EFFECTS OF FOREST MANAGEMENT PRACTICES ON BALD EAGLES NESTING ON STATE AND PRIVATE LAND IN OREGON

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Effects of forest management practices on bald eagles nesting on state and private land in Oregon

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Abstract

Habitat management for bald eagles (*Haliaeetus leucocephalus*) nesting in Oregon developed in response to laws enacted to counter declining populations. Thirty-seven percent of bald eagle nest trees documented in Oregon from 1971-2002 (n = 1,106) were on state or private (non-federal) land. Many were managed under U.S. Fish and Wildlife Service guidelines prior to 1991, and Oregon Department of Forestry (ODF) Forest Practices Rules (FPRs) from 1991 to 2002. We evaluated FPRs indirectly using data on bald eagle nesting outcomes for 1971-2002, and forestry operations reported in ODF's Forest Activity Computerized Tracking System (FACTS) from 1991-2002.

Nesting parameters for breeding areas on federal vs. non-federal land, non-federal land before vs. after FPRs were implemented, 53 selected non-federal breeding areas before vs. after FPRs were implemented, and non-federal breeding areas west vs. east of the crest of the Cascade Mountains were compared. For breeding areas on federal vs. non-federal land, change in number of breeding areas occupied, percent of breeding areas occupied, patterns of nest tree use, nesting success, and productivity were similar, whereas nest tree changes per year occupied was greater ($P < 0.01$) for breeding areas on non-federal land. For breeding areas on non-federal land before vs. after FPRs were implemented, percent of breeding areas occupied and nesting success were similar, while change in number of breeding areas

occupied and number of eaglets/occupied breeding area were greater ($P < 0.01$) after FPRs were implemented. For 53 non-federal breeding areas before vs. after FPRs were implemented, percent of breeding areas occupied, patterns of nest use, nesting success, and productivity were all similar. The west vs. east comparison resulted in similar statistics on percent of breeding areas occupied, nesting success, and productivity for both areas.

FACTS data on number and extent of operations for 53 non-federal breeding areas correlated with nesting success and productivity produced no statistically significant correlations. However, negative correlations between extent of operations and nesting success ($r = -0.179$) and productivity ($r = -0.251$) were evident and suggested that FPRs may not achieve the goal of avoiding reduced productivity at breeding areas where extent of operations was high.

Commercial timber harvest or road building occurred within 800 m of at least one nest tree in 94-96% of breeding areas ($n = 53$) during 1991-2002, indicating high potential for disturbance of nesting or destruction of habitat. However, our results indicated that disturbance to nesting eagles or destruction of habitat did not occur, and that FPRs achieved the protection goal of preventing resource site destruction, abandonment, or reduced productivity during 1991-2002.

Buffer zone management following minimum U.S. Fish and Wildlife

Service guidelines and FPRs apparently protected many nest trees for at least 10-20 years. Nest tree changes within breeding areas on non-federal land occurred on average every 6-8 years, and distances of moves with nest tree changes within breeding areas averaged 660 m (n = 72) on non-federal land after FPRs were implemented. Distance of moves indicated a need for nesting habitat outside the area protected by current buffer zone management.

Management recommendations include measuring nest tree and forest characteristics at bald eagle nest sites, continued monitoring of nesting bald eagles, quantifying size, location, and timing of forestry operations within 800 m of nest trees, and long-term research on fate of nest trees and unlogged buffers at managed breeding areas. Finally, we recommend maintaining current FPRs for bald eagle nesting resource sites regardless of the state or federal ESA listing status, because of their apparent effectiveness at protecting nest sites and productivity.

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Introduction

Management of bald eagle (*Haliaeetus leucocephalus*) nesting habitat was developed because of declining eagle populations, and in response to federal and state laws enacted to protect the species (see Appendix 1 for a detailed account for Oregon). In general, habitat protection for bald eagle nest trees has followed a strategy suggested by Mathisen et al. (1977), who described concentric buffer zones around nest trees with protective measures specific to each zone: 330 ft (101 m) - no human activity anytime; 330 to 660 ft (101-201 m) - no activity during the nesting season, and limited activity outside that time; 660 to 1,320 ft (201-402 m) - no activity during the nesting season, with no restrictions outside that time; and 1,320 to 2,640 ft (402-805 m) - restrictions during the nesting season if justified. A similar buffer-zone strategy was the basis for federal habitat management guidelines for nest trees in Oregon and Washington (U.S. Department of the Interior 1981), and was recommended as a minimum protective measure for nest trees in the Pacific Bald Eagle Recovery Plan (U.S. Fish and Wildlife Service 1986).

Bald eagles were listed as a "threatened" species in Oregon under the federal Endangered Species Act (ESA) in 1978 (U.S. Department of the Interior 1978) and under the Oregon ESA (Oregon Revised Statutes 496.171-497.182) in 1987. In 1991, the Oregon Board of Forestry (BOF) adopted Forest Practices Rules (FPRs) to protect bald eagle nesting resource sites

on non-federal forest lands in Oregon (Oregon Department of Forestry 2003). Bald eagle nesting resource sites were defined as "...the active nest tree and all identified key components...". An active nest tree was defined as a tree "...in which a bald eagle has nested in the past..." and that is "...structurally capable of successful future use, whether or not the tree still contains a nest." Key Components of a bald eagle nesting site were "...perching and fledging trees, replacement nest trees, and a forested buffer around the nest tree." The critical period of use for bald eagle nesting resource sites was defined as 1 January through 31 August (Oregon Department of Forestry 2003:60) based on nesting phenology (Isaacs et al. 1983).

From 1991 through 2002, forestry operations on non-federal land within 1/2 mile (805 m) of bald eagle nesting resource sites in Oregon were evaluated by Oregon Department of Forestry (ODF) for potential effects on nesting eagles. When warranted, protective measures based on a buffer-zone strategy were applied as prescribed in the Forest Practices Rules (Oregon Department of Forestry 2003). During the same period, data on type, size, and location of forestry operations on non-federal land were collected by ODF in the Forest Activity Computerized Tracking System (FACTS, Oregon Department of Forestry 1998).

The beginning of the first comprehensive survey of the bald eagle nesting population in Oregon (Isaacs et al. 1983) coincided with federal ESA listing in

1978. From 1978-2002, the minimum bald eagle nesting population in Oregon increased in size, expanded in distribution, and nesting success and productivity increased (Authors 1 and 2 unpublished data). A similar trend occurred nationally, resulting in a 1999 proposal by U.S. Fish and Wildlife Service to remove the species from the federal list of threatened and endangered species (U.S. Department of the Interior 1999).

When a species is removed from the list of threatened and endangered species by the U.S. Fish and Wildlife Service (federal list) or the Oregon Fish and Wildlife Commission (state list), the Oregon Board of Forestry must determine whether continued protection of resource sites is warranted, based on the best available information. After 12 years of use, the effectiveness of the Forest Practices Rules had not been evaluated, so we proposed this project to test effectiveness of the rules at protecting bald eagle nesting resource sites on non-federal land in Oregon.

The Oregon Department of Forestry's FACTS database (Authors 3 and 5, unpublished data) and annual bald eagle nest survey results for 1991-2002 (Authors 1 and 2, unpublished data) contained complementary information on forestry operations and bald eagle reproductive success at breeding areas in Oregon. In addition, the annual nest survey results included data collected for 20 years (1971-1990) prior to implementation of FPRs (Authors 1 and 2 unpublished data). Therefore, we developed this project to investigate the effectiveness of Forest Practices Rules at meeting the resource site

protection goal, which was "...to ensure that forest practices do not lead to resource site destruction, abandonment or reduced productivity..." (Oregon Department of Forestry 2003:57).

The primary purpose of the project was to report on observations of nesting bald eagles on non-federal forest lands in Oregon relative to forest management activities, and to evaluate the success of the applied protection levels required by Oregon Administrative Rule 629-665-0220 (Oregon Department of Forestry 2003:60). The objective was to answer the following questions:

1) What were the habitat characteristics of bald eagle nesting resource sites located on state and private (non-federal) forest land?

2) What forest management activities took place within 1/2 mile (805 m) of nest trees?

3) Did the applied protection levels retain the bald eagle nesting resource site and protect it from damage?

4) Did the applied protection levels affect the occupancy or productivity of nesting bald eagles?

5) What were important habitat characteristics associated with successful bald eagle breeding areas in managed forests?

Funding was inadequate to conduct new field work on habitat characteristics or wind throw. We addressed the objectives logically and within budget, but the damage portion of question 3 was not evaluated, and

previously published information was used to address questions 1 and 5. Questions 2 and 4, and the retention portion of question 3 were addressed indirectly using existing data on nesting bald eagles from annual reports on the bald eagle nest survey in Oregon (Authors 1 and 2 unpublished data), and on forestry operations from the FACTS database (Authors 3 and 5 unpublished data).

Study area

Oregon contains 30 million acres (12.1 million ha) of forest land. One million acres (405,000 ha) are managed by the Oregon Department of Forestry, mostly in the Clatsop, Elliot, and Tillamook state forests in western Oregon. Eleven million acres (4.5 million ha) are in private ownership (Campbell et al. 2004). Most state and private forest lands are located in the western one-third of the state, and in many areas are interspersed with federal forest lands (Loy 2001:92). Douglas-fir (*Pseudotsuga menziesii*) - western hemlock (*Tsuga heterophylla*) is the primary forest type in western Oregon, while ponderosa pine (*Pinus ponderosa*) and mixed-conifer (*Pseudotsuga* sp., *Pinus* sp., *Abies* sp., etc.) types predominate in eastern Oregon (Franklin and Dyrness 1973). Bald eagle nest trees occurred in all major forest types (Anthony and Isaacs 1989). Through 2002, 1,106 nest trees had been documented at 427 breeding areas in Oregon; 414 nest trees (37.4%) were on state (n = 28, 2.5%) and private (n = 386; 34.9%) forest land (Authors 1 and 2 unpublished data). Our study focused on bald eagle breeding areas on state and private (non-federal) land, but included comparisons to breeding areas on federal land.

