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Northern Goshawk

Accipiter gentilis

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Written by Steven M. Desimone and David W. Hays

GENERAL RANGE AND WASHINGTON DISTRIBUTION

The northern goshawk (*Accipiter gentilis)* is holarctic in distribution, occupying a wide variety of boreal and montane forest habitats throughout Eurasia and North America (Palmer 1988, Johnsgard 1990). Three subspecies of the goshawk are recognized in North America (Johnsgard 1990, James and Palmer 1997), but only the northern goshawk (*A.g. atricapillus*) is known in Washington.

Figure 1. Shaded areas contain the general forest conditions that could provide potential suitable habitat for the northern goshawk (*Accipiter gentilis)* in Washington.

Northern goshawks can occur in all forested regions of Washington (see Figure 1). As of 2003, there were 338 documented breeding territories in the state (Washington Department of Fish and Wildlife [WDFW], unpublished data). The exact number is not known, because monitoring is not currently being conducted. The number of historical breeding sites lost due to habitat alteration and the number of new territories in suitable habitat are also unknown. About 50% of the documented breeding territories occur in the eastern Cascades, 27% in the western Cascades, 12% in other forested areas of northeast and southeast Washington, and 10% in the Olympic Peninsula (WDFW, unpublished data). Breeding birds formerly occurred in the Puget trough (Jewett et al. 1953). Less than one percent of recent breeding records have been recorded from this area and southwest Washington (south of the Puget Sound and west to the coast). Wintering goshawk populations in Washington include resident birds (Bloxton 2002; WDFW, unpublished data) and migrants that move into the state during winters when food shortages occur in their territories (Squires and Reynolds 1997). Overall, densities of territorial pairs in Washington appear to be lower than elsewhere in the western United States (Table 1) but this is partly dependent on habitat quality.

Table 1. Density estimates of northern goshawk territories in the western United States. Forest management in the study areas ranged from intensive to minimal timber harvest.

Study	Number of pairs	Mean distance (km) to nearest-neighbor	Density (territories/ 1000 ha)	Spacing (ha/pair)	Reference
Western Washington industrial forest	3	-	0.04-0.13	-	Bosakowski et al. 1999
Upper Yakima River, Washington	1 4 5	- - -	0.1 [a, b] 0.5 [a, c] 0.5 [a, d]	9091 2083 1852	Wagenknecht et al. 1998
Eastern Oregon National Forests	20	4.4	0.7	1538	DeStefano et al. 1994
Eastern Oregon	4	5.6	-	2750	Reynolds and Wight 1978
Klamath National Forest, California	21	3.3	0.6 - 1.1	1750 - 935	Woodbridge and Detrich 1994
North Kaibab NF, Arizona	100	2.5	2.0	491	Reynolds 1997, Reynolds and Joy 1998

[a] Estimate calculated with one year of survey data in each forest type; [b] Open Douglas-fir/ponderosa pine; [c] mixed conifer-lodgepole pine; [d] mixed Douglas-fir, grand fir, western hemlock

RATIONALE

The northern goshawk is a Federal Species of Concern and State Candidate species in Washington because of concerns about its population status. Although a decline in populations of northern goshawks has been suggested based on reduced nesting in areas of extensive harvest of mature forest (Crocker-Bedford 1990, 1995; Ward et al. 1992), Kennedy (1997) found no evidence to support the contention that goshawk populations in the western United States were declining, increasing, or stable. Kennedy (1997) acknowledged, however, that population declines might not be apparent due to insufficient sampling techniques. In Washington, goshawks appear to have been largely extirpated from urbanized landscapes and from some areas that are moderately developed or intensively managed for timber on short rotations (WDFW, unpublished data). There are no studies evaluating the population status of the goshawk in the Pacific Northwest. Because goshawks build multiple nests within nesting territories that are often used by other raptor species (Moore and Henny 1983, Buchanan et al. 1993; S. Desimone, unpublished data), the loss of goshawks might indirectly affect other forest species.

HABITAT REQUIREMENTS

Research in western North America suggested that the home range of breeding goshawks can be split into three functional divisions: the nest area or areas, the post-fledging family area (PFA), and the foraging area; the sum of these areas compose a northern goshawk's home range (Reynolds et al. 1992) (Figure 2). Habitat information relevant to each of these scales is provided below.

Nest Area

The nest area (in some studies referred to as the *nest stand*) is composed of one to several forest stands that contain the active and alternate nest structures (Figure 2). Usually occupied by breeding goshawks from March until

September, nest area boundaries are determined by the movement and behavior of the adults and newly fledged young, and by the locations of prey plucking areas and roosts that are usually within the nest area. (Reynolds et al. 1982). The term "occupied" is defined by the presence of at least one adult goshawk in the area or territory during a breeding season surveys (Desimone 1997; Finn et al. 2002a, b). The size of nest areas ranged between 8-12 ha (20-30 ac) (Reynolds 1983, Crocker-Bedford and Chaney 1988, Reynolds et al. 1992), but other studies suggest that nest areas can be larger (39 ha [96 ac; Finn et al. 2002a] up to 115 ha [284; Woodbridge and Detrich 1994]).

Within the nest area, the nest site is defined for this document as the immediate vicinity surrounding the nest tree, usually = 1.0 ha (2.5 ac; see McGrath et al. 2003). Goshawks in Washington nest almost exclusively in coniferous forest, although a few nests have been found in smaller aspen (*Populus* spp.) groves within the larger coniferous forest landscape in Okanogan County, Washington (WDFW, unpublished data; S. Desimone, personal observation).

Stand age. Studies in North America indicate that goshawks typically select mature or old forest habitat for nesting (Reynolds et al. 1982, Moore and Henny 1983, Fleming 1987, Crocker-Bedford and Chaney 1988, McGrath 1997, Daw and DeStefano 2001; Finn et al. 2002a, b). Research in Washington and Oregon has shown links between nest stand occupancy and forest stand age. Finn et al. (2002a) found late-seral forest consistently averaged 64-75% of the nest areas (39 ha [96 ac]), PFA (177 ha [437 ac]) and home ranges (1886 ha [4660 ac]) of occupied goshawk territories on the Olympic Peninsula, and the average age of trees at occupied nest stands in managed and unmanaged forest were 147 years (95% CI 97-198) (Finn et al. 2002b). These forests are generally characterized by large sawtimber, >50% canopy closure, two or more canopy layers, gaps in the canopy, abundance of large diameter crowns, and the presence of shade tolerant trees. Most goshawk nests in eastern Washington (Finn 1994, McGrath 1997; J. Buchanan, unpublished data) and Oregon (Reynolds et al. 1982, Desimone 1997, Daw and DeStefano 2001, McGrath et al. 2003) were in mature or older forest. In eastern Oregon, Daw and DeStefano (2001) showed that goshawk nest stands were negatively associated with regenerating and young (average diameter at breast height [dbh]: 12-22 cm [5-9 in]) forest at the nest stand scale (10 ha [25 ac]). In east-central Washington and eastern Oregon, McGrath (1997) determined that increasing the amount of early-seral forest by 1% within specified areas surrounding the nest tree would decrease the odds of the site being suitable for nesting by 10%.

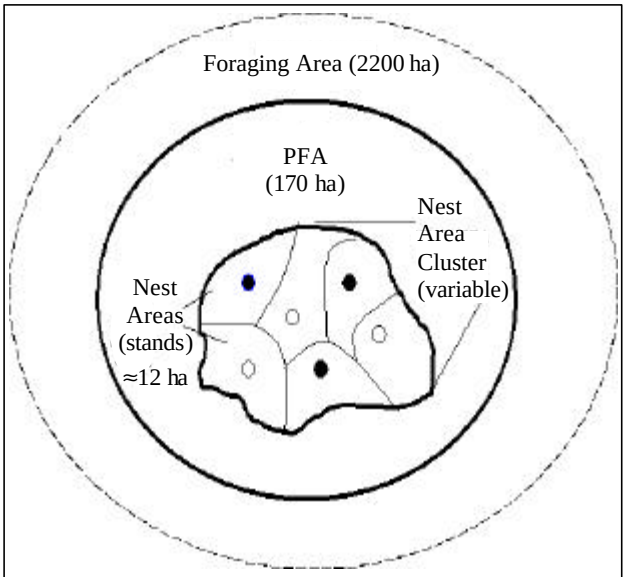


Figure 2. An idealized diagram (not to scale) for management of the breeding home range of the northern goshawk. Filled circles represent a possible nest site (i.e., tree where nest is located); open circles are nest sites within replacement nest areas (suitable or developing stands). Scale sizes represent averages. The Foraging Area of 2200 ha does not include the PFA and Nest Areas (i.e., 2200+170+72 = 2442 ha = total Home Range).

Finn (unpublished data) studied landscape patterns and habitat patch features around 25 goshawk nests in the upper Yakima River basin from 1992-1996. They found that the landscape surrounding nests was more homogeneous and contained less seedling/sapling and forest edge than what was available at the combined nest areas scale (32 ha [79 ac]) and at the post-fledging family area scale (210 ha [519 ac]). At the foraging range scale (3,566 ha [8,812 ac]), no differences were found between areas used by goshawks versus other areas in the landscape.

Tree density. Goshawk nest areas generally have a high density of large trees. On the Olympic Peninsula, the average diameter of trees within occupied nest areas was 59 cm (23 in; 95% CI 51 - 67cm) (Finn et al. 2002b). These stands had more large-diameter (≥63cm [25.7 in; 95% CI 22-59 cm]) trees than unoccupied historic nest areas. In the Olympic Peninsula and western Cascades, dominant and co-dominant trees in nesting stands averaged 43-48 cm (17-19 in) dbh and generally exceeded 27 m (89 ft) in height (Fleming 1987). On average, there were 482 trees/ha (195 trees/acre) >6 cm dbh (2.4 in) within nest stands in eastern Oregon (Reynolds et al. 1982). Finn (1994)

found that goshawk nest stands contained more snags and down woody material, had greater basal area, and an increased number of tree species than random plots in Okanogan County, Washington.

