Bridger Teton National Forest
Sensitive Species Conservation Assessment
Northern Goshawk

Revised as of 6/10/2019

Introduction

The Bridger-Teton Land and Resource Management Plan (Forest Plan) provides the following direction to develop quantifiable objectives to improve the status of Regional Forester's Sensitive Species (here after sensitive species).

> Sensitive Species Management Standard: Quantifiable objectives will be developed to identify and improve the status of sensitive species and eliminate the need for listing. Crucial habitats of priority I, II, and III species as listed by Wyoming Game and Fish Department and the Intermountain Region sensitive species list will be protected and maintained. The Forest Service will cooperate with Wyoming Game and Fish Department on management programs when needed to maintain population objectives of these species, especially with species which have been identified as needing immediate attention and active management to ensure a significant decline in breeding populations do not occur. Information collection and interpretive programs will promote the conservation of these species and their habitats. National Forest managers will participate in species and habitat surveys and monitoring programs needed to gain necessary data to determine population status. (U.S. Forest Service 1990, page 157.)

Pursuant to this direction, on 9/5/2013, the Forest Leadership Team approved nine objectives intended to further the conservation of Sensitive Species. The objectives identify and assess: 1) existing species occurrence and habitat baseline data; 2) data gaps in the baseline data and survey/monitor plans and protocols to fill those data gaps; and, 3) species habitat requirements, risk factors and potential conservation actions. One objective was to prepare conservation assessments for each species that summarizes known or suspected status at the Regional and Forest scales. The assessments provide: 1) information on the species status, habitat requirements, risk factors, and potential conservation actions, and 2) habitat maps based on modeling. The assessments also identify survey monitoring needs to address species data gaps.

Conservation assessments provide the basic framework for conserving sensitive species and preventing downward trends at the Forest level that may lead to federal listing. Identification of habitat requirements and risk factors assist biologists in recommending potential conservation actions that would: 1) mitigate and/or avoid undesirable impacts; and, 2) enhance and/or restore habitat conditions where feasible. The assessments are intended to be updated as information becomes available through inventory and monitoring and/or from recently completed research publications that provide "best science" applicable at local and regional scales.

This document presents a conservation assessment for northern goshawks (hereafter "goshawk") on the Bridger-Teton National Forest (BTNF). The status, habitat requirements, and risk factors

for goshawks are summarized using information from research documents, literature reviews, and scientific publications. The literature most relevant to the goshawk on the BTNF includes:

- Northern goshawk: Northern Region overview; key findings and project considerations (Brewer et al. 2009).
- Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. M.S. Thesis (Patla 1997).
- Management recommendations for the northern goshawk in the southwestern United States. Gen. Tech. Rep. RM-217 (Reynolds et al. 1992).
- Species assessment for northern goshawk (*Accipiter gentilis*) in Wyoming (Smith and Keinath 2004).
- Northern goshawk ecology: an assessment of current knowledge and information needs for conservation and management (Squires and Kennedy 2006).
- A Conservation assessment of the northern goshawk, blacked-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region (Samson 2006).
- Wyoming State Wildlife Action Plan (WGFD 2010).

Species Status

Legal Status

The goshawk is designated as a Sensitive Species for all National Forests in the U.S. Forest Service Intermountain Region, including the BTNF (Regional Forester's Sensitive Species list at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5370041.pdf, updated June 2016). The NatureServe Conservation Status Rank for the goshawk is (NatureServe: http://www.natureserve.org/explorer/ranking.htm, accessed May 13, 2019):

- Globally (G5): Secure - common; widespread and abundant.
- Nationally (N4P, N4N): Apparently Secure - uncommon but not rare; some cause for long-term concern due to declines or other factors.
- State (S2B, S3N): Breeding - imperiled because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation. Non-Breeding - vulnerable due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

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The goshawk is also designated **NSSU** in the Wyoming State Wildlife Action Plan (WGFD 2017). Its population status and trends are unknown, and additional forest surveys are needed. (WGFD 2017). In North America, goshawks are found breeding in a variety of boreal and temperate forest habitat types in the eastern and western United States, and in portions of Alaska, Canada, and Mexico. The primary influences on the amount, distribution and suitability of goshawk habitat and subsequently, goshawk populations (Reynolds, 1989, Crocker-Bedford 1990, Squires and Reynolds 1997) are management treatments in forest vegetation (e.g., thinning, timber harvest, prescribed fire) and stand-replacing wildfires (Squires and Ruggiero 2006). However, there is no evidence goshawks are declining in numbers or distribution in the western United States (Kennedy 1997, USDI Fish and Wildlife Service 1998, Kennedy 2003, Anderson et al. 2004, Squires and Kennedy 2006).

Regional and Local Status

Intermountain Region

Goshawks breed in mountainous conifer and deciduous forest habitat throughout Region 4. They also winter throughout their breeding range and in a diversity of habitats at lower elevations outside areas used during the breeding season. All National Forests in Region 4 have known goshawk presence and/or suitable habitat present. Patla (2005) and Fairhurst and Bechard (2005), in Collins et al. (2009), have both documented declines in goshawk territory occupancy over the past 10-15 years in relatively small target populations in eastern Idaho/western Wyoming and northern Nevada, respectively. Patla (2005) suggested these declines may indicate a decline in some goshawk populations across the Intermountain West, but emphasized the need to develop more comprehensive and statistically valid monitoring plans that can track population trends, reproductive success and habitat relationships in a more meaningful way.

State of Wyoming

The subspecies *atricapillus*, is a resident breeder and short distance migrant in the state of Wyoming. Dorn and Dorn (1999 in Smith and Keinath 2004) list the goshawk as a "Yearlong resident, uncommon in summer, rare in winter, with migration peaks in March and October". Goshawks breed throughout the State (Figs. 1 and 2), with the possible exception being east of the Laramie Mountains in the east/southeast part of Wyoming where only wintering birds have been observed (Dorn and Dorn 1999 and Luce et al. 1999).

Breeding goshawks are a forest bird of high regional priority and concern in the Northern Rockies BCR10, which includes Wyoming and the BTNF because of declining or unknown population trend. The only research in the region within or immediately adjacent to Wyoming where population trend data has been reported is the goshawk monitoring project on the Targhee NF (Patla 2005). In a comparison of mean territory occupancy rate between two five year periods (1990-1994 and 1998-2002), goshawk occupancy was down by greater than half (from 64% to 31%). Nest success (nests producing at least one fledgling) at monitored territories also declined from 56% to 19%. Occupancy rates and success rates during the later period were higher in undisturbed territories than those located in timber harvest areas (Patla 2005).

Figure. 1. Goshawk Range Map – Occupancy – for Wyoming. WYNDD (version 2010-01-19) with support from the WGFD and US Geological Survey. Proportion of range deemed known based on documented occurrences: 0.599. Details of range map creation noted in Keinath et al. (2010a).

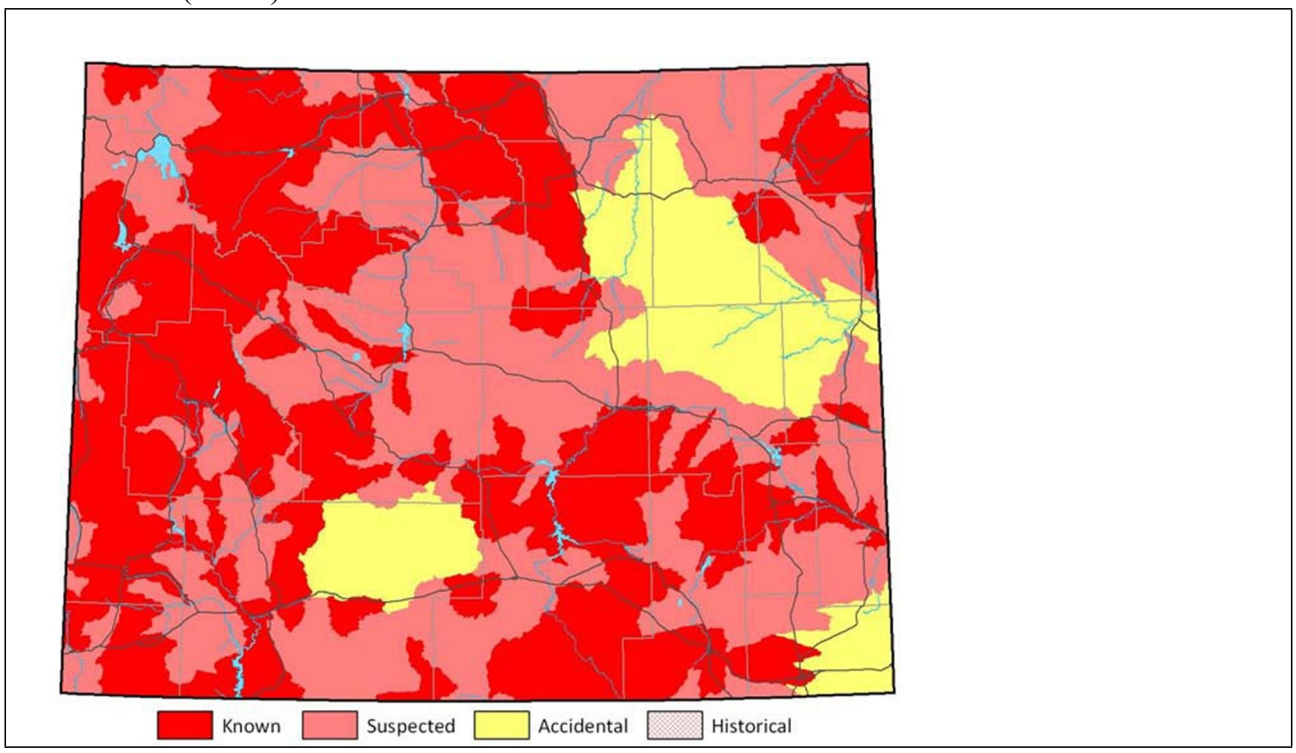
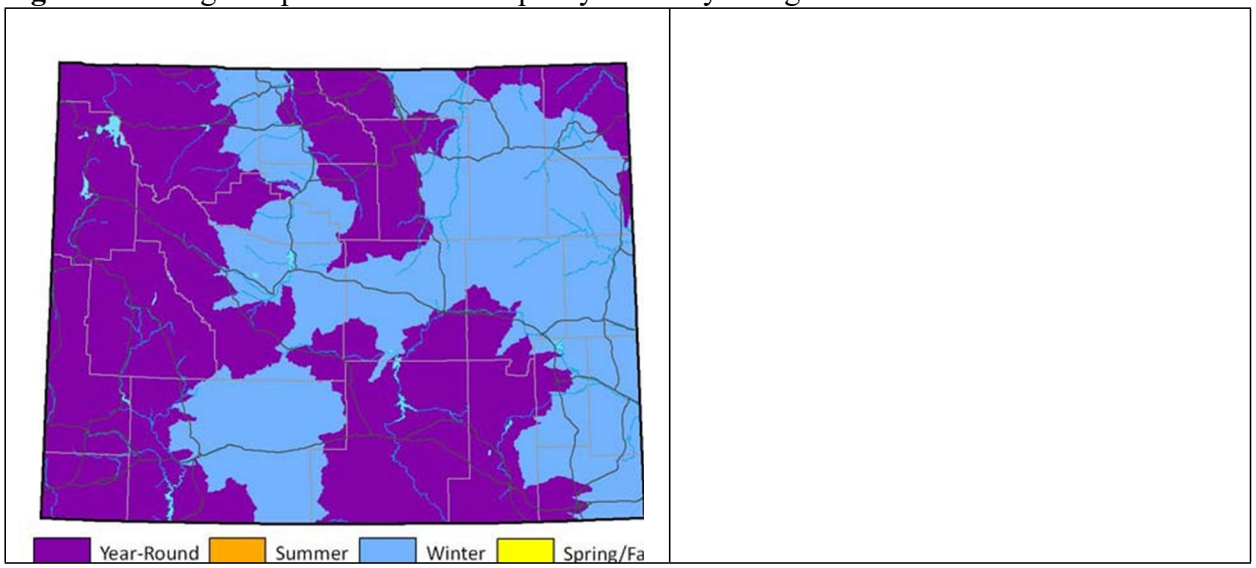


Figure. 2. Range Map – Seasonal Occupancy – for Wyoming.



