young was reported for 46% of successful breeding attempts, two young for 51% of successes, and 3 young for 3% of successful breeding attempts (App. 13).

Nesting success varied from 47–67% from 1978–2007 and averaged 62% for all breeding areas with known outcome (n = 7,696). The annual variation in nesting success decreased as the nesting population increased (Fig. 14A). The variation in nesting success among watersheds with ≥5 occupied breeding areas (56–74%, Table 3) was significant (X^2 = 16.604, 6 df, $p = 0.011$). Nesting success was greater than expected in the Northeast ($p < 0.01$) and Willamette ($p < 0.05$) watersheds and lower than expected in the Columbia ($p < 0.01$) watershed (Table 3, Fig. 16). The Columbia watershed had the lowest nesting success overall (Table 3, Fig. 16) and was the only watershed with a year of 0.00 success, which occurred in 1980. The 1980 breeding season included the 18 May eruption of Mount Saint Helens, subsequent flooding and siltation of the Cowlitz and Columbia rivers, and an associated ash fall on 25 May (Findley 1981:55). The flooding, siltation, and ash fall impacted the hunting areas of all ten occupied breeding areas known in the Columbia watershed that year. Nesting success for the Columbia watershed increased significantly during the study (r = 0.608, $p < 0.01$, Fig. 18A), and in 2007 it was not significantly different from the other watersheds (X^2 = 2.053, 6 df, $p > 0.10$, Fig 17A).

Productivity (young/occupied breeding area) varied annually from 0.67–1.08, increased with time (Fig. 14B), and averaged 0.97 over the 30-year period (n = 7,696).

Productivity was > 1.0 during the last decade of the study. As with nesting success, the variability in productivity within and between watersheds decreased with time. The Columbia watershed had the lowest productivity during the early years of the study and increased the most (Fig. 17B). The number of young per successful breeding attempt (brood size) averaged 1.57 (n = 4,743) and was positively correlated with the number of young per occupied breeding area ($y = 0.486x + 1.094$, $r = 0.683$, $p < 0.01$, App. 23B). The annual variation in productivity decreased as the population increased, while annual variation in brood size was less variable over all years of the study (Fig. 14B).

Productivity and brood size varied among watersheds (Table 3). Overall, productivity was highest in the Snake (1.93, n = 15) and lowest in the Columbia (0.89, n = 1,454, Table 3). Productivity varied significantly among watersheds ($X^2 = 36.995$, 6 df, $p < 0.01$). Productivity of the Northeast (1.21) and Willamette (1.13) watersheds was greater than expected ($p < 0.01$), while that of the Columbia watershed (0.89) was lower than expected ($p < 0.01$, Table 3). Brood size ranged from 1.93–1.44 young/successful breeding area in the Snake and Harney watersheds, respectively, with only 3 occupied breeding areas in each watershed in 2007. There was no significant difference in brood size among watersheds with ≥5 breeding areas in 2007 ($X^2 = 4.268$, 6 df, $p > 0.10$) where brood size ranged from 1.52 in the Pacific to 1.65 in the Willamette.

Abandoned Breeding Areas

Resource managers often wanted to know if breeding areas were abandoned even though our annual survey protocol was not designed to make such a definitive determination. Breeding areas that were classified as unoccupied during any given year in our study potentially were abandoned. However, 65% of breeding areas that were unoccupied one year (n = 327) were occupied the following year (Fig. 19), and there were 87%, 95%, 98%, and 99% chances that an unoccupied breeding area would be occupied after 2, 3, 4, or 5 years of being unoccupied, respectively. Conversely, there was only a 13%, 5%, 2%, and 1% chance that a breeding area would remain unoccupied for 2, 3, 4, or 5 years, respectively. This resulted in an exponentially diminishing chance that a breeding area would remain unoccupied indefinitely (Fig. 19), and the probability that a breeding area remained unoccupied for > 5 years was < 0.01.

Only seven breeding areas (1%, n = 662) were unoccupied ≥4 nesting seasons in our study. Four of those breeding pairs (Caterpillar Island WA, Plantation West, Cottonwood Island WA and Coon Island) may have shifted activity centers further than expected and subsequently were reported as new breeding pairs, but we could not determine this since the adults eagles were not individually marked. In addition, one breeding area (Mosquito Creek) may not have been occupied by bald eagles because it was in unlikely habitat and we only had two observations of eagles (bald eagle once and golden eagle once) out of 26 surveys of the site in seven years. As a result, we concluded that only two breeding areas (0.3%, n = 662) were abandoned (Warm Springs River and Elk Creek) during the 30 years of our study. These two areas contained nests known to have been built and used by bald eagles, and as of 2007 they had been classified as unoccupied for nine and ten years, respectively.

Aquatic Features Associated with Breeding Areas

Breeding areas were associated with rivers, Pacific Ocean, estuaries, reservoirs, marshes, and natural lakes, or were unclassified, and breeding populations increased in all seven groups (Table 4). The wide range in population growth rates (r = 0.035–0.128,

Table 4) and significant differences in number of breeding areas occupied between different water bodies (X^2 = 18.584, 6 df, $p < 0.01$) resulted in a significant change in the distribution of breeding areas among aquatic features (X^2 = 503.61, 6 df, $p < 0.01$). For example, natural lakes contained 40% of breeding areas in 1978 and only 15% in 2007 (Fig. 20). Natural lakes had slow population growth (r = 0.035, Table 4) and lower than expected ($p < 0.01$) number of breeding areas occupied (Fig. 21). In contrast, the proportion of breeding areas along rivers, where the population growth rate was highest (r = 0.128), increased from 6% in 1978 to 22% in 2007 (Fig. 20). Increase in the number of breeding areas also was higher ($p < 0.05$) for estuaries, ocean, and reservoirs, and number of breeding areas occupied was higher than expected ($p < 0.10$) for the ocean and reservoirs (Fig. 21). Significant differences in nesting success between types of water bodies (X^2 = 24.954, 6df, $p < 0.01$) also may have contributed to different population growth rates. Number of successful breeding attempts was highest for rivers and unclassified areas and lowest for estuaries and natural lakes (Fig. 21).

Band Returns and Marked Eagles

We received banding reports from the Bird Banding Laboratory from 22 of 157 (14.0%) bald eagles banded as nestlings on the study area (Table 5). Twenty (12.7%) were recoveries of bands from dead individuals and two represented one live subadult and one live adult that were released after the band number was read. Twelve reports were of subadults (55%), and 10 were adults (45%). Age of dead subadults (n = 11) ranged from 3 months to 4 years, 6 months with a 1 year, 9 month average. Age of dead adults (n = 9) ranged from 6 years, 2 months to 26 years, 3 months and averaged 13 years, 5 months.

Encounter locations for 22 bald eagles banded in Oregon were 13 in Oregon (59.1%), 3 in British Columbia, Canada (13.6%), 2 in California (9.1%) and 1 eagle each (4.5%) in Sonora, Mexico, Nevada, Idaho, and Washington (Table 5). Subadults were found in all seven of these areas with 5 of 12 in Oregon (42%) and 7 found outside the state (58%). In contrast, 8 of 10 adults were recovered in Oregon (80%) and 2 were found outside the state (20%). Average distance for all 22 eagles from nest to encounter location was 309 km (192 mi). Average distance for all 12 subadults was 438 km (272 mi), which was greater than the 153 km (95 mi) average for all 10 adults ($t = 1.603$, $df = 20$, $p < 0.20$). Distances for recoveries during the breeding season, February-August, also were greater for subadults ($n = 4$), average 264 km (164 mi), than for 7 adults, 59 km (37 mi) average ($t = 2.457$, $df = 9$, $p = 0.038$). These results indicate that some of the banded nestlings had returned to areas near to their natal areas to breed and nest.

In addition to the 22 band reports described above, we compiled records on 111 bald eagles marked with bands, colored markers (leg bands or patagial markers), or radio transmitters and were observed on or near the study area (App. 12). Thirty-three (29.7%) were encounters with birds marked in Oregon. Those observations or reports occurred from 1979–1987 and consisted of 18 subadults (53%), 13 adults (39%), and 2 un-aged birds (6%); and most (29) were alive (88%), 3 were dead (9%), and 1 was status unknown (3%). Twenty-six eagles that originated in Oregon were encountered east of the crest of the Cascades (79%), 5 were west of the Cascades (15%), and 2 were in northern California (6%).

Seventy-eight of 111 records (70.3%) were from 1979–2010 and included 62 non-resident bald eagles and 16 that had unknown origin (App. 12). The 62 non-residents were comprised of 46 from California (74%), 5 from Arizona (8%), 3 each from Glacier National Park and Wyoming (5% each), 2 from Washington (3%), and 1 each from Idaho, Mexico, and Yellowstone National Park (2% each). Distribution by age was 51 subadults (65%), 14 adults (18%), and 13 un-aged (17%). Fifty-nine of the birds (76%, n = 78) were alive, 11 were dead (14%), 4 were condition unknown (5%), and 2 each were injured and captive, and captured and released (3% each). Distribution of observations encompassed one Washington county and 20 or 22 (56% or 61%) of Oregon's 36 counties.

Within Oregon, distribution of 61 marked non-resident eagles east or west of the Cascade crest was similar by area and county. Thirty-six percent of eagles were observed west of the Cascades and 64% were east of the mountains, which approximated 33% of the land area west and 67% east of the Cascade crest. Marked eagles were reported from 10 of 18 counties west of the Cascades (56%) and 8 or 9 of 18 counties east of the Cascade crest (44% or 50%). In contrast, the number of encounters was concentrated in Klamath (24.6%), Lake (19.7%), and Deschutes (6.6%) counties of south-central Oregon, where a total of 50.8% of encounters occurred, whereas 49.2% of encounters were distributed over the other 15 to 16 counties that had reports of marked non-resident bald eagles.

Columbia River Segments

Columbia was the only watershed where we surveyed breeding areas in two states, so results for Oregon and Washington were comparable (Table 6). The number of occupied breeding areas in both states increased exponentially, although the increase was slightly lower for Washington (Fig. 22A). Similarly, the number of young produced per breeding area increased significantly throughout the study (Fig. 23) and was not different between the two states ($t = 1.146$, $df = 51$, $p > 0.10$). The proportion of breeding areas that were occupied during the study did not change significantly (Fig. 22B) and was higher for Washington ($t = 2.666$, $df = 53$, $p = 0.010$). However, occupancy rates for the last ten ($t = 2.045$, $df = 18$, $p = 0.56$) and five ($t = 0.428$, $df = 8$, $p > 0.10$) years were not different between the states (Fig. 22B).

Occupancy of breeding areas (Fig. 6) and nesting success (Fig. 16) were lower for the Columbia watershed than for other watersheds. Productivity along the Columbia River increased with distance from the Pacific Ocean ($y = 0.004x + 0.724$, $r = 0.369$, $p < 0.01$, Fig. 24), although there was considerable variability along all segments of the river. Nesting success and productivity were lower than expected for river miles 0–47 (0–76 km) and greater than expected upstream of river mile 47 (76 km) ($X^2 = 33.757$, $df = 6$, $p < 0.01$, Fig. 25A). Breeding areas associated with river miles 13–31 (21–50 km) had the lowest productivity (Fig. 25A) because of the large proportion of breeding areas with productivity ≤ 0.50 young/year occupied (Fig. 25B).

Breeding areas with productivity of ≤ 0.50 young/occupied site/year were not distributed evenly among watersheds ($X^2 = 9.785$, $df = 6$, $p > 0.10$, Fig. 26) or segments of the Columbia River ($X^2 = 27.400$, $df = 6$, $p < 0.01$, Fig. 25B). The Columbia and Rogue watersheds had more breeding areas ($p < 0.10$) with ≤ 0.50 productivity than the other watersheds (Fig. 26). The Columbia watershed included 35% of the breeding areas with ≤ 0.50 productivity in the study area ($n = 60$), and 67% of the breeding areas with ≤ 0.50 productivity along the Columbia ($n = 21$) occurred between river miles 13 and 31 (Fig. 24). Six breeding areas (Cathlamet Bay OR, Karlson Island OR, Knappton

Bay WA, Pigeon Bluff WA, Svensen Island OR, and Three Tree Bay WA) on this segment of the Columbia River had no successful reproduction (0.00 young per year occupied) during the study. There were only ten breeding areas in the entire study area that had zero productivity in 30 years.

Density of Breeding Areas

The amount of shoreline per occupied breeding area was used as a measure of density of breeding populations for seven water bodies. This index decreased from 1978–2007 at all seven water bodies as breeding populations increased (Table 7). This decrease ranged from 94% in the Columbia River estuary ($n = 100.7$ km) to 44% at Odell Lake ($n = 4.3$ km) and Lake Billy Chinook ($n = 20.1$ km). As predicted, population growth rate was correlated positively to the amount of shoreline for the seven areas at the start of the study ($r = 0.730$, $p = 0.041$, Fig. 27), which exemplified the amount of shoreline available for population expansion at the start of our study.

We also predicted that productivity would decrease in a density dependent way as density of the breeding population increased (i.e., decrease in length of shoreline/ breeding area). However, the relationship of productivity to the density of breeding areas varied by water body (Table 7). Contrary to our prediction, productivity decreased as the amount of shoreline per breeding area increased (i.e., low density) in the Columbia River Estuary ($r = -0.620$, $p < 0.01$), Willamette River ($r = -0.742$, $p < 0.01$), and Upper Klamath and Agency lakes ($r = -0.430$, $p = 0.017$). In contrast and according to our prediction, productivity decreased with increased breeding density at Odell Lake ($r = 0.328$, $p > 0.10$), Crane Prairie and Wickiup reservoirs ($r = 0.195$, $p > 0.10$), and Lake Billy Chinook ($r = 0.479$, $p = 0.097$), but none of these relationships were statistically significant (Table 7). Positive population growth rates and increased productivity as density of breeding populations increased indicated that density dependent factors probably were not affecting productivity of breeding populations at Columbia River Estuary, Willamette River, and Upper Klamath and Agency lakes. However, there was some evidence that density of the breeding populations may have resulted in low growth and decreasing productivity at Crane Prairie and Wickiup reservoirs, Lake Billy Chinook, and Odell Lake.

The relationship between population density, growth rate and productivity was different for Odell Lake versus Umpqua River. Population growth at Odell Lake was higher than that of Upper Klamath and Agency lakes (0.065 vs. 0.031), and productivity declined as the amount of shoreline per occupied breeding area decreased. Population growth rate was slightly lower on the Umpqua River than for Odell Lake (0.056 vs. 0.065), but productivity increased as the amount of shoreline per occupied breeding area decreased. We speculate that density dependent affect(s) were taking place at Odell Lake because of the low amount of shoreline per occupied breeding area at the end of the study (2.4 km, Table 7). In contrast, we believe that density dependence probably was not a factor along the Umpqua River because the amount of shoreline per occupied breeding area at the end of the study was much greater (8.0 km) than at Odell Lake, and greater than that of Upper Klamath and Agency lakes (3.7 km) and Columbia River Estuary (5.9 km, Table 7). Of the seven water bodies, Umpqua River had the least reliable survey data because of limited access, rugged terrain, and less effort searching for new breeding areas. Consequently, our data on population growth rate and productivity may not be as accurate for the Umpqua River population as compared to the other areas.

Upper Klamath and Agency lakes excluding Spence Mountain and Eagle Ridge (Upper Klamath, hereafter) and Spence Mountain and Eagle Ridge (Spence, hereafter) had similar population growth rates, 0.032 at Upper Klamath and 0.030 at Spence (Table 7). Upper Klamath had a significant correlation of increased productivity with decreased amount of shoreline per occupied breeding area ($r = -0.383$, $p = 0.038$), suggesting that density dependant factors were not affecting that population. On the other hand, there was no relationship between productivity and length of shoreline per occupied breeding area for Spence (r -0.016, $p > 0.10$, Table 7), suggesting that density dependent factors may have been affecting that population. Shoreline length at Spence in 2007 was 2.8 km per occupied breeding area vs. 4.3 km for Upper Klamath (Table 7). Consequently, the density at Spence was similar to Odell Lake where shoreline length was 2.4 km per occupied breeding area (Table 7), and we suspect that density dependent factors were affecting productivity there also.

Distance from Water and Elevation of Breeding Areas

Bald eagles typically nest near permanent aquatic habitats. In Oregon and along the lower Columbia River, 90% of the most recently used nest trees in breeding areas ($n = 662$) were ≤ 3,200 m (2 mi) from water, and the distribution was skewed towards shorter distances (84% ≤ 1,600 m, 73% ≤ 800m, and 60% ≤ 400 m, Fig. 28). Only 3% of nest trees were > 3,200 m (2 mi) from water, and 7% were classified as “atypical” because aquatic habitat for foraging was distant, dispersed, intermittent, or nonexistent. Median distance to water varied among watersheds and ranged from 105 m in the

Columbia watershed to 493 m in Klamath watershed (Table 8). Nest trees west of the Cascade Mountain crest were closer to water than nest trees east of the Cascades (188 m median distance west vs. 384 m east, $Z = 6.429$, $p < 0.01$, Table 8).

There was some evidence that productivity was positively related to distance from water for the Klamath watershed (Table 9) but the correlation was weak ($r_s = 0.213$, $p = 0.025$) and likely a result of the large sample size for that area. In contrast, there was no relationship between productivity and distance to water of breeding areas for the other watersheds and for the entire study area ($r_s = 0.058$, $p > 0.10$). Nesting success and productivity were greater ($p < 0.05$) for atypical breeding areas (Fig. 29), which were not associated with permanent aquatic habitats, than for breeding areas directly associated with permanent aquatic habitats (nesting success $t = 4.519$, df = 56, $p < 0.001$; young per occupied breeding area $t = 4.457$, df = 56, $p < 0.001$).

Breeding areas occurred from 3–2,027 m above sea level (2,027 m at East Lake, Deschutes County), and the distribution by elevation was bi-modal (Fig. 30). The maxima of the modes were skewed toward elevations near sea level (coastal estuaries and rivers) and those of lakes and reservoirs in mountainous areas east of the Cascade crest (e.g., Upper Klamath and Odell lakes, Crane Prairie and Wickiup reservoirs). The sea level mode consisted of 431 breeding areas at ≤ 1,200 m elevation (median = 82 m, 25% = 9 m, 75% = 256 m), and the mountain mode included 231 breeding areas > 1,200 m (median = 1,396 m, 25% = 1,329 m, 75% = 1,503 m). Annual average elevation of new breeding areas ranged from 1,172 m (n = 8) in 1981 to 311 m (n = 31) in 2004 and decreased annually ($y = -18.431x + 37{,}364.715$, $r = -0.677$, $p < 0.01$) during the study because most of the population growth occurred at the lower elevations west of the Cascades (Fig. 9).

Elevations of breeding areas by watershed varied from a median of 6 m (25% = 3 m, 75% = 52 m) in the Columbia watershed to 1,399 m (25% = 1,324 m, 75% = 1,494 m) in the Klamath watershed (Table 10). Elevation west of the Cascades (median = 68 m or 223 ft, 25% = 6 m, 75% = 189 m) was lower ($Z = 20.026$, $p < 0.01$) than east of the Cascades (median = 1,364 m, 25% = 1,271 m, 75% = 1,463 m, Table 10). Productivity of breeding areas within watersheds decreased as elevation increased for the Willamette ($r_s = -0.409$, $p < 0.01$), Columbia ($r_s = -0.163$, $p = 0.091$, and Pacific ($r_s = -0.274$, $p = 0.012$) watersheds. This relationship also was significant but not strong for the entire study area ($r_s = -0.111$, $p < 0.015$), but not for the Northeast, Deschutes, Klamath, or Rogue watersheds (Table 11).

The Willamette, Pacific, and Rogue watersheds included breeding areas with locations that ranged from sea level to the west slope of the Cascade Mountains, and the Deschutes and Klamath watersheds included the east slope of the Cascades (Fig. 1). The decreased productivity with increased elevation for the study area apparently was the result of similar trends for the Willamette and Pacific watersheds (Table 11). Comparison of nesting success of breeding areas grouped into elevation categories and direction from the crest of the Cascades revealed that lower nesting success occurred at breeding areas above 900 m (2,953 ft) on the west slope of the Cascades ($X^2 = 15.962$, $df = 4$, $p < 0.01$).

Historical Breeding Population

We estimated that there were at least 728–1,456 breeding areas of bald eagles in Oregon and along the lower Columbia River circa 1800 (Table 12). Distribution of breeding areas by watershed circa 1800 probably was similar to 2007 because the distribution of forested habitats near major water bodies was thought to have been similar. The 662 breeding areas listed in 2007 were 91% of the minimum estimate and 45% of the maximum estimate for circa 1800 (Table 12). An estimate of 1,200 breeding areas was selected arbitrarily as the 1780 starting point for our model of change (Fig. 31). Anecdotal evidence suggested that the population declined considerably until the 1960's or 1970's and was increasing slightly when our study began in 1978 (Fig. 31).

The number of breeding areas by watershed in 2007 were below the circa 1800 minimums for the Northeast, Pacific, Snake, Harney, Rogue, and Owyhee watersheds, and were between the minimums and maximums for the Columbia, Deschutes, Willamette, and Klamath watersheds (Table 12). As of 2007, no watersheds had reached the maximum estimate for 1800; however, the Columbia (73%), Willamette (65%), Klamath (61%), and Deschutes watersheds (60%) were approaching maximum estimates (Table 12).

Mate Changes at Breeding Areas

Probable mate changes were reported at 56 of 7,966 occupied breeding areas from 1978-2007 based on observations of eagles in subadult or near adult plumage in breeding pairs. Mate changes where adults replaced adults could not be detected because individual eagles were not marked or identifiable. Documentation of mate changes was not a primary goal of our study; therefore we could not determine the rate of mate change in the population. Consequently, our opportunistic records of mate change represent a minimum subset (where subadults or near adults replaced adults) of the actual number of mate changes that occurred during the study. Sex of the new mate was reported for 38 of 56 mate changes (68%), and the new mate was a female 32 of 38 times (84%) and males 6 times (16%). Three new mates were identified as subadults (5.4%, n = 56) and 53 (94.6%) were near adults. All three subadults were female.

Nesting success before, during, and after years of mate changes indicated a significant effect of mate change on productivity ($X^2 = 20.908$, df = 10, $p = 0.022$). Nesting success was less the year of the mate change than for years before or after the change ($p < 0.001$). Productivity (Fig. 32) followed a similar pattern with years 5–2 before and 2–5 after the mate change being greater than the overall 0.97 young per occupied breeding area for the study area. Productivity one year before (0.79), the year of (0.36), and one year after (0.83) were below the average rate of 0.97.

Nest Building and Copulation

Nest building by bald eagles (n = 361) was reported for every month of the year, but was more prevalent during some months ($X^2 = 219.551$, df = 11, $p < 0.01$). Nest building was observed more often than expected during October ($p < 0.005$), November ($p < 0.001$), February ($p < 0.001$), and March ($p < 0.001$) and less than expected during April ($p < 0.05$), June ($p < 0.001$), July ($p < 0.001$), and August ($p < 0.10$) relative to the total number of observations by month. Nest building was reported for all months except August at breeding areas with successful nesting and for all months except September for breeding areas with failed nesting attempts. Successful breeding attempts had less nest building than expected ($p < 0.01$), and failed attempts had more nest building than expected ($p < 0.05$) in April, relative to the number of observations of nest building (n = 165 at successes and n = 196 at failures).

Bald eagles were observed copulating 80 times during the study (0.31%, n = 25,641). Seventy-four records of copulation were used to quantify monthly occurrence because six were repeats within the same month and breeding area. The earliest reported copulation date was 17 January at a breeding area with eventual nesting success and the latest was 12 May at a breeding area where nesting failed. Copulation was reported once in January and twice in May. The remaining 71 copulations were in February (13), March (46) and April (12). The proportion of copulations declined by month (62% in February, 54% in March, 17% in April) for successful breeding attempts and increased by month where nesting attempts failed (38% in February, 46% in March, 83% in April).

Nest Trees, Nests, Gaps in Use, and Nest Tree Changes

All but one bald eagle nest in Oregon and along the lower Columbia River were built in trees (n = 1,645). The exception was at Smith Lake, Multnomah County, in 2004 when a pair nested successfully on an artificial osprey (*Pandion haliaetus*) platform on a utility pole. The following year, the eagles at Smith Lake built a nest in a tree and nested successfully. Three other successful nesting attempts on artificial osprey platforms were observed at Gerber Reservoir in 1986, Martin Creek in 1986, and Woodruff Mountain in 1981; however all were on manmade platforms placed in trees, and each was used the first year the pair was known. By the third year of occupancy, all three pairs built new nests in trees. Out of 1,644 bald eagle nests in trees, 98% were built in live trees; six

(0.4%) were built in dead trees, and tree condition when the nest was built was unknown for 26 (1.6%).

We visited 201 nest trees with history of use by eagles during 1979-1982 and found that nest trees were dominant or co-dominant individuals in forest stands and that primary nest tree species were ponderosa pine east of the Cascades and Douglas-fir west of the Cascades (Anthony and Isaacs 1989). The following list of nest tree species and relative abundance from that study were ponderosa pine (65%), Douglas-fir (25%), Sitka spruce (5%), sugar pine (3%), and one nest tree each (< 1% each) of white fir, Shasta red fir, and western hemlock (n = 201). In addition, there were four unused nests in black cottonwood trees, which we suspected were built by bald eagles.

Relative abundance of nests in coniferous trees apparently stayed constant from 1983-2007 with ponderosa pine and Douglas-fir being the primary species east and west of the Cascades, respectively. During that period, three species of conifers (incense-cedar, lodgepole pine, and western Juniper) and four deciduous species, big-leaf maple, Oregon white oak, quaking aspen (*Populus tremuloides*) and willow (*Salix* sp.) were added to the list of tree species used for nesting by bald eagles in the study area. The greatest change in the proportion of tree species used for nesting during the study was the increase in deciduous trees, primarily black cottonwood (Fig. 33). Deciduous trees comprised 1.8% of nest trees in 1978 (n = 164), but increased to 16% of nest trees in 2007 (n = 1,613). In 2007, 31% of newly discovered nests (n = 101) were in deciduous trees, and the proportion of deciduous trees was greater than in 1978 for all watersheds. Most of the nests in cottonwoods were along the Columbia and Willamette Rivers.

The cumulative number of nest trees per breeding area increased significantly with the length of time that a breeding area was known ($r = 0.928$, $p < 0.01$, Fig. 34A). This increase was the result of old nests being destroyed or abandoned and new nests being built. Breeding areas known for one year averaged 1.10 nest trees per breeding area ($n = 31$, range 1-3), and breeding areas with 37 years of history averaged 5.19 nest trees per breeding area ($n = 36$, range 1-14, Fig. 34A). As of 2007, the average number of nest trees documented per breeding area was 2.49 ($n = 1,645$ including one utility pole) and was increasing (Fig. 34B).

Even though virtually all nests (≥98%, $n = 1,644$) were built in live trees, bald eagles continued to use nests that were originally built in live trees after the trees died. Our surveys of 84 nest trees that were used for nesting before and after nest trees died indicated that mortality of the nest tree did not negatively affect productivity ($r = 0.476$, $p > 0.10$), and the number of young per occupied breeding area with evidence of eggs was not different from the entire population ($t = 0.042$, $df = 39$, $p > 0.10$). The primary negative impact of mortality of nest trees was accelerated loss of nests (Fig. 35). From 1–5 years prior to mortality of nest trees, annual loss of nests was low and relatively stable (5–7%, $n = 61$ and 82, respectively). However, nest loss was 12% the year of mortality ($n = 84$) and increased to 61% five years after mortality ($n = 61$).

Distances between nest trees within breeding areas ranged from 2–6,472 m, and the distribution was skewed towards shorter distances (median = 462 m, 25% = 177 m, 75% = 1,010 m, Fig. 36). Forty-five percent of distances between nest trees within breeding areas ($n = 2,243$) were 0–400 m, 68% were 0–800 m, 87% were < 1,600 m, and 98% were < 3,200 m.

The actual number of nests existing per breeding area was difficult to determine because we did not observe every nest tree every year. We estimated that there was an average of 1.08–1.51 nests per breeding area in 2007 (Fig. 34B) based on the range between the minimum and maximum number of nests known to exist. The range widened with time because the proportion of nests not observed each year increased as the number of nest trees per breeding area increased (Fig. 34B).

From 1971–2007, 692 nests fell apart or were destroyed and not rebuilt (42%, n = 1,645 nest trees), which resulted in high turnover in used nests. Of 563 missing nests, 85% were reported as gone from the nest tree, and 15% were reported as destroyed when the nest tree fell down. The specific cause of nest loss usually was unknown. Deterioration of unused nests, and nests or nest trees blowing down in high winds, probably were the primary causes of nest loss. Specific cause of nest tree destruction was reported for 22 nest trees out of 86 that were destroyed. Sixteen were burned by wildfire, four were cut down by humans, and one was struck by lightning. In addition, one nest was salvaged for education outside the nesting season after the eagles in the breeding area built a new nest in a nearby tree and the supporting limbs of the salvaged nest were breaking (Fernhill Wetlands, Washington County in 2005).

Nest longevity was difficult to determine precisely because the date when nests were built usually was unknown, many nests still existed in 2007, and nests often were not observed if eagles were found using another nest in a breeding area. Minimum nest longevity was calculated from histories of 692 nests that no longer existed in 2007. Lower and upper limits to average minimum nest age were 6.83 and 9.44 years, respectively (6.83 ± 5.94 SD, range 1–33; 9.44 ± 7.56 SD, range 1–36). Average minimum longevity was likely longer because dates of nest construction often were unknown.

There was a significant correlation between year of nest discovery and nest survival ($r = 0.935$, $p < 0.01$) suggesting that an average cohort of nests would last approximately 30 years (Fig. 37). Average annual rate of nest loss from 1978–2007 for the 1978 cohort of nest trees was 2.9% (32 nest trees, 84% loss over 29 years). Five nests that existed in 1971 were still present in 2007 (minimum age 37 years) indicating a much longer turnover time for some nests that were frequently repaired by eagles, especially those built in live individuals of long-lived species of trees with strong support branches.

Histories of nest use included occasions where nests were re-used after one or more years not used (gaps in nest use), nests fell or were blown out of trees, a new nest was built in the same tree (gaps in nest presence), and periods when breeding areas were unoccupied for one or more years before being reoccupied (gaps in breeding area occupancy, Table 13). Gaps in use occurred in 12.5% of nest trees (n = 1,645), ranged from 1–12 years, and the distribution of length of gaps was skewed towards 1 year (median = 1 year, 25% = 1 year, 75% = 2 years). Most (90%) nests with gaps in use were re-used after three years. Absence of nests (new nests built in former nest trees) occurred in 4.2% of nest trees (n = 1,645), ranged from < 1–14 years, and the distribution of length of absences was skewed towards 1 year (median = 1 year, 25% = <1 year, 75% = 3 years). Gaps in occupancy occurred at 18.4% of breeding areas (n = 662), ranged from 1–7 years, and the distribution of gap lengths was strongly skewed towards 1 year (median, 25%, and 75% all = 1 year).

The number of years that breeding areas were occupied with evidence of eggs was used to evaluate rate of nest tree change because the trees that were used for nesting those years were known. Changes in use of nest trees within breeding areas occurred 1,032 times in 6,325 occasions when incubation posture or young were observed, which resulted in changes approximately every six years and an overall 16.3% rate of change. The number of changes observed for individual breeding areas ranged from 0–14, and the distribution was skewed towards 1 (n = 626, median = 1, 25% = 0, 75% = 2.75). Average number of changes in use of nest trees after there was evidence of eggs being laid was correlated positively with the number of years that a breeding area was occupied ($r = 0.944$, $p < 0.01$, Fig. 38). For example, breeding areas with 1 year of evidence of eggs had 0 changes (n = 63), those with 15 years of evidence of eggs averaged 2.6 changes (n = 22), and those with 28 years of evidence of eggs had an average of 4.8 changes (n = 6).

Years that breeding areas were occupied with known outcome were used to examine the relationship between productivity and change in use of nest trees. Overall 1,011 changes in use of nest trees were observed at 7,413 breeding areas with ≥ 5 years of occupancy. This translated to changes in nest trees approximately every seven years and a 13.6% rate of change (n = 7,413). The rate of change in use of nest trees for individual breeding areas was variable and ranged from 0–52%, and the distribution of rates was skewed towards 10% (median = 11%, 25% = 0%, 75% = 20%) for 479 breeding areas with ≥ 5 years occupation. The correlation between the rate of change in use of nests with productivity for those 479 breeding areas was not significant (r_s = -

0.039, $p > 0.10$) indicating that change in use of nest trees did not have an influence on productivity.

Loss of nests due to wind, failure of nesting structures, or other reasons was a factor in 20% of changes in use of nest trees (n = 591). Losses of nests (n = 120) occurred during the nesting season (13%) but were more frequent between nesting seasons (87%). Changes in use of nest trees were associated with nest losses during the nesting season (n = 16) and were analyzed independently because nest loss directly affected nesting success the year of nest loss. Nesting success was 0% when nest loss occurred during the nesting season (n = 13 nest losses during nesting the year before a nest tree change) because nests that fell apart when young were developed enough to escape onto branches or captured for rehabilitation were not included in this analysis. Nesting success the year after the loss of nests during the nesting season (92%, n = 13) was not different from overall nesting success for occupied breeding areas with evidence of eggs (78%, n = 6,105, $X^2 = 0.401$, df = 1, $p > 0.10$). When nest loss occurred during the nesting season, eagles at 5 of 13 (38%) breeding areas moved to new nests the year after, while the other 8 (62%) used a pre-existing nest.

Even though changes in use of nest trees did not affect overall productivity ($r = -0.039$, $p > 0.10$), there was a significant difference in nesting success before vs. after 575 changes in nest tree use ($X^2 = 7.811$, 1 df, $p < 0.01$). These nest tree changes were comprised of 471 occasions (82%) with no nest loss and 104 occasions (18%) with nest loss between nesting seasons (Table 14). These incidents represented four different circumstances surrounding the change in use of nest trees: 1) A1 = nest change without nest loss and move to a pre-existing (old) nest tree, 2) A2 = nest change without nest loss and move to a previously unknown (new) nest tree, 3) B1 = nest change with nest loss and move to a pre-existing nest tree, and 4) B2 = nest change with nest loss and move to a new nest tree. Nesting success for all four groups was greater the year after nest change (A1 = 19% greater, A2 = 12%, B1 = 3%, and B4 = 4%) but the difference was significant only for A1 (X^2 = 7.58, 1 df, $p < 0.01$). Nesting success was greater when new nests were used after nest changes both without nest loss (72% at old vs. 76% at new) and with nest loss (79% at old vs. 84% at new). The differences in nesting success before vs. after changes were not significant when tested among all four groups separately (X^2 = 1.136, 3 df, $p > 0.10$) or when use of old and new nests were combined (X^2 = 0.605, 1 df, $p > 0.10$).

Three of 56 changes in mates (see: Results: Mate Changes at Breeding Areas) coincided with changes in use of nest trees within breeding areas. The ratio of mate change to change in use of nest trees was 1: 18.43 (56 mate changes per 1,032 nest tree changes) for the population, and the ratio of mate changes that coincided with changes in nest trees was 1:18.67 (3 mate changes per 56 nest tree changes), which indicated that there was no relationship between mate changes and changes in nest trees, at least for mate changes that involved individuals with subadult or near-adult plumage.

New Breeding Areas

We found new breeding areas every year (Fig. 2), but we usually didn't know if these breeding areas existed in previous years. Reports of bald eagle activity and interviews with local residents or agency personnel suggested that most breeding areas probably were present for one or more years before the first nests were discovered. In contrast, 38 new breeding areas were found the same year that the first nest was known to have been built, so we assumed those breeding areas were established that year. Productivity at new breeding areas (Fig. 39) was lower than expected the year of establishment but greater than expected 3–5 years after establishment, and the difference was significant (X^2 = 16.261, df = 5, $p < 0.01$).

Other Species and Bald Eagle Nests

Seven avian species other than bald eagle used or were associated with 5.3% of nest trees (n = 1,645) in 10.6% of breeding areas (n = 662) during 1.5% of surveys (n = 9,616), so these occurrences were infrequent. When they did occur, Canada goose was the most often reported species that used bald eagle nests, and geese were found on nests in 48% of nest trees (n = 88) during 57% of surveys of breeding areas that detected other species (n = 140). Red-tailed hawk, 20% of nest trees during 16% of surveys; osprey,14% of nest trees during 13% of surveys; great horned owl, 9% of nest trees during 8% of surveys; golden eagle, 6% of nest trees during 4% of surveys; common raven, 2% of nest trees during 1% of surveys; and peregrine falcon, 1% of nest trees during 1% of surveys were the other six species that used bald eagle nests that had inter-specific use (Table 15).

Patterns of use of nests by other species varied. Canada geese, great horned owls, and peregrine falcons used bald eagle nests, but did not build nests suitable for eagles. Red-tailed hawks and ospreys built stick nests that bald eagles sometimes built on top of, and red-tailed hawks used nests originally built by bald eagles. Osprey were not observed using nests built by bald eagles; however, bald eagles used nests that were built by ospreys on both natural and artificial structures. Bald eagles were not observed using nests originally built by golden eagles and common ravens, even though both species built stick nests and were observed using nests originally built by bald eagles.

Four unusual events involved inter-specific use of bald eagle nests. First, peregrine falcons attempted to nest on a bald eagle nest at the Megler breeding area in Washington. In 2004, an adult peregrine was observed in incubating or brooding posture on 1 June. In 2005, a peregrine-sized scrape on the eagle nest and adult peregrine perched nearby were observed on 6 April, then two unattended peregrine falcon eggs were observed on the surface of the same nest on 15 June.

Second, two bald eagle nestlings and one, live red-tailed hawk nestling were found on a nest at the Jones Swamp breeding area on 29 May 2001. The nest was checked frequently thereafter, and the red-tail nestling fledged circa 19 June and was observed landing on the nest when one adult and two nestling bald eagles were present on 20 June. The eagle nestlings were assumed to have fledged sometime after 13 July when they were last observed fully feathered and perched on branches away from the nest.

Third, bald eagles nested successfully on a manmade structure for the first time in Oregon at Smith Lake in 2004. The eagles raised two eaglets to fledging in early July from a nest that was on a power pole and was originally built by osprey.

Fourth, bald and golden eagles nested successfully in close proximity at Cottonwood Reservoir in 1995. Both nests were originally built by bald eagles in live ponderosa pines that were 510 m apart. Nest tree 516 was used by bald eagles to raise one young in 1993. In 1994, the bald eagles moved to a new nest in nest tree 618 where they raised two young while the nest in nest tree 516 was unused. On 28 April 1995, an adult golden eagle was on the nest in nest tree 516 in incubating or brooding position and an adult bald eagle was on the nest in nest tree 618 in incubating position. On 12 June 1995, there was one golden eagle nestling on the nest in nest tree 516 and a bald eagle nestling on the nest in nest tree 618. The nests were not in direct line-of-sight from one another because of a forested ridge of land between the nest trees.

Ownership of Nest Trees

Because of the large number (n = 1,645) and wide distribution (Fig. 8D) of bald eagle nest trees in the study area, nest trees and breeding areas were found on land of 18 different owners (App. 24A & B). Lands owned by private parties (637 nest trees), U.S. Forest Service (482), and Bureau of Land Management (170) accounted for 78% of nest trees. Land ownership of breeding areas was similar with private parties (226 breeding areas), U.S. Forest Service (172), multiple owners (73) and Bureau of Land Management (66) accounting for 81% of breeding areas (n = 662). The remaining 22% of nest trees and 19% of breeding areas were found on lands owned by 15 and 14 other parties, respectively, and all except for the unknowns were public owners ranging from cities to national parks (App. 24B). Sixty percent of nest trees and 52% of breeding areas were found on public lands, while 39% of nest trees and 34% of breeding areas were found on privately owned lands.

Land ownership of breeding areas and nest trees varied considerably among watersheds (App. 24A & B). Approximately half of breeding areas and nest trees were owned by public parties in the Northeast, Columbia and Willamette watersheds. Ownership was approximately 40% private and 60% public in the Klamath and Pacific watersheds, and approximately 15% private and 85% public in the Deschutes and Rogue watersheds. Klamath was the only watershed where the ratio of private to public ownership was different between breeding areas and nest trees (X^2 = 18.418, 1 df, $p < 0.01$) with 31% private and 69% public for breeding areas versus 40% private and 60% public for nest trees.

Distribution of breeding areas by elevation west and east of the Cascade Mountains was different for private and public lands. Breeding areas on private lands were lower in elevation than those on public lands on both sides of the mountains (west: Z = 5.082, $p < 0.10$; east: Z = 4.460, $p < 0.01$). Elevations of breeding areas on private lands west of the Cascade Mountains ranged from 3–500 m (median = 41 m, 25% = 6 m, 75% = 88 m), and those on public lands ranged from 2–1,676 m (median = 122 m, 25% = 6 m, 75% = 360 m). Elevations of breeding areas on private lands east of the Cascades ranged from 24–1,579 m (median 1,305 m, 25% = 914 m, 75% = 1,394 m), and those on public lands were found at 30–2,027 m (median = 1,387 m, 25% = 1,295 m, 75% = 1,502 m).

Nesting success for breeding areas on private and public lands varied significantly among watersheds (X^2 = 28.684, 13 df, $p < 0.01$); however the difference between ownerships was not significant overall (X^2 = 0.224, 1 df, $p > 0.10$). There were significant differences in nesting success of breeding areas between private and public lands for the Deschutes (X^2 = 4.406, 1 df, p = 0.037) and Rogue (X^2 = 4.593, 1 df, p = 0.033) watersheds, and the difference for the Willamette watershed was close to significant (X^2 = 3.524, 1 df, p = 0.061, Fig. 40). Even though overall nesting success was similar for breeding areas on private and public lands, productivity was greater (t =

2.590, 407 df, p = 0.01) for breeding areas on private lands (n = 147, mean = 1.06 young per year occupied, SE = 0.038) than for those on public lands (n = 262, mean = 0.949, SE = 0.024). This difference was a result of more young being produced (larger brood size) at breeding areas on private than on public lands (X^2 = 5.635, 1 df, p = 0.018).

Population Size by Month

According to our model of relative abundance, the number of bald eagles in Oregon and along the lower Columbia River changed monthly through the year (Fig. 41). Resident bald eagles were most abundant during the breeding season when nestlings were feathered or recently fledged (June and July) and least abundant in the fall (October and November) when some residents apparently moved to hunting areas outside the study area. In contrast, non-resident bald eagles were most abundant in late winter (February or early March) when they were at wintering areas on the study area and least abundant in late spring and early summer (May-July) when most were at breeding areas outside the study area. Abundance of residents and non-residents combined was greatest in February or early March when wintering eagles from other areas were most abundant and the resident population was associated with breeding areas in preparation for nesting. The bald eagle population on the study area was lowest in late September or early October when some residents were off the study area and most non-residents had not arrived.

Year-To-Year Nesting Outcomes

Changes in nesting success at breeding areas from one year to the next were summarized by 15 outcome categories and resulted in an array of year-Y to year-Y + 1 proportions (App. 14A). Nine categories that represented unoccupied breeding areas and uncertain nesting outcomes (OCCF, UNOC, OCEX, OC2X, OC1X, OCCX, OCXX, UNOX, and NS) were combined into an "other" category, leaving six categories representing occupied breeding areas with known nesting outcome (1, 2, 3, OCEF, OC2F, and OC1F). The proportions of breeding areas with success (1, 2, or 3) or failure (OCEF, OC2F, or OC1F) in year-Y+1 after success or failure in year Y (Table 16) resulted in a model of nesting outcomes that was similar statistically to monitoring results for 1978–2007 (X^2 = 1.491, 5 df, $p > 0.10$) and provided year Y+1 probabilities for modeling purposes.

The most likely outcome of breeding attempts in year Y+1 for four of six known outcome categories was a repeat of the outcome in year Y (Table 16), but there were exceptions for production of three young (category 3) and occupied failures when one adult was observed (category OC1F). The most likely outcome the year after three young were produced was two young, and the most likely outcome the year after an occupied failure with one adult was production of one young. The frequencies of outcomes in year Y+1 within year-Y categories were different from expected for all six year-Y categories ($p < 0.01$, Fig. 42). In addition, the outcome in year Y was repeated in year Y+1 more often than expected. In other words, the outcomes of breeding attempts on the study area tended to repeat from one year to the next.

The year-to-year ratios of nesting outcomes (Table 16) were used to model probabilities of future occupancy of breeding areas and nesting success. The rate of breeding areas being occupied in two successive years was 0.939 (7,107 breeding areas occupied in year Y+1 out of 7,571 occupied in year Y, App. 14B), which indicated that the chance of an occupied breeding area remaining occupied declined annually but was >50% after 10 years and >10% after 35 years (Fig. 43). The rate for breeding attempts being successful in two successive years was 0.686 (3,085 breeding attempts with successful nesting in year Y+1 out of 4,498 successful in year Y, App. 14B), which was greater than for failures in two successive years (0.471, 1,316 breeding attempts that failed in year Y+1 out 2,796 that failed in year Y, App. 14B). There was greater chance of failure than success after two consecutive years of successful nesting, and nesting success was more likely than failure the year after a failure (Fig. 44). The rate of breeding areas being unoccupied in two successive years was 0.355 (n = 327, App. 14B), which indicated that the probability of an area being unoccupied in three successive years was < 0.05, or conversely, the probability the area would be reoccupied after three successive years of being unoccupied was approximately 95% (Fig. 19).

DISCUSSION

Population Size

Prior to 1750, aboriginal humans in the Pacific Northwest probably coexisted with breeding bald eagles in an equilibrium that existed for centuries. The species held spiritual significance and was utilized at least for ceremonial purposes by some aboriginal cultures. However, size and distribution of the breeding population of bald eagles and the impacts of aboriginal use of the species prior to 1750 are unknown. From 1750–1800, epidemics of introduced European diseases initiated a decline of the aboriginal human population (Loy et al. 2001:16). Concurrently, the arrival of European and white American explorers, trappers, traders, and settlers started an unprecedented change in human culture that included an exponential increase in the human population (Loy et al. 2001:37), capitalization of natural resources (Loy et al. 2001:88-101), and environmental pollution (Carson 1962:6). The breeding population of bald eagles apparently declined from the late 1700's or early 1800's until the 1960's or 1970's before the recent (1978–2007) increase (this study).

Our model of the annual cycle of change in population size for bald eagles in Oregon and along the lower Columbia River indicated the population fluctuated based on timing of the nesting season and movements to and from the area by resident and non-resident eagles. The eagle population was largest in late winter and smallest in late summer and early fall. The number of bald eagles in the study area at any given time was the result of a complicated pattern of movements by bald eagles in the western United States and Canada, which was influenced by eagle age, origin, traditional migration routes, season, weather, food abundance and availability, and asynchronous nesting seasons (Beebe 1974:42-44, Stalmaster 1987:44, Palmer et al. 1988:203). Band recoveries and movements of marked eagles provided specific examples of movements of bald eagles to and from Oregon.

One of our objectives was to determine the size and trend of the breeding population from 1978 to 2007. We believe that the breeding population in 1978 was close to an historical low, which occurred sometime in the 1960s or early-to-mid 1970s (U.S. Department of the Interior 2007:37, 347, Palmer et al. 1988:199). The number of breeding pairs at that time in Oregon and along the lower Columbia River was unknown

(Marshall 1969). However, we suspect it was < 100, which was < 7% and < 14% of our estimated minimum (n = 728) and maximum (n = 1,456) number of breeding pairs on the study area circa 1800. From 1978–2007, the number of occupied breeding areas increased from 66 to 553, with 553 representing 76% and 38% of the minimum and maximum estimates circa 1800, respectively. The accuracy of our annual results probably improved during the first five years of the project because of increased knowledge and improved timing and technique.

The bald eagle population in the study area from mid March–August included pairs of adults occupying breeding areas, non-breeding adults, subadults, and nestlings. It was not feasible for us to estimate the number of non-breeding adults, subadults or juveniles in the population; however, the number of subadults and juveniles observed during our surveys increased significantly during the study. The annual cohort of nestlings was approximately 1 (0.97) per occupied breeding area; consequently, our minimum population estimate for resident bald eagles at the end of each breeding season was approximately three times the number of occupied breeding areas (2 adults + 1 nestling per occupied breeding area). Therefore, the minimum size of the resident population increased from 198–1,659 individuals excluding non-breeding adults and subadults from 1978–2007.

The exponential increase in the number of occupied breeding areas from 1978–2007 was the result of the annual addition of occupied breeding areas, an increase in the proportion of breeding areas occupied, and a low proportion of breeding areas that were abandoned. Our count of 553 occupied breeding areas in the study area in 2007 was approximately 5.6% of the estimated breeding population of the lower

48 states (n = 9,789) (U.S. Department of the Interior 2007:37,348). Assuming that the proportions of occupied breeding areas by state were accurate for 2007, the breeding population of bald eagles in Oregon in 2007 was seventh largest among the lower 48 states (U.S. Department of the Interior 2007:37, 349).

Population growth rates varied considerably in the different watersheds of the study area. Growth rates were positive in all watersheds but they ranged from 0.048 in the Deschutes to 0.147 in the Willamette with an overall average of 0.073 (7.3% increase per year). Population growth rates were correlated negatively (r = -0.761, p = 0.018) with the initial population size for the region; consequently we observed an increasing proportion of occupied breeding areas in the Columbia, Willamette, and Rogue watersheds as proportions in the Deschutes, Pacific, and Klamath watersheds decreased. As a result, the overall distribution of the population changed from 36% west and 64% east of the Cascades in 1978, to 58% west and 42% east in 2007.

The exponential increase in population size resulted in increased densities of the breeding population around most water bodies. Densities at seven water bodies in the study area increased and ranged from one occupied breeding area per 2.4 km (1.5 mi) of shoreline at Odell Lake to 1 per 11.9 km (7.4 mi) along the main stem of the Willamette River in 2007. Population densities reported for stable populations of bald eagles elsewhere ranged from 1 breeding area per 0.8 km (0.5 mi) of shoreline at Kruzof Island, Alaska (Hodges and Robards 1982 *in* Buehler 2000:13) to 1 per 14.8 km (9.2 mi) at Besnard Lake, Saskatchewan (calculated from data *in* Gerrard et al. 1992). We observed increasing productivity with increasing density in some regions, which suggested that density dependent factors were not occurring in the Columbia River

Estuary (1 breeding area per 5.2 km), Willamette River (1 per 11.9 km), Umpqua River (1 per 8.0 km), and Upper Klamath and Agency lakes excluding Spence Mountain and Eagle Ridge (1 per 4.3 km). Conversely, stable or decreasing productivity with increasing density suggested that density dependent factors may have operated at Odell Lake (1 breeding area per 2.4 km), Crane Prairie and Wickiup reservoirs (1 per 6.5 km), Lake Billy Chinook (1 per 11.1 km), and Spence Mountain and Eagle Ridge (1 per 2.8 km).

In previous research, we determined that density dependent factors likely began affecting nesting success when occupied nests in adjacent breeding areas were < 3,200 m (2 mi) apart, and there was a strong negative influence at < 1,600 m (1 mi, Anthony et al. 1994). The actual distance between nearest-neighbor breeding pairs at which density dependent effects occurred probably varied by water body because of differences in food availability, shoreline configuration, distribution of suitable nest trees, and behavioral differences among breeding pairs. For example, the amount of shoreline per occupied breeding area was greater than straight-line distance between nests in some adjacent breeding areas. Our data suggested that 1 occupied breeding area per 3.2 km (2 mi) of shoreline could be used as a conservative threshold for onset of density dependent effects on nesting success.

Estimates of the size of territories of bald eagles have been made with different methods and have produced varying results (Stalmaster 1987:50–52, Garrett et al. 1993). For example, unused nests within occupied breeding areas may act as territorial markers (Stalmaster 1987:50–56). Using such an approach with our data, we found that 87% of distances between nest trees within breeding areas were ≤ 1,600 m (1 mi) and

98% were ≤ 3,200 m (2 mi, n = 2,243, Fig. 36). These results and the finding that density dependent effects on nesting success were significant when adjacent occupied nests were < 1,600 m (1 mi) apart (Anthony et al. 1994) suggested that territory size was defined by distances of 1,600–3,200 m (1–2 mi) between occupied nest trees in our study area. Consequently, breeding densities of one occupied breeding area per 1.6–3.2 km (1–2 mi) of shoreline indicated that habitats were approaching or had reached carrying capacity. Densities at Odell Lake (1 per 2.4 km) and Spence Mountain-Eagle Ridge (1 per 2.8 km) had reached this threshold and were exhibiting slow population growth and stable or declining productivity. As a result, we concluded that population densities in those regions may have reached maximum densities by 2007.

We estimated that there were at least 10,543 km (6,551 mi) of shoreline that was potential bald eagle habitat in our study area based on the amount of river miles and shoreline. That corresponded to a density of 1 occupied breeding area per 19.1 km (11.9 mi) of shoreline for 553 occupied breeding areas in 2007. A density of 1 per 3.2 km (2 mi) for the study area would result in a potential for 3,295 occupied breeding areas. However, this estimate is unrealistic because of limits to food availability and suitable nest trees in proximity to some aquatic habitats. An overall density of 1 occupied breeding area per 6.4 km (4 mi) for seven water bodies in a variety of habitats may be more realistic for our study area, and this density resulted in an estimate of 1,647 potential occupied breeding areas for Oregon and along the lower Columbia River. This estimate compared to the 553 occupied breeding areas in 2007 suggests that the breeding population of bald eagles will continue to increase two-to-threefold in the future.

Marked Eagles

The recovery rate for bald eagles banded as nestlings in Oregon from 1978–1986 was 12.7% (n = 157) through 2009 and was typical of recovery rates for banded bald eagles elsewhere. For example, recovery rates were 9.2% for 1,168 eagles banded in Florida in the 1930's and 1940s (Stalmaster 1987:42), 10% for 303 eagles banded in Glacier National Park from 1977–1993 (McClelland et al. 2006), and 14.2% for 344 banded from 1979–1997 in the Greater Yellowstone Ecosystem (Harmata et al. 1999). Recovery rates for bald eagles were similar to 7–11% for ospreys (Poole 1989:46), higher than the overall band recovery rate of 5.6% (n = 63,000,000 birds banded) reported by the Bird Banding Lab for 1902–2002 (U.S. Geological Survey 2010a), and much higher than for some species, e.g. 0.087% for white-crowned sparrows (*Zonotrichia leucophrys*) (Cortopassi and Mewaldt 1965 *in* Welty 1982:551).

Band returns from 22 bald eagles banded as nestlings in Oregon provided valuable data on longevity and movements. Ages of 20 dead resident bald eagles ranged from 0 years, 3 months to 26 years, 3 months and averaged 7 years, 0 months, which matched the 7-year-1-month average for 31 migrant eagles banded at Glacier National Park, Montana (McClelland et al. 2006). The 26-year-3-month-old bird was a longevity record for Oregon, the fourth oldest bird reported from west of the Mississippi River, and the tenth oldest wild individual reported to date. The longevity record for the species was 36.5 years for a bird banded in Florida (Wood 2009), the second through sixth oldest also were from east of the Mississippi and were 32 years, 10 months through 29 years, 7 months reported by the Bird Banding Laboratory (U.S. Geological Survey 2010b). The overall seventh and ninth oldest, and first and third oldest west of the Mississippi were 28 years,11 months and 27 years, 9 months, respectively, banded in Glacier National Park, Montana (B. R. McClelland personal communication, 12 May 2010 e-mail); the 27-year-9-month-old bird was found dead recently (7 April 2010) under a power line in Lake, County, Oregon (C. L. Foster, personal communication, 12 May 2010 e-mail). The eight oldest overall and second oldest west of the Mississippi was a 28-year-0-month-old bird from southeast Alaska (Schempf 1997).