Canopy attributes. Researchers have used various methods to measure forest canopy and this may influence the ability to compare different data sets. Despite this, the overwhelming majority of stands used by nesting goshawks have relatively closed canopies (i.e., >50%) and are often characterized by multiple canopy layers. In western Washington, Fleming (1987) found goshawk nests in stands with an average canopy closure of about 60-65%. Additionally, nest stands had one to three canopy layers with generally poor development of understory vegetation. Similarly, Finn et al. (2002b) found that canopy closure in occupied nest areas averaged 78% in the Olympic Peninsula. Occupied nest areas had relatively greater canopy depth (i.e., the difference between the average maximum and minimum overstory height; Finn et al. 2002a) as compared to unoccupied historic nest areas. The odds of occupancy at historical nest areas increased with increasing overstory canopy depth (Finn et al. 2002a). Greater canopy depth coupled with low shrub density best discriminated occupied nest areas versus unoccupied historic nest areas (Finn et al. 2002a). This research also showed that occupancy of a stand by goshawks decreased by 47% with each 10% increase in understory shrub cover. Overall, increasing early-seral forest cover was associated with decreasing goshawk occupancy at historical nest stands on the Olympic Peninsula (Finn et al. 2002a).

Canopy attributes east of the Cascades are relatively similar to the previously discussed west-side attributes. Goshawk nest stands in eastern Oregon typically had multi-layered canopies with green foliage occurring a few meters to over 40 m (131 ft) above the ground, and the tops of understory trees overlapped with the lower crowns of overstory trees (Reynolds et al. 1982). In Okanogan County, average overstory canopy closure in nest stands was 75% (Finn 1994), and canopy closure in the eastern Cascades averaged 74% in stands where spotted owls exploited goshawk nests for breeding (J. Buchanan, personal communication). In east-central Washington, canopy closure averaged 73% (McGrath 1997). In eastern Oregon, mean canopy closure was 60% (Reynolds et al. 1982) and 88% (Moore and Henny 1983) within nest stands.

Size. The sizes of goshawk nest areas in the Pacific Northwest are variable. On the Olympic Peninsula, occupied goshawk nest areas averaged 33 ha (82 ac) (range: 12-69 ha [30-170 ac]) (Finn et al. 2002b). The conclusions of Finn et al. (2002a) indicated that the composition of nest areas was largely (about 67%) late-seral forest.

In eastern Oregon, Reynolds and Wight (1978) found that the size of nest areas or stands varied with topography and the availability of large trees in dense patches of at least 10 ha (25 ac). Woodbridge and Detrich (1994) found that goshawk territories in northern California contained one to five different forested nesting stands (average = 2). These nest stands were homogeneous in composition, age, and structure relative to the surrounding forest (Woodbridge and Detrich 1994). Stands <10 ha (25 ac) typically contained one or two nests that were occasionally occupied by goshawks, whereas stands >20 ha (49 ac) often contained several nests that were frequently occupied (Woodbridge and Detrich 1994).

Spacing and number of nests. Established pairs of goshawks have multiple nest areas that are often structurally similar within a home range (Reynolds et al. 1992). Goshawks may build =10 nest structures within a territory that can be occupied over multiple generations (Crocker-Bedford 1990; S. Joy and T. Fleming, personal communications). In western Washington, the distance between alternate nests of the same territory averaged 536 m (1759 ft) (S. Finn, unpublished data). In more arid forested habitats such as pine and mixed conifer, the average distance between alternate nests within a territory ranged between 245 and 273 m (804-896 ft) (Reynolds et al. 1994, Woodbridge and Detrich 1994, Desimone 1997).

Nest tree and nest site. Nest structures in western Washington are often in Douglas-fir (*Pseudotsuga menziesii*), with western hemlock (*Tsuga heterophylla*) used to a lesser extent (Fleming 1987, Finn 2000). Nests in deciduous trees are uncommon (Fleming 1987; S. Finn and T. Bloxton, unpublished data). Deciduous trees used for nesting west of the Cascade mountain crest (e.g., red alder [*Alnus rubra*]) were generally found in the sub-canopy and isolated in coniferous forest stands comprised of less than 2% deciduous species (Finn et al. 2002b). Goshawks in eastern Washington and Oregon nest in Douglas-fir, ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), grand fir (*Abies grandis*) and occasionally aspen (Finn 1994,

McGrath 1997; WDFW, unpublished data). In areas of heavy mistletoe infection, goshawks will use mistletoe "brooms" as a nesting substrate (Moore and Henny 1983, Buchanan et al. 1993, Finn 1994). They may also occasionally nest in dead trees (Moore and Henny 1983; S. Desimone, unpublished data). Average nest tree size in the Pacific Northwest is >53 cm (21 in) dbh (range: 25-172 cm [10-68 in]) (Moore and Henny 1983, Fleming 1987, Bull and Hohmann 1994, McGrath et al. 2003; S. Finn, unpublished data). Goshawks build fairly large, bulky stick nests (about 0.6-0.9 m [2-3 ft] outside diameter), and nest placement is usually in the lower third of the forest canopy and relatively close to the tree trunk (Reynolds et al. 1982, McGrath 1997, Finn 2000).

Basal area at the nest site is usually higher than that of the surrounding stand. McGrath (1997) measured vegetation attributes around 82 active goshawk nests in eastern Oregon and central Washington east of the Cascade crest. At the nest site scale (1 ha [2.5 ac]), higher basal area best discriminated nest sites from random sites. Nest sites had higher average basal area/tree, and greater live stem density compared to random sites (McGrath 1997). In Montana and northern Idaho, 0.04 ha (0.1 ac) plots around nest sites (n=17) had an average of about 6 trees/plot that were >30 cm dbh (64 trees/ac >12 in) (Hayward and Escano 1989). In northeastern Oregon, Moore and Henny (1983) reported an average of 208 trees/ha >32 cm dbh (84 trees/ac >13 in) surrounding 34 nests.

Goshawks pluck the hair or feathers of their prey before consuming or bringing it to the nest for incubating/brooding females or young. Consequently, established 'plucking posts' (i.e., perches used to pluck captured prey) may be present within the nest area and are typically within 100 m (328 ft) of an active nest (S. Desimone, unpublished data).

Water and topography. It is unclear whether goshawks prefer to nest close to water, but close proximity to water may improve nesting conditions in drier forest types based on the results of several studies (see Reynolds et al. 1982, Hargis et al. 1994, Squires and Reynolds 1997). Bathing by a brooding goshawk in hot dry climates may help to maintain proper humidity in the nest during incubation, and may aid in thermoregulation (Hennessy 1978). However, Crocker-Bedford and Chaney (1988) found no association with water in Arizona where actual breeding density was high. Overall, goshawk nests in western Washington generally averaged >200 meters (654 ft) from perennial water (WDFW, unpublished data). On the Olympic Peninsula, water bodies were an average of 232 m (761 ft) from nest sites (S. Finn, unpublished data). Other studies found that goshawk nests were generally within 200-300 m (656-984 ft) of permanent water sources in Idaho (Hayward and Escano 1989), northeastern Oregon (Bull 1992), and in the eastern Cascades of Washington (McGrath 1997). However, McGrath (1997) found that eastern Oregon nest sites averaged =335 m (1099 ft) from water. Goshawk nests in east-central Washington and Oregon were generally associated with low topographic position (i.e., lower 1/3 or bottom of drainage; McGrath et al. 2003; J. Buchanan, personal communication), most likely because the larger trees at lower elevations provided a more favorable microclimate. McGrath et al. (2003) found only a single nest near a ridge top east of the Cascades, and Bull (1992) found no goshawk nests near ridge tops in eastern Oregon.

Nest area cluster. Woodbridge and Detrich (1994) suggested that the aggregate of all nest stands and alternate nests within a goshawk pair's territory form a "cluster" of nest stands (i.e, "nest stand cluster"; see Figure 2). For this document, the aggregate of nest areas will be referred to as the "Nest Area Cluster" (NAC). A pair's NAC generally does not overlap with NACs of neighboring territories. NACs are variable in size and their size is believed to be less than that of the PFA (Woodbridge and Detrich 1994). It is possible the NAC coincides with PFAs, but this has not been verified. The occupancy of nesting stands (or nesting areas) by marked territorial adults was used as a basis for the NAC concept (Woodbridge and Detrich 1994).

On the Klamath National Forest in California, NACs ranged between 11 and 114 ha (26-282 ac) (Woodbridge and Detrich 1994). Occupancy rates of clusters <20 ha (49 ac) were typically less than 50%. However, occupancy at clusters that were 40 ha (99 ac) and 41-61 ha (100-151 ac) were 75-80% and about 90%, respectively, and nearly 100% of clusters >61 ha (151 ac) were occupied. Overall, long-term territory occupancy was positively correlated with the size of clusters and with larger proportions of mature forest (Woodbridge and Detrich 1994). This larger percent of area in older forest appears to provide more opportunities to maximize a pair's chance of maintaining occupancy.

Mid- and late-successional habitat is strongly associated with goshawk sites at the NAC scale. In eastern Oregon, Desimone (1997) found that substantial amounts of mid- (average dbh of 23-53 cm [9-21 in]) and late-successional

(average dbh >53 cm [21 in]) forest at the NAC scale (52 ha [128 ac]) were important to the persistence of goshawks in historic territories. Occupied areas during that study had more forest area with these characteristics than historic territories without goshawks. Within the 52 ha (128 ac) surrounding historic nests, habitat around recently occupied sites was not significantly different from occupied historic sites at the time they were last known to be active. The historic sites where no goshawks were located had significantly lower amounts of combined mid-age and late-successional forest within the NAC. It was concluded that recent site conditions within the NAC that most resembled the historic conditions contributed to the persistence of goshawks in a territory over time (Desimone 1997).