Methods

Terminology

Terminology used to describe the places bald eagles nest can be confusing. Terms using “nest”, “nesting”, or “breeding”, followed by “site”, “territory”, or “area” have been used interchangeably to refer to an area that contains one or more nests and is used by one pair of eagles for breeding. To standardize terminology in studies of breeding eagles, Postupalsky (1983:D3) recommended using the term “breeding area” to describe “...the local area associated with one territorial pair of eagles and containing one or more nest structures.” The Oregon Forest Practices Rules define “nesting territory” as an area “...that contains, or historically contained, one or more nests of a mated pair of birds” (Oregon Department of Forestry 2003:3), which is synonymous with “breeding area” as defined by Postupalsky (1983:D3).

Oregon Forest Practices Rules define resource sites used by threatened and endangered species that are sensitive to forest practices for the purposes of protection. For bald eagle nesting sites, “...the resource site is the active nest tree and all identified key components” (Oregon Department of Forestry 2003:60). “The key components associated with bald eagle nesting are perching and fledging trees, replacement nest trees, and a forested buffer around the nest tree” (Oregon Department of Forestry 2003:60). Our analyses focused on “ active nest trees”. We did not evaluate

other key components of resource sites. We use “nest tree” as a synonym for “active nest tree”, and “breeding area” when referring to an area containing one or more nest trees used by one pair of eagles for breeding. In general, breeding areas are used by mated pairs that are the same individual eagles from year to year; if one of the pair dies, the remaining adult will take a new mate (Stalmaster 1987:45). Consequently, breeding areas may be inhabited by different individual eagles over time.

Nest surveys

Surveys of bald eagle breeding areas in Oregon were conducted annually from February through early August, 1978-2002 (Isaacs et al. 1983, Authors 1 and 2 unpublished data). Nest survey data also included results of surveys conducted by others during 1971-1977 (Authors 1 and 2 unpublished data). Nest survey techniques and terminology were based on Postupalsky (1974, 1983) and Steenhof (1987). Bald eagles and nest trees were observed by air or ground from mid-February through mid-May to determine which breeding areas were occupied by breeding pairs, then from late May through early August to determine nesting success and productivity. Additional monitoring was conducted when possible at breeding areas where status was uncertain. Previously unknown nest trees were added to the inventory list each year, and location and ownership were documented for all nest trees.

Oregon population: federal vs. non-federal ownership

We compared nesting parameters between breeding areas located on federal and non-federal land throughout Oregon to investigate the potential for differences due to perceived but unquantified differences in management strategies. For example, federal managers often protected more than the minimum areas recommended in U.S. Fish and Wildlife Service guidelines, including harvest curtailed or aimed specifically at improving bald eagle habitat, whereas state and private managers usually protected minimum areas recommended in guidelines (Author 1 personal observation).

Breeding areas were categorized by ownership based on nest tree locations. Breeding areas where all nest trees were on land managed by federal agencies were grouped, and breeding areas with all nest trees on private or state (non-federal) land were combined. Federal agencies represented were U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and National Park Service; non-federal owners were private, Oregon Department of Forestry, counties, cities, and Oregon Division of State Lands. Breeding areas with mixed or unclassified ownership were excluded from analyses.

Population size, nest tree use, and reproductive success were used to compare federal and non-federal breeding areas. Population size was characterized by change in number of occupied breeding areas from 1979 to

2002 and percent of breeding areas occupied. Nest tree use was based on frequency and distance of moves between nest trees within breeding areas, 1971-2002. Move distance provided a way to compare changes in nest tree locations within breeding areas to prescribed buffer zones. Eight-hundred meters was chosen as a cutoff distance because most (59%, n = 1,207) nest trees within breeding areas in Oregon were closer than 800 m (Author 1 unpublished data), disturbance of bald eagles from human activities was low beyond that distance (Fraser et al. 1985, McGarigal et al. 1989), that was the maximum buffer distance recommended in regional guidelines (U.S. Department of the Interior 1981, U.S. Fish and Wildlife Service 1986), and FPRs were applied when operations were within 805 m (1/2 mi) of nest trees on non-federal land in Oregon (Oregon Department of Forestry 2003:60).

Breeding areas were categorized by distance between nest trees and history of nesting within the breeding area: 1) STAYED = breeding areas that were consistently occupied and nest trees were ≤ 800 m apart; 2) MOVED = breeding areas that were consistently occupied and nest trees were > 800 m apart; 3) ABANDONED = breeding areas that were occupied, then not occupied for ≥ 3 years; and 4) UNCERTAIN = breeding areas that could not be placed in one of the above categories. Other nest use parameters were nest tree changes per year occupied, average distance of moves with nest tree changes, percent of moves < 100 m, percent of moves 100-800 m, and percent of moves > 800 m. Reproductive success was quantified using

percent of nesting attempts successful (nesting success) and number of eaglets produced per occupied breeding area (productivity) during 1979-2002.

Oregon population: non-federal 1979-1990 vs. non-federal 1991-2002

These analyses included all non-federal breeding areas in Oregon and were used to determine if there were changes in bald eagle nesting parameters after FPRs were implemented. We compared nesting parameters for breeding areas on non-federal land for 12 years before to 12 years after FPRs were implemented (1979-1990 vs. 1991-2002). Change in number of breeding areas occupied, percent of breeding areas occupied, nesting attempts successful, and number of eaglets/occupied breeding area were used to compare 12-year periods.

The non-federal study population: FACTS data

We selected 53 breeding areas on non-federal land for detailed study because each had ≥ 4 years of nesting history, all nest trees were under non-federal ownership, and forestry was assumed to be the primary activity within 800 m of nest trees (Appendix 2). We used nest tree locations within those breeding areas and FACTS data to quantify type and extent of forestry activities that occurred within 800 m of nest trees from 1991-2002.

The FACTS database was developed to catalog forestry operations by type and location, and track progress of projects on non-federal land in Oregon (Oregon Department of Forestry 1998). Locations of operations were recorded by 1/16 section in the Township and Range public land survey system (Loy 2001:18). Type and size of operations, and 1/16 sections included in operations were recorded in the database. The database was not designed to provide the type of spacial information we needed, so four steps were required to summarize data by breeding area and distance from nest trees:

1) Nest tree locations were plotted on U.S. Geological Survey, 7.5-minute quadrangle, topographic maps and used to determine which sections of land were within 800 m of nest trees. One section of land = a surveyed area approximately 1 mile (1,609 m) on a side containing approximately 640 acres (259 ha, Loy 2001:18).

2) The FACTS database was queried for commercial timber harvest and road building operations that occurred within sections selected in step one. Types of commercial timber harvest were commercial thinning, selective cutting, clear cuts, overstory removal, shelterwood, seed-tree harvest, windstorm salvage, cedar salvage, hauling right-of-way clearing, chipping, hog-fuel production, and commercial firewood cutting.

3) Geographic information system software (ArcView 3.2 by Environmental Systems Research Institute and the "Make 1/4 Sections" script by R. Henszey) was used to delineate 1/16 sections for all sections of land within 800 m of nest trees, and select all 1/16 sections with centers within 800 m of nest trees. That procedure resulted in a range of 9 to 66 1/16 sections selected for breeding areas. The range was due to variable nest tree locations, and number and distribution of nest trees at

breeding areas (Figure 1). When nest trees were less than 1600 m apart, the same, overlapping 1/16 sections were selected for different nest trees. Overlapping 1/16 sections within breeding areas with more than one nest tree were counted only once for the breeding area to avoid double sampling. Overlapping 1/16 sections between adjacent breeding areas were counted once for each breeding area. The 800-m radius area was chosen because that approximated the 1/2-mile (805 m) distance at which FPRs were implemented (Oregon Department of Forestry 2003:60).

4) Finally, we determined the number of 1/16 sections with centers within 800 m of nest trees that had forestry operations, and the total number of operations per breeding area. Because the number of 1/16 sections varied by breeding area, we used the proportion of 1/16 sections with operations (proportion of 1/16 sections with operations = number of 1/16 sections with operations ÷ number of 1/16 sections selected), and the number of operations per 1/16 section (number of operations per 1/16 section = number of operations ÷ number of 1/16 sections) as response variables for each breeding area.

FACTS data was non-spatial; even though a 1/16 section was listed as included in an operation, there was no indication of how much of the 1/16 section was impacted by the operation. Also, when multiple types of operations were listed with multiple 1/16 sections, we could not determine which types of operations occurred in each 1/16 section. In addition, timing of operations could not be determined precisely, because operators had several years to complete work, and actual completion dates were not reported.

Commercial timber harvest and road building were used as selection criteria in step two. Even though we usually could determine if either

occurred in an operation, we could not be certain if the activity was within the 1/16 sections with centers within 800 m of nest trees. In addition, we could not determine the extent of harvest or road building because they were quantified by operation rather than by 1/16 section, and operations usually involved several 1/16 sections that may or may not have been selected as within 800 m of nest trees. Consequently, commercial harvest and road building were quantified as “yes”, “maybe”, or “no” for each breeding area studied (Appendix 2 Figure 1).

The breeding areas studied by Arnett et al. (2001) were not included in our analyses of FACTS data because protection of bald eagle nest trees during that operation was accomplished by an ODF approved alternate plan which deviated from the protection standards prescribed in OAR 629-665-0220. The results of our study refer to breeding areas where the protection standards prescribed by OAR 629-665-0220 were applied to many operations located throughout the state on land owned by the state and many different private landowners.

