Commentary

Northern Goshawk Habitat: an Intersection of Science, Management, and Conservation

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ABSTRACT We responded to the claim by Greenwald et al. (2005) that the management recommendations for the northern goshawk in the Southwestern United States (MRNG; Reynolds et al. 1992), a food web-based conservation plan that incorporated both northern goshawk (*Accipiter gentilis*) and multiple prey habitats, may be inadequate to protect goshawks. Greenwald et al. (2005) based this claim on their review of 12 telemetry studies of goshawk habitat selection and 5 nontelemetry studies of the effects of vegetation structure at the home range scale on goshawk nest occupancy and reproduction that appeared after the 1992 publication of the MRNG. Greenwald et al. (2005) summarized their review as showing that 1) goshawks were habitat specialists limited to forests with mature and old-growth structures including large trees, high canopy cover, multiple canopy layering, and abundant woody debris; 2) habitats were not selected on the basis of prey abundance and, therefore, managing for prey habitats diluted goshawk habitats; and 3) selection for openings, edges, and habitat diversity was inconclusive. Our review found that when the studies' respective authors pooled their radiotagged goshawks there were weak to strong selections for old forest structures. However, the studies also documented extensive variation in use of vegetation types and structures by individual goshawks; some avoided openings, edges, young forests, and old forests, whereas others selected for these characteristics. Additionally, by virtue of their wide geographic distribution, the studies showed that the focal populations themselves occurred in a variety of forest types, some with large structural differences. We found no evidence in Greenwald's et al. (2005) review that the MRNG are inadequate to protect goshawks. Rather, the studies reviewed by Greenwald et al. (2005), as well as many studies they missed, supported the MRNG. The suggestion of inadequacy by Greenwald et al. (2005) appeared rooted in misunderstandings of goshawk habitats described in the MRNG, a discounting of the extent of variation in vegetation structural and seral stages used by goshawks, a limited understanding of the extent to which prey limits goshawks, a failure to recognize the dynamic nature of forests, and an incomplete review of the literature. We believe the MRNG are adequate because they maximize the sustainable amount of mature and old forests in goshawk home ranges and specify the kinds and intermixtures of prey habitats within home ranges. Implementation of MRNG should reduce the likelihood that the availability of vegetation structures suited to goshawk nesting and foraging, as well as abundance and availability of prey, will limit goshawk nest occupancy and reproduction. (JOURNAL OF WILDLIFE MANAGEMENT 72(4):1047–1055; 2008)

DOI: 10.2193/2007-131

KEY WORDS *Accipiter gentilis*, conservation, forest management, habitat selection, home range, limiting factors, northern goshawk.

Greenwald et al. (2005:120) claimed that their review of northern goshawk (*Accipiter gentilis*) habitat studies conducted since the 1992 publication of the management recommendations for the northern goshawk in the Southwestern United States (MRNG; Reynolds et al. 1992; see also Graham et al. 1994, 1999; Reynolds et al. 1996; 2006*a*) "suggest that current goshawk management plans in the western United States may be inadequate." Greenwald et al. (2005) reached this conclusion based on a review of 17 studies, including 12 telemetry studies of home range habitat use by goshawks and 5 that correlated goshawk occupancy and productivity to home range habitat characteristics. We reviewed both the 17 studies in Greenwald et al. (2005, see table 1 for list of studies) and several studies that were not included in Greenwald et al. (2005). Because Greenwald et al. (2005) cited literature on habitat of Palearctic goshawks (*A. g. gentilis*), we also reviewed that literature. We assumed that studies appearing after June 2004 were not available to the literature search of Greenwald et al. (2005). However, because several studies similar to those reviewed by Greenwald et al. (2005) appeared after 2004, we reviewed these as well. For this rebuttal, we evaluated each study for evidence supporting or not supporting the approach, methodology, or the habitats described in the MRNG. Where appropriate, we commented on the design, sample size, and sampling efforts of the studies reviewed by Greenwald et al. (2005). We defined vegetation type as a plant community having a distinct physiognomy associated with its plant composition and structure, and use vegetation type to distinguish among broadly distinct plant communities such as grasslands, scrublands, woodlands, forests, and agricultural lands, and to distinguish among forest types, forest seral and structural stages, openings, and edges.