Post-fledging Family Area

The Post-fledging Family Area (PFA) contains the nest area(s) and is an area of concentrated use by adult females and developing juveniles after fledging and prior to natal dispersal (Reynolds et al. 1992, Kennedy et al. 1994). The PFA surrounds and includes nest area habitat (Kennedy et al. 1994), and provides foraging opportunities for adult females and fledgling goshawks, as well as hiding cover for fledglings (Reynolds et al. 1992). The parameters used to calculate the PFA included the average core area used by nesting females as well as the average distance juveniles dispersed from the nest tree over a specified time period (Kennedy et al. 1994). PFAs in New Mexico were high-use core areas used by breeding females that averaged 168 ha (415 ac; Kennedy et al. 1994), and may have corresponded to the defended areas of goshawk pairs (Reynolds et al. 1992). Similarly, high-use areas of adult breeding females (post-hatching) in western Washington averaged about 143 ha (353 ac) (S. Finn, unpublished data). These values are similar to the average of 168 ha (415 ac) reported by Kennedy et al. (1994) for core-use areas of breeding females.

Studies on the use of habitats by northern goshawks in the PFA indicate the importance of structurally complex forests. McGrath (1997) measured structural stages on the eastern Cascades within 83 and 170 ha (205 and 420 ac) areas around recently active nests. He found that "stand initiation phase" (clearcut/sapling stage) accounted for 7% (range 0-23%) of the 83 ha (205) plot and 10% of the 170 ha (420) plot; both values were significantly smaller than random sites. In the southwestern United States, the PFA contained 40% (by area) mature and old forest with >40% canopy closure (Reynolds et al. 1992). In eastern Oregon (with forest types similar to the southwestern U.S.) PFAs consisted of an average of 22% (Desimone 1997) and 29% (Daw and DeStefano 2001) dense canopy, late-seral (>50% canopy closure and =20 trees/ha >53cm) forest. In western Washington, PFAs contained an average of 72% (95% CI = 59-84) mature (>10% of trees >53 cm [21 in] dbh) coniferous forest (Finn et al. 2002a). PFAs consisted of forests with a dense cover of trees and an abundant number of snags and down logs (Reynolds et al. 1992).

Foraging Areas (breeding season) and Home Range

Foraging areas are the various habitats where goshawks secure prey. Foraging areas also define the goshawk's home range during the breeding season. Home range (HR) size estimates for goshawk pairs in western states (other than Washington) ranged between 569-3774 ha (1400-9321 ac) (Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Kennedy et al. 1994). The average HR size on managed forest landscapes in western Washington was 3710 ha (9164 ac) (range 844 to 10,730 ha [2084-26500 ac]) (Bloxton 2002). Males generally had larger HRs than females, while HRs of non-breeders tended to be larger than that of breeders. Two years of unusually wet conditions was thought to partly explain variability in foraging distances from nests of male goshawks (Bloxton 2002).

Goshawks forage in a variety of forest types. Limited information describing goshawk foraging habitat is available for Washington. Bloxton (2002) found that goshawks tended to hunt in stands with larger diameter (= 50 cm [20 in]) trees, and they avoided stands in the sapling and pole stages. Kill sites had greater basal area (average = 52 m^2/ha), snag density (average = 77 snags/ha = 13 cm dbh [31 snags/ac =5 in]), large tree density (average = 62 trees/ha >50 cm dbh [25 snags/ac = 20 in]) and higher average dbh (32 cm [13 in]) than random sites. Bloxton (2002) reported that a disproportionately high number of goshawk kill sites were in forests with a 25-36 cm (10-14 in) quadratic mean dbh (Qdbh; i.e., the dbh of a tree with average basal area in a stand) as well as in mature (35-51 cm [14-20 in] Qdbh) and old-growth (>51 cm [20 in] Qdbh) structural classes. Also, 96% of kill sites had canopy closures = 60% (average = 77%). Bloxton (2002) noted that young (< 30 years) forests generally did not provide

appropriate conditions (i.e., large trees with well developed canopies, adequate flight space beneath the canopy) for goshawk hunting.

In ponderosa pine forests of northern Arizona, breeding male goshawks preferred to forage in mature forests with higher basal areas and higher densities of trees >41 cm (16 in) dbh (Beier and Drennan 1997). In winter, foraging sites used by the same birds had higher canopy closure and more trees between 20-40 cm (8-16 in) dbh as compared to random sites (Drennan and Beier 2003). Based on these findings, one could conclude that in landscapes where the coverage of older forest has decreased, foraging areas and home ranges would become larger and territories more widely spaced (see Crocker-Bedford 1998).

Goshawks in the Cascade Range of northern California selected closed canopy mature and old-growth stands for foraging (>51 cm [21 in] average dbh and >40% canopy closure) (Austin 1993). Greater basal area, more large trees (>46 cm [18 in] dbh), and higher canopy closure characterized areas of goshawk use in eastern California as compared to random sites (Hargis et al. 1994).

Studies in the western United States (Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Desimone 1997, Patla 1997, Daw and DeStefano 2001; Finn et al. 2002a, b) indicate that mid- to late-successional forested habitats comprise a significant proportion of the total home range area. Average habitat composition of the HR (1886 ha [4660]) was 64% (95% CI 54-78) "late-seral" forest on the Olympic Peninsula (Finn et al. 2002a). Historical goshawk sites were more likely to be occupied in landscapes (i.e., home ranges) dominated by large uniform patches in late-seral stages.

Diet

Goshawks are considered opportunistic foragers (Beebe 1974), as exhibited by the wide range of prey taken in the United States (Squires and Reynolds 1997). Douglas' squirrel (*Tamiasciurus douglasii*), grouse, and snowshoe hare (*Lepus americanus*) were the most frequently represented prey species (representing 54% of all prey in the eastern slope of the Cascade range and Okanogan county and 41% in the Olympic peninsula and west slope of Cascade range) (Watson et al. 1998). Chipmunks (*Tamias* spp.), northern flying squirrel (*Glaucomys sabrinus*), Steller's jay (*Cyanocitta stelleri*), northern flicker (*Colaptes auratus*) and small woodpeckers (Picidae) each constituted >3% of the goshawks diet by frequency. Passerine bird species (e.g., American robin [*Turdus migratorius*]) accounted for 28% of west-side and 18% of the east-side prey by frequency (Watson et al. 1998). Goshawks in the northeastern Cascades took the highest proportions of grouse, while those in the Olympics took the fewest. Combined grouse and snowshoe hare accounted for the majority of all prey biomass consumed. Similar prey species and ratios were documented in eastern Oregon (Reynolds and Meslow 1984, Bull and Hohman 1994, Cutler et al. 1996).

In northeastern Washington and the Blue Mountains, the red squirrel (*T. hudsonicus*) replaces the Douglas' squirrel as an important food item (Hayward and Escano 1989, Patla 1997; D. Base and S. Fitkin, personal communications). In Klickitat County, a western gray squirrel (*Sciurus griseus*) was observed being taken by an immature goshawk in ponderosa pine/Garry oak (*Quercus garryana*) habitat (M. Linders, personal communication).

Bloxton (2002) studied goshawk foraging behavior and prey use among 15 territories in an intensively managed forest landscape in western Washington. He found that grouse (ruffed and blue combined) and band-tailed pigeon (*Columbia fasciata*) were the predominant prey by frequency, followed by Steller's jay, snowshoe hare, thrushes (Turdidae), woodpeckers, Douglas' squirrel, northern flying squirrel, other rodents, and birds. Grouse and hares probably represented the majority of biomass consumed.

Given the importance of snowshoe hare in Washington goshawk diets, it is possible that goshawk territory occupancy could fluctuate in response to cyclical changes in snowshoe hare abundance (e.g., see Doyle and Smith 1994). However, the variety of prey species identified suggests that Washington's goshawks are not dependent on hare and grouse abundance because of opportunistic feeding on other prey species (Watson et al. 1998).

Dispersal

Dispersal data for adult goshawks in the western U.S. is limited. The cycling population patterns of snowshoe hare and grouse are believed to influence periodic southward movement of goshawks from northern Canada (Squires and Reynolds 1997). Although some goshawks appear to disperse short distances during the non-breeding season, most populations are believed to be non-migratory (Johnsgard 1990, Squires and Reynolds 1997, Bloxton 2002, Drennan and Beier 2003). These short-distance movements are likely a response to prey availability during winter (Keane and Morrison 1994, Reynolds et al. 1994, Squires and Ruggiero 1995, Drennan and Beier 2003; T. Bloxton, personal communication). In western Washington, female goshawks had higher winter site fidelity to their breeding areas compared to their mates (Bloxton 2002). Adult northern goshawks are not believed to make significant movements to seek new breeding sites (Detrich and Woodbridge 1994, Doyle and Smith 1994, Reynolds and Joy 1998).

Limited information is available about dispersal patterns in Washington. In one unpublished study, four immature goshawks were captured, marked, and released near Chelan, Washington, in autumn; they occupied transitional areas between coniferous forest and either subalpine parkland or lower elevation shrub-steppe savannah. Monitored until their deaths (average survival time: 13 weeks), they remained within 150 km of their banding site (J. Smith, personal communication).

LIMITING FACTORS

Generally, the two most significant limiting factors to the long-term productivity and survival of raptors are the availability of suitable prey and nesting habitat (Newton 1979). Although the effects of timber harvesting on goshawks in the United States are not fully understood, there is evidence to suggest that harvest impacts nest site selection (Reynolds 1989, Crocker-Bedford 1990, Ward et al. 1992, Woodbridge and Detrich 1994, Desimone 1997; Finn 2002a, b), and potentially, nesting rates (Crocker-Bedford 1990, 1995). In addition, nesting goshawks appear to be largely absent from some extensive forested landscapes in western Washington that have been intensively managed on rotations =50 years (WDFW, unpublished data). Fragmentation of suitable habitat potentially increases interaction with competing raptors (e.g., red-tailed hawks [*Buteo jamaicensis*], great horned owls [*Bubo virginianus*]) (Moore and Henny 1983, Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990, Kenward 1996). The impact of regulated falconry on wild raptor populations is thought to be minimal (Conway et al. 1995, Kenward 1997, Mosher 1997), but is largely unknown for goshawks (Squires and Reynolds 1997).