Linear regression was used to determine correlations between nesting parameters and extent and number of operations cataloged for 1991-2002 and within 800 m of nest trees. Nesting parameters were percent of years occupied, percent of nesting attempts successful, and number of eaglets produced/year; response variables were proportion of 1/16 sections with operations and number of operations per 1/16 section.

The non-federal study population: 1979-1990 vs. 1991-2002

These analyses were used to determine if there were changes in bald eagle nesting parameters after FPRs were implemented at 53 breeding areas that comprised the non-federal study population. We compared nesting parameters for 12 years before FPRs to 12 years after FPRs were implemented (1979-1990 vs. 1991-2002). Percent of breeding areas occupied, nest tree changes/year occupied, average distance of moves, distance of moves by three distance categories, nesting attempts successful, and number of eaglets/occupied breeding area were used to compare 12-year periods.

The non-federal study population: west vs. east

In general, forest types and commercial timber harvest practices in Oregon differed by location west or east of the crest of the Cascade Mountains. West side forests where bald eagles occur were dominated by Douglas-fir, and clearcutting was the primary tree harvest technique. Ponderosa pine was the dominant tree species in bald eagle habitat in east-side forests that were usually selectively harvested. We divided breeding areas in the non-federal study population by geographic location east or west of the crest of the Cascade Mountains, then compared bald eagle nesting parameters between the regions to look for evidence of differences related

to harvest technique or forest type. Parameters tested were percent of breeding areas occupied, percent of nesting attempts successful, and number of eaglets/year occupied.

Statistical analyses

Simple Chi-Square tests were used to test for differences in nesting parameters between groups. Student's T-Test was used to test for differences in distances of moves between groups. Linear Regression and Pearson' Correlation were used to describe and test significance of correlations. Program STATsimple version 2.0.5, copyright 1997-99, Chris Pereira, Nidus Technologies was used for statistical calculations. Statistical differences in parameters were considered significant at $P < 0.05$.

Results

Oregon population: federal vs. non-federal ownership

The federal ownership group (n = 208) consisted of breeding areas on U.S. Forest Service (n = 143), Bureau of Land Management (n = 53), USFWS (n = 6), U.S. Army Corps of Engineers (n = 5), and National Park Service (n = 1). The non-federal group (n = 155) consisted of breeding areas on private (n = 128), ODF (n = 11), counties (n = 7), cities (n = 7), Oregon Division of State Lands (n = 1), and ODF + private (n = 1).

Bald eagle population size, nest tree use, and reproductive success on federal and non-federal ownership were similar (Table 1). Change in number of breeding areas from 1979 to 2002 was 371% for federal and 372% for non-federal; breeding area occupation for the same period was 95% for federal and 92% for non-federal; the pattern of nest tree use was similar for federal and non-federal breeding areas ($P > 0.50$); average distance of moves was 640 m for FED and 616 m for non-federal; moves by distance category were similar ($P > 0.50$); rate of nesting success was 61% for federal and 63% for non-federal; and number of eaglets produced per occupied breeding area was 0.95 for federal and 1.00 for non-federal. The only statistically significant difference was in number of nest tree changes per year occupied, which was 0.11 at federal breeding areas and 0.16 at non-federal breeding areas ($P > 0.01$).

Oregon population: non-federal 1979-1990 vs. non-federal 1991-2002

Two of four bald eagle nesting parameters were significantly different statistically for the 12-year periods before and after FPRs were implemented (Table 2). Population increase was 72% for 1979-1990 and 163% for 1991-2002 ($P < 0.01$), and number of eagles produced per occupied breeding area was 0.88 during 1979-1990 and 1.06 for 1991-2002 ($P < 0.01$). Proportion of breeding areas occupied (92% for 1979-1990 vs. 93% for 1991-2002, $P > 0.50$) and proportion of nesting attempts successful (59% for 1979-1990 vs. 64% for 1991-2002, $0.25 > P > 0.10$) were slightly greater after FPRs were implemented, but differences were not statistically significant.

The non-federal study population: FACTS data

Fifty-three non-federal breeding areas met criteria indicating that the primary human activities within 800 m of nest trees were forestry operations conducted under FPRs for bald eagle resource sites (Appendix 2). FACTS statistics provided a general description of forestry operations around nest trees during 1991 to 2002 (Appendix 2 Figure 1). The average number of 1/16 sections with centers within 800 m of nest trees was 19 (range 11 - 40, SD = 7) per breeding area. Mean number of 1/16 sections with operations per breeding area was 10 (range 0 - 29.0, SD = 6), and the mean proportion of 1/16 sections with operations was 0.55 (range 0.00 -

1.00, SD = 0.28). Mean number of operations per breeding area was 26 (range 0 - 107, SD = 22), and average number of operations per 1/16 section was 1.37 (range 0.00 - 5.29, SD = 1.06). Commercial timber harvest occurred at 85 to 91% of breeding areas (n = 53; 45 yes, 3 maybe, 5 no) and road building at 34 to 59% (n = 53; 18 yes, 13 maybe, 22 no). Ninety-four to ninety-six percent of breeding areas (n = 53) had at least one operation within 800 m of at least one nest tree during 1991-2002 (Appendix 2 Figure 1).

There were no statistically significant correlations between number and extent of forest operations within 800 m of nest trees and bald eagle nesting parameters for 53 non-federal breeding areas (Table 3). Percent of years occupied had a low positive correlation with proportion of 1/16 sections with operations ($r = +0.054$, $P = > 0.50$) and a low negative correlation with number of operations per 1/16 section ($r = -0.090$, $P = > 0.50$). Percent of nesting attempts successful was negatively correlated with proportion of 1/16 sections with operations ($r = -0.179$, $0.20 > P > 0.10$) and number of operations per 1/16 section ($r = -0.061$, $P = > 0.50$). Number of eaglets produced per year occupied was negatively correlated with proportion of 1/16 sections with operations ($r = -0.251$, $P = 0.067$) and number of operations per 1/16 section ($r = -0.071$, $P = > 0.50$). Even though no correlations were statistically significant at $P < 0.05$, percent of nesting attempts successful, and number of eaglets produced per occupied breeding

area had relatively high negative correlations with mean proportion of 1/16 sections with operations, r = -0.179 and r = -0.254, respectively (Figure 2).

The non-federal study population: 1979-1990 vs. 1991-2002

Six parameters of bald eagle nesting activity measured for 53 breeding areas on non-federal land were similar for 12-year periods before and after FPRs were implemented (Table 4). Proportion of breeding areas occupied (94% before vs. 96% after, $P > 0.50$), nest tree changes per year occupied (0.10 before and 0.14 after, $P > 0.50$), average distance of moves between nest trees within breeding areas (484 m before and 660 m after, $0.50 > P > 0.20$), and number of eaglets produced per occupied breeding area (0.98 before and 1.04 after, $0.50 > P > 0.25$) were all greater after FPRs were implemented, but none of the differences were statistically significant. Proportion of nesting attempts successful was greater before FPRs (66% before vs. 64% after), but that difference also was not statistically significant ($P > 0.50$).

The non-federal study population: west vs. east

When the 53 non-federal breeding areas used in the FACTS analyses were divided into groups based on location; 34 (64%) were located west of the Cascades and 19 (36%) were east. There were no statistically significant differences between west and east breeding areas for three nesting

parameters (Table 5). Proportion of breeding areas occupied was greater for breeding areas west of the Cascades (98% west vs. 92% east, $0.50 > P > 0.25$). Proportion of nesting attempts successful (62% west vs. 69% east, $0.50 > P > 0.25$), and number of eaglets produced per occupied breeding area (0.99 west vs. 1.03 east, $0.25 > P > 0.10$) were greater for eastern breeding areas.

Discussion

Our objective was to answer the five questions listed in the Introduction. The discussion addresses those questions in the order they were posed, followed by a section on buffer zones, frequency of nest changes, and distance of moves with nest changes.

1) What were the habitat characteristics of bald eagle nesting resource sites located on state and private forest land?

This question was not addressed directly because funds were inadequate for conducting new field work on habitat characteristics. Past research on the subject (Anthony and Isaacs 1989) provided minimum nest tree and forest stand characteristics for bald eagle breeding areas based on measurements taken of nest trees and the surrounding 100-m radius area for 41 nest trees in the Douglas-fir forest type, 89 in mixed conifer, and 53 in ponderosa pine (Table 6). Nest trees and surrounding stands measured in that study were located on federal, state and private land, but ownership was not distinguished. Nest trees also were in altered and unaltered habitat. Altered breeding areas were changed by forest management after the nest was built and before they were sampled; unaltered breeding areas were unchanged between nest construction and sampling. Consequently, the suggested characteristics were described as minimums because they represented a compromise between altered and unaltered habitat. Similar

nest tree and forest stand characteristics were reported for the ponderosa pine forest type in California, and for the Douglas-fir type in Washington (Anthony et al. 1982).

2) What forest management activities took place within 1/2 mile (805 m) of nest trees?

Results from analyses of data from FACTS showed that commercial timber harvest occurred within 800 m of at least one nest tree at 85-91% of breeding areas (n = 53), and that road building occurred within 800 m of at least one nest tree at 34-59% of breeding areas (n = 53) during 1991-2002. When combined, commercial timber harvest or road building occurred within 800 m of at least one nest tree at 94-96% of non-federal breeding areas (n = 53) during 1991-2002 (Appendix 2 Figure 1). Those results show the high amount of forestry-related human activity that occurred within 800 m of bald eagle nest trees, and implied that there was high potential for habitat destruction or disturbance during nesting if FPRs had not been applied.