Recovery locations for banded resident bald eagles indicated that long-range movements were common and provided evidence of natal philopatry. Seven of twelve subadults (58%) were recovered in California, Nevada, Idaho, Washington, British Colombia, Canada and Sonora, Mexico, indicating that subadults from Oregon traveled long distances from their natal areas. Long-range movements by the species have been documented range-wide (Buehler 2000:4) and during research in Washington (Watson and Pierce 2001:13), Glacier National Park, Montana (McClelland et al. 1994), the Greater Yellowstone Ecosystem (Swenson et al. 1986, Harmata et al. 1999), Arizona (Hunt et al. 2009, Southwestern Bald Eagle Management Committee 2010), and California (Linthicum et al. 2007, Institute For Wildlife Studies 2010).

In contrast to the long-range movements of subadults, eight of ten resident adults overall and six of seven resident adults recovered during the breeding season were found within Oregon. Distance from the natal area of the seven adults recovered during the breeding season ranged from 18–148 km (11 to 92 mi) and averaged 59 km (37 mi) in contrast to the 264 km (164 mi) average distance for four subadults recovered during the breeding season. The finding that adults banded as nestlings in Oregon were breeding within 150 km (93 mi) of their natal areas suggested a strong degree of natal philopatry and may explain the clumped population growth pattern and slow increase in areas where the breeding population was small or nonexistent at the beginning of our study. Natal philopatry is a common breeding strategy for raptors (Newton 1979:173) and has been documented for bald eagles in the greater Yellowstone area; Saskatchewan, Canada; and Texas (Buehler 2000:21), and Florida (Wood 2009).

Encounters with marked non-resident bald eagles demonstrated the importance of Oregon to eagles from other areas. This is especially true for non-breeders as at least 73% of 62 encounters were subadults. Non-residents were reported in Oregon all months of the year and averaged one per month in May and June (n = 2) and five per month for July through April (n = 51). The low number of reports during May and June probably was because non-residents were more likely to be outside of Oregon and near their nesting areas during the breeding season. Non-residents were encountered in 20 to 22 of the 36 Oregon counties, indicating that many parts of the state provided habitat for non-residents. Non-residents encountered in Oregon came from Washington; Northwest Territories and Alberta, Canada via Glacier National Park, Montana (McClelland et al. 1994:30-33); Idaho; the Greater Yellowstone Ecosystem; Wyoming; California; Arizona; and Mexico. Consequently, the combined ranges of resident and non-resident bald eagles potentially encompasses the area west of the Rocky Mountains from northwestern Mexico to Alaska and northwestern Canada, and east of the Rockies in Alberta and Northwest Territories, Canada.

Distribution

The distribution of breeding areas in the study area expanded annually from 1978–2007. Four "subpopulations" were evident in 1978 based on concentrations along the lower Columbia River, around Crane Prairie and Wickiup reservoirs, at Upper Klamath Lake, and along the coast. By 1987, the four original "subpopulations" had increased in size and expanded in distribution, and two occupied breeding areas were located on the lower Rogue River, and one of two breeding areas in northeast Oregon was occupied. No breeding areas were known along the Willamette River between Eugene and Portland or upstream of Portland along the Columbia River during the first decade of the study. By 1997, the distinction between the original "subpopulations" had faded as the number of occupied breeding areas increased within and around each area and expanded along the Columbia, Willamette, and Umpqua rivers. In addition, the number of occupied breeding areas along the Rogue River and in central and northeast Oregon had increased. Population growth during the final 10 years of the study further blurred the distinction between the original four "subpopulations" as gaps between those areas were filled by new breeding pairs. In 2007, a relatively small number of widely scattered breeding areas in northeast Oregon were still somewhat isolated from the rest of the population, and no breeding areas were known in southeast Oregon. The absence of breeding pairs in southeastern Oregon during the study likely was due to prior local extermination of the species. Re-colonization probably had not occurred because potential source nests were too few and distant, and forested shoreline was lacking.

Distribution of the breeding population was associated with the distribution of aquatic habitats with forested shorelines as is typical throughout the species' range (Stalmaster 1987:119, Buehler 2000:6). Ninety percent of the most recently used nest trees in breeding areas were ≤ 3,200 m (2 mi) from the mean high water line of an aquatic habitat and 84% were ≤ 1,600 m (1 mi, Fig. 28). In Washington, 99% of nest trees (n = 817) were within approximately 1,600 m (1 mi) of a shoreline and 97% were within 914 m (3,000 ft) of aquatic habitat (Stinson et al. 2007:14). In southeast Alaska, 99% of nest trees (n = 2,732) were within 200 m (0.12 mi) of the nearest shore (Robards and Hodges 1977 *in* Stalmaster 1987:119). Distance from water probably increased with decreasing latitude because a greater proportion of treeless or developed shoreline and arid habitats resulted in nest trees being located further from water. We found 46 breeding areas (7%, n = 662) that we considered atypical because they were not associated with a specific aquatic habitat, and 50% of these atypical breeding areas (n = 46) were > 3,200 m (2 mi) from a permanent aquatic habitat. Contrary to our expectations, nesting success and productivity were higher ($p < 0.05$) for atypical breeding areas than for breeding areas that were associated with permanent aquatic habitats. These results suggested that there was more suitable habitat in the study area than we estimated by measuring shoreline of permanent water bodies and rivers, so it is possible the breeding population may increase more than we have predicted herein.

The proportion of the breeding population associated with different aquatic features changed from natural lakes (40%), estuaries (28%), and reservoirs (18%) in 1978 to estuaries (31%), rivers (22%), reservoirs (21%), and natural lakes (15%) in

2007. This change mostly was a result of a decreased proportion of breeding areas at natural lakes (40% to 15%) and an increased proportion at rivers (6% to 22%). This disparity occurred because populations were already high around natural lakes in 1978 and population growth rate for natural lakes (0.035) was lower than that of rivers (0.128). The probable reasons for the large difference between population growth rates were that vacant lake habitat was less abundant than river habitat statewide (Loy et al. 2001:162-167), lake habitat was more densely occupied in 1978, and lake habitat was more abundant east than west of the Cascades (Loy et al. 2001:166). Consequently, populations increased faster along rivers west of the Cascades.

In our study, distance of nest trees to water varied by watershed, and west versus east of the Cascades Mountains. These differences apparently were because large trees capable of supporting nests were farther from water in arid habitats east of the Cascades. However, the distance of nest trees from water had little effect on productivity except in the Klamath watershed where productivity increased slightly with the distance nest trees were from water ($r_s = 0.213$, $p = 0.025$). The reason for this result may have been the effect of high breeding density (1 breeding area per 2.8 km or 1.7 mi) on productivity at Spence Mountain and Eagle Ridge (west side of Upper Klamath Lake) where nest trees were closer to water (median = 207 m n = 19) than those for the rest of the watershed (median = 580 m, n = 116).

Distribution of breeding areas by elevation was bi-modal because breeding areas were concentrated near sea level west of the Cascades and around high elevation lakes and reservoirs east of the mountains. In addition, productivity decreased slightly with elevation for the study area ($r_s = -0.111$, $p = 0.015$), but it was a weak relationship that resulted from significant decreases in productivity with increased elevation in the Willamette (r_s = -0.409, $p < 0.01$) and Pacific watersheds (r_s = -0.274, $p = 0.012$). Both of these regions extended from sea level to the crest of the Cascades, and nesting success was higher below 900 m (2,953 ft) elevation and lower above 900 m elevation. Nesting success also was lower at the higher elevations east of the Cascades but the difference was not as great.

Weather was the likely cause of lower nesting success above 900 m (2,953 ft) elevation. Oregon's highest precipitation fell as rain and snow at 610–1219 m (2,000-4,000 ft) on the west slope of the Coast Range and above 914 m (3,000 ft) on the west slope of the Cascades during November–April (Taylor and Hannan 1999:8, Loy et al. 2001:154–155). Egg-laying occurred from mid February through April, and severe cold and wet weather during these months probably increased nesting failures above 900 m (3,000 ft) elevation. The effect of weather probably was weaker on the east slope of the Cascades because of the "rain shadow" that resulted in less precipitation east of the crest (Taylor and Hannan 1999:8). Severe late-winter and spring weather was shown to affect bald eagle productivity in Yellowstone National Park (Swenson et al. 1986:28-29), and spring storms were the suspected cause of low productivity at Besnard Lake, Saskatchewan in 1975 (Gerrard et al. 1983:55).

The distribution of breeding areas between private and public ownerships was similar to distribution of land by ownership in the study area. Private landowners had 44% of the land and 39% of breeding areas, while public land comprised 56% of the land base and had 60% of the breeding areas. Overall, nesting success was similar for breeding areas on private and public lands; however, nesting success was higher on private land in the Deschutes and Rogue watersheds ($p < 0.05$). Additionally, productivity was higher for breeding areas on private land in general ($t = 2.590$, df = 407, $p = 0.01$). Breeding areas on private land were lower in elevation than breeding areas on public land both west ($Z = 5.082$, $p < 0.01$) and east ($Z = 4.460$, $p < 0.01$) of the Cascades. Consequently, we attributed the differences in nesting success and productivity between private and public land to the significant decrease in nesting success and productivity with increasing elevation (see above). In other words, the difference in breeding success was due to differences in elevation of breeding areas on different land ownerships, not ownership per se.

Nesting Phenology

The onset of the nesting season was difficult to judge until incubation began because courtship, pair formation, and pair bonding can occur away from the nest and months or years before egg laying (Palmer et al. 1988:208). In addition, day length, food supply, weather, and prior nesting experience can affect date of egg laying of most raptors (Newton 1979:98-106). Nest building and copulation were obvious pre-nesting behaviors observed at breeding areas in our study. Nest building was reported every month of the year, while copulation was seldom observed. Observations of copulation ($n = 75$) were recorded in January (1%), February (17%), March (61%), April (17%), and May (3%), but 95% of the observations occurred during February–April, which were the months of egg laying on the study area.

Timing and duration of nesting seasons of bald eagles varies by latitude with southern populations nesting earlier and with less synchrony than northern populations (Stalmaster 1987: 63, Buehler 2000:14). For example, egg laying in Florida (28°N) occurred during the seven-month period from October–April (Buehler 2000:15), while in southwest Yukon (61°N) egg laying occurred during the latter half of April and early May (Blood & Anweiler 1990). Egg laying in our study area (44°N) occurred during three months, February–April. We observed evidence of eggs at 79% of occupied breeding areas with known outcome (n = 7,696).

Thousands of observations spanning 37 breeding seasons resulted in detailed charts of breeding phenology for successful and failed nesting attempts. The long breeding season for individual pairs plus asynchrony of nesting for the population resulted in the breeding season lasting from January–August. Observations during the non-breeding season revealed that > 60% of breeding areas were occupied by at least one adult bald eagle from September–December, which indicated that they were year-round residents at most breeding areas. Most resident adults that were monitored closely occupied breeding areas year-round in south-central and central Oregon (Frenzel 1984:19, 118, Clowers 2005), and along the lower Columbia River (Garrett et al. 1993). Similarly, some adult bald eagles equipped with radio transmitters in Washington were year-round residents and some moved north for up to six weeks after the breeding season (Stinson et al. 2007:10). The population of adult bald eagles resident in our study area probably contained both year-round residents and individuals that moved north in late summer and fall.

Detailed information on breeding phenology provided guidance on the best timing for surveys to determine occupancy and productivity of breeding areas. The best time to survey for occupancy of breeding areas was 27 March–10 April because evidence of eggs was highest during this 15-day period. Similarly, the best time to count young was

26 May-15 June because eaglets were large and feathered at most breeding areas while fledging was just starting at a few areas where nesting was early. Even with two properly-timed surveys, the asynchrony of nesting for the population resulted in the need for follow-up visits when breeding areas were not occupied during the early (occupancy) survey or when brooding adults or downy young were observed during the productivity survey.

Evidence of eggs at breeding areas where nesting was successful occurred five days earlier during 2003–2007 than during 1971–1992 (Fig. 13A-D). This shift was detected at breeding areas west of the Cascades but was not evident for breeding areas east of the Cascades. Parallel regression curves indicated that the shift in breeding phenology was uniform over the breeding season and that early and average egg-laying and hatching dates probably advanced by five days, although that could not be verified because we did not determine exact dates for those events. In other studies, average egg-laying dates advanced 8.8 days for 20 bird species in the United Kingdom from 1971–1995 (Crick et al. 1997), and egg-laying dates for tree swallows (*Tachycineta bicolor*) across North America advanced by 5–9 days from 1959–1991 (Dunn and Winkler 1999). These shifts in breeding phenology have been attributed to warming and drying climatic conditions. Temperature is an important regulator of avian reproductive rhythm and warming weather in spring can stimulate nesting (Welty 1982:174). During the 20th century, average surface temperature in the Pacific Northwest increased 0.7–0.9°C (0.4–0.5°F, Mote 2003) and was sufficient to advance the arrival of spring by 5–10 days (Cayan et al. 2001). Consequently, we believe that the shift in bald eagle breeding phenology to earlier dates west of the Cascades was likely a response to warmer spring temperatures during the latter years of our study.

In contrast, we did not observe a shift in nesting phenology east of the Cascades. Breeding areas east of the Cascade crest were at significantly higher elevations and in a different climatic zone than breeding areas west of the Cascades (Mote 2003:274). Warming also was greatest in winter (January–March) at lower elevations in the maritime zone (Mote 2003). Consequently, temperature increases east of the Cascades may not have been of sufficient magnitude or timed so that they affected breeding phenology of the species in that region.

Productivity

Surveys of breeding populations of bald eagles were rare and local before 1960 (Sprunt et al. 1973) and were more common and widespread after the species was listed as threatened and endangered (Buehler 2000:37, 39). Surveys have ranged from regional efforts covering one year (e.g., Grubb et al. 1975) to statewide, multi-year projects (e.g., this study). Results of surveys usually were reported as percent of breeding areas that were occupied and nesting was successful (nesting success), number of young per occupied breeding area (productivity), and number of young per successful nesting attempt (brood size). For multi-year studies, nesting success has ranged from 10% along Great Lakes shores (1961–1970, Sprunt et al. 1973) to 77% for inland Wisconsin (1983–1988, Kozie and Anderson 1991). Likewise, productivity has ranged from 0.13 young per occupied breeding area at Prince of Wales Island, Alaska during 1991–1993 (Anthony 2001) to 1.30 for inland Wisconsin (1983–1988, Kozie and Anderson 1991). Brood size has ranged from 1.10 young per successful breeding area at Prince of Wales Island, Alaska (Anthony 2001) to 1.92 in Colorado and Wyoming from 1981–1989 (Kralovec et al. 1992). Sprunt et al. (1973) concluded that nesting success ≥ 50% and productivity ≥ 0.70 were required to maintain population stability but this was based on circular reasoning. In addition, other combinations of nesting success and productivity can result in stable populations because nesting success and productivity are highly correlated in bald eagle populations (Steidl et al. 1997). Most importantly, survival rates have been shown to be more important than reproductive rates in determining population stability of the species (Grier 1980). During our study, nesting success was 66%, productivity was 1.04 young per occupied breeding area, and brood size was 1.57 young per successful breeding area. These results were comparable to those of increasing populations in other areas (Buehler 2000:39). Even though the survival rate of adults was unknown, relatively high productivity and exponential population growth suggest survival was high.

Nesting success in our study varied by watershed, and differences between the regions decreased with time and as populations in each watershed increased. The Columbia watershed was the only area with nesting success consistently < 50% and productivity < 0.70 during the first 15 years of our study. Concerns about low productivity in the Columbia watershed resulted in research on home range and habitat use, human activities, and environmental contaminants during the 1980s (Garrett et al. 1993, Anthony et al. 1993, McGarigal et al. 1991). Results of those studies indicated that environmental contaminants, particularly DDE (average 9.7 ppm wet mass basis in fresh eggs, n = 17, range = 4.0-20.0 ppm), dioxin (2,3,7,8-TCDD, average 31.98 ppm, n = 5, range = 5.1-61.0 ppm), and PCB's (average 12.7 ppm, n = 17, range = 4.8-26.7

ppm), were a likely cause of low nesting success in the Columbia watershed (Anthony et al. 1993). A follow-up study of contaminants in eagle eggs was conducted during 1994 and 1995 (Buck et al. 2005) and documented decreased levels of those contaminants (DDE average 6.3 ppm wet mass basis in fresh eggs, $n = 13$, range = 3.5-12.5 ppm; 2,3,7,8-TCDD average 24 ppm, $n = 13$, range = 18-37 ppm; and PCB's average 5.4 ppm, $n = 13$, range = 3.4-11.4 ppm). However, levels were still high enough in the mid 1990s to impair reproduction at some breeding areas and productivity at older breeding areas on the lower segment of the river had not improved since the 1980s (Buck et al. 2005).

The breeding population along the Columbia River increased exponentially during our study and productivity improved significantly ($p < 0.01$) through 2007. However, breeding areas with low productivity persisted and were concentrated below river mile 47 (km 75.6) where 35% of breeding areas ($n = 54$) had < 0.50 productivity. That segment of river also included six breeding areas with ≥ 5 years of occupation and zero productivity. In contrast, only 4% of breeding areas ($n = 55$) above river mile 47 (km 75.6) had < 0.50 productivity and none had zero productivity. Low productivity in the lower 47 miles (75.6 km) of the Columbia River persisted through 2007. Effects of contaminants were especially evident between river miles 13 and 31 (km 21–50) where six breeding areas with zero productivity were located. In addition, two breeding areas with < 0.50 productivity above river mile 47 (km 75.6) were located in the 25-mile (40.2 km) stretch of river below Bonneville Dam (river mile 146 or km 235) where polychlorinated biphenyl (PCB) 105 was found concentrated in osprey eggs (Henny et al. 2004:378).

There are many possible causes of nesting failures and determination of the cause(s) of failures at specific breeding areas requires more in-depth investigations than occur during routine nest surveys (Anthony et al. 1994). We found that low productivity coincided with mate changes and establishment of new territories, which indicated that inexperience of first-time breeders was a likely reason for failure in those situations. Anthony et al. (1994) identified mate change as a possible cause of nesting failures, and Jenkins and Jackman (2006) quantified the effects of mate replacement on breeding in a population of marked individuals. Jenkins and Jackman (2006) reported that productivity decreased significantly from 1.50 young per occupied breeding area the year before to 0.35 the year after a mate change. Their results were very similar to the productivity of 0.36 young per occupied breeding area the year of a mate change in our study. Our data also indicated that productivity was lower than expected the year before the mate change, whereas Jenkins and Jackman (2006) reported normal productivity the year prior. We suspect the difference in results of the two studies was due to the use of marked eagles in the study by Jenkins and Jackman (2006). They could determine exactly when a mate change occurred and knew when adults replaced adults. In our study, we could not recognize a mate change until the following breeding season, and our observations were based on non-adults replacing adults. We found a similar pattern of low productivity during establishment of new breeding areas. Low productivity the year of establishment followed by improvement to normal productivity in three years suggested that inexperience was a likely reason for high failure rates at new breeding areas. We found no other reference to low productivity at newly established breeding areas in the literature.

Gerrard et al. (1983:52) reported that nest failure one year was associated with lower breeding success at the same breeding area the following year, and Steidl et al. (1997) noted that breeding areas with successful nesting attempts one year had greater nesting success the following year. Both studies suggested that the reason for repeated nesting outcomes could have been related to the individuals in the breeding pair, quality of the breeding territory, or both. Our analysis of nesting success within breeding areas indicated that successful nesting attempts followed successes 69% of the time (n = 4,498 successes) and failed attempts followed failures 47% of the time (n = 2,793 failures). On a finer scale, we determined that success or failure of nesting attempts the following year were repeats of the previous years' success or lack thereof more than expected for all six known nesting outcome categories. We then used the following-year (Y+1) proportions to predict future survey results such as the chances of repeated occupation and the chances of continued nesting success or failure within breeding areas.

Nest Trees and Nests

All bald eagle nests observed in Oregon and along the lower Columbia River except for one were built in trees (n = 1,645). Primary nest tree species were Douglas-fir, Sitka spruce, and black cottonwood west of the Cascades and ponderosa pine and Douglas-fir east of the Cascades (Anthony and Isaacs 1989, this study). Use of black cottonwood increased during the study because of large increases in bald eagles nesting in riparian corridors along the Columbia and Willamette rivers where black cottonwood was the dominant tree species. Nests usually were built in live trees (≥ 98%, n = 1,644); however, nests in dead trees were used without reduced productivity.

Nest longevity in dead trees was limited because tree structure deteriorated over time. Over 60% of nests were destroyed five years after nest trees died ($n = 84$). Other studies have described nest tree and nest stand characteristics for the Pacific Northwest and Oregon (Anthony et al. 1982, Anthony and Isaacs 1989) and range-wide (Stalmaster 1987:120–124, Buehler 2000:6, 15). In general, nest trees used by bald eagles in the study area were the dominant individuals in forest stands located near water bodies with an abundant food supply and some degree of isolation from human activity. Research on the effects of forest management and human activity on nesting bald eagles within the study area have been published (Anthony et al. 1982, Anderson 1985, Anthony and Isaacs 1989, McGarigal et al. 1991, Arnett et al. 2001, Isaacs et al. 2005); however, the increase in breeding populations and expanded distribution has resulted in occupation of urban and arid habitats that have not been studied.

The cumulative number of bald eagle nest trees within breeding areas in the study area increased with time ($r = 0.928$, $p < 0.01$) from approximately 1 the first year a breeding area was known to approximately 5 after 30 years. The number of nest trees existing per breeding area could not be determined precisely because not all nest trees were observed in 2007; however, we estimated there were between 1.08 and 1.51 nest trees per breeding area in 2007 based on the number known to exist when nest trees were last observed. Nests and nest trees that were destroyed each year resulted in the difference between cumulative and existing nest trees per breeding area. Nest and nest tree “survival” averaged 97% per year over 28 years, and 16% of nest trees discovered in 1978 still had nests in 2007. Average length of time nest trees held nests was difficult to determine because the year that a nest was built often was unknown, and many nest trees still held nests at the end of the study; consequently our estimates of longevity are minimums. With this in mind, we estimated the range of average minimum longevity at approximately 7–9 years. Five trees that held nests in 1971 still held nests in 2007 resulting in those nests being ≥ 37 years old. Extreme longevity of bald eagle nests has received wide publicity in the literature (e.g., 36 years *in* Herrick 1934:4, > 50 years *in* Stalmaster 1987:54, possibly 60+ years *in* Palmer et al. 1988:211); however nests typically last < 10 years (Stalmaster 1987:55, Buehler 2000:16, this study), and there can be reasonably high turnover rates of nests in some areas. The high turnover of nests and nest trees makes it imperative that forest stands are managed so alternate nest trees are available for future nesting populations (see recommendations below).

Bald eagles often moved from one nest tree to another between years within breeding areas (n = 1,032 nest changes). The number of nest changes per breeding area increased with time ($r = 0.944$, $P < 0.01$) and occurred approximately every five years, on average. Overall, productivity tended to decrease with increasing number of nest changes; however this trend was not significant ($r_s = -0.039$, $p > 0.10$). Nest changes caused by destruction of nests between breeding seasons had no effect on nesting success or productivity the following year. Breeding areas where nest changes occurred without nest destruction had higher nesting success and productivity the year following a change than the year before.

Steidl et al. (1997) reported that successful pairs were more likely to reuse the same nest tree the following year, implying that nest changes were more likely the year after failures. Our results agree with that implication, but the cause(s) of low productivity prior to nest changes without nest loss were unknown. Improved nesting success and productivity after the change in nests suggested that limited-duration events such as mate change, severe weather, temporary disruption of food supply, or unusual human activity were likely causes of nesting failures. We found that mate changes involving subadult eagles did not result in increased rate of nest change, which indicated that mate change was not a cause. Steidl et al. (1997) suggested that low prey availability before or during incubation caused some nesting failures in interior Alaska. Consequently, low food supply early in the breeding season was one factor that could have explained low productivity during years before nest changes and indirectly resulted in nest changes in our study.

Nest tree changes and subsequent reuse of nests after ≥ 1 year resulted in gaps in use of nest trees. Gaps in use of breeding areas occurred when breeding areas were unoccupied for ≥ 1 year then reoccupied; gaps in use of nests occurred at 12% of nest trees (n = 1,645) and ranged from 1–12 years (median = 1); gaps in nest presence occurred at 4% of nest trees and ranged from < 1–14 years (median = 1); and gaps in occupancy of breeding areas occurred at 18% of breeding areas (n = 662) and ranged from 1–7 years (median = 1). Nest switching within breeding areas and reoccupation of temporarily vacant breeding areas have been reported for other bald eagle populations (Buehler 2000:16, Palmer et al. 1988:210–211); however, the frequency of occurrence has not been reported elsewhere to the best of our knowledge. In addition, we found no reference to nests being rebuilt in trees from which nests had previously fallen, although we suspect this behavior is fairly common when the tree can still support a nest and other features of the breeding area have not changed.

Use of nests by other species was rare but notable. Other avian species were observed during 1.4% of surveys (n = 9,585) and at 5.2% of nest trees (n = 1,645). Fifty-one percent of nests used by bald eagles and another species (n = 86) were built by bald eagles, 14% were built by ospreys, 5% by red-tailed hawks, and 30% had unknown builders. Six species were observed using bald eagle nests, and four of these (red-tailed hawk, osprey, great horned owl, and peregrine falcon) were documented previously (Palmer et al. 1988:210, Therres and Chandler 1993, Stinson et al. 2007:13, Whitman and Caikoski 2008). To our knowledge the other two species (Canada goose and golden eagle) have not been reported using bald eagle nests except for one reference to our observations (Stinson et al. 2007:13). Canada geese used bald eagle nests in 80 of 138 records of inter-specific nest use (58%), while 5 records (4%) were for golden eagles. Bald eagle nests provided an important nest substrate for Canada geese in some portions of our study area, particularly the lower Columbia River.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Increased population size, expanded distribution, low breeding area abandonment, and improved productivity indicated that the nesting population of bald eagles in the study area had recovered from the low population size and reduced productivity that occurred during the 20th Century and led to its listing as a threatened species. As a result, the species was removed from federal and state of Washington lists of threatened species. The management implications of delisting include reduced monitoring of breeding populations, less habitat protection, reduced funding for research, and provisions for take that have been adopted recently by the U.S. Fish & Wildlife Service (U.S. Department of the Interior 2009). All of these actions have the potential to impact local populations, particularly on privately owned lands. Consequently, we believe that it is important to comment on these potential impacts and provide some management recommendations.

Population Size

Food supply, territory size, and suitable habitat for nesting determine the carrying capacity of an area for a breeding population of bald eagles. During population increase, density of occupied breeding areas will increase until one of those factors becomes limiting. Increased population size and improved productivity overall during our study indicated that habitat was not limiting for most of the study area. In addition, recent production of eaglets (51% of 7,439 were produced from 2000-07) and increasing numbers of subadults in the population indicated that a large number of eagles will be reaching breeding age annually. The combination of suitable, unoccupied habitat and large cohorts of new breeders should result in continued increase in the breeding population and expanded distribution of the species for several more years. Our analysis of potential habitat in the study area suggested that the population could double or triple before reaching carrying capacity for most of the study area.

Implications of continued population increase include increased conflicts between territorial eagles resulting in decreased productivity in some areas, more conflicts with humans, more bald eagles breeding in atypical habitat, eagles using unusual nesting substrates such as manmade structures or cliffs, and increased depredation on domestic and wild prey. Conflicts between bald eagles and colonies of nesting seabirds have been observed along the Oregon Coast (R. Lowe, personal communication, U.S. Fish & Wildlife Service) and the lower Columbia River (D. Roby, personal communication, U.S. Geological Survey), and these types of conflicts are likely to increase. Resource managers should be aware of these implications and potential conflicts.

Recommendation

Collect data on causes of bald eagle injury and death, conflicts between bald eagles and humans, and depredation on other species by bald eagles, especially colonial nesting water birds, to quantify changes in those parameters.

Monitoring

We surveyed approximately 96% of known breeding areas and searched for new breeding areas annually. By conducting several surveys of each breeding area per year, we were able to determine occupancy rates, estimate the number of breeding pairs, and determine productivity of breeding areas annually for approximately 83% of sites surveyed. The post-delisting monitoring plan for the 48 contiguous United States was implemented with federal delisting of the species (U.S. Fish & Wildlife Service 2009b). That plan recommends that one aerial survey of nests located in a sample of the region be conducted early in the breeding season once every five years. Consequently, the post-delisting monitoring plan will not provide as much detailed information on occupancy rates and productivity as ours because their technique focuses on nests rather than breeding areas, does not determine productivity, and will represent a small sample of the nest trees in Oregon. In addition, the national monitoring plan relies on a list of known nest locations updated every five years, which is used to revise the list frame for their dual-frame sampling design (Otto and Sauer 2007). As a result, it is important that more intensive surveys be conducted on a state and regional basis to support the national monitoring plan.

Recommendation

We recommend a state-wide monitoring plan that would be conducted at least every three or four years to determine nesting success and productivity for enough breeding areas to provide statistically valid data for each watershed. This could be a survey of the entire state in any given year, or surveys of different portions of the state during a three to four-year period. We also recommend that locations of new nest trees be cataloged and that the individual trees be given unique identification numbers to be used to track nest and nest tree status and history of nest use. In addition, breeding areas should be searched for rebuilt or new nests when breeding areas appear to be unoccupied. The results of surveys should be archived at a central location so that the information is available to resource managers to conserve nesting habitat and avoid disturbance during the breeding season.

Habitat Management

While the bald eagle was federally listed, management of nesting habitat was site-specific, proactive, and cautious. Both authors and many cooperators were involved in numerous discussions and development of site-specific management plans for breeding areas on both public and private lands. Our results and personal observations indicated that habitat management while the species was listed under the Endangered Species Act was effective and resulted in conservation of much nesting habitat in our study area. Since de-listing, recommendations for conservation and habitat management at the federal level have been general and voluntary (U.S. Fish and Wildlife Service 2007). The species is now protected federally by the Bald Eagle Protection Act (U.S. Congress 1940) and Migratory Bird Treaty Act (U.S. Congress 1918), which provide little habitat protection. Fortunately, both Oregon and Washington provide some protection of bald eagle habitat on private land under state law (Washington Department of Fish and Wildlife 2010, Oregon State Archives 2010). We believe that habitat protection and proactive management based on knowledge of nest locations provided by intensive monitoring were important to the recovery of the species, and that these same actions will be important in the future. Without monitoring, some nesting habitat may be lost due to ignorance because nests are not known and locations are not recorded, and some habitat may be lost because of intentional destruction.

Recommendation

As long as the bald eagle population continues to increase, the loss of a small percentage of breeding areas likely is inconsequential. However, if the nesting population stabilizes or begins to decline, efforts to preserve all breeding areas should be renewed. Under those circumstances, we recommend that the habitat management guidelines for breeding areas based on recommendations in the Pacific Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service 1986) and efforts to promote site-specific habitat management planning (Stalmaster 1987:165) that were implemented by U.S. Forest Service, Bureau of Land Management, U.S. Fish & Wildlife Service, Washington Department of Fish and Wildlife, and Oregon Department of Forestry while bald eagles were federally listed, be continued indefinitely in order to protect and conserve nesting and foraging habitat for the species.

Occupation of Breeding Areas

Our results on occupation of breeding areas have implications for both monitoring and habitat management. Approximately 60% of breeding areas apparently were occupied year-round, nest building was observed every month of the year, abandonment of breeding areas was very rare and difficult to prove, most unoccupied breeding areas were reoccupied within two years, and nesting phenology was asynchronous.

Recommendation

Managers should assume that breeding areas are occupied year-round and be aware that more than two properly-timed, annual surveys often are necessary to determine occupancy and productivity. They should also know that human activities near nest trees any time of the year potentially are disturbing to the resident adults or other bald eagles that are tolerated in, or intruding upon, their territory. Breeding areas should not be considered abandoned until there are no nest structures present within 3.2 km (2 mi) of the last known nest location and the breeding area has been monitored to protocol and classified as unoccupied for at least five years after a nest structure was last observed.

Nest Trees

Species, condition, turnover rates, rate of reuse of nest trees and proximity to other nest trees also have implications for monitoring and habitat management. Ninety-eight percent of nests were built in live trees and 87% were within 1,600 m (1 mi) of other nest trees in the same breeding area. The most common species used for nesting (ponderosa pine, Douglas fir, Sitka spruce, western hemlock) were valuable commercially, and most nest trees were older than the age at which trees are harvested commercially (Anthony and Isaacs 1989, Anthony et al. 1982). Breeding areas monitored for 37 years averaged approximately 5 nest trees that were used during that time, and 1.1–1.5 nest trees that existed simultaneously per breeding area for all breeding areas known through 2007. In addition, approximately 17% of nests and nest trees were reused after being vacant for up to 14 years.

Recommendation

Forest management in nesting habitat for bald eagles should be focused on preserving existing nest trees and growing replacement nest trees within 1,600 m (1 mi) of recently used nest trees to provide a constant supply of suitable nest trees within breeding areas. This implies that management be on a stand-level basis rather than an individual tree basis in order to conserve nesting habitat indefinitely (Anthony and Isaacs 1989). Forest management in riparian zones for other purposes such as water quality, fisheries, wildlife corridors, or scenic beauty should contain a large tree component for bald eagles.

Marked Eagles

Banded bald eagles from Oregon dispersed widely throughout western North America as juveniles and subadults, and exhibited evidence of natal philopatry (breeding near their place of birth) as adults. Marked bald eagles from other western states, Canada and Mexico were encountered throughout Oregon year round, especially as subadults.

Recommendation

Coordinate bald eagle research and habitat management with other western states (Alaska, Washington, Idaho, Montana, Wyoming, Utah, Nevada, California, and Arizona), Canada, and Mexico because of the complex nature of long-range seasonal movements of the species, especially subadults from all areas and adults from far north.

Habitat Use Outside The Breeding Season

Bald eagles hatched in Oregon can be year-round residents or travel long distances within or out of the state. Non-residents often travel to Oregon from distant origins. Both subpopulations congregate and mix where food is abundant and they may roost together in communal night roosts. Therefore, foraging, perching, and roosting habitats used during the non-breeding season (collectively referred to as wintering habitat) are important to survival and reproductive success of both resident and non-resident populations. This study focused on nesting habitat; however, we recognized the importance of wintering habitat and observed that wintering and nesting habitat overlap for many year-round residents. Winter habitat requirements were summarized in the Pacific States Recovery Plan (U.S. Fish and Wildlife Service 1986) and were the subject of several research projects in Oregon (see pertinent citations in App. 3). Components of wintering habitat are subject to state bald eagle protection rules in Washington (Stinson et al. 2007:77) and resource site protection rules in Oregon (Oregon State Archives 2010).

Recommendation

Document the population size and distribution of bald eagles in Oregon during the non-breeding season by conducting eagle counts along standardized routes at foraging areas, and at point count locations for communal roosts during January, February, and March at least once every five years. Search for undocumented communal roosts near foraging areas where five or more eagles congregate during the day and communal roost locations are unknown. Once discovered, determine roost location and document eagle use for at least three nights in as short a period of time as possible. Document standardized routes, number of eagles at foraging areas, roost locations, and number of eagles using communal roosts. The results of winter counts should be archived at a central location so that the information is available to resource managers to conserve wintering habitat and avoid disturbance during the winter.

Future Research

Even though much has been learned about the species, there is still much about the ecology of bald eagles that is not well understood. Our results, personal observations, and review of the literature suggested a number of future research topics.

Recommendation

Our top priorities for future studies are: 1) periodic sampling of contaminants in eagle eggs from the Columbia River, 2) estimating survival rates of resident juveniles, subadults, and adults, 3) quantifying movements and dispersal from nestling to adult via satellite telemetry, 4) continued monitoring of the nesting population to determine densities, productivity, and carrying capacity, 5) determining the effects of delisting on habitat management, 6) determining the effects of weather and climate on nesting phenology, nesting success, and productivity (including more detailed analysis using our data), and 7) studying habitat utilization of breeding pairs in atypical versus typical habitat. Other topics, in no particular order of importance, include effects of eagle depredation on prey (especially seabird colonies), contaminants in bald eagle eggs from the Klamath Basin, effects of lead and other environmental contaminants on survival and nesting success, food habits, and lifetime reproduction.

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LITERATURE CITED

Adamus, P. R., K. Larsen, G. Gillson, and C. R. Miller. 2001. Oregon Breeding Bird Atlas. CD-ROM. OFO Special Publication No. 16. Oregon Field Ornithologists, Eugene, Oregon, USA.

Allison, I. S. 1966. Fossil Lake, Oregon Its geology and fossil faunas. Studies in Geology Number Nine. Oregon State University Press, Corvallis, Oregon, USA.

Anderson, J. 1971. Eagle habitat requirements and forest management. Pages 56-69 *in* Proceedings of fish and wildlife habitat management training conference. U.S.D.A. Forest Service, Region 6. November 30 - December 2, 1971, Eugene, Oregon, USA.

Anderson, R. J. 1985. Bald eagles and forest management. Pages 189-193 *in* Forestry and wildlife management in Canada, a symposium. University of British Columbia, Vancouver. 7-10 May 1984. The Forestry Chronicle, April 1985.

Anthony, R. G. 2001. Low productivity of bald eagles on Prince of Wales Island, southeast Alaska. Journal of Raptor Research 35:1-8.

Anthony, R. G., R. W. Frenzel, F. B. Isaacs, and M. G. Garrett. 1994. Probable causes of nesting failures in Oregon's bald eagle population. Wildlife Society Bulletin 22:576-582.

Anthony, R. G. and F. B. Isaacs. 1989. Characteristics of bald eagle nest sites in Oregon. Journal of Wildlife Management 53:148-159.

Anthony, R. G., M. G. Garrett, and C. A. Schuler. 1993. Environmental contaminants in bald eagles in the Columbia River estuary. Journal of Wildlife Management 57:10-19.

Anthony, R. G., M. G. Garrett, and F. B. Isaacs. 1999. Double-survey estimates of bald eagle populations in Oregon. Journal of Wildlife Management 63:794-802.

Anthony, R. G., R. L. Knight, G. T. Allen, B. R. McClelland, and J. I. Hodges. 1982. Habitat use by nesting and roosting bald eagles in the Pacific Northwest. Pages 332-342 in Transactions of the 47th North American Wildlife and Natural Resources Conference, 1982. Wildlife Management Institute, Washington, D.C., USA.

Arnett, E. B., R. J. Anderson, C. Sokol, F. B. Isaacs, R. G. Anthony, and W. P. Erickson. 2001. Relationships between nesting bald eagles and selective logging in south-central Oregon. Wildlife Society Bulletin 29:795-803.

Bald Eagle Working Team for Oregon and Washington. 1990. Working implementation plan for bald eagle recovery in Oregon and Washington. Washington Department of Wildlife, Olympia, Washington, USA.

Beans, B. E. 1996. Eagle's Plume, The Struggle to Preserve the Life and Haunts of America's Bald Eagle. University of Nebraska Press, Lincoln, Nebraska, USA.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia. Occasional Papers of the British Columbia Provincial Museum No. 17. Victoria, British Columbia, Canada.

Bent, A. C. 1937. Life Histories of North American Birds of Prey, Part 1.Smithsonian Institution U.S. National Museum Bulletin 167 (Reprinted in 1961 by Dover Publications, New York, New York, USA).

Bishop, E. M. 2003. In Search of Ancient Oregon: A Geological and Natural History. Timber Press, Inc., Portland, Oregon, USA.

Blood, D. A., and G. G. Anweiler. 1990. Nesting chronology and success of bald eagles in southwest Yukon. Northwestern Naturalist 71:9-11.

Bruner, H., and F. B. Isaacs. 1990. Supplemental feeding and monitoring of bald eagles on Cathlamet Bay, Clatsop County, Oregon. Oregon Eagle Foundation, Inc., Klamath Falls, Oregon, USA.

Buck, J. A., R. G. Anthony, C. A. Schuler, F. B. Isaacs, and D. E. Tillitt. 2005. Changes in productivity and contaminants in bald eagles nesting along the lower Columbia River, USA. Environmental Toxicology and Chemistry 24:1779-1792.

Buehler, D. A. 2000. Bald Eagle (Haliaeetus leucocephalus). In The Birds of North America, No. 506 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, Pennsylvania, USA.

Carpenter, G. P. 1990. An illustrated guide for identifying developmental stages of bald eagle nestlings in the field, final draft, April 1990. San Francisco Zoological Society, San Francisco, California, USA.

Carson, R. 1962. Silent Spring. Houghton Mifflin Company, Boston, Massachusetts, USA.

Caswell, H. 2000. Matrix population models: construction, analysis and interpretation. Second Edition. Sinauer Associates, Sunderland, Massachusetts, USA.

Cayan, D. R., S. A. Kammerdiener, M. D. Dettinger, J. M. Caprio, and D. H. Peterson. 2001. Changes in the onset of spring in the western United States. Bulletin of the American Meteorological Society 82:399-415.

Clowers, G. N. 2005. BOR Wickiup Reservoir wildlife study final report 2005. Raven Research West, Madras, Oregon, USA.

Cortopassi, A. J., and L. R. Mewaldt. 1965. The circumannual distribution of white-crowned sparrows. Bird-Banding 36:141-169.

Crick, H. Q. P., C. Dudley, D. E. Glue, and D. L. Thomson. 1997. UK birds are laying eggs earlier. Nature 388:526.

DellaSala, D. A., C. L. Thomas, and R. G. Anthony. 1989. Use of domestic sheep carrion by bald eagles wintering in the Willamette Valley, Oregon. Northwest Science 63:104-108.

Dunn, P. O., and D. W. Winkler. 1999. Climate change has affected the breeding date of tree swallows throughout North America. Proceedings, The Royal Society of London B 266:2487-2490.

Findley, R. 1981. Eruption of Mount St. Helens. National Geographic 159:1-65.

Fleischer, Jeff. 2005. Winter Raptor Survey Project. East Cascades Bird Conservancy. CD-ROM. Information available online at: http://www.ecbcbirds.org/Default.aspx?tabid=73 7 February 2010

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon, USA. General Technical Report PNW-8.

Frenzel, R. W. 1984. Environmental contaminants and ecology of bald eagles in southcentral Oregon. Ph.D Thesis. Oregon State University, Corvallis, Oregon, USA.

Frenzel, R. W. 1988. Home ranges, habitat use, and activity patterns of three bald eagles nesting on northwestern Upper Klamath Lake and observations of other bald eagles in the vicinity of Pelican Butte, Oregon, 1979-1982. A report submitted to Beak Consultants Incorporated, Portland, Oregon, USA.

Frenzel, R. W., and R. J. Anthony. 1989. Relationship of diets and environmental contaminants in wintering bald eagles. Journal of Wildlife Management 53:792-802.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis, Oregon. Reprinted 1970 as: Birds of the Pacific Northwest. Dover Publications, New York, New York, USA.

Garrett, M, R. G. Anthony, J. W. Watson, and K. McGarigal. 1988. Ecology of bald eagles on the lower Columbia River. Final Report to U. S. Army Corps of Engineers 1 August 1988. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, Oregon, USA.

Garrett, M. G., J. W. Watson, and R. G. Anthony. 1993. Bald eagle home range and habitat use in the Columbia River estuary. Journal of Wildlife Management 57:19-27.

Gerrard, J. M., and G. R. Bortolotti. 1988. The Bald Eagle, Haunts and Habits of a Wilderness Monarch. Smithsonian Institution Press, Washington DC, USA.

Gerrard, J. M., P. N. Gerrard, G. R. Bortolotti, and D. W. A. Whitfield. 1983. A 14-year study of bald eagle reproduction on Besnard Lake, Saskatchewan. Pages 47-57 *in* D. M. Bird, (Chief Ed.), Biology and Management of Bald Eagles and Ospreys. Harpell Press, Ste. Anne de Bellevue, Quebec, Canada.

Gerrard, J. M., Pauline N. Gerrard, P. Naomi Gerrard, G. R. Bortolotti, and E. H. Dzus. 1992. A 24-year study of bald eagles on Besnard Lake, Saskatchewan. Journal of Raptor Research 26:159-166.

Google, 2010. Google earth. Available online at: http://www.google.com/earth/index.html 30 September 2010.

Grayson, D. K. 1976. A note on the prehistoric avifauna of the Lower Klamath Basin. The Auk 93:830-833.

Grier, J. W. 1980. Modeling approaches to bald eagle population dynamics. Wildlife Society Bulletin 8:316-322.

Grubb, T. G., D. A. Manuwal, and C. M. Anderson. 1975. Nest distribution and productivity of bald eagles in western Washington. The Murrelet 56:2-6.

Henny, C. J., R. A. Grove, J. L. Kaiser, and V. F. Bentley. 2004. An evaluation of osprey eggs to determine spatial residue patterns and effects of contaminants along the lower Columbia River, U.S.A. Pp. 369-388. *In* Chancellor, R., and B. Meyburg, eds., Raptors Worldwide: WWGBP/MME, Budapest, Hungary.

Harmata, A. R., G. J. Montopoli, B. Oakleaf, P. J. Harmata, and M. Restani. 1999. Movements and survival of bald eagles banded in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 63:781-793.

Herrick, F. H. 1934. The American Eagle, A Study in Natural and Civil History. D. Appleton-Century Company, Inc., New York, New York, USA.

Hodges, J. I., and F. C. Robards. 1982. Observations of 3,850 bald eagle nests in southeast Alaska. Pp. 37-46 *in* A symposium and workshop on raptor management and biology in Alaska and western Canada (W. N. Ladd and P. F. Schempf, Editors). U.S. Fish and Wildlife Service, Anchorage, Alaska, USA.

Howard, H. 1932. Eagles and eagle-like vultures of the Pleistocene of Rancho La Brea. Contributions to Paleontology, Publication No. 429, Carnegie Institution of Washington, District of Columbia, USA.

Howard, H. 1946. A review of the Pleistocene Birds of Fossil Lake, Oregon. Contributions to Paleontology, Publication 551, pages 141-195, Carnegie Institution of Washington, District of Columbia, USA.

Hunt, W. G., D. E. Driscoll, R. I. Mesta, J. H. Barclay, and R. E. Jackman. 2009. Migration and survival of juvenile bald eagles from Arizona. Journal of Raptor Research 43:121-126.

Institute for Wildlife Studies. 2010. Bald eagle. Available on-line at: http://www.iws.org/ 9 September 2010.

Isaacs, F. B. 2007. Results of Midwinter Eagle Counts by route and year in Oregon, 1988-2007. Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA.

Isaacs, F. B., and R. G. Anthony. 1980. Bald eagle nest locations and history of use in Oregon. Oregon Cooperative Wildlife Research Unit, Oregon State University, Corvallis, Oregon, USA.

Isaacs, F. B., and R. G. Anthony. 1987. Abundance, foraging, and roosting of bald eagles wintering in the Harney Basin, Oregon. Northwest Science 61:114-120.

Isaacs, F. B., and R. G Anthony. 2003. Bald Eagle. Pages 140-144 in Birds of Oregon: A General Reference. D. B. Marshall, M. G. Hunter, and A. L. Contreras, Editors. Oregon State University Press, Corvallis, Oregon, USA.

Isaacs, F. B., and R. G. Anthony. 2008. Bald eagle nest locations and history of use in Oregon and the Washington portion of the Columbia River Recovery Zone, 1971 through 2007. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, Oregon, USA.

Isaacs, F. B., R. G. Anthony, M. Vander Heyden, C. D. Miller, and W. Weatherford. 1996. Habits of bald eagles wintering along the upper John Day River, Oregon. Northwest Science 70:1-9.

Isaacs, F. B., R. G. Anthony, and R. J. Anderson.1983. Distribution and productivity of nesting bald eagles in Oregon, 1978-1982. The Murrelet 64:33-38.

Isaacs, F. B., R. G. Anthony, R. W. Krahmer, B. D. Callahan, and J. P. Peck. 2005. Effects of forest management practices on bald eagles nesting on state and private land in Oregon. Oregon Cooperative Fish and Wildlife Research Unit, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, USA.

Isaacs, F. B., R Goggans, R. G. Anthony, and T. Bryan. 1993. Habits of bald eagles wintering along the Crooked River, Oregon. Northwest Science 67:55-62.

Jenkins, J. M., and R. E. Jackman. 1993. Mate and nest site fidelity in a resident population of bald eagles. The Condor 95:1053-1056.

Jenkins, J. M., and R. E. Jackman. 2006. Lifetime reproductive success of bald eagles in northern California. The Condor 108:730-735.

Jobanek, G. A., and D. B. Marshall. 1992. John K. Townsend's 1836 report of the birds of the lower Columbia River region, Oregon and Washington. Northwestern Naturalist 73:1-14.

Johnson, D. M., R. R. Petersen. D. R. Lycan, J. W. Sweet, M. E. Neuhaus, and A. L. Schaedel. 1985. Atlas of Oregon Lakes. Oregon State University Press, Corvallis, Oregon USA.

Keister, G. P., Jr., and R. G. Anthony. 1983. Characteristics of bald eagle communal roosts in the Klamath Basin, Oregon and California. Journal of Wildlife Management 47:1072-1079.

Keister, G. P., Jr., R. G. Anthony, and E .J. O'Neill. 1987. Use of communal roosts and foraging areas by bald eagles wintering in the Klamath Basin. Journal of Wildlife Management 51:415-420.

Keister, G. P., Jr., R. G. Anthony, and H. R. Holbo. 1985. A model of energy consumption in bald eagles: an evaluation of night communal roosting. Wilson Bulletin 97:148-160.

Kozie, K. D., and R. K. Anderson. 1991. Productivity, diet, and environmental contaminants in bald eagles nesting near the Wisconsin shoreline of Lake Superior. Archives of Environmental Contaminants and Toxicology 20:41-48.

Kralovec, M. L., R. L. Knight, G. R. Craig, and R. G. McLean. 1992. Nesting productivity, food habits, and nest sites of bald eagles in Colorado and southeastern Wyoming. Southwestern Naturalist 37:356-361.

Lincer, J. L., W. S. Clark, and M. N. LeFranc, Jr. 1979. Working bibliography of the bald eagle. National Wildlife Federation, Washington, District of Columbia, USA.

Lincoln, R. J., and G. A. Boxshall. 1990. The Cambridge illustrated dictionary of natural history. Cambridge University Press, New York, New York, USA.

Linthicum, J., R. E. Jackman, B. C. Latta, J. Koshear, and M. Smith. 2007. Annual migrations of bald eagles to and from California. Journal of Raptor Research 41:106-112.

Loy, W. G. (editor), S. Allan, A. R. Buckley, and J. E. Meacham (authors). 2001. Atlas of Oregon. Second Edition. University of Oregon Press, Eugene, Oregon, USA.

Marr, N. V., W. D. Edge, R. G. Anthony, and R. Valburg. 1995. Sheep carcass availability and use by bald eagles. Wilson Bulletin 107:251-257.

Marshall, D. B. 1969. Endangered plants and animals of Oregon. III. Birds. Special Report 278, Agricultural Experiment Station, Oregon State University, Corvallis, Oregon, USA.

Marshall, D. B., M. G. Hunter, and A. L. Contreras, Eds. 2003. Birds of Oregon: A General Reference. Oregon State University Press, Corvallis, Oregon, USA.

Marshall, D. B., M. W. Chilcote, and H. Weeks. 1996. Species at risk: sensitive, threatened and endangered vertebrates of Oregon. 2nd edition. Oregon Department of Fish and Wildlife, Portland, Oregon, USA).

McClelland, B. R., L. S. Young, P. T. McClelland, J. G. Crenshaw, H. L. Allen, and D. S. Shea. 1994. Migration ecology of bald eagles from autumn concentrations in Glacier National Park, Montana. Wildlife Monographs 125.

McClelland, B. R., P. T. McClelland, and M. E. McFadzen. 2006. Longevity of bald eagles from autumn concentrations in Glacier National Park, Montana and assessment of wing-marker durability. Journal of Raptor Research 40:151-155.

McCollough, M. A.1989. Molting sequence and aging of Bald Eagles. Wilson Bulletin 101:1-10.

McGarigal, K., R. G. Anthony, and F. B. Isaacs. 1991. Interactions of humans and bald eagles on the Columbia River estuary. Wildlife Monographs 115.

McShane, C., R. Tressler, and S. Bondi. 1998. Nesting bald eagle food habits study, Pelton Round Butte hydroelectric project, final report, FERC No. 2030. Prepared for Portland General Electric Company, Portland, Oregon, USA.

Miller, L. 1957. Bird remains from an Oregon Indian midden. Condor 59:59-63.

Mote, P. W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the Twentieth Century. Northwest Science 77:271-282.

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

Nisbet, J. 2009. The Collector: David Douglas and the Natural History of the Northwest. Sasquatch Books, Seattle, Washington, USA.

Opp, R. R. 1979. Oregon's first annual mid-winter bald eagle survey; January 13-27, 1979. Oregon Birds 5:1-11.

Opp, R. R. 1980. Status of the bald eagle in Oregon - 1980. Pages 35-41 in R. L. Knight, G. T. Allen, M. V. Stalmaster, and C. W. Servheen (editors). Proceedings of the Washington Bald Eagle Symposium, 14-15 June 1980. The Nature Conservancy, Seattle, Washington, USA.

Oregon Blue Book. 2009. Oregon almanac: native Americans to shoes, oldest. Available on-line at http://www.bluebook.state.or.us/facts/almanac/almanac05.htm 2 July 2009.

Oregon Coast Atlas. 2009. About estuaries in Oregon. Available on-line at http://www.coastalatlas.net/index.php?option=com_content&task=view&id=1&Itemid=9 10 July 2009.

Oregon Department of Energy. 2009. Climate change in Oregon. Available on-line at http://www.oregon.gov/ENERGY/GBLWRM/images/Panel1.jpg 7 July 2009.

Oregon Department of Fish and Wildlife. 1997. Backgrounder: Questions and answers about the Oregon Threatened and Endangered Species Act. Oregon Department of Fish and Wildlife, Portland, Oregon, USA.

Oregon Department of Fish and Wildlife 2006. The Oregon Nearshore Strategy. Marine Resources Program, Newport, Oregon, USA.

Oregon Department of Fish and Wildlife. 2010a. Wildlife Division, Wildlife Diversity (Nongame) Program. Species Information. Threatened, Endangered, and Candidate Fish and Wildlife Species in Oregon. Available on-line at http://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp 29 October 2010.

Oregon Department of Fish and Wildlife. 2010b. ODFW Resources: Hunting Resources. Available online at http://www.dfw.state.or.us/resources/hunting/index.asp 23 September 2010.

Oregon Department of Forestry. 1997. Forest practices administrative rules, chapter 629, division 680, the process to inventory and protect special resources on forest lands. Oregon Department of Forestry, Salem, Oregon, USA.

Oregon Forest Resources Institute. 2009. Oregon forest facts and figures 2009. Available on-line at http://www.oregonforests.org/FactsAndResources/Publications.html 9 July 2009.

Oregon Natural Heritage Information Center. 2009. Available on-line at http://oregonstate.edu/ornhic/ 23 July 2009.

Oregon State Archives. 2010. Department of Forestry; Division 665; Specified resource site protection rules. Available on-line at: http://arcweb.sos.state.or.us/rules/OARS_600/OAR_629/629_665.html 21 September 2010.

Otto, M. C., and J. R. Sauer. 2007. Contiguous 48 State Bald Eagle Breeding Pair Survey Design. Pages 21-51 *In* U.S. Fish and Wildlife Service Bald Eagle Monitoring Team. Draft post-delisting monitoring plan for the Bald Eagle (*Haliaeetus leucocephalus*). U.S. Fish and Wildlife Service, Washington, D.C., USA.

Palmer, R. S., J. S. Gerrard, and M. V. Stalmaster. 1988. Bald Eagle. Pp. 187-237 *In* Handbook of North American birds. Volume 4 (R. S. Palmer, editor). Yale University Press, New Haven, Connecticut, USA.

Poole, A. F. 1986. Ospreys: Natural and Unnatural History. 1989. Cambridge University Press, New York, New York, USA.

Popp, D. No Date. Methods to observe bald eagles for nest site plans. Oregon Eagle Foundation, Inc., Klamath Falls, Oregon, USA.