MANAGEMENT RECOMMENDATIONS

Management recommendations for goshawks in Washington before the publication of this volume largely relied on the Northern Goshawk Scientific Committee's (GSC) recommendations developed for forests in the southwestern United States (Reynolds et al. 1992). The GSC recommendations were prescriptions that reflected a balance of different forest age classes to provide "desired forest conditions" needed to sustain goshawk populations and an adequate prey population in the U.S. Forest Service's (USFS) Southwestern Region (Reynolds et al. 1992). Many of the following recommendations for Washington are still based, at least in part, on the GSC guidelines because there is currently limited information for northern goshawks in the Pacific Northwest. However, where appropriate, some of the following prescriptions are based on recent research in western Washington.

Certain general forest types listed in the GSC guidelines may be similar to some forest types in eastern Washington (e.g., ponderosa pine and higher elevation mixed conifer) and the guidelines may be more applicable to these forest types east of the Cascade crest (S. Desimone, personal observation; R. Anthony and R. Reynolds, personal communications). Although eastern Washington vegetation data have not been fully evaluated in goshawk studies, some information exists that can be used to make limited comparisons (see Finn 1994, McGrath 1997). However, the GSC guidelines have not been assessed in Washington, particularly for moist forest types west of the Cascade crest (e.g., western hemlock/Douglas-fir and Sitka spruce zones). Also, eastern Washington lodgepole pine, moist Douglas-fir/grand fir/western larch, and true fir/Engelmann spruce (*Picea engelmannii*) forest stands have not been

assessed. Overall, the GSC does not recommend applying specific management prescriptions outside of the southwestern United States. Rather, they recommend the application of general GSC model concepts elsewhere (R. Reynolds, personal communication). In addition, Anthony and Holthausen (1997) caution that the appropriateness of the PFA and foraging area estimates need to be tested for applicability to the Pacific Northwest.

Nest Areas

Nest areas should be approximately 12 ha (30 ac) in size (Reynolds et al. 1992). At least three suitable nest areas should be protected per home range (Reynolds et al. 1992). In addition, at least three replacement areas should be present per home range, for a total of 72 ha (180 ac) (Table 2). If only one nest area is known, additional stands and replacement areas within the PFA management areas should be identified and protected. Alternate nest areas selected by managers should be structurally similar to known nest areas (Reynolds et al. 1992). Replacement nest areas are needed because goshawk nest areas are subject to disturbances such as fire and windthrow. Selection of nest areas should prioritize active or most recent nest areas over historical areas. Nest areas should be delineated using known nests and plucking posts where possible. In mixed conifer and ponderosa pine forests of eastern Washington, data from Table 2 can be evaluated with stand-specific and area data to estimate local habitat needs. All nest areas should be located within approximately 0.8 km (0.5 mi) of the goshawk pair's adjacent nest areas (Reynolds et al. 1992).

Table 2. Size recommendations for areas within goshawk home range as reported by the Goshawk Scientific Committee (Reynolds et al. 1992).

Attribute	Home Range Components		
	Nest Area	**PFA**	**Foraging Area** [a]
Total areas	6	1	1
Suitable nest areas	3	N/A	N/A
Replacement nest areas	3	N/A	N/A
Size in hectares (acres)	12 (30) each	170 (420)	2,185 (5,400)
Management season	Oct - Feb	Oct - Feb	Oct - Feb

[a] Foraging area figures do not include the nest areas and PFA.

Human presence should be minimized in active nest areas during the nesting season (1 March - 30 September) (Reynolds et al. 1992). Broadcasting calls for survey purposes should not be implemented until June 1 (for recommended survey protocol guidelines and information, contact WDFW's goshawk specialist in Olympia). Data on human disturbances are lacking; however, in the absence of such data, the disturbance guidelines established for other raptors should be observed: activities such as road building, logging, site preparation and herbicide and pesticide application should not occur within 0.8 km (0.5 mi) of active nests during the nesting season (e.g., Washington Forest Practices Board 2001). On known occupied territories, if the active nest is not located during the year of management activity, then a 0.8 km (0.5 mi) radius from the geographic center of previous known nest sites should be protected. Road densities should be minimized in the vicinity of nest areas and should be managed within the context of adaptive management (a systematic process for continually improving management practices by learning from the outcomes of earlier practices) (Reynolds et al. 1992).

An average canopy closure of 70-80% for both western and eastern Washington nest areas should be retained (McGrath 1997, Finn et al. 2002b). Activities conducted within suitable and replacement nest areas should be limited to those designed to enhance stand development and maintain habitat structure (Reynolds et al. 1992). Selective overstory removal, patch harvests, or clearcut harvests resulting in complete removal of trees or the reduction of large stem density and canopy volume over a landscape compromises goshawk nesting habitat (Ward et al. 1992, Crocker-Bedford 1995, Desimone 1997; Finn et al. 2002a, b). Activities in nest areas that are detrimental to desired nesting structure for goshawks should not occur at any time in areas managed for goshawks (Reynolds et al. 1992). All intact forest patches in late stages of forest development within the nest area should be retained (Daw

and DeStefano 2001, Henjum et al. 1996). Fidelity of some goshawks to nest areas in winter (T. Bloxton, personal communication) underscores the importance of protecting mature and old forested habitat in nest areas to sustain resident prey populations.

No overstory or regeneration harvest should take place within the NAC at any time (Woodbridge and Detrich 1994, Desimone 1997, Daw and DeStefano 2001). For the Olympic Peninsula, controlled understory thinning to enhance development of stands for desirable nest characteristics should be carefully monitored so that dominant overstory trees are not removed and deep overstory canopy attributes are maintained (see Finn et al. 2002b); average canopy closure should remain =70%. Thinning may help younger stands develop characteristics conducive to nest habitat sooner than if left unmanaged. However, their potential for use by goshawks will be negated if the newly enhanced stands are not allowed to exist over an extended time period (e.g., 20-70 years) beyond a harvest rotation age (depending on stand age and site conditions). Thinning and stand enhancements for nest areas should be done within the context of local forest conditions and within an adaptive management framework.

Post-fledging Family Area (PFA)

The size of the PFA should be approximately 170 ha (420 ac) in addition to the identified suitable and replacement nest areas (Reynolds et al. 1992). This area should be delineated and centered on active and alternate nest areas (i.e., the nest area cluster [Woodbridge and Detrich 1994]), and include as much mature and old forest as possible (Desimone 1997, Daw and DeStefano 2001).

In western Washington and moist forests east of the Cascade crests, canopy closure in the PFA should average ≥70% (Finn et al. 2002a, b), and ≥60% in the drier pine-dominated forests east of the Cascades (Finn 1994, McGrath 1997, Wagenknecht et al. 1998). Preference should be given to stands that are similar in structure to the nest area (Reynolds et al. 1992, Daw and DeStefano 2001). Forest management should emphasize the retention and enhancement of complex forest structure and desirable canopy closure (Finn et al. 2002a, b). PFA attribute information for eastern Washington forests is virtually unknown; therefore, forest management should avoid reducing or further fragmenting existing late-seral forest in PFAs (Beier and Drennan 1997, Daw and DeStefano 2001) until more data are collected. If possible, the PFA should not contain >10% seedling/sapling or early forest cover (Finn et al. 2002a). Retaining snags and down logs will likely enhance goshawk prey abundance (Reynolds et al. 1992).

Foraging Area (Home Range)

The GSC recommends that 60% of the foraging habitat be equally divided between mid-aged (20%), mature (20%), and old (20%) successional classes of forest by area based on work in the southwestern United States (Reynolds et al. 1992). These percentages might not be adequate in western Washington, because the average proportion of late-seral forest in foraging areas was at least 1.5 times that of the southwest in certain forest types (Finn et al. 2002a). In addition, goshawks made most kills in mature and older closed-canopy forest in western Washington (Bloxton 2002). Goshawks also occupied landscapes where ≥54% of the foraging area (i.e., home range) was comprised of late-seral forest, and averaged no more than 11% seedling/sapling or early forest stages (Finn et al. 2002a). Based on these findings, it is recommended at least 60% of the foraging area be retained in mature and old forest. This is in addition to the mature and old forest area that should be retained in nest areas and PFAs.

Snags are important resources for sheltering birds and mammals that are goshawk prey. Large-diameter snags and logs should be retained within managed goshawk foraging areas to provide cover for important prey species. While no information exists for goshawk foraging areas in ponderosa pine forests in eastern Washington, we recommend the retention of at least 5 large ($\geq$ 46 cm dbh [18 in], $\geq$ 9.1 m [30 ft] in height) snags/ha (2 large snags/ac), and at least 7 large ($\geq$ 30 cm [12 in] diameter, $\geq$ 2 m [7 ft] in length) downed logs/ha (3 logs/ac) based on the guidelines of Reynolds et al. (1992). At least 7 large snags/ha (3/ac) with at least 12 large downed logs/ha (5/ac) should be retained in interior-fir forests (Reynolds et al. 1992). These criteria are recommended until more local information is obtained for eastern Washington.

Few studies have documented snag abundance within goshawk home range habitat in western Washington. Foraging habitat patches should be structurally similar to mimic suitable nesting habitat as well as the habitat of

preferred prey. Based on Bloxton (2002), average snag density in intensively managed habitats should average 14 snags/ha >30 cm (6 snags/ac >12 in); however, additional research is needed.