The amount of forestry activity that occurred within 800 m of nest trees was represented by the proportion of 1/16 sections with operations, and number of operations per 1/16 section derived from FACTS (Appendix 2 Figure 1). There were no statistically significant correlations between those two parameters of forestry activity and three parameters of bald eagle

nesting activity (Table 3). However, there were negative correlations between proportion of 1/16 sections with operations and percent of nesting attempts successful (Figure 2a), and proportion of 1/16 sections with operations and number of eaglets produced per year occupied (Figure 2b) that may have had biological significance. Those results indicated that bald eagle nesting success and productivity declined as the proportion of 1/16 sections with forestry operations within 800 m of nest trees increased.

Proportion of 1/16 sections with operations quantified the amount of area around nest trees that was impacted by operations, whereas the number of operations per 1/16 section may or may not have been related to area. For example, number of operations could have been high and impacted a small area, or low and impacted a large area. Consequently, proportion of 1/16 sections with operations probably was a better indicator of cumulative impacts of commercial timber harvest and road building around nest trees than number of operations per 1/16 section.

Biological significance of these results is indicated because both nesting success (Figure 2a) and productivity (Figure 2b) were above recovery goals (U.S. Fish and Wildlife Service 1986:27) at low proportion of 1/16 sections with operations and below recovery goals at high proportions. Unfortunately, due to limitations in the FACTS data, we could not further elaborate on details of operation type, size, location, or timing. Any of those factors alone or in combination could have contributed to reduced nesting success

and productivity.

Breeding attempts by bald eagles can fail for a variety of reasons, and causes of nesting failure are difficult to determine (Anthony et al. 1994). However, the negative correlations between nesting success and productivity, and proportion of 1/16 sections with operations may have been the result of forestry activities rather than other factors, because the 53 non-federal breeding areas studied were widely distributed, had four or more years of nesting history, and were located in areas where forestry was probably the primary human activity within 800 m of nest trees. Those qualities probably reduced the effects of local and annual causes of breeding failure such as weather, prey availability, contaminants, inter- and intra-specific competition, and infertility or mortality of breeding adults. Also, the cumulative effects of forestry activities within 800 m of nest trees could indirectly result in reduced nesting success and productivity by providing increased exposure to human activities unrelated to forestry but possible because of increased logging roads and reduced vegetative screening of nest trees.

Similar results were reported by Anthony and Isaacs (1989), who found a negative correlation between bald eagle productivity and proximity to clearcuts and main logging roads for breeding areas in Oregon. That study was conducted during 1978-1982 when USFWS guidelines were in place (U.S. Department of the Interior 1981), and before FPRs were implemented.

3) Did the applied protection levels retain the bald eagle nesting resource site and protect it from damage?

Direct measurement of bald eagle nesting resource sites and the damage they might have sustained from forestry operations were beyond the scope of this study (see Introduction last paragraph). Instead, we used indirect evidence from annual bald eagle nest surveys to address the retention part of the question.

Parameters of population size, breeding area occupation, and breeding area abandonment were used as indicators of breeding area retention. Statewide, change in number of breeding areas occupied and percent of breeding areas occupied were similar for federal vs. non-federal ownership for 1979-2002 (Table 1). For all non-federal breeding areas before vs. after FPRs, change in number of breeding areas occupied was significantly greater after FPRs ($P < 0.01$), while percent of breeding areas occupied were not significantly different (Table 2). Also, there was no significant difference between percent of breeding areas occupied for the 53 breeding areas in the non-federal study population before vs. after FPRs were implemented (Table 4). Finally, only 2 of 53 (4%) non-federal breeding areas may have been abandoned (Author 1 unpublished data); one of those (Combs Flat) had no operations within 800 m of the nest tree, and it is not known for certain

whether the breeding areas were abandoned or the pairs moved to new nest trees at undiscovered locations. Assuming both breeding areas were abandoned, the 4% non-federal abandonment rate during 12 years of FPRs was similar to 3% (n = 201) at federal breeding areas, and less than 6% (n = 146) for non-federal breeding areas over 24 years (Table 1). Consequently, there was no evidence that breeding area retention was reduced on non-federal land during the period studied.

Nest tree changes and distance of moves with nest tree changes were examined to address the question of nest tree retention. Parameters of nest tree use and distance of moves at federal vs. non-federal breeding areas were similar, except for a significantly greater ($P < 0.01$) rate of nest tree changes/year occupied at non-federal breeding areas (Table 1). There were no significant differences in patterns of use or distance of moves for the non-federal study population before vs. after FPRs were implemented (Table 4).

Bald eagles change nests within breeding areas for a variety of reasons. Destruction of the previously used nest by natural or human causes are the most obvious reasons for change. Other possible reasons for change include new individuals in breeding pairs, interactions with neighboring bald eagle breeding pairs, local patterns of human activity, shifts in prey distribution, to avoid parasites in previously used nests, to fulfill nestbuilding urges, or territory advertisement (Stalmaster 1987:55). Consequently, the biological

significance of the greater rate of nest tree changes/year occupied at non-federal breeding areas statewide is unknown, and could result from factors other than timber harvest operations.

Bald eagles live a long time; up to 47 years in captivity (Stalmaster 1987:22), and at least 28 years in the wild (Schempf 1997). They also exhibit strong breeding area fidelity (Jenkins and Jackman 1993). In Oregon, nesting pairs have persisted in using breeding areas even after significant changes to nesting habitat occurred, e.g., the Twilight nest tree was first reported in 1976 when it was clearcut around; the tree died in 1980; was used for nesting until 1992; and blew down in 1993 (Authors 1 and 2 unpublished data). In addition, individual bald eagle nests can last for decades (Stalmaster 1987:54). Several nests in Oregon first documented in 1971 were still present 31 years later (Authors 1 and 2 unpublished data). Therefore, even though we found no evidence that breeding areas or nest trees were not being retained on non-federal land, the 12 years that FPRs have been used may not be a long enough time period for problems to become evident.

4) Did the applied protection levels affect the occupancy or productivity of nesting bald eagles?

Occupancy and productivity were examined using data on percent of breeding areas occupied, percent of nesting attempts successful, and

number of eaglets/occupied breeding area. There were no significant differences in those parameters for bald eagle breeding areas on federal land vs. non-federal land (Table 1). Thus, perceived but unquantified differences in management strategies between the federal and non-federal groups were nonexistent or biologically insignificant for the parameters tested.

Two of four nesting parameters changed significantly for all non-federal breeding areas before vs. after FPRs were implemented. Change in number of breeding areas occupied increased from 72% before FPRs to 163% after ($P < 0.01$), and number of eaglets produced/occupied breeding area increased from 0.88 before to 1.06 after FPRs were implemented ($P < 0.01$, Table 2). These results suggest that FPRs had a positive effect on population increase and reproductive success on non-federal land, but the magnitude of that effect is unknown because the size and reproductive success of the statewide population increased concurrently (Authors 1 and 2 unpublished data).

There were no significant differences in occupancy or productivity for 12-year periods before and after FPRs were implemented (Table 4), or based on breeding area location west or east of the crest of the Cascade Mountains (Table 5) for the non-federal study population. These results suggest that FPRs, or different types of forest management due to location west vs. east of the Cascades had no discernible effect on bald eagle

population size or reproductive success.

Overall, occupancy and productivity at bald eagle breeding areas improved after FPRs were implemented. It is not known if protection levels caused those increases because a similar trend occurred statewide (Authors 1 and 2 unpublished data). If FPRs had been ineffective, then occupancy and productivity rates probably would have decreased because of the high potential for nest tree destruction and nesting disturbance implied by the FACTS results.

5) What were important habitat characteristics associated with successful bald eagle breeding areas in managed forests?

Funding was inadequate to conduct new research on this topic. See the answer to question one for the best available information on site-specific habitat characteristics.

Two previous studies evaluated bald eagle nesting success in relation to forest management activities in Oregon. Anderson (1985) described the integration of commercial forest management and site-specific planning for bald eagle breeding areas on Weyerhaeuser Company lands in Oregon and Washington from 1971-1984. Arnett et al. (2001) reported on the effects of selective timber harvest on bald eagles nesting along the west side of Klamath Lake seven years after the project was completed. Both studies involved a relatively small area with a single private landowner, and a dense,

contiguous eagle population. Anderson's (1985) work occurred prior to the implementation of FPRs, while the project described by Arnett et al. (2001) was conducted under an ODF approved plan that allowed for alternate practices which provided for equal or better results than those prescribed by OAR 629-665-0220. The goal of that operation was to stop tree mortality due to drought, insects, and disease, and reduce fire hazard while retaining as much bald eagle nesting habitat as possible. Results of both studies suggested that carefully-planned and properly-timed selective timber harvest with multiple objectives, including providing nesting habitat for eagles, did not harm the eagle nesting population. Neither paper included specific habitat characteristics for breeding areas, and both covered relatively short time periods.

Buffer zones, frequency of nest changes, and distance of moves with nest changes

Several factors affect bald eagle use of nesting habitat in breeding areas. Long life span of eagles, persistence of nests, and breeding area fidelity result in breeding areas being occupied for many years; probably indefinitely as long as adult bald eagles, adequate food, and suitable nest trees exist. These factors probably explain why nesting pairs continued to use nest trees after major changes occurred in surrounding forest habitat in Oregon (Author 1 personal observation).

Some habitat changes in breeding areas can affect the location of nest trees. Wind throw, fire, disease, insects, and timber harvest can destroy nest trees, but not result in breeding area abandonment, if replacement nest trees are available. Under those circumstances, eagles usually build a new nest in another suitable nest tree in the breeding area.

Habitat management strategies based on buffer zones have been used extensively for nesting bald eagles in Oregon because of the emphasis on buffer zone management in USFWS guidelines (U.S. Department of the Interior 1981) and Oregon Department of Forestry's Forest Practices Rules (Oregon Department of Forestry 2003). Even though evaluation of buffer zones was not mentioned in the objectives, the topic is closely related to nest tree and breeding area protection and deserves discussion.