Popp, D. 1992. Incubation summaries for the Cottage Grove Reservoir bald eagle pair. Oregon Eagle Foundation, Inc., Klamath Falls, Oregon, USA.

Popp, D. and F. B. Isaacs. 1989. Supplemental feeding of bald eagles at Thompson Reservoir, Lake County, Oregon. Oregon Eagle Foundation, Inc., Klamath Falls, Oregon, USA.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Pages 21-31 in F. N. Hamerstrom, Jr., B. E. Harrell, and R. R. Olendorff, editors. Management of raptors. Raptor Research Report No. 2, Raptor Research Foundation, Vermillion, South Dakota, USA.

Postupalsky, S. 1983. Techniques and terminology for surveys of nesting bald eagles. Appendix D. in J. W. Grier, J. B. Elder, F. J. Gramlich, N. F. Green, J. V.

Kussman, J. E. Mathisen, and J. P. Mattson, editors. Northern states bald eagle recovery plan. U.S. Fish and Wildlife Service, Twin Cities, Minnesota, USA.

Puchy, C. A. , and D. B. Marshall. 1993. Oregon Wildlife Diversity Plan. Oregon Department of Fish and Wildlife, Portland, Oregon, USA.

Robards, F. C., and J. I. Hodges. 1977. Observations from 2,760 bald eagle nests in southeast Alaska. Progress Report 1969-1976. U.S. Department of Interior, Fish and Wildlife Service, Juneau, Alaska, USA.

Schempf, P. F. 1997. Bald eagle longevity record from southeastern Alaska. Journal of Field Ornithology 68:150-151.

Shufeldt, R. W. 1913. Review of the fossil fauna of the desert region of Oregon, with a description of additional material collected there. Bulletin of the American Museum of Natural History 32:123-178.

Shull, R. 1978. Bald Eagle Nesting, U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Deschutes National Forest, Bend, Oregon, USA.

Smith, C. 1991. Technical review: bald eagle. Forest Practices Program, Oregon Department of Forestry, Salem, Oregon, USA.

Southwestern Bald Eagle Management Committee. 2010. Sub adult bald eagle migration study. Available on-line at: http://www.swbemc.org/migration_study.html 9 September 2010.

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

Stalmaster, M. V. 1987. The Bald Eagle. Universe Books, New York, New York, USA.

Steenhof, K. 1987. Assessing raptor reproductive success and productivity. Pages 157-70 in B. A. G. Pendleton, B. A. Millsap, K. W. Cline, and D. M. Bird, editors. Raptor Management Techniques Manual. National Wildlife Federation, Scientific and Technical Series No. 10.

Steenhof, K., L. Bond, K. K. Bates, and L. L. Leppert. 2002. Trends in midwinter counts of bald eagles in the contiguous United States, 1986-2000. Bird Populations 6:21-32.

Steenhof, K., L. Bond, and L. L. Dunn. 2008. The midwinter bald eagle survey results and analysis1986-2005. U.S. Geological Survey, National Biological Information

Infrastructure, and Northwest Alliance for Computational Science and Engineering. Available on-line at http://www.nacse.org/nbii/eagles 22 July 2009.

Steidl, R. J., K. D. Kozie, and R. G. Anthony. 1997. Reproductive success of bald eagles in interior Alaska. Journal of Wildlife Management 61:1313-1321.

Stinson, D. W., J. W. Watson, and K. R. McAllister. 2007. Washington state status report for the bald eagle. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Swenson, J. E., K. L. Alt, and R. L. Eng. 1986. Ecology of bald eagles in the Greater Yellowstone Ecosystem. Wildlife Monographs 95.

Taylor, G. H., and A. Bartlett. 1993a. The climate of Oregon: Climate Zone 1, Coastal Oregon. Special Report 913. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993b. The climate of Oregon: Climate Zone 2, Willamette Valley. Special Report 914. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993c. The climate of Oregon: Climate Zone 3, Southwest Interior. Special Report 915. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993d. The climate of Oregon: Climate Zone 4, Northern Cascades. Special Report 916. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993e. The climate of Oregon: Climate Zone 5, High Plateau. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA. Special Report 917.

Taylor, G. H., and A. Bartlett. 1993f. The climate of Oregon: Climate Zone 6, North Central Area. Special Report 918. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993g. The climate of Oregon: Climate Zone 7, South Central Area. Special Report 919. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993h. The climate of Oregon: Climate Zone 8, Northeast Area. Special Report 920. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and A. Bartlett. 1993i. The climate of Oregon: Climate Zone 9, Southeast Area. Special Report 921. Oregon Climate Service, Oregon State University, Corvallis, Oregon, USA.

Taylor, G. H., and C. Hannan. 1999. The Climate of Oregon: From Rain Forest to Desert. Oregon State University Press, Corvallis, Oregon, USA.

Terkel, S. 1980. American dreams: lost and found. Pantheon Books, New York, New York, USA.

Therres, G. D., and S. K. Chandler. 1993. Ospreys use bald eagle nests in Chesapeake Bay area, Journal of Raptor Research 27:217-218.

Tressler, R., S. Bondi, and C. McShane. 1999. 1996-1997 bald eagle communal roost study, final report, Pelton Round Butte hydroelectric project, FERC No. 2030. Prepared for Portland General Electric Company, Portland, Oregon USA.

U.S. Census Bureau. 2009. Population estimates. Available on-line at http://www.census.gov/popest/states/NST-ann-est.html 7 July 2009.

U.S. Congress. 1918. Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712; Ch. 128; July 13, 1918; 40 Stat. 755) as amended by: Chapter 634; June 20, 1936; 49 Stat. 1556; P.L. 86-732; September 8, 1960; 74 Stat. 866; P.L. 90-578; October 17, 1968; 82 Stat. 1118; P.L. 91-135; December 5, 1969; 83 Stat. 282; P.L. 93-300; June 1, 1974; 88 Stat. 190; P.L. 95-616; November 8, 1978; 92 Stat. 3111; P.L. 99-645; November 10, 1986; 100 Stat. 3590 and P.L. 105-312; October 30, 1998; 112 Stat. 2956

U.S. Congress. 1940. Bald Eagle Protection Act of 1940 (16 U.S.C. 668-668d, 54 Stat. 250) as amended -- Approved June 8, 1940, and amended by P.L 86-70 (73 Stat. 143) June 25, 1959; P.L. 87-884 (76 Stat. 1346) October 24, 1962; P.L. 92-535 (86 Stat. 1064) October 23, 1972; and P.L. 95-616 (92 Stat. 3114) November 8, 1978.

U.S. Department of Agriculture. 2009. National Agricultural Statistics Service, 2008 State Agricultural Overview, Oregon. Available on-line at http://www.nass.usda.gov/Statistics_by_State/Oregon/index.asp 7 July 2009.

U.S. Department of the Interior. 1978. Determination of certain Bald Eagle populations as endangered or threatened. Federal Register 43:6230-6233.

U.S. Department of the Interior. 2007. Endangered and threatened wildlife and plants; removing the Bald Eagle in the lower 48 states from the list of endangered and threatened wildlife; final rule. Federal Register 72:37346-37372.

U.S. Department of the Interior. 2009. Eagle permits; take necessary to protect interests in particular localities; final rule. Federal Register 74:46836-46879.

U.S. Fish and Wildlife Service. 1986. Recovery plan for the Pacific bald eagle. U.S. Fish and Wildlife Service, Portland, Oregon, USA.

U.S. Fish and Wildlife Service. 2007. Post-delisting Conservation Plan for the Bald Eagle. U.S. Fish and Wildlife Service, Washington, D.C., USA.

U.S. Fish and Wildlife Service. 2009a. Oregon Islands National Wildlife Refuges. Available on-line at http://www.fws.gov/oregoncoast/oregonislands/index.htm 2 July 2009.

U.S. Fish and Wildlife Service. 2009b. Post-delisting Monitoring Plan for the Bald Eagle (*Haliaeetus leucocephalus*) in the Contiguous 48 States. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Midwest Regional Office, Twin Cities, Minnesota, USA, 75pp.

U.S. Geological Survey. 2009. Raptor information system. Available on-line at http://ris.wr.usgs.gov/ 4 September 2009.

U.S. Geological Survey. 2010a. 100 years of bird banding in North America 1902-2002. Available on-line at http://www.pwrc.usgs.gov/BBL/homepage/100years.htm#today 27 October 2010.

U.S. Geological Survey. 2010b. Longevity records of North American birds. Available on-line at http://www.pwrc.usgs.gov/BBL/homepage/longvlst.cfm 27 October 2010.

Washington Department of Fish and Wildlife. 2008. Wildlife survey data management database, Bald Eagle nest occurrences in Washington State Bald Eagle Recovery Zone 10. Wildlife Survey Data Management Unit, Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Washington Department of Fish and Wildlife. 2009. About WDFW. Fish and Wildlife Commission, Meeting Minutes & Agendas. Available on-line at http://wdfw.wa.gov/commission/meetings/2008/01/jan1108.html 16 Jul 2009.

Washington Department of Fish and Wildlife. 2010. Bald eagle management & protection in Washington state. Available on-line at: http://wdfw.wa.gov/conservation/bald_eagle/ 21 September 2010.

Watson, J. W. 1993. Responses of nesting bald eagles to helicopter surveys. Wildlife Society Bulletin 21:171-178.

Watson, J. W., and D. J. Pierce. 2001. Skagit River bald eagles: movements, origins, and breeding population status. Final Report. Washington Department of Fish and Wildlife, Olympia, Washington, USA.

Watson, J. W., M. G. Garrett, and R. G. Anthony. 1991. Foraging ecology of bald eagles in the Columbia River estuary. Journal of Wildlife Management 55:492-499.

Welty, J. C. 1982. The Life of Birds, Third Edition. CBS College Publishing, New York, New York, USA.

Wheeler, B. K. 2003. Raptors of Western North American, The Wheeler Guide. Princeton University Press, Princeton, New Jersey, USA.

Whitman, J. S., and J. R. Caikoski. 2008. Peregrine falcon nesting in tree stick-nest in Alaska. Journal of Raptor Research 42:300-302.

Wood, P. B. 2009. Recovery distances of nestling bald eagles banded in Florida and implications for natal dispersal and philopatry. Journal of Raptor Research 43:127-133.

Woodcock, A. R. 1902. An annotated list of the birds of Oregon. Oregon Agricultural Experiment Station Bulletin 68. Corvallis, Oregon, USA.

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Table 15. Summary of use at nests built by bald eagles and used by other species, and nests built by other species and used by bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007.

Table 16. Year-to-year nesting outcomes at breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers that are <1 are proportions of outcomes shown at the top of the column (Year Y+1) that followed the outcomes shown at the left end of the row (Year Y). For example, 0.079 of breeding areas with an outcome of 3 in year Y (n = 127) had an outcome of 3 the following year (Y+1); 0.409 had an outcome of 2; and 0.236 had an outcome of 1, etc. The Year Y+1 outcome that had the greatest positive deviation from expected is underlined and all underlined values occurred more often than expected ($p < 0.10$).

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Figure 11. Breeding areas where breeding age eagles or nestlings were detected during surveys in Oregon and along the Washington side of the Columbia River, 1971-2007, based on 15,688 daily records on successes and 9,953 on failures. Sample size varied by period; success 5-day periods ranged from 15-1,311 observations/period and 30-day periods ranged from 40-183; failure 5-day periods ranged from 22-757 observations/period and 30-day periods ranged from 32-65.

Figure 12. Eaglet development at breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Relationship to developmental stages identified by Carpenter (1990): Downy = Stages 1a, 1b, and 2; Partly Feathered = Stages 3a and 3b; and Feathered = Stages 3c and 3d. Eaglets were considered to be Fledged when they had flown from the nest tree at least once. These observations were based on 6,553 records. Sample size varied from 19-1,153 records/five day period.

Figure 13. Proportion of breeding areas occupied by bald eagles that had evidence of eggs and successful nesting by 5-day period in Oregon and along the Washington side of the Columbia River, 1971-2007. Period 1 = 7-11 Mar, 2 = 12-16 Mar, 3 = 17-21 Mar, 4 = 22-26 Mar, 5 = 27-31 Mar, 6 = 1-5 Apr, 7 = 6-10 Apr, 8 = 11-15 Apr, 9 = 16-20 Apr, 10 = 21-25 Apr, and 11 = 26-30 Apr. Sample sizes for A. ranged from 67-556 observations/5-day period, B. 54-539, C. 17-165, and D. 15-210. All r values were significant at $p > 0.05$. Curves are order 2 polynomial trendlines. Figure A dashed curve = East regression and solid line = West regression. Figures B-D dashed curves = 1971-1992 and solid curves = 2003-2007.

Figure 14. Nesting success (A) and productivity (young/occupied breeding area with known outcome) and brood size (young/successful breeding area) (B.) for bald eagles in Oregon and along the Washington side of the Columbia River, 1978-2007. Sample size increased annually from 57 occupied breeding areas with known outcome in 1978 to 535 in 2007.

Figure 15. Relationship of nesting success (x axis) and young/occupied breeding area with known outcome (y axis) by year ($n = 30$) at breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1978-2007.

Figure 16. Nesting success by watershed with ≥5 occupied breeding areas for bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected ($p < 0.10$).

Figure 17. Trends of nesting success (A.) and productivity (B.) by watershed for bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007. Columbia watershed is depicted by the dashed line; other watersheds are represented by solid lines. The dotted lines are lower thresholds of nesting success and productivity suggested necessary to maintain stable populations (Sprunt et al. 1973).

Figure 18. Nesting success (A.) and productivity (young/occupied breeding area with known outcome) (B.) for bald eagles nesting along the Columbia River, where it forms the border between Oregon and Washington, 1978-2007.

Figure 19. Proportion of unoccupied breeding areas that remained unoccupied over time (0.355, n = 327) in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers above columns are the percent of unoccupied breeding areas that were occupied in subsequent years.

Figure 20. Proportion of breeding areas of bald eagles by aquatic feature in Oregon and along the Washington side of the Columbia River, 1978 (n = 103) and 2007 (n = 662). The unclassified group was comprised of breeding areas where the aquatic feature was not determined because the primary hunting area was unknown, atypical, or there were multiple possibilities. The Ocean group includes two breeding areas that were first listed in 1979 even though they probably existed in 1978. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.05$).

Figure 21. Occupation and nesting success at breeding areas of bald eagles by aquatic feature in Oregon and along the Washington side of the Columbia River, 1978-2007. Numbers in parentheses are sample sizes (occupation, success). Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

Figure 22. Number (A.) and occupied proportion (B.) of breeding areas of bald eagles along the Columbia River, where it forms the border between Oregon and Washington, 1978-2007.

Figure 23. Productivity at breeding areas of bald eagles along the Columbia River, where it forms the border between Oregon and Washington, 1978-2007.

Figure 24. Productivity (young/year occupied with known outcome) at breeding areas of bald eagles with ≥5 years of known outcome (n = 109) by river mile along the Columbia River, where it forms the border between Oregon and Washington, 1972-2007.

Figure 25. Nesting success (A.) and proportion of breeding areas with ≥5 years occupation with known outcome and productivity ≤0.50 (B.) by Columbia River segment, 1971-2007. Segment 1 = river miles 0-13 (0-21 km), 2 = miles 13-31 (21-50 km), 3 = miles 31-47 (50-76 km), 4 = miles 47-86 (76-138 km), 5 = miles 86-106 (138-171 km), 6 = miles 106-146 (171-235 km), and 7 = miles 146-309 (235-497 km). Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

Figure 26. Proportion of breeding areas with ≥5 years occupation with known outcome and productivity ≤0.50 by watershed, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

Figure 27. Population growth rate (r) (y axis) relative to initial length of shoreline or river length/occupied bald eagle breeding area (x axis) for seven water bodies in Oregon and along the Washington side of the Columbia River, 1978-2007. Shoreline or river length was the average length/occupied breeding area during the start year of the period for which population growth was calculated.

Figure 28. Distance of breeding areas of bald eagles (n = 662) from the nearest mean high water line of the nearest permanent aquatic habitat in Oregon and along the Washington side of the Columbia River, 1971-2007. Distance was measured from the most recently used nest tree in each breeding area as of 2007. The atypical category included sites where aquatic habitat was distant, dispersed, intermittent, or nonexistent and hunting area was unknown.

Figure 29. Nest survey results for breeding areas of bald eagles associated with permanent aquatic habitat features that were known hunting areas (Typical, n = 30 years) versus breeding areas where hunting areas were distant, dispersed, intermittent, or unknown (Atypical, n = 28 years) in Oregon and along the Washington side of the Columbia River, 1978-2007. Raw data for Typical breeding areas were 8,624 surveyed, 7,176 occupied with known outcome, 4,389 successful, and 6,869 young; and for Atypical were 629, 520, 354, and 570, respectively. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.05$).

Figure 30. Distribution of breeding areas of bald eagles (n = 662) by elevation in Oregon and along the Washington side of the Columbia River, 1971-2007. Elevation was based on the topographic location of the most recently used nest tree in the breeding area as of 2007.

Figure 31. Hypothetical model of change in the number of breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, approximately 1780 to approximately 1980. A = circa 1800 estimate, B = decline due to direct persecution, habitat change, and prey depletion, C = decline due to direct persecution, habitat change, prey depletion, and chemical contamination, and D = nadir circa 1975.

Figure 32. Productivity at breeding areas of bald eagles five years before, year of, and five years after mate changes in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.001$).

Figure 33. Proportions of coniferous and deciduous nest trees used by bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes.

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Columbia River. Min = nest trees/breeding area observed during the annual survey and known to hold nests; Max = nest trees/breeding area that held nests when last observed but were not observed during the annual survey; Total-Max = nest trees/breeding area that no longer held a nest when last observed. The actual number of nest trees/breeding area that held nests in a given year was between the Max and Min lines of Figure B. Numbers in parentheses are sample sizes.

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Figure 37. Proportion of nest trees of bald eagles still holding nests in 2007 by year discovered in Oregon and along the Washington side of the Columbia River, 1978-2007. Numbers in parentheses are sample sizes. Nest trees with uncertain nest status in 2007 were not included.

Figure 38. Relationship of the average number of nest tree changes/year occupied with evidence of eggs (y) to the number of years breeding areas were occupied with evidence of eggs (x) for 626 breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes.

Figure 39. Productivity at bald eagle breeding areas during the year of establishment and for five years after in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

Figure 40. Nesting success at breeding areas of bald eagles with ≥5 years occupation with known outcome by watershed in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes (private, public). Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.05$).

Figure 41. Model of monthly variation in the bald eagle population in Oregon and along the Washington side of the Columbia River. Resident eagles fledged from nests on the study area; non-residents fledged from nests in other western states and Canada. A = largest population of bald eagles because most residents were present and non-residents were at their highest abundance. B = increase in residents because of annual production at breeding areas on the study area. C = low abundance of non-residents because most were at breeding areas in other western states or Canada. D = low eagle abundance because some residents had left the study area and most non-residents had

not arrived. E = increasing abundance because residents that had left the study area were returning and non-residents were arriving.

Figure 42. Deviation from expected year Y+1 nesting outcomes within six outcome categories for breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Outcome definitions: 3, 2 and 1 = 3, 2 and 1 eaglet(s) reported, respectively; OCEF = occupied with evidence of eggs and no eaglets; OC2F = occupied, 2 breeding age eagles and no evidence of eggs; and OC1F = occupied, 1 breeding age eagle and no evidence of eggs. Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected ($p < 0.05$).

Figure 43. The probability that an occupied breeding area of bald eagles will remain occupied based on a 0.939 repeat rate for occupied breeding areas (n = 7,571) in Oregon and along the Washington side of the Columbia River, 1971-2007.

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Appendix 13. Cumulative results of surveys of bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007.

Appendix 14A. Year-to-year nesting outcomes at bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers are proportions of outcomes shown at the top of the column (Year Y+1) that followed the outcomes shown at the left end of the row (Year Y). For example, 0.079 of breeding areas with an outcome of 3 in year Y (n = 127) had an outcome of 3 the following year (Y+1); 0.409 had an outcome of 2; and 0.236 had an outcome of 1, etc.

Appendix 14B. Raw data on year-to-year nesting outcomes at bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007.

Appendix 15. Minimum number of occupied bald eagle breeding areas in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Appendix 16. Proportion of breeding areas occupied by bald eagles in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Appendix 17. Proportion of breeding areas occupied by bald eagles by watershed at the start of the study and at 10-year intervals in Oregon and along the Washington side of the Columbia River, 1978-2007. Number of occupied breeding areas increased annually; total sample sizes were 66, 160, 311, and 553 for 1978, 1987, 1997 and 2007, respectively.

Appendix 18. Nesting phenology for bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Start and end dates for Egg Laying, Incubation, Hatching, and Nestling stages are based on observations at the earliest (Fernhill Wetlands 2002 and 2003) and latest (Killin Wetlands/Banks 2006) successful nesting attempts, and a ±35 day incubation period (Buehler 2000:17). Fledging dates are based on the earliest (Birch Creek 2004) and latest (Killin Wetlands/Banks 2006) dates reported. Post-fledging care (2-11 weeks) and dispersal are based on published literature summarized in Buehler (2000:19).

Appendix 19. Nesting status at bald eagle breeding areas where breeding pairs failed to raise young in Oregon and along the Washington side of the Columbia River, 1971-2007, based on 9,953 records. Sample size varied by period; 22-757 observations/period for five-day periods and 32-65 for thirty-day periods. Proportion of breeding areas occupied + evidence of eggs + eaglets + no eagles detected (not shown) = 1.000.

Appendix 20. Nesting success for breeding areas of bald eagles by watershed in Oregon and along the Washington side of the Columbia River by Recovery Zone, 1978-2007.

Appendix 21A-E. Three measures of productivity for bald eagle breeding areas with known outcome (n) in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Appendix 22. Distribution of breeding areas of bald eagles with 1-4, ≥5 and ≥10 years of known outcome by productivity category in Oregon and along the Washington side of the Columbia River, 1971-2007. Sample sizes were 175, 479, and 339 breeding areas for the 1-4, ≥5 and ≥10 years with known outcome groups, respectively.

Appendix 23. Correlations of Yg/OC and Yg/OCE (A.), Yg/OC and Yg/Succ (B.), and Yg/OCE and Yg/Succ (C.) by year for bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007 (Yg/OC = Young/Occupied Breeding Area With Known Outcome, Yg/OCE = Young/Occupied Breeding Area With Evidence Of Eggs And Known Outcome, and Yg/Succ = Young /Breeding Area Where Known Outcome Was Success).

Appendix 24A. Number of bald eagle nest trees (n = 1,645) by landowner in Oregon and along the Washington side of the Columbia River, 1971-2007. Owyhee watershed is not shown because no nest trees were known there as of 2007.

Appendix 24B. Number of bald eagle breeding areas (n = 662) by landowner in Oregon and along the Washington side of the Columbia River, 1971-2007. Owyhee watershed is not shown because no breeding areas were known there as of 2007.

Table 1. Bald eagle population size, nesting success, productivity, and brood size in Oregon and along the Washington side of the Columbia River, 1971-2007.

		Breeding Areas Occupied[1] (Population Size)		Occupied Breeding Areas					
					Successful[2] (Nesting Success)				
Year	Breeding Areas Surveyed	n	%	With Known Outcome	n	%	Young	Young / Occupied Breeding Area[3] (Productivity)	Young / Successful Breeding Pair (Brood Size)
1971[4]	33	17	51.5	15	14	93.3	19	1.27	1.36
1972[4]	32	16	50.0	16	14	87.5	19	1.19	1.36
1973[4]	52	23	44.2	22	21	95.5	29	1.32	1.38
1974[4]	57	31	54.4	28	21	75.0	27	0.96	1.29
1975[4]	51	20	39.2	15	11	73.3	14	0.93	1.27
1976[4]	61	28	45.9	21	17	81.0	26	1.24	1.53
1977[4]	49	23	46.9	16	13	81.3	18	1.13	1.38
1978	90	66	73.3	57	38	66.7	58	1.02	1.53
1979	112	85	75.9	80	49	61.3	73	0.91	1.49
1980	123	98	79.7	89	45	50.6	68	0.76	1.51
1981	131	108	82.4	103	62	60.2	97	0.94	1.56
1982	136	112	82.4	108	51	47.2	72	0.67	1.41
1983	146	118	80.8	113	63	55.8	93	0.82	1.48
1984	156	126	80.8	120	75	62.5	111	0.93	1.48
1985	167	142	85.0	136	79	58.1	119	0.88	1.51
1986	179	152	84.9	145	93	64.1	141	0.97	1.52
1987	186	160	86.0	155	85	54.8	124	0.80	1.46
1988	203	172	84.7	172	97	56.4	148	0.86	1.53
1989	215	177	82.3	173	86	49.7	134	0.77	1.56
1990	223	182	81.6	177	109	61.6	154	0.87	1.41
1991	239	202	84.5	195	123	63.1	193	0.99	1.57
1992	271	222	81.9	214	131	61.2	213	1.00	1.63
1993	280	239	85.4	225	129	57.3	193	0.86	1.50
1994	294	254	86.4	234	134	57.3	231	0.99	1.72
1995	305	263	86.2	251	150	59.8	237	0.94	1.58
1996	341	291	85.3	278	170	61.2	254	0.91	1.49
1997	360	311	86.4	308	179	58.1	277	0.90	1.55
1998	392	351	89.5	345	206	59.7	326	0.94	1.58
1999	412	372	90.3	365	220	60.3	350	0.96	1.59
2000	453	405	89.4	397	246	62.0	405	1.02	1.65
2001	476	420	88.2	413	273	66.1	420	1.02	1.54
2002	499	432	86.6	427	280	65.6	452	1.06	1.61
2003	521	452	86.8	447	282	63.1	468	1.05	1.66
2004	548	475	86.7	451	291	64.5	463	1.03	1.59
2005	572	505	88.3	488	321	65.8	493	1.01	1.54
2006	588	521	88.6	495	320	64.6	496	1.00	1.55
2007	632	553	87.5	535	356	66.5	576	1.08	1.62
Total for:									
1971-07	9,585	8,124	84.8	7,829	4,854	62.0	7,591	0.97	1.56
1978-07	9,250	7,966	86.1	7,696	4,743	61.6	7,439	0.97	1.57

[1] Occupied Breeding Area - breeding area where one or two adults and a nest were observed.

[2] Successful Breeding Area - breeding area where one or more nestlings or fledglings were observed.

[3] Calculated using the number of breeding areas where the outcome of nesting was known.

[4] 1971-1977 data from unpublished reports by others prior to the start of this study.

Table 2. Size and growth rate of the breeding population of bald eagles in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Watershed	Start Year[1]	Start Year Breeding Areas Occupied		2007 Breeding Areas Occupied		Population Growth Rate[2]
		n	%	n	%	
Willamette	1978	1	1.5	72	13.0	0.147
Snake	1999	1	-	3	0.5	0.137
Rogue	1978	1	1.5	27	4.9	0.114
Northeast	1984	1	-	11	2.0	0.104
Columbia	1978	7	10.6	140	25.3	0.103
Harney	1991	1	-	3	0.5	0.069
Pacific	1978	15	22.7	96	17.4	0.064
Klamath	1978	24	36.4	129	23.3	0.058
Deschutes	1978	18	27.3	72	13.0	0.048
Owyhee	-	-	-	-	-	-
Study Area	1978	66		553		0.073

[1] Start year was 1978 or the first year that a breeding area in the watershed was occupied.

[2] Instantaneous rate of growth = r = $[\ln(N_t/N_0)]/t$, where N_t was the population at time t (2007), N_0 was the initial (Start Year) population size, and t was the number of time periods (N_t-N_0).

Table 3. Bald eagle population size, nesting success, productivity, and brood size by watershed in Oregon and along the Washington side of the Columbia River, 1978-2007.

Watershed	Breeding Areas Surveyed	Breeding Areas Occupied[1] (Population Size) n	Breeding Areas Occupied[1] (Population Size) %	Occupied Breeding Areas: With Known Outcome	Occupied Breeding Areas: Successful[2] (Nesting Success) n	Occupied Breeding Areas: Successful[2] (Nesting Success) %	Young	Young / Occupied Breeding Area[3] (Productivity)	Young / Successful Breeding Pair (Brood Size)
Northeast	200	141	70.5	131	97	74.0	159	1.21	1.64
Columbia	1,889	1,535	81.3	1,454	811	55.8	1,289	0.89	1.59
Deschutes	1,364	1,183	86.7	1,160	724	62.4	1,117	0.96	1.54
Willamette	826	747	90.4	695	473	68.1	782	1.13	1.65
Pacific	1,720	1,509	87.7	1,459	912	62.5	1,388	0.95	1.52
Snake[4]	18	15	83.3	15	15	100.0	29	1.93	1.93
Harney[4]	27	27	100.0	27	18	66.7	26	0.96	1.44
Klamath	2,806	2,443	87.1	2,394	1,473	61.5	2,306	0.96	1.57
Rogue	400	366	91.5	361	220	60.9	343	0.95	1.56
Owyhee[5]	-	-	-	-	-	-	-	-	-
Study Area	9,250	7,966	86.1	7,696	4,743	61.6	7,439	0.97	1.57

[1] Occupied Breeding Area - breeding area where one or two adults and a nest were observed.

[2] Successful Breeding Area - breeding area where one or more nestlings or fledglings were observed.

[3] Calculated using the number of breeding areas where the outcome of nesting was known.

[4] Watershed with fewer than five occupied breeding areas in 2007.

[5] No breeding areas known as of 2007.

Table 4. Size and growth rate of breeding populations of bald eagles by aquatic feature in Oregon and along the Washington side of the Columbia River, 1978-2007.

Aquatic Feature	Start Year[1]	Breeding Areas Occupied: Start Year n	%	2007 n	%	Population Growth Rate[2]
River	1978	3	4.5	122	22.1	0.128
Ocean	1979	1	-	15	2.7	0.097
Estuary	1978	16	24.2	171	30.9	0.082
Reservoir	1978	12	18.2	122	22.1	0.080
Marsh	1978	2	3.0	13	2.4	0.065
Unclassified	1978	5	7.6	32	5.8	0.064
Natural Lake	1978	28	42.4	78	14.1	0.035
Study Area	1978	66		553		0.073

[1] Start year was 1978 or the first year that a breeding area in the Aquatic Feature group was occupied.

[2] Instantaneous rate of growth = $r = [\ln(N_t/N_0)]/t$, where N_t was the population at time t (2007), N_0 was the initial (Start Year) population size, and t was the number of time periods.

Table 5. Age and distance from banding location to encounter location for 22 bald eagles banded as nestlings in Oregon, 1979-1986 (n = 157), and subsequently encountered as subadults (<5 years old) or adults (≥5 years old), 1979-2009.

Band Number (prefix 0629)	Banding Date	Banding Location Breeding Area Name (nest tree number)	Date Encountered	Age[1] (Yr_Mo)	Encounter Location[2]	Distance[3] (km)	(mi)
Subadult When Encountered (n = 12)							
_06201	6/11/1979	Chicken Hills (028)	9/6/1981[4]	02_05	Sprague River, OR	67	42
_06203	6/12/1979	Eagle Ridge (432)	9/24/1979[4]	00_05	Babine Lake, BC, Canada	1,300	808
_06204	6/13/1979	Modoc Point (447)	1/8/1980[4]	00_09	Weaverville, CA	233	145
_06217	6/17/1979	Bates Butte (311)	7/24/1979[4]	00_03	Sunriver, OR	9	6
_06246	6/1/1980	Lobert Draw (436)	January 1981[5]	00_09	Sonora, Mexico	1,300	808
_06268	6/9/1981	Lemolo Lake (347)	10/10/1985[4]	04_06	Bella Coola, BC, Canada	1,000	621
_06270	6/10/1981	Wickiup Res. E (356)	3/17/1985[4]	03_11	Sutherlin, OR	149	93
_09525	6/10/1981	Modoc Point (450)	Winter 1984[4]	03_08	Odessa Creek, OR	16	10
_09532	6/18/1981	Rocky Point (424)	May 1982[4]	01_01	Washoe Lake, NV	448	278
_09580	6/16/1983	Malone Springs (425)	4/30/1984[4]	01_00	Notus, ID	450	280
_18167	6/28/1985	Mayger (115)	12/27/1985[4,6]	00_08	Rockport, WA	282	175
_18183	7/2/1986	Clifton Channel (116)	9/1/1986[4]	00_05	Brownsmead, OR	4	2
Mean Age of Dead Subadults (n = 11) =				01_09			
Mean Distance for All Subadults (n = 12) =						438	272
Mean Distance for Subadults (n = 4) Encountered During the Breeding Season (February-August) =						264	164
Adult When Encountered (n = 10)							
_06207	6/15/1979	Crane Prairie Res. NE (317)	10/1/1985[4]	06_06	Bella Coola, BC, Canada	1,000	621
_06215	6/17/1979	Suttle Lake (339)	6/14/1985[4]	06_02	Warm Springs Reservation, OR	18	11
_06279	6/7/1980	Rocky Point (424)	7/22/1987[4]	07_03	Sevenmile Creek, OR	18	11
_06285	6/10/1980	Gerber Res. (458)	10/16/1992[4]	12_06	Westside, OR	47	29
_09526	6/11/1981	Gerber Res. (459)	11/12/1987[5]	06_07	Keno, OR	71	44
_09529	6/13/1981	Bates Butte (311)	7/8/2007[4]	26_03	Prineville, OR	85	53
_09530	6/14/1981	Crescent Lake (354)	4/26/1992[4]	11_00	Paulina Lake, OR	63	39
_09575	6/14/1983	Plantation S (042)	4/27/1991[4]	08_00	Iron Gate Reservoir, CA	46	29
_09576	6/14/1983	Odessa Dump (479)	3/21/2009[4]	25_11	Medco Pond, OR	35	22
_18177	6/15/1986	Mill Creek (114)	5/7/2003[4]	17_01	Ainsworth State Park, OR	148	92
Mean Age of Dead Adults (n = 9) =				13_05			
Mean Distance for All Adults (n = 10) =						153	95
Mean Distance for Adults (n = 7) Encountered During the Breeding Season (February-August) =						59	37
Mean Age of All (n = 20) Dead Bald Eagles =				07_00			
Mean Distance for All (n = 22) Bald Eagles =						309	192
Mean Distance for All Bald Eagles (n = 11) Encountered During the Breeding Season (February-August) =						134	83

[1] Based on a hatching date of 1 April; ages for dead eagles were maximums because they were found dead.
[2] Precision of the encounter location varied by report.
[3] Distances were straight-line from the nest tree to the encounter location.
[4] Dead
[5] Alive
[6] Captured alive 12/27/85; rehabilitated, released then found dead one month later (1/21/86) at the same location.

Table 6. Bald eagle population size, nesting success, productivity, and brood size along the Columbia River, Oregon and Washington, 1973-2007.

Year	Breeding Areas Occupied (Population Size)		Occupied Breeding Areas With Known Outcome		Occupied Breeding Areas Successful		Nesting Success[1]		Young		Young/Occupied Breeding Area[1] (Productivity)		Young/Successful Breeding Area[1] (Brood Size)	
	OR	WA[2]	OR	WA	OR	WA	OR (%)	WA (%)	OR	WA	OR	WA	OR	WA
1973[3]	1	-	1	0	1	-	100.0	-	1	-	1.00	-	1.00	-
1974[3]	2	-	2	0	2	-	100.0	-	2	-	1.00	-	1.00	-
1975[3]	0	2	0	2	-	1	-	50.0	0	2	-	1.00	-	2.00
1976[3]	1	0	1	0	1	-	100.0	-	1	-	1.00	-	1.00	-
1977[3]	3	0	2	0	2	-	100.0	-	3	-	1.50	-	1.50	-
1978	6	1	4	1	2	1	50.0	100.0	3	1	0.75	1.00	1.50	1.00
1979	6	2	6	0	2	-	33.3	-	3	-	0.50	-	1.50	-
1980	9	1	7	1	0	0	0.0	0.0	0	0	0.00	0.00	-	-
1981	8	2	7	2	3	1	42.9	50.0	4	1	0.57	0.50	1.33	1.00
1982	10	1	9	1	3	0	33.3	0.0	4	0	0.44	0.00	1.33	-
1983	9	5	9	4	4	1	44.4	25.0	6	1	0.67	0.25	1.50	1.00
1984	9	9	8	9	5	2	62.5	22.2	8	3	1.00	0.33	1.60	1.50
1985	11	10	11	7	6	1	54.5	14.3	8	2	0.73	0.29	1.33	2.00
1986	11	12	10	6	6	6	60.0	100.0	9	7	0.90	1.17	1.50	1.17
1987	12	12	10	12	2	4	20.0	33.3	3	6	0.30	0.50	1.50	1.50
1988	12	11	12	11	3	4	25.0	36.4	3	7	0.25	0.64	1.00	1.75
1989	12	9	12	7	4	3	33.3	42.9	4	5	0.33	0.71	1.00	1.67
1990	11	12	11	10	5	6	45.5	60.0	6	7	0.55	0.70	1.20	1.17
1991	15	16	15	15	11	3	73.3	20.0	15	3	1.00	0.20	1.36	1.00
1992	19	19	19	18	11	10	57.9	55.6	15	15	0.79	0.83	1.36	1.50
1993	22	20	22	15	11	10	50.0	66.7	16	16	0.73	1.07	1.45	1.60
1994	22	22	17	16	6	11	35.3	68.8	15	17	0.88	1.06	2.50	1.55
1995	21	25	17	21	8	8	47.1	38.1	11	12	0.65	0.57	1.38	1.50
1996	26	26	25	23	13	15	52.0	65.2	18	21	0.72	0.91	1.38	1.40
1997	30	28	30	28	9	13	30.0	46.4	15	18	0.50	0.64	1.67	1.38
1998	40	32	40	32	20	18	50.0	56.3	30	29	0.75	0.91	1.50	1.61
1999	39	36	38	34	20	21	52.6	61.8	32	31	0.84	0.91	1.60	1.48
2000	43	39	42	38	22	18	52.4	47.4	37	32	0.88	0.84	1.68	1.78
2001	48	38	47	38	28	25	59.6	65.8	46	34	0.98	0.89	1.64	1.36
2002	50	41	50	41	28	25	56.0	61.0	45	44	0.90	1.07	1.61	1.76
2003	55	43	54	43	35	22	64.8	51.2	58	38	1.07	0.88	1.66	1.73
2004	61	45	59	41	34	25	57.6	61.0	56	39	0.95	0.95	1.65	1.56
2005	73	55	72	52	46	34	63.9	65.4	76	54	1.06	1.04	1.65	1.59
2006	76	57	74	54	42	39	56.8	72.2	71	62	0.96	1.15	1.69	1.59
2007	83	57	81	56	56	40	69.1	71.4	94	73	1.16	1.30	1.68	1.83
Total for:														
1973-07	856	688	824	638	451	367	54.7	57.5	718	580	0.87	0.91	1.59	1.58
1978-07	849	686	818	636	445	366	54.4	57.5	711	578	0.87	0.91	1.60	1.58

[1] Based on young/occupied breeding area with known outcome.

[2] Survey results through 1994 provided by Washington Department of Wildlife.

[3] 1973-1977 data from unpublished reports by others prior to the start of this study.

Table 7. Relationship between young per occupied breeding area (y axis) and shoreline length per occupied breeding area (x axis) for bald eagles breeding at seven water bodies in Oregon and along the Washington side of the Columbia River, 1978-2007.

Water Body	Shoreline or River Length (km)	Years With ≥5 Breeding Areas		Number of Occupied Breeding Areas		Population Growth Rate[2]	Shoreline or River Length Per Occupied Breeding Area (km)		Linear Regression Results[3]		
		Start	End	Start	2007		Start Year	2007			
Columbia River Estuary[1]	704.9	1978	2007	7	119	0.098	100.7	5.9	$y = -0.0063x + 0.9158$	$r = -0.621$	$p < 0.01$
Odell Lake	21.4	1998	2007	5	9	0.065	4.3	2.4	$y = 0.1077x + 0.6766$	$r = 0.328$	$p > 0.10$
Crane Prairie and Wickiup reservoirs	117.2	1978	2007	8	18	0.028	14.7	6.5	$y = 0.0217x + 0.6626$	$r = 0.195$	$p > 0.10$
Lake Billy Chinook	100.3	1995	2007	5	9	0.049	20.1	11.1	$y = 0.0761x - 0.1105$	$r = 0.479$	$p = 0.097$
Willamette River	297.7	1996	2007	5	25	0.146	59.5	11.9	$y = -0.0144x + 1.7218$	$r = -0.742$	$p < 0.01$
Umpqua River	193.1	1985	2007	7	24	0.056	27.6	8.0	$y = -0.0085x + 1.1065$	$r = -0.165$	$p > 0.10$
Upper Klamath and Agency lakes	182.7	1978	2007	20	49	0.031	9.1	3.7	$y = -0.0544x + 1.1964$	$r = -0.430$	$p = 0.017$
Upper Klamath and Agency lakes subdivided:											
Excluding Spence Mountain and Eagle Ridge	130.1	1978	2007	12	30	0.032	10.8	4.3	$y = -0.036x + 1.2375$	$r = -0.383$	$p = 0.038$
Spence Mountain and Eagle Ridge	52.6	1978	2007	8	19	0.030	6.6	2.8	$y = -0.0055x + 0.7818$	$r = -0.017$	$p > 0.10$

[1] Columbia River estuary shoreline length was estimated by tripling river miles from the Pacific Ocean to Bonneville Dam.

[2] Instantaneous rate of growth = r = $[\ln(N_t/N_0)]/t$, where Nt was the population at time t (2007), N_0 was the initial (Start Year) population size, and t was the number of time periods (N_t-N_0).

[3] Linear regression of shoreline or river length/occupied breeding area (x) and young/occupied breeding area (y).

Table 8. Distance from water of breeding areas of bald eagles by location east or west of the crest of the Cascade Mountains in Oregon and along the Washington side of the Columbia River, 1971-2007.

			Distance From Water (m)				
Watershed[1]	Region	n	Minimum	Maximum	Median	25% Quartile	75% Quartile
Columbia	East	15	32	3,257	325	88	1,285
Deschutes	East	73	22	7,092	338	142	818
Klamath	East	135	15	5,553	493	180	1,576
Northeast	East	15	10	4,507	210	55	1,098
Columbia	West	156	5	4,016	105	62	328
Pacific	West	107	16	6,251	311	161	576
Rogue	West	31	22	2,911	247	130	777
Willamette	West	79	15	3,593	174	82	376
East Total		243	10	7,092	384[2]	146	1,268
West Total		373	5	6,251	188	82	442

[1] Watersheds with ≥5 breeding areas.

[2] East median distance was greater significantly than west ($Z = 6.429$, $p < 0.01$).

Table 9. Relationship of productivity (y axis) to distance from water (x axis) for bald eagle breeding areas with ≥5 years of occupation (n) by watershed with ≥5 occupied breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007.

Watershed	n	Linear Regression Results	Spearman Rank Correlation Coefficient Results	
Northeast	8	$y = 0.0549x + 1.1108$	$r_s = 0.262$	$p > 0.10$
Columbia	106	$y = 0.0035x + 0.9422$	$r_s = -0.092$	$p > 0.10$
Deschutes	60	$y = 0.1191x + 0.8755$	$r_s = 0.173$	$p > 0.10$
Willamette	53	$y = -0.0149x + 1.119$	$r_s = -0.126$	$p > 0.10$
Pacific	81	$y = 0.0254x + 0.9835$	$r_s = 0.023$	$p > 0.10$
Klamath	112	$y = 0.0522x + 0.8826$	$r_s = 0.213$	$p = 0.025$
Rogue	24	$y = -0.0563x + 0.9994$	$r_s = 0.033$	$p > 0.10$
Study Area	444	$y = 0.0301x + 0.9583$	$r_s = 0.058$	$p > 0.10$

Table 10. Elevation of breeding areas of bald eagles by watershed in Oregon and along the Washington side of the Columbia River, 1971-2007.

			Elevation (m)				
Watershed[1]	Region	n	Minimum	Maximum	Median	25% Quartile	75% Quartile
Deschutes	East	82	402	2,027	1,334	981	1,411
Klamath	East	155	893	1,914	1,399	1,324	1,494
Northeast	East	16	174	1,408	1,140	785	1,253
Columbia	West	176	2	707	6	3	52
Pacific	West	111	3	1,631	116	62	198
Rogue	West	32	49	1,576	544	372	945
Willamette	West	84	3	1,676	110	62	342
East Total		274	24	2,027	1,364[2]	1,271	1,463
West Total		388	2	1,676	68	6	189

[1] Watersheds with ≥5 breeding areas.

[2] East median elevation was significantly greater than west ($Z = 20.026$, $p < 0.01$).

Table 11. Relationship of productivity (y axis) to elevation (x axis) for breeding areas of bald eagles with ≥5 years of occupation (n) in Oregon and along the Washington side of the Columbia River, 1971-2007.

Watershed	n	Linear Regression Results	Spearman Rank Correlation Coefficient Results	
Northeast	9	$y = -0.0002x + 1.4262$	$r_s = -0.283$	$p > 0.10$
Columbia	109	$y = 0.0002x + 0.9406$	$r_s = -0.163$	$p = 0.091$
Deschutes	65	$y = -0.0001x + 1.1556$	$r_s = -0.163$	$p > 0.10$
Willamette	55	$y = -0.0007x + 1.3279$	$r_s = -0.409$	$P < 0.01$
Pacific	84	$y = -0.0002x + 1.0369$	$r_s = -0.274$	$p = 0.012$
Klamath	129	$y = -0.0002x + 1.2285$	$r_s = -0.073$	$p > 0.10$
Rogue	25	$y = -0.0002x + 1.1438$	$r_s = -0.207$	$p > 0.10$
Study Area	476	$y = -0.00006x + 1.0297$	$r_s = -0.111$	$p = 0.015$

Table 12. Minimum and maximum estimates of the number of bald eagle breeding areas circa 1800 and the actual number of breeding areas reported in 2007 for Oregon and the Washington side of the Columbia River.

	Circa 1800			2007	
Watershed	Minimum Estimate	Maximum Estimate	2007 Actual	% of 1800 Minimum	% of 1800 Maximum
Columbia	120	240	176	147	73
Klamath	128	256	155	121	61
Pacific	204	408	111	54	27
Willamette	65	130	84	129	65
Deschutes	68	136	82	121	60
Rogue	50	100	32	64	32
Northeast	56	112	16	29	14
Snake	19	38	3	16	8
Harney	9	18	3	33	17
Owyhee	9	18	0	0	0
Total	728	1456	662	91	45

Table 13. Frequency and duration of gaps in nest use, nest presence, and occupation of breeding areas by bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007.

Gap Duration (Years)	< 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
GAPS IN NEST USE (n = 1,645, 87.5% without gaps)[1]																
Number of Gaps	-	191	68	40	12	10	5	2	1	0	1	1	1	-	-	332
Percent	-	57.5	20.5	12.0	3.6	3.0	1.5	0.6	0.3	0.0	0.3	0.3	0.3	-	-	
Descriptive Statistics:	Median = 1 year, 25% Quartile = 1 year, 75% Quartile = 2 years.															
GAPS IN NEST PRESENCE (n = 1,645, 95.8% without gaps)[2]																
Number of Gaps	28	12	11	7	4	5	2	1	1	2	0	0	1	0	1	75
Percent	37.3	16.0	14.7	9.3	5.3	6.7	2.7	1.3	1.3	2.7	0.0	0.0	1.3	0.0	1.3	
Descriptive Statistics:	Median = 1 year, 25% Quartile = <1 year, 75% Quartile = 3 years.															
GAPS IN BREEDING AREA OCCUPATION (n = 662, 81.6% without gaps)[3]																
Number of Gaps	-	130	26	8	1	1	0	1	-	-	-	-	-	-	-	167
Percent	-	77.8	15.6	4.8	0.6	0.6	0.0	0.6	-	-	-	-	-	-	-	
Descriptive Statistics:	Median = 1 year, 25% Quartile = 1 year, 75% Quartile = 1 year.															

[1] Minimum gap duration; does not include nests that fell and were rebuilt.

[2] Minimum gap duration where nests fell and were rebuilt.

[3] Minimum gap duration based on unoccupied breeding areas with occupation before and after the gap.

Table 14. Nesting success and productivity at breeding areas of bald eagles for years before and after nest changes under four different circumstances in Oregon and along the Washington side of the Columbia River, 1971-2007.

	A1 No Nest Loss		A2		B1 With Nest Loss		B2	
	Move To A Pre-Existing Nest		Move To A New Nest		Move To A Pre-Existing Nest		Move To A New Nest	
Breeding Area Parameters	Year Before	Year After	Year Before	Year After	Year Before	Year After	Year Before	Year After
Number Occupied With Evidence of Eggs And Known Outcome	266	263	205	198	29	29	75	73
Number Successful	141	189	132	151	22	23	60	61
Percent Successful	53	72	64	76	76	79	80	84
Number of Young	207	285	207	235	35	35	101	97
Young/Occupied Breeding Area With Evidence of Eggs And Known Outcome	0.78	1.08	1.01	1.19	1.21	1.21	1.35	1.33
Number Successful	$X^2 = 7.58$, df = 1, $p < 0.01$		$X^2 = 2.036$, df = 1, $p > 0.10$		$X^2 = 0.022$, df = 1, $p > 0.10$		$X^2 = 0.033$, df = 1, $p > 0.10$	
Number of Young	$X^2 = 13.0$, df = 1, $p < 0.01$		$X^2 = 2.93$, df = 1, $p > 0.087$		$X^2 = 0.000$, df = 1, $p > 0.10$		$X^2 = 0.020$, df = 1, $p > 0.10$	

Table 15. Summary of use at nests built by bald eagles and used by other species, and nests built by other species and used by bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007.

		Nest Tree Years		Nest Trees		Nest[1] Originally Built By:				
								Osprey		
Species[2]		n	%	n	%	Bald Eagle	Unknown Species	Natural Platform	Artificial Platform	Red-tailed Hawk
Canada Goose	*(Branta canadensis)*	80	57.1	42	47.7	28	13	0	1	0
Red-tailed Hawk[4]	*(Buteo jamaicensis)*	22	15.7	18	20.5	7	7	0	0	4
Osprey[5]	*(Pandion haliaetus)*	18	12.9	12	13.6	0	1	7	4	0
Great Horned Owl	*(Bubo virginianus)*	11	7.9	8	9.1	6	2	0	0	0
Golden Eagle[6]	*(Aquila chrysaetos)*	5	3.6	5	5.7	2	3	0	0	0
Common Raven[7]	*(Corvus corax)*	2	1.4	2	2.3	2	0	0	0	0
Peregrine Falcon[8]	*(Falco peregrinus)*	2	1.4	1	1.1	1	0	0	0	0
Total		140		88		46	26	7	5	4

[1] Nests not built by bald eagles were observed being used by bald eagles or were judged to have had nesting material added by bald eagles.

[2] Species other than bald eagle reported using a bald eagle nest or that built a nest that was used subsequently by bald eagles.

[3] Some nests were used by other species for more than one year.

[4] One red-tailed hawk chick fledged from a bald eagle nest at Jones Swamp in 2001 where the eagles simultaneously fledged two eaglets.

[5] The first successful nesting by bald eagles on a manmade structure in Oregon was at Smith Lake in 2004 on a nest previously used by osprey.

[6] Golden eagles and bald eagles nested successfully 510m apart at Cottonwood Reservoir in 1995 in tree nests originally built by bald eagles.

[7] Ravens reported but not confirmed using a bald eagle nest at Unity Res. in 1994 and a raven took a stick from a bald eagle nest at Tenmile Cr, in 1980.

[8] Peregrine falcons attempted to nest on a bald eagle nest at Megler, Washington in 2004 and 2005.

Table 16. Year-to-year nesting outcomes at breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers that are <1 are proportions of outcomes shown at the top of the column (Year Y+1) that followed the outcomes shown at the left end of the row (Year Y). For example, 0.079 of breeding areas with an outcome of 3 in year Y (n = 127) had an outcome of 3 the following year (Y+1); 0.409 had an outcome of 2; and 0.236 had an outcome of 1, etc. The Year Y+1 outcome that had the greatest positive deviation from expected is underlined and all underlined values occurred more often than expected ($p < 0.10$).

Year Y		Year Y+1 Outcome							
Outcome	n	3	2	1	OCEF	OC2F	OC1F	Other	Total
3	127	0.079	0.409	0.236	0.134	0.079	0.031	0.031	1.000
2	2263	0.026	0.418	0.274	0.128	0.072	0.039	0.041	1.000
1	2108	0.016	0.315	0.318	0.155	0.090	0.046	0.061	1.000
OCEF	1310	0.013	0.211	0.228	0.246	0.140	0.076	0.086	1.000
OC2F	945	0.007	0.172	0.206	0.174	0.222	0.096	0.122	1.000
OC1F	538	0.000	0.149	0.217	0.154	0.177	0.123	0.180	1.000
Other	2123	0.002	0.066	0.079	0.042	0.046	0.036	0.729	1.000
Overall n	9414	130	2321	2099	1292	950	524	2098	
Overall Y+1 Proportion		0.014	0.247	0.223	0.137	0.101	0.056	0.223	1.000

3 = Successful 3 Young - includes both 3 and 3 downy outcomes.
2 = Successful 2 Young - includes both 2 and 2 downy outcomes.
1 = Successful 1 Young - includes both 1 and 1 downy outcomes.
OCEF = Occupied Evidence Of Eggs Failed - evidence of eggs, no young observed.
OC2F = Occupied 2 Failed - two breeding-age eagles and no evidence of eggs
OC1F = Occupied 1 Failed - one breeding-age eagle and no evidence of eggs.
Other = OCCF, UNOC, OCEX, OC2X, OC1X, OCCX, OCXX, UNOX, and NS combined.

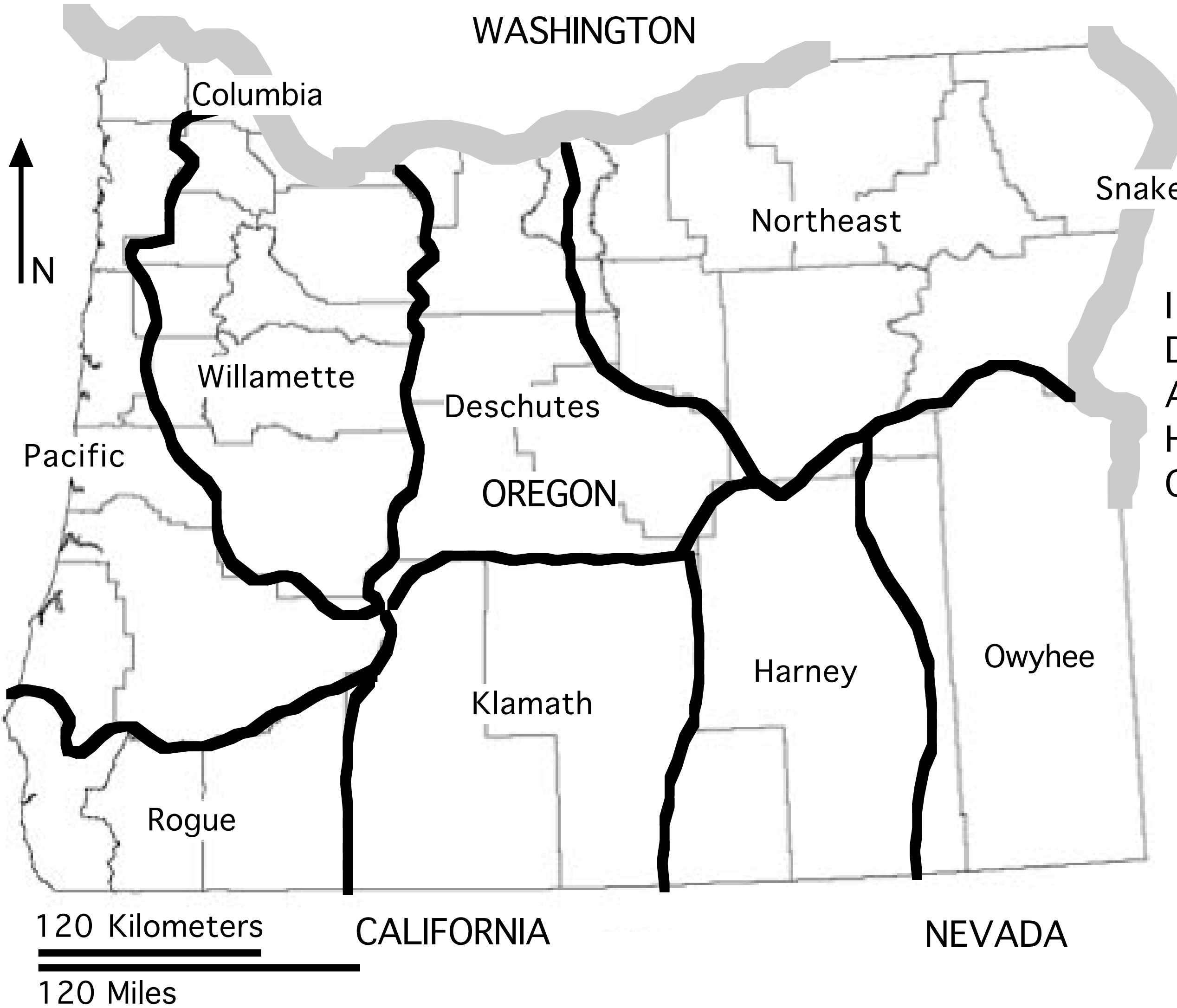


Figure 1. Study area and watershed locations for bald eagles breeding in Oregon and along the Washington side of the Columbia River, 1978-2007.