Landscape Management

Planning in Pacific Northwest forests should occur at the landscape scale because site-by-site management will not maintain viable populations (Kennedy 1991, Bright-Smith and Mannan 1994, Hargis et al. 1994). Conservation and management strategies should consider multiple spatial scales (e.g., watershed, forest-wide, territory, etc.) and potential overlap between adjacent territories. Emphasis should be placed on retaining vegetative diversity and sufficient amounts of mature forested habitat for goshawk nesting and foraging (Crocker-Bedford 1990, Reynolds et al. 1992, Bright-Smith and Mannan 1994, Hargis et al. 1994, Beier and Drennan 1997, Crocker-Bedford 1998, Finn et al. 2002a, Drennan and Beier 2003).

Because of limited information on the habitat requirements of goshawks (especially in eastern Washington), it is recommended that habitat manipulations occur using adaptive management techniques. More direct observational data of goshawk habitat use will be required to develop management plans, predict the species distribution, and aid in the assessment of habitat for goshawks on a landscape-level in eastern Washington (Dewhurst et al. 1995, Braun et al. 1996).

Forest Management

Although largely untested, recommendations for silvicultural manipulations within goshawk home ranges have been proposed. The GSC recommended forest manipulations to benefit goshawk prey (Reynolds et al. 1992). Merrill (1989) and Lilieholm et al. (1993, 1994) recommended the use of a stand density index to manage goshawk habitat in Utah and Idaho. They provided recommendations on desirable stand conditions as well as some specific examples of stand management.

Forest stands in lower elevations of western Washington begin to develop suitable nesting habitat characteristics at about 50 years (Bosakowski et al. 1999, Finn et al. 2002b). However, current timber rotations on industrial lands are approximately 35-50 years (Finn et al. 2002b; F. Silvernail, personal communication). The net result may be the sustained loss of suitable nesting and foraging habitat in intensively managed forests in Washington. We concur with researchers (e.g., Merrill 1989; Lilieholm et al. 1993, 1994; Bloxton 2002, Finn et al. 2002a) who recommend that portions of intensively managed forested landscapes surrounding existing late-seral forest patches be allowed to mature beyond industrial rotational ages (e.g., 70-120 years on the Olympic peninsula and lowland western Washington) to benefit goshawks. Such practices would ensure that some suitable nesting and foraging habitat is available across the managed landscape. Existing occupied marbled murrelet (*Brachyramphus marmoratus*) habitat, which is composed primarily of late forest structure (Ralph et al. 1995), may potentially provide some interim goshawk nest sites (WDFW, unpublished data). However, the potential of these patches to provide adequate PFA and foraging habitat to sustain potential goshawk nest areas is limited to the size and adjacency of mature forests that are within the range of the murrelet in western Washington (i.e., generally within 80 km [50 mi] of marine waters).

To promote the development of nest habitat in western Washington, managers should thin young (30-35 years) conifer stands by removing the understory trees to a density of 345-445 trees/ha (140-180 trees/ac) (Finn et al. 2002a). This forest practice will accelerate tree growth and should eventually result in a deep overstory canopy and a low density of shrub cover if the stand is allowed to mature beyond 50-70 years.

Because goshawks have a strong fidelity to high quality nest areas, there can be a temporal lag before birds respond to habitat changes (T. Bloxton, unpublished data; S. Desimone, personal observation). Abandonment of a nest area following timber management depends on the proximity, timing, and extent of the habitat removal. Habitat assessment models and change detection (e.g., McGrath 1997, Desimone 1997) can evaluate the effects of management on site suitability. However, these processes sometimes lead to an overestimation of suitable habitat if the assumptions of the model are not explicitly addressed (McGrath 1997). A landscape-scale habitat model is currently being developed for predicting nesting habitat for goshawks in Washington (S. Finn, personal communication).

Falconry

The impact of removing wild goshawks for falconry is thought to be negligible (Squires and Reynolds 1997). Of the various hawk species captured, Kenward (1997) estimated that 50-93% are eventually lost or released back into the wild. In Washington, falconry permit holders reported 64 northern goshawks taken from the wild between 1990 and 2002; one immature escaped and one adult died in captivity between 1998 and 2002 (WDFW, unpublished data). As the data are relatively sparse for Washington birds, the removal of northern goshawks from the wild for falconry should continue to be closely monitored.

REFERENCES

Anthony, R. G., and R. S. Holthausen. 1997. Applying concepts of the Southwest goshawk management plan to the Pacific Northwest: What do we need to know? Presented at Ecology and Management for Northern Goshawks in Eastside Forests of the Pacific Northwest Workshop, Spokane, Washington, USA.

Austin, K. 1993. Habitat use and home range size of breeding northern goshawks in the southern Cascades. Thesis, Oregon State University, Corvallis, Oregon, USA.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia. Number 17. Occasional Papers of the British Columbia Provincial Museum, Victoria, British Columbia, Canada.

Beier, P., and J. E. Drennan. 1997. Forest structure and prey abundance in foraging areas of northern goshawks. Ecological Applications 7:564-571.

Bloxton, T. 2002. Prey abundance, space use, demography, and foraging habitat of northern goshawks in western Washington. Thesis, University of Washington, Seattle, Washington, USA.

Bosakowski T., B. McCullough, F. J. Lapsansky, and M. E. Vaughn. 1999. Northern goshawks nesting on a private industrial forest in western Washington. Journal of Raptor Research 33:240-244.

Braun, C. E., J. H. Enderson, M. R. Fuller, Y. B. Linhart, and C. D. Marti. 1996. Northern goshawk and forest management in the southwestern United States. Wildlife Society Technical Review 96-2.

Bright-Smith, D. J., and R. W. Mannan. 1994. Home range and habitat characteristics of male northern goshawks. Studies in Avian Biology 16:58-65.

Buchanan, J. B., L. L. Irwin, and E. L. McCutchen. 1993. Characteristics of spotted owl nest trees in the Wenatchee National Forest. Journal of Raptor Research 27:1-7.

Bull, E. L. 1992. Northern goshawks in northeastern Oregon. Unpublished Report, USDA Forest Service, Pacific Northwest Research Station, La Grande, Oregon, USA.

____, and J. E. Hohmann. 1994. Breeding biology of northern goshawks in northeastern Oregon. Studies in Avian Biology 16:103-105.

Conway, C. J., S. H. Anderson, D. E. Runde, and D. Abbate. 1995. Effects of experimental nestling harvest on prairie falcons. Journal of Wildlife Management 59:311-316.

Crocker-Bedford, D. C. 1990. Goshawk reproduction and forest management. Wildlife Society Bulletin. 18:262-269.

____. 1995. Northern Goshawk reproduction relative to selection harvest in Arizona. Journal of Raptor Research 29:42-43.

____. 1998. The value of demographic and habitat studies in determining the status of northern goshawks (*Accipiter gentiles atricapillus*) with special reference to Crocker-Bedford (1990) and Kennedy (1997). Journal of Raptor Research 32:329-336.

____, and B. Chaney. 1988. Characteristics of goshawk nesting stands. Pages 210-217 *in* R. L., Glinski, B. C. Pendleton, M. B. Moss, M. N. LeFranc, Jr., B. A. Millsap, and S. W. Hoffman, editors. Proceedings of the Southwest Raptor Management Symposium and Workshop. National Wildlife Federation Scientific Technical Series, Washington D.C., USA.

Cutler, T. L., R. J. Steidl, and S. DeStefano. 1996. Diets of northern goshawks in Oregon. Unpublished Report, Oregon Cooperative Wildlife Research Unit, Corvallis, Oregon, USA.

Daw, S. K., and S. DeStefano. 2001. Forest characteristics of northern goshawk nest stands and post-fledging areas in Oregon. Journal of Wildlife Management 65:59-65.