Minimum habitat protection advised under USFWS guidelines is a 330-foot (101-m) radius area (buffer zone) around nest trees (U.S. Department of the Interior 1981). FPRs recommend a forested buffer that protects a nest tree from wind throw. As far as we know, no forested buffers > 200-m radius were utilized by non-federal operators, and most were 150 m or less (Authors 1 and 3 unpublished data).

Nest changes occurred at a rate of 0.16 per year occupied at all non-federal breeding areas, 1971-2002 (Table 1), and 0.14 per year in the non-federal study population after FPRs were implemented (Table 4). Distance of moves associated with those nest changes averaged 616 m (n = 270, SD =

825 m, Table 1) and 660 m (n = 72, SD = 1,024 m, Table 4), respectively. Seventy-seven percent of moves (n = 270) at all non-federal breeding areas were > 100 m (Table 1) and 66% of moves (n = 72) in the non-federal study population after FPRs were implemented were > 100 m (Table 4). These data indicate that bald eagle pairs changed nest trees within breeding areas every 6-8 years and that most moves were greater than 100 m.

Changes that have occurred over 25-32 years at breeding areas in Oregon provide a relatively long-term view of nest loss and cumulative distance of moves within breeding areas; 84% (n = 61) of nests known on non-federal land in Oregon during 1971-1978 were absent in 2002, and the average distance moved between the 1970s nest tree and the 2002 nest tree was 822 m (n = 31, SD 1,037; Author 1 unpublished data).

Management implications and recommendations

Characteristics of bald eagle nesting habitat

Questions one and five of our objectives asked for descriptions of habitat characteristics of bald eagle breeding areas on non-federal forest land, and for important habitat characteristics associated with successful breeding areas in managed forests. Funding was inadequate to conduct new research on either topic. Published research was limited to one study covering 1979-1982 (Anthony and Isaacs 1989). Since then, the nesting population has increased in size and expanded in distribution (Authors 1 and 2 unpublished data), and there has been much forest management within 800 m of bald eagle nest trees (Author 1 personal observation). New research on characteristics of bald eagle nesting habitat in relation to forest management in Oregon would provide resource managers with valuable information for future habitat management for the species.

Forest management activities within 800 m of non-federal nest trees, nest tree retention and protection, and occupancy and productivity of nesting bald eagles

Ninety-four to ninety-six percent of bald eagle breeding areas on non-federal land (n = 53) had logging or roadbuilding within 800 m during 1991-2002 (Appendix 2 Table 1), indicating high potential for habitat destruction or nesting disturbance by forestry operations if they had not been regulated

by FPRs. Despite the high potential for destruction and disturbance, our results indicate that FPRs apparently were effective at protecting nest trees, and avoiding reduced nesting success and productivity during the 12 years studied. However, there were negative correlations between nesting success and productivity and amount of area within 800 m of nest trees at breeding areas impacted by operations that may have had biological significance, even though they were not statistically significant (Figures 2a and 2b). Those results indicated that the cumulative effects of numerous forestry activities within 800 m of nest trees resulted in reduced nesting success and productivity at some breeding areas, even when FPRs were applied during each individual operation. Cumulative effects of operations within 800 m of nest trees on nesting success and productivity should be studied for their long-term consequences.

Frequency of nest changes, distance of moves, and buffer zones

The rate of nest tree changes and distances moved between nest trees within breeding areas, both sequentially and cumulatively, indicate that new trees are often outside of recommended buffer zones around existing nest trees. Replacement nest trees outside buffer zones are not addressed by FPRs because protecting existing nest trees is their primary goal. The long-term consequence of nest tree selection outside of protected areas is unknown, but may be important to consider, especially where nesting habitat

is limited. Long-term changes in nest tree locations in breeding areas should be evaluated by continued tracking of nest tree locations and annual monitoring of nesting outcome at breeding areas.

Forest Activity Computerized Tracking System (FACTS)

The Oregon Department of Forestry FACTS database provided basic information on forestry activities within 1/2 mile (805 m) of bald eagle nest trees, but its usefulness was limited because it was non-spatial and did not include specific information on where, when, and how FPRs were applied. Much of that information may have been available in site-specific written plans, but gathering, summarizing and analyzing that information was beyond the scope of this study. The FACTS database would be more useful for evaluating effects on nesting bald eagles if operations were accurately mapped, actual dates of operations were specified, and records included details on how operations were modified to fulfill FPRs. We recommend research to determine specifically where bald eagle protection was applied, and to quantify conditions of the retained area immediately after operations, compared to conditions at the time of future study. Conditions to consider include health, vigor, and mortality rates of nest trees and other retained trees, and kind and extent of damage to trees in buffer zones.

Forest Practices Rules for bald eagle nest trees

Bald eagle nest trees are a key component of bald eagle resource sites that are sensitive to forest practices, and 37% of all bald eagle nest trees documented in Oregon through 2002 were located on non-federal lands subject to Oregon Department of Forestry's Forest Practices Rules. FPRs have been effective at protecting nest trees from destruction or abandonment and reducing disturbance to nesting bald eagles. Consequently, the administration and implementation of FPRs for bald eagle nest trees are essential for maintaining bald eagle conservation efforts on non-federal forest lands in Oregon. Therefore, we recommend that FPRs for bald eagle nest trees be maintained regardless of the federal or state ESA listing status of the species.

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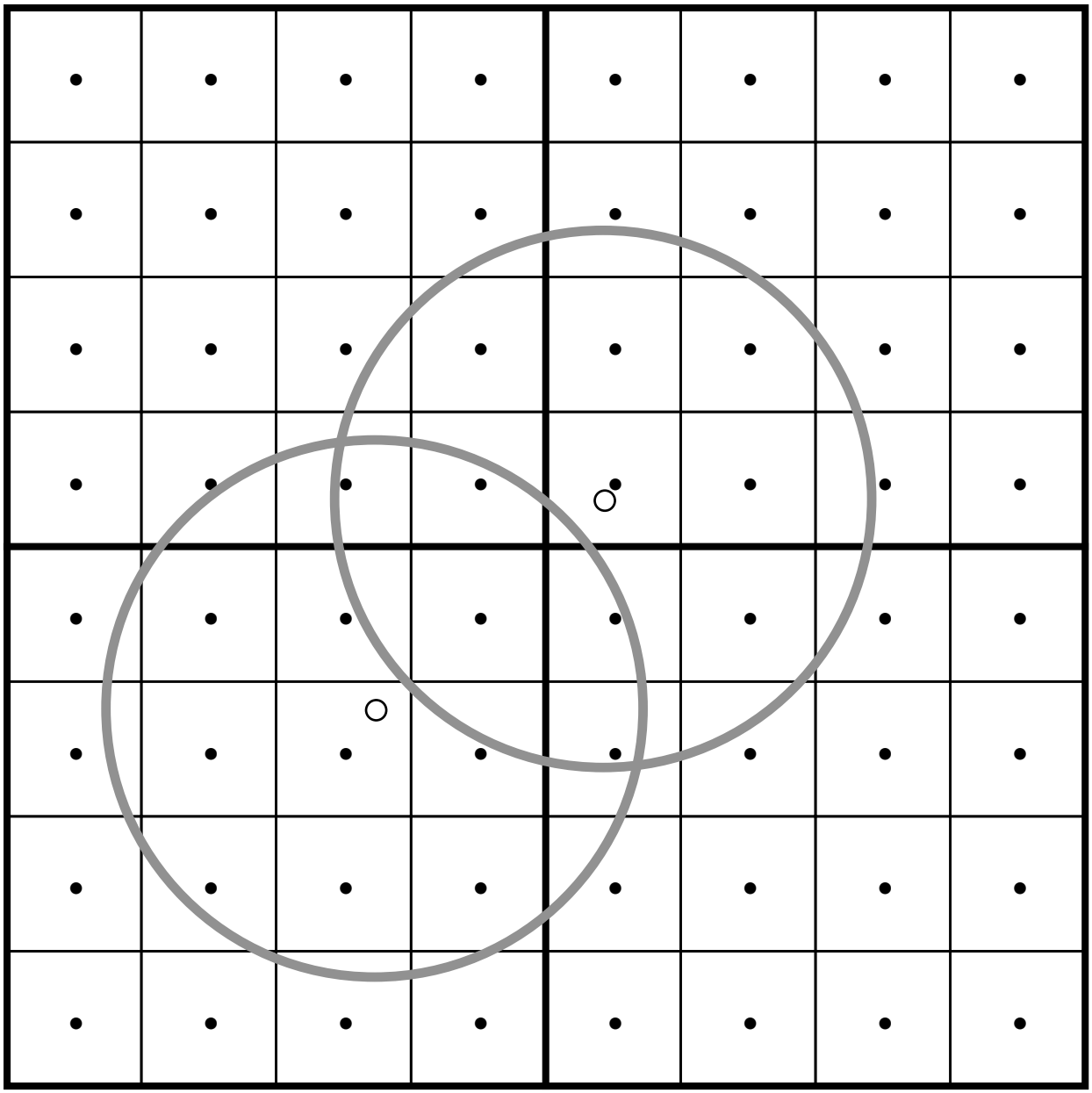

Figure 1. Grid representing 4, approximately 1-mile square (259.0 ha) sections of land as they would appear in the Township and Range public land survey system (Loy 2001:18). Each section is divided into 16, approximately 40-acre (16.2 ha) parcels. Centers of 1/16 sections are shown by black dots. Nest tree locations are small open circles. Boundaries 800 m from nest trees are shown by large open circles.