Maps and report were created by and are available from the Wyoming Natural Diversity Database. (http://uwadmnweb.uwyo.edu/wyndd/). ***Doug Keinath***, Senior Zoologist, and ***Mark Andersen***, GIS Specialist.

Range and Status at the Forest Level

There are approximately 19 known (active and inactive) goshawk territories on the BTNF dating from 2001 (Fig. 6). Annual monitoring of these territories has been sporadic over the past decade. Ten of the territories were monitored in 2012. At least 8 of these territories were occupied by birds in 2012, and active nest sites were found in 7 of the 8 territories. Six of the active territories were newly found in 2012. Of the four older territories monitored in 2012, only two were active. Nine fledglings were observed at four of the 7 active nest sites.

The extent of potentially suitable nesting habitat across the Forest landscape is shown in Table 1 and Fig. 6. The population and trend of breeding pairs and non-breeding birds on the Forest is not known.

Table 1. Number of known (active and inactive) goshawk territories, and acres of primary and secondary goshawk nesting habitat on the BTNF based on a model developed by Langston et al. (2011, unpublished).

District	Goshawk Territories	Nesting Habitat		
	#	***Primary***	***Secondary***	***Total***
Big Piney	8	59672	19161	78833
Buffalo	4	57382	8519	65901
Greys River	6	40977	11931	52908
Jackson		64682	9303	73985
Kemmerer		31119	13354	44473
Pinedale	1	37746	20484	58230
Total	19	291578	82752	374330

Habitat Requirements

General

In North America, the goshawk is a forest habitat generalist (Reynolds et al. 1992), occurring in all major forest types (coniferous, deciduous, and mixed). These forests, because of natural and man-caused disturbances (fires, diseases, insects, logging), contain a wide variety of forest ages, structural conditions and successional stages. Goshawks are most commonly found in dense canopy, mature and old-growth stands (Reynolds et al. 1982, Crocker-Bedford and Chaney 1988, McCarthy et al. 1987, Hayward and Escano 1989, Whitford 1991). The Fish and Wildlife Service found that while the goshawk typically uses mature forests or larger trees for nesting habitat, it is not dependent on large, unbroken tracts of "old growth" or mature forest (63 FR 35183, June 29, 1998), nor selects for "old growth" forest (Whitford 1991, McGrath et al. 2003). On four National Forests east of the Rocky Mountain front in Montana (Bush et al. 2012, unpublished data), found only 14% (n=49) of goshawk nest stands and nest tree plots (n=57) met the criteria for the Region 1 old growth forest definition (Green et al. 1992, errata 2005). Neither did the majority of goshawks select for the largest or tallest nest trees in their nest stands. This is also substantiated by Clough (2000) who, in a random sample of available vegetation types in west central Montana, found goshawks selected for nest stands of mature and older forest that were approximately 40 acres in size, surrounded by a mix of younger forest and non-forested openings. However, because of its relatively large body size and wing span, the goshawk seldom

uses young, dense forests (Fischer 1986), particularly for nesting. In these habitats, there are few large trees in which the goshawk can place its large nest, and there is insufficient space in and below the canopy to facilitate flight and capture of prey.

Three spatial scales (Fig. 3) are used to describe how breeding northern goshawks use landscapes:

- a 25 to 150 acre core nest area (NA), with one to eight alternate nests located in different stands within the nest area (180 to 300 acres);
- a 150 to 600 acre post-fledging area (PFA) surrounding the nest and used by young from the time of fledging to independence; and
- a 1200 to 6000 acre foraging area (FA) used by the breeding pair to forage for prey (Reynolds et al. 1992, Kennedy et al. 1994, Woodbridge and Dietrich 1994, Patla 1997, Clough 2000 , Daw and Destefano 2001, McGrath et al. 2003).

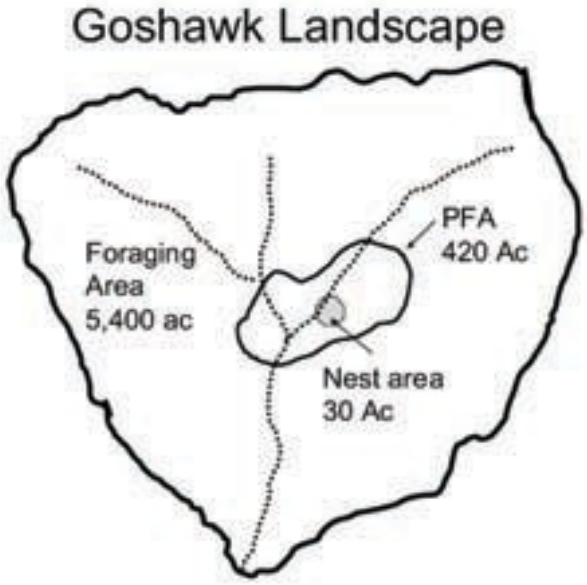


Figure 3. Conceptualized goshawk home range. Three levels of spatial organization at goshawk nest sites, including the NA, PFA, and FA.

Squires and Kennedy (2006) concluded that habitat structure may be as important as prey abundance when selecting NAs and PFAs. The principal structural components include a high density of large trees, high canopy closure, and high tree basal area than generally available in the landscape. These components are provided in mature and old forests. Foraging areas are more heterogeneous, but often include mature-forest components as well. As spatial scale increases from the nest site to the landscape in which home ranges are embedded, habitat heterogeneity increases (McGrath et al. 2003). Goshawks are more of a habitat generalist at these larger spatial scales then at the scale of the nest site. The limited data on non-breeding habitat use patterns also suggest that goshawks are more of a habitat generalist during the non-breeding season then during the breeding season.

Overall, the goshawk is a habitat generalist, but may be more of a habitat specialist around the nest. Goshawks in most of their range in western North American breed in forested habitats, and appear to select old-growth and mature forests for nesting (Squires and Kennedy 2006). This preference seems strongest within approximately 250 acres of the nest stand. Goshawks often place their nests in the larger or largest trees in a stand, and stands in which nests are placed tend to be older than adjacent stands. However, not all goshawk territories are equally suitable. Thus, nesting habitat diversity may increase with nesting density because lower-quality territories are more regularly occupied at higher densities. These lower-quality territories may have different structural characteristics than high quality territories.

Food availability (Salafsky et al. 2005) and lack of predation, in addition to forest composition and structure characterize high quality habitat (Squires and Kennedy 2006). However, more than habitat composition or any other factor (i.e. prey abundance), territoriality determines nest distribution, and spring weather determines nest success (Joy 2002, Reich et al. 2004).

Nesting Habitat

Goshawks nest in many forest types throughout their range (Squires and Reynolds 1997, USFWS 1998, Samson 2006, Squires and Kennedy 2006). These forests include Douglas-fir, various pine and aspen forests in western North America (Reynolds et al. 1982, Hall 1984, Younk and Bechard 1994, Siders and Kennedy 1996, Squires and Ruggiero 1996, Clough 2000, McGrath et al. 2003), and ponderosa pine-mixed conifer forest (Erickson 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Bull and Hohmann 1994, Reynolds et al. 1994, Siders and Kennedy 1996, Daw and DeStefano 2001, McGrath et al. 2003). Nests from the central Rocky Mountains have been described in lodgepole pine dominated conifer, mixed conifer, and quaking aspen forests (Squires and Ruggiero 1996). Douglas-fir was the most common forest type in nest stands in 3 National Forests east of the Rocky Mountain Front in Montana, followed by lodgepole pine (Bush et al. 2012, unpublished), which was consistent with forest-wide landscape compositions. On the Targhee National Forest (TNF) all goshawk nests were found in the montane zone, dominated by Douglas fir and lodgepole pine which occur in pure stands or in mixed conifer forests with Engelmann spruce, subalpine fir, whitebark pine or limber pine. A few nests were found in aspen stands along the lower elevation edges of the montane zone, or mixed within predominantly conifer forests at higher elevations (Patla 1997).

Deciduous and coniferous trees both provide adequate structure for goshawk nests. Squires and Ruggiero (1996) found that aspen and lodgepole pine boles were utilized in proportion to their availability in southern Wyoming. There was no apparent preference for deciduous or conifer trees; however, it appeared that goshawks avoided nesting in sub-alpine fir. Ferland (2006) and Clough (2000) also found that spruce-fir forests were avoided for nesting; however, Ferland (2006) reported that spruce-fir and mixed conifer forests containing >10% aspen cover were more likely to contain goshawk nests. Spruce-fir forests containing goshawk nest sites had twice as much mean aspen canopy cover as random sites and mixed conifer forests had four times as much. Aspen was the primary nest tree species in 66% of the goshawk territories within Ferland's study area in southwest Colorado. The low proportion of documented nests within spruce-fir forests could be due to a number of factors, including prey abundance and availability (persistent late spring snow pack), and tree and forest structure (Ferland 2006). Additionally, Joy (2002) and Clough (2000) suggested the typically dense understories of

spruce-mixed forests might limit access to prey, thereby negatively influencing the probability of goshawk nesting. Likewise, Engelmann spruce and subalpine fir trees both tend to have downward sloping branches lower on the bole that do not provide good nest support. Structurally, trees with fewer limbs below the canopy are desirable (Ferland 2006, Patla 1997, Squires and Ruggiero 1996). Patla (1997) found the number of Douglas fir nest trees (38) to outnumber lodgepole pine (9), aspen (1), and Engelmann spruce (1) combined in southeast Idaho/western Wyoming.

In the Sierra Madre and Medicine Bow Mountains of south central Wyoming Squires and Ruggiero (1996) found goshawks in lodgepole pine and mixed lodgepole pine and aspen forests where they preferred the largest trees available at the nest-tree area or within nests stands. Nest-tree area canopy cover was high (mean = 66.7%, SE = 2.0), but did not differ significantly from random sites. Nest stand results also suggest that goshawks nesting in lodgepole pine forests selected stands lower in overall tree density, but higher in density of trees in the large size class. These nests stands were composed of fewer small-diameter trees than randomly selected stands. Nest stands were not old growth in the classic sense of being multi-storied stands with large diameter trees, high canopy closure and abundant woody debris. Rather, nest stands were in even-aged, single-storied, mature forests stands of lodgepole pine. Patla (1997) found goshawk nest sites on the TNF located in areas of extensive mature forest habitat, primarily in Douglas fir cover types. Mature forest cover averaged over 60% in all three analysis areas (NA, PFA and FA). Goshawks selected nest sites within home range areas that had greater basal area, taller and older trees, greater under canopy space, and higher density of larger trees in the 15.0-18.0" dbh size class. Nests also tended to be placed on north and western aspects in single species stands on the middle and lower portions of slopes.

Daw et al. (1998) summarized data from goshawk habitat studies in the West and concluded goshawks tend to select nest stands that are characterized by relatively large trees and relatively high canopy closure (>50– 60%), regardless of region or forest type. McGrath et al. (2003) compared tree basal area among North American goshawk studies and found that basal area at nest sites ranged from 124–221 ft^2/ ac compared to 90–185 ft^2/ac at random sites. Despite differences in some habitat characteristics, high canopy closure and tree basal area at nest areas were the most uniform habitat characteristic between study areas in northern Idaho and western Montana (Hayward and Escano 1989).

Average patch size of the core nest area varies based on local habitat conditions and has been reported as ranging up to 250 acres. Squires and Ruggiero (1996) reported a range of 1 to 32 acres in south-central Wyoming, while ~200 acres was reported by Patla (1997) in southeast Idaho/western Wyoming. More recent research conducted in Montana recommends nest stands be a minimum of 40 acres in size (Clough 2000, Brewer et al. 2009). However, the amount of contiguous forest (>5.0 dbh with >50% canopy cover) around nest sites may be more important to site occupancy. Reynolds (1983) and Reynolds et al. (1982) defined the nest area as approximately 30 to 60 acres of intensified use surrounding the nest, and recommended 30 acres as the minimum nest stand size (Reynolds et al. 1992) in the southwestern U.S. Woodbridge and Detrich (1994) suggested that although small (30-60 acres) stands were used successfully for nesting, goshawks preferred larger (85–200 acre) stands for nesting because occupancy rates of forest stands used for nesting decreased with decreasing stand size. In their study, stand clusters

less than 49 acres had occupancy rates less than 20 percent, while stand clusters greater than 151 acres had occupancy rates of nearly 100 percent. They recommended no less than 84 acres. The larger (60 trending to125 acre) core area reported by Daw and Destefano (2001) further supports the hypothesis that larger patches of mature forest surrounding goshawk nests may be important.