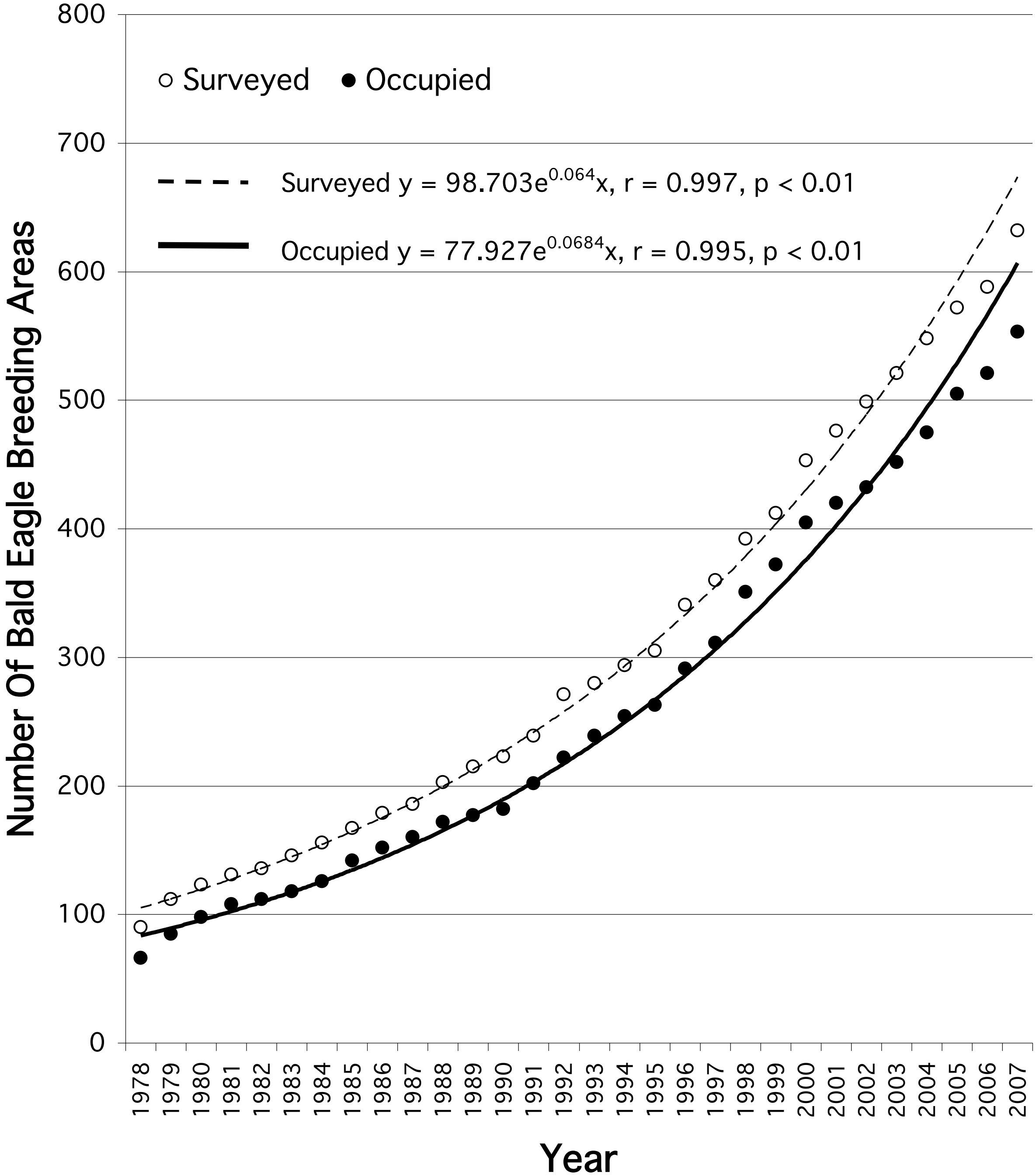


Figure 2. Number of breeding areas surveyed and occupied by bald eagles in Oregon and along the Washington side of the Columbia River, 1978-2007.

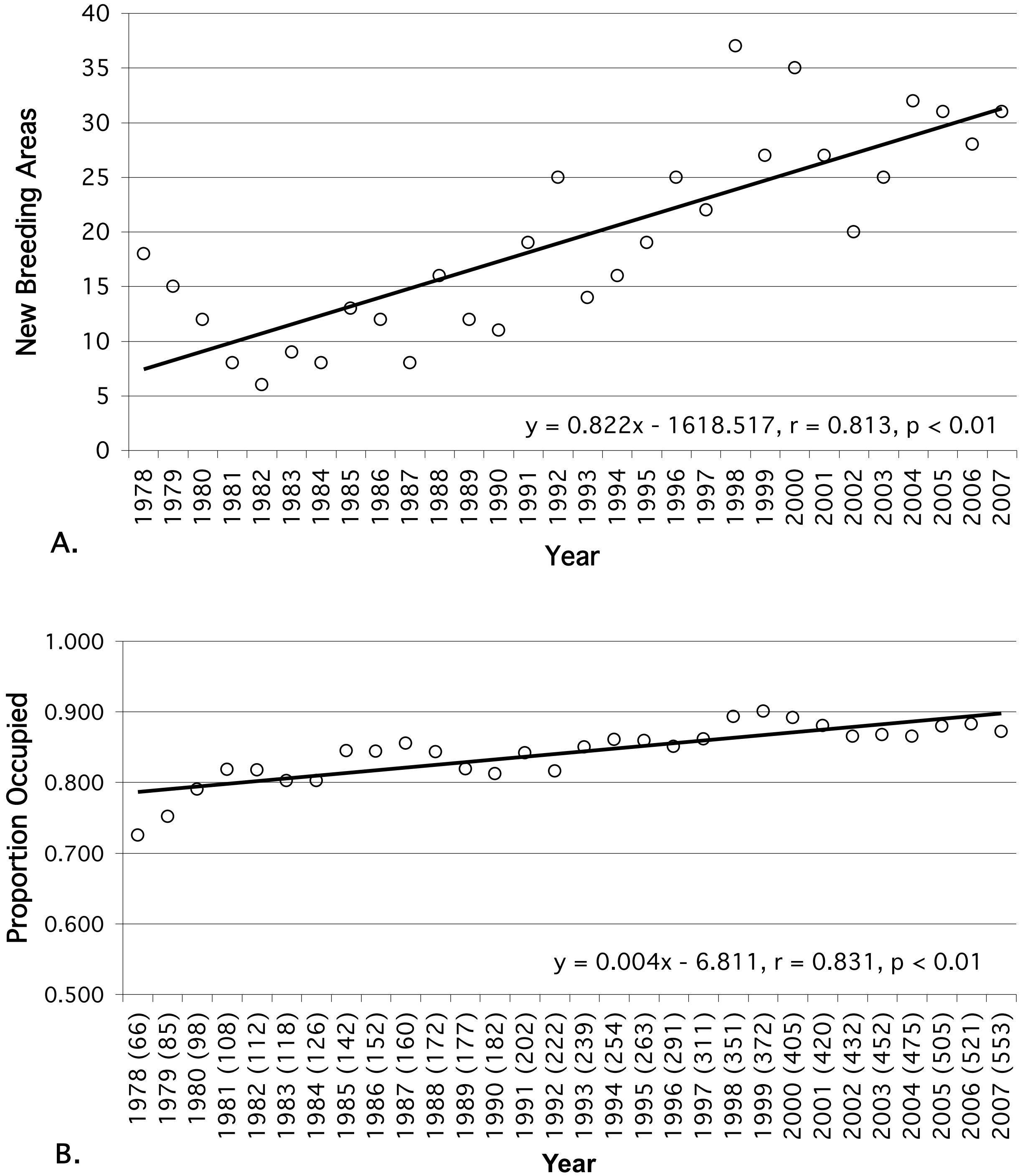


Figure 3. Number of new breeding areas of bald eagles reported each year (A.) and proportion of all breeding areas that were occupied (B.) in Oregon and along the Washington side of the Columbia River, 1978-2007. Numbers in parentheses are sample sizes.

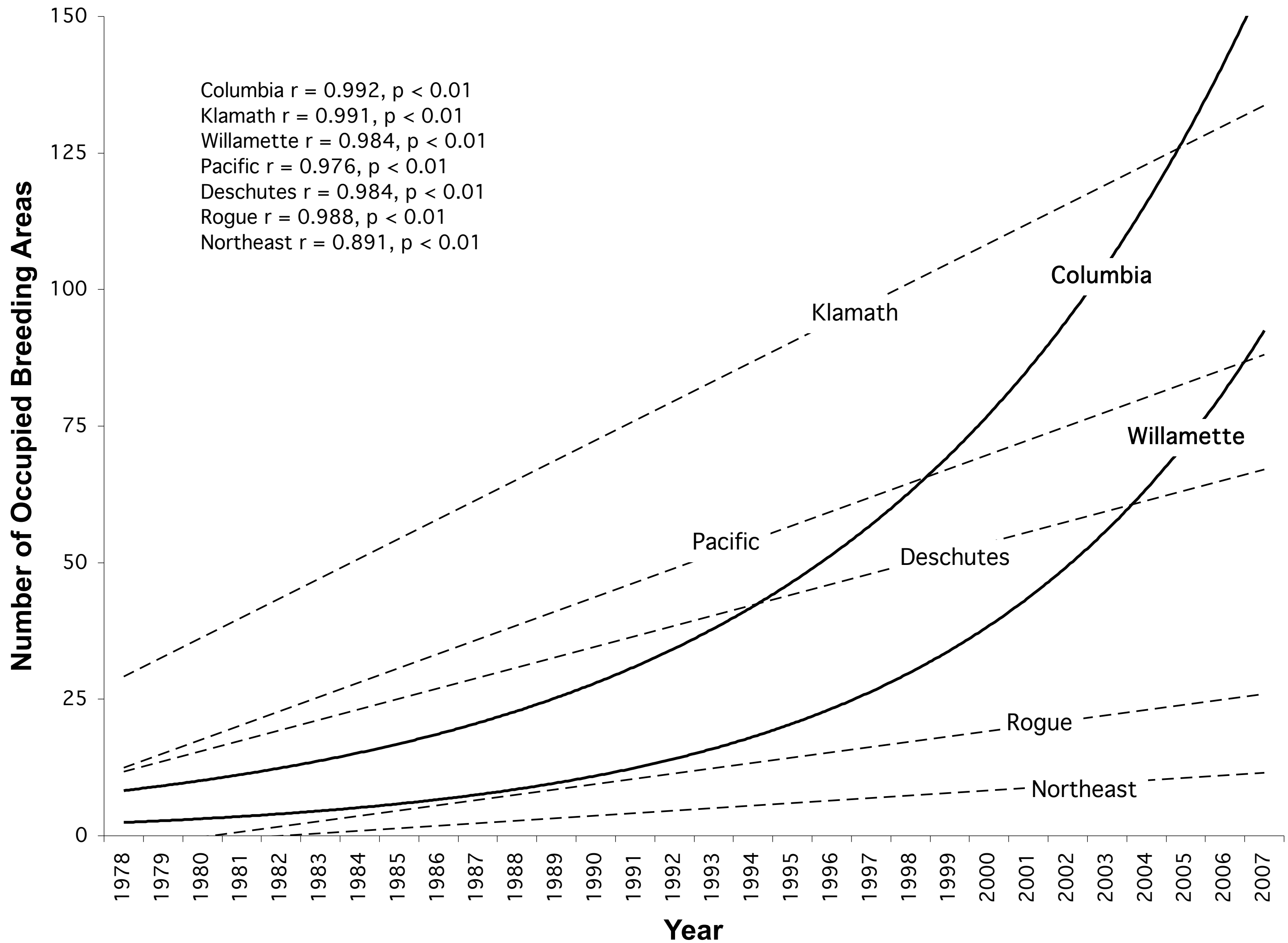


Figure 4. Number of breeding areas occupied by bald eagles in Oregon and along the Washington side of the Columbia River for watersheds with ≥5 breeding areas, 1978-2007.

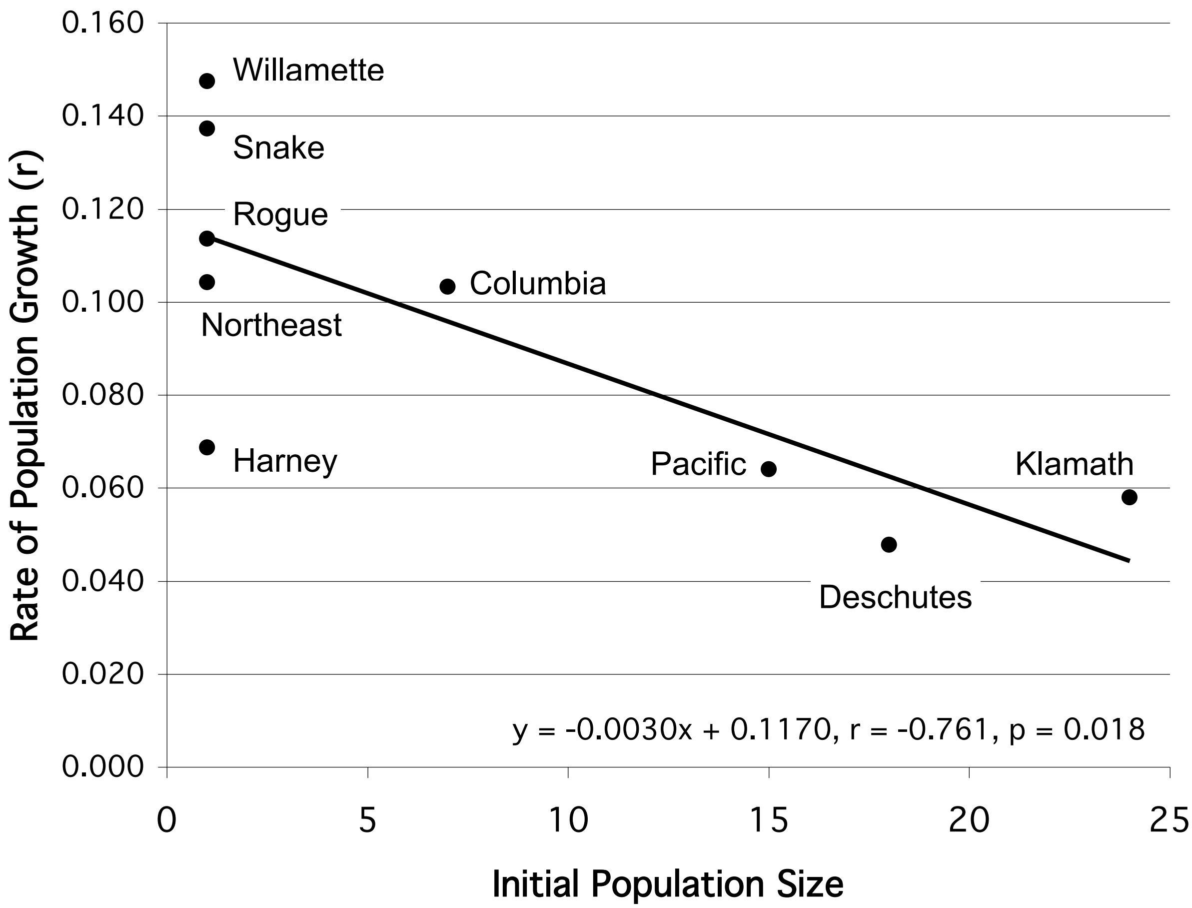


Figure 5. Relationship of rate of population growth (r) (y axis) to initial population size (x axis) for occupied breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

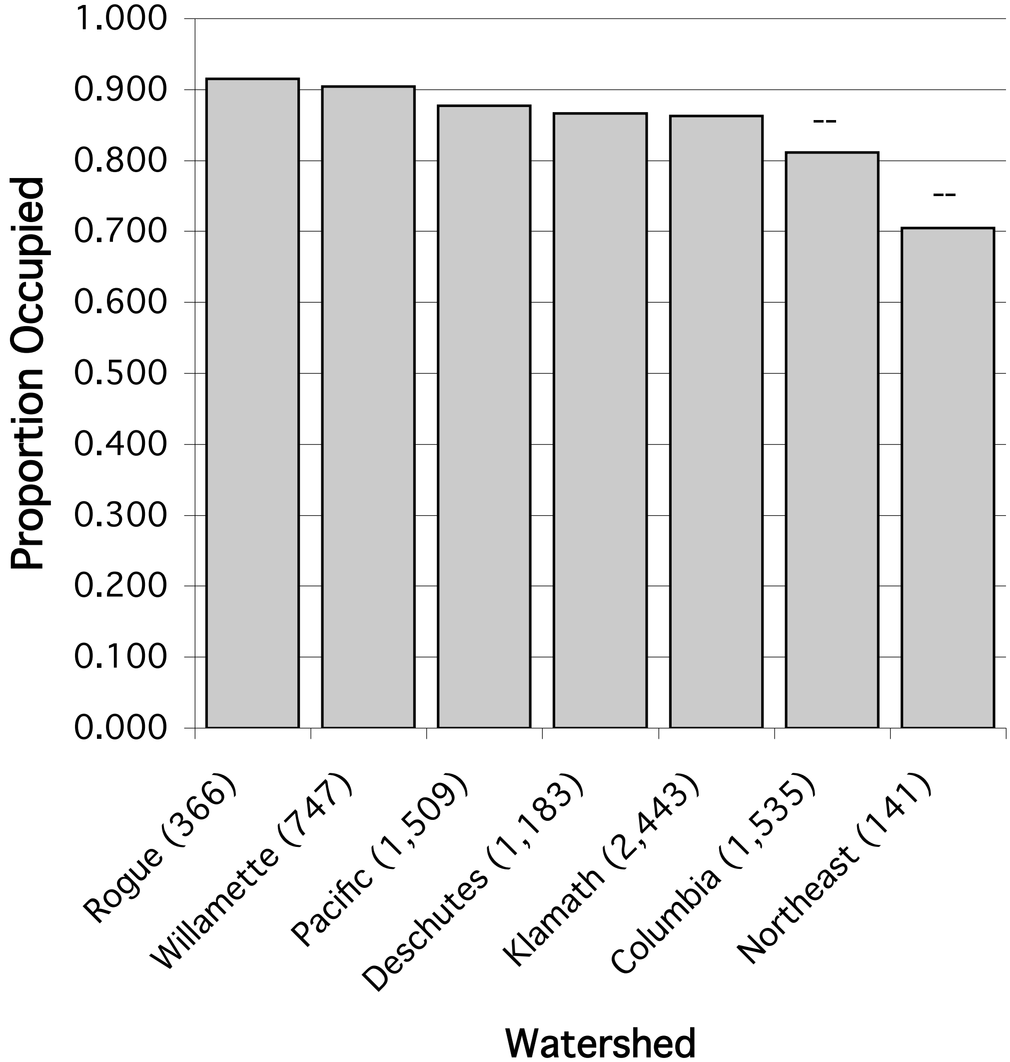


Figure 6. Occupation of breeding areas by bald eagles for watersheds with ≥5 occupied breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007. Numbers in parentheses are sample size. Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected ($p < 0.05$).

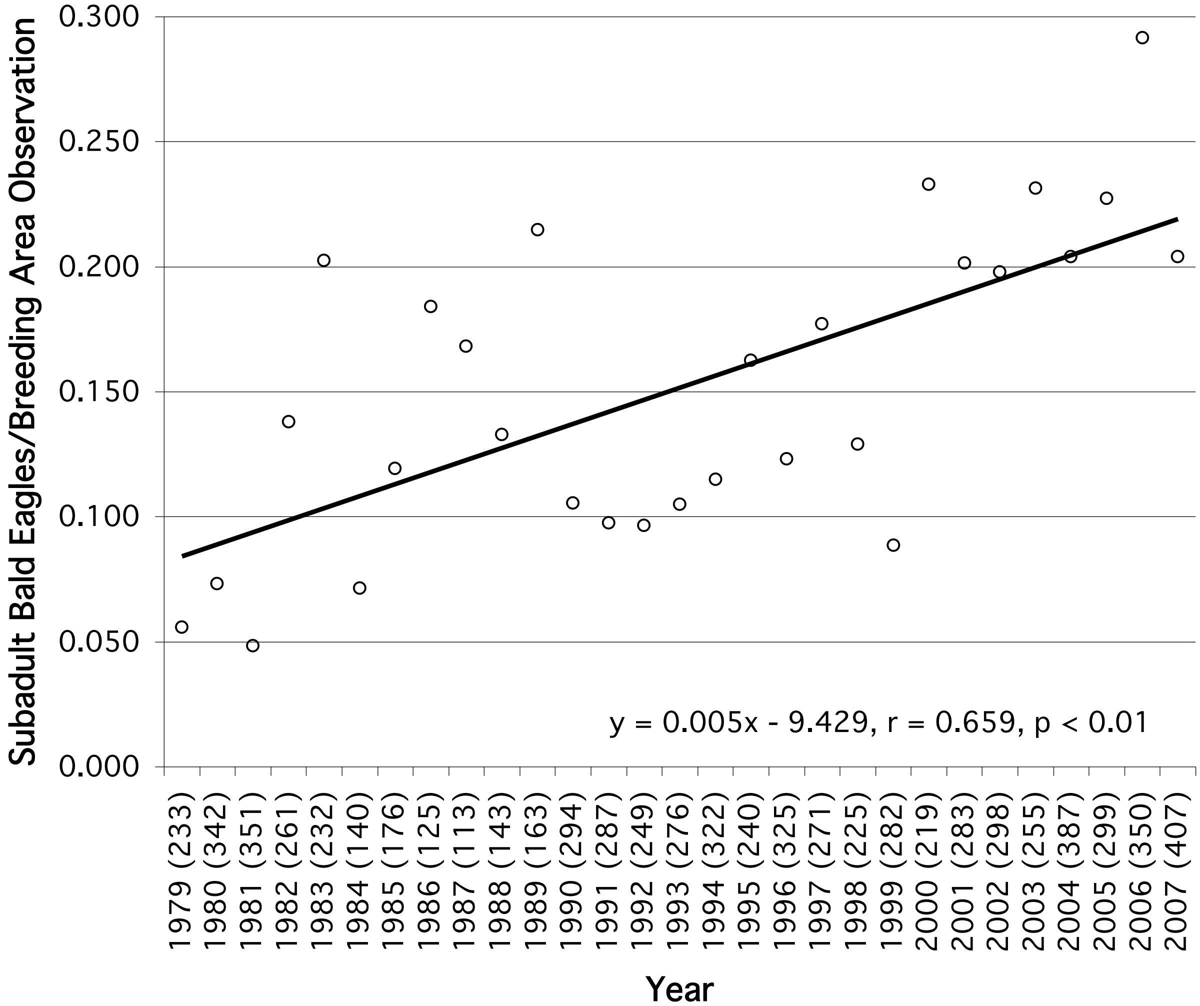


Figure 7. Subadult bald eagles/breeding area observation in Oregon and along the Washington side of the Columbia River, 1979-2007. Subadults were birds in Juvenal through Basic III plumages as defined by McCollough (1989). Numbers in parentheses are sample sizes.

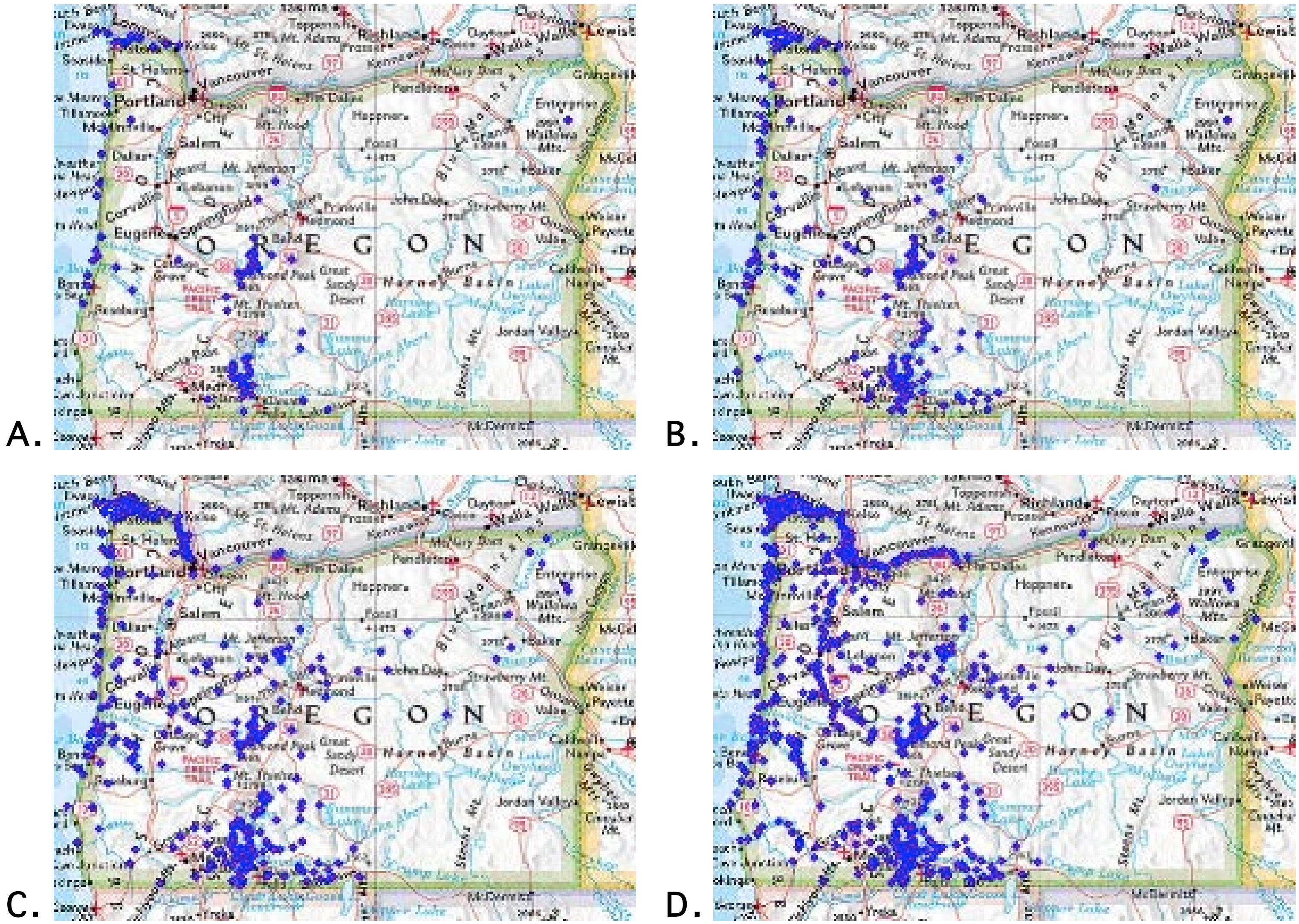


Figure 8. Locations of breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River in 1978 (A.101 breeding areas), 1987 (B. 192), 1997 (C. 370), and 2007 (D. 662).

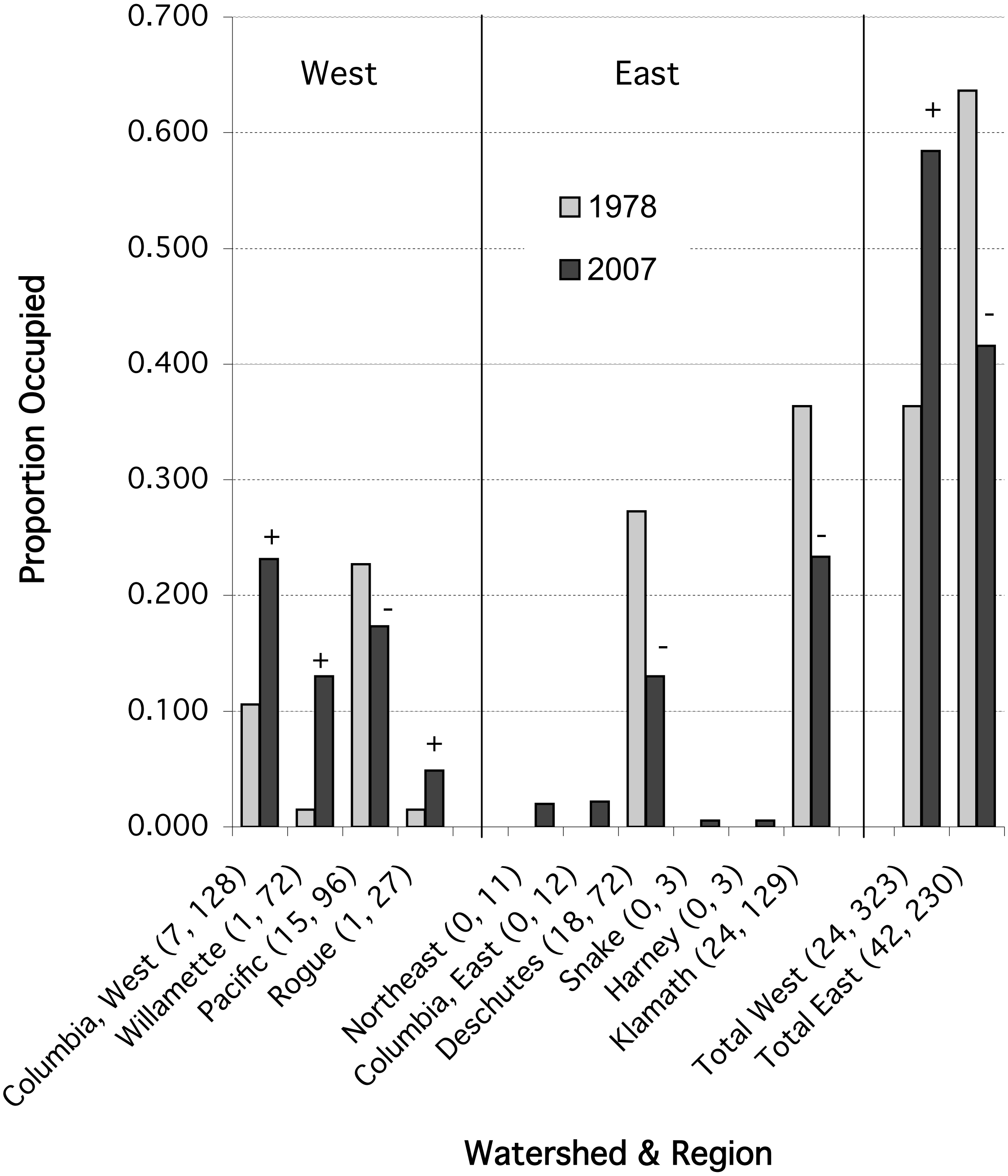


Figure 9. Breeding areas occupied by bald eagles in Oregon and along the Washington side of the Columbia River by watershed and location west or east of the crest of the Cascade Mountains, 1978 and 2007. Numbers in parentheses are sample sizes (1978, 2007). Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected (p < 0.01).

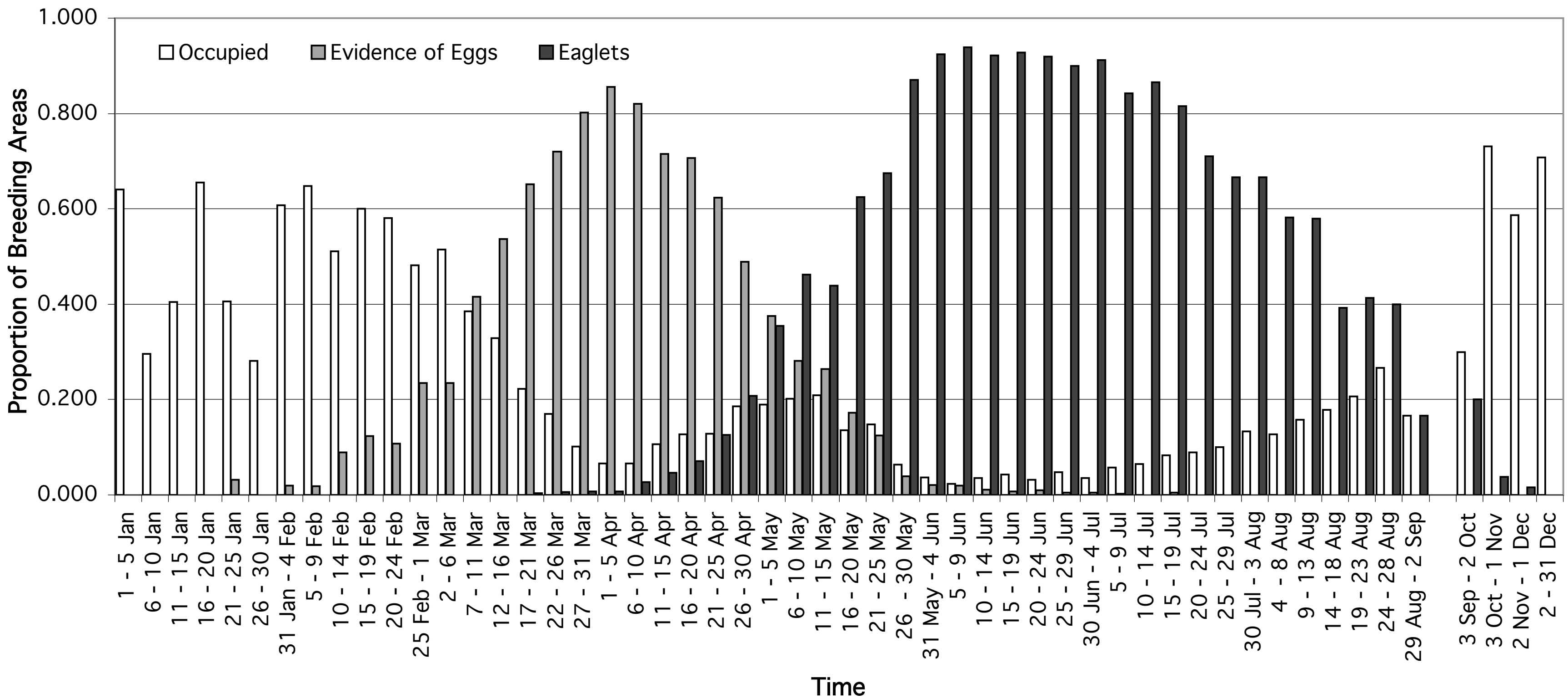


Figure 10. Nesting status at breeding areas of bald eagles where pairs successfully raised young in Oregon and along the Washington side of the Columbia River based on 15,688 observations from 1971 to 2007. Sample sizes varied by period ranging from 15 to 1,311 observations for 5-day periods and 12 to 51 for 30-day periods.

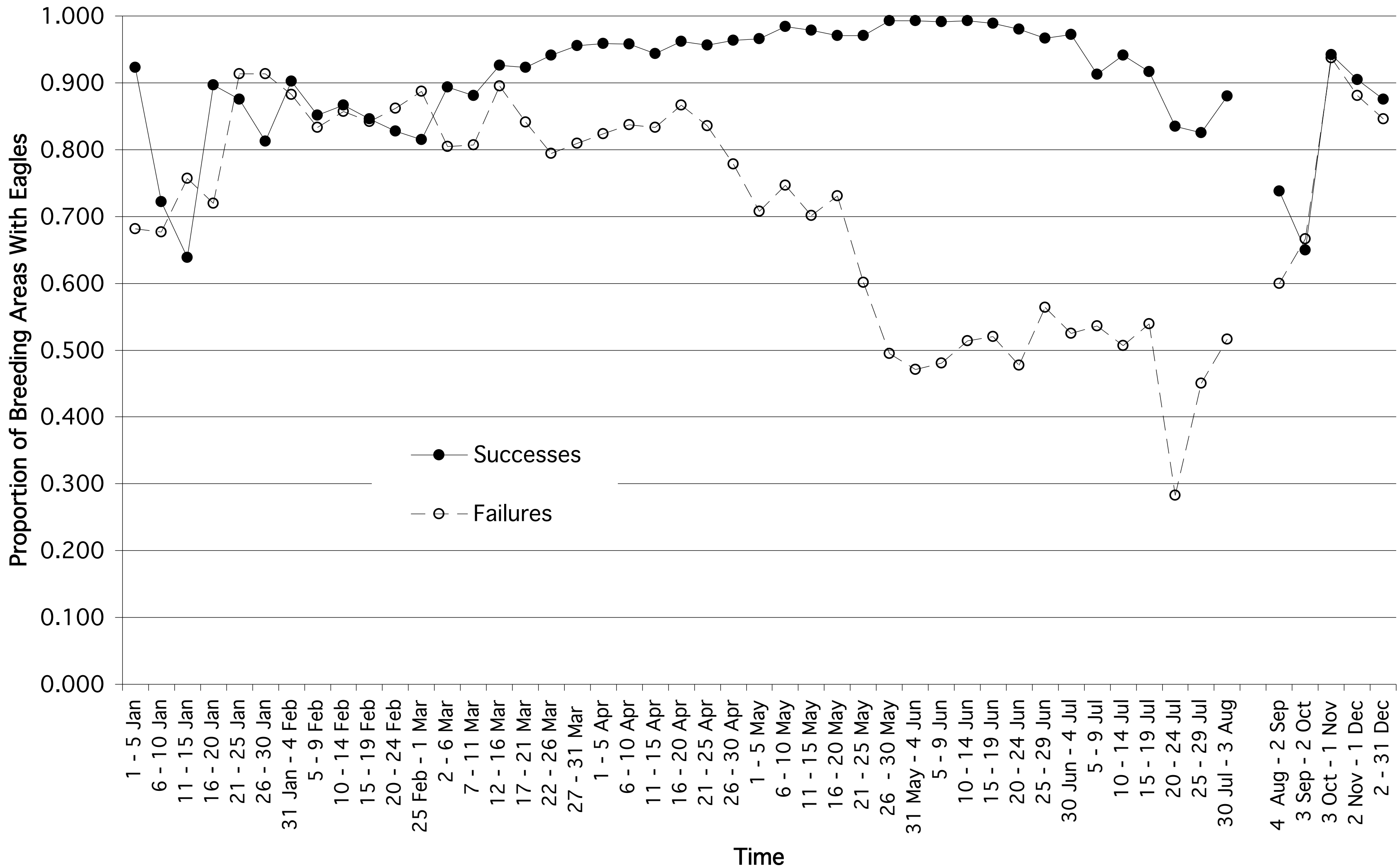


Figure 11. Breeding areas where breeding age eagles or nestlings were detected during surveys in Oregon and along the Washington side of the Columbia River, 1971-2007, based on 15,688 daily records on successes and 9,953 on failures. Sample size varied by period; success 5-day periods ranged from 15-1,311 observations/period and 30-day periods ranged from 40-183; failure 5-day periods ranged from 22-757 observations/period and 30-day periods ranged from 32-65.

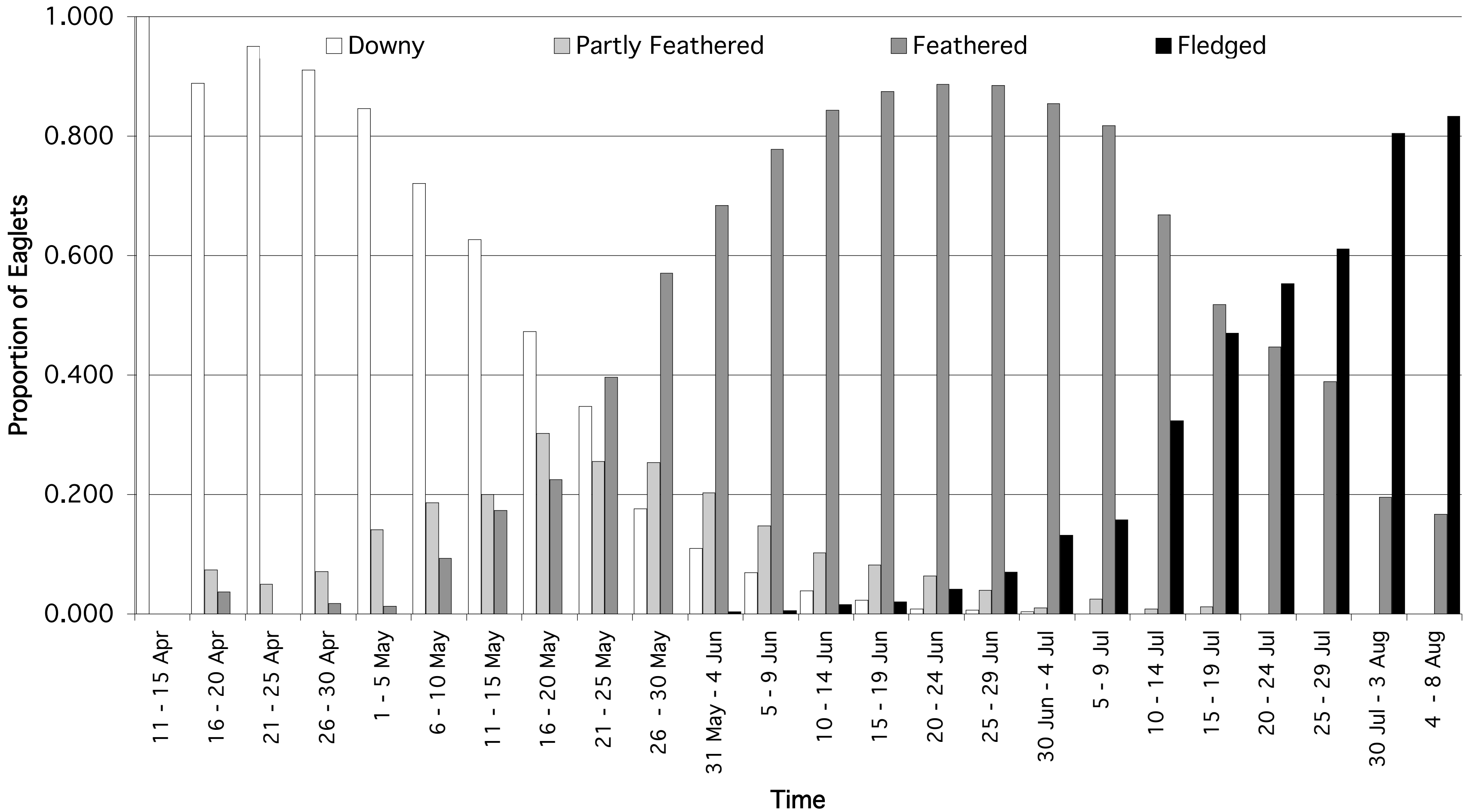


Figure 12. Eaglet development at breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Relationship to developmental stages identified by Carpenter (1990): Downy = Stages 1a, 1b, and 2; Partly Feathered = Stages 3a and 3b; and Feathered = Stages 3c and 3d. Eaglets were considered to be Fledged when they had flown from the nest tree at least once. These observations were based on 6,553 records. Sample size varied from 19-1,153 records/five day period.

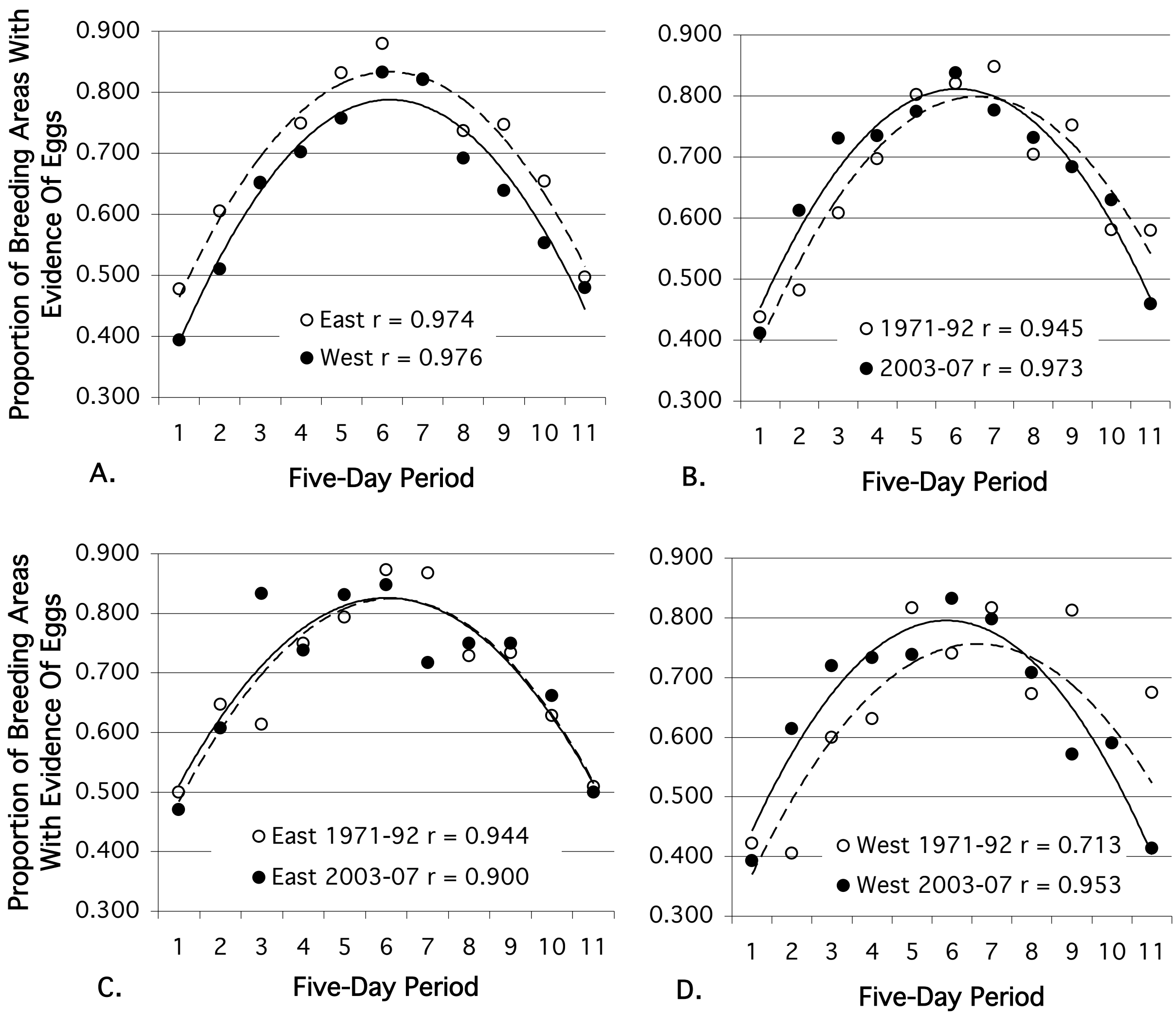


Figure 13. Proportion of breeding areas occupied by bald eagles that had evidence of eggs and successful nesting by 5-day period in Oregon and along the Washington side of the Columbia River, 1971-2007. Period 1 = 7-11 Mar, 2 = 12-16 Mar, 3 = 17-21 Mar, 4 = 22-26 Mar, 5 = 27-31 Mar, 6 = 1-5 Apr, 7 = 6-10 Apr, 8 = 11-15 Apr, 9 = 16-20 Apr, 10 = 21-25 Apr, and 11 = 26-30 Apr. Sample sizes for A. ranged from 67-556 observations/5-day period, B. 54-539, C. 17-165, and D. 15-210. All r values were significant at $p > 0.05$. Curves are order 2 polynomial trendlines. Figure A dashed curve = East regression and solid line = West regression. Figures B-D dashed curves = 1971-1992 and solid curves = 2003-2007.

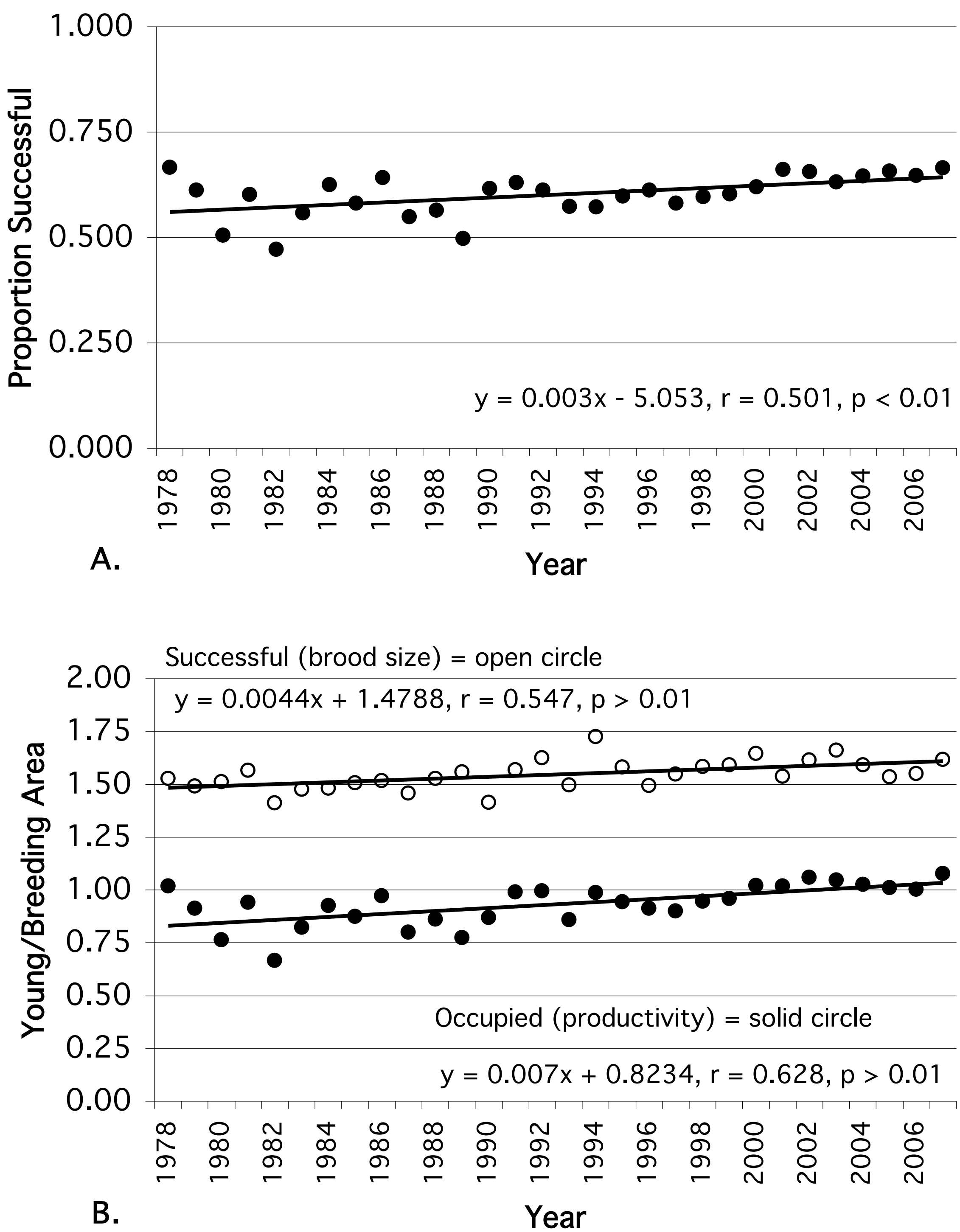


Figure 14. Nesting success (A) and productivity (young/occupied breeding area with known outcome) and brood size (young/successful breeding area) (B.) for bald eagles in Oregon and along the Washington side of the Columbia River, 1978-2007. Sample size increased annually from 57 occupied breeding areas with known outcome in 1978 to 535 in 2007.

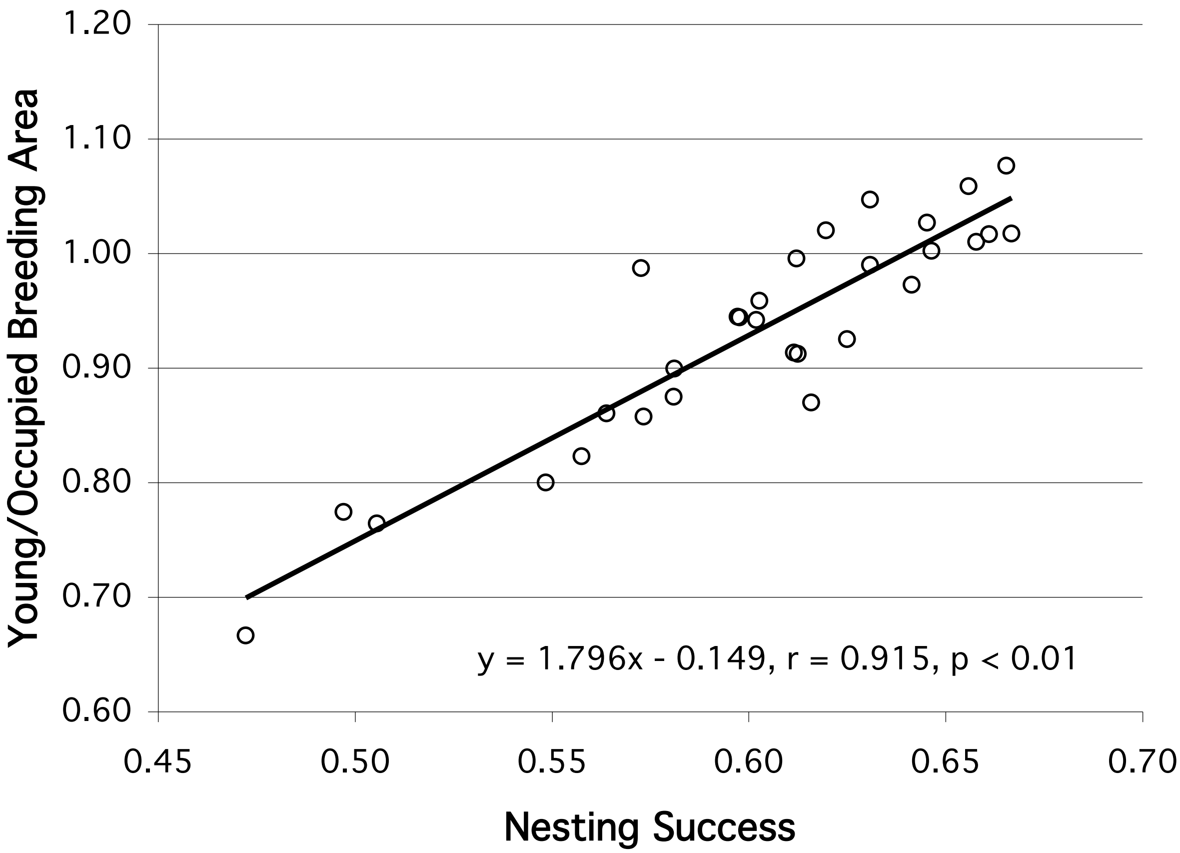


Figure 15. Relationship of nesting success (x axis) and young/occupied breeding area with known outcome (y axis) by year (n = 30) at breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1978-2007.