Desimone, S. M. 1997. Occupancy rates and habitat relationships of northern goshawks in historic nesting areas in Oregon. Thesis, Oregon State University, Corvallis, Oregon, USA.
DeStefano, S., S. K. Daw, S. M. Desimone, and E. C. Meslow. 1994. Density and productivity of northern goshawks: implications for monitoring and management. Studies in Avian Biology 16:88-91.
Detrich, P. J., and B. Woodbridge. 1994. Territory fidelity, mate fidelity, and movements of color-marked northern goshawks in the southern Cascades of California. Studies in Avian Biology 16:130-132.
Dewhurst, S. M., W. W. Covington, and D. B. Wood. 1995. Developing a model for adaptive ecosystem management: Goshawk management on Arizona's Kaibab plateau. Journal of Forestry 93:35-41.
Doyle, F. I., and J. M Smith. 1994. Population responses of northern goshawks to the 10-year cycle in numbers of snowshoe hares. Studies in Avian Biology 16:122-129.
Drennan, J. E., and P. Beier. 2003. Forest structure and prey abundance in winter habitat of northern goshawks. Journal of Wildlife Management 67:177-185.
Finn, S. P. 1994. Northern goshawk nest stand characteristics in Okanogan County, Washington. Unpublished Report, Washington Department of Fish and Wildlife, Ephrata, Washington, USA.
____. 2000. Multi-scale habitat influences on northern goshawk occupancy and reproduction on the Olympic Peninsula, Washington. Thesis, Boise State University, Boise, Idaho, USA.
____, J. Marzluff, and D. E. Varland. 2002a. Effects of landscape and local habitat attributes on northern goshawk site occupancy in western Washington. Forest Science 48:1-10.
____, D. E. Varland, and J. Marzluff. 2002b. Does northern goshawk breeding occupancy vary with nest-stand characteristics on the Olympic Peninsula, Washington? Journal of Raptor Research 36:265-279.
Fleming, T. L. 1987. Northern goshawk status and habitat associations in western Washington with special emphasis on the Olympic Peninsula. Unpublished Report. USDA Forest Service, Pacific Northwest Research Station, Olympia, Washington, USA.
Hargis, C. D., C. McCarthy, and R. D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biology 16:66-74.
Hayward, G. D., and R. E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91:476-479.
Henjum, M.G., D.A. Perry, J. R. Carr, D.L. Bottom, J.C. Bednarz, S.G. Wright, S.A. Beckwitt, and E. Beckwitt. 1996. Maintaining ecological integrity of inland forest ecosystems in Oregon and Washington. Wildlife Society Bulletin 24(2): 227-232.
Hennessy, S. P. 1978. Ecological relationships of *Accipiter gentilis* in northern Utah, with special emphasis on the effects of human disturbance. Thesis, Utah State University, Logan, Utah, USA.
James, M., and B. K. Palmer. 1997. 90-day finding for a petition to list the northern goshawk in the contiguous United States west of the 100th meridian: supplementary background information. Federal Register 62:50892-50896.
Jewett, S. G., S. P. Taylor, W. T. Shaw, and J. W. Aldrich. 1953. The birds of Washington state. University of Washington Press, Seattle, Washington, USA.
Johnsgard, P. A. 1990. Hawks, eagles, and falcons of North America. Smithsonian Institution Press. Washington, D.C., USA.
Keane, J. J., and M. L. Morrison. 1994. Northern goshawk ecology: effects of scale and levels of biological organization. Studies in Avian Biology 16:3-11.
Kennedy, P. L. 1991. Reproductive strategies of northern goshawks and Cooper's hawks in north-central New Mexico. Dissertation, Utah State University, Logan, Utah, USA.
____. 1997. The northern goshawk (*Accipiter gentilis atricapillus*): Is there evidence of a population decline? Journal of Raptor Research 31:95-106.
____, J. M. Ward, G. A. Rinker, and J. A. Gessaman. 1994. Post-fledging areas in northern goshawk home ranges. Studies in Avian Biology 16:75-82.
Kenward, R. E. 1996. Goshawk adaptation to deforestation: Does Europe differ from North America? Pages 233-243 *in* D. Bird, D. Varland, and J. Negro, editors. Raptors in human landscapes: adaptations to built and cultivated environments. Academic Press, San Diego, California, USA.
____. 1997. Inferring sustainable yields for raptor populations. Journal of Raptor Research 31:295-296.
Lilieholm, R. J., W. B. Kessler, and K. Merrill. 1993. Stand density index applied to timber and goshawk habitat objectives in Douglas-fir. Environmental Management 17:773-779.
____, J. N. Long, and S. Patla. 1994. Assessment of goshawk nest area habitat using stand density index. Studies in Avian Biology 16:18-23.

McGrath, M. T. 1997. Northern goshawk habitat analysis in managed forest landscapes. Thesis, Oregon State University, Corvallis, Oregon, USA.

____, S. DeStefano, R. A. Riggs, L. L. Irwin, and G. J. Roloff. 2003. Spatially explicit influences on northern goshawk nesting habitat in the interior Pacific Northwest. Wildlife Monograph 154:1-63

Merrill, K. 1989. Silvicultural prescription for development of goshawk habitat. Thesis, Utah State University, Logan, Utah, USA.

Moore, R. K., and C. J. Henny. 1983. Nest site characteristics of three co-existing accipiter hawks in northeastern Oregon. Raptor Research 17:65-76.

Mosher, J. A. 1997. Falconry harvest in the United States. Journal of Raptor Research 31:294-295.

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

Palmer, R. S. 1988. Northern Goshawk *Accipiter gentilis*. Handbook of North American birds. Volume 4: diurnal raptors. Yale University Press, New Haven, Connecticut, USA.

Patla, S. M. 1997. Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. Thesis, Idaho State University, Pocatello, Idaho, USA.

Ralph, C. J., G. L. Hunt, Jr., M. G. Raphael, and J. F. Piatt, technical editors. 1995. Ecology and conservation of the marbled murrelet. USDA Forest Service General Technical Report PSW-GTR-152. Arcata, California, USA.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. USDA Forest Service General Technical Report RM-102, Rocky Mountain and Range Experiment Station, Fort Collins, CO, USA

____. 1989. Accipiters. Pages 92-101 *in* B. G. Pendleton, editor. Proceedings of the Western Raptor Management Symposium and Workshop. Number 12. National Wildlife Federation Technical Series, Washington, D.C., USA.

____. 1997. Ecology and population biology of northern goshawks on the Kaibab Plateau, Arizona. Presented at Ecology and management for northern goshawks in eastside forests of the Pacific Northwest Workshop, Spokane, Washington, USA.

____, R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service General Technical Report GTR-RM-217. Fort Collins, Colorado, USA.

____, and S. M. Joy. 1998. Distribution, territory, occupancy, dispersal, and demography of northern goshawks on the Kaibab Plateau, Arizona. Final Report for Arizona Game and Fish Heritage Project Number 194045. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado, USA.

____, ____, and D. G. Leslie. 1994. Nest productivity, fidelity, and spacing of northern goshawks in Arizona. Studies in Avian Biology 16:106-113.

____, ____, and H. M. Wight. 1982. Nesting habitat of co-existing Accipiter in Oregon. Journal of Wildlife Management 46:124-138.

____, and E. C. Meslow. 1984. Partitioning of food and niche characteristics of co-existing Accipiter during breeding. Auk 101:761-779.

____, and H.M. Wight. 1978. Distribution, density, and productivity of accipiter hawks breeding in Oregon. Wilson Bulletin 90:182-196.

Squires, J. R., and L. F. Ruggiero. 1995. Winter movements of northern goshawks that nested in south-central Wyoming. Journal of Raptor Research 29:5-9.

____, and R. T. Reynolds. 1997. Northern Goshawk (*Accipiter gentiles*). Number 298 *In in* A. Poole and F. Gill, editors. The Birds of North America. Academy of National Science and American Ornithologists' Union, Philadelphia, Pennsylvania, USA.

Wagenknecht J.F., S.P. Finn, and L. Stream. 1998. Northern goshawk breeding ecology in the Upper Yakima River basin, 1994 to 1996. Unpublished Report, Washington Department of Fish and Wildlife, Yakima, Washington, USA.

Ward, L.Z., D.K Ward and T.J. Tibbitts. 1992. Canopy density analysis at goshawk nesting territories on the North Kaibab Ranger District, Kaibab National Forest. Final Report, Arizona Department of Fish and Game, Phoenix, Arizona, USA.

Washington Forest Practices Board. 2001. Forest Practices Rules: Title 222 Washington Administrative Code. Washington Department of Natural Resources, Olympia, Washington, USA.

Watson, J. W., D. W. Hays, S. P. Finn, and P. Meehan-Martin. 1998. Prey of breeding northern goshawks in Washington. Journal of Raptor Research 32:297-305.
Woodbridge, B., and P. J. Detrich. 1994. Territory occupancy and habitat patch size of northern goshawks in the southern Cascades of California. Studies in Avian Biology 16:83-87.

PERSONAL COMMUNICATIONS

Robert Anthony, Unit Leader
Oregon Cooperative Wildlife Research Unit
Corvallis, Oregon

Dana Base, Wildlife Biologist
Washington Department of Fish and Wildlife
Colville, Washington

Thomas K. Bloxton, Wildlife Biologist
University of Washington
Seattle, Washington

Joseph Buchanan, Wildlife Biologist
Washington Department of Fish and Wildlife
Olympia, Washington

Sean Finn, Wildlife Biologist
U.S. Geological Survey
Boise, Idaho

Scott Fitkin, Wildlife Biologist
Washington Department of Fish and Wildlife
Winthrop, Washington

Tracy Fleming, Wildlife Biologist
National Council for Air and Stream Improvement
Vancouver, Washington

Suzanne Joy, Wildlife Biologist
U.S. Forest Service
Fort Collins, Colorado

Mary Linders, Wildlife Biologist
Washington Department of Fish and Wildlife
Olympia, Washington

Jeff Smith, Director of Research
HawkWatch International
Salt Lake City, Utah

Richard Reynolds, Wildlife Research Biologist
U.S. Forest Service
Fort Collins, Colorado

Frank Silvernail, Forester
Crown-Pacific Corporation
Port Angeles, Washington

KEY POINTS

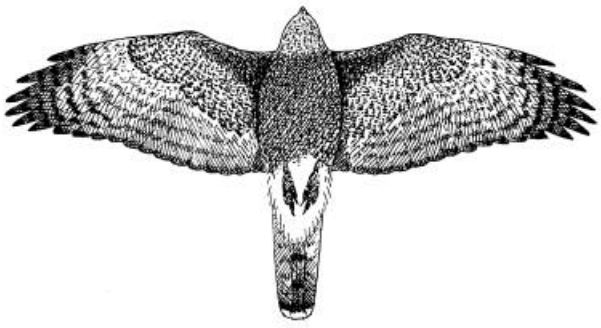
Habitat Requirements

- Home ranges for breeding goshawks can be split into three functional divisions: the nest area or areas, post-fledgling family area (PFA), and foraging area.
- Nest areas are composed of one or several forest stands that contain active or alternate nest structures that are usually occupied by goshawks between March and September.
- Nest areas are typically located in mature or old coniferous forest with a high density of large trees. Additionally, nest areas primarily are composed of stands with a closed canopy and multiple canopy layers.
- Nests are often found in Douglas-fir in western Washington and in Douglas-fir, ponderosa pine, western larch, lodgepole pine, and grand fir east of the Cascades.
- Nest areas typically have a higher basal area than that of surrounding forest east of the Cascade crest.
- Plucking posts are usually found within 100 m (328 ft) of active nests.
- Goshawks apparently prefer to nest close to water and at low topographic positions.
- All nests and alternate nests of a pair form a cluster that generally does not overlap with clusters of neighboring territories.
- The PFA is an area of concentrated use by adult females and developing juvenile goshawks.
- PFAs are typically comprised of complex forest structure and typically contain mature and old forest
- Foraging areas are where goshawks secure prey and it defines their home range during the breeding season. Goshawks forage in a variety of forest types.
- Goshawks are considered opportunistic foragers, as exhibited by the wide range of prey taken.