Goshawks have been found to use the same nesting areas for decades (Reynolds 1983), but frequently change nest locations in consecutive years. A high percentage of breeding pairs (55 to 75%) change nest locations yearly and these nests can be as far as 1.5 miles from a previously used nest (Reynolds et al. 2005). The average re-occupancy rate of individual nests at 26 territories in northern California (Woodbridge and Detrich 1994) over at least 5 years was 49% (+- 11%). Of 46 instances of nest area re-use in successive years by goshawks on the Targhee NF, only twice did pairs use the same nest tree. Over the course of the six year study, there was an 8% incidence of nest re-use (n=18; Patla 1997). Nesting territories contained a number of alternate nests (range 1-7). Eighty seven percent of alternate nests used within 1-2 years were located more than 330 feet from the last nest used (Patla 1997). The mean distance measured between alternate nests occupied in consecutive years in different parts of the western United States was quite consistent: 935 feet on the TNF (n=24), 892 feet in northern California (n=65) (Woodbridge and Detrich 1994), and 873 feet in northern Arizona (n=17) (Reynolds et al, 1994). Alternate nests can be clumped in one–three nest stands or widely distributed throughout the bird's home range (Squires and Reynolds 1997).

Breeding Chronology

In south-central Wyoming, migratory adults returned to nest areas between 23 March and 12 April (Squires and Ruggiero 1996). Patla (1997) observed goshawks returning to nesting areas between late March and early April on the Targhee NF, generally corresponding with the emergence from hibernation of Uinta ground squirrels. Based on data from 37 successful nesting pairs from the Targhee NF (1989-1994) mean date for onset of incubation was May 5 (range April 20-May 20) and mean hatch date was June 6 (range May 22-June 21; Patla 1997). In a 17-year study of color-banded goshawks in Arizona (Reynolds et al. 2005), temporal and spatial variation in egg laying was shown to be extensive (7-86% of goshawks laid eggs in a year, none laid eggs every year, and some territorial goshawks skipped breeding for 7 consecutive years).

Nestlings are reliant upon adults during development in the nest for 36-42 days from hatching to fledging (Boal 1994). A provisioning period of approximately 25 days follows, during which fledglings remain within 985-1300 feet of the nest, and continue to receive prey items from both parents. Self-feeding begins as early as 20 days after fledging and young increasingly feed themselves from 26-27 days on. Reduced adult provisioning continued in south central Wyoming up to 62 days post-hatch (Good et al 2001).

PFA Habitat

The PFA surrounds the nest area and, based on studies of family movement patterns, is defined as the area used by the family group from the time the young fledge until they are no longer dependent on the adults for food (Reynolds et al. 1992; Kenward et al. 1993; Kennedy et al. 1994; Kennedy and Ward 2003). The PFA may represent the defended portion of the home range (Reynolds et al. 1992). Additionally, the PFA may provide protection from predation and

serve as an area where young birds develop flying and hunting skills (Reynolds et al. 1992, Kennedy et al. 1994, Squires and Kennedy 2006). McGrath et al. (2003) characterize PFA's in their eastern Oregon and Washington study area, as a core area (200 acres) around goshawk nests where the forest is represented by large trees with high canopy closure (>50%) and this core is surrounded by a heterogeneous landscape with forest cover types that are equally abundant. Some amount of mid- to late-seral forest with > 50% canopy cover, small openings and structural diversity in the understory appear important at the PFA scale (Daw and DeStefano 2001; Finn et al. 2002; McGrath et al. 2003; Samson 2006; Squires and Kennedy 2006). Compared to nesting habitat, PFAs have:

- similar dominant species to that in nest sites (Patla 1997, McGrath et al. 2003, LaSorte et al. 2004);
- less canopy closure and more younger trees in comparison to the nest site (Patla 1997, Clough 2000, McGrath et al. 2003); and
- less structure and more difference in structure as distance increases from the nest site (Daw and Destefano 2001, McGrath et al. 2003).

The area of continuous, non-fragmented forest in the PFA that surrounds the nest site may also vary with local conditions. For example studies in different parts of the country have found areas of continuous forest surrounding the nest site out to a variety of distances, such as 981 feet in west central Montana (Clough 2000), 1640 feet in Oregon and Washington (McGrath et al. 2003), 2116 feet in Arizona (La Sorte et al. 2004), and 2402 feet in New Mexico (Kennedy et al. 1994). Patla (1997) described the range of mature forest found in northern goshawk PFAs to be 16 to 100%, but 93% and 63%, respectively, of the PFAs had >40% and >60% mature forest cover. The amount of young forest in PFAs differed by dominant tree species; 15% in Douglas-fir to 3% in lodgepole forest. Overall, PFAs examined by Patla (1997) averaged 66.0 ± 4 % mature timber, 6.0 ± 2 % young trees, 17.0 ± 4 % seedlings, and 11.0 ± 2 % open grass/shrub. In contrast, Patla and Derusseau (2010) found only 19.3% mature and older forest cover in PFAs on the BTNF. Likewise, Clough's (2000) analyses of PFAs in Montana showed only 11.3 ± 5.1 % contained old growth or mature forest. About 77% of the PFAs in Clough's study area were covered by forest. Small-sized trees dominated 66% of these PFAs, and only 11.3% was dominated by medium- or large-sized trees. Forest canopy cover was >50% in 69% of the PFAs, while 8.9% of the PFA had 25% to 50% canopy closure.

Foraging Habitat

The goshawk is a habitat and prey generalist at the FA scale. Goshawk FAs are heterogeneous and may include some mature forest components (Squires and Kennedy 2006) as well as a mix of other forest and non-forest components (i.e. sagebrush, grasslands, lowland riparian, and agriculture) (Reynolds et al. 1992, Younk and Bechard 1994, Reynolds 1994, Patla et al. 1997, Samson 2006, Squires and Kennedy 2006). A mix of seral stages similar to the PFA serves as a general description of desired goshawk foraging habitat (Hargis et al. 1994). Although goshawks hunt species with diverse habitat requirements, several habitat features appear to be important to a variety of prey species (Reynolds et al. 1992). These features include snags, downed logs (>12inch diameter and 8 feet long), large trees (>18 inch diameter), openings and associated herbaceous and shrubby vegetation, interspersion, and canopy cover.

Goshawks are an opportunistic predator that take prey items on the ground, on vegetation, in the air, and rely on a variety of forested and non-forested habitats (Reynolds et al. 1992). They often select forests with a high density of large trees, greater canopy cover, high tree basal area, and open understories (Doyle and Smith 1994, Hargis et al. 1994, Beier and Drennan 1997), but with much variation (Kenward 1982, Widen 1989, Austin 1993, Bright-Smith and Mannan 1994, Hargis et al. 1994, Younk and Bechard 1994, Beier and Drennan 1997). Small openings, tree fall gaps, edges, riparian zones, and rock outcrops are examples of small-scale landscape elements that may be important to foraging goshawks (Squires and Reynolds 1997). Thus, the wide variation in habitats occupied by goshawks suggests that foraging habitat may be as closely tied to prey availability as to habitat structure or composition (Reynolds 1989, Kenward and Widen 1989). Preferences in goshawk foraging habitat are likely determined, in part, by habitat characteristics that influence their ability to access prey as well as prey abundance (Reynolds et al. 1992, Drennan and Beier 2003).

Goshawks typically forage on a suite of 8–15 species (Reynolds et al. 1992). Tree squirrels, ground squirrels, rabbits, hares, songbirds, woodpeckers, and grouse species are taken as prey (Squires and Reynolds 1997; Squires and Kennedy 2006, Clough 2000, Patla 1997). Salafsky et al. (2006) found that alternate prey species are commonly substituted for one another as a function of prey availability. Nesting goshawks in south central Wyoming consumed at least 33 species of prey, 14 mammalian and 19 avian (Squires 2000). The study characterized prey which occurred in stands of predominantly lodgepole pine, subalpine fir, and Engelmann spruce (Marston and Clarendon 1988 in Squires 2000). Dominant prey species in south-central Wyoming in order of occurrence, included: red squirrel, northern flicker, American robin, golden-mantled and Uinta ground squirrel or least chipmunk, respectively (Squires 2000). Woodpeckers were present in 52 percent of pellets (Squires 2000). Prey analysis in southeast Idaho/western Wyoming suggests that avian prey makes up a greater percentage of the daily diet of goshawks in this region as compared to central Wyoming. Mammalian prey, adjusted for weight, accounted for 59% of the goshawk diet, and birds 41% (Patla 1997). Grouse species may account for this difference, as of the known prey biomass in western Wyoming, ruffed grouse, blue grouse and unknown grouse species account for 28%, whereas grouse are not indicated as principle prey in southern Wyoming by either Squires (2000) or Good et al. (2001). Snowshoe hare (30% of total biomass) and Uinta ground squirrel (15%) were the primary mammalian prey items in western Wyoming (Patla 1997).

In south-central Wyoming, Good (1998) described foraging habitat of five male goshawks at nest sites. He examined four factors at each kill site: prey abundance, habitat characteristics, landscape patterns, and habitat needs of prey species. Similar to Beier and Drennan's (1997) study, Good (1998) found the relative use of kill areas correlated with habitat characteristics rather than prey abundance. The majority of goshawks (N = 3) in his sample returned most often to sites with more mature forests, gentler slopes (6–60%), lower ground coverage of woody plants (1–30%) and greater densities of large conifers (9–15 inch dbh, range = 0–11 stems/acre). Goshawk kill areas were often associated with small natural openings, as were many prey species. Good also suggested that goshawks may return to areas more often where large numbers of prey are present because two individuals in his sample regularly returned to kill sites with high prey abundance.

In their literature review, Squires and Reynolds (1997) reported prey abundance and availability strongly affects breeding area occupancy and productivity. Based on the assumption that goshawk populations are regulated by food availability, Reynolds et al. (1992), emphasize that forest management practices may strongly influence the availability of prey items for the goshawk, thus being a determining factor in the long-term persistence of the species (Kennedy and Andersen 1999). Beier and Drennan (1997) and Drennan and Beier (2003) concluded that goshawks did not select foraging areas based on prey abundance, but rather selected areas with higher canopy closure, greater tree density, and greater density of trees >16 inch dbh than on contrast plots. They suggest that goshawk morphology and behavior are adapted for hunting in moderately dense, mature forests, and that prey availability is more important than prey density in habitat selection. Drennan and Beier (2003) also hypothesize that goshawk habitat selection may be a two-tiered process. First, goshawks select broad landscapes that support abundant populations of large-bodied prey, before selecting moderately dense stands of mature forests where they can use their maneuverability to capture prey.

Winter Habitat

The goshawk is considered a winter resident throughout its breeding range; however, some goshawks regularly winter outside their breeding areas (Squires and Reynolds 1997). Limited evidence on goshawks in the Intermountain West suggest these populations are migratory or partially migratory (Squires and Ruggerio 1995, Dewey et al. 2003, Squires and Reynolds 1997). Some individuals maintain year-round occupancy of nest territories while other individuals in the population undergo seasonal movements to wintering areas (Berthold 1993).

Squires and Ruggiero (1995) documented that four goshawks, which nested in south-central Wyoming, were short-distance migrants (range = 40–115 miles from nesting area), beginning movements in mid-September and returning to nest sites between March 23 and April 12. These four goshawks wintered in aspen with mixed conifer, large stands of spruce-fir, lodgepole pine and cottonwood groves surrounded by sagebrush.

In the Uinta Mountains of northern Utah goshawks also exhibited short-distance migratory movement, wherein winter range did not include the nest stand of the previous breeding season (Stephens 2001). Sonsthagen (2002) found that Utah goshawks were partial migrants; migrations involving short-distance movements. Of 34 females fitted with satellite transmitters, 19 wintered near their breeding area and 15 were migrants. The migrants moved 30–380 miles to wintering areas, and only 2 birds moved > 310 miles.