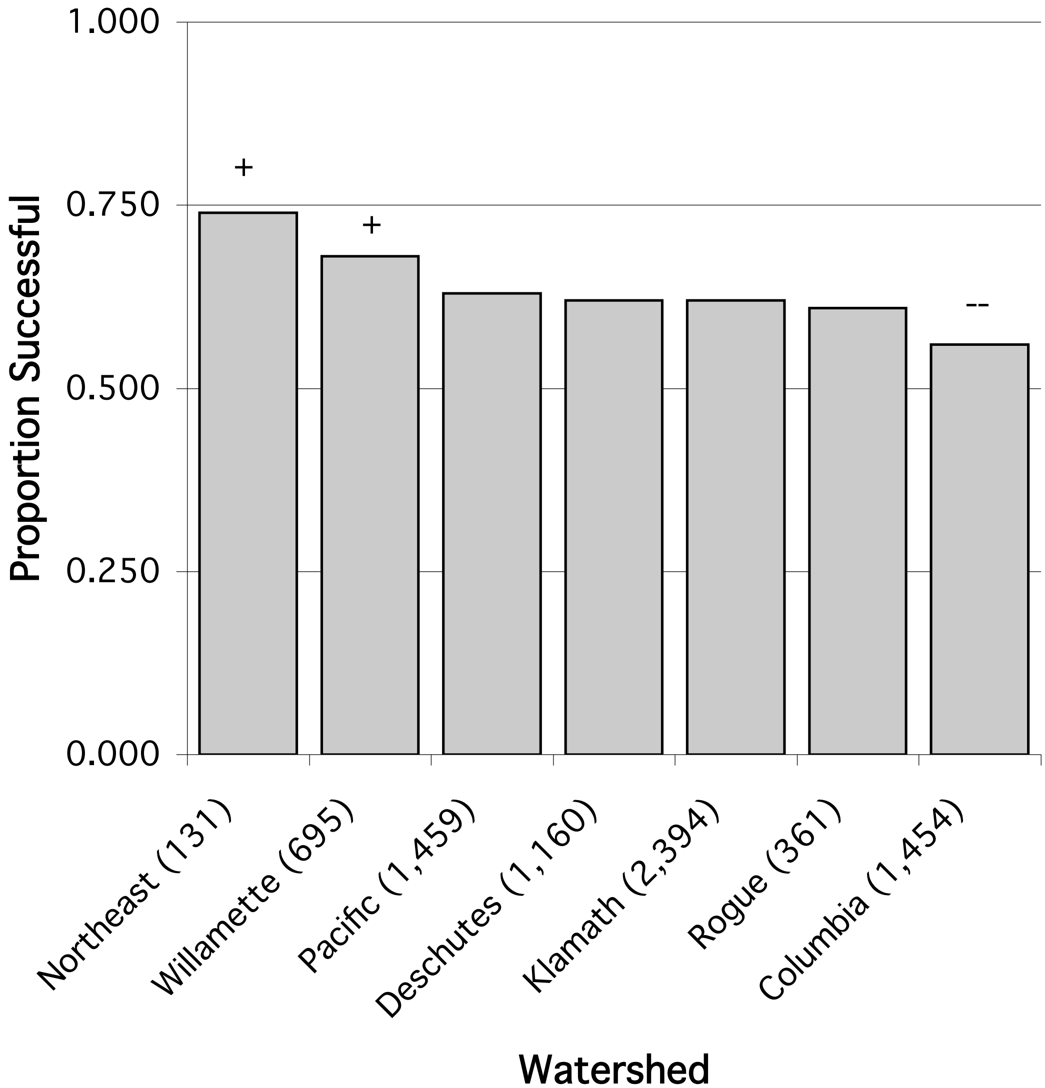


Figure 16. Nesting success by watershed with ≥5 occupied breeding areas for bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected ($p < 0.10$).

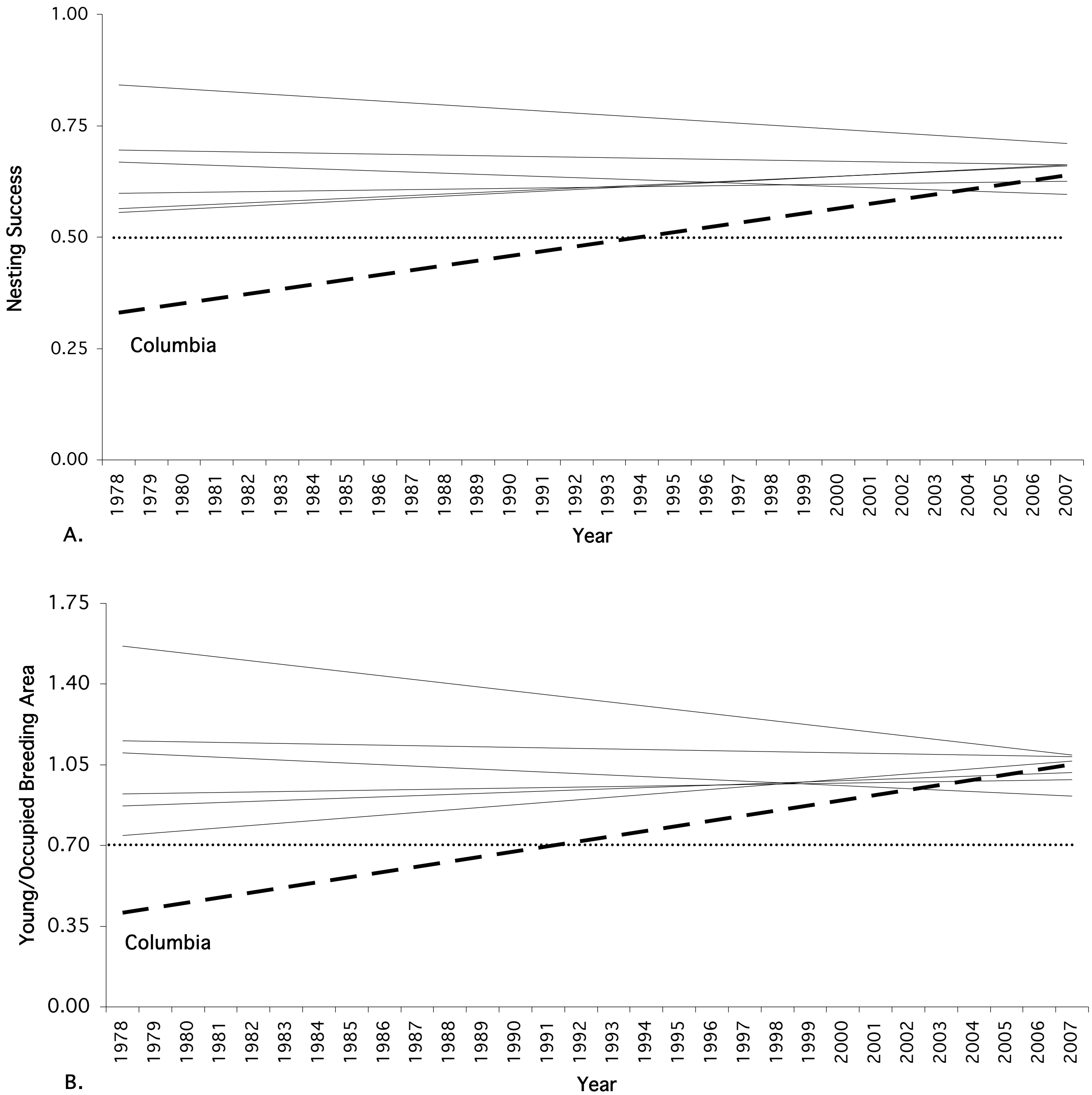


Figure 17. Trends of nesting success (A.) and productivity (B.) by watershed for bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007. Columbia watershed is depicted by the dashed line; other watersheds are represented by solid lines. The dotted lines are lower thresholds of nesting success and productivity suggested necessary to maintain stable populations (Sprunt et al. 1973).

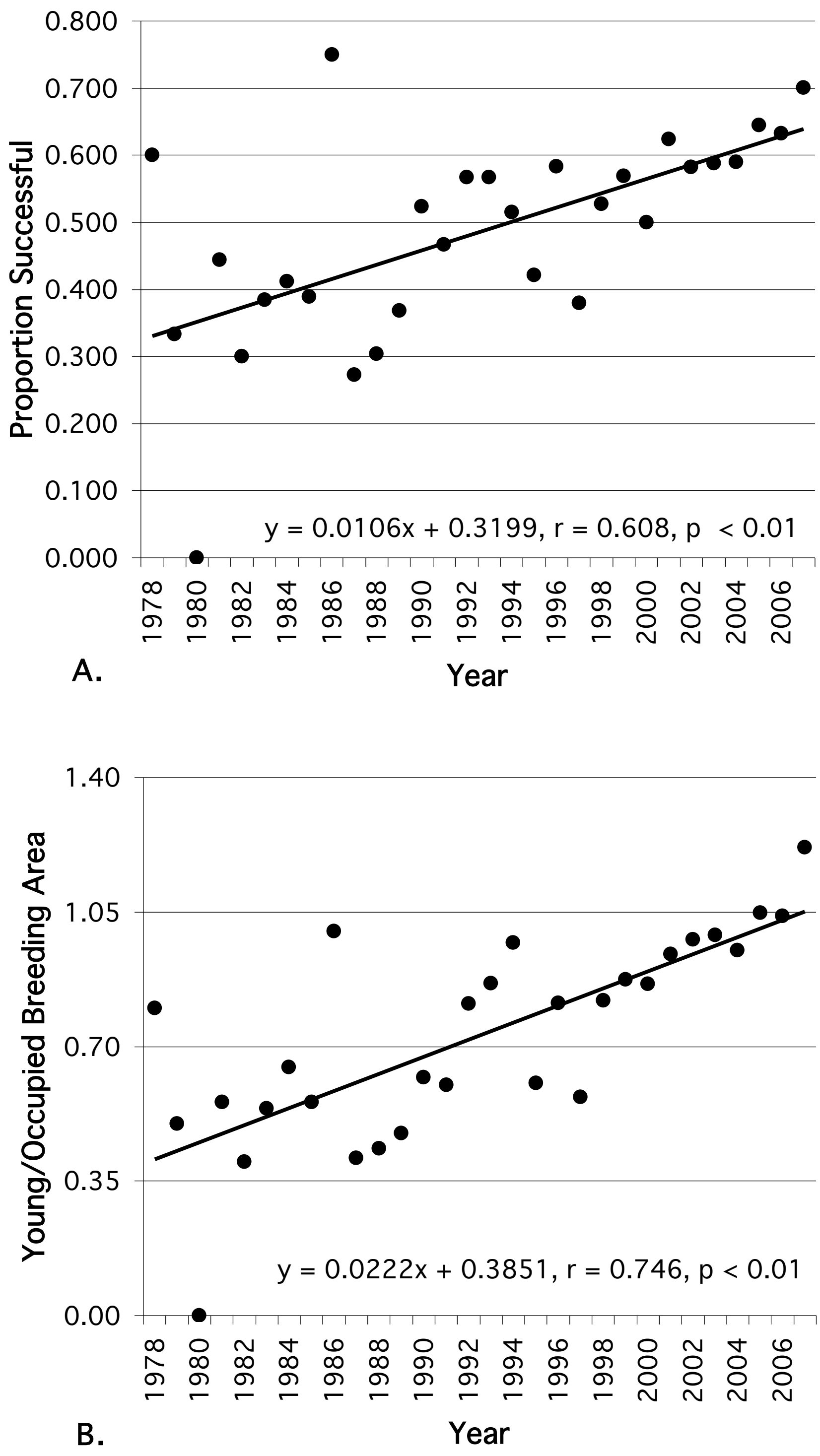


Figure 18. Nesting success (A.) and productivity (young/occupied breeding area with known outcome) (B.) for bald eagles nesting along the Columbia River, where it forms the border between Oregon and Washington, 1978-2007.

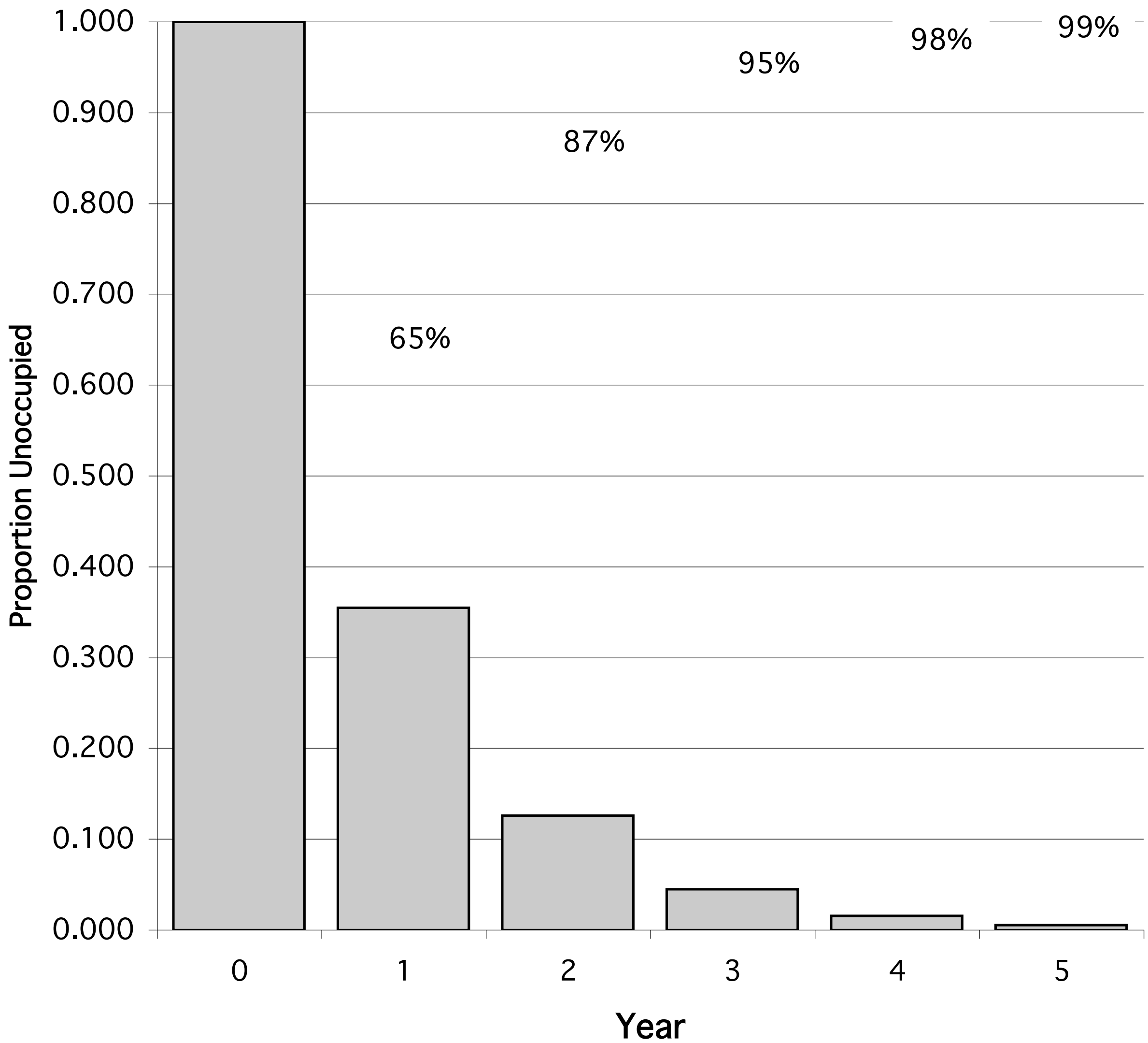


Figure 19. Proportion of unoccupied breeding areas that remained unoccupied over time (0.355, n = 327) in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers above columns are the percent of unoccupied breeding areas that were occupied in subsequent years.

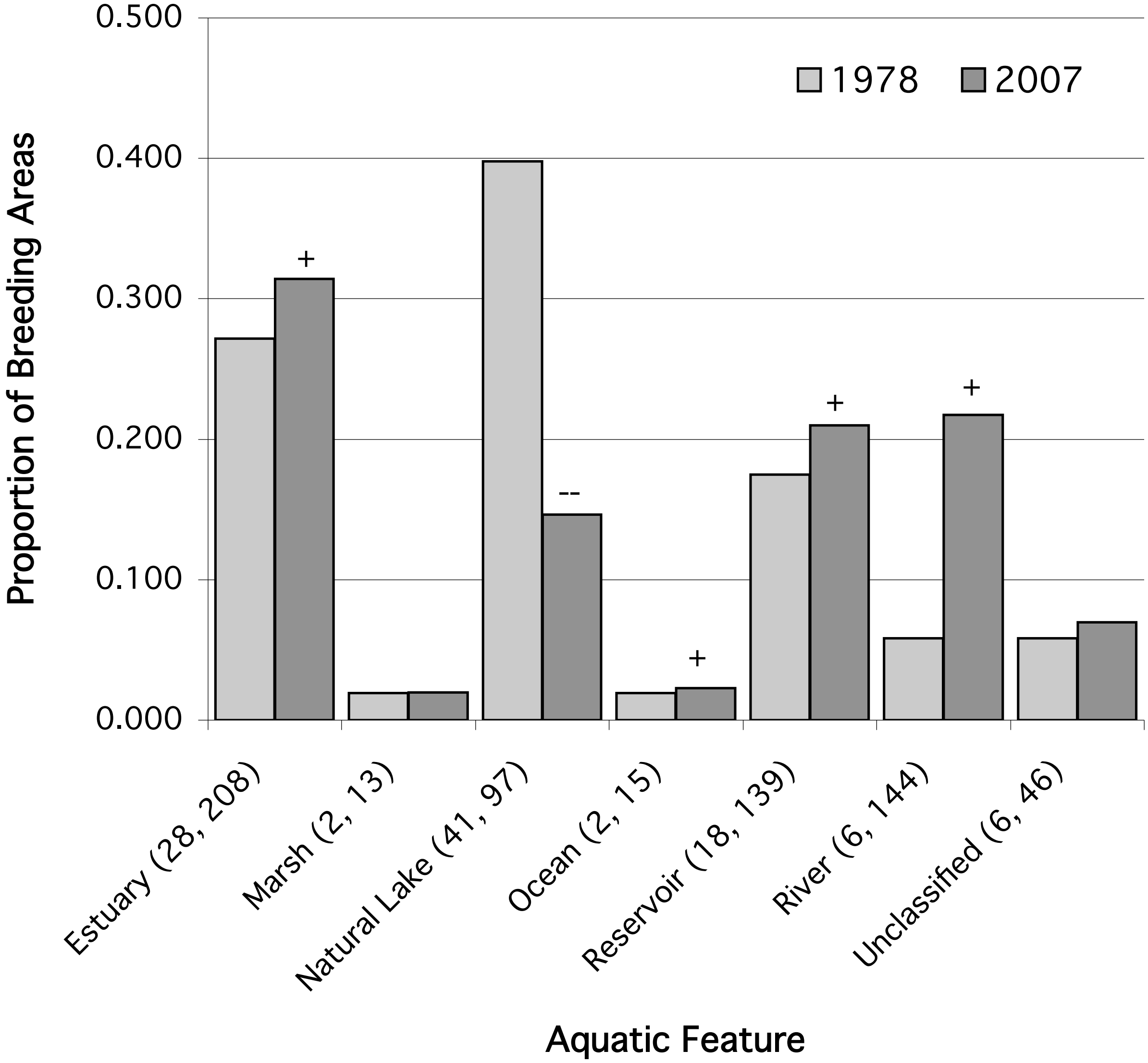


Figure 20. Proportion of breeding areas of bald eagles by aquatic feature in Oregon and along the Washington side of the Columbia River, 1978 (n = 103) and 2007 (n = 662). The unclassified group was comprised of breeding areas where the aquatic feature was not determined because the primary hunting area was unknown, atypical, or there were multiple possibilities. The Ocean group includes two breeding areas that were first listed in 1979 even though they probably existed in 1978. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.05$).

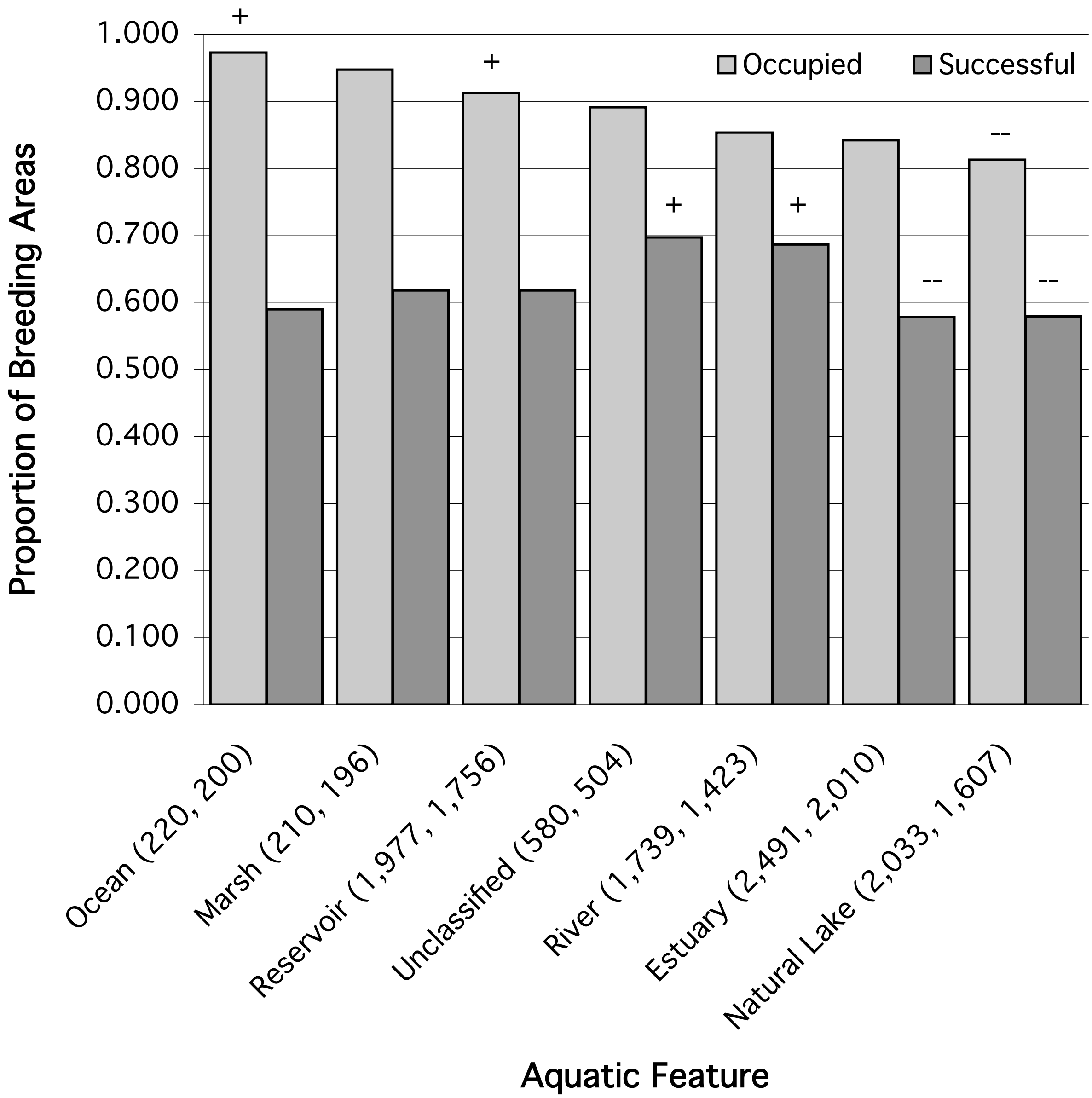


Figure 21. Occupation and nesting success at breeding areas of bald eagles by aquatic feature in Oregon and along the Washington side of the Columbia River, 1978-2007. Numbers in parentheses are sample sizes (occupation, success). Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

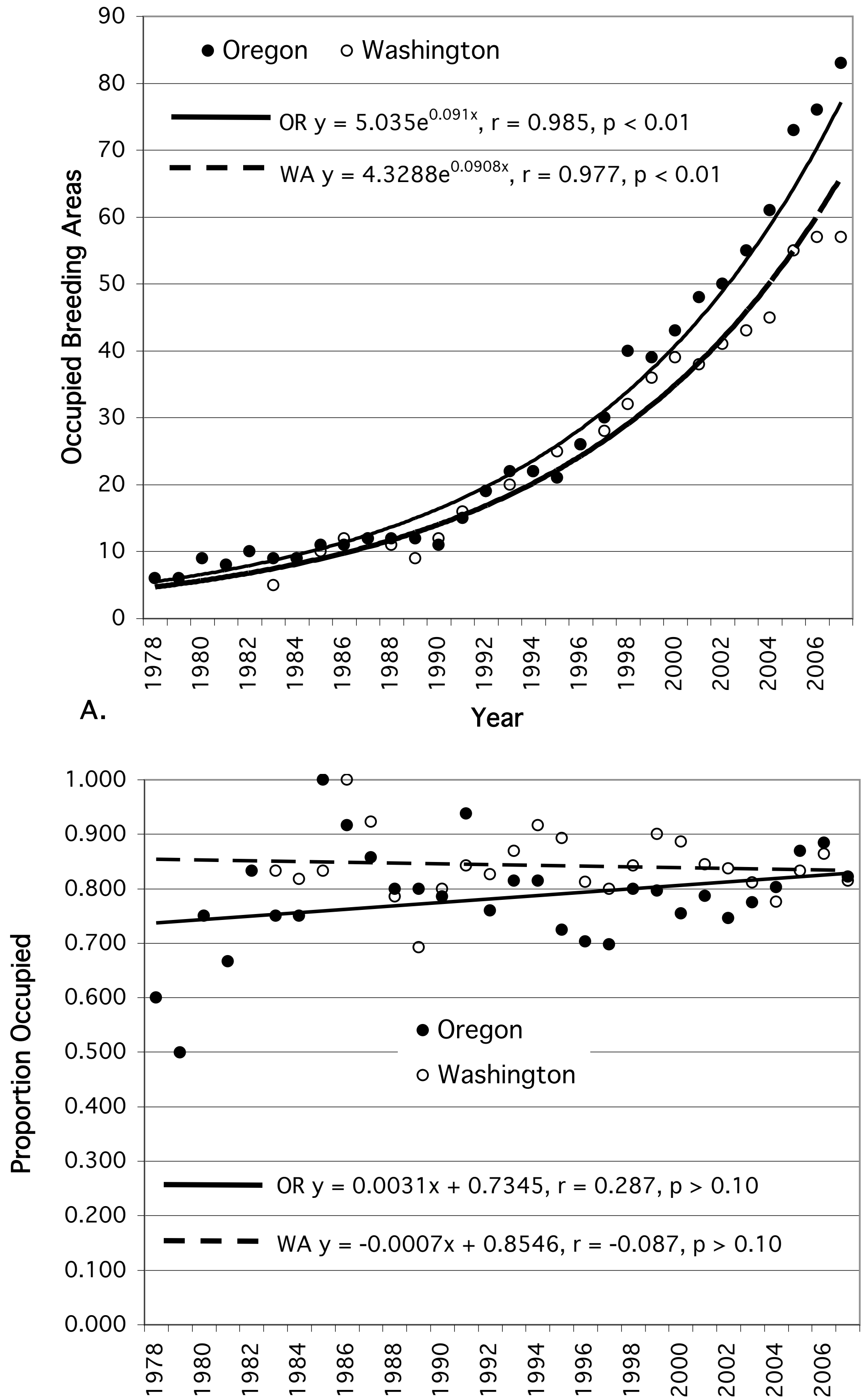


Figure 22. Number (A.) and occupied proportion (B.) of breeding areas of bald eagles along the Columbia River, where it forms the border between Oregon and Washington, 1978-2007.

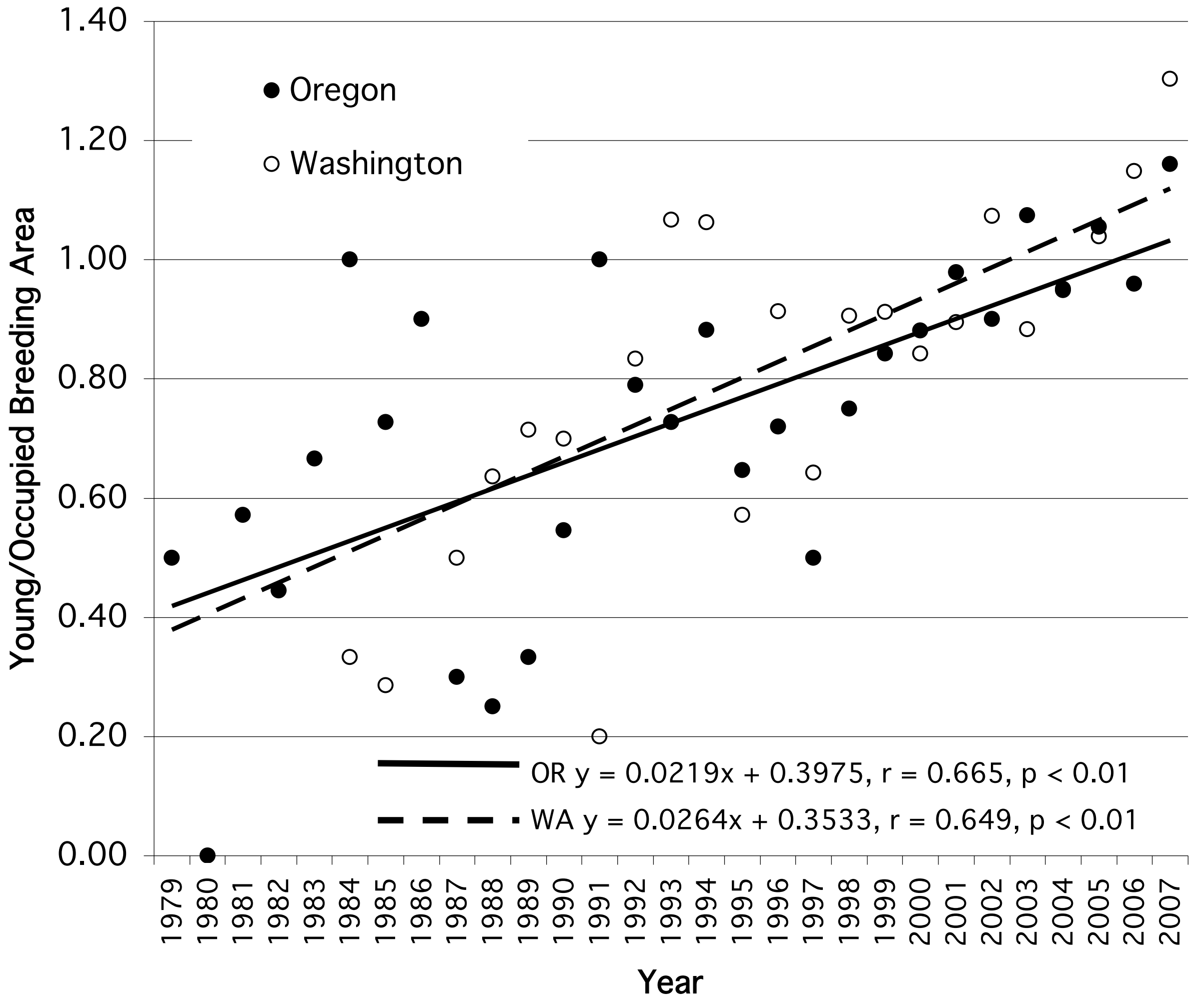


Figure 23. Productivity at breeding areas of bald eagles along the Columbia River, where it forms the border between Oregon and Washington, 1978-2007.

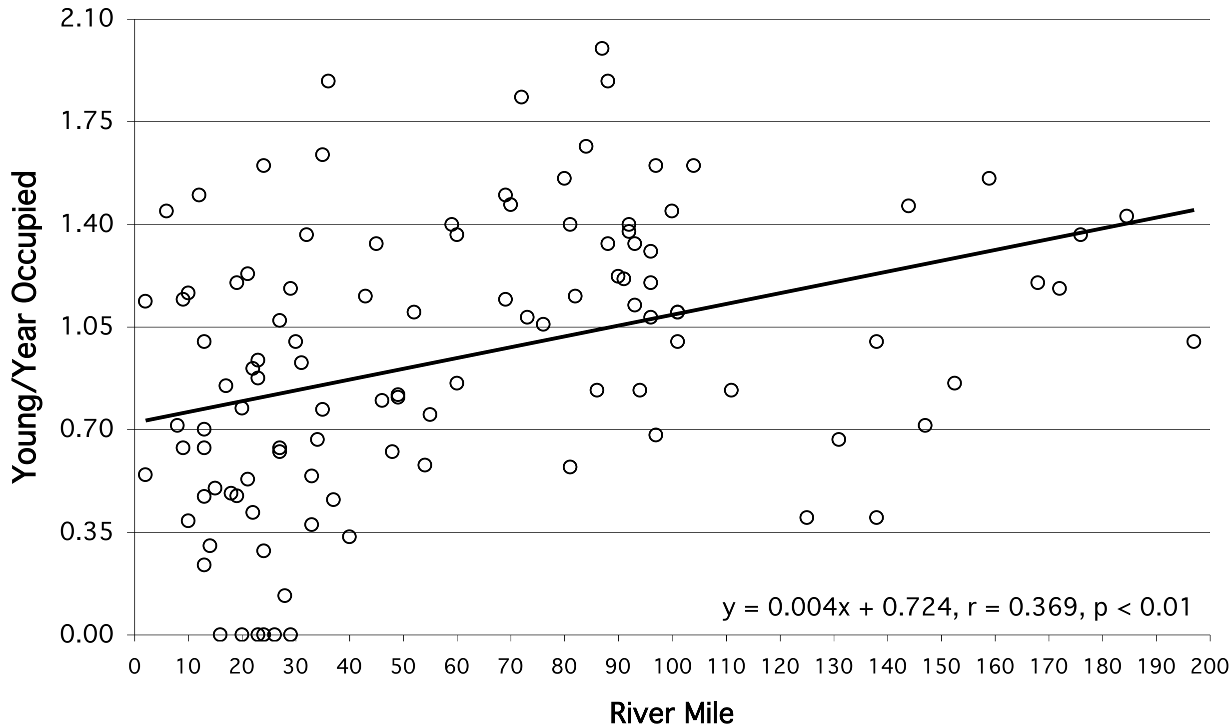


Figure 24. Productivity (young/year occupied with known outcome) at breeding areas of bald eagles with ≥5 years of known outcome (n = 109) by river mile along the Columbia River, where it forms the border between Oregon and Washington, 1972-2007.

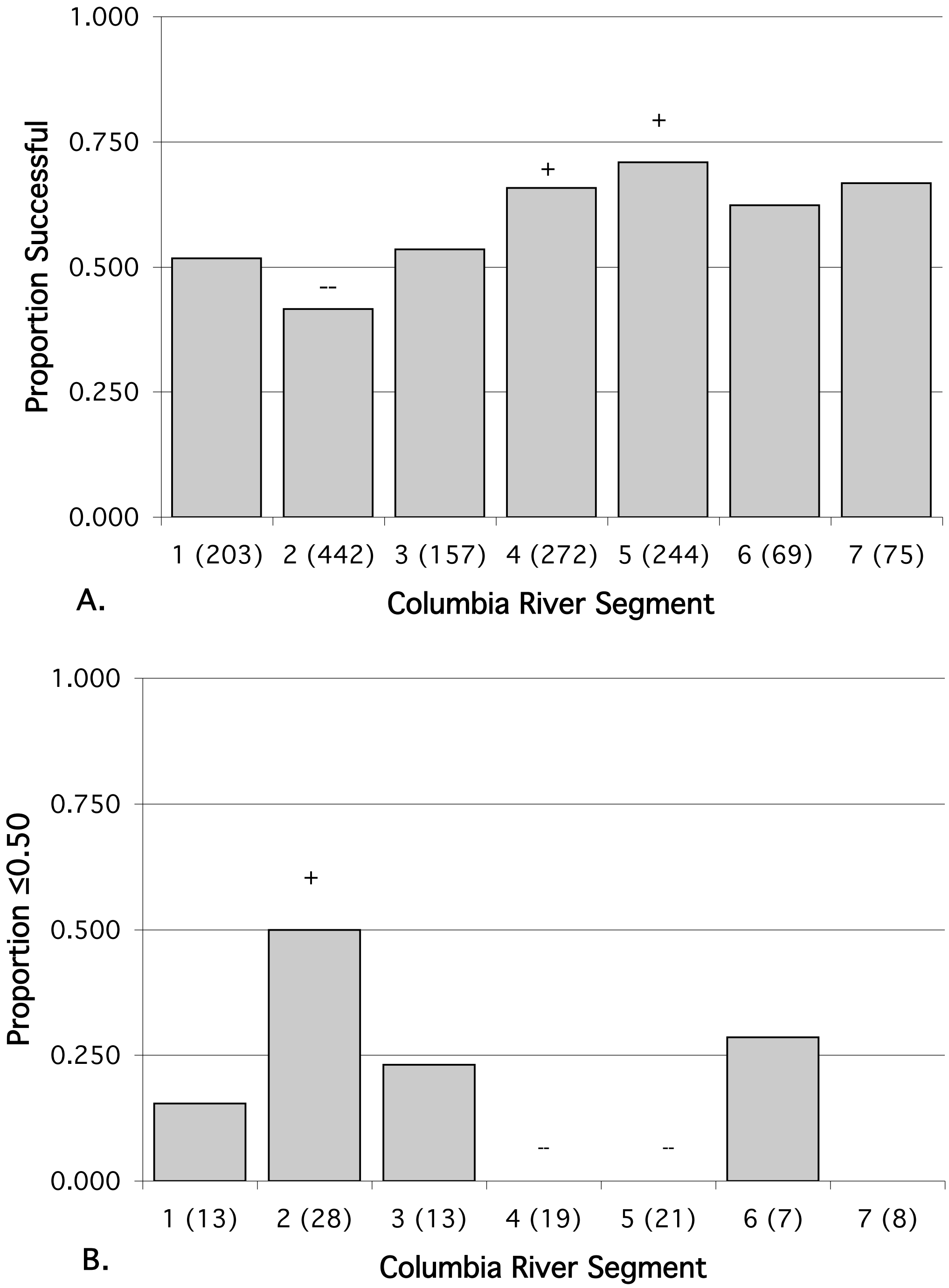


Figure 25. Nesting success (A.) and proportion of breeding areas with ≥5 years occupation with known outcome and productivity ≤0.50 (B.) by Columbia River segment, 1971-2007. Segment 1 = river miles 0-13 (0-21 km), 2 = miles 13-31 (21-50 km), 3 = miles 31-47 (50-76 km), 4 = miles 47-86 (76-138 km), 5 = miles 86-106 (138-171 km), 6 = miles 106-146 (171-235 km), and 7 = miles 146-309 (235-497 km). Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

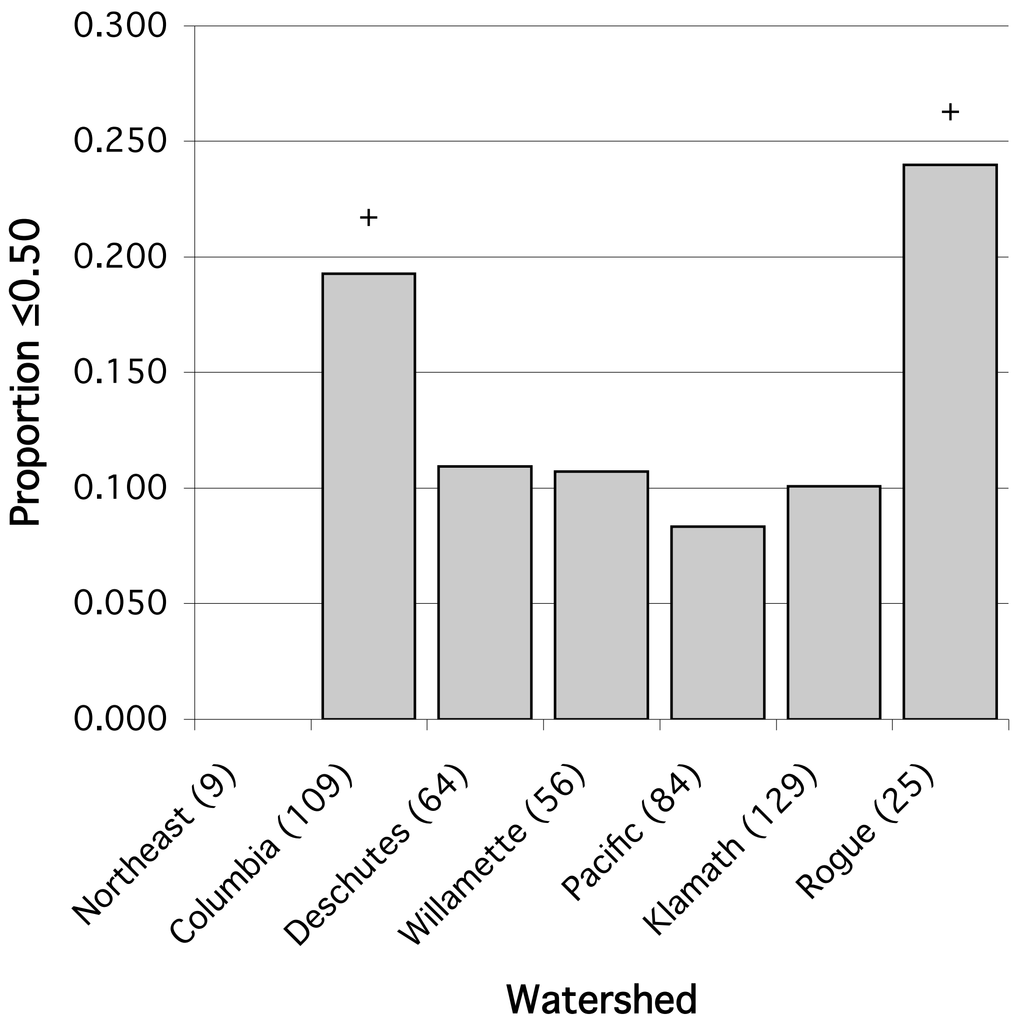


Figure 26. Proportion of breeding areas with ≥5 years occupation with known outcome and productivity ≤0.50 by watershed, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

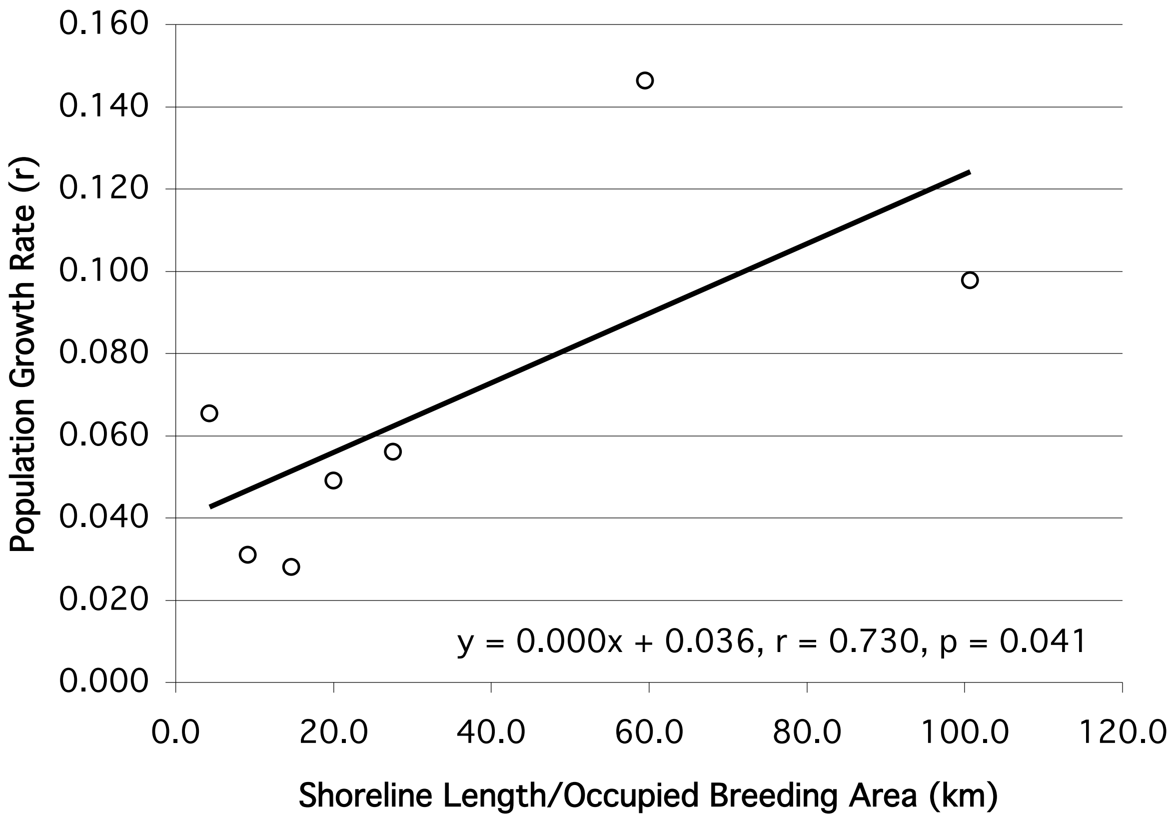


Figure 27. Population growth rate (r) (y axis) relative to initial length of shoreline or river length/occupied bald eagle breeding area (x axis) for seven water bodies in Oregon and along the Washington side of the Columbia River, 1978-2007. Shoreline or river length was the average length/occupied breeding area during the start year of the period for which population growth was calculated.

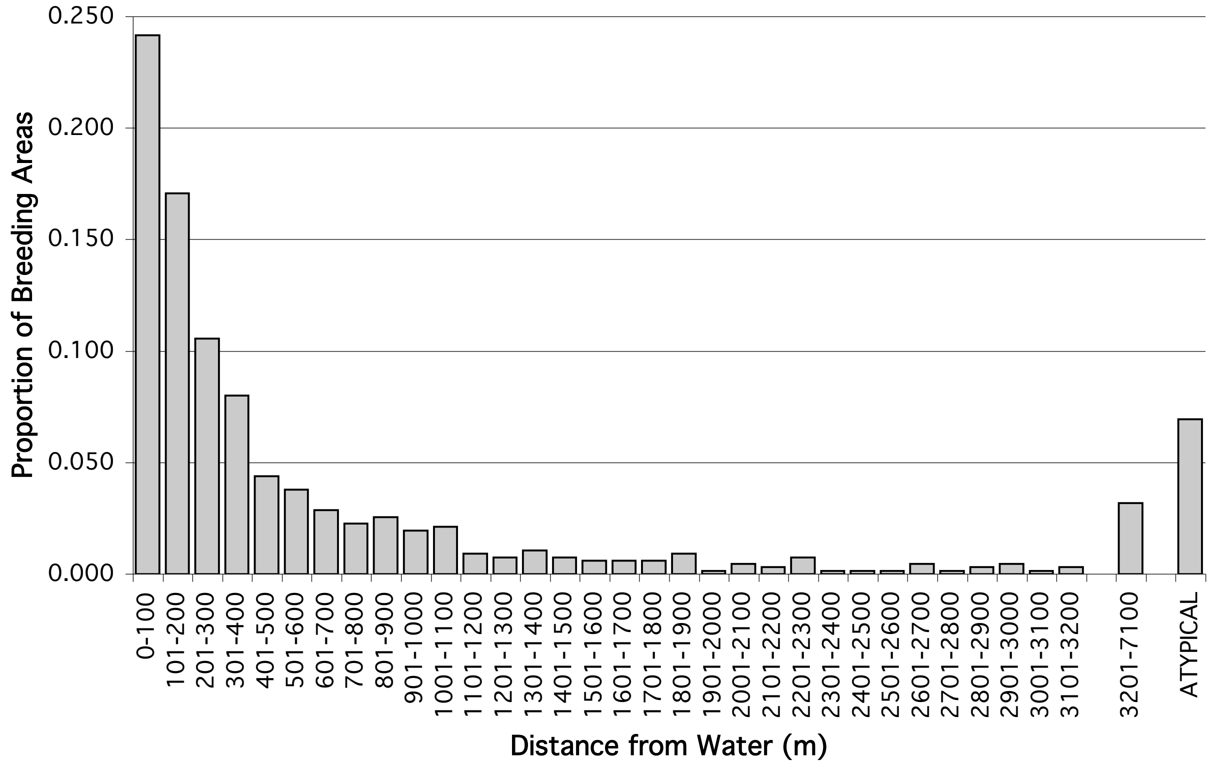


Figure 28. Distance of breeding areas of bald eagles (n = 662) from the nearest mean high water line of the nearest permanent aquatic habitat in Oregon and along the Washington side of the Columbia River, 1971-2007. Distance was measured from the most recently used nest tree in each breeding area as of 2007. The atypical category included sites where aquatic habitat was distant, dispersed, intermittent, or nonexistent and hunting area was unknown.

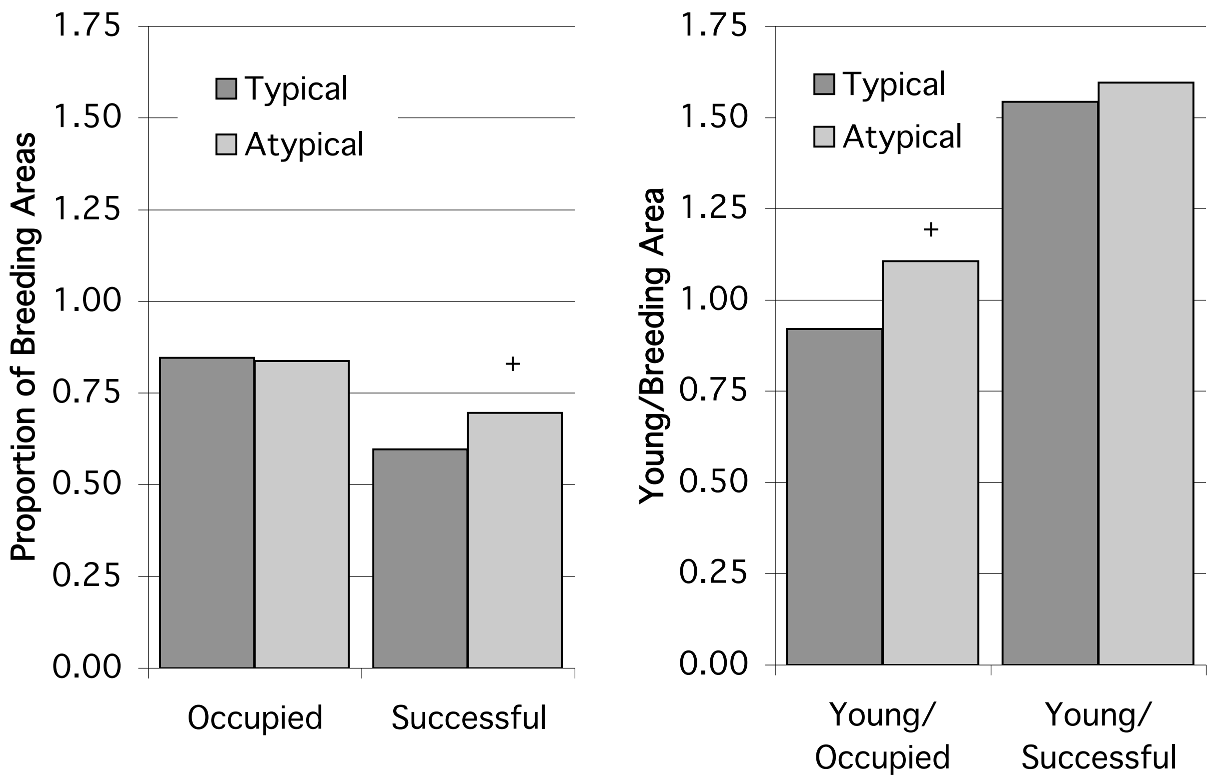


Figure 29. Nest survey results for breeding areas of bald eagles associated with permanent aquatic habitat features that were known hunting areas (Typical, n = 30 years) vs. breeding areas where hunting areas were distant, dispersed, intermittent, or unknown (Atypical, n = 28 years) in Oregon and along the Washington side of the Columbia River, 1978-2007. Raw data for Typical breeding areas were 8,624 surveyed, 7,176 occupied with known outcome, 4,389 successful, and 6,869 young; and for Atypical were 629, 520, 354, and 570, respectively. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.05$).

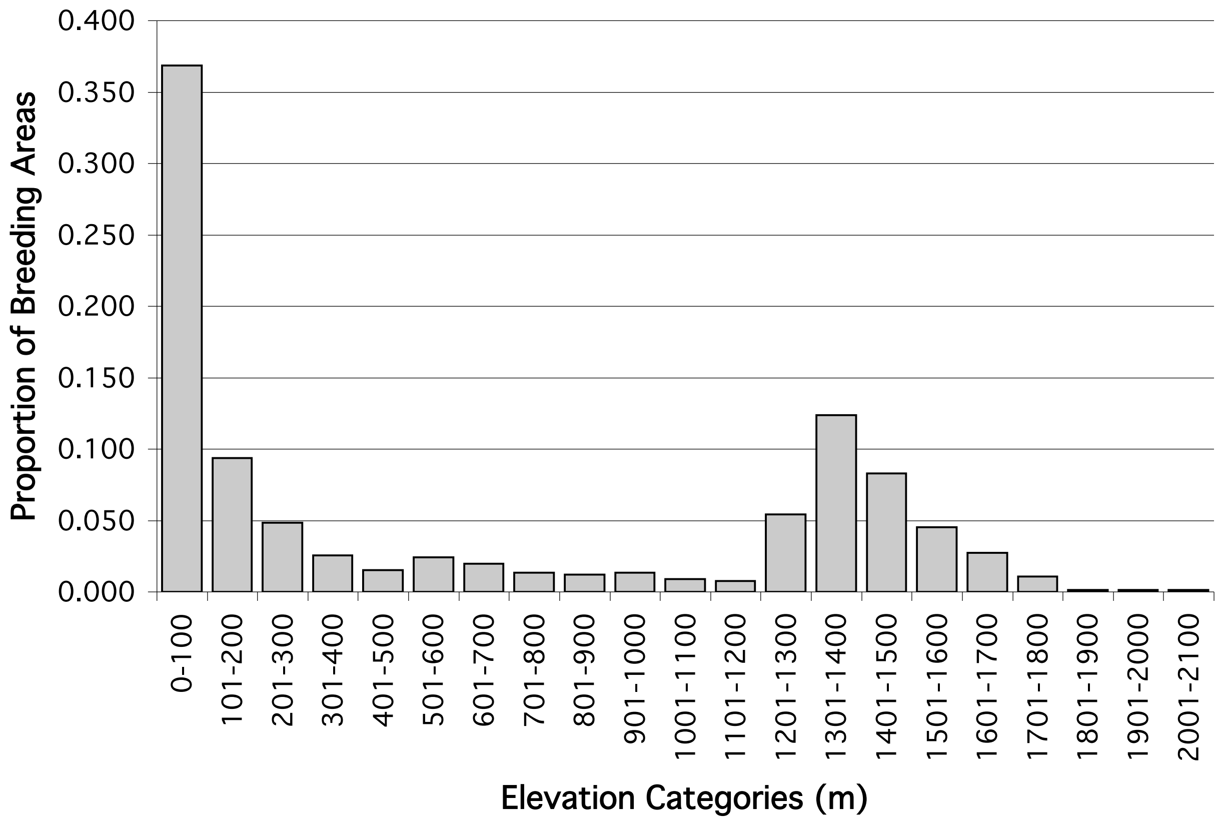


Figure 30. Distribution of breeding areas of bald eagles (n = 662) by elevation in Oregon and along the Washington side of the Columbia River, 1971-2007. Elevation was based on the topographic location of the most recently used nest tree in the breeding area as of 2007.