- Goshawks are believed to be non-migratory

Management Recommendations

- Protect at least three nest areas and three alternate nest areas per home range. Each nest area should be at least 12 ha (30 ac) in size, and selected nest areas should be structurally similar to known nest areas.
- Minimize human disturbance in active nest areas between March 1st – September 30th.
- Retain an average canopy closure of 70-80% and maintain forest in late stages of forest development.
- Limit all overstory or regeneration harvest and increase harvest rotation length in nest area clusters.
- Delineate and center areas to managed as PFAs on active and alternate nests. PFAs should be approximately 170 ha (420 ac) and include as much old and mature forest as possible.
- Manage PFAs for $\geq$ 70% canopy closure in western Washington and for moist forests east of the Cascade crest. Drier forests east of the Cascade crest should have $\geq$ 60 canopy closure.
- Avoid removing late-seral forest in PFAs, and retain snags and downed logs.
- Retain at least 60% of foraging habitat in mid-aged (20%), mature (20%), and old (20%) forest successional classes.
- Large diameter snags and logs should be retained in goshawk foraging areas.
- Retain at least 5 large ($\geq$ 46 cm dbh [18 in], $\geq$ 9.1 m [30 ft] in height) snags/ha (2 large snags/ac), and at least 7 large ($\geq$ 30 cm [12 in] diameter, $\geq$ 2 m [7 ft] in length) downed logs/ha (3/ac) in foraging areas comprised of ponderosa pine forest in eastern Washington. At least 7 large snags/ha (3/ac) with at least 12 large downed logs/ha (5/ac) should be retained in interior-fir forests.
- Conservation of goshawk habitat should be managed on a landscape-scale and multiple spatial scales (e.g., watershed, forest-wide, territory, etc.)
- Forest management should consider increasing timber harvest rotations (e.g., 70-120 years in western Washington lowlands and Olympic peninsula) because intensively managed forest appear to negatively impact goshawks.
- Thin young (30-35 years) conifer stands to a density of 345-445 trees/ha (140-180/ac) to promote the development of nesting habitat in western Washington. If allowed to mature beyond 50-70 years, this practice should result in preferred forest conditions.
- Closely monitor the impact of the removal of northern goshawks from the wild for falconry purposes.



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Ferruginous Hawk

Buteo regalis

Last updated: 1999

Written by Scott Richardson, Morie Whalen, Dinah Demers, and Ruth Milner

GENERAL RANGE AND WASHINGTON DISTRIBUTION

Ferruginous hawks inhabit the arid, open country of 17 western states and 3 Canadian provinces during the breeding season. They winter primarily in Mexico and the southwestern and southcentral United States (American Ornithologists' Union 1983, Olendorff 1993).

Ferruginous hawks breed in the Lower Columbia Basin and surrounding arid lands of southeast Washington (see Figure 1). The Washington breeding range includes Adams, Benton, Columbia, Douglas, Franklin, Garfield, Grant, Kittitas, Lincoln, Walla Walla, Whitman, and Yakima counties.

Figure 1. Breeding range of the ferruginous hawk, *Buteo regalis,* in Washington. Map derived from WDFW data files and GAP Analysis of Washington (Smith et al. 1997).

RATIONALE

The ferruginous hawk, a State Threatened species, is an uncommon breeding species and rare winter visitor east of the Washington Cascades (Washington Department of Fish and Wildlife 1996). Uncultivated land is a major component of ferruginous hawk habitat (Lokemoen and Duebbert 1976; Schmutz 1984, 1987; Olendorff 1993). Loss of uncultivated land and the prey base it supports (Howard and Wolfe 1976, Woffinden and Murphy 1977) may limit the frequency and success of ferruginous hawk nesting efforts. This species is also sensitive to human disturbance, particularly early in the breeding cycle (Smith and Murphy 1978, Schmutz 1984, White and Thurow 1985, Olendorff 1993). The amount of undisturbed natural habitat within the ferruginous hawk's Washington range has been reduced, which may make the population vulnerable.

HABITAT REQUIREMENTS

Ferruginous hawks are obligate grassland or desert-shrub nesters (Woffinden and Murphy 1989). In Washington, they frequent shrub-steppe in the channeled scablands, as well as juniper-savannah areas of the Columbia Basin.

Nesting

Landscapes comprised primarily of shrub-steppe, native prairie, haylands, and pasture are favored for nesting, while cropland is avoided (Howard 1975, Gilmer and Stewart 1983, Schmutz 1984, Roth and Marzluff 1989). Most nests are found in areas with a high proportion of grassland, shrubland, and juniper forest and a low proportion of wheatland, although nests can be found in areas with 50% to 100% wheatland within 3 km (1.9 mi) (Bechard et al. 1990). Ferruginous hawk populations decline consistently once cultivated land exceeds 30% of the area (Schmutz 1987, 1989). This species' nesting requirements may not be adequately accommodated in areas where native grasses are replaced by dense and tall cultivated crops (Schmutz 1987).

In Washington, ferruginous hawks nest on rock outcrops, steep low cliffs, ledges on hills, in some canyons, in isolated trees [juniper (*Juniperus* spp.), black locust (*Robinia pseudoacacia*) and others], and on powerline towers or other artificial structures (Washington Department of Fish and Wildlife 1996).

Ferruginous hawks are sensitive to disturbance; pairs may abandon nests even when mildly disturbed during nest building or incubation (1 March through 31 May) (Smith and Murphy 1978, White and Thurow 1985, Olendorff 1993, Washington Department of Fish and Wildlife 1996). Furthermore, disturbed nests fledge fewer young, and they often are not reoccupied the year following disturbances (White and Thurow 1985). Rather than becoming acclimated to repeated disturbance, ferruginous hawks become sensitized and flush at greater distances (White and Thurow 1985), which may result in increased clutch or brood mortality due to exposure, predation, starvation, or nest desertion.

Ferruginous hawks typically nest farther from human habitations than closely related raptor species (Schmutz 1984, Gaines 1985). In South Dakota, occupied nest sites were significantly farther from human activity as opposed to sites selected at random (Lokemoen and Duebbert 1976). Nests located in physically remote areas or on posted land tend to fledge more young than nests in areas where human access is not limited (Olendorff and Stoddart 1974).

Food

The diet of ferruginous hawks consists primarily of small- to medium-size mammals and, to a lesser extent, snakes, birds, and insects (Olendorff 1993). Northern pocket gophers appear to dominate the diet of Washington ferruginous hawks. Other rodents, snakes, and insects are also common prey (Washington Department of Fish and Wildlife 1996).

Density of major prey species may influence productivity and limit ferruginous hawk populations (Howard and Wolfe 1976). In years of food scarcity, many nesting territories may be left vacant, territorial pairs may fail to nest, clutch sizes may be reduced, or productivity may decline (Woffinden and Murphy 1977, Smith et al. 1981).

Home Range

The average home range for ferruginous hawks in the western states is 7.0 km^2 (2.7 mi^2), but size varies with habitat conditions and prey availability (Olendorff 1993). Some home ranges in Washington are considerably larger (i.e., mean = 79 km^2 [49 mi^2] for 7 males), mainly due to long-distance foraging flights (Leary 1996).

LIMITING FACTORS

Ferruginous hawks may be limited by availability of suitable nesting sites in undisturbed habitats supporting adequate prey populations (Olendorff and Stoddart 1974, Lokemoen and Duebbert 1976, Smith and Murphy 1978, Schmutz 1984, Schmutz et al. 1984, Schmutz 1987).

MANAGEMENT RECOMMENDATIONS

Habitat Protection

Landowners should protect at least half of the native shrub-steppe within ferruginous hawk home ranges (Gilmer and Stewart 1983, Schmutz 1984).

Disturbance

Brief human access and intermittent ground-based activities should be avoided within a distance of 250 m (820 ft) of nests during the hawks' most sensitive period (1 March to 31 May) (White and Thurow 1985). Prolonged activities (0.5 hr to several days) should be avoided, and noisy, prolonged activities should not occur, within 1 km (0.6 mi) of nests during the breeding season (1 March to 15 August) (Suter and Joness 1981). Construction or other developments near occupied nests should be delayed until after the young have dispersed (Konrad and Gilmer 1986), which generally occurs about a month after fledging (Olendorff 1993; A. Jerman, unpubl. data).

Spatial and temporal buffers should be tailored to the individual hawks involved (Knight and Skagen 1988), based on factors such as line-of-sight distance between nest and disturbance, nest structure security, history of disturbance, observed responses, and nest elevation in relation to the disturbance.

Natural Nest Structures

Isolated trees should be protected from cattle rubbing by surrounding them with stick piles or fences. Old, unoccupied nest trees should not be cut for at least 10 years after they have been abandoned by ferruginous hawks. Junipers and black locusts may be planted to provide future nest sites.

In areas where natural nesting materials are in short supply, sagebrush stems and other large sticks may be provided in the vicinity of potential nest structures.

After the dispersal of young, the amount of material in nests may be reduced to avoid having nest-site competitors (e.g., great horned owls) usurp the nests prior to the hawks' return.

Artificial Nest Structures

Artificial nest structures are an effective tool for encouraging successful ferruginous hawk nesting (Tigner et al. 1996). Such structures can be especially valuable if prey populations are adequate, disturbances are minimal, and nest sites are thought to be limiting. However, they may also enhance populations or productivity under other conditions.