The average size of core use winter ranges of 12 goshawks wintering in Utah was 6375 acres +- 6252 acres (Stephens 2001). Winter range size was highly variable as it ranged from 2471–19645 acres. Stephens attributed the large variance to three of the goshawks that wintered in landscapes fragmented by agriculture, where home ranges were very large (6450 – 19645 acres). Habitats used during winter show a wider variation than during the breeding season as birds move down in elevation to more open habitats along the forest-shrubland ecotones (Reynolds et al 1994, Squires and Ruggiero 1995, Stephens 2001, Sonsthagen 2002, in Squires and Kennedy 2006).

Spatial Needs

Size of the typical home range or foraging area for the goshawk (1,400 to 8,650 acres) may vary depending on a number of factors such as age and sex of the bird, prey abundance, prey availability, local habitat conditions, etc. (Keane and Morrison 1994, Keane 1999, Squires and Reynolds 1997, Kennedy 2003, Boal et al. 2003). Patla (1997) calculated a mean home range size of approximately 10917 acres using nearest neighbor distances. Male home ranges are typically larger than those of females (Hargis et al. 1994; Kennedy et al. 1994). Reynolds et al. (1992) recommend home ranges of about 5,000 acres in the southwestern United States, whereas Wisdom et al. (1999) suggest home ranges in the Interior Columbia River Basin may be closer to 7,000 acres. Moser (2007) found that goshawk home ranges in northern Idaho are much larger than other regions (mean of 13,383 acres for females; 9,535 acres for males). In south-central Idaho, mean home range size for six males was 1,952 acres (Hasselbad and Bechard 2007).

Birds usually have one to several core-use areas within a home range that include nest and primary foraging sites. Core areas have been estimated to be approximately 32% of the home range area in one population in New Mexico (Kennedy et al. 1994). Shapes of home ranges vary from circular to almost linear and may be disjunct depending on habitat configuration (Hargis et al. 1994). Neighboring pairs may overlap in use of foraging areas but not in habitat used for a nest or PFA (Squires and Reynolds 1997). In Minnesota, home range overlap between members of breeding pairs was typically ≤50% (Boal et al. 2003).
More than habitat composition or any other factor (i.e. prey abundance), territoriality determines nest distribution, and spring weather determines nest success (Joy 2002, Reich et al. 2004). Spacing of nests by the northern goshawk is consistent and a value of 1.0 mile is provided by Reich et al. (2004). The spacing of nests at 1.0 mile suggests use of an area (hexagon) of 545 acres. Goshawk population growth rate is influenced by density-dependent territoriality (Reich et al. 2004). The density of mid-latitude populations in the western half of North America ranges from 3.6–10.7 pairs/39 mi^2 (Squires and Reynolds 1997).

Risk Factors

Squires and Kennedy (2006) concluded that goshawk breeding populations are limited by food, predation, and density-dependent territoriality. High-quality territories which are regularly occupied and very productive likely contain high abundance of prey, low abundance of predators, and forest structural characteristics that enhance prey acquisition and predator avoidance. Management activities that pose a threat to goshawk populations include those that have a negative effect on prey populations, increase goshawk's risk of predation or other mortality factors, or degrade or destroy nesting habitat within a home range (Squires and Ruggiero 2006). The primary influences on the amount, distribution and suitability of goshawk habitat and goshawk populations (Reynolds 1989, Crocker-Bedford 1990, Squires and Reynolds 1997) are management treatments in forest vegetation (e.g., thinning, timber harvest, prescribed fire) and stand-replacing wildfires (Squires and Ruggiero 2006). Fire suppression, grazing, and insect and tree pathogen outbreaks also can result in the deterioration or loss of nesting habitat (Graham et al. 1999). Natural factors (disease, parasites, exposure and predation) and human-related activities (shooting, poisons and falconry) affect individuals more than populations (Reynolds 1989, Squires and Reynolds 1997, Reynolds et al. 200).

Human Disturbance
The USFWS (USDI FWS 1998) reported that disturbance generally does not appear to be a significant factor affecting the long-term survival of any North American goshawk population. However, human disturbance such as timber harvesting near nests can cause failure, especially during incubation (Squires and Reynolds 1997). Logging activities such as tree cutting, loading, and skidding within 165 to 330 feet of a nest can cause abandonment even with 20-day-old nestlings present (J. Squires, unpubl. data, as cited in Squires and Kennedy 2006). Camping near nests has also caused failures (N = 2; Speiser 1992 in Squires and Kennedy 2006).

McGrath et al. (2003) found that goshawks in central Washington and northeastern Oregon (n = 82 nests) occurred closer to human disturbances (i.e., forest roads) compared with random sites. Goshawk productivity levels for these nests were well within the ranges reported for other studies in managed and unmanaged landscapes throughout the western United States. McGrath stated that human disturbance does not appear to be a factor for the goshawk as long as 70% of the nest area structure is maintained and timber management operations are restricted to avoid activity during breeding and fledging time periods.

Livestock Grazing
In some areas, goshawk nest habitat is vulnerable to livestock grazing. In northern Nevada, for example, goshawks frequently nest in stands of aspen (Younk and Bechard 1994). Browsing by livestock, elk, deer and moose retards aspen regeneration and can result in loss of stands (Lucas and Oakleaf 1975). Grazing can also reduce herbaceous fuels and consequently suppress wildfires that can stimulate aspen regeneration. Livestock grazing can be particularly destructive to aspen stands because they often occur on more level benches in swales and next to streams where livestock tend to concentrate. Grazing pressure may contribute to a loss of habitat complexity and decline of prey base in aspen stands and riparian communities (Reynolds et al. 1992). Livestock grazing also alters the structure and composition of herbaceous and shrub cover under the forest canopy and in non-forest openings resulting in changes to goshawk prey species' habitat. Reduction of these fine fuels also can alter fire regimes and consequently, the composition and structure of goshawk habitat.

Forest Management Activities (Timber harvest, fuel reduction, firewood removal, prescribed fire)
Squires and Kennedy (2006) concluded that forest management—cutting, thinning, and controlled burning—is the primary human-caused activity impacting goshawk populations. These impacts can either enhance or degrade goshawk habitat depending on type and extent of habitat alterations, especially as they affect the density of large trees and canopy closure (Squires and Kennedy 2006, Squires and Reynolds 1997, Crocker-Bedford 1990, Reynolds 1989). Reynolds et al. (2005) concluded after 14 years of data collected on nesting goshawks from the southwestern United States that a number of factors, including; weather, predators, competitors, and disease, significantly confound the detection of forest management effects on goshawk reproduction.

Forest management and fuelwood removal can impact both the structure and function of goshawk habitat (Reynolds 1989, Crocker-Bedford 1990, Bright-Smith and Mannan 1994, Woodbridge and Detrich 1994, Beier and Drennan 1997, Desimone 1997, USDI Fish and

Wildlife Service 1998, Greenwald et al. 2005). Potential threats to habitat caused by various silvicultural treatments include forest fragmentation, creation of even-aged and monotypic stands, potential increases in area of younger age classes and removal of older forest, and loss of tree species diversity (Squires and Kennedy 2006). Removing nest trees, modifying (reduced stand density) or removing entire nest stands, and removing canopy, older, larger trees (dying, diseased, deformed), snags, and downed wood can reduce the quality and quantity of nesting and foraging habitat long-term (summarized in Squires and Kennedy 2006). Reducing canopy cover below a certain threshold, which may vary by geographic region, in close proximity to occupied nests can increase solar radiation and heat stress, reduce buffering from adverse weather, increase vulnerability to predators, and affect nest success (USFWS 1998). Desimone and DeStefano (2005) found that altering historical goshawk nest stands to < 50% canopy closure increased the likelihood of goshawks not reoccupying the stand. R.T. Reynolds (personal communication 2006 in Ferland 2006) suggests that 40% canopy closure should be the minimum management target for goshawk nesting habitat in most regions of North America.

Some studies have found that modification of nesting areas from timber harvest has minimal effects on goshawk reoccupancy and productivity. Limited data suggest goshawks can tolerate timber harvesting near their nesting area below some threshold (Penteriani and Faivre 2001, McGrath et al. 2003). Forest harvest may be compatible with goshawk management provided that habitat needs are provided at multiple spatial scales (Reynolds et al. 1992).

In west-central British Columbia, Mahon and Doyle (2005) evaluated nest reoccupation rates and fledgling productivity across 79 nest areas, of which 27 nest areas were subject to clearcutting. Data were recorded prior to treatments, and nest areas were monitored for at least two years post-harvest. There were no differences in goshawk nest re-occupation and fledgling productivity rates between untreated control and clearcut nest areas, even for those areas with more than 50% of the nest area removed.

Moser and Garton (2009) described the results of a goshawk study (n = 18) in northern Idaho. The 18 breeding areas (420 acres around the nest) in their study included areas with a range of 11-38% of the breeding area disturbed by timber harvest (50-99% overstory removal) and intact habitat in non-harvested controls (n = 9). Breeding areas were harvested in 2002 (n = 4) and 2003 (n = 5). Goshawks in all breeding areas successfully fledged young the year prior to treatment and productivity was the same between proposed treatment and non-treatment breeding areas prior to timber harvest. Timber harvest had no effect on goshawk breeding area occupancy, nest success, or productivity 1 to 2 years after treatments. Occupancy of harvested goshawk breeding areas was 89% and 75% after year 1 and 2, respectively, compared to 80% and 78% in non-treatment areas after year 1 and 2, respectively. Goshawk nest success and productivity were influenced more by late winter/spring weather rather than timber harvest. Moser and Garton (2009) concluded that timber harvest (clear-cutting) outside the breeding season (after August 15th) does not appear to affect northern goshawk breeding area occupancy, nest success, or productivity 2 years after harvest as long as suitable nesting habitat remains within the PFA breeding area (>39%) following timber harvest.

In eastern California, harvest areas where overstory trees were removed but numerous mature stands were retained, birds still nested approximately two-thirds of the time (*n* = 14 year) and

produced typically 2–3 young/nest (Hargis et al. 1994). In California, nesting densities remained fairly high despite fragmentation of mature forests from timber harvest (Woodbridge and Detrich 1994); but, territories associated with large contiguous forest patches were more consistently occupied compared to highly fragmented stands. Forest management that reduces the size of nest stands may decrease occupancy rates (Woodbridge and Detrich 1994). In post-harvest territories, high occupancy sites had significantly greater amounts of mature forest cover left within the nest area (Patla 1997, Woodbridge and Detrich 1994). Although nesting frequently occurs in areas impacted by timber harvest, the long-term viability of these populations is unknown. Clough (2000) reported that occupied goshawk nest areas in Montana had been heavily influenced by tree harvests, roads, and grazing relative to more interior forests where there were no nesting goshawks. Another example of goshawks persisting in highly fragmented landscapes is in the high elevation regions of Nevada where goshawks nest within small (mean = 24.9 ± 21.9 ha), isolated aspen patches (Younk and Bechard 1994).

In contrast, other studies found a negative relationship between timber harvest and goshawk nest reoccupancy and productivity; breeding densities may be lowered or individuals may redistribute to adjacent areas. Harvest methods that create large areas of reduced forest canopy cover (<35–40%) may be especially detrimental (Bright-Smith and Mannan 1994, Beier and Drennan 1997). Removal or excessive fragmentation of mature forests in habitat suitable for nesting and foraging is a considerable extrinsic threat to goshawks (Keane and Morrison 1994). Opening the canopy structure in nesting habitat may increase predation of goshawks and especially their nestlings by great-horned owls. The creation of more open, fragmented habitat may lead to replacement of nesting goshawks by early successional competition and predation from red-tailed hawks, Cooper's hawk, great horned owls, great gray owls, and ravens (Crocker-Bedford 1990, Woodbridge and Detrich 1994, Patla 1997 and Erdman et al. 1998). Great gray owls also use goshawk alternate nests. Results from both Johnson's (1992) great horned owl and La Sorte and others' (2004) red-tailed hawk/goshawk habitat differences indicated that habitat fragmentation can increase the potential for greater abundance of avian competitors and predators like these two raptors, but empirical data that demonstrates whether competition is truly affecting the viability of goshawk populations are lacking. Whether this is a linear relationship or if some threshold level of fragmentation exists where these species may have a negative impact on populations of goshawks via increased predation and/or competition is unknown.