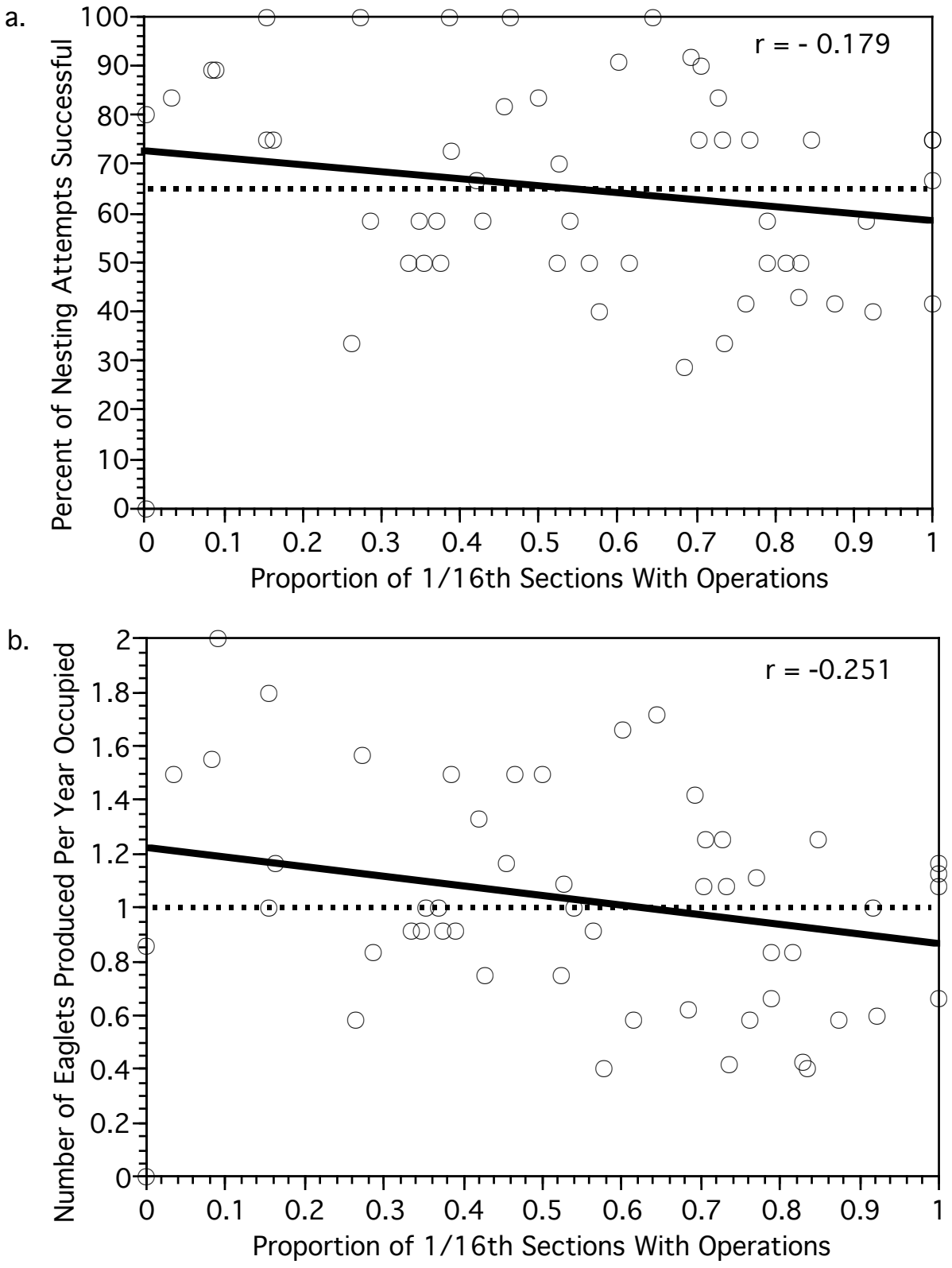

Figure 2. Linear correlations of nesting success (a.) and productivity (b.) of bald eagles with proportion of 1/16 sections with operations within 800 m of nest trees at 53 breeding areas on non-federal land in Oregon, 1991- 2002. Dotted lines represent recovery goals (U.S. Fish and Wildlife Service 1986:27).

Table 1. Population size, nest tree use, and nesting outcome for bald eagle breeding areas on federal and non-federal land in Oregon.
* = difference significant at P < 0.05.

Parameter	Federal		Non-federal		Statistical Test Results
Population Size 1979-2002					
Number of Breeding Areas Occupied 1979	41		29		
Number of Breeding Areas Occupied 2002	193		137		
Change in Number of Breeding Areas Occupied	371%		372%		df = 1, X^2 = 0.002, P > 0.50
Percent of Breeding Areas Occupied	95	n = 2662	92	n = 1674	df = 1, X^2 = 0.974, 0.50 > P > 0.25
Nest Tree Use 1971-2002					
Stayed (Alternate Nests Within 800 m)	73%	n = 201	69%	n = 146	
Moved (Alternate Nests Beyond 800 m)	17%	n = 201	19%	n = 146	
Abandoned	3%	n = 201	6%	n = 146	
Uncertain	7%	n = 201	6%	n = 146	df = 7, X^2 = 2.259, P > 0.50
Nest Tree Changes Per Year Occupied	0.11	n = 2601	0.16	n = 1542 *	df = 1, X^2 = 14.504, P < 0.01
Average Distance of Moves (m)	640 (SD = 898)	n = 336	616 (SD = 825)	n = 270	df = 604, t = 0.332, P > 0.50
Moves < 100 m	19%	n = 336	23%	n = 270	
Moves 100-800 m	56%	n = 336	57%	n = 270	
Moves > 800 m	25%	n = 336	20%	n = 270	df = 5, X^2 = 2.783, P > 0.50
Reproductive Success 1979-2002					
Nesting Attempts Successful	61%	n = 2433	63%	n = 1480	df = 1, X^2 = 0.246, P > 0.50
Number of Eaglets/Occupied Breeding Area	0.95	n = 2433	1.00	n = 1480	df = 1, X^2 = 2.194, 0.25 > P > 0.10

Table 2. Population size and nesting outcome for bald eagle breeding areas on non-federal land in Oregon before and after Forest Protection Rules (FPRs) for bald eagle resource sites were implemented by Oregon Department of Forestry. * = difference significant at P < 0.05.

Parameter	Before FPRs (1979-1990)		After FPRs (1991-2002)			Statistical Test Results
Population Size						
Number of Breeding Areas at Beginning of Period	29		52			
Number of Breeding Areas at End of Period	50		137			
Change in Number of Breeding Areas Occupied	72%		163%		*	df = 1, X^2 = 11.791, P < 0.01
Percent of Breeding Areas Occupied	92	n = 546	93	n = 1128		df = 1, X^2 = 0.031, P > 0.50
Reproductive Success						
Nesting Attempts Successful	59%	n = 478	64%	n = 1002		df = 1, X^2 = 1.797, 0.25 > P > 0.10
Number of Eaglets/Occupied Breeding Area	0.88	n = 478	1.06	n = 1002	*	df = 1, X^2 = 9.690, P < 0.01

Table 3. Linear correlations of occupation, nesting success, and productivity with proportion of 1/16 sections with operations, and number of operations per 1/16 section within 800 m of nest trees at 53 bald eagle breeding areas on non-federal land in Oregon. * = significant difference at P < 0.05.

Parameter 1991-2002	Proportion of 1/16 Sections With Operations	Number of Operations Per 1/16 Section
Percent of Years Occupied	r = +0.054 df = 51, t = 0.385 P = > 0.50	r = -0.090 df = 51, t = 0.647 P = > 0.50
Percent of Nesting Attempts Successful	r = -0.179 df = 51, t = 1.303 0.20 > P > 0.10	r = -0.061 df = 51, t = 0.435 P > 0.50
Number of Eaglets Produced/Year Occupied	r = -0.251 df = 51, t = 1.879 P = 0.067	r = -0.071 df = 51, t = 0.507 P = > 0.50

Table 4. Occupation, nest tree use, and nesting outcome at 53 bald eagle breeding areas on non-federal land in Oregon before and after Forest Protection Rules (FPRs) were implemented by Oregon Department of Forestry. * = difference significant at P < 0.05.

Parameter	Before FPRs (1979-1990)		After FPRs (1991-2002)		Statistical Test Results
Population					
Percent of Breeding Areas Occupied	94	n = 304	96	n = 545	df = 1, X^2 = 0.085, P > 0.50
Nest Tree Use					
Nest Tree Changes/Year Occupied)	0.10	n = 273	0.14	n = 504	df = 3, X^2 = 2.801, P > 0.50
Average Distance of Moves (m)	484 (SD = 817)	n = 28	660 (SD = 1,024)	n = 72	df = 98, t = 0.811, 0.50 > P > 0.20
Moves < 100 m	36%	n = 28	33%	n = 72	
Moves 100-800 m	54%	n = 28	47%	n = 72	
Moves > 800 m	11%	n = 28	19%	n = 72	df = 5, X^2 = 1.103, P > 0.50
Reproductive Success					
Nesting Attempts Successful	66%	n = 277	64%	n = 510	df = 1, X^2 = 0.105, P > 0.50
Number of Eaglets/Occupied Breeding Area	0.98	n = 277	1.04	n = 510	df = 1, X^2 = 0.539, 0.50 > P > 0.25

Table 5. Occupation, nesting success, and productivity at bald eagle breeding areas on non-federal land west (n = 34) and east (n = 19) of the Cascade Mountains in Oregon, 1991-2002. * = significant difference ar P < 0.05.