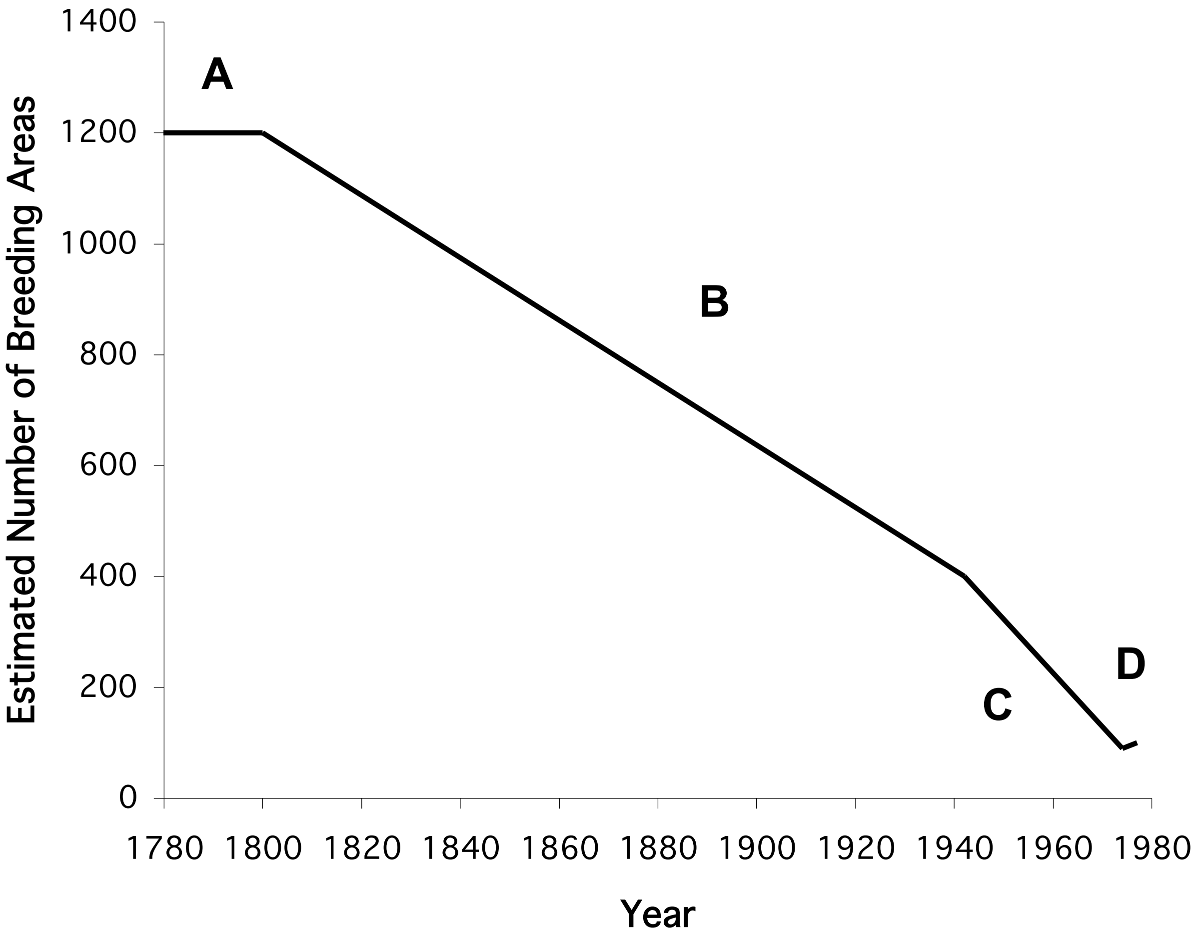


Figure 31. Hypothetical model of change in the number of breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, ≈1780 to ≈1980. A = circa 1800 estimate, B = decline due to direct persecution, habitat change, and prey depletion, C = decline due to direct persecution, habitat change, prey depletion, and chemical contamination, and D = nadir circa 1975.

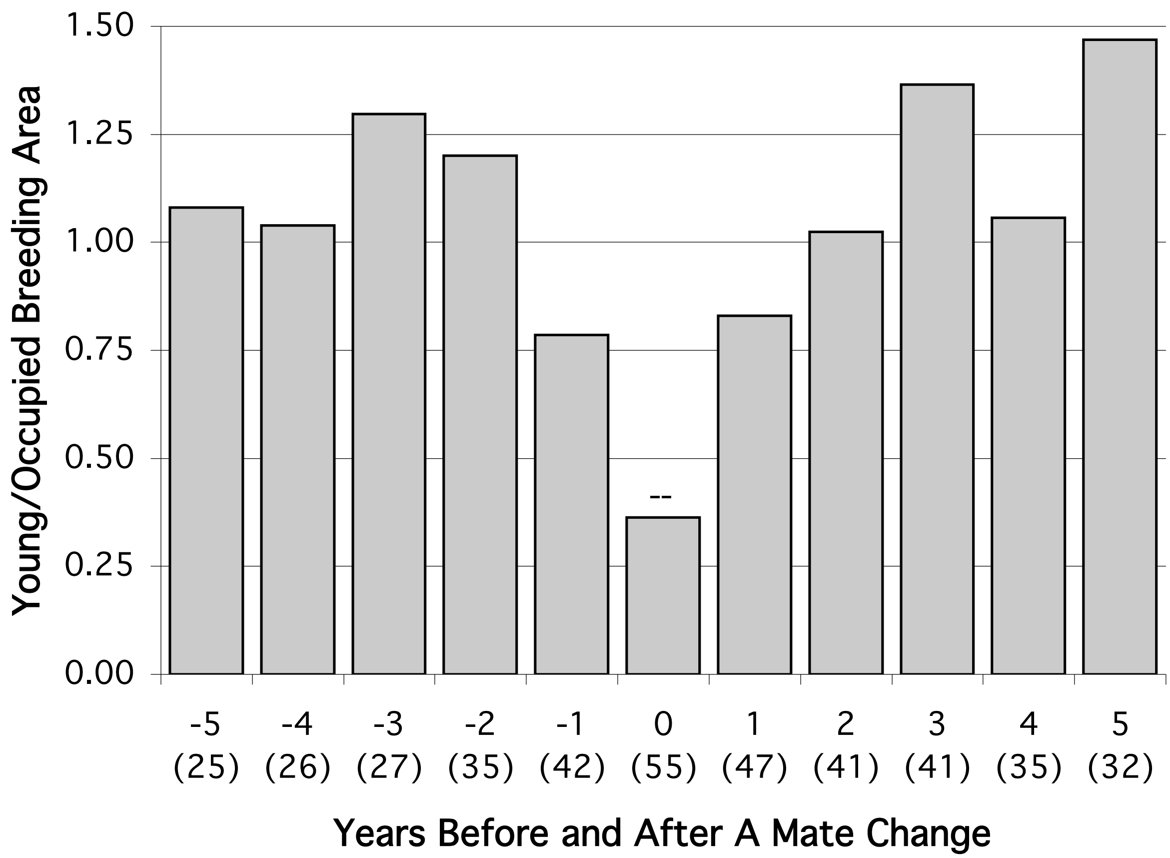


Figure 32. Productivity at breeding areas of bald eagles five years before, year of, and five years after mate changes in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.001$).

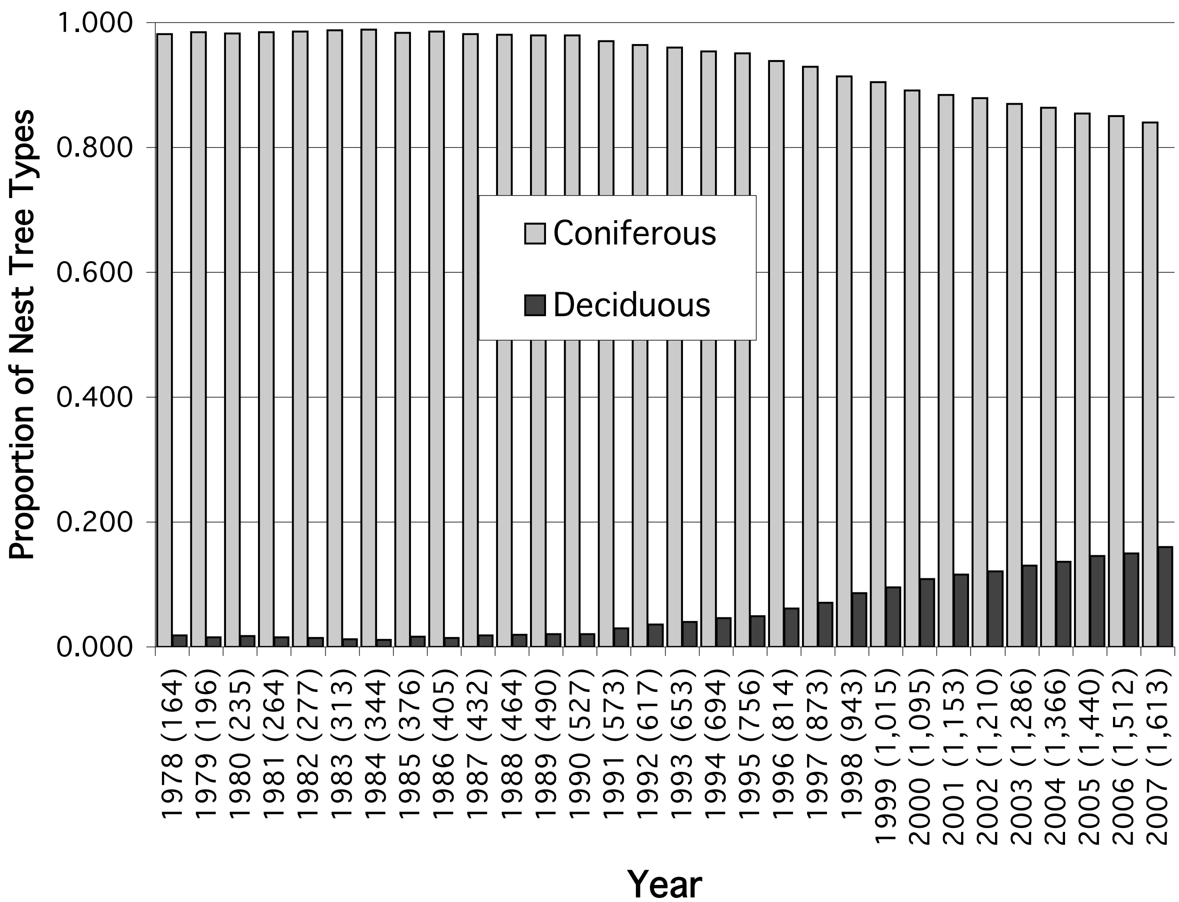


Figure 33. Proportions of coniferous and deciduous nest trees used by bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes.

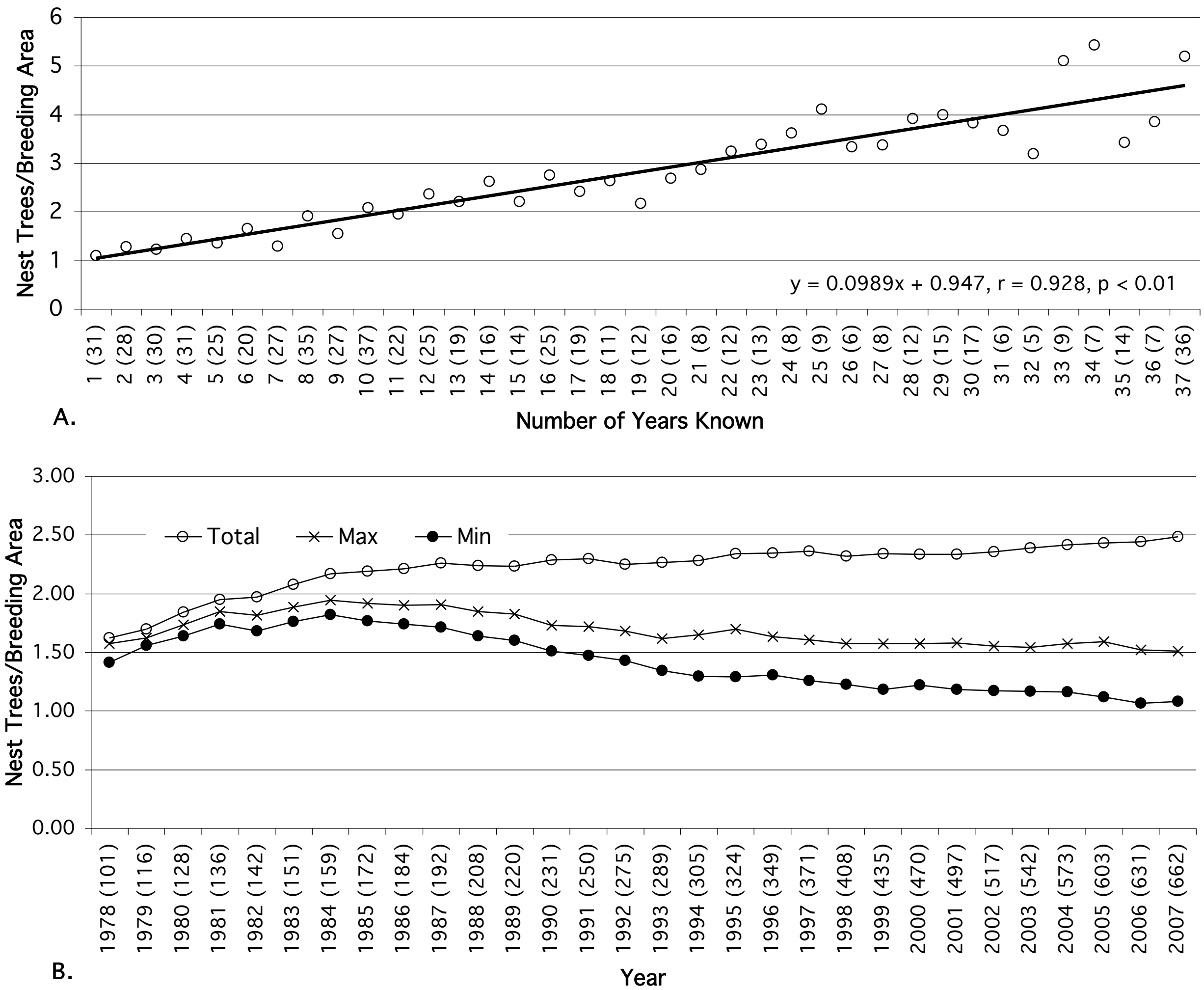


Figure 34. Average cumulative number of bald eagle nest trees/breeding area by number of years breeding areas were known, 1971-2007 (A.), and bald eagle nest trees/breeding area, 1978-2007 (B.), in Oregon and along the Washington side of the Columbia River. Min = nest trees/breeding area observed during the annual survey and known to hold nests; Max - Min = nest trees/breeding area that held nests when last observed but were not observed during the annual survey;
Total - Max = nest trees/breeding area that no longer held a nest when last observed. The actual number of nest trees/breeding area that held nests in a given year was between the Max and Min lines of Figure B. Numbers in parentheses are sample sizes.

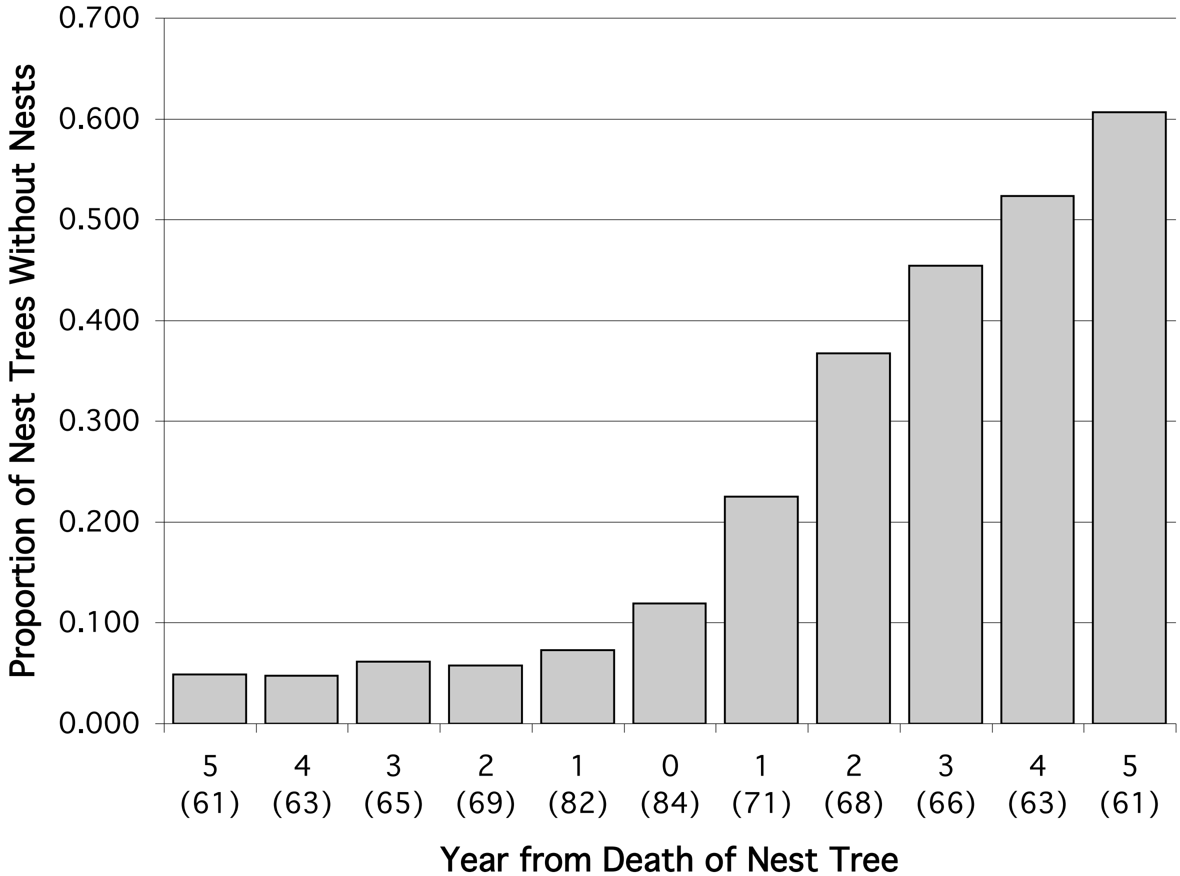


Figure 35. Loss of bald eagle nests from five years before to five years after nest tree death in Oregon and along the Washington side of the Columbia River, 1971-2007. Based on nesting histories of 84 nest trees that died while holding nests. Numbers in parentheses were sample sizes.

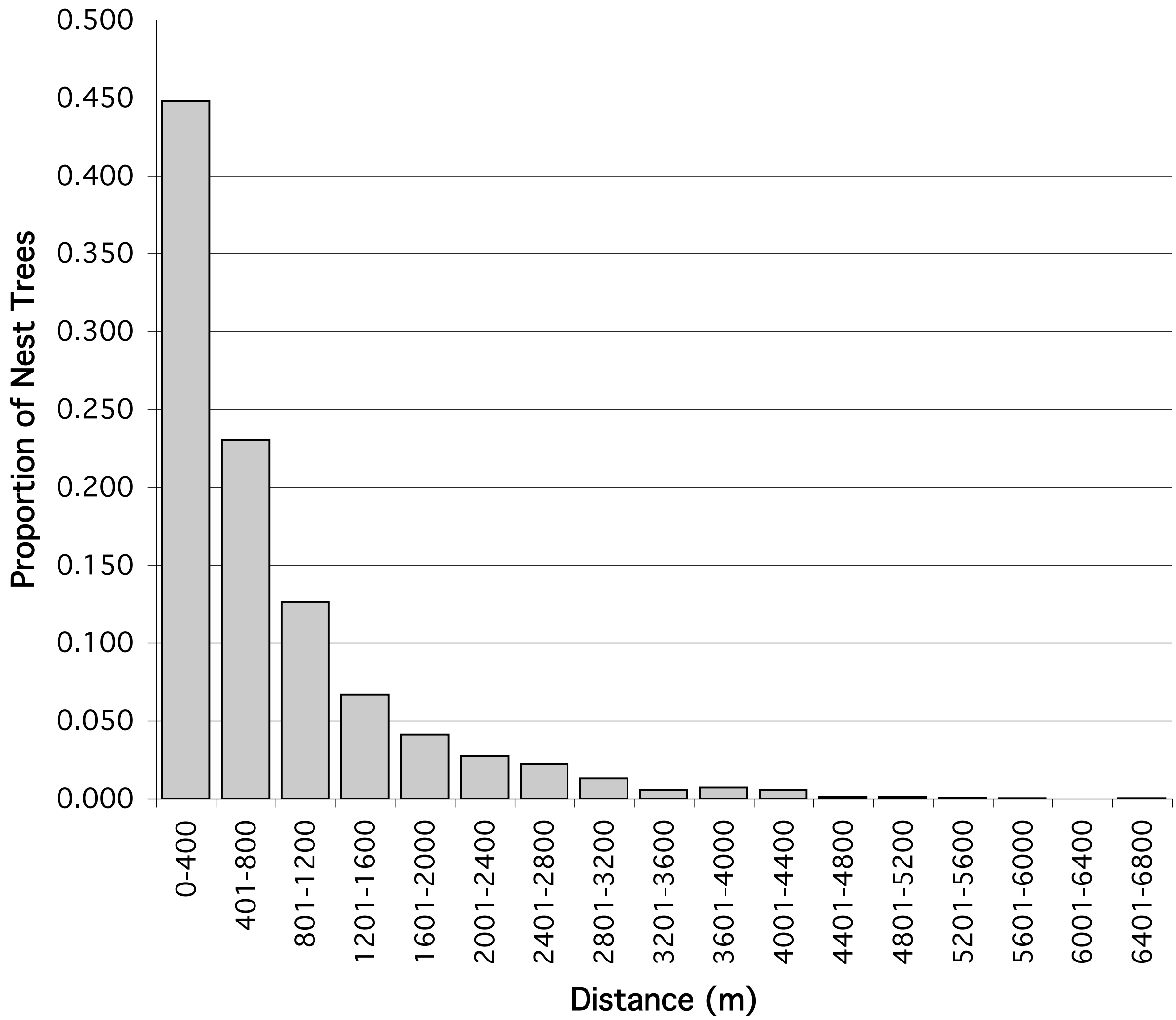


Figure 36. Distribution of distances between bald eagle nest trees within breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007 (n = 2,243 distances).

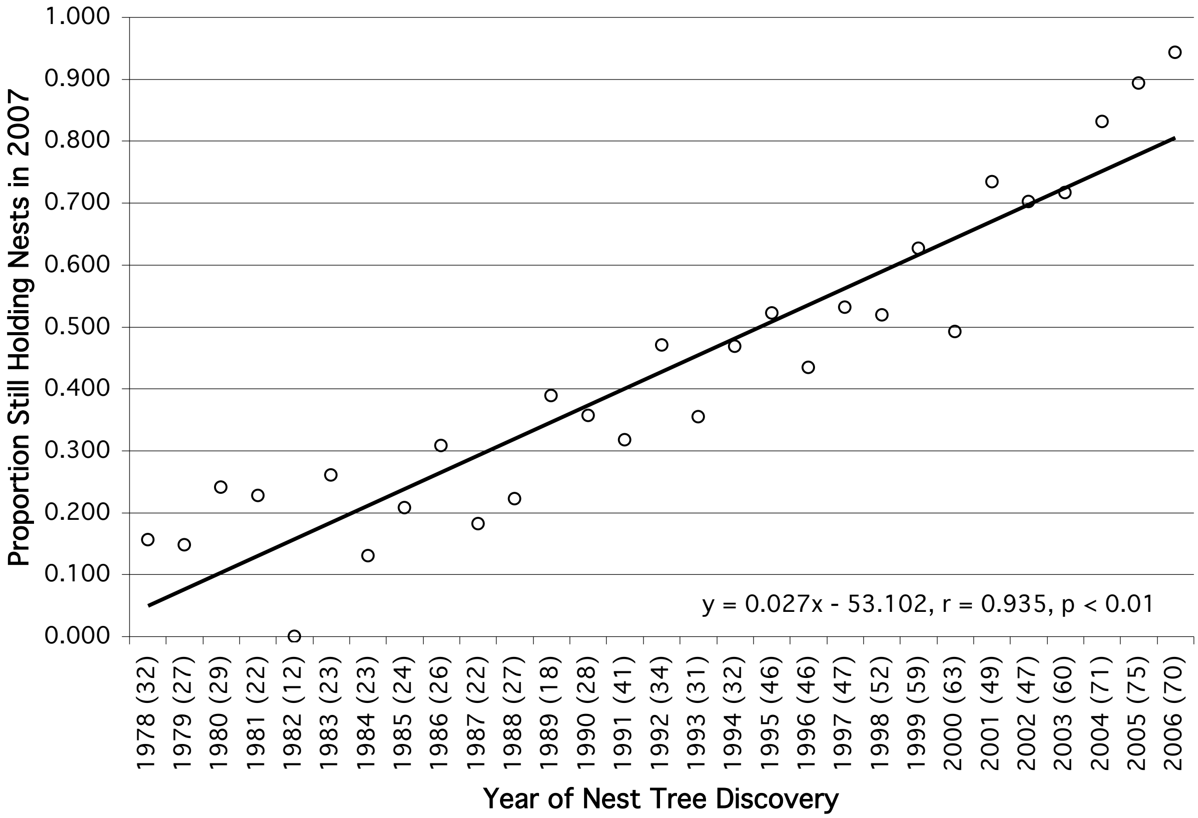


Figure 37. Proportion of nest trees of bald eagles still holding nests in 2007 by year discovered in Oregon and along the Washington side of the Columbia River, 1978-2007. Numbers in parentheses are sample sizes. Nest trees with uncertain nest status in 2007 were not included.

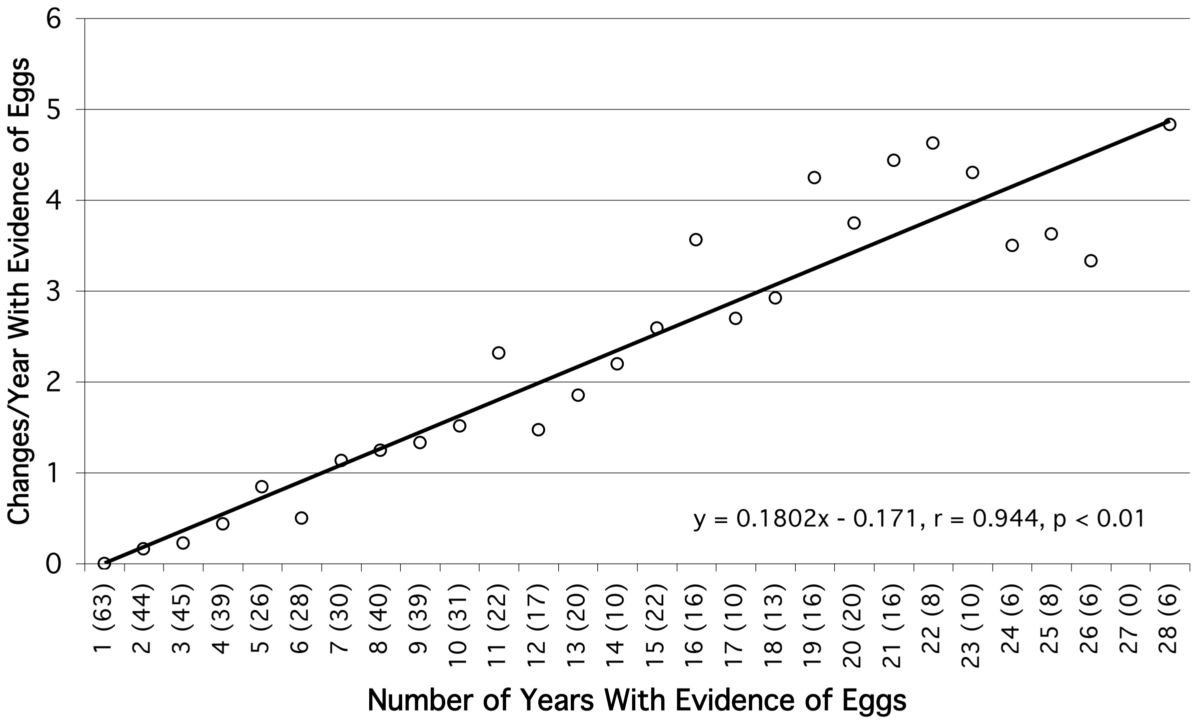


Figure 38. Relationship of the average number of nest tree changes/year occupied with evidence of eggs (y axis) to the number of years breeding areas were occupied with evidence of eggs (x axis) for 626 breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes.

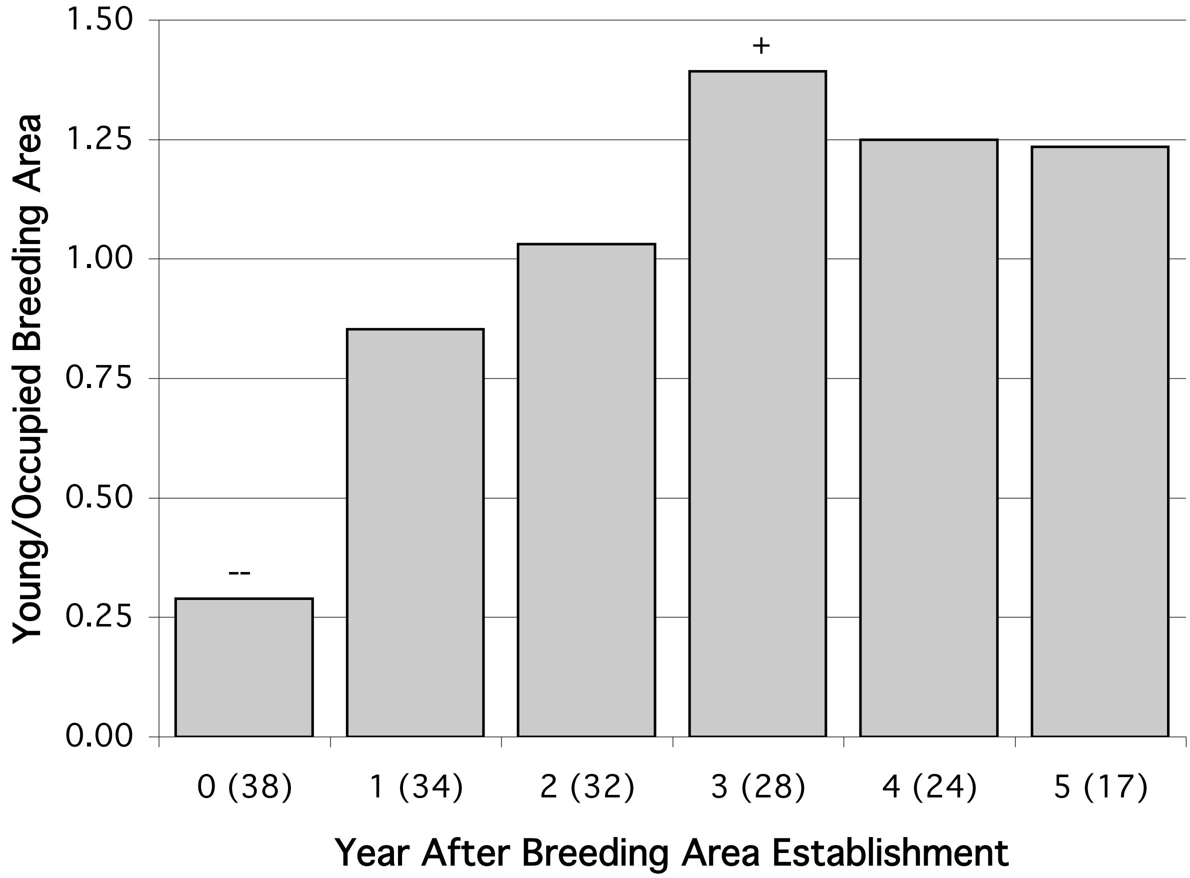


Figure 39. Productivity at bald eagle breeding areas during the year of establishment and for five years after in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes. Symbols above columns indicate if the frequency was more (+) or less (--) than expected ($p < 0.10$).

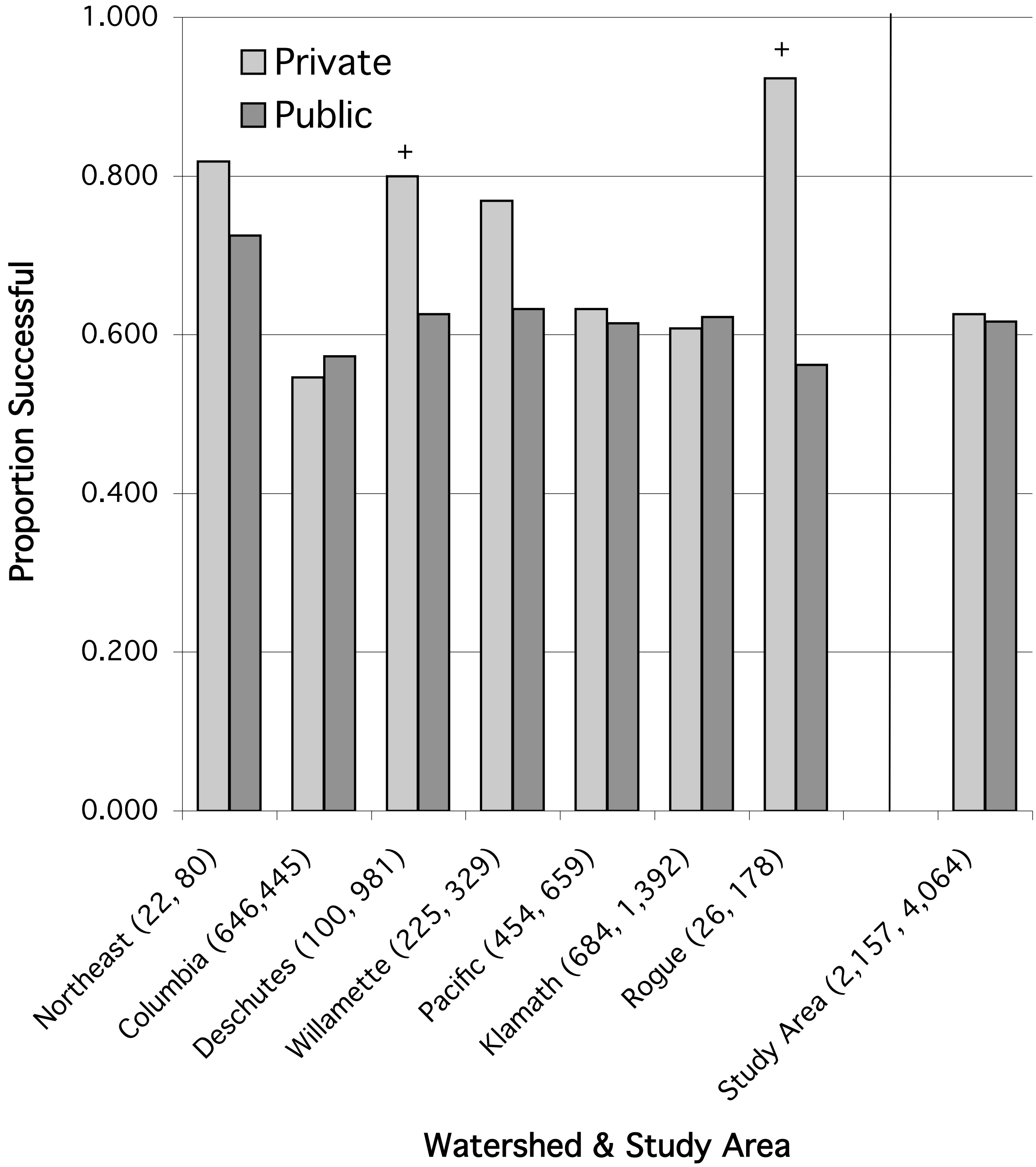


Figure 40. Nesting success at breeding areas of bald eagles with ≥5 years occupation with known outcome by watershed in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers in parentheses are sample sizes (private, public). Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected ($p < 0.05$).

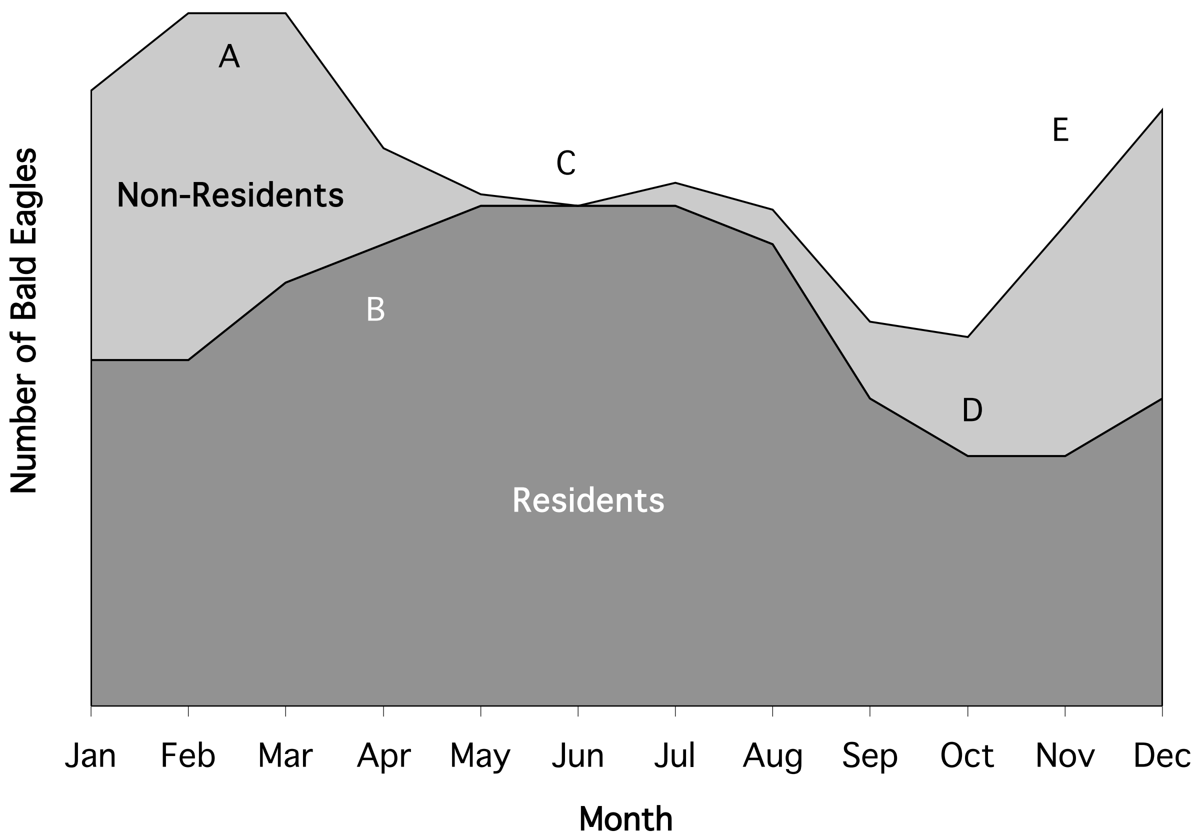


Figure 41. Model of monthly variation in the bald eagle population in Oregon and along the Washington side of the Columbia River. Resident eagles fledged from nests on the study area; non-residents fledged from nests in other western states and Canada. A = largest population of bald eagles because most residents were present, and non-residents were at their highest abundance. B = increase in residents because of annual production at breeding areas on the study area. C = low abundance of non-residents because most were at breeding areas in other western states or Canada. D = low eagle abundance because some residents had left the study area, and most non-residents had not arrived. E = increasing abundance because residents that had left the study area were returning, and non-residents were arriving.

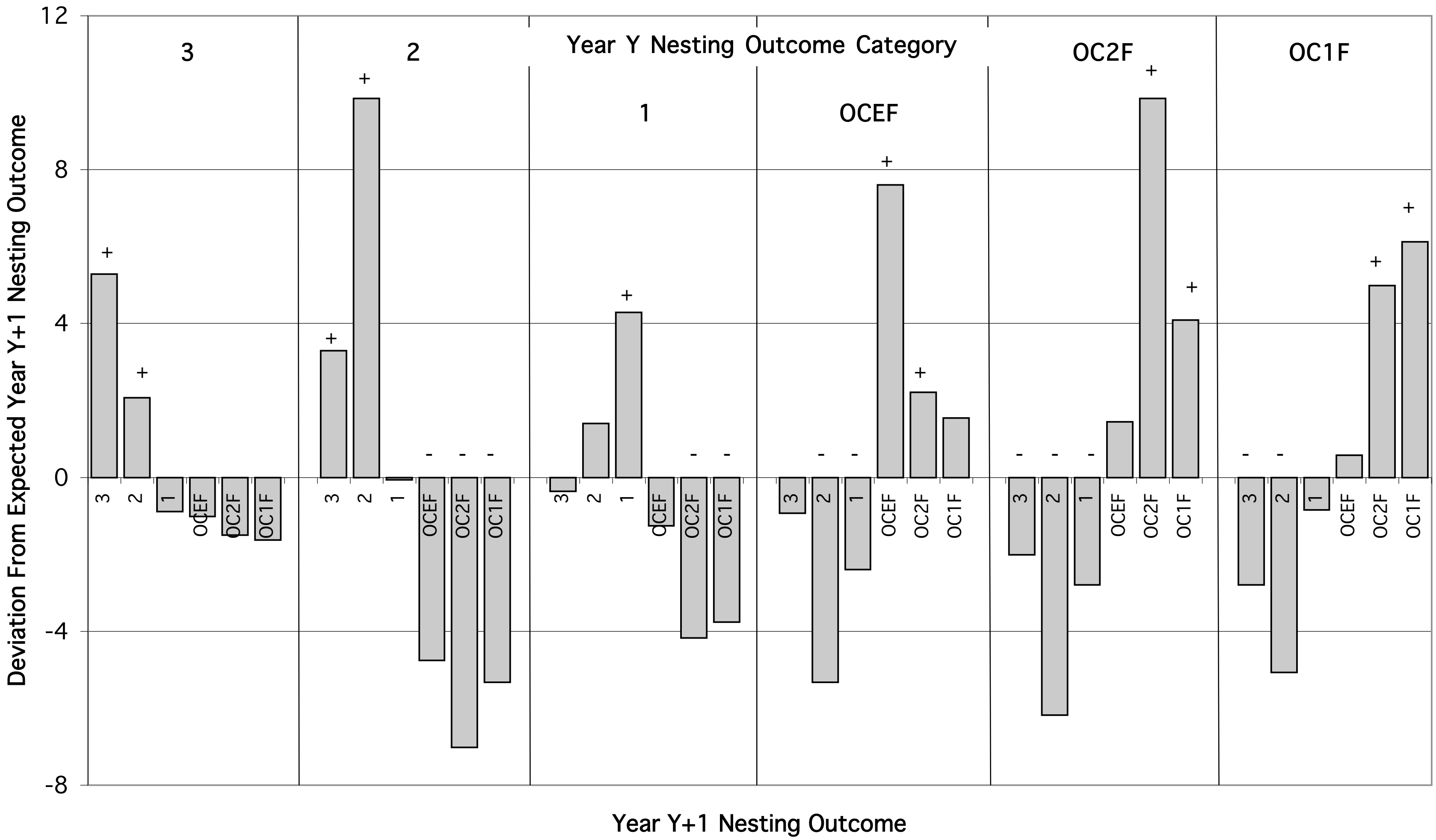


Figure 42. Deviation from expected year Y+1 nesting outcomes within six outcome categories for breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Outcome definitions: 3, 2 and 1 = 3, 2 and 1 eaglet(s) reported, respectively; OCEF = occupied with evidence of eggs and no eaglets; OC2F = occupied, 2 breeding age eagles and no evidence of eggs; and OC1F = occupied, 1 breeding age eagle and no evidence of eggs. Symbols above columns indicate if the frequency was significantly more (+) or less (--) than expected ($p < 0.05$).

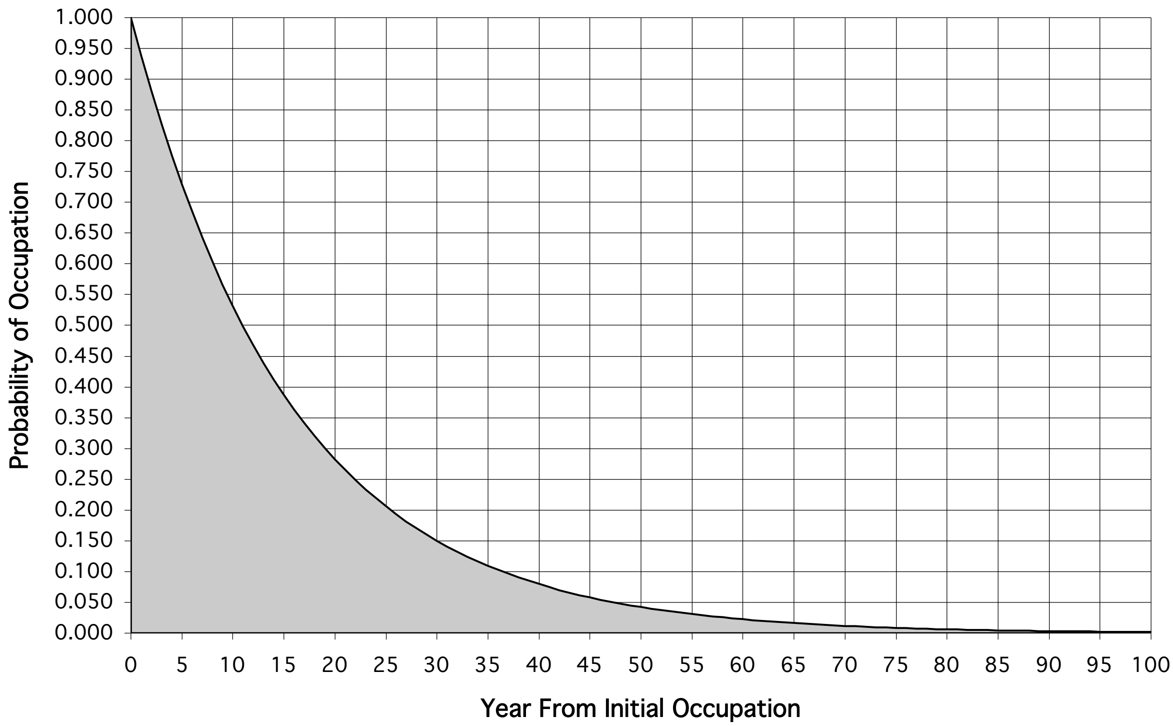
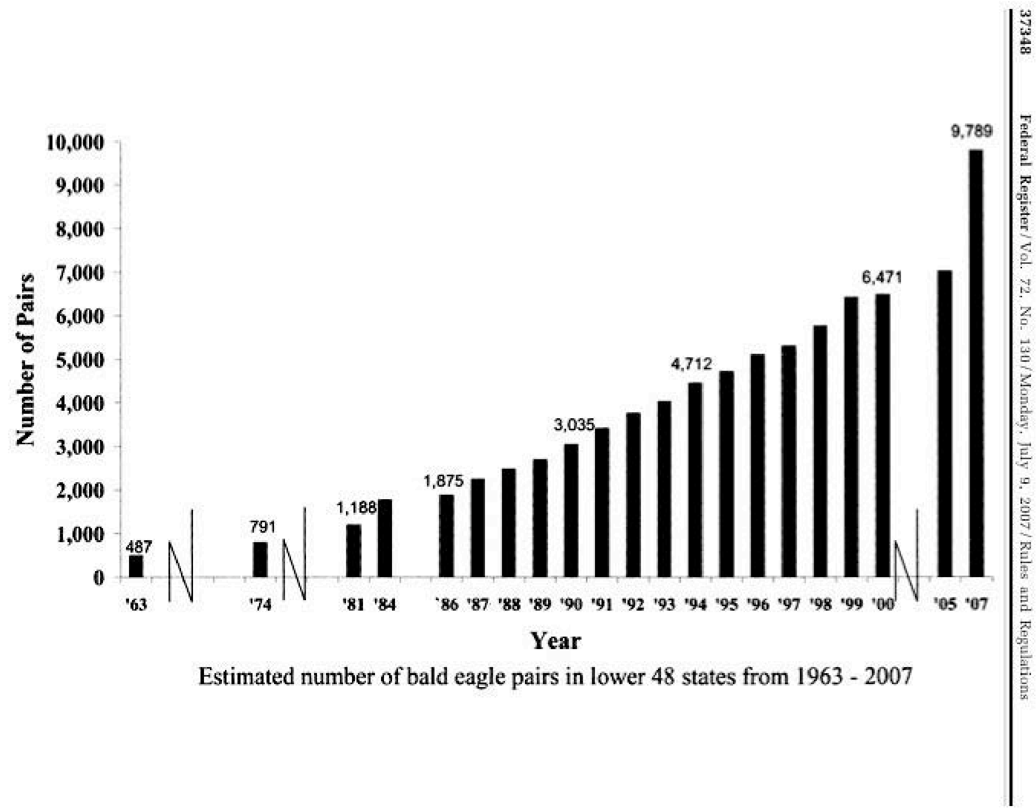


Figure 43. The probability that an occupied breeding area of bald eagles will remain occupied based on a 0.939 repeat rate for occupied breeding areas (n = 7,571) in Oregon and along the Washington side of the Columbia River, 1971-2007.

Figure 44. The probability that a breeding area of bald eagles with nesting success or failure will continue to succeed or fail over time based on 0.686 and 0.471 repeat rates for success (n = 4,498) and failure (n = 2,796), respectively, in Oregon and along the Washington side of the Columbia River, 1971-2007.

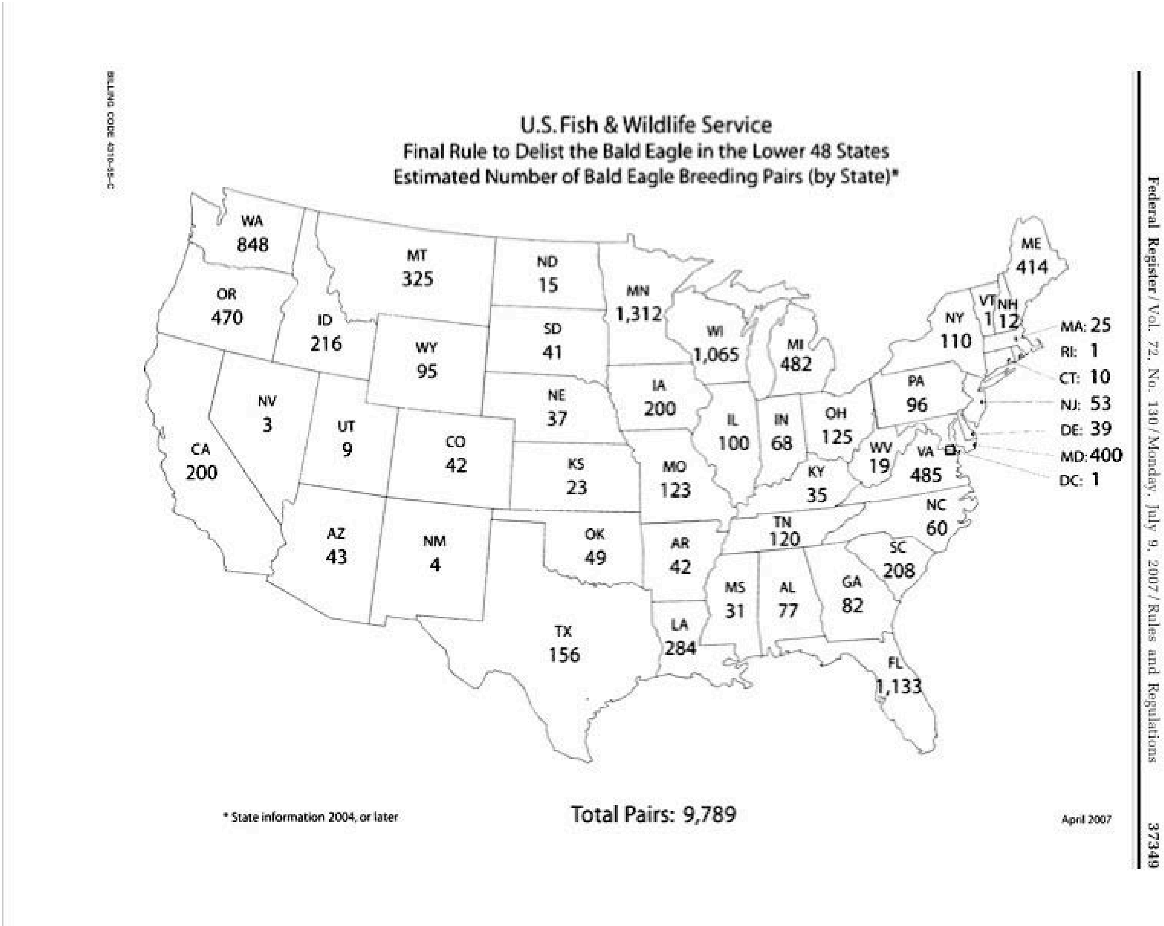
Appendix 1.



Estimated number of bald eagle pairs in lower 48 states from 1963 - 2007

Appendix 1. Estimates of the number of breeding pairs of bald eagles in the lower 48 United States, 1963-2007 (U.S. Department of the Interior 2007: 37,348).

Appendix 2.



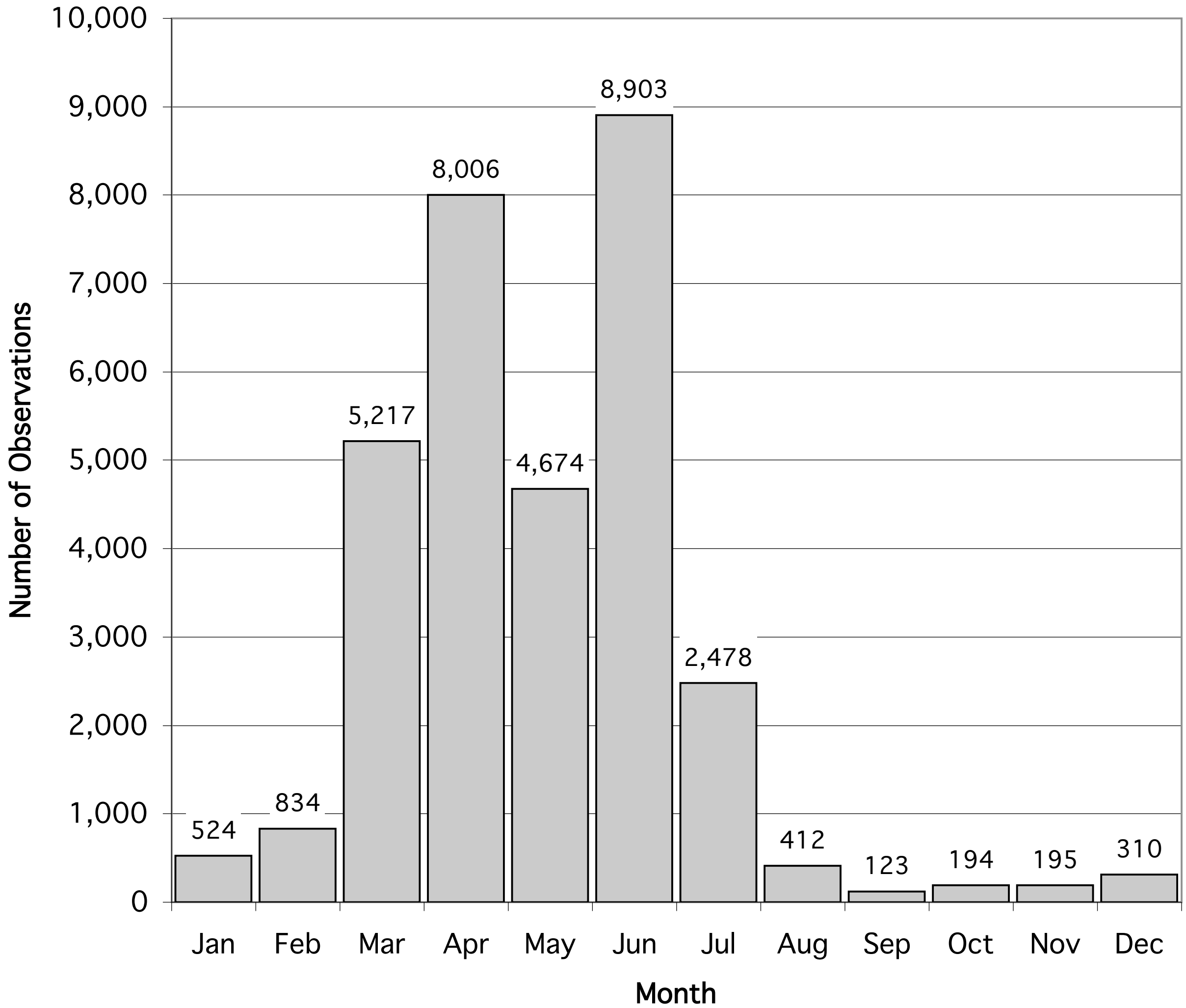
Appendix 2. Distribution of breeding pairs of bald eagles in the lower 48 United States based on state estimates, 2004-2007 (U.S. Department of the Interior 2007:37,349).