Data from 15 nest areas in northern Arizona, six of which were subjected to harvest, (Crocker-Bedford 1990) showed that goshawk re-occupancy and productivity in post-harvest territories were much lower, compared to untreated nest areas, even if nest buffers up to 500 acres were retained around known nests. Between 1985 and 1987, 66% of control nests were reoccupied at least once compared with only 12% of buffered nests. Occupancy was low in both small (3–6 acres) and large (40-495 acres) buffered nests, a result suggesting that the sizes of buffer areas were inadequate. Reduction in prey populations, competition for nest sites by more open country raptors, and predation by great horned owls were suggested as possible factors affecting goshawk reproductive success (Crocker-Bedford 1995). Both occupancy and productivity appeared to be inversely related to the amount of harvesting that had taken place within the home range area. Territories were grouped into four categories: 1) little or no harvesting (n=12); 2) 10-39% of home range harvested (n=14); 3) 40-69% harvested (n=16), and 4) 70-90% harvested. For these

categories occupancy rates in 1987 were 83%, 43%, 31% and 9%, and productivity rates were 1.67, 0.86, 0.31 and 0.00 respectively (Crocker-Bedford 1995).

In southeastern Idaho and western Wyoming, Patla (2005) analyzed goshawk nest occupancy and productivity in 16 nest areas, eight of which were subject to timber harvest. Patla determined that harvested nest areas had significantly lower re-occupancy, but no difference in mean productivity rates between pre-and post-harvest territories. Looking only at post-harvest territories, those with high occupancy rates had significantly more mature forest cover within the NA. Analysis of habitat at three historical territories where goshawks no longer nest supported the idea that a threshold effect may occur when a certain level of habitat loss has been exceeded. Averages of mature forest cover within the NA, PFA, and FA at these territories were substantially lower than averages measured at current occupied territories.

Fire Suppression

Fire suppression has altered the natural fire regime. Fire frequency has decreased and intensity/severity has increased in many forests since the early 20th century. Goshawks and goshawk prey species evolved in and continue to occupy forests that were structured by fire, including low severity/high frequency understory fires, high severity/stand-replacing fires, and a mixture of both (Brown 2000, Covington and Moore 1994).

Fire suppression continues to change vegetation composition and structure leading to further reductions in goshawk nesting habitat, prey numbers, and foraging opportunities. Transition of older forests dominated by shade-intolerant tree species to a dense structure of shade-tolerant tree species, primarily due to fire exclusion (Wisdom et al. 2000), is an on-going progression of changing forest conditions limiting suitable habitat. This increase in shade-tolerant species has increased the forest's susceptibility to stand-replacing fires, and has adversely affected habitat suitability by 1) obstructing flight corridors used by goshawks to obtain prey, and 2) reducing herbaceous understory that supports prey species (Wisdom et al. 2000). Increased densities of trees above some threshold ultimately may render habitats unsuitable for nesting and foraging goshawks as well as some prey species (Reynolds et al. 1992, USFWS 1998, and Squires and Kennedy 2006). In recent years, xeric forests throughout much of the Intermountain West have become overstocked with small diameter trees due to suppression of fire (Agee 1998). Bloxton (2002) suggests this condition has likely reduced the ability of goshawks to hunt in these forests, particularly in younger stands, where less space exists between the overstory canopy and the shade tolerant understory conifers. Insects and diseases are also changing the species composition and structure of many stands, reducing their suitability for goshawk habitat and potentially increasing their risk to the threat of stand replacing wildfire, and subsequent loss of goshawk nesting habitat.

In the Northern Region, in goshawk nesting habitat in low- to mid-elevation Douglas-fir, such as present on the BTNF, on-going fire suppression over the past 80+ years may have caused a shift from frequent, low-intensity understory burns to stand-replacement regimes (Arno 2000, Hessberg and Agee 2003, Hessberg et al. 2005, Schoennagel et al. 2004, Sala et al. 2005). An uncharacteristic increase in saplings provide ladder fuels that allow fires to spread to the crowns and burn over larger areas compared to earlier times, especially under severe drought conditions such as in recent years. A reduction in goshawk habitat is probable following severe wildfires

(McGarth et al. 2003). Goshawk nest sites in lower-slope stands with high basal area and high stem densities probably are susceptible to fires because of their high fuel loads. In these warm and dry forest communities reducing tree densities and continuity of forest fuels by thinning from below or basal area limit harvests, may reduce forest fuels while simultaneously creating stand conditions that are favorable for goshawk nesting and foraging (Reynolds et al. 1992, Squires and Kennedy 2006).

Reynolds et al. (1992) and Graham et al. (1999) have suggested that the use of controlled fire and thinning may improve goshawk habitat by creating more favorable conditions for goshawks and their prey (i.e., promoting diameter growth in overstory trees, creating open understories, downed wood, snags, and stimulating grass/forb/shrub growth). Maurer (2000) measured vegetation around 31 active goshawk nests in California and reported that more often than expected nests were in areas recently burned by low-severity and moderate-severity fires.

Conservation Goals and Potential Conservation Actions

The following list of conservation goals and potential conservation actions may be used to develop alternatives and provide potential mitigation measures in project level environmental analyses. Potential conservation actions identified in these documents are not intended to be mandatory, but may be recommended as design features of alternatives or mitigation measures during project analysis. The decision document (Decision Memo, Decision Notice, or ROD) would identify the specific conservation actions selected for the project.

Goal 1: Provide suitable nesting, PFA and foraging habitat within active and inactive (occupied within past 10 years) goshawk home ranges.
Potential Conservation Actions:

- NOGO-PCA-1: Forested areas within goshawk nesting home ranges should consist of an interspersed mosaic of forest conditions, from regenerating stands to mature second-growth or old-growth stands -- to increase the diversity of habitat for goshawks and their many prey species (Reynolds et al. (1992).
- NOGO-PCA-2: To sustain the desired condition of older forest structure with small dispersed openings (i.e., mid-aged, mature and old forests) for goshawk and their prey at the home range and landscape scale, Reynolds et al. (1992) recommended;
    - 10% of a naturally forested landscape be in a grass-forb-shrub stage (to 20 years),
    - 10% in a seedling-sapling stage (to 50 years),
    - 20% in young forest (to 96 years),
    - 20% in mid-aged, 20% in mature, and 20% in old forest.
- NOGO-PCA-3: To the extent feasible, vegetation treatments should be consistent with historic forest patterns, by forest type, and consider spatial arrangement and micro-site requirements (Squires and Kennedy 2006). Forest management for goshawks, where possible, should follow a design that mimics "regional natural disturbance regimes", as large even-aged stands, monoculture, or predominantly early seral stage forests will not be conducive to goshawk habitation (Kennedy 2003).

Goal 2: Conserve existing conditions in the core nest areas because desired conditions are assumed present around recently-occupied nest areas in each foraging area.

Potential Conservation Actions:

- NOGO-PCA-4: Maintain at least 240 acres of suitable nesting habitat in known or potential goshawk territories per 5400 +-acre FA in stands of at least 40 acres (Samson 2006).
    - Selection of suitable nesting habitat is focused on desired stand conditions in the active nest area and all inactive nest areas occupied at least once in the past 10 years (Reynolds et al. 2005, Woodbridge and Hargis 2006).
    - The intent is to maintain at least three suitable and three replacement nest areas (Fig. 4) per home range (Reynolds et al. 1992). Patch shape and size (40 to 240 acres) of the nest stand may vary depending on topography, forest composition and structural conditions or other local factors (such as multiple alternate nests found in close proximity to one another).
    - In the absence of information on location of inactive nest areas, alternate or replacement suitable nest stands are best located approximately 0.5 miles from each other.

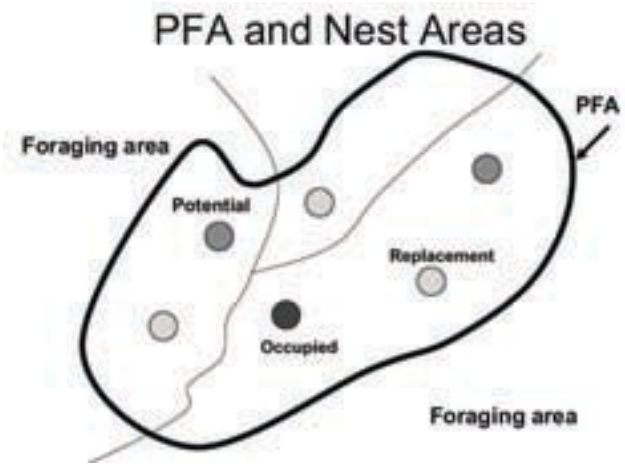


Fig. 4. Conceptualized Goshawk PFA and Nest Areas.

- NOGO-PCA-5: Replacement nest stands can be treated (generally non-uniform thinning from below) to achieve desired forest structure and composition if necessary (Reynolds et al. 1992).
- NOGO-PCA-6: Do not conduct ground disturbance or vegetation manipulation inside the nest stand until the nest area is no longer used by the breeding pair for 10 years.
- NOGO-PCA-7: Desired conditions (high probability of nesting) of forest stand structure for nesting habitat.
    - Mature/old forest should dominate nest areas (>60%; >55% LPP and >70% DF).
    - Tree dominance group order of preference: Douglas-fir, lodgepole pine, aspen, spruce-fir
    - Tree size: >12inches (9 +" LPP and 14+"DF); Groups or clumps of larger trees are desirable.
    - Canopy cover: >60% (>50% LPP and >60 DF)
    - Basal area: 180 (60 to 220 square feet/acre)
    - Structure class: 1, 2
    - Slope: <30%

- Aspect: 225 to 450 (SW to NE)
- Elevation: <8500 feet

Goal 3: Provide habitat for hiding/escape cover for goshawk fledglings and goshawk prey, and foraging opportunities for adults and fledglings during the fledgling-dependency period (Reynolds et al. 1992). Maintain an interspersed mosaic of structural stages, young to old forest, to increase the diversity of habitat for goshawks and their many prey species.
Potential Conservation Actions:

- NOGO-PCA-8: Identify a PFA of approximately 300 to 600 (mean 420) acres centered on nest stands. The PFA contains a mosaic of forest structural conditions and prey habitat attributes scattered throughout in small to large patches. Interspersed small openings, large trees, snags, downed logs, and woody debris are critical PFA attributes (Reynolds et al. 1992).
- NOGO-PCA-9: No ground disturbing activities inside known occupied PFAs from April 1 through August 15 (Patla 1997) to protect the goshawk pair and young from disturbance until fledglings are capable of sustained flight. After August 15, treatment-related activities may commence within the PFA, but outside the nest area, unless site-specific monitoring supports earlier or later entry.
- NOGO-PCA-10: Develop treatments as needed that maintain and/or restore the stand structure, composition, and patterns of the desired habitat conditions characteristic of pre-settlement disturbance regimes.
    - Use a combination of even-aged and uneven-aged silvicultural systems across the PFA, with a significant portion of the stands managed for an uneven-aged structure, to create a mosaic of forest conditions. All tree sizes, including some very large trees (>18”), should be represented in the post-harvest stand. Maintain a minimum mature forest canopy cover of at least 40% (preferably 60% in mid-aged to old Doug-fir, 50% in lodgepole, and 70% in spruce-fir) across at least 40% of the PFA.
    - Preferred silvicultural practices in the mature and older forest to achieve or preserve desired structural diversity (irregular, clumped spacing, interlocking crowns, increased basal area) include; shelterwood with reserve trees (clumps and singles), irregular group shelterwood, group selection with structural retention, sanitation, liberation and improvement treatments. In the younger forest stands, thin (variable density) from below to lower basal areas and promote faster tree growth, crown development and herb/shrub development (Reynolds et al. 1992).
    - Create more open stand structures in Douglas-fir to improve and enhance the growth of large conifers and deciduous species and reduce vulnerability to insects, disease, and severe fire. These low to mid- elevation forests are often overly dense and contain numerous small trees. Use a combination of fire and mechanical treatments to reduce densities to levels found historically.
    - Encourage aspen regeneration and a diversity of structural stages where it occurs. Prescribed burns that simulate surface and mixed severity fire can be effective in combination with mechanical thinning to reduce understory stand density and create openings for conifer and aspen regeneration in Douglas-fir and mixed fir stands. In aspen stands, moderate to high severity fire is necessary to stimulate the greatest sucker response and is needed to assure sustained fire spread and

sufficient overstory mortality. If conifer encroachment cannot be reduced through fire, conifers should be cut. Regardless of short-term effects, regeneration of aspen through treatments such as burning and clearcutting will, in the long run, benefit goshawks by ensuring clone perpetuation.