Commonly, artificial structures are platforms mounted on poles, trees, or cliffs. Poles should be buried at least 1 m (3.3 ft) deep and should be located away from watering holes, gates, and other areas where livestock congregate. Platforms should be approximately 1 m^2 (10.8 ft^2) to allow space for 3 or 4 nestlings to lie down during strong winds. The structure should allow adult hawks to anchor nest materials. Shade is not required. Specifications for cliff nest structures are available from the Spokane office of the Bureau of Land Management.

Although largely beneficial, artificial structures may attract undesirable or competitive species and are prone to increased disturbance due to their conspicuousness (Howard and Hilliard 1980, Suter and Joness 1981).

Prey

Ferruginous hawks will benefit from land-use practices that ensure an adequate prey base. Landowners should protect shrub-steppe and grassland habitats that harbor significant populations of small mammals and other prey. Habitat conversions, especially through chemical application, should be discouraged where ferruginous hawks occur. Developments (e.g., oil, gas, or geothermal exploration; pipeline and road construction; campgrounds;

interpretive facilities) should be kept at least 400 m (¼ mi) from important prey concentrations, such as ground squirrel colonies (Suter and Joness 1981). Pesticides and rodenticides should not be used within this 400 m area. Appendix A provides useful contacts to help assess the use of pesticides, herbicides, and their alternatives.

Range management activities such as chaining, disking, and brush burning may be detrimental to prey populations and should be avoided. In areas where chaining cannot be avoided, brush may be windrowed to provide nesting and cover for prey species. Reseeding of native plant species after chaining or burning promotes habitat stability and is beneficial to ferruginous hawk prey populations (Olendorff 1993).

REFERENCES

American Ornithologists' Union. 1983. Check-list of North American birds. Sixth edition. Allen Press, Washington, D.C, USA.

Bechard, M. J., R. L. Knight, D. G. Smith, and R. E. Fitzner. 1990. Nest sites and habitats of sympatric hawks (*Buteo* spp.) in Washington. Journal of Field Ornithology 61:159-170.

Gaines, R. C. 1985. Nest site selection, habitat utilization, and breeding biology of the ferruginous hawk in central North Dakota. Thesis, North Dakota State University, Fargo, North Dakota, USA.

Gilmer, D. S., and R. E. Stewart. 1983. Ferruginous hawk populations and habitat use in North Dakota. Journal of Wildlife Management 47:146-157.

Howard, R. P. 1975. Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho. Thesis, Utah State University, Logan, Utah, USA.

____, and M. Hilliard. 1980. Artificial nest structures and grassland raptors. Raptor Research 14:41-45.

____, and W. L. Wolfe. 1976. Range improvement practices and ferruginous hawks. Journal of Range Management 29:33-37.

Knight, R. L., and S. K. Skagen. 1988. Effects of recreational disturbance on birds of prey: a review. Pages 355-359 *in* R. L. Glinski, B. G. Pendleton, M. B. Moss, M. N. LeFranc, Jr., B. A. Millsap, and S. W. Hoffman, editors. Proceedings of the southwest raptor management symposium and workshop. Science and Technology Series No. 11. National Wildlife Federation, Washington D.C., USA.

Konrad, P. M., and D. S. Gilmer. 1986. Post-fledging behavior of ferruginous hawks in North Dakota. Raptor Research 20:35-39.

Leary, A. W. 1996. Home ranges, core use areas, and dietary habits of ferruginous hawks in southcentral Washington. Thesis, Boise State University, Boise, Idaho, USA.

Lokemoen, J. T., and H. F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. Condor 78:464-470.

Olendorff, R. R. 1993. Biology and management of ferruginous hawk (*Buteo regalis*): a review. Occasional Papers Number 1. Raptor Research and Technical Assistance Center, U.S. Bureau of Land Management, Boise, Idaho, USA.

____, and J. W. Stoddart, Jr. 1974. Potential for management of raptor populations in western grasslands. Pages 47-88 *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.

Roth, S. D., Jr., and J. M. Marzluff. 1989. Nest placement and productivity of ferruginous hawks in western Kansas. Transactions of Kansas Academic Sciences 92:132-148.

Schmutz, J. K. 1984. Ferruginous and Swainson's hawk abundance and distribution in relation to land use in southeastern Alberta. Journal of Wildlife Management 48:1180-1187.

____. 1987. The effect of agriculture on ferruginous and Swainson's hawks. Journal of Range Management 40:438-330.

____. 1989. Hawk occupancy of disturbed grasslands in relation to models of habitat selection. Condor 91:362-371.

Schmutz, J. K., R. W. Fyfe, D. A. Moore, and A. R. Smith. 1984. Artificial nest sites for ferruginous and Swainson's hawks. Journal of Wildlife Management 48:1009-1013.

Smith, D. G., and J. R. Murphy. 1978. Biology of the ferruginous hawk in central Utah. Sociobiology 3:79-95.

____, J. R. Murphy, and N. D. Woffinden. 1981. Relationships between jackrabbit abundance and ferruginous hawk reproduction. Condor 83:52-56.

Smith, M. R., P. W. Mattocks, Jr., and K. M. Cassidy. 1997. Breeding birds of Washington State. Volume 4 *in* K. M. Cassidy, C. E. Grue, M. R. Smith and K. M. Dvornich, editors. Washington State Gap Analysis-Final Report. Seattle Audubon Society Publications in Zoology Number 1, Seattle, Washington, USA.
Suter, G. W., II, and J. L. Joness. 1981. Criteria for golden eagle, ferruginous hawk and peregrine falcon nest site protection. Raptor Research 15:12-18.
Tigner, J. R., M. W. Call, and M. N. Kochert. 1996. Effectiveness of artificial nesting structures for ferruginous hawks in Wyoming. Pages 137-146 *in* D. W. Bird, D. E. Varland, and J. J. Negro, editors. Raptors in human landscapes, Academic Press, New York, New York, USA.
White, C. M., and T. L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.
Washington Department of Fish and Wildlife. 1996. Washington state recovery plan for the ferruginous hawk. Washington Department of Fish and Wildlife, Olympia, Washington, USA.
Woffinden, N. D., and J. R. Murphy. 1977. Population dynamics of the ferruginous hawk during a prey decline. Great Basin Naturalist 37:411-425.
____, and ____. 1989. Decline of a ferruginous hawks population: a 20-year summary. Journal of Wildlife Management 53:1127-1132.

PERSONAL COMMUNICATIONS

Aimee Jerman, Thesis Candidate
Boise State University
Boise, Idaho

CONTACTS

Bureau of Land Management
Spokane District Office
1103 N. Fancher
Spokane, WA, 99212-1275
Phone: (509) 536-1200
FAX: (509) 536-1275
E-Mail: or130mb@or.blm.gov

KEY POINTS

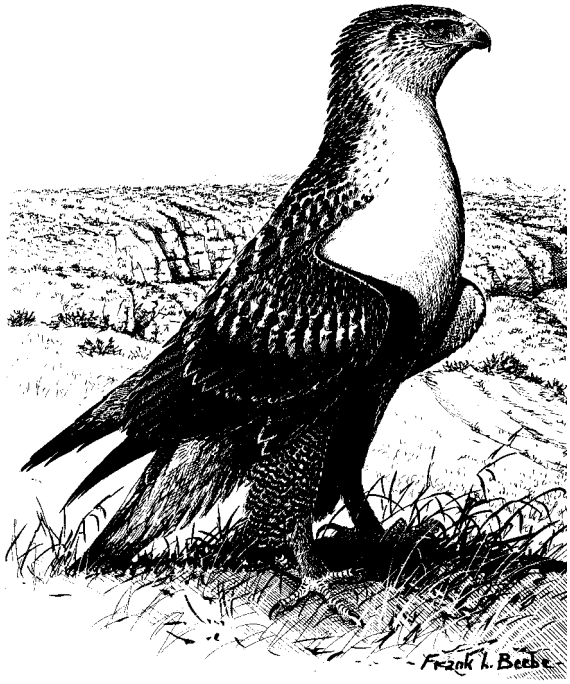
Habitat Requirements

- Sparse, short vegetation in steppe and shrub-steppe habitats is preferred by ferruginous hawks.
- Ferruginous hawks avoid nesting in heavily cultivated lands.
- Ferruginous hawks in Washington generally nest on rock outcrops, steep cliffs, isolated trees, or artificial platforms.
- Ferruginous hawks feed primarily upon a variety of small- to medium-size mammals.

Management Recommendations

- Encourage surrounding landowners to protect 50% or more of the shrub-steppe within ferruginous hawk home ranges.
- Avoid disturbance within 250 m (820 ft) of nests from 1 March through 31 May.
- Delay development near occupied nests until one month after young hawks fledge.

- Avoid construction within 1.6 km (1 mi) of nest sites.
- Install "No Trespassing" signs to prevent harassment.
- Fence isolated trees which show signs of abuse from livestock (e.g., rubbing, soil erosion).
- Retain trees and shrubs greater than 1 m (3.3 ft) in height and within 1.6 km (1 mi) of one another.
- Plant trees, especially junipers and black locusts, in isolated situations.
- Avoid cutting nest trees for at least 10 years after they are abandoned.
- Construct artificial nest structures where nest sites are limited.
- Remove some material from nests in the autumn to prevent nest loss to competitive species or weathering during the non-nesting season.
- Preserve remaining steppe and shrub-steppe habitat types that harbor significant populations of hares, rabbits, and small- and medium-size rodents.
- Maintain a "no disturbance" buffer of 400 m (¼ mi) around periphery of ground squirrel colonies and other prey concentrations.
- Avoid spray application of pesticides when possible. For spray application near ground squirrel colonies, add additional width to the 400 m (¼ mi) buffer to account for pesticide drift. Refer to Appendix A for contacts useful in assessing pesticides, herbicides, and their alternatives.
- Plant 5 m (16 ft) buffer of rye around edge of agricultural crops to protect against rodent damage.
- Avoid chaining, disking, and brush burning where prey species are concentrated or affected. Windrow brush where chaining or disking is necessary.



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