Parameter	West		East		Statistical Test Results
Percent of Breeding Areas Occupied	98	n = 350	92	n = 195	df = 1, X^2 = 0.503, 0.50 > P > 0.25
Nesting Attempts Successful	62%	n = 338	69%	n = 172	df = 1, X^2 = 1.040, 0.50 > P > 0.25
Number of Eaglets/Year Occupied	0.99	n = 338	1.13	n = 172	df = 1, X^2 = 2.328, 0.25 > P > 0.10

Table 6. Suggested minimum nest-tree and forest-stand requirements for bald eagle nest sites in 3 forest types in Oregon, 1979-1982.

Reprint of Table 8 from: Anthony, R.G., and F.B. Isaacs. 1989. Characteristics of bald eagle nest sites in Oregon. Journal of Wildlife Management 53:148-159.

Characteristic	Douglas-fir	Mixed Conifer	Ponderosa Pine
Nest Tree			
Dbh (cm)	170	110	110
Ht (m)	55	40	40
Forest stand			
Mean dbh (cm)	65	55	50
Density (trees/ha > 27 cm)	160	100	110
Crown closure (%)	55	30	30
Basal area (m^2/ha)	50	25	20
7.6-14.9-m ht class (%)	15	25	35
15.0-22.6-m ht class (%)	25	30	25
22.7-30.2-m ht class (%)	20	25	20
30.3-37.8-m ht class (%)	15	13	15
38.0-45.5-m ht class (%)	10	5	5
45.6-53.1-m ht class (%)	8	2	
53.2-60.8-m ht class (%)	5		
60.9-68.3-m ht class (%)	2		

Appendix 1. History of bald eagle habitat management in Oregon, emphasizing the Oregon Department of Forestry's Forest Practices Rules.

Management of bald eagle (*Haliaeetus leucocephalus*) nesting habitat was developed in response to federal and state laws enacted to protect the species because of declining populations. Bald eagles and their nests were first protected in all states except Alaska by the Bald Eagle Protection Act of 1940 (Millar 2002). In 1978, the bald eagle was listed as a "threatened" species in Oregon, Washington, Michigan, Minnesota, and Wisconsin, and "endangered" in the other 43 contiguous United States under the federal Endangered Species Act (ESA) of 1973 (U.S. Department of the Interior 1978). Initiation of the first comprehensive statewide survey of the bald eagle nesting population in Oregon (Isaacs et al. 1983) coincided with federal ESA listing in 1978.

Federal Endangered Species Act listing resulted in increased concern for habitat protection. Habitat protection for breeding areas implemented after federal listing utilized a strategy suggested by Mathisen et al. (1977), who described concentric buffer zones around nest trees with protective measures specific to each zone. The 330-foot (101 m) zone had no human activity anytime; the 330 to 660-foot (101-201 m) zone allowed no activity during the nesting season, and limited activity outside that time; the 660 to 1,320-foot (201-402 m) zone called for no activity during the nesting

season, with no restrictions outside that time; and the 1,320 to 2,640-foot (402-805 m) zone could have restrictions during the nesting season if justified.

The buffer zone strategy was the basis for revised habitat management guidelines for Oregon and Washington published by U.S. Fish and Wildlife Service (USFWS) in 1981 (U.S. Department of the Interior 1981). Those guidelines were advisory only, and called for primary and secondary zones with minimum distances from nest trees of 330 feet (101 m) and 660 feet (201 m), respectively. In general, primary zones were to have no human activity, and secondary zones were to have no human activity during the nesting season. Zone boundaries could be modified depending on characteristics of the breeding area, behavior of the nesting pair, or nature of the activity. Timber harvest in the secondary zone was to "...consider eagle habitat requirements and vulnerability." Furthermore, those guidelines "...recommended that an individual management plan be prepared for each nesting site." In general, both federal and state resource managers consulted USFWS guidelines (U.S. Department of the Interior 1981) when conducting forest management activities around bald eagle nest trees in Oregon from 1978 to 1990 (Author 1 personal observation). Usually, but with exceptions, federal agencies (e.g., U.S. Forest Service, U.S. Bureau of Land Management) protected more than the minimum areas recommended in USFWS guidelines, while state and private landowners used minimum areas

suggested in the guidelines (Author 1 personal observation).

In 1986, the Pacific Bald Eagle Recovery Plan was approved by U.S. Fish and Wildlife Service (1986). Among other needs, the Recovery Plan emphasized management planning on a site-specific basis (Stepdown Narrative Section 1.25), recommended that forest management promote eagle habitat characteristics (Stepdown Narrative Section 1.32), identified the need to protect and maintain the long-term viability of existing habitat (Stepdown Narrative Section 1.3211), suggested that buffer zones be based on characteristics of individual sites (Stepdown Narrative Section 1.331), and promoted limiting certain human activities in 400 and 800-m buffer zones during the nesting season (Stepdown Narrative Section 1.332). The Recovery Plan stated that, "Until site specific management plans are available... guidelines prepared by the U.S. Fish and Wildlife Service Region 1 should serve as minimum protective measures" (Stepdown Narrative Section 1.331).

Following publication of the Recovery Plan, The Bald Eagle Working Team for Oregon and Washington identified the need to provide detailed guidance on achieving recovery goals to state and local land managers. In 1990, the Working Team published an implementation plan to fulfill that need (Bald Eagle Working Team for Oregon and Washington 1990). That plan included a "Guide to Site Planning for Bald Eagles", which outlined steps for preparing site-specific management plans for bald eagle habitat. That guide did not

specify buffer zone sizes, shapes, or restrictions. Instead, it called for management area boundaries based on resident eagle behavior and habitat use patterns, and physical characteristics of the site. The goal for nesting habitat in the site planning process outlined in that guide was "...to maintain productive nesting pairs..." by determining how "...to best maintain or improve current condition of the site...", and "...insure equal or enhanced future habitat condition."

Bald eagles were listed as a state "threatened" species under the Oregon Endangered Species Act in 1987 (Oregon Revised Statutes 496.171-497.182). Major amendments to Oregon's Forest Practices Act also occurred in 1987. Statutory changes that year (House Bill 3396) enacted requirements for site-specific protection for state and federally listed threatened and endangered species on non-federal forest land. In 1991, the Oregon Board of Forestry (BOF) adopted process rules (Oregon Administrative Rule 629-680-100) to inventory and protect resource sites used by threatened and endangered species on non-federal forest lands. Those rules provided a method for the Oregon Board of Forestry to evaluate threatened and endangered fish and wildlife species that use resource sites that are sensitive to forest practices. The Board of Forestry reviewed special resources used by bald eagles on non-federal forest lands in Oregon (Smith 1991) and determined that nest sites were "resource sites" that were sensitive to forest practices. The Board of Forestry then adopted

Forest Practices Rules (FPRs) to protect bald eagle nesting resource sites on non-federal timber lands in 1991 (Oregon Department of Forestry 2003).

The Oregon Department of Forestry (2003) defined resource sites for bald eagle nesting as "...the active nest tree and all identified key components...". An active nest tree was defined as a tree "...in which a bald eagle has nested in the past..." and that is "...structurally capable of successful future use, whether or not the tree still contains a nest." Key Components of a bald eagle nesting site were "...perching and fledging trees, replacement nest trees, and a forested buffer around the nest tree." The FPRs required operators to provide protection measures when operating within or near a bald eagle nesting resource site. The active nest tree and all identified key components had to be retained and protected from damage in accordance with Oregon Administrative Rule (OAR) 629-665-0220 (Oregon Department of Forestry 2003:60) during and after forest operations.

Rather than adopt prescriptive protection/buffer requirements in administrative rule, the Board of Forestry chose to adopt the concept of resource site (i.e. nest tree and associated key components) protection in rule and allow field personnel the flexibility to implement protection measures on a site-specific basis to accomplish the goal of resource site protection. The goal of resource site protection was to ensure that forest practices did not lead to resource site destruction, abandonment, or reduced productivity. Designing operations to protect the nest tree and associated

key components from wind throw was given primary importance in avoiding damage to the resource site during the critical period of use. Forest operations had to be designed and conducted to not disturb bald eagles using the nesting site. In general, restrictions on the timing of forest operations were required because they could cause eagles to flush from the active nest tree or perch trees. During the critical period, operations were not approved within one-quarter mile (402 m) of active resource sites unless Oregon Department of Forestry determined that the proposed operations would not cause eagles to flush from the active nest tree or perch trees. That distance was extended to one-half mile (805 m) if operations were in direct line-of-sight of resource sites. The critical period of use for bald eagle nesting resource sites was defined as 1 January through 31 August (Oregon Department of Forestry 2003:60) based on nesting phenology in Isaacs et al. (1983).

The process used by Oregon Department of Forestry for protecting bald eagle nesting resource sites on non-federal forest land as of 2004 is summarized below:

1) The Oregon Department of Forestry is required to maintain an inventory of protected resource sites that are used by threatened and endangered species, including bald eagle nesting sites.

2) When a “Notification of Operation” is submitted by a landowner/operator, the Oregon Department of Forestry compares the operation location to the

resource inventory to determine if a bald eagle nesting resource site is located within one-half mile (805 m) of the proposed operation.

3) When an operation is proposed within one-half mile (805 m) of a bald eagle nesting resource site, the Oregon Department of Forestry must inspect the site with the landowner or landowner's representative, operator, and Oregon Department of Fish and Wildlife biologist as prescribed by OAR 629-665-0020 (Oregon Department of Forestry 2003:57). The purpose of the onsite inspection is to identify the location of the nesting site; develop a thorough understanding of the proposed forest operation; discuss how the nesting site may be affected by the proposed operation; and discuss protection requirements for the nesting site.

4) The Oregon Department of Forestry must determine whether the proposed operation conflicts with protection of the nesting site.

5) If the proposed forest operation conflicts with the nesting site, structural and/or temporal protection are required to eliminate the conflict in accordance with OAR 629-665-0220.