- NOGO-PCA-11: Use prescribed fire or cutting to reduce the density of lodgepole pine forests. Thinning based on a diameter limit is more desirable in lodgepole pine forests than thinning that retains uniform spacing; it results in a mosaic of habitat structure and pattern similar to the results of some fires that enhance many desirable habitat features of bird communities
- NOGO-PCA-12: Small, scattered openings (up to 4 acres) in the forest are desired habitat for some prey species and are required for forest regeneration. If created forested openings are 1.0 acre or greater in Doug-fir, LPP, or mixed conifer species, then 6 large mature and/or old reserve trees per acre should be left in groups. If spruce-fir forest openings are 0.5 acres or greater, two groups of 6 reserve trees are left per acre. A variable spacing of trees is preferred for developing groups of trees with interlocking crowns. Center tree groups on existing red squirrel middens.
- NOGO-PCA-13: Provide at least 3 large snags per acre [at least 18 inches dbh, at least 30 feet tall] to maintain habitat for goshawk prey species. Retain broken, dead-topped, diseased and dying trees, and live trees with cavities as snag replacements.

Goal 4: Where roads and trails pass through active or inactive goshawk NAs, maintain security for breeding pairs, nesting, and nestling/fledgling goshawks.
Potential Conservation Actions:

- NOGO-PCA-14: Consider seasonal road closures within the NA during the nesting season (March 15 through August 1), or permanent closures/obliteration of the prisms where access is no longer needed for resource management activities.

Habitat Mapping

Langston et al. (2011, unpublished) developed a goshawk nest habitat model for the BTNF (Fig. 5) based on relevant literature, local expertise and the R1 goshawk NA models. The physical and forest habitat variables included in their model are noted below.

Model Parameters

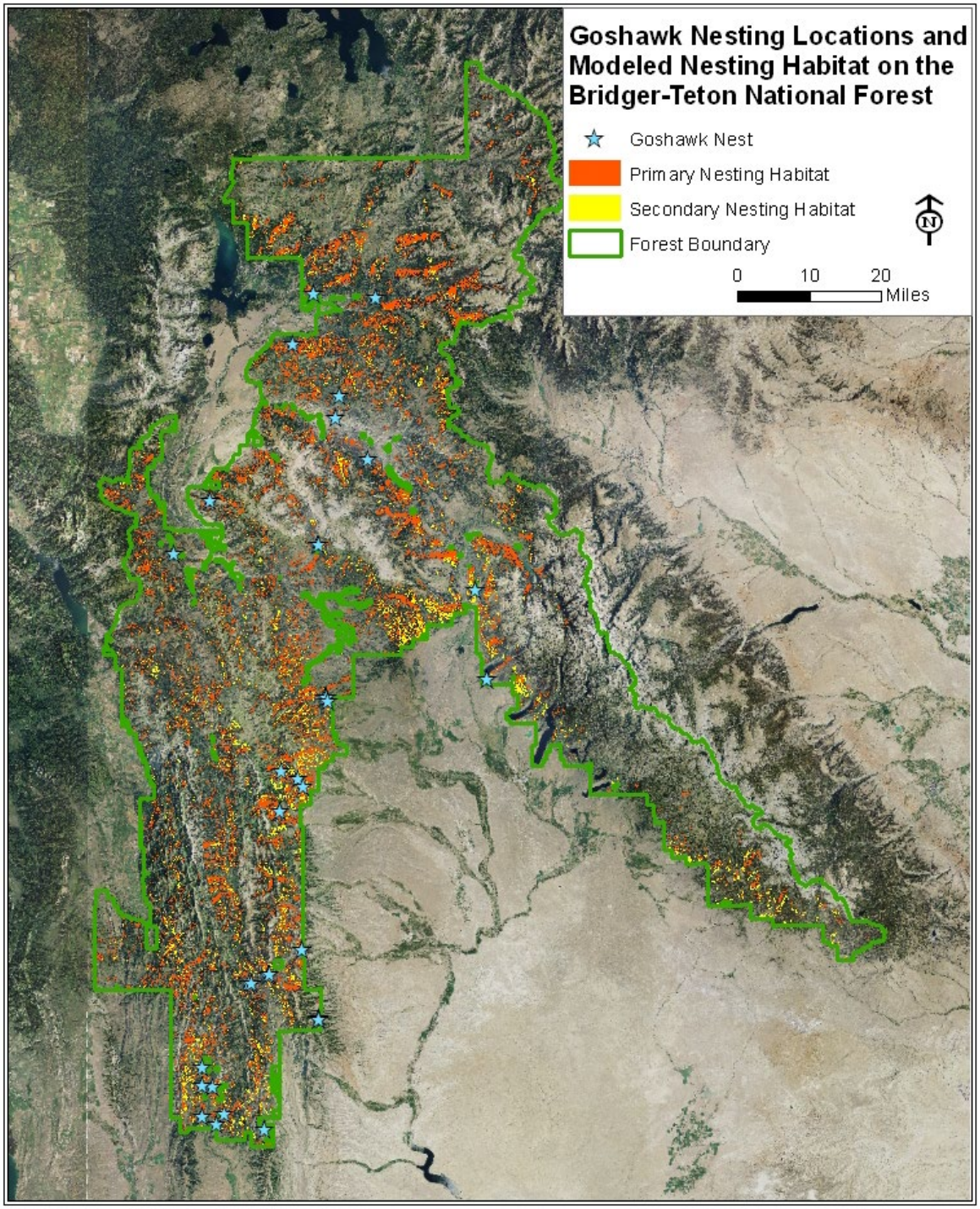
Primary Goshawk Nesting Habitat:

Physical Parameters:
Elevation < 9500 ft. (2591 m)
Slope ≤ 50%
Aspect 270^0 to 90^0

Vegetative Parameters:
Forest Types: Aspen, Lodgepole Pine, Douglas fir, Spruce/Subalpine Fir
Canopy closure ≥ 45%
Size ≥ 5" DBH
Patch size ≥ 40 acres

Secondary Goshawk Nesting Habitat: All parameters the same as listed above, with the addition of Aspect 91^0 to 261^0.

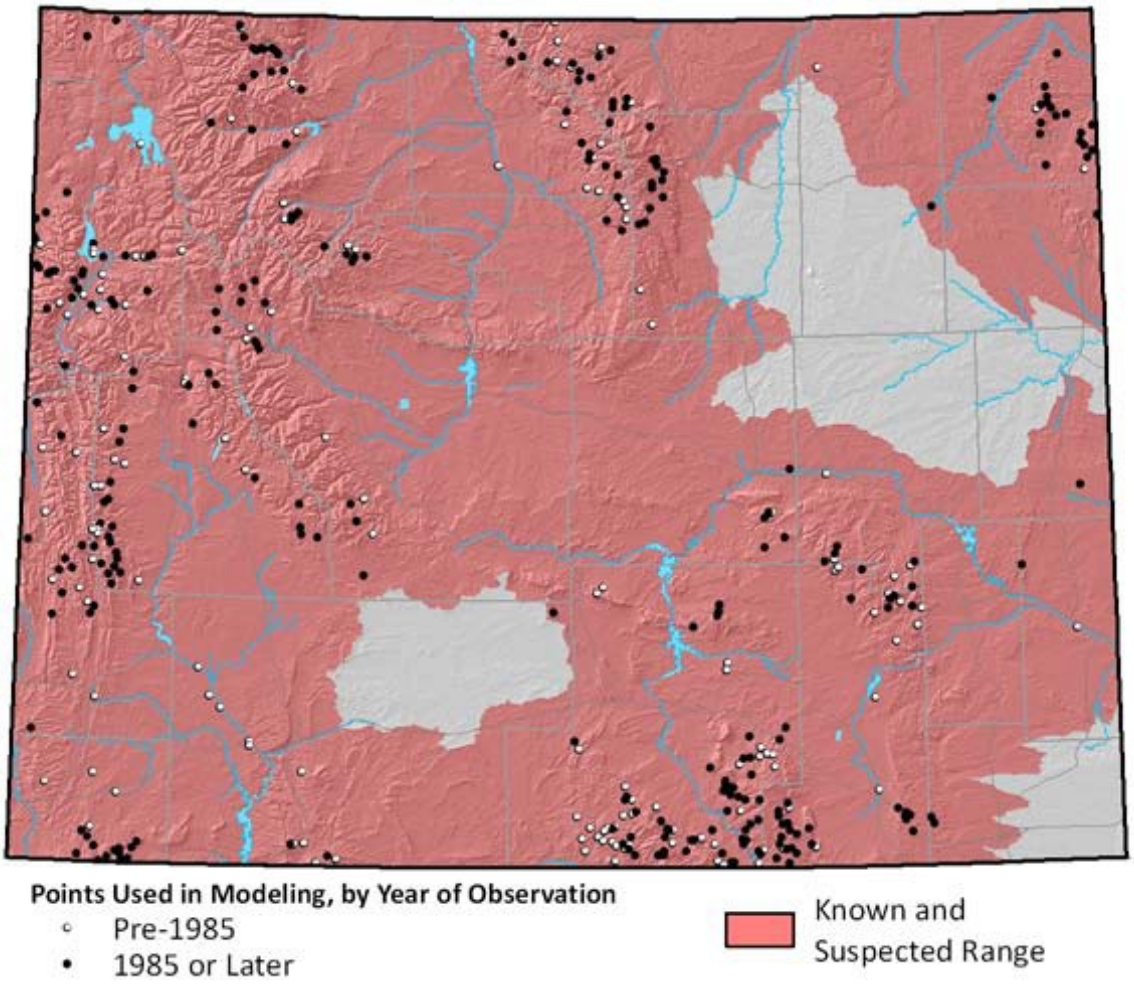
Figure 5. Goshawk nest locations and modeled nesting habitat on the BTNF.



Goshawk Observations on the BTNF

The most recently available mapped locations of goshawk observations in Wyoming and on the BTNF are displayed in Fig 6 and 7.

Figure 6. Goshawk occurrence data for a Distribution Model (Fig. 9) developed by the WYNDD.



Occurrence Summary Statistics

- Number of Occurrences in AWVED master dataset: 1,580
- Number of Occurrences used to create distribution model: 421
- Average Point Quality Index (highest quality is 12.00): 6.58 ± 2.41
- Most recent occurrence used: 2008
- Oldest occurrence used: 1969
- Occurrence File: LARGE_AREA_SAMPLE_POINTS_ALL.CS V

Figure 7. Goshawk observations on the BTNF and adjacent BLM lands in the Wyoming Range.