Appendix 3. Selected topics and corresponding references found in the Literature Cited section of this report on bald eagles in Oregon and along the Washington side of the Columbia River, 1978-2007.

Research Topic	Citation(s)	
Causes of nesting failure	Anthony et al. 1994	
Effects of human activity	Anthony and Isaacs 1989	McGarigal et al. 1991
Energetics and communal roosting	Keister et al. 1985	
Environmental contaminants	Frenzel and Anthony 1989 Buck et al. 2005	Anthony et al. 1993 Frenzel 1985
Food habits	Isaacs and Anthony 1987 DellaSala et al. 1989 Isaacs et al.1993 Marr et al. 1995 Frenzel 1985	Frenzel and Anthony 1989 Watson et al. 1991 Isaacs et al.1996 McShane et al. 1998
Habitat management	Anderson 1971 Arnett et al. 2001	Anderson 1985 Isaacs et al. 2005
Home range and habitat use	Garrett et al. 1993 Frenzel 1985	Frenzel 1988
Midwinter population 1979-1983	Opp 1979 Isaacs 2007	Opp 1980
Midwinter population 1988-2007	Isaacs 2007	Steenhof et al. 2002, 2008
Nest site characteristics	Anthony et al. 1982	Anthony and Isaacs 1989
Nesting population 1978-1982	Opp 1980	Isaacs et al. 1983
Population estimation	Anthony et al. 1999	
Roost site characteristics	Anthony et al. 1982 Isaacs and Anthony 1987 Isaacs et al.1996	Keister and Anthony 1983 Isaacs et al.1993
Site-specific Planning For Nest Sites	Popp no date	
Supplemental Feeding	Popp and Isaacs 1989	Bruner and Isaacs 1990
Time budgets	Watson et al. 1991	Popp 1992
Winter counts, habits, habitat, and communal roosting	Opp 1980 Keister et al.1987 DellaSala et al. 1989 Isaacs et al.1993 Tressler et al. 1999	Keister and Anthony 1983 Frenzel and Anthony 1989 Isaacs and Anthony 1987 Isaacs et al.1996 Fleischer 2005

Appendix 4. Watersheds and subdivisions based on recovery zones (U.S. Fish and Wildlife Service 1986).

Watershed	Geographic Areas Based On Recovery Zones
Northeast	09_1 = Wallowa R & Grande Ronde R 09_2 = Northeast Oregon other
Columbia	10_1o = Oregon side Columbia R Miles 0-13 10_1oY = Oregon side Columbia R Miles 0-13, Youngs R and Bay 10_2o = Oregon side Columbia R Miles 13-31 10_3o = Oregon side Columbia R Miles 31-47 10_4o = Oregon side Columbia R Miles 47-86 10_5o = Oregon side Columbia R Miles 86-102 10_6o = Oregon side Columbia R Miles 102-146 10_7o = Oregon side Columbia R Miles 146-313 10_1w = Washington side Columbia R Miles 0-13 10_2w = Washington side Columbia R Miles 13-31 10_3w = Washington side Columbia R Miles 31-47 10_4w = Washington side Columbia R Miles 47-86 10_5w = Washington side Columbia R Miles 86-102 10_6w = Washington side Columbia R Miles 102-146 10_7w = Washington side Columbia R Miles 146-313
Deschutes	11_1a = Deschutes R, Odell L 11_1b = Deschutes R, Crescent L 11_1c = Deschutes R, Davis L 11_1d = Deschutes R, Wickiup Res 11_1e = Deschutes R, Crane Pr Res 11_1f = Deschutes R above Crane Pr Res 11_1g = Deschutes R below Wickiup Res 11_1h = Deschutes R other 11_2a = Deschutes R, Bend to L Billy Chinook 11_2b = Deschutes R, L Billy Chinook 11_2c = Deschutes R below L Billy Chinook 11_3 = Crooked R and Awbrey Mountain
Willamette	12_1 = Willamette R corridor 12_2a = Coast and Middle Fork Willamette R 12_2b = McKenzie R 12_2c = Santiam R 12_2d = Tualatin R 12_2e = Clackamas R 12_2f = Sandy R 12_2g = Willamette and Sandy R other
Pacific	13_1 = Coast north of the Siuslaw R basin 13_2 = Coast, Siuslaw R basin and south, including Humbug Mountain 13_3a = Umpqua R main-stem corridor 13_3b = Umpqua R, Smith R 13_3c = Umpqua R, North Umpqua R 13_3d = Umpqua R, South Umpqua R
Snake	14_1 = Snake River
Harney	21_1 = Harney Basin and Warner Mountains
Klamath	22_1a = Upper Klamath Lake, all but Spence Mt-Eagle Ridge group 22_1b = Upper Klamath Lake, Spence Mt-Eagle Ridge group 22_2a = Klamath Basin other 22_2b = Klamath Basin, Williamson R 22_2c = Klamath Basin, Sprague R 22_2d = Klamath Basin, Gerber Res 22_2e = Klamath Basin, Lost R 22_2f = Klamath Basin, Klamath R 22_3a = Fort Rock and Summer L 22_3b = Goose L
Rogue	23_1a = Rogue R downstream of Grants Pass 23_1b = Rogue R upstream of Grants Pass 23_2 = Rogue R Basin lakes and reservoirs
Owyhee	37_1 = Malheur R [no sites reported as of 2007] 37_2 = Owyhee R [no sites reported as of 2007]



Appendix 5. Timing of 31,870 observations of bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers are the total number of observations for the month.

Appendix 6. Monitoring protocol and reporting guide supplied to cooperators prior to the 2007 nesting season for surveying breeding areas of bald eagles in Oregon and along the Washington side of the Columbia River.

OBSERVATIONS AT BALD EAGLE NEST SITES IN OREGON: MONITORING PROTOCOL & REPORTING GUIDE
2/12/07

Dear Cooperator -

Following is information on protocol and reporting for the bald eagle nest survey in Oregon. It has six sections: 1) INTRODUCTION, 2) PROTOCOL, 3) REPORTING, 4) EXAMPLES OF REPORTS, 5) WHERE TO SEND REPORTS, and 6) RELEVANT LITERATURE. Please send questions or comments on the survey, and suggestions for improvements to Frank Isaacs <isaacsf@onid.orst.edu>.

1) INTRODUCTION

Nesting season is underway and its time to begin monitoring bald eagle breeding areas. The goal of this project is to determine the outcome of nesting at every breeding area monitored. The following information will help you plan and report your monitoring efforts. If you have committed to monitoring a site but find that you won't be able to complete the task, please notify Frank as soon as possible so that arrangements can be made to get the site covered before the end of the breeding season.

Some thoughts on attitude and approach:
The bald eagle nesting population in Oregon has been increasing and the distribution of nest sites has been expanding for 30+ years. It is rare for a breeding area to not be occupied by at least one adult bald eagle.

There are two sources of error that observers should be aware of and try to keep at a minimum:

Error 1 is concluding that a breeding area is unoccupied after minimal survey effort. What we perceive as a failure by bald eagles to occupy a site is more likely a failure of the observer to find the eagles. If eagles are not found on the first visit then follow-up visits are necessary. If all known nests in a breeding area appear to be unused, then a search for a new nest is warranted. Fresh material will usually be present on the edge of the nest in use.

Error 2 occurs when trying to determine the number of eaglets on a nest. Eaglets can be out of view for long periods of time. Minimal survey effort can result in nests with young being classified as failures, or only one eaglet being counted where there are actually two or three.

If no chicks are immediately visible on a nest, look for evidence of young. White feces on the tree trunk or limbs adjacent to the nest surface may indicate the presence of unseen young. Eaglets defecate over the edge of the nest and much of the feces ends up on tree trunk and branches. Down feathers stuck to sticks on and around the nest surface also might indicate there are young present. If you see either of those clues, suspect young and spend more time observing. If you see one chick on a nest and don't have a clear view of the nest surface, then suspect two or three chicks, and wait until an adult visits the nest with prey before concluding there is just one chick. Upon arrival of an adult a second, or even two more chicks may stand or move into view. The extra time spent observing the nest will often be rewarded with interesting eagle action that would otherwise be missed.

Thanks for helping with this project and have fun watching eagles!

2) PROTOCOL

NESTS SHOULD BE OBSERVED FROM A DISTANT LOCATION THAT DOES NOT DISTURB THE EAGLES. WE RECOMMEND OBSERVING WITH A SPOTTING SCOPE FROM A DISTANCE GREATER THAN 800 METERS (1/2 MILE), BUT REALIZE THAT YOU MAY NEED TO BE CLOSER. IF YOU DISTURB AN EAGLE, THEN LEAVE THE AREA.

DO NOT TRESPASS; ALWAYS GET PERMISSION BEFORE ENTERING PRIVATE PROPERTY!

OUR OBJECTIVE IS TO DETERMINE THE OUTCOME OF NESTING FOR EVERY PAIR OF BALD EAGLES IN OREGON, AND ALONG THE WASHINGTON SIDE OF THE COLUMBIA RIVER. This requires at least 2 visits to nest sites at strategic times during the breeding season, which lasts from January through August. We realize that some of you observe nest sites outside the breeding season, and we welcome reports for September through December even when no eagles are observed, because they help fill in gaps in our knowledge of bald eagle use of nest sites during that period.

The goal of the first monitoring session is to determine if a breeding area is occupied, the second session is conducted to determine the outcome of nesting. MORE THAN TWO VISITS MAY BE REQUIRED TO DETERMINE NESTING OUTCOME.

THE BEST TIMING FOR THE FIRST MONITORING SESSION IS LATE MARCH OR EARLY APRIL. If no eagles are observed during that visit, the breeding area should be checked weekly until one or more adult bald eagles are observed, or 15 May, whichever comes first.

THE SECOND MONITORING SESSION SHOULD BE WITHIN A WEEK OF 1 JUNE. If mostly-feathered nestlings are observed; i.e., stage 3b or older (Carpenter 1990), and you are sure how many there are, or you are sure that the nesting attempt failed, no further visits are required. If the number of nestlings is uncertain, downy nestlings are observed (stage 3a or younger), or outcome is uncertain, additional monitoring is required. If nestlings are feathered and you need to verify the number of nestlings, then return within a few days. If outcome is uncertain, then return weekly until outcome is determined. If nestlings are downy during the late-May/early-June visit, then return in 4 weeks. Be aware that early nesting pairs may have eaglets that are at or near fledging on 1 June.

When conducting a monitoring session, assume it will take 2 hours to determine nest status. Usually it doesn't take that long, but its better to expect 2 hours and use 30 minutes than to think you will be done in a few minutes and then be disappointed for 2 hours. When looking for nestlings, assume there are nestlings and don't give up hope until you are certain none are present; it can take 2 or more hours or return visits to be positive. At places where nests are easy to observe, short monitoring sessions weekly or every two weeks are as effective as two long sessions.

PLEASE SEND A REPORT FOR EVERY DAY YOU OBSERVE A SITE. We realize that some of you observe sites almost daily, and will only send reports for significant events such as nest building, start of incubation, hatching, nesting outcome determined, fledging, etc. The goal is to determine the number of feathered nestlings. Fledging dates are not essential, but provide valuable information and should be reported when known.

The earliest nesting pairs begin incubating in mid February; late nesters begin incubating in late April. Egg laying has not been observed after 1 May. If a nest is not being used by 15 May, it will probably not be used that season. If you know that a pair are unusually early or late nesters, adjust your observation schedule accordingly.

Age of young should be described following the attached aging guide from Carpenter (1990).

3) REPORTING

THERE ARE NO FORMS, JUST SEND COPIES OF FIELD NOTES OR WRITTEN SUMMARIES OF YOUR OBSERVATIONS THAT INCLUDE THE INFORMATION DESCRIBED BELOW.

FIELD NOTES OR WRITTEN SUMMARIES OF OBSERVATIONS have provided the best descriptions of bald eagle nesting activities during this study. They can be submitted a variety of ways (e-mail, US mail, or phone voice message), can follow a variety of formats or writing styles, and can be as concise or extensive as needed. Abbreviations can be used, as long as the meanings are obvious.

THE GOAL OF EACH REPORT SHOULD BE TO ACCURATELY DESCRIBE WHAT WAS OBSERVED DURING A MONITORING SESSION.

Reports should contain the following information: Observer Name and Contact Information (if you send e-mail that is automatically included); Date of Monitoring Session; Site Name; Survey Method (if it is something other than viewing from the ground); Location of Observation Point; Number, Age Class, and Behavior of Each Bald Eagle Observed, including plumage stage of eaglets; Nest and Nest Tree Condition (if there has been a change); Observation Times; and Other Notes on anything that seems pertinent (other observers present, human activity that appears to be disturbing, weather that could have affected eagle behavior or the accuracy of the report, prey, eagle interactions with other species, etc.) For new nests, describe the nest, the nest tree, and the location of the new nest tree (send a detailed map if possible). If you use GPS coordinates to describe observation points or nest tree locations, then include the datum used (NAD27 or NAD83/WGS84). If you use compass bearings, indicate if they are based on magnetic north or true north.

Finally, If you don't want to change the way you have been submitting reports, then continue as you have done in the past and the information will still be used.

4) EXAMPLES OF REPORTS:

1/12/04 - 0830-0855 - Weatherly Cr. - Observed from the ODOT elevated pull off N of Hwy. 38 across the river from the nest stand. No eagles observed. The new nest from last year is present, but I'm too far to judge nest condition; no obvious new material. Visibility is reduced due to low clouds and rain.

3/18/04 - 1800-1805 - Melrose -Observed from Evelyn Lane, W of the nest stand. Upon arrival there were 4 BEs in flight above the nest stand; 2 adults, 1 adult or nearadult, and 1 subadult. 1 adult dropped to the nest, where it landed and settled into incubating position. The subadult was last observed flying SE and the other adult and adult-or-nearadult were flying close together, but I didn't follow them to see where they went.

4/13/04 - 1838-1844 - Ball Point - Observed from where Eagle Ridge Rd. leaves the shoreline and begins climbing towards Eagle Ridge Point. Located 1 nest with 1 adult present in incubating position. By map location, I assume the nest tree is 711. The nest is in a live co-dominant conifer and appears to be at or near the tree top. 1848 - Adult moving as if tending eggs or small young. 1851 - Both adults are on the nest, then 1 flew NW. 1852 - 1 adult still moving around on the nest.

4/27/04 - 1025-1032 - Potters -Observed this new nest tree from Sprague River Rd. between milepost 11 and the bridge. The nest tree has a manmade osprey platform on top; the nest is built on lateral branches below the platform. 1 adult perched on the platform. At least 2, plumage stage 1b-2, chicks active on the nest.

4/30/04 - 1030-1047- Bloody Point - Observed this site by walking into the open ponderosa pine stand W of the nest tree. First located 1 adult BE perched in a co-dom. snag, then found the nest with 1 adult BE perched on the nest rim. Could not see both birds from the same location. We flushed a RT Hawk from a nest near our observation point. That bird flew around calling and was joined by a 2nd RT Hawk. The Ad BE on the nest edge was also aware of our presence and watched us the entire time. 2nd Ad eventually arrived at the nest, then immediately flew when it saw us. Whitewash on a branch adjacent to the nest and adult behavior suggest there are small young present. NAD27 UTMs at the observation point = 615037e, 4758533n.

5/6/04 - 1740-1745 - Wallowa Lake - Observed from the Hwy. 82 pull off NE of the nest stand. 2 chicks active on the nest; one in stage 2 and one in stage 3a plumage. Three young men sitting on the riverbank approximately 100 feet from the nest tree smoking and drinking. No adult BEs observed as of 1750.

6/10/04 - 1325 - Recreation Creek - Observed from the road W of the nest tree. Two stage 3d chicks on the nest; one standing and one laying.

5) WHERE TO SEND REPORTS

AFTER EACH MONITORING SESSION, SUBMIT YOUR REPORT to Frank Isaacs using one of the following methods:

e-mail:
isaacsf@onid.orst.edu

US Mail:
Frank Isaacs
24178 Cardwell Hill Dr.
Philomath, OR 97370

Phone:
541-929-7154

Cell Phone:
541-231-1674

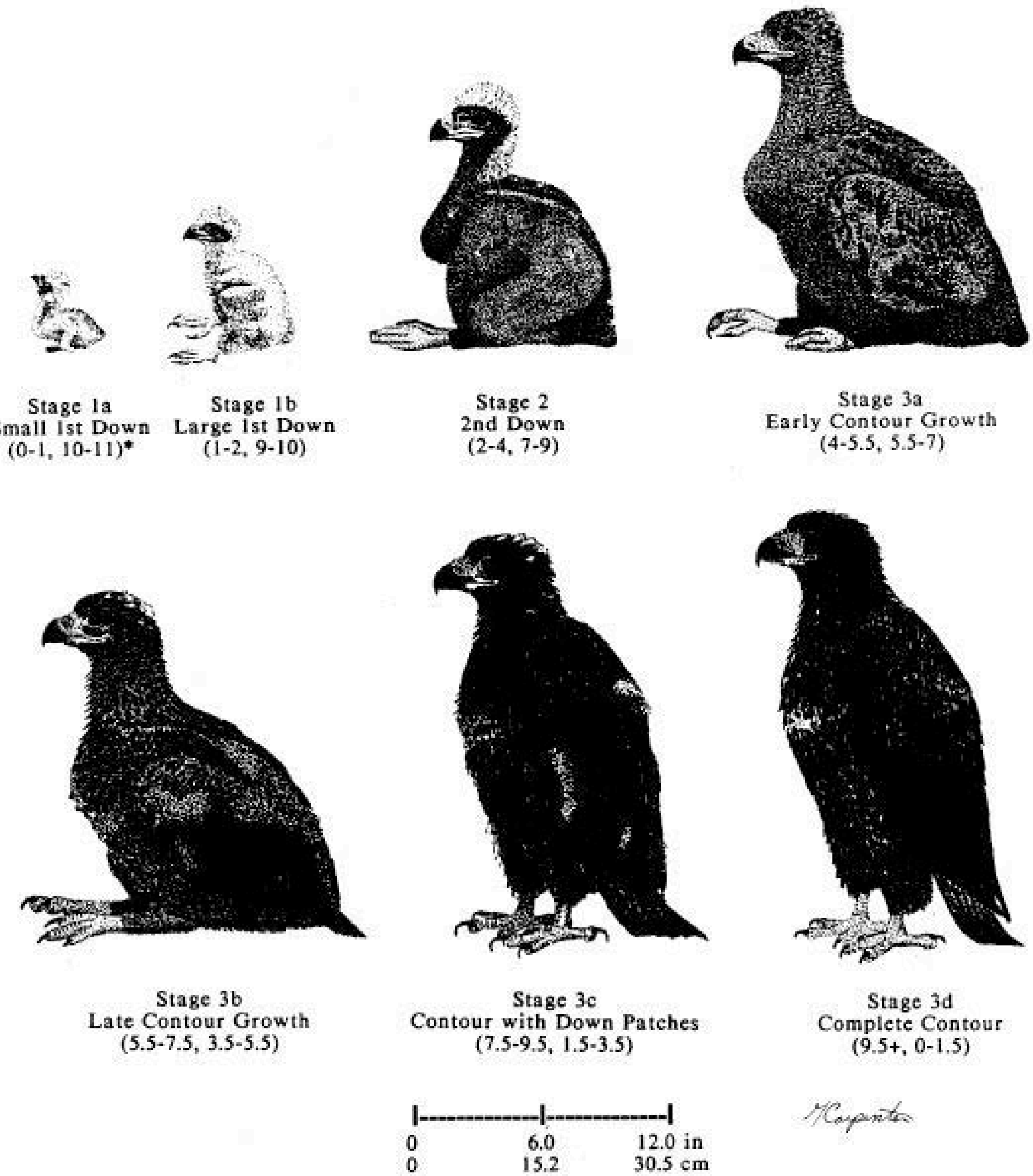
6) RELEVANT LITERATURE

CARPENTER, G.P. 1990. An illustrated guide for identifying developmental stages of bald eagle nestlings in the field. Final draft, April 1990. San Francisco Zoological Society, Sloat Blvd. at the Pacific Ocean, San Francisco, California 94132 (415-753-

7080).

ISAACS, F.B. and R.G. ANTHONY. 2007. Bald eagle nest locations and history of use in Oregon and the Washington portion of the Columbia River Recovery Zone, 1971 through 2006. Oregon Cooperative Fish and Wildlife Research Unit, Oregon State University, Corvallis, Oregon, USA.

MCCOLLOUGH, M.A. 1989. Molting sequence and aging of bald eagles. The Wilson Bulletin. 101:1-10.



* (approximate number of weeks since hatching, approximate number of weeks until fledging)

FROM: Carpenter, George P. 1990. An illustrated guide for identifying developmental stages of bald eagle nestlings in the field. Final draft, April 1990. San Francisco Zoological Society, San Francisco, CA 94132.

Appendix 7. Plumage classes of bald eagle nestlings.

Appendix 8. Dates of aerial surveys of bald eagle nests in Oregon and along the Washington side of the Columbia River, 1978-2007. NS = not surveyed. Coast flight included Umpqua River breeding areas, 1978-1989.

	Area					
Year	Columbia River	Coast	Willamette Basin	Cascade Lakes	Klamath Basin	Umpqua River
1978	27 & 28 April	27 & 28 April	NS	NS	2-May	NS
1978	8-Jun	8-Jun	NS	15 &19 June	19-Jun	NS
1979	26 & 27 April	26 & 27 April	NS	25-Apr	24-Apr	NS
1979	5 & 6 June	5 & 6 June	NS	8-Jun	7 & 8 June	NS
1980	2-Apr	2-Apr	NS	3 & 4 April	3-Apr	NS
1980	23 & 30 May	23 & 30 May	NS	5-Jun	4-Jun	NS
1981	30-Mar	30-Mar	NS	14-Apr	15-Apr	NS
1981	22-May	22-May	NS	3-Jun	4 & 5 June	NS
1982	10 & 11 March	10 & 11 March	NS	24-Mar	24 & 25 March	NS
1982	26-May	26-May	NS	3-Jun	4-Jun	NS
1983	24-Mar	24-Mar	NS	4-Apr	4 & 5 April	NS
1983	10 & 11 June	10 & 11 June	NS	13-Jun	13 & 14 June	NS
1984	27 March & 17 April	27 March & 17 April	NS	29-Mar	30-Mar	NS
1984	11, 12, & 13 June	11, 12, & 13 June	NS	21-Jun	20-Jun	NS
1985	25 & 29 March	25 & 29 March	NS	19-Mar	20-Mar	NS
1985	14, 17, & 24 June	14, 17, & 24 June	NS	19-Jun	19 & 20 June	NS
1986	(Garrett et al. 1988:15)	13-Mar	13-Mar	28-Mar	27-Mar	NS
1986	(Garrett et al. 1988:15)	10-Jun	5-Jun	5-Jun	5 & 6 June	NS
1987	3-Apr	25-Mar	25-Mar	26-Mar	26 & 27 March & 2 April	NS
1987	2-Jun	2 & 3 June	3 & 11 June	11-Jun	26 May, 11 & 12 June	NS
1988	2-Apr	1-Apr	1-Apr	8-Apr	2, 7, & 8 April	NS
1988	8-Jun	8 & 10 June	10 & 14 June	14-Jun	14, 15, & 17 June	NS
1989	8-Apr	7-Apr	7-Apr	10-Apr	5-Apr	NS
1989	7-Jun	6-Jun	6-Jun	12-Jun	8-Jun	NS
1990	NS	NS	NS	NS	10-Apr	NS
1990	15-Jun	14 June (N)	NS	NS	5-Jun	NS
1991	2-Apr	NS	NS	NS	3-Apr	NS
1991	24 & 25 June	5 June (N)	NS	NS	13-Jun	NS
1992	9, 13, & 20 April	12 April (N)	NS	NS	18-Apr	NS
1992	15 & 23 June	2 (N) & 4 June (S)	NS	NS	1-Jun	NS
1993	13-Apr	14 April (S)	NS	NS	5-Apr	NS
1993	9-Jun	8 (S) & 24 June (N)	NS	NS	2-Jun	NS
1994	14-Apr	11 April (S)	NS	NS	8-Apr	NS
1994	17-May	8 (S) & 10 June (N)	NS	NS	3-Jun	NS
1995	10-Apr	23-May	NS	NS	5-Apr	NS
1995	30 May, 11 July	7, 8 & 21 June (N)	NS	NS	9-Jun	NS
1996	5-Apr	25-May	NS	NS	3-Apr	NS
1996	19-Jun	4 & 18 (N), 5 & 11 June (S)	NS	NS	6-Jun	NS
1997	9-Apr	22-May	20-Mar	NS	2 & 3 April	NS
1997	23-Jun	10 &18 (S), 9 &19 June (N)	NS	NS	4-Jun	NS
1998	7-Apr	NS	11-Mar	NS	1-Apr	NS
1998	9-Jun	9 (S) &11 June (N)	27-May	NS	2-Jun	NS
1999	9-Apr	NS	23-Mar	NS	23 & 24 March	NS
1999	8-Jun	3 (N) & 9 June (S)	2-Jun	NS	2 & 3 June	NS
2000	4-Apr	NS	28-Mar	NS	28 & 29 March	NS
2000	13-Jun	8, 15 (S) & 16 June (N)	6-Jun	NS	6 & 7 June	8-Jun
2001	3-Apr	NS	26-Mar	NS	26 & 27 March	NS
2001	5-Jun	31 May (S), 6 & 7 June (N)	29-May	29-May	30-May	31-May
2002	2-Apr	NS	26-Mar	NS	26, 27 & 28 March	NS
2002	5-Jun	31 May (S), 3 June (N)	28-May	28-May	28, 29 & 30 May	31-May
2003	1-Apr	28 March (S)	25-Mar	NS	25, 26 & 27 March	28-Mar
2003	3-Jun	30 May (S), 9 June (N)	27-May	NS	27, 28 & 29 May	30-May
2004	6-Apr	NS	NS	NS	NS	NS
2004	1-Jun	NS	NS	NS	NS	NS
2005	5 April (OR) & 6 April (WA)	NS	NS	NS	NS	NS
2005	14 June (OR) & 15 June (WA)	NS	NS	NS	NS	NS
2006	21 March (OR) & 22 March (WA)	NS	NS	NS	NS	NS
2006	6 June (OR) & 7 June (WA)	NS	NS	NS	NS	NS
2007	20 March (OR) & 21 March (WA)	NS	NS	NS	NS	NS
2007	5 June (OR) & 6 June (WA)	NS	NS	NS	NS	NS

Appendix 9. Details on codes and information recorded in the spreadsheet of observation records on bald eagles nesting in Oregon and along the Washington side of the Columbia River, 1978-2007.

Field 1 = Geographic Area Based On Recovery Zone - A code consisting of numbers and letters based on breeding area location in a management zone from the Recovery Plan.

Field 2 = Breeding Area Number - A unique number assigned to all nest trees in a breeding area.

Field 3 = Breeding Area Name - A name assigned to individual breeding areas based on nest tree names, which usually were based on nearby geographical features.

Field 4 = Date - The day the breeding area was observed in month/day/year format (e.g., 3/7/79). If the exact date was unknown, an approximate date was entered, and "Date?" was included in the "Note" field for that record.

Field 5 = Method - A code corresponding to the survey type (FW = fixed-wing aircraft, H = helicopter, G = land or water, NR = not reported).

Field 6 = Number of Adults - The number of adult bald eagles observed at the breeding area (0, 1, or 2). If more than 2, then extra adults were recorded in the "Note" field.

Field 7 = Status - A coded description of breeding activity in one of fourteen categories: 1) NS = Not Surveyed; 2) UND = Undetected - nest present, but no breeding-age eagles detected; 3) UNDX = Possibly Undetected - not enough information, or survey was inadequate, status unknown; 4) OCX = Possibly Occupied - not enough information to be certain, or survey was inadequate, status unknown; 5) OCC = Occupied - number of breeding-age eagles not reported; 6) OC1 = Occupied 1 - one breeding-age eagle and a nest; 7) OC2 = Occupied 2 - two breeding-age eagles and a nest; 8) OCE = Occupied Evidence Of Eggs - adult on the nest in incubating or brooding posture, incubation or brooding exchange by the adults, egg(s), food offered to unseen young; 9) 1d = 1 Small Young - less than five weeks old; 10) 2d = 2 Small Young - one or both less than five weeks old; 11) 3d = 3 Small Young - at least one less than five weeks old; 12) 1 = 1 Young - older than five weeks or fledged; 13) 2 = 2 Young - older than five weeks or fledged; 14) 3 = 3 Young - older than five weeks or fledged.

Field 8 = Nest Tree Number - The number of the nest tree holding the nest that had evidence of eggs on the most recent or a previous observation during a breeding season. Nest tree number was not entered if there was no evidence of eggs before or during the most recent observation. Nest tree numbers were not entered for breeding areas where there was no evidence of eggs observed during the breeding season.

Field 9 = Nestling Plumage - A coded description of nestling(s) plumage: DOWN = downy, 0-4 weeks old; PARTF = partly feathered, 4-7.5 weeks old; FEATH = feathered, 7.5+ weeks; FLEDG = fledged; or, starting in 2001, plumage stage from Carpenter (1990). Frequently, two plumage stages were recorded as a range (i.e., 3a-b) because observers were uncertain which was correct or the eaglet(s) exhibited characteristics of more than one stage. Occasionally, eaglets in the same nest would fit into different plumage stages because of developmental differences and both categories were recorded (i.e., 3a & 3b). This was especially noticeable when eagles in stage 2 and 3 plumages were in the same nest. Nestling plumage was not always reported.

Field 10 = Outcome - One of 18 possible categories for the final result of the annual survey, entered once per breeding area per year in the record for the date the determination was made or in the record for the last observation of the site for the breeding season. Codes were 1) NS = Not Surveyed; 2) UNOC = Unoccupied - nest present, but no breeding-age eagles detected; 3) UNOX = Possibly Unoccupied - not enough information to be certain, status unknown; 4) OCXX = Possibly Occupied - not enough information to be certain, status unknown; 5) OCCX = Occupied - number of breeding-age eagles not reported, outcome unknown; 6) OC1X = Occupied 1 - one breeding-age eagle and a nest, outcome unknown; 7) OC2X = Occupied 2 - two breeding-age eagles and a nest, outcome unknown; 8) OCEX = Occupied Evidence Of Eggs - outcome unknown; 9) OCCF = Occupied Failed - breeding-age eagle(s) and a nest observed, no evidence of eggs; 10) OC1F = Occupied 1 Failed - one breeding-age eagle and a nest observed, no evidence of eggs; 11) OC2F = Occupied 2 Failed - two breeding-age eagles and a nest observed, no evidence of eggs; 12) OCEF = Occupied Evidence Of Eggs Failed - evidence of eggs, no young observed; 13) 1d = Successful 1 Small Young - less than five weeks old; 14) 2d = Successful 2 Small Young - one or both less than five weeks old; 15) 3d = Successful 3 Small Young - at least one less than five weeks old; 16) 1 = Successful 1 Young - older than five weeks or fledged; 17) 2 = Successful 2 Young - older than five weeks or fledged; 18) 3 = Successful 3 Young - older than five weeks or fledged.

Field 11 = Outcome Tag - Repeat of the outcome code in Field 10 attached to all records for a site for each calendar year and used for summarizing data.

Field 12 = Note - Other important information relating to an observation, for example nest building and appropriate nest tree number; pseudoincubation; copulation; "Date?" when the exact date of the report was unknown; nest or nest tree condition, or nest tree species if noteworthy; number of subadults; adult behavior if enlightening or unusual; "NEW NEST" to designate that a new nest was discovered; “NEW SITE” to designate a previously undocumented breeding area; nest(s) that were not located; sex of adult(s), if determined; other adults in the area; young out of nest (branching); brooding or brooding position; other species using nest and appropriate nest number; comments on plumage if breeding subadults suspected; dead eagles; unusual human activity; other pertinent observations or questions arising from the visit; observer(s) through 2003; etc. For 1971 to 2003, the note field usually was empty if one of the authors made the observation, and there was no other information to record, after 2003 observers were entered in Fields 13+.

Fields 13+ = Observers - Starting in 2004, a first name field, last name field, and affiliation field, were added for each observer.

Appendix 10. Codes for nesting outcome and their relationship to basic statistics calculated for bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007.

Outcome		Status		
Code	Description	Occupancy	Productivity	Outcome
NS	Not surveyed, status unknown	Unknown	Status Unknown	Not Surveyed
UNOC	Surveyed and not occupied	Unoccupied	Unoccupied	Unoccupied
UNOX	Survey deficient, status unknown	Unknown	Status Unknown	Status Unknown
OCXX	Survey deficient, status unknown	Unknown	Status Unknown	Status Unknown
OCCX	Occupied, number of adults not reported, outcome unknown	Occupied	Unknown Outcome	Occupied Unknown Outcome
OC1X	Occupied, 1 adult, outcome unknown	Occupied	Unknown Outcome	Occupied Unknown Outcome
OC2X	Occupied, 2 adults, outcome unknown	Occupied	Unknown Outcome	Occupied Unknown Outcome
OCEX	Occupied, evidence of eggs, outcome unknown	Occupied	Unknown Outcome	Occupied Unknown Outcome
OCCF	Occupied, number of adults not reported, failed	Occupied	Known Outcome	Failed
OC1F	Occupied, 1 adult, failed	Occupied	Known Outcome	Failed
OC2F	Occupied, 2 adults, failed	Occupied	Known Outcome	Failed
OCEF	Occupied, evidence of eggs, failed	Occupied	Known Outcome	Failed
1d	1 young less than 5 weeks old	Occupied	Known Outcome	Successful 1 Young
2d	2 young less than 5 weeks old	Occupied	Known Outcome	Successful 2 Young
3d	3 young less than 5 weeks old	Occupied	Known Outcome	Successful 3 Young
1	1 young older than 5 weeks	Occupied	Known Outcome	Successful 1 Young
2	2 young older than 5 weeks	Occupied	Known Outcome	Successful 2 Young
3	3 young older than 5 weeks	Occupied	Known Outcome	Successful 3 Young
Basic Reproductive Statistics:				
	Number of Breeding Areas or Years Occupied[1]	Total Occupied		
	Number of Breeding Areas or Years with Known Outcome[1]		Total Occupied with Known Outcome	
	Number of Young			Total Number of Young
	Young / Breeding Area or Year Occupied with Known Outcome[1]			Total Number of Young / Total Number Occupied with Known Outcome

[1] Summarized by number of breeding areas for population statistics, or by number of years surveyed for breeding area stastics.

Appendix 11. Descriptive statistics derived from the database of nesting outcomes for bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007.

DESCRIPTIVE STATISTIC	Method or Formula
LISTED =	Count of breeding areas at the end of the most recent survey
NOT SURVEYED =	Count of the number of NS[1] outcomes
SURVEYED =	LISTED - NOT SURVEYED
PERCENT SURVEYED =	SURVEYED / LISTED X 100
OCCUPATION UNCERTAIN =	Sum of the number of NS[1], UNOX[3], and OCXX[4] outcomes
PERCENT OCCUPATION UNCERTAIN =	OCCUPATION UNCERTAIN / LISTED X 100
UNOCCUPIED =	Count of the number of UNOC[2] outcomes
PERCENT UNOCCUPIED =	UNOC[2] / (SURVEYED - OCCUPATION UNCERTAIN) X 100
OCCUPIED =	LISTED - (OCCUPATION UNCERTAIN + UNOC[2])
PERCENT OCCUPIED =	OCCUPIED / (SURVEYED - OCCUPATION UNCERTAIN) X 100
OCCUPIED UNKNOWN OUTCOME =	Sum of the number of OCCX[5], OC1X[6], OC2X[7], and OCEX[8] outcomes
PERCENT UNKNOWN OUTCOME =	OCCUPIED UNKNOWN OUTCOME / (SURVEYED - OCCUPATION UNCERTAIN) X 100
OCCUPIED KNOWN OUTCOME =	Sum of the number of OCCF[9], OC1F[10], OC2F[11], OCEF[12], 1d[13], 2d[14], 3d[15], 1[16], 2[17], and 3[18] outcomes
EVIDENCE OF EGGS KNOWN OUTCOME =	Sum of the number of OCEF[12], 1d[13], 2d[14], 3d[15], 1[16], 2[17], and 3[18] outcomes
SUCCESSFUL =	Sum of the number of 1d[13], 2d[14], 3d[15], 1[16], 2[17], and 3[18] outcomes
PERCENT SUCCESSFUL =	SUCCESSFUL / OCCUPIED KNOWN OUTCOME X 100
5-YEAR PERCENT SSUCCESSFUL =	Sum of five years SUCCESSFUL / sum of same five years OCCUPIED KNOWN OUTCOME X 100
YOUNG =	(1 X (count of 1d[13] + count of 1[16])) + (2 X (count of 2d[14] + count of 2[17])) + (3 X (count of 3d[15] + count of 3[18]))
YOUNG / OCCUPIED KNOWN OUTCOME =	YOUNG / OCCUPIED KNOWN OUTCOME
5-YEAR YOUNG / OCCUPIED KNOWN OUTCOME =	Sum of five years YOUNG / sum of same five years OCCUPIED KNOWN OUTCOME
YOUNG / EVIDENCE OF EGGS KNOWN OUTCOME =	YOUNG / EVIDENCE OF EGGS KNOWN OUTCOME
5-YEAR YOUNG / EVIDENCE OF EGGS KNOWN OUTCOME =	Sum of five years YOUNG / sum of same five years EVIDENCE OF EGGS KNOWN OUTCOME
YOUNG / SUCCESSFUL =	YOUNG / SUCCESSFUL
5-YEAR YOUNG / SUCCESSFUL =	Sum of five years YOUNG / sum of same five years SUCCESSFUL
OCCUPIED NO. OF ADULTS NOT REPORTED FAILURES =	Count of the OCCF[9] outcomes
OCCUPIED 1 ADULT FAILURES =	Count of the OC1F[10] outcomes
OCCUPIED 2 ADULTS FAILURES =	Count of the OC2F[11] outcomes
EVIDENCE OF EGGS FAILURES =	Count of the OCEF[12] outcomes
NESTS WITH 1 YOUNG =	Sum of 1d[13] and 1[16] outcomes
NESTS WITH 2 YOUNG =	Sum of 2d[14] and 2[17] outcomes
NESTS WITH 3 YOUNG =	Sum of 3d[15] and 3[18] outcomes
PERCENT OCCUPIED NO. OF ADULTS NOT REPORTED FAILURES =	OCCUPIED NO. OF ADULTS NOT REPORTED FAILURES / OCCUPIED KNOWN OUTCOME X 100
PERCENT OCCUPIED 1 ADULT FAILURES =	OCCUPIED 1 ADULT FAILURES / OCCUPIED KNOWN OUTCOME X 100
PERCENT OCCUPIED 2 ADULT FAILURES =	OCCUPIED 2 ADULT FAILURES / OCCUPIED KNOWN OUTCOME X 100
PERCENT EVIDENCE OF EGGS FAILURES =	EVIDENCE OF EGGS FAILURES / OCCUPIED KNOWN OUTCOME X 100
PERCENT 1 YOUNG =	NESTS WITH 1 YOUNG / OCCUPIED KNOWN OUTCOME X 100
PERCENT 2 YOUNG =	NESTS WITH 2 YOUNG / OCCUPIED KNOWN OUTCOME X 100
PERCENT 3 YOUNG =	NESTS WITH 3 YOUNG / OCCUPIED KNOWN OUTCOME X 100
CHANGE IN POPULATION SIZE =	(OCCUPIED - previous OCCUPIED) / previous OCCUPIED X 100

[1] NS = Not surveyed, status unknown
[2] UNOC = Surveyed and not occupied
[3] UNOX = Survey deficient, status unknown
[4] OCXX = Survey deficient, status unknown
[5] OCCX = Occupied, no. of adults not reported, outcome unknown
[6] OC1X = Occupied, 1 adult, outcome unknown
[7] OC2X = Occupied, 2 adults, outcome unknown
[8] OCEX = Occupied, evidence of eggs, outcome unknown
[9] OCCF = Occupied, number of adults not reported, failed
[10] OC1F = Occupied, 1 adult, failed
[11] OC2F = Occupied, 2 adults, failed
[12] OCEF = Occupied, evidence of eggs, failed
[13] 1d = 1 young less than 5 weeks old
[14] 2d = 2 young less than 5 weeks old
[15] 3d = 3 young less than 5 weeks old
[16] 1 = 1 young older than 5 weeks
[17] 2 = 2 young older than 5 weeks
[18] 3 = 3 young older than 5 weeks

Appendix 12. Origins and encounter locations of 111 marked bald eagles observed in or near Oregon, 1979-2010. Does not include USFWS band returns for nestlings banded in Oregon that are included in Table 5. Juveniles, subadults and near adults were grouped as subadults for analyses.

	Encounter				
Origin (State or Place)	Date	Age Class	Location (State, County)	Marker Type (marker code if known)	Condition/ Status
Oregon	7/21/79	Juvenile	Oregon, Klamath	Colored Leg Band, Green	Alive/Wild
Oregon	7/29/79	Juvenile	Oregon, Klamath	Patagial, Green	Alive/Wild
Oregon	7/29/79	Juvenile	Oregon, Klamath	Patagial, Green & Colored Leg Band	Alive/Wild
Oregon	7/29/79	Juvenile	Oregon, Klamath	Patagial, Green	Alive/Wild
Oregon	7/29/79	Juvenile	Oregon, Klamath	Patagial, Green	Alive/Wild
Oregon	7/31/79	Juvenile	Oregon, Klamath	USFWS Leg Band	Alive/Wild
Oregon	4/11/80	Subadult	Oregon, Clatsop	Patagial, Green	Alive/Wild
Oregon	7/30/80	Juvenile	Oregon, Deschutes	Patagial, Green	Alive/Wild
Oregon	2/16/81	Adult	Oregon, Klamath	Transmitter	Alive/Wild
Oregon	2/16/81	Adult	Oregon, Klamath	Transmitter	Alive/Wild
Oregon	February 81	Juvenile or Subadult	Oregon, Klamath	Transmitter	Alive/Wild assumed
Oregon	3/24/81	Adult	Oregon, Deschutes	Transmitter (HL07)	Alive/Wild assumed
Oregon	3/24/81	Subadult	Oregon, Deschutes	Patagial, Green	Alive/Wild
Oregon	3/24/81	Adult	Oregon, Deschutes	Transmitter (HL12)	Alive/Wild assumed
Oregon	3/24/81	Adult	Oregon, Deschutes	Transmitter (HL08)	Alive/Wild assumed
Oregon	3/25/81	Adult	Oregon, Deschutes	Transmitter (HL07)	Alive/Wild assumed
Oregon	3/25/81	Adult	Oregon, Deschutes	Transmitter (HL12)	Alive/Wild assumed
Oregon	7/17/81	Juvenile	Oregon, Klamath	Patagial, Green	Alive/Wild
Oregon	7/22/81	Juvenile	Oregon, Deschutes	Patagial, Green (A69)	Alive/Wild
Oregon	2/10/82	Subadult	Oregon, Lane	Patagial, Green	Alive/Wild
Oregon	4/10/82	Adult	Oregon, Deschutes	Transmitter (HL12)	Alive/Wild assumed
Oregon	4/21/82	Juvenile or Subadult	Oregon, Deschutes	Patagial, Green	Alive/Wild
Oregon	Summer 82	Juvenile	Oregon, Klamath	Transmitter	Dead
Oregon	2/16/83	Juvenile or Subadult	Oregon, Lane	Patagial, Green	Alive/Wild
Oregon	5/5/83	Subadult	Oregon, Curry	Patagial, Green	Alive/Wild
Oregon	Summer 83	_not reported_	Oregon, Lake	Patagial, Green	Dead
Oregon	Winter 83-84	Adult	Oregon, Lane	Patagial, Green	Alive/Wild
Oregon	January 84	Subadult	California, Siskiyou	Patagial, Green	Alive/Wild
Oregon	2/11/85	Adult	Oregon, Klamath	Patagial, Bluish-Green	Alive/Wild
Oregon	5/7/86	Adult	Oregon, Wasco	Transmitter	Dead
Oregon	Spring 87	_not reported_	Oregon, Klamath	Patagial, Green	Unknown
Oregon	5/21/87	Adult	Oregon, Klamath	Patagial, Green	Alive/Wild assumed
Oregon	1987	Adult(s)	California, northern	Patagial, Green	Alive/Wild possibly nesting
Arizona	Summer 86	Juvenile	Oregon, Union	Transmitter	Alive/Wild
Arizona	Summer 87	Juvenile	Oregon, Baker & Union	Transmitter	Alive/Wild
Arizona	July 95	Juvenile	Oregon, Curry	USFWS Leg Band	Alive/Captured & Released
Arizona	September 03	Subadult	Oregon, Klamath	USFWS & Colored Leg Bands & Transmitter	Dead
Arizona	Fall 07	Near Adult or Adult	Oregon, Klamath	USFWS Leg Band & Transmitter	Dead
California	August 79	Juvenile	Oregon, Tillamook	USFWS Leg Band	Injured/Captive
California	March or April 85	Juvenile or Subadult	Oregon, Lake	Transmitter	Alive/Wild
California	3/5/93	Adult	Oregon, Klamath	USFWS Leg Band	Dead
California	3/31/93	Adult	Oregon, Crook	USFWS Leg Band	Dead
California	12/15/93	Subadult	Oregon, Lake	Patagial, Orange (15)	Alive/Wild
California	Summer 94	_not reported_	Oregon, Klamath	Patagial (color not reported)	Alive/Wild assumed
California	11/5/95	Near Adult	Oregon, Deschutes	Patagial, Orange (23)	Alive/Wild
California	9/29/97	Subadult	Oregon, Deschutes	Patagial, Orange (60)	Alive/Wild
California	3/6/99	Juvenile	Oregon, Clackamas	USFWS Leg Band & Colored Leg Band	Alive/Wild
California	1/15/01	Juvenile	Oregon, Klamath	Patagial, Orange (02)	Alive/Wild
California	July 02	Juvenile	Oregon, Lake	Patagial, Reddish-Orange (13)	Alive/Wild
California	8/31/02	Juvenile	Oregon, Tillamook	Patagial, Reddish-Orange (22)	Alive/Wild
California	1/10/03	Subadult	Oregon, Klamath	Patagial, Orange (10) & Colored Leg Band	Alive/Wild
California	2/9/03	Juvenile	Oregon, Tillamook	Patagial, Orange (22)	Alive/Wild
California	September 03	Juvenile	Oregon, Lincoln	Patagial, Orange (35) & Colored Leg Band	Alive/Wild
California	12/3/03	Juvenile	Oregon, Lake	Patagial, Blue	Alive/Wild
California	9/4/04	Subadult	Oregon, Crook	Patagial, Blue (12)	Alive/Wild
California	9/14/04	Subadult	Oregon, Tillamook	Patagial, Turquoise (17)	Alive/Wild
California	10/12/04	Subadult	Oregon, Wasco	Patagial, Orange (10)	Alive/Wild
California	4/28/05	Juvenile	Oregon, Lane	Patagial, Orange (45)	Alive/Wild
California	7/26/06	Juvenile	Washington, Skamania	Patagial, Blue (46)	Alive/Wild
California	1/19/08	Juvenile	Oregon, Klamath	Patagial, Reddish (73)	Alive/Wild
California	9/30/08	Subadult	Oregon, Deschutes	Patagial, Blue (46)	Alive/Wild
California	10/9/08	Juvenile	Oregon, Lane	Patagial, Orange (88)	Alive/Wild
California	10/18/08	Juvenile	Oregon, Curry	Patagial, Orange (88)	Alive/Wild
California	12/24/08	Subadult	Oregon, Klamath	Patagial, Blue (46)	Alive/Wild
California	7/22/09	Subadult	Oregon, Lane	Patagial, Orange (88)	Alive/Wild
California likely	January 82	Juvenile or Subadult	Oregon, Lane	Patagial, Red	Alive/Wild
California likely	December 83	_not reported_	Oregon, Klamath	Patagial, Red	Unknown

Appendix 12. Origins and encounter locations of 111 marked bald eagles observed in or near Oregon, 1979-2010. Does not include USFWS band returns for nestlings banded in Oregon that are included in Table 5. Juveniles, subadults and near adults were grouped as subadults for analyses.

	Encounter				
Origin (State or Place)	Date	Age Class	Location (State, County)	Marker Type (marker code if known)	Condition/ Status
California likely	February 89	Juvenile or Subadult	Oregon, Douglas	Patagial, Orange	Alive/Wild
California likely	April 89	_not reported_	Oregon, Douglas	Patagial, Orange	Alive/Wild assumed
California likely	March 92	Adult	Oregon, Lake	Patagial, Orange	Alive/Wild assumed
California likely	3/8/94	Adult	Oregon, Lake	Patagial, Orange	Alive/Wild
California likely	3/17/94	Adult	Oregon, Lake	Patagial, Orange	Alive/Wild
California likely	3/19/94	Subadult	Oregon, Lake	Patagial, Orange	Alive/Wild
California likely	7/15/96	_not reported_	Oregon, Harney or Grant	Patagial, Orange (6 or 9) & Transmitter	Unknown (markers only)
California likely	8/19/98	Subadult	Oregon, Lincoln	Patagial, Orange (81)	Alive/Wild
California likely	11/11/01	Juvenile or Subadult	Oregon, Jackson	Patagial, Red	Alive/Wild
California likely	12/3/01	Juvenile or Subadult	Oregon, Clackamas	Patagial, Red	Alive/Wild
California likely	Spring 03	Subadult	Oregon, Coos or Curry	Patagial, Orange & Transmitter	Dead
California likely	8/29/04	Subadult	Oregon, Union	Patagial, Blue	Alive/Wild
California likely	March 05	Adult	Oregon, Harney	Patagial, Orange	Alive/Wild
California likely	6/10/05	Juvenile or Subadult	Oregon, Deschutes	Patagial, Red (7)	Alive/Wild
California likely	7/10/06	Adult	Oregon, Douglas	Patagial, Blue	Alive/Wild
California likely	7/18/06	Subadult	Oregon, Lake	Patagial, Blue	Alive/Wild
California likely	12/15/09	Juvenile or Subadult	Oregon, Lake	Patagial, Red	Alive/Wild assumed
Glacier NP	February 81	_not reported_	Oregon, Klamath	Transmitter	Alive/Wild assumed
Glacier NP	Winter 84-85	_not reported_	Oregon, Klamath	USFWS Leg Band	Injured/Captive
Glacier NP	4/7/10	Adult	Oregon, Lake	USFWS Leg Band	Dead
Idaho	5/19/92	Juvenile	Oregon, Klamath	USFWS Leg Band	Dead
Mexico	September 89	Juvenile	Oregon, Clatsop	USFWS Leg Band & Colored Leg Band	Alive/Wild
Washington	2/13/81	_not reported_	Oregon, Klamath	Transmitter	Alive/Wild assumed
Washington	Winter 84-85	_not reported_	Oregon, Columbia	Transmitter	Alive/Wild
Wyoming	10/22/86	Juvenile	Oregon, Lake	Transmitter	Alive/Captured & Released
Wyoming	November 86	Juvenile	Oregon, Klamath	Transmitter	Alive/Wild
Wyoming	11/30/93	Juvenile	Oregon, Klamath	USFWS Leg Band	Dead
Yellowstone NP	Winter 84-85	Juvenile	Oregon, Clatsop	USFWS Leg Band	Alive/Wild
Unknown	6/24/82	Adult	Oregon, Deschutes	Transmitter	Alive/Wild
Unknown	March 86	Adult	Oregon, Klamath	Patagial, Green	Alive/Wild assumed
Unknown	March or April 86	Adult	Oregon, Lincoln	Transmitter	Alive/Wild
Unknown	July 87	_not reported_	Oregon, Klamath	USFWS Leg Band	Dead
Unknown	Winter 87-88	_not reported_	Oregon, Klamath	Transmitter	Alive/Wild commual roosting
Unknown	March 89	Juvenile or Subadult	Oregon, Deschutes	Colored Leg Band, Green	Unknown
Unknown	3/20/90	Adult	Oregon, Coos	USFWS Leg Band	Alive/Wild nesting
Unknown	6/17/93	Adult	Oregon, Douglas	USFWS Leg Band	Alive/Wild
Unknown	9/28/93	Adult	Oregon, Klamath	USFWS Leg Band	Dead
Unknown	December 93	Juvenile or Subadult	Oregon, Klamath	USFWS Leg Band & Colored Leg Band	Dead
Unknown	Winter 93-94	_not reported_	Oregon, Wallowa	unspecified ("tagged")	Unknown
Unknown	2/24/94	Near Adult	Oregon, Lake	Transmitter	Alive/Wild
Unknown	8/14/95	Subadult	Oregon, Coos	USFWS Leg Band & Colored Leg Band	Alive/Wild
Unknown	1/8/99	Juvenile or Subadult	Oregon, Marion or Linn	USFWS Leg Band & Colored Leg Band	Alive/Wild
Unknown	7/22/05	Subadult	Oregon, Deschutes	Leg Bands & Transmitter	Alive/Wild
Unknown	Summer 07	_not reported_	Oregon, Deschutes	Patagial (color not reported)	Alive/Wild

Appendix 13. Cumulative results of surveys of bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007.

OUTCOME GROUP		All Breeding Areas		Known Outcome Breeding Areas		Failed Nesting Attempts		Successful Nesting Attempts	
Code(s)	Description	n	%	n	%	n	%	n	%
UNDETERMINED									
NS	Not Surveyed Total	391							
UNOX, OCXX	Occupation Uncertain	952							
OCCX, OC1X, OC2X, OCEX	Occupied Outcome Unknown	270							
	Undetermined Total	1,222	13.2						
UNOCCUPIED									
UNOC	Unoccupied Total	332	3.6						
OCCUPIED FAILED									
	Occupied Number of Adults								
OCCF	Not Reported	3		3		3	0.1		
OC1F	Occupied 1 Adult	556		556		556	18.8		
OC2F	Occupied 2 Adults	1,032		1,032		1,032	34.9		
OCEF	Occupied Evidence of Eggs	1,362		1,362		1,362	46.1		
	Occupied Failed Total	2,953	31.9	2,953	38.4	2,953	100		
OCCUPIED SUCCESSFUL									
1d	1 Downy Nestling	103		103				103	2.2
2d	2 Downy Nestlings	105		105				105	2.2
3d	3 Downy Nestlings	8		8				8	0.2
1	1 Feathered or Fledged	2,079		2,079				2,079	43.8
2	2 Feathered or Fledged	2,321		2,321				2,321	48.9
3	3 Feathered or Fledged	127		127				127	2.7
	Occupied Successful Total	4,743	51.3	4,743	61.6			4,743	100
	Total (excluding Not Surveyed)	9,250	100.0	7,696	100				

Appendix 14A. Year-to-year nesting outcomes at bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007. Numbers are proportions of outcomes shown at the top of the column (Year Y+1) that followed the outcomes shown at the left end of the row (Year Y). For example, 0.079 of breeding areas with an outcome of 3 in year Y (n = 127) had an outcome of 3 the following year (Y+1); 0.409 had an outcome of 2; and 0.236 had an outcome of 1, etc.