6) The landowner must prepare a written plan and submit it to the ODF before starting operations. The written plan must contain specific information applicable to the operation, such as the location of roads and landings, felling and bucking trees, yarding systems and layout, buffer strips, and nesting site protection measures.

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Appendix 2. Explanation for selecting 53 out of 174 breeding areas for detailed analyses of data derived from the Forest Activities Computerized Tracking System, including nesting and forestry data for the 53 sites selected.

While summarizing Forest Activities Computerized Tracking System (FACTS) data by breeding area, we eliminated 40 breeding areas for the following reasons: forest management was under an alternate plan that deviated from administration and implementation of Forest Practices Rules approved for bald eagle nesting resource sites as prescribed in Oregon Administrative Rule 629-665-0220 (n = 18; Arnett et al. 2001); ownership included nest trees on federal land (n = 14); incorrect or incomplete location searches were conducted (n = 3); nesting history was too short (n = 3); ownership changed from private to federal (n = 1); and breeding area was apparently abandoned prior to implementation of FACTS (n = 1). Thus 134 (77%) breeding areas remained of the 174 that had commercial logging or road building in sections that were within 800 m of nest trees.

Finally, we reduced the number of breeding areas used in subsequent analyses to 53 (Appendix 2 Figure 1). Those were selected because they had ≥ 4 years of nesting history, were in completely non-federal ownership, and forestry was assumed to be the primary activity within 800 m of nest trees. Eighty-one breeding areas were excluded because nesting histories were less

than four years, or because forestry operations were probably not the primary activity influencing nesting. Specifically, breeding areas were eliminated for the following reasons: less than four years of nesting history (n = 25); located in riparian areas surrounded by agricultural land (n = 17); mixed ownership (n = 16); located near residential areas and some had additional agricultural and recreational influences (n = 7); located on islands primarily influenced by agricultural or industrial activities (n = 5); mixed ownership and located near residential areas (n = 4); under special management unrelated to FPRs (n = 3); located in an isolated tree in an agricultural area (n = 1); uncertain nesting history (n = 1); located on power company land (n = 1); and located on state park land (n = 1). The remaining 53 breeding areas were assumed to represent bald eagle habitat managed under Oregon Department of Forestry FPRs for nesting bald eagles.

Appendix 2 Figure 1. Nesting and Forest Activity Computerized Tracking System (FACTS) data for 53 bald eagle breeding areas on non-federal land in Oregon. The 53 sites were chosen because they had 4 or more years of nesting history, all nest trees were on state or private land, and forestry was probably the primary activity within 800 m of nest trees.
Sur = Surveyed; Oc = Occupied; Ops = Forestry Operations; Prop = Proportion.

	Nesting									FACTS						
				Years Occupied Outcome Known		Years Successful		Eaglets Produced Per Year Occupied		1/16 Sections			Operations			
	Bald Eagle Nest Site Name	Years Sur	Years Oc	n	%	n	%	n	Mean	n	With Ops	Prop With Ops	n	Ops Per 1/16 Section	Commercial Harvest?	Road Building?
1	Agency Cr/ Klamath Agency	10	9	9	90	8	89	18	2.00	11	1	0.09	2	0.18	Yes	No
2	Aldrich Point/ Quinns Is	12	12	12	100	9	75	14	1.17	31	5	0.16	13	0.42	Yes	Yes
3	Algoma	12	12	12	100	7	58	12	1.00	13	7	0.54	8	0.62	Maybe	No
4	Alsea Bay/ Eckman Slough	12	12	12	100	6	50	11	0.92	30	10	0.33	20	0.67	Yes	Yes
5	Aspen L	12	12	11	100	8	73	11	0.92	18	7	0.39	14	0.78	Yes	No
6	Awbrey Mt	12	12	12	100	8	67	13	1.08	13	13	1.00	52	4.00	Yes	Maybe
7	Bear Flat	7	5	4	71	2	50	2	0.40	12	10	0.83	14	1.17	Yes	No
8	Bessey Cr/ Dellwood...	9	9	8	100	6	75	10	1.11	13	10	0.77	34	2.62	Yes	Yes
9	Big Canyon	9	9	9	100	8	89	14	1.56	12	1	0.08	1	0.08	Maybe	No
10	Brown Cr/ Williamsport...	12	12	12	100	5	42	7	0.58	21	16	0.76	46	2.19	Yes	Yes
11	Clifton Channel/a /Clifton	12	12	12	100	6	50	11	0.92	16	9	0.56	24	1.50	Yes	Yes
12	Combs Flat	6	4	4	67	0	0	0	0.00	13	0	0.00	0	0.00	No	No
13	Coos County	12	12	12	100	6	50	11	0.92	16	6	0.38	16	1.00	Yes	Yes
14	Cottage Grove Res	12	12	12	100	9	75	14	1.17	14	14	1.00	74	5.29	Yes	Yes
15	Crooked Cr	4	4	4	100	4	100	6	1.50	13	5	0.38	6	0.46	Yes	No
16	Cutoff Point	12	12	12	100	6	50	7	0.58	13	8	0.62	15	1.15	Yes	Yes
17	Devils L	12	12	12	100	7	58	12	1.00	12	11	0.92	26	2.17	Yes	Yes
18	Fogarty Cr	4	4	4	100	3	75	4	1.00	13	2	0.15	3	0.23	Yes	Yes
19	Fopiano Ranch	7	7	5	100	4	80	6	0.86	21	0	0.00	0	0.00	No	No
20	Foster Res	12	12	12	100	9	75	15	1.25	13	11	0.85	30	2.31	Yes	Yes
21	Gnat Cr	7	6	6	86	3	50	4	0.67	19	15	0.79	25	1.32	Yes	Yes
22	Goble	12	12	12	100	6	50	9	0.75	21	11	0.52	14	0.67	Yes	Maybe
23	Hagg L	7	7	7	100	7	100	12	1.71	14	9	0.64	33	2.36	Yes	Maybe
24	Hobsonville Point	7	7	7	100	7	100	11	1.57	11	3	0.27	3	0.27	Yes	No
25	Joyce Cr/ Leitel Cr	12	6	5	50	5	100	9	1.50	28	13	0.46	29	1.04	Yes	Yes
26	Kleger/ Wallace Is	12	12	11	100	9	82	14	1.17	33	15	0.45	46	1.39	Yes	Yes
27	Lane Cr	12	12	12	100	5	42	7	0.58	16	14	0.88	37	2.31	Yes	Maybe

28	Long L N	12	12	12	100	7	58	10	0.83	19	15	0.79	48	2.53	Yes	No
29	Long L S	12	12	12	100	9	75	13	1.08	15	11	0.73	24	1.60	Yes	No
30	Long L W/ Long L Valley	12	7	7	58	3	43	3	0.43	35	29	0.83	80	2.29	Yes	No
31	Lower Desert	12	12	10	100	9	90	15	1.25	17	12	0.71	22	1.29	Yes	No
32	Lower Twomile Cr	5	5	5	100	2	40	3	0.60	13	12	0.92	33	2.54	Yes	Yes
33	Lower Valley/ Promise Road	12	6	6	50	4	67	8	1.33	31	13	0.42	107	3.45	Yes	Yes
34	Marys Cr	8	8	7	100	2	29	5	0.62	19	13	0.68	23	1.21	Yes	Maybe
35	McKay Cr	12	12	11	100	10	91	20	1.67	15	9	0.60	19	1.27	Maybe	Maybe
36	Mettman Ridge	12	12	12	100	7	58	10	0.83	14	4	0.29	8	0.57	Yes	No
37	Nehalem R	12	12	12	100	6	50	10	0.83	27	22	0.81	41	1.52	Yes	Yes
38	Palouse Cr	12	12	12	100	7	58	9	0.75	14	6	0.43	8	0.57	Yes	Yes
39	Randolph Is	5	5	5	100	2	40	2	0.40	26	15	0.58	27	1.04	Yes	Maybe
40	Round L	12	12	12	100	10	83	15	1.25	11	8	0.73	16	1.45	Yes	No
41	Scottsburg/ Weatherly Cr	12	12	12	100	4	33	5	0.42	34	25	0.74	58	1.71	Yes	Yes
42	Siletz Bay	12	12	12	100	9	75	13	1.08	27	19	0.70	53	1.96	Yes	Yes
43	South Slough	12	12	12	100	11	92	17	1.42	13	9	0.69	24	1.85	Yes	Maybe
44	Sprague R	12	12	12	100	7	58	12	1.00	19	7	0.37	7	0.37	Yes	No
45	Swan L SSW	12	12	12	100	5	42	8	0.67	21	21	1.00	58	2.76	Yes	Maybe
46	Tillamook Bay	12	12	12	100	7	58	11	0.92	23	8	0.35	21	0.91	Yes	Maybe
47	Wauna/ Nicolai Ridge	11	11	10	100	7	70	12	1.09	40	21	0.53	47	1.18	Yes	Yes
48	West Scottsburg	5	5	5	100	5	100	9	1.80	13	2	0.15	6	0.46	Yes	No
49	Whiteline Res	8	8	8	100	6	75	9	1.12	13	13	1.00	25	1.92	Yes	Maybe
50	Willow Point	6	6	6	100	5	83	9	1.50	12	6	0.50	10	0.83	Yes	No
51	Winchester Bay	12	12	12	100	6	50	12	1.00	17	6	0.35	11	0.65	Yes	Maybe
52	Yaquina Bay	12	12	12	100	10	83	18	1.50	30	1	0.03	3	0.10	Yes	Maybe
53	Youngs R	12	12	12	100	4	33	7	0.58	19	5	0.26	10	0.53	Yes	No
									Mean =	19	10	0.55	26	1.37		