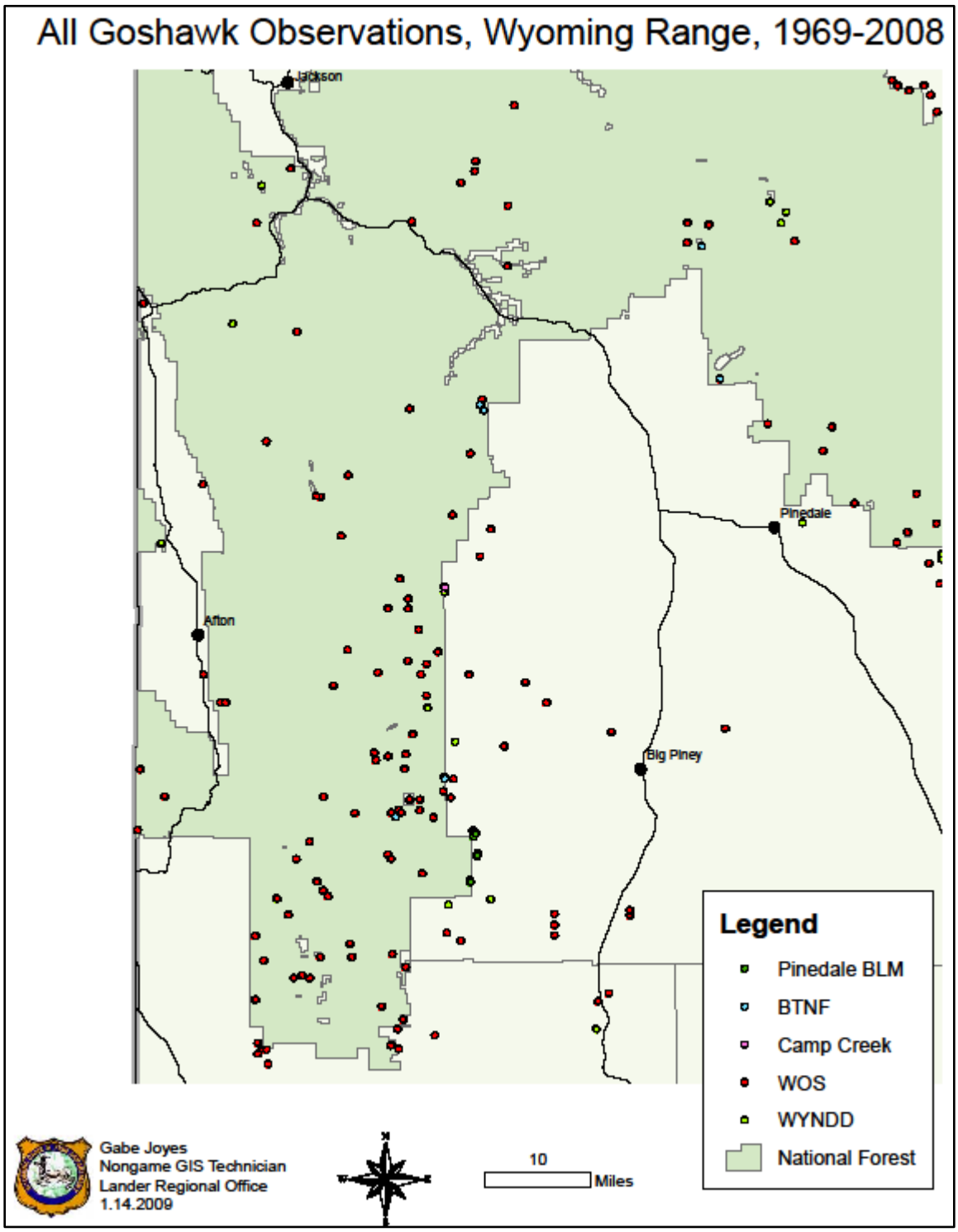
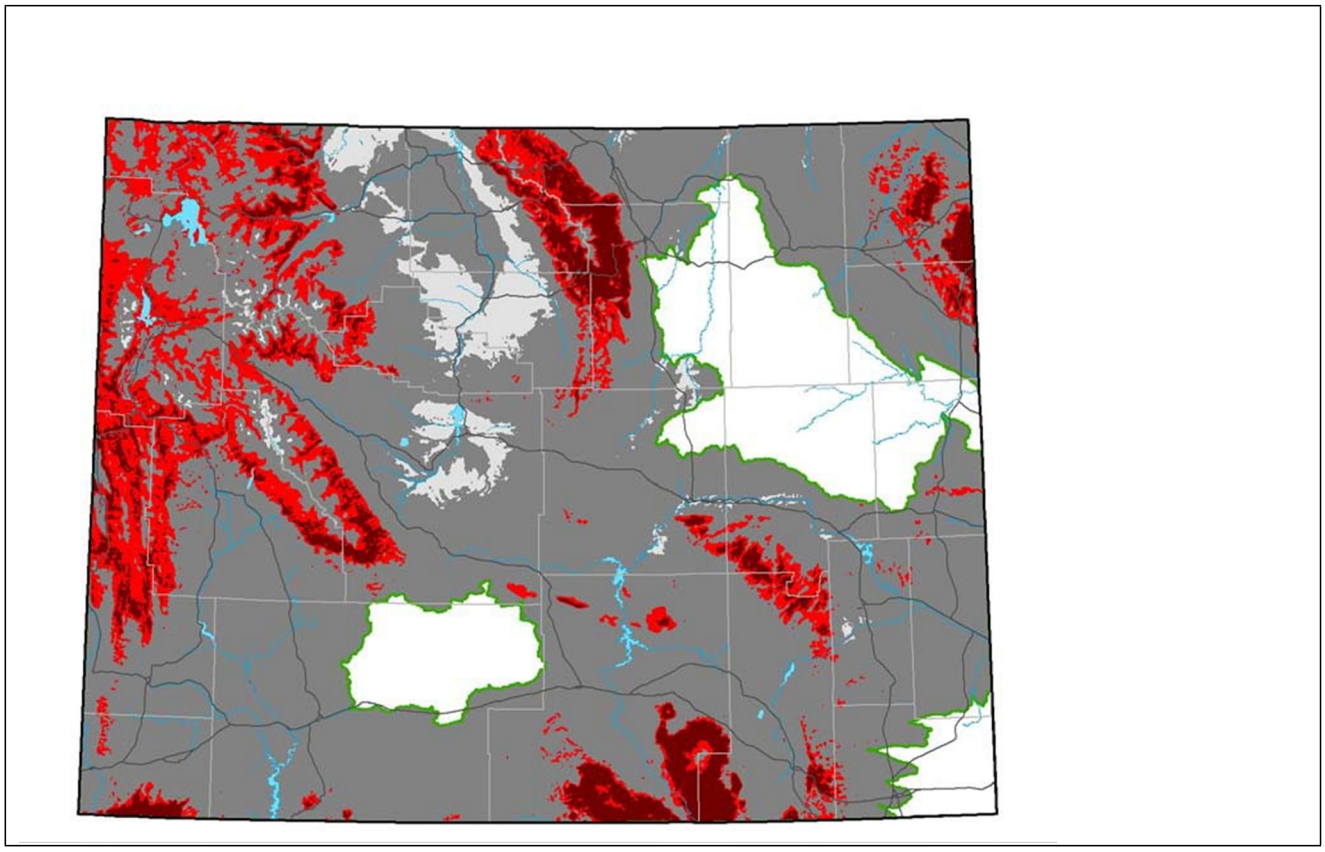


Figure 9. Wyoming Range Map and Distribution Model for Northern Goshawk, August 20, 2010, based on the goshawk occurrence data presented in Fig.7. Season modeled: Breeding (April 15 to August 7). Model quality: Medium. Details of distribution model creation are presented in Keinath et al. (2010b).



Predicted Present

- **Medium Probability of Occurrence**
- **High Probability of Occurrence**

Predicted Absent

Outside Known/Suspected Range

- **Very Low Probability of Occurrence**
- **Low Probability of Occurrence**

Monitoring

Habitat and population monitoring should be coordinated at a landscape scale with federal, state, and private partners. Habitat monitoring should also occur at the project level. Focus items include:

- NOGO-MON-1: Annually, monitor all known and probable goshawk nest site areas for occupancy and successful reproduction using direct observations, goshawk sign and broadcast call survey protocol during the pre-nesting, late nestling and fledgling periods.

- NOGO-MON-2: During project level planning, establish the presence of goshawks to determine whether activity restriction or habitat recommendations should be applied to minimize potential disturbance to breeding pairs and their nestlings/fledglings and maintain and/or enhance forest habitat conditions. Begin systematic ground surveys using the broadcast call protocol during the pre-nesting, nestling and fledgling periods within and adjacent to the analysis area.
- NOGO-MON-3: In occupied goshawk home ranges affected by forest management actions or natural disturbance events, assess post-treatment/disturbance response of goshawks to habitat changes within NA, PFA and FA.
- NOGO-MON-4: All data on goshawk observations and surveys will be entered into the National Resource Information System (NRIS) application of the USDA Forest Service.

Literature Cited

Agee, J. K., 1998. The landscape ecology of western forest fire regimes. Northwest Sci., 72 (special issue): 24-34.

Andersen, D. E., K. E. M. Galley, S. DeStefano, M. I. Goldstein, K. Titus, C. Crocker-Bedford, J. . Keane, R. G. Anthony, and R. N. Rosenfield. 2004. The status of northern goshawks in the western United States. Technical Review, Wildlife Society. 24 p.

Arno, S. F. 2000. Fire in western forest ecosystems [Chapter 5], in J. K. Brown and J. K. Smith eds., Wildland fire in ecosystems: effects of fire on flora. Ogden, UT, USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-42-vol. 2, p. 97-120.

Austin, K. 1993. Habitat use by breeding goshawks in the southern Cascades. Thesis. Oregon State University, Corvallis, Oregon.

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

Berthold, P. 1993. Bird migration: a general survey. Oxford University Press, New York, NY U.S.A.

Bloxton, T. D., Jr. 2002. Prey abundance, space use, demography, and foraging habitat of Northern Goshawks in western Washington. M.S. thesis, Univ. of Washington, Seattle, WA U.S.A.

Boal, C. W. 1994. A photographic and behavioral guide to aging nestling northern goshawks. Studies in Avian Biology 16:32-40.

Boal, C. W., D. E. Andersen, and P. L. Kennedy. 2003. Home range and residency status of northern goshawks breeding in Minnesota. Condor 105:811-816.

Brewer, L. T., R. Bush, J. E. Canfield, and A. R. Dohmen. 2009. Northern goshawk Northern Region overview; key findings and project considerations. USDA Forest Service R1, Missoula, MT. 47p.

Bright-Smith, D. J. and R. W. Mannan. 1994. Habitat use by breeding male northern goshawks in northern Arizona. Studies in Avian Biology 16:58-65.

Brown, R. 2000. Thinning, fire and forest restoration: a science-based approach for national forests in the interior Northwest. Defenders of Wildlife, Washington D.C.

BTNF. 2009. Five year monitoring and evaluation report, version 1. Bridger-Teton National Forest. Jackson, WY.

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

Clough, L. T. 2000. Nesting habitat selection and productivity of northern goshawks in west-central Montana. Missoula, MT: University of Montana. 87 p. Thesis.

Covington, W. W., and M. M. Moore. 1994. Post-settlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry 2:153–181.

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

Crocker-Bedford, D. C. and B. Chaney. 1988. Characteristics of goshawk nesting stands. Pages 210-217 in R. L. Glinski, B. G. Pendleton, M. B. Moss, M. N. LeFranc, Jr., B. A. Millsap, and S. W. Hoffman, eds. Proceedings of the southwest raptor management symposium and workshop, 21-24 May 1986, University of Arizona, Tucson. National Wildlife Federation Scientific and Technical Series No. 11. National Wildlife Federation, Washington, DC.

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.

Daw, S. K., S. DeStefano, and R. J. Steidl. 1998. Does survey method bias the description of northern goshawk nest-site structure? Journal of Wildlife Management 62:1379-1384.

Desimone, S. M. 1997. Occupancy rates and habitat relationships of northern goshawks in historic nesting areas in Oregon. Thesis. Oregon State University, Corvallis, Oregon.

Desimone, S. M., and S. DeStefano. 2005. Temporal patterns of Northern Goshawk nest area occupancy and habitat: a retrospective analysis. J. Raptor Res 39:310–323.

Dewey, S. R., P. L. Kennedy, and R. M. Stephens. 2003. Are dawn vocalization surveys effective for monitoring goshawk nest-area occupancy? Journal of Wildlife Management 67:390–397.

Dorn, J, L., and R. D. Dorn. 1999. Wyoming Birds. 2nd edition. Mountain West Publishing, Cheyenne, WY.

Doyle, F. I., and J. N. 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.

Erdman, T. C., D. F. Brinker, J. P. Jacobs, J. Wilde, and T. O. Meyer. 1998. Productivity, population trend, and status of northern goshawks, Accipiter gentilis atricapillus, in northeastern Wisconsin. Canadian Field-Naturalist 112:17-27.

Erickson, M. G. 1987. Nest site habitat selection of the goshawk (Accipiter gentilis) in the Black Hills National Forest of South Dakota. Thesis. University of South Dakota, Springfield, South Dakota.

Fairhurst, G. D., and M. J. Bechard. 2005. Relationships between winter and spring weather and northern goshawk (Accipiter gentilis) reproduction in northern Nevada. Journal of Raptor Research 39:229-236.

Ferland, C. L. 2006. Northern goshawk breeding habitat selection within high-elevation forest of southwestern Colorado. M.S. Thesis. Oregon State University. Corvallis, OR.
IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on **02 March 2013**.

Fischer, D. L. 1986. Daily activity patterns and habitat use of coexisting Accipiter hawks in Utah. Dissertation. Brigham Young University, Provo, Utah.