Year Y	Sample	Year Y+1 Outcome															
Outcome	Size	3	2	1	OCEF	OC2F	OC1F	OCCF	UNOC	OCEX	OC2X	OC1X	OCCX	OCXX	UNOX	NS	Total
3	127	0.079	0.409	0.236	0.134	0.079	0.031	0.000	0.000	0.024	0.000	0.000	0.000	0.000	0.008	0.000	1.000
2	2263	0.026	0.418	0.274	0.128	0.072	0.039	0.000	0.007	0.006	0.004	0.002	0.000	0.012	0.008	0.002	1.000
1	2108	0.016	0.315	0.318	0.155	0.090	0.046	0.000	0.007	0.011	0.005	0.005	0.000	0.012	0.014	0.006	1.000
OCEF	1310	0.013	0.211	0.228	0.246	0.140	0.076	0.001	0.021	0.008	0.002	0.008	0.004	0.021	0.020	0.002	1.000
OC2F	945	0.007	0.172	0.206	0.174	0.222	0.096	0.000	0.038	0.003	0.014	0.007	0.000	0.032	0.022	0.005	1.000
OC1F	538	0.000	0.149	0.217	0.154	0.177	0.123	0.002	0.054	0.009	0.015	0.011	0.000	0.041	0.043	0.006	1.000
OCCF	3	0.000	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.000	0.000	0.000	0.333	0.000	1.000
UNOC	327	0.000	0.052	0.058	0.046	0.067	0.040	0.000	0.355	0.003	0.003	0.009	0.000	0.067	0.266	0.034	1.000
OCEX	92	0.000	0.250	0.217	0.109	0.087	0.054	0.000	0.043	0.109	0.011	0.011	0.000	0.011	0.076	0.022	1.000
OC2X	98	0.010	0.143	0.153	0.102	0.143	0.061	0.000	0.010	0.031	0.133	0.041	0.000	0.061	0.092	0.020	1.000
OC1X	80	0.000	0.063	0.100	0.138	0.088	0.075	0.000	0.050	0.000	0.075	0.100	0.000	0.050	0.225	0.038	1.000
OCCX	7	0.000	0.143	0.143	0.286	0.000	0.000	0.000	0.000	0.286	0.000	0.000	0.000	0.000	0.000	0.143	1.000
OCXX	373	0.005	0.078	0.110	0.046	0.046	0.048	0.000	0.054	0.005	0.011	0.005	0.000	0.273	0.188	0.131	1.000
UNOX	682	0.001	0.040	0.062	0.026	0.028	0.032	0.000	0.092	0.006	0.022	0.022	0.001	0.101	0.397	0.169	1.000
NS	461	0.000	0.050	0.046	0.015	0.024	0.015	0.000	0.015	0.004	0.009	0.009	0.000	0.076	0.154	0.584	1.000
Overall n =	9414	130	2321	2099	1292	950	524	3	337	84	87	76	7	371	653	480	
Overall Y+1 Ratio =		0.014	0.247	0.223	0.137	0.101	0.056	0.000	0.036	0.009	0.009	0.008	0.001	0.039	0.069	0.051	1.000

3 = Successful 3 Young - includes both 3 and 3d outcomes.
2 = Successful 2 Young - includes both 2 and 2d outcomes.
1 = Successful 1 Young - includes both 1 and 1d outcomes.
OCEF = Occupied Evidence Of Eggs Failed - evidence of eggs, no young observed.
OC2F = Occupied 2 Failed - two breeding-age eagles and a nest observed, no evidence of eggs
OC1F = Occupied 1 Failed - one breeding-age eagle and a nest observed, no evidence of eggs.
OCCF = Occupied Failed - breeding-age eagle(s) and a nest observed, no evidence of eggs.
UNOC = Unoccupied - nest present, but no breeding-age eagles detected.
OCEX = Occupied Evidence Of Eggs - outcome unknown.
OC2X = Occupied 2 - two breeding-age eagles and a nest, outcome unknown.
OC1X = Occupied 1 - one breeding-age eagle and a nest, outcome unknown.
OCCX = Occupied - number of breeding-age eagles not reported, outcome unknown.
OCXX = Possibly Occupied - not enough information to be certain, status unknown.
UNOX = Possibly Unoccupied - not enough information to be certain, status unknown.
NS = Not Surveyed

Appendix 14B. Raw data on year-to-year nesting outcomes at bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1971-2007.

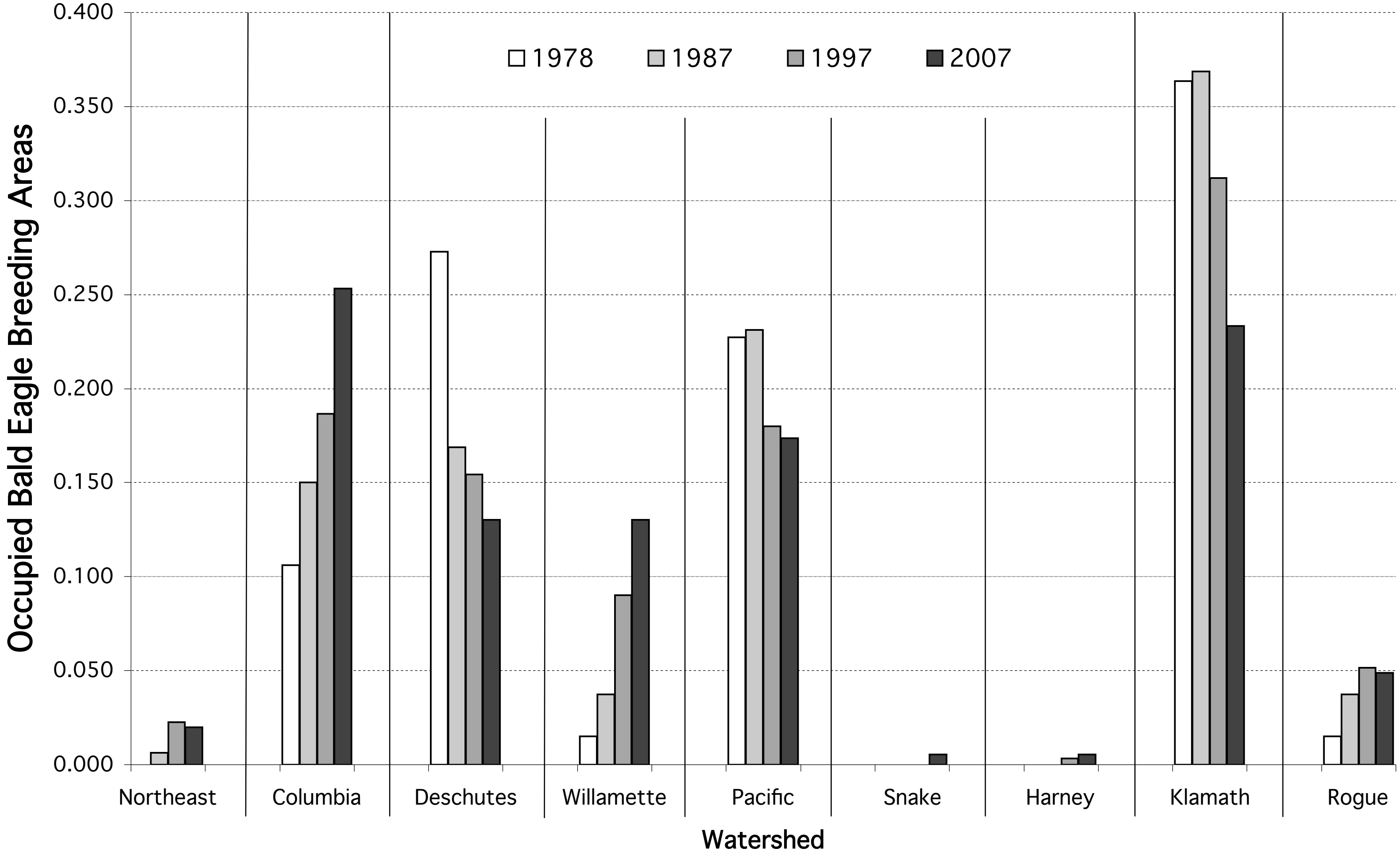
Year Y		Year Y+1 Outcome															
Outcome	n	3	2	1	OCEF	OC2F	OC1F	OCCF	OCEX	OC2X	OC1X	OCCX	OCXX	UNOX	UNOC	NS	n
3	127	10	52	30	17	10	4	0	3	0	0	0	0	1	0	0	127
2	2,263	59	947	621	290	164	89	1	14	9	4	0	27	18	15	5	2,263
1	2,108	33	663	670	326	190	97	0	23	10	11	1	26	30	15	13	2,108
OCEF	1,310	17	276	299	322	183	100	1	11	3	11	5	27	26	27	2	1,310
OC2F	945	7	163	195	164	210	91	0	3	13	7	0	30	21	36	5	945
OC1F	538	0	80	117	83	95	66	1	5	8	6	0	22	23	29	3	538
OCCF	3	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	3
OCEX	92	0	23	20	10	8	5	0	10	1	1	0	1	7	4	2	92
OC2X	98	1	14	15	10	14	6	0	3	13	4	0	6	9	1	2	98
OC1X	80	0	5	8	11	7	6	0	0	6	8	0	4	18	4	3	80
OCCX	7	0	1	1	2	0	0	0	2	0	0	0	0	0	0	1	7
OCXX	373	2	29	41	17	17	18	0	2	4	2	0	102	70	20	49	373
UNOX	682	1	27	42	18	19	22	0	4	15	15	1	69	271	63	115	682
UNOC	327	0	17	19	15	22	13	0	1	1	3	0	22	87	116	11	327
NS	461	0	23	21	7	11	7	0	2	4	4	0	35	71	7	269	461
	9,414																9,414
		130	2,321	2,099	1,292	950	524	3	84	87	76	7	371	653	337	480	9,414
OC Y >	OC Y+1																
7,571	7,107	0.939															
S Y >	S Y+1																
4,498	3,085	0.686															
F Y >	F Y+1																
2,796	1,316	0.471															
Unoc >	Unoc																
327	116	0.355															

Appendix 15. Minimum number of occupied bald eagle breeding areas in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

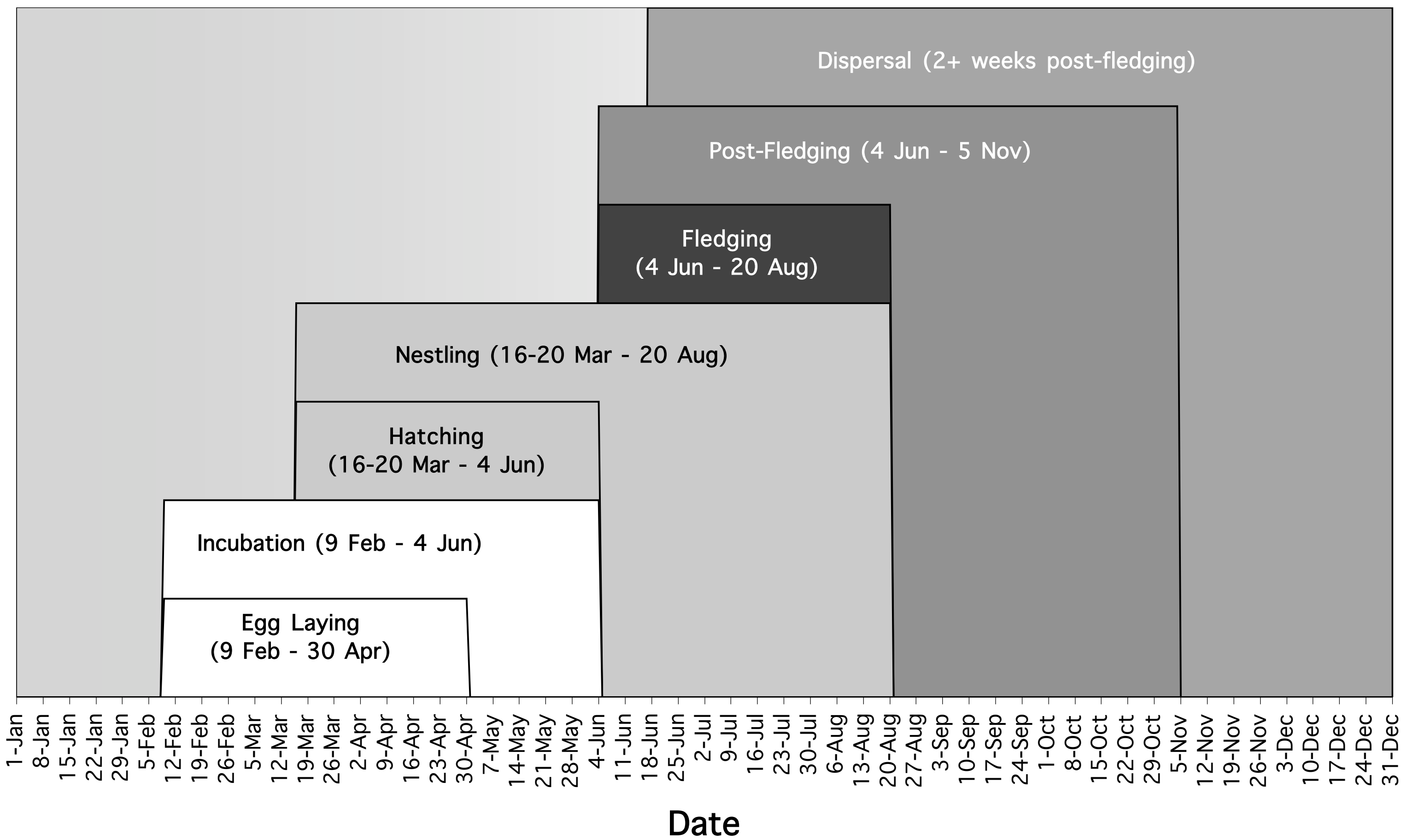
	Watershed										Study
Year	Northeast	Columbia	Deschutes	Willamette	Pacific	Snake	Harney	Klamath	Rogue	Owyhee	Area
1978	0	7	18	1	15	0	0	24	1	0	66
1979	0	8	17	2	20	0	0	37	1	0	85
1980	0	10	19	2	25	0	0	41	1	0	98
1981	0	10	23	3	27	0	0	44	1	0	108
1982	0	11	22	4	24	0	0	48	3	0	112
1983	0	14	20	4	25	0	0	50	5	0	118
1984	1	18	20	4	29	0	0	50	4	0	126
1985	1	21	22	5	33	0	0	55	5	0	142
1986	1	23	24	7	34	0	0	59	4	0	152
1987	1	24	27	6	37	0	0	59	6	0	160
1988	1	23	30	7	39	0	0	65	7	0	172
1989	2	21	31	10	40	0	0	64	9	0	177
1990	4	23	33	10	37	0	0	65	10	0	182
1991	3	31	32	12	42	0	1	71	10	0	202
1992	3	38	34	16	46	0	1	72	12	0	222
1993	5	42	37	18	45	0	1	78	13	0	239
1994	6	44	39	19	45	0	1	87	13	0	254
1995	5	46	40	22	46	0	1	88	15	0	263
1996	5	52	45	27	52	0	1	94	15	0	291
1997	7	58	48	28	56	0	1	97	16	0	311
1998	7	72	52	35	63	0	1	105	16	0	351
1999	9	75	53	40	65	1	2	107	20	0	372
2000	9	82	57	51	68	1	2	116	19	0	405
2001	11	86	58	51	75	1	2	116	20	0	420
2002	9	91	57	54	79	1	2	119	20	0	432
2003	8	98	62	55	79	2	2	125	21	0	452
2004	11	106	61	58	84	2	2	127	24	0	475
2005	11	128	64	60	91	2	2	125	22	0	505
2006	10	133	66	64	92	2	2	126	26	0	521
2007	11	140	72	72	96	3	3	129	27	0	553
Total	141	1,535	1,183	747	1,509	15	27	2,443	366	0	7,966
Percent Increase	1,000	1,900	300	7,100	540	200	200	438	2,600	-	738

Appendix 16. Proportion of breeding areas occupied by bald eagles in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

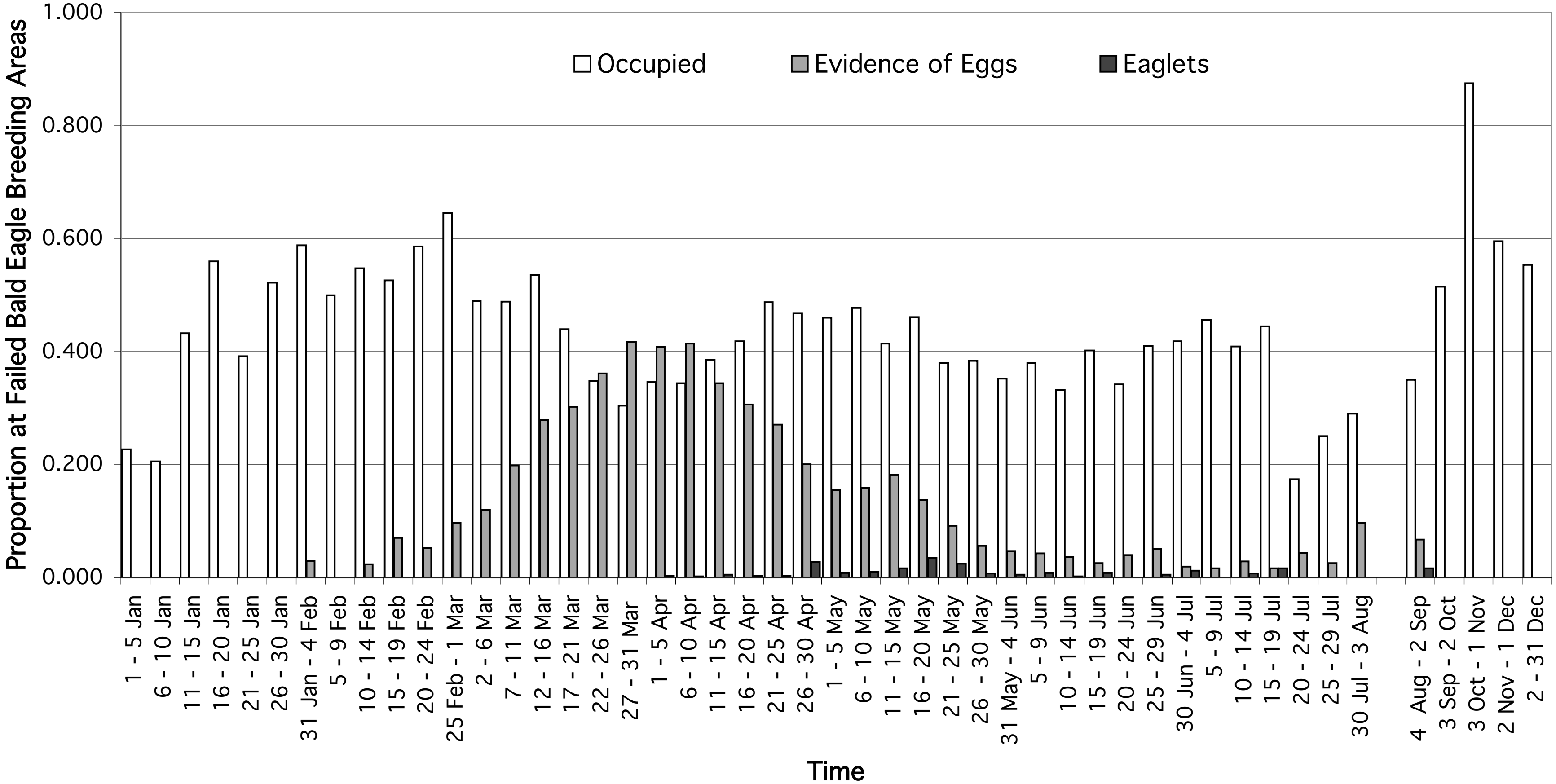
Year	Watershed										Annual	
	Northeast	Columbia	Deschutes	Willamette	Pacific	Snake	Harney	Klamath	Rogue	Owyhee	Proportion Occupied	Breeding Areas Surveyed
1978	-	0.583	0.750	1.000	0.833	-	-	0.727	1.000	-	0.733	90
1979	-	0.571	0.680	1.000	0.909	-	-	0.787	1.000	-	0.759	112
1980	-	0.714	0.731	1.000	1.000	-	-	0.759	1.000	-	0.797	123
1981	-	0.667	0.852	1.000	1.000	-	-	0.772	1.000	-	0.824	131
1982	-	0.786	0.786	1.000	0.857	-	-	0.828	1.000	-	0.824	136
1983	-	0.778	0.714	1.000	0.893	-	-	0.806	1.000	-	0.808	146
1984	0.500	0.783	0.741	1.000	0.935	-	-	0.781	0.800	-	0.808	156
1985	0.500	0.913	0.759	1.000	0.868	-	-	0.846	1.000	-	0.850	167
1986	0.500	0.958	0.774	1.000	0.829	-	-	0.855	0.800	-	0.849	179
1987	0.500	0.889	0.818	0.857	0.881	-	-	0.855	1.000	-	0.860	186
1988	0.500	0.793	0.882	1.000	0.796	-	-	0.867	1.000	-	0.847	203
1989	0.500	0.750	0.838	1.000	0.800	-	-	0.831	1.000	-	0.823	215
1990	0.800	0.793	0.868	0.909	0.740	-	-	0.813	1.000	-	0.816	223
1991	0.600	0.886	0.800	0.857	0.824	-	1.000	0.866	0.909	-	0.845	239
1992	0.429	0.792	0.850	0.889	0.821	-	1.000	0.809	1.000	-	0.819	271
1993	0.625	0.840	0.881	0.947	0.804	-	1.000	0.857	1.000	-	0.854	280
1994	0.600	0.863	0.867	0.905	0.804	-	1.000	0.897	1.000	-	0.864	294
1995	0.714	0.807	0.870	0.917	0.836	-	1.000	0.880	1.000	-	0.862	305
1996	0.556	0.754	0.938	0.964	0.839	-	1.000	0.862	1.000	-	0.853	341
1997	0.636	0.744	0.960	0.903	0.862	-	1.000	0.898	1.000	-	0.864	360
1998	0.700	0.818	0.963	0.972	0.863	-	1.000	0.921	1.000	-	0.895	392
1999	0.900	0.843	0.930	0.930	0.878	1.000	1.000	0.930	0.952	-	0.903	412
2000	0.900	0.812	0.919	0.981	0.883	1.000	1.000	0.928	0.826	-	0.894	453
2001	0.917	0.811	0.935	0.911	0.872	1.000	1.000	0.921	0.800	-	0.882	476
2002	0.750	0.784	0.864	0.900	0.919	1.000	1.000	0.902	0.833	-	0.866	499
2003	0.667	0.790	0.912	0.859	0.908	1.000	1.000	0.912	0.840	-	0.868	521
2004	0.786	0.791	0.884	0.841	0.933	0.667	1.000	0.901	0.923	-	0.867	548
2005	0.917	0.853	0.889	0.857	0.958	0.667	1.000	0.880	0.846	-	0.883	572
2006	0.833	0.875	0.868	0.865	0.939	0.667	1.000	0.881	0.929	-	0.886	588
2007	0.786	0.819	0.900	0.900	0.923	1.000	1.000	0.890	0.844	-	0.875	632
All Years Combined	0.705	0.813	0.867	0.904	0.877	0.833	1.000	0.871	0.915	-	0.861	
Breeding Areas Surveyed	200	1,889	1,364	826	1,720	18	27	2,806	400	-	9,250	



Appendix 17. Proportion of breeding areas occupied by bald eagles by watershed at the start of the study and at 10-year intervals in Oregon and along the Washington side of the Columbia River, 1978-2007. Number of occupied breeding areas increased annually; total sample sizes were 66, 160, 311, and 553 for 1978, 1987, 1997 and 2007, respectively.



Appendix 18. Nesting phenology for bald eagles in Oregon and along the Washington side of the Columbia River, 1971-2007. Start and end dates for Egg Laying, Incubation, Hatching, and Nestling stages are based on observations at the earliest (Fernhill Wetlands 2002 and 2003) and latest (Killin Wetlands/Banks 2006) successful nesting attempts, and a ±35 day incubation period (Buehler 2000:17). Fledging dates are based on the earliest (Birch Creek 2004) and latest (Killin Wetlands/Banks 2006) dates reported. Post-fledging care (2-11 weeks) and dispersal are based on published literature summarized in Buehler (2000:19).



Appendix 19. Nesting status at bald eagle breeding areas where breeding pairs failed to raise young in Oregon and along the Washington side of the Columbia River, 1971-2007, based on 9,953 records. Sample size varied by period; 22-757 observations/period for five-day periods and 32-65 for thirty-day periods. Proportion of breeding areas occupied + evidence of eggs + eaglets + no eagles detected (not shown) = 1.000.

Appendix 20. Nesting success for breeding areas of bald eagles by watershed in Oregon and along the Washington side of the Columbia River by Recovery Zone, 1978-2007.

Year	Watershed										Annual	
	Northeast	Columbia	Deschutes	Willamette	Pacific	Snake	Harney	Klamath	Rogue	Owyhee	Overall	n
1978	-	0.600	0.688	-	0.667	-	-	0.652	1.000	-	0.667	57
1979	-	0.333	0.688	1.000	0.579	-	-	0.611	1.000	-	0.613	80
1980	-	0.000	0.579	1.000	0.591	-	-	0.514	0.000	-	0.506	89
1981	-	0.444	0.636	1.000	0.640	-	-	0.591	0.000	-	0.602	103
1982	-	0.300	0.400	1.000	0.500	-	-	0.489	0.333	-	0.472	108
1983	-	0.385	0.500	1.000	0.478	-	-	0.633	0.600	-	0.558	113
1984	1.000	0.412	0.684	0.500	0.680	-	-	0.620	1.000	-	0.625	120
1985	1.000	0.389	0.500	1.000	0.600	-	-	0.618	0.600	-	0.581	136
1986	1.000	0.750	0.500	0.714	0.559	-	-	0.729	0.250	-	0.641	145
1987	1.000	0.273	0.519	0.800	0.600	-	-	0.593	0.667	-	0.548	155
1988	1.000	0.304	0.467	0.571	0.641	-	-	0.615	0.857	-	0.564	172
1989	0.500	0.368	0.567	0.500	0.325	-	-	0.587	0.667	-	0.497	173
1990	0.667	0.524	0.719	0.700	0.528	-	-	0.631	0.600	-	0.616	177
1991	0.667	0.467	0.677	0.818	0.600	-	1.000	0.652	0.700	-	0.631	195
1992	1.000	0.568	0.667	0.500	0.585	-	1.000	0.592	0.833	-	0.612	214
1993	0.800	0.568	0.611	0.688	0.535	-	1.000	0.527	0.615	-	0.573	225
1994	1.000	0.515	0.568	0.500	0.738	-	1.000	0.518	0.462	-	0.573	234
1995	0.800	0.421	0.725	0.526	0.565	-	0.000	0.655	0.533	-	0.598	251
1996	0.800	0.583	0.568	0.619	0.569	-	0.000	0.677	0.533	-	0.612	278
1997	0.571	0.379	0.617	0.750	0.582	-	1.000	0.646	0.500	-	0.581	308
1998	0.714	0.528	0.569	0.656	0.651	-	1.000	0.631	0.375	-	0.597	345
1999	0.875	0.569	0.725	0.641	0.631	1.000	0.500	0.561	0.350	-	0.603	365
2000	0.625	0.500	0.536	0.646	0.706	1.000	0.500	0.678	0.632	-	0.620	397
2001	0.500	0.624	0.655	0.625	0.747	1.000	0.500	0.658	0.700	-	0.661	413
2002	0.375	0.582	0.719	0.679	0.705	1.000	0.500	0.650	0.700	-	0.656	427
2003	0.875	0.588	0.597	0.679	0.722	1.000	0.500	0.569	0.714	-	0.631	447
2004	0.800	0.590	0.667	0.760	0.613	1.000	1.000	0.650	0.542	-	0.645	451
2005	0.700	0.645	0.609	0.714	0.714	1.000	0.500	0.610	0.714	-	0.658	488
2006	0.875	0.633	0.692	0.782	0.552	1.000	1.000	0.597	0.750	-	0.646	495
2007	0.818	0.701	0.704	0.662	0.659	1.000	0.667	0.602	0.600	-	0.665	535
All Years Combined	0.740	0.558	0.624	0.681	0.625	1.000	0.667	0.615	0.609	-	0.616	7,696
n	131	1,454	1,160	695	1,459	15	27	2,394	361	-	-	7,696

Appendix 21A. Three measures of productivity for bald eagle breeding areas with known outcome (n) in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Year	Watershed							
	Northeast				Columbia			
	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]
1978	0	-	-	-	5	0.80	1.33	1.33
1979	0	-	-	-	6	0.50	0.75	1.50
1980	0	-	-	-	8	0.00	0.00	0.00
1981	0	-	-	-	9	0.56	0.63	1.25
1982	0	-	-	-	10	0.40	0.50	1.33
1983	0	-	-	-	13	0.54	0.70	1.40
1984	1	2.00	2.00	2.00	17	0.65	0.69	1.57
1985	1	2.00	2.00	2.00	18	0.56	0.63	1.43
1986	1	2.00	2.00	2.00	16	1.00	1.14	1.33
1987	1	3.00	3.00	3.00	22	0.41	0.64	1.50
1988	1	2.00	2.00	2.00	23	0.43	0.56	1.43
1989	2	1.00	2.00	2.00	19	0.47	0.69	1.29
1990	3	0.67	1.00	1.00	21	0.62	0.81	1.18
1991	3	1.33	2.00	2.00	30	0.60	0.67	1.29
1992	3	1.67	1.67	1.67	37	0.81	0.88	1.43
1993	5	1.20	1.20	1.50	37	0.86	1.10	1.52
1994	5	2.00	2.00	2.00	33	0.97	1.14	1.88
1995	5	1.60	1.60	2.00	38	0.61	0.85	1.44
1996	5	1.00	1.00	1.25	48	0.81	0.95	1.39
1997	7	0.86	0.86	1.50	58	0.57	0.79	1.50
1998	7	1.14	1.33	1.60	72	0.82	1.20	1.55
1999	8	1.25	1.25	1.43	72	0.88	1.07	1.54
2000	8	1.13	1.50	1.80	80	0.86	1.23	1.73
2001	10	0.70	1.00	1.40	85	0.94	1.31	1.51
2002	8	0.63	1.00	1.67	91	0.98	1.33	1.68
2003	8	1.63	1.63	1.86	97	0.99	1.32	1.68
2004	10	1.40	1.40	1.75	100	0.95	1.28	1.61
2005	10	1.00	1.11	1.43	124	1.05	1.34	1.63
2006	8	1.38	1.38	1.57	128	1.04	1.30	1.64
2007	11	1.18	1.30	1.44	137	1.22	1.56	1.74
All Years Combined	131	1.21	1.36	1.64	1,454	0.89	1.15	1.59

[1] Yg/OC = young/occupied breeding area with known outcome.

[2] Yg/OCE = young/occupied breeding area with evidence of eggs and known outcome.

[3] Yg/Succ = young/breeding area where outcome was successful.

Appendix 21B. Three measures of productivity for bald eagle breeding areas with known outcome (n) in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Year	Watershed							
	Deschutes				Willamette			
	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]
1978	16	1.19	1.73	1.73	0	-	-	-
1979	16	1.00	1.23	1.45	2	1.00	1.00	1.00
1980	19	0.79	1.00	1.36	2	1.50	1.50	1.50
1981	22	1.14	1.39	1.79	2	2.00	2.00	2.00
1982	20	0.55	0.79	1.38	4	1.75	1.75	1.75
1983	20	0.55	0.79	1.10	3	2.00	2.00	2.00
1984	19	1.00	1.19	1.46	4	0.75	1.00	1.50
1985	22	0.82	1.38	1.64	5	1.80	1.80	1.80
1986	24	0.71	1.00	1.42	7	1.43	2.00	2.00
1987	27	0.81	0.96	1.57	5	1.00	1.25	1.25
1988	30	0.80	1.00	1.71	7	0.86	1.20	1.50
1989	30	1.03	1.48	1.82	10	0.80	1.33	1.60
1990	32	0.97	1.15	1.35	10	1.20	1.71	1.71
1991	31	1.26	1.44	1.86	11	1.27	1.56	1.56
1992	33	1.09	1.33	1.64	16	0.88	1.00	1.75
1993	36	0.92	1.14	1.50	16	1.06	1.21	1.55
1994	37	0.95	1.25	1.67	18	0.83	1.00	1.67
1995	40	1.18	1.42	1.62	19	0.89	1.31	1.70
1996	44	0.80	1.06	1.40	21	0.86	1.29	1.38
1997	47	0.85	1.21	1.38	28	1.29	1.50	1.71
1998	51	0.84	1.30	1.48	32	1.19	1.46	1.81
1999	51	1.12	1.36	1.54	39	1.08	1.31	1.68
2000	56	0.84	1.18	1.57	48	1.02	1.36	1.58
2001	58	1.07	1.35	1.63	48	1.02	1.20	1.63
2002	57	1.09	1.29	1.51	53	1.28	1.62	1.89
2003	62	0.94	1.29	1.57	53	1.11	1.37	1.64
2004	60	0.98	1.31	1.48	50	1.28	1.56	1.68
2005	64	0.92	1.26	1.51	56	1.14	1.42	1.60
2006	65	1.06	1.30	1.53	55	1.18	1.41	1.51
2007	71	1.08	1.33	1.54	71	1.10	1.42	1.66
All Years Combined	1,160	0.96	1.25	1.54	695	1.13	1.40	1.65

[1] Yg/OC = young/occupied breeding area with known outcome.

[2] Yg/OCE = young/occupied breeding area with evidence of eggs and known outcome.

[3] Yg/Succ = young/breeding area where outcome was successful.

Appendix 21C. Three measures of productivity for bald eagle breeding areas with known outcome (n) in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007

Year	Watershed							
	Pacific				Snake			
	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]
1978	12	0.92	1.22	1.38	0	-	-	-
1979	19	0.89	1.31	1.55	0	-	-	-
1980	22	0.77	0.94	1.31	0	-	-	-
1981	25	0.84	1.05	1.31	0	-	-	-
1982	24	0.67	0.94	1.33	0	-	-	-
1983	23	0.61	0.78	1.27	0	-	-	-
1984	25	0.88	1.00	1.29	0	-	-	-
1985	30	0.87	1.13	1.44	0	-	-	-
1986	34	0.88	1.03	1.58	0	-	-	-
1987	35	0.80	1.00	1.33	0	-	-	-
1988	39	0.92	1.00	1.44	0	-	-	-
1989	40	0.45	0.72	1.38	0	-	-	-
1990	36	0.83	1.30	1.58	0	-	-	-
1991	40	0.85	1.06	1.42	0	-	-	-
1992	41	0.93	1.09	1.58	0	-	-	-
1993	43	0.81	1.03	1.52	0	-	-	-
1994	42	1.19	1.43	1.61	0	-	-	-
1995	46	0.80	1.06	1.42	0	-	-	-
1996	51	0.82	1.27	1.45	0	-	-	-
1997	55	0.84	1.15	1.44	0	-	-	-
1998	63	0.89	1.19	1.37	0	-	-	-
1999	65	1.03	1.29	1.63	1	1.00	1.00	1.00
2000	68	1.19	1.31	1.69	1	2.00	2.00	2.00
2001	75	1.12	1.31	1.50	1	2.00	2.00	2.00
2002	78	1.10	1.28	1.56	1	1.00	1.00	1.00
2003	79	1.20	1.44	1.67	2	2.00	2.00	2.00
2004	80	0.99	1.27	1.61	2	3.00	3.00	3.00
2005	91	1.10	1.28	1.54	2	1.50	1.50	1.50
2006	87	0.89	1.20	1.60	2	2.00	2.00	2.00
2007	91	1.04	1.28	1.58	3	2.00	2.00	2.00
All Years Combined	1,459	0.95	1.20	1.52	15	1.93	1.93	1.93

[1] Yg/OC = young/occupied breeding area with known outcome.
[2] Yg/OCE = young/occupied breeding area with evidence of eggs and known outcome.
[3] Yg/Succ = young/breeding area where outcome was successful.

Appendix 21D. Three measures of productivity for bald eagle breeding areas with known outcome (n) in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

	Watershed							
Year	Harney				Klamath			
	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]
1978	0	-	-	-	23	0.96	1.10	1.47
1979	0	-	-	-	36	0.92	1.22	1.50
1980	0	-	-	-	37	0.89	1.00	1.74
1981	0	-	-	-	44	0.95	1.05	1.62
1982	0	-	-	-	47	0.70	0.80	1.43
1983	0	-	-	-	49	1.04	1.13	1.65
1984	0	-	-	-	50	0.96	1.04	1.55
1985	0	-	-	-	55	0.91	1.11	1.47
1986	0	-	-	-	59	1.10	1.18	1.51
1987	0	-	-	-	59	0.88	1.04	1.49
1988	0	-	-	-	65	0.91	1.04	1.48
1989	0	-	-	-	63	0.87	1.15	1.49
1990	0	-	-	-	65	0.88	1.08	1.39
1991	1	2.00	2.00	2.00	69	1.04	1.26	1.60
1992	1	2.00	2.00	2.00	71	1.01	1.24	1.71
1993	1	1.00	1.00	1.00	74	0.76	1.04	1.44
1994	1	1.00	1.00	1.00	85	0.88	1.23	1.70
1995	1	0.00	0.00	-	87	1.08	1.31	1.65
1996	1	0.00	0.00	-	93	1.12	1.32	1.65
1997	1	1.00	1.00	1.00	96	1.07	1.29	1.66
1998	1	1.00	1.00	1.00	103	1.09	1.40	1.72
1999	2	1.00	2.00	2.00	107	0.90	1.17	1.60
2000	2	1.00	2.00	2.00	115	1.10	1.33	1.62
2001	2	0.50	1.00	1.00	114	1.01	1.24	1.53
2002	2	0.50	1.00	1.00	117	1.00	1.27	1.54
2003	2	1.00	1.00	2.00	123	0.96	1.23	1.69
2004	2	1.50	1.50	1.50	123	0.98	1.23	1.51
2005	2	1.00	1.00	2.00	118	0.87	1.14	1.43
2006	2	1.00	1.00	1.00	124	0.90	1.25	1.50
2007	3	1.00	1.00	1.50	123	0.90	1.21	1.50
All Years Combined	27	0.96	1.13	1.44	2,394	0.96	1.20	1.57

[1] Yg/OC = young/occupied breeding area with known outcome.

[2] Yg/OCE = young/occupied breeding area with evidence of eggs and known outcome.

[3] Yg/Succ = young/breeding area where outcome was successful.

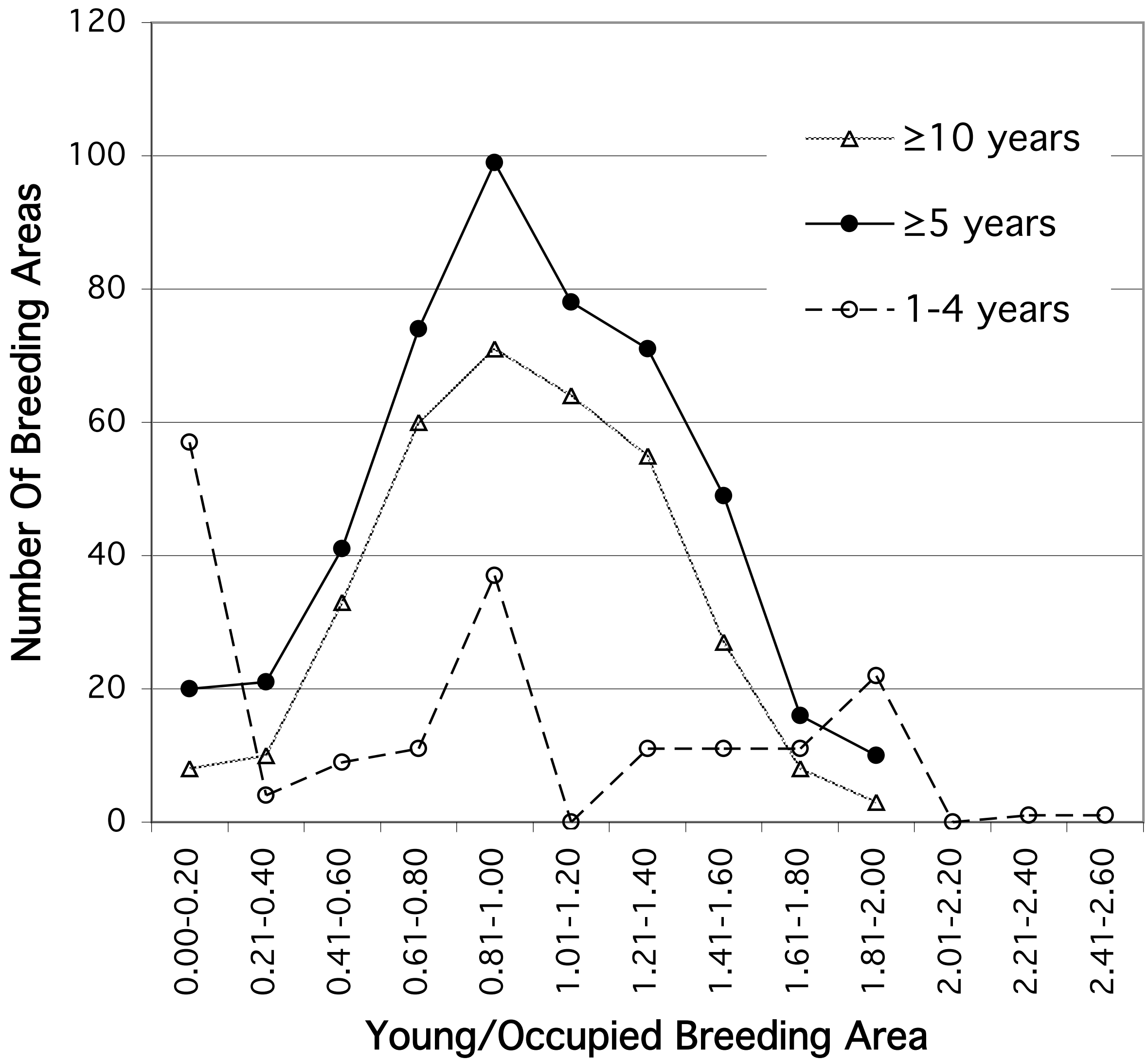
Appendix 21E. Three measures of productivity for bald eagle breeding areas with known outcome (n) in Oregon and along the Washington side of the Columbia River by watershed, 1978-2007.

Year	Watershed: Rogue				Study Area			
	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]	n	Yg/OC[1]	Yg/OCE[2]	Yg/Succ[3]
1978	1	2.00	2.00	2.00	57	1.02	1.32	1.53
1979	1	2.00	2.00	2.00	80	0.91	1.22	1.49
1980	1	0.00	0.00	-	89	0.76	0.93	1.51
1981	1	0.00	0.00	-	103	0.94	1.09	1.56
1982	3	0.33	0.33	1.00	108	0.67	0.83	1.41
1983	5	0.80	0.80	1.33	113	0.82	0.98	1.48
1984	4	1.50	1.50	1.50	120	0.93	1.03	1.48
1985	5	0.80	0.80	1.33	136	0.88	1.10	1.51
1986	4	0.25	0.33	1.00	145	0.97	1.14	1.52
1987	6	0.83	1.00	1.25	155	0.80	0.99	1.46
1988	7	1.57	1.83	1.83	172	0.86	1.01	1.53
1989	9	1.22	1.83	1.83	173	0.77	1.12	1.56
1990	10	0.90	1.13	1.50	177	0.87	1.13	1.41
1991	10	1.00	1.11	1.43	195	0.99	1.18	1.57
1992	12	1.33	1.45	1.60	214	1.00	1.16	1.63
1993	13	1.00	1.18	1.63	225	0.86	1.09	1.50
1994	13	1.00	1.44	2.17	234	0.99	1.27	1.72
1995	15	0.73	1.10	1.38	251	0.94	1.21	1.58
1996	15	0.73	0.92	1.38	278	0.91	1.17	1.49
1997	16	0.75	1.09	1.50	308	0.90	1.16	1.55
1998	16	0.56	0.82	1.50	345	0.94	1.29	1.58
1999	20	0.60	0.86	1.71	365	0.96	1.20	1.59
2000	19	1.05	1.33	1.67	397	1.02	1.30	1.65
2001	20	1.00	1.18	1.43	413	1.02	1.27	1.54
2002	20	1.15	1.28	1.64	427	1.06	1.33	1.61
2003	21	1.10	1.35	1.53	447	1.05	1.33	1.66
2004	24	0.92	1.22	1.69	451	1.03	1.32	1.59
2005	21	1.05	1.10	1.47	488	1.01	1.26	1.54
2006	24	1.00	1.14	1.33	495	1.00	1.28	1.55
2007	25	1.04	1.30	1.73	535	1.08	1.36	1.62
All Years Combined	361	0.95	1.17	1.56	7,696	0.97	1.22	1.57

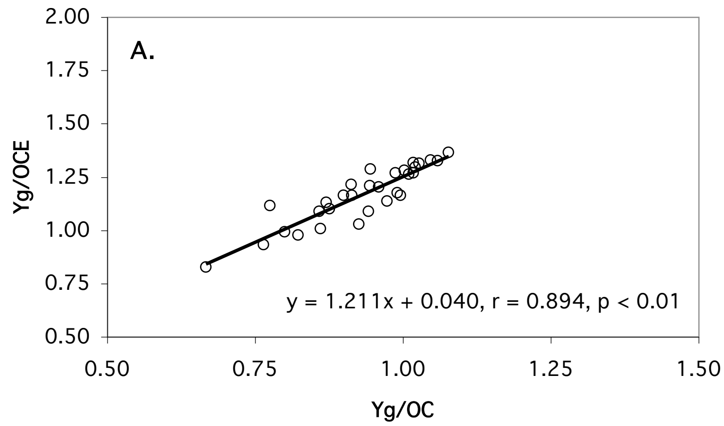
[1] Yg/OC = young/occupied breeding area with known outcome.

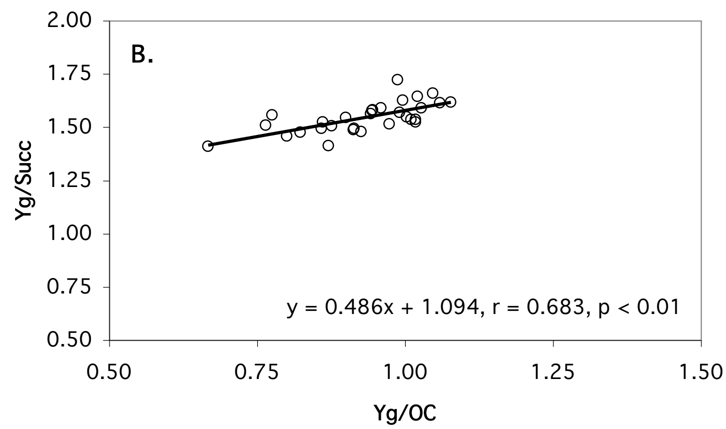
[2] Yg/OCE = young/occupied breeding area with evidence of eggs and known outcome.

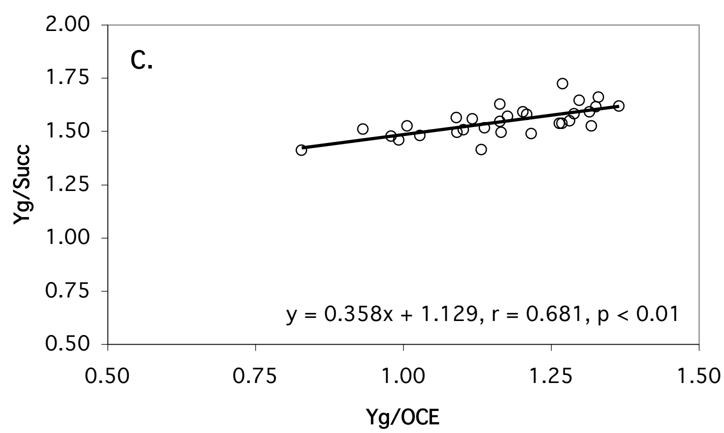
[3] Yg/Succ = young/breeding area where outcome was successful.



Appendix 22. Distribution of breeding areas of bald eagles with 1-4, ≥5 and ≥10 years of known outcome by productivity category in Oregon and along the Washington side of the Columbia River, 1971-2007. Sample sizes were 175, 479, and 339 breeding areas for the 1-4, ≥5 and ≥10 years with known outcome groups, respectively.







Appendix 23. Correlations of Yg/OC and Yg/OCE (A.), Yg/OC and Yg/Succ (B.), and Yg/OCE and Yg/Succ (C.) by year for bald eagle breeding areas in Oregon and along the Washington side of the Columbia River, 1978-2007 (Yg/OC = Young/Occupied Breeding Area With Known Outcome, Yg/OCE = Young/Occupied Breeding Area With Evidence Of Eggs And Known Outcome, and Yg/Succ = Young /Breeding Area Where Known Outcome Was Success).

Appendix 24A. Number of bald eagle nest trees (n = 1,645) by landowner in Oregon and along the Washington side of the Columbia River, 1971-2007. Owyhee watershed is not shown because no nest trees were known there as of 2007.

	Watershed																		Study Area	
	Northeast		Columbia		Deschutes		Willamette		Pacific		Snake		Harney		Klamath		Rogue		Total	
Landowner	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Private[1]	15	48.4	197	47.6	34	15.4	82	49.4	114	38.6	4	100.0	0	0.0	181	40.5	10	15.6	637	38.7
U.S. Forest Service	12	38.7	19	4.6	173	78.3	27	16.3	61	20.7	0	0.0	2	66.7	176	39.4	12	18.8	482	29.3
U.S. Bureau of Land Management	0	0.0	2	0.5	10	4.5	15	9.0	62	21.0	0	0.0	1	33.3	43	9.6	37	57.8	170	10.3
U.S. Fish and Wildlife Service	0	0.0	60	14.5	0	0.0	2	1.2	4	1.4	0	0.0	0	0.0	11	2.5	0	0.0	77	4.7
Oregon Parks and Recreation Department	1	3.2	10	2.4	2	0.9	9	5.4	38	12.9	0	0.0	0	0.0	1	0.2	0	0.0	61	3.7
Counties	0	0.0	13	3.1	0	0.0	5	3.0	4	1.4	0	0.0	0	0.0	17	3.8	2	3.1	41	2.5
Cities	1	3.2	17	4.1	1	0.5	8	4.8	0	0.0	0	0.0	0	0.0	7	1.6	0	0.0	34	2.1
Oregon Department of Forestry	0	0.0	19	4.6	0	0.0	0	0.0	9	3.1	0	0.0	0	0.0	4	0.9	1	1.6	33	2.0
Oregon Department of Fisn and Wildlife	1	3.2	19	4.6	1	0.5	0	0.0	0	0.0	0	0.0	0	0.0	6	1.3	0	0.0	27	1.6
unknown	0	0.0	17	4.1	0	0.0	6	3.6	2	0.7	0	0.0	0	0.0	0	0.0	0	0.0	25	1.5
Washington State Parks	0	0.0	20	4.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	1.2
U.S. Army Corps of Engineers	0	0.0	6	1.4	0	0.0	11	6.6	0	0.0	0	0.0	0	0.0	0	0.0	1	1.6	18	1.1
Washington Department of Fish and Wildlife	0	0.0	9	2.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	0.5
U.S. Coast Guard	0	0.0	3	0.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.2
Oregon Department of Transportation	0	0.0	0	0.0	0	0.0	1	0.6	1	0.3	0	0.0	0	0.0	0	0.0	1	1.6	3	0.2
Washington Department of Natural Resources	0	0.0	2	0.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.1
Oregon Department of State Lands	1	3.2	1	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	2	0.1
U.S. National Park Service	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2	0	0.0	1	0.1
Total	31	100	414	100	221	100	166	100	295	100	4	100	3	100	447	100	64	100	1,645	100

[1] The private category (n = 637) consisted of many different owners including individuals, local businesses, and multinational corporations (96%); and a Native American tribe, power companies, an irrigation district, and a conservation organization (4%).

Appendix 24B. Number of bald eagle breeding areas (n = 662) by landowner in Oregon and along the Washington side of the Columbia River, 1971-2007. Owyhee watershed is not shown because no breeding areas were known there as of 2007.

	Watershed																		Study Area	
	Northeast		Columbia		Deschutes		Willamette		Pacific		Snake		Harney		Klamath		Rogue		Total	
Landowner	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Private[1]	7	43.8	81	46.0	13	16.0	35	41.2	40	36.0	3	100.0	0	0.0	43	27.7	4	12.5	226	34.1
U.S. Forest Service	5	31.3	10	5.7	56	69.1	15	17.6	18	16.2	0	0.0	2	66.7	61	39.4	5	15.6	172	26.0
Multiple[2]	3	18.8	15	8.5	7	8.6	7	8.2	16	14.4	0	0.0	0	0.0	17	11.0	8	25.0	73	11.0
U.S. Bureau of Land Management	0	0.0	0	0.0	2	2.5	9	10.6	18	16.2	0	0.0	1	33.3	22	14.2	14	43.8	66	10.0
U.S. Fish and Wildlife Service	0	0.0	18	10.2	0	0.0	1	1.2	0	0.0	0	0.0	0	0.0	4	2.6	0	0.0	23	3.5
Oregon Parks and Recreation Department	0	0.0	4	2.3	1	1.2	3	3.5	10	9.0	0	0.0	0	0.0	1	0.6	0	0.0	19	2.9
Unknown	0	0.0	11	6.3	0	0.0	5	5.9	2	1.8	0	0.0	0	0.0	0	0.0	0	0.0	18	2.7
Oregon Department of Fisn and Wildlife	1	6.3	11	6.3	1	1.2	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6	0	0.0	14	2.1
Cities	0	0.0	7	4.0	1	1.2	3	3.5	0	0.0	0	0.0	0	0.0	1	0.6	0	0.0	12	1.8
Counties	0	0.0	2	1.1	0	0.0	2	2.4	2	1.8	0	0.0	0	0.0	4	2.6	0	0.0	10	1.5
Oregon Department of Forestry	0	0.0	5	2.8	0	0.0	0	0.0	4	3.6	0	0.0	0	0.0	0	0.0	0	0.0	9	1.4
U.S. Army Corps of Engineers	0	0.0	4	2.3	0	0.0	5	5.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	9	1.4
Washington State Parks	0	0.0	3	1.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.5
Washington Department of Fish and Wildlife	0	0.0	3	1.7	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	3	0.5
Oregon Department of Transportation	0	0.0	0	0.0	0	0.0	0	0.0	1	0.9	0	0.0	0	0.0	0	0.0	1	3.1	2	0.3
U.S. Coast Guard	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
Oregon Department of State Lands	0	0.0	1	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2
U.S. National Park Service	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.6	0	0.0	1	0.2
Total	16	100	176	100	81	100	85	100	111	100	3	100	3	100	155	100	32	100	662	100

1 The Private category (n = 226) consisted of many different owners including individuals, local businesses, and multinational corporations (96%); and a Native American tribe and a conservation organization (4%).

2 The Multiple category included breeding areas where at least two individual nest trees within a breeding area were on land with different owners.