Finn, S. P., J. M. Marzluff, and D. E. Varland. 2002. Effects of landscape and local habitat attributes on northern goshawk site occupancy in western Washington. Forest Science 48:427-436.
Good, R. E., S. H. Anderson, J. R. Squires, and G. McDaniel. 2001. Observations of northern goshawk prey delivery behavior in south central Wyoming. Intermountain Journal of Science 7:34-40.

Graham, R. T., R. L. Rodriguez, K. M. Paulin, R. L. Player, A. P. Heap, and R. Williams. 1999. The northern goshawk in Utah: habitat assessment and management recommendations. General Technical Report RMRS-GTR-22. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado.

Green, P., J. Joy, D. Sirucek, W. Hann, A. Zack, and B. Naumann. 1992. Old-growth forest types of the northern region. U.S. Forest Service, Northern Region R1 SES 4/92.

Greenwald, D. N., D. C. Crocker-Bedford, L. Broberg, K. F. Suckling, and T. Tibbitts. 2005. A review of northern goshawk habitat selection in the home range and implications for forest management in the western United States. Wildlife Society Bulletin 33; 120-129.

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.

Hasselblad, K. and M. Bechard. 2007. Male Northern Goshawk home ranges in the Great Basin of south-central Idaho. Journal of Raptor Research 41:150-155.

Hayward, G. D., and R. E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91:476-479.

Hessburg, P. F., and J. K. Agee. 2003. An environmental narrative of Inland Northwest United States forests, 1800–2000. Forest Ecology and Management 178:23–59.

Hessberg, P. F., J. K. Agee, and J. F. Franklin. 2005. Dry Forests and Wildland Fires of the Inland Northwest USA: Contrasting the Landscape Ecology of the Pre-Settlement and Modern Eras. Forest Ecology and Management, 2005.

Joy, S. M. 2002. Northern goshawk habitat on the Kaibab National Forest in Arizona: factors affecting nest locations and territorial quality. Dissertation, Colorado State University, Fort Collins, Colorado.

Keane, J. J. 1999. Ecology of the northern goshawk in the Sierra Nevada, California. Dissertation. University of California, Davis, California.

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.

Keinath, D. A., M. D. Andersen, and G. P Beauvais. 2010a. Range maps for Wyoming's species of greatest conservation need. Report prepared for the Wyoming Game and Fish Department by the Wyoming Natural Diversity Database, Laramie, Wyoming. January 19, 2010.

Keinath, D. A., M. D. Andersen, and G. P. Beauvais. 2010b. Range and modeled distribution of Wyoming's species of greatest conservation need. Report prepared by the Wyoming Natural Diversity Database, Laramie Wyoming for the Wyoming Game and Fish Department, Cheyenne, Wyoming and the U.S. Geological Survey, Fort Collins, Colorado. August 20, 2010.

Kennedy, P. L. 1988. Habitat characteristics of Cooper's hawks and northern goshawks nesting in New Mexico. Pages 218-227 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, 21-24 May 1986, University of Arizona, Tucson. National Wildlife

Federation Scientific and Technical Series No. 11. National Wildlife Federation, Washington, DC.

Kennedy, P. L. 1997. The northern goshawk (Accipiter gentilis atricapillus): is there evidence of a population decline? Journal of Raptor Research 31:95-106.

Kennedy, P. L. 1998. Evaluating northern goshawk (Accipiter gentilis atricapillus) population status: a reply to Smallwood and Crocker-Bedford. Journal of Raptor Research 32:336-342.

Kennedy, P. L. 2003. Northern goshawk (Accipiter gentilis atricapillus): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region.

Kennedy, P. L. and D. E. Andersen. 1999. Research and monitoring plan for northern goshawks in the western Great Lakes region. Final Report. Submitted to National Council of the Paper Industry for Air and Stream Improvement, Inc., US Forest Service, US Fish and Wildlife Service, Wisconsin Department of Natural Resources, Michigan Department of Natural Resources and Minnesota Department of Natural Resources. Minnesota Cooperative Fish & Wildlife Research Unit, University of Minnesota, St. Paul, Minnesota.

Kennedy, P. L. and J. M. Ward. 2003. Effects of experimental food supplementation on movements of juvenile Northern Goshawks (Accipiter gentilis atricapillus). Oecologia 134:284-291.

Kennedy, P. L., J. M. Ward, G. A. Rinker, and J. A. Gessamen. 1994. Post-fledging areas in northern goshawk home ranges. Studies in Avian Biology 16:75-82.

Kenward, R. E. 1982. Goshawk hunting behavior, and range size as a function of food and habitat availability. Journal of Animal Ecology 51:69-80.

Kenward, R. E., and P. Widén. 1989. Do goshawks Accipiter gentilis need forests? Some conservation lessons from radio tracking. Pages 561-567 in B.U. Meyburg and R.D. Chancellor, editors. Raptors in the modern world. Proceedings of the III World Conference on Birds of Prey and Owls, Eilat, Israel, 22-27 March 1987. World working group on birds of prey, Berlin, Germany.

Kenward, R. E., V. Marcström, and M. Karlbom. 1993. Post-nesting behaviour in goshawks, Accipiter gentilis: I. The causes of dispersal. Animal Behaviour 46:365-370.

La Sorte, F. A., R.W. Mannan, R. T. Reynolds, and T. G. Grubb. 2004. Habitat associations of sympatric red-tailed hawks and northern goshawks on the Kaibab Plateau. Journal of Wildlife Management 68:307-3 17.

Loope, L. L. and G. E. Gruell. 1973. The ecological role of fire in the Jackson Hole area, northwestern Wyoming. Quat. Res. 3:425-443.

Lucas, P., and R. J. Oakleaf. 1975. Population surveys, species distribution, and key habitats of selected non-game species. Federal Aid Wildlife Restoration Project W-53-R, Study 1. Nevada Department of Fish and Game, Reno, Nevada. 42 p.

Luce, B., A. Cerovski, B. Oakleaf, J. Priday and L. Van Fleet. 1999. Atlas of birds, mammals, reptiles, and amphibians in Wyoming. Wyoming Game and Fish Department, Cheyenne. 194 pp.

Mahon, T. and F. I. Doyle. 2005. Effects of timber harvesting near nest sites on the reproductive success of Northern Goshawks (Accipiter gentilis). J. Raptor Res., 335–341.

Marston, R. A., and D. T. Clarendon. 1988. Land system inventory of the Medicine Bow Mountains and Sierra Madre, Medicine Bow National Forest, Wyoming. USDA For. Serv. Res. Pap. MBNF-88-01:1–31.

Maurer, J. R. 2000. Nesting habitat and prey relations of the northern goshawk in Yosemite National Park, California. Thesis, University of California. Davis, USA.

McCarthy, C., W. D. Carrier, and W. F. Laudenslayer. 1987. Coordinating timber management activities with raptor nesting habitat requirements. Western Raptor Management Symposium and Workshop, Oct. 26-28, 1987.

McGrath, M. T., 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 Monographs 154:1–63.

Moser, B. W. 2007. Space use and ecology of goshawks in northern Idaho. Ph.D. dissertation, Univ. of Idaho, Moscow, ID U.S.A.

Moser, B. W., and E. O. Garton. 2009. Short-term effects of timber harvest and weather on goshawk reproduction in northern Idaho. Journal of Raptor Research 43:1-10.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: August 10, 2016).

Patla, S. 1997. Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem. M.S. Thesis, Idaho State University, Pocatello, ID. 149p.

Patla, S. and S. Derusseau. 2010. Summary of habitat analysis at active goshawk nests in the Wyoming Range, BTNF 2009, and 2010 BTNF northern goshawk spatial analysis. Unpublished report. WGFD. Jackson, WY.

Penteriani, V., and B. Faivre. 2001. Effects of harvesting timber stands on goshawks in two European areas. Biological Conservation 101: 211-216.

Reich, R. M., S. M. Joy, and R. T. Reynolds. 2004. Predicting the location of northern goshawk nests: modeling the spatial dependency between locations and forest structure. Ecological Modeling 176: 109-133.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting Accipiter hawks. USDA Forest Service, General Technical Report RM-102.

Reynolds, R. T. 1989. Accipiters. Pages 92-101 in Pendleton, B.G., ed. Proceedings of the western raptor management symposium and workshop. National Wildlife Federation, Washington, DC.

Reynolds, R. T., E. C. Meslow, and H. M. Wight. 1982. Nesting habitat of coexisting Accipiters in Oregon. Journal of Wildlife Management 46:124-138.

Reynolds, R. T., S. M. Joy, and D. G. Leslie. 1994. Nest productivity, fidelity, and spacing of northern goshawks in northern Arizona. Studies in Avian Biology 16:106-113.

Reynolds, R. T., 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. General Technical Report RM-217, 90 pp. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO, USA.

Sala, A., G. D. Peters, L. R. McIntyre, and M. G. Harrington. 2005. Physiological responses of ponderosa pine in western Montana to thinning, prescribed fire and burning season. Tree Physiol. 25:339–348.

Salafsky, S. R., R. T. Reynolds, B. R. Noon and J. A. Wiens. 2005. Reproductive responses of northern goshawks to variable prey populations. J. Wildl. Manage. 71 (7): 2274-2283.

Samson, F. B. 2005 (amended March 6, 2006). A Conservation assessment of the northern goshawk, blacked-backed woodpecker, flammulated owl, and pileated woodpecker in the Northern Region, USDA Forest Service. Unpublished report on file, Northern Region, Missoula, Montana, USA.

Schoennagel, T., T. T. Veblen, and W. H. Romme. 2004. The interaction of fire, fuels and climate across Rocky Mountain Forests. Bioscience 54:661-676.

Siders, M. S. and P. L. Kennedy. 1996. Forest structural characteristics of accipiter nesting habitat: is there an allometric relationship? Condor 98:123-132.

Smith, H., and D. A. Keinath. 2004. Species assessment for northern goshawk (Accipiter gentilis) in Wyoming. USDI BLM, Cheyenne, WY. 48p.

Sonsthagen, S. A. 2002. Year-round habitat, movement, and gene flow of northern goshawks breeding in Utah. Thesis. Brigham Young University, Provo, Utah.

Speiser, R. 1992. Notes on the natural history of the northern goshawk. Kingbird 42:133-137.

Squires, J. R. 2000. Food habits of northern goshawks nesting in south central Wyoming. Wilson Bulletin 112:536-539.

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

Squires, J. R., and L. F. Ruggiero. 1996. Nest-site preference of northern goshawks in south central Wyoming. Journal of Wildlife Management 60:170-177.

Squires, J. R. and P. L. Kennedy. 2006. Northern goshawk ecology: an assessment of current knowledge and information needs for conservation and management. Studies in Avian Biology No. 31: 8-62.

Squires, J. R. and R. T. Reynolds. 1997. Northern Goshawk (Accipiter gentilis), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/298.

Stephens, R. M. 2001. Migration, habitat use, and diet of northern goshawks (Accipiter gentilis) that winter in the Uinta Mountains, Utah. Thesis. University of Wyoming, Laramie, Wyoming.

USDI Fish and Wildlife Service. 1998. Status review of the northern goshawk in the forested west. Portland, Oregon, USA.

Whitford, T. C. 1991. Old-growth Douglas-fir forests of central Montana and the northern goshawk (Accipiter gentilis). M.S. thesis, University of Montana, Missoula.

Widén, P. 1989. The hunting habitats of goshawks Accipiter gentilis in boreal forests of central Sweden. Ibis 131:205-231.

Wisdom, M. J., R. S. Holthausen, B. C. Wales, C. D. Hargis, V. A. Saab, D. C. Lee, W. J. Hann, T. D. Rich, M. M. Rowland, W. J. Murphy, and M. R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: broad-scale trends and management implications. USDA Forest Service General Technical Report PNW,-GTR-485, Portland, Oregon, USA.

Woodbridge, B., and C. D. Hargis. 2006. Northern goshawk inventory and monitoring technical guide. Gen.Tech. Rep. WO-71. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

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.

Wyoming Game and Fish Department. 2010. State wildlife action plan 2010. Cheyenne, WY.

Wyoming Game and Fish Department. 2017. State wildlife action plan 2017. Cheyenne, WY.

Younk, J. V., and M. J. Bechard. 1994. Breeding ecology of the northern goshawk in high-elevation aspen forest of northern Nevada. Studies in Avian Biology 16:119-121.