OVERVIEW OF THE MRNG

The MRNG described sets of desired goshawk breeding habitats in Southwestern ponderosa pine (*Pinus ponderosa*), mixed conifer, and spruce–fir (*Picea engelmannii*–*Abies lasiocarpa*) forests based on syntheses of 1) life histories and habitats of goshawks, 2) life histories and habitats of primary Southwest goshawk prey, and 3) ecology of the dominant overstory and understory plants in each forest type (Reynolds et al. 1992, 2006*a*). Goshawk habitat was described at 3 spatial scales: nest area (12 ha; comprised of large trees and high canopy cover relative to forest type), postfledging family area (PFA; 170 ha encircling a nest area

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with vegetation transitioning with increasing radii from nest area–like structures to forest structures suited to goshawk foraging [see below]); and foraging area (2,186 ha encircling a PFA comprised mostly of older forests with subcanopy flight space [lifted crowns] and a mosaic of prey habitats). Total managed home range (6 nest areas [73 ha] + PFA + foraging area) was 2,680 ha. Prey habitats included highly interspersed groups of mid-aged (about 140 yr), mature (about 200 yr), and old trees (240 yr) with interlocking tree crowns for tree squirrels (*Sciurus* spp., *Tamiasciurus* spp.); small (typically <0.5 ha) openings around tree groups for ground squirrels (*Spermophilus* spp.), rabbits (*Sylvilagus* spp., *Lepus* spp.), and birds; decadent reserve trees and snags for woodpeckers (*Colaptes* spp., *Melanerpes* spp., *Picoides* spp.) and tree squirrels; logs for ground squirrels, rabbits, and woodpeckers; and wood debris for ground squirrels, rabbits, and birds. Predator and prey habitats were spatially synthesized into desired landscapes so that their distribution and interspersion optimized availability to territorial goshawks and their prey with the objective of maximizing goshawk occupancy, reproduction, and survival (Reynolds et al. 2006*a*). The synthesis resulted in general habitat descriptions such as small tree groups with interlocking crowns and small openings. However, to assure that the desired habitats were within the bio-physical capabilities of sites and the desired vegetation could, therefore, be both attained and sustained, the desired habitats were fine-tuned by incorporating local site variation in vegetation composition, growth rates, longevity, and succession (Reynolds et al. 1992, Long and Smith 2000).

A MRNG literature review of the habitats of important goshawk prey showed that older forest structures (i.e., mid-aged, mature, and old forests) provided the best habitat for many prey species, whereas small openings were critical for others (Reynolds et al. 1992, table 7). Because they typically have lifted crowns (sub-canopy flight space) older forests also suited goshawks. Thus, an ideal goshawk home range would entirely consist of older forests with small dispersed openings. However, landscapes of old forests cannot be sustained. To estimate a sustaining landscape proportion of older forest, the MRNG used maturation rates of Southwestern forests to define 6 vegetation structural stages (VSS) from forest initiation (VSS 1) to old forest (VSS 6) and recommended that about 10% of a naturally forested landscape be in a grass–forb–shrub stage (VSS 1; to 20 yr), 10% in a seedling–sapling stage (VSS 2; to 50 yr), 20% in young forest (VSS 3; to 96 yr), 20% in mid-aged forest (VSS 4), 20% in mature forest (VSS 5), and 20% in old forest (VSS 6; Reynolds et al. 1992, appendix 5, table 1). Over time, the desired landscape comprised a temporally shifting mosaic of highly interspersed groups of different VSS whose proportions (area-based) were approximately constant (Reynolds et al. 1992).

In Southwestern ponderosa pine the desired foraging areas comprised mosaics of small (<0.3 ha; 2–44 trees), highly interspersed groups of different VSS, which closely approximated the natural (prior to tree harvests and fire suppression) conditions in Southwestern ponderosa pine (Pearson 1923, 1950; Cooper 1961; White 1985). At the coarse scale (landscape), ponderosa pine was all-aged, but trees within each VSS group (fine scale) were of similar age. The desired within-group structure in older VSS (VSS 4–6) included open understories, interlocking tree crowns (high canopy cover), abundant large limbs (goshawk hunting perches), and shade to protect mycorrhizal fungi (food of several prey species; Reynolds et al. 1992). Grass, herb, shrub habitat was interspersed around the VSS groups and provided habitat for rabbits, ground squirrels, and birds. Scattered throughout the landscape were reserve trees (7.4–12.3 trees/ha), large snags (4.9 trees/ha), large logs (7.4 logs/ha), and wood debris (2.2–3.1 Mg/ha). Finally, ideal goshawk landscapes had home ranges spaced at about 4 km between centers (Reynolds et al. 1992, 2005).

The MRNG described different desired habitats for each of the 3 Southwestern forest types because each had different suites of prey and different vegetation compositions with unique developmental pathways and disturbances. The desired conditions in mixed-conifer forests were similar to those in ponderosa pine but with larger VSS groups comprised of multiple tree species (e.g., *Pinus* spp., *Pseudotsuga* sp., *Abies* spp., *Pices* spp., *Populus* spp.), and more reserve trees, snags, and wood debris. The desired conditions in spruce–fir were higher tree densities and canopy closure with scattered small openings and more snags and wood debris (Reynolds et al. 1992, table 1). Habitats described in the MRNG were developed for goshawks and their prey in forests in the southwestern United States. To develop habitats for goshawk and their prey in other forests and bioregions, we recommended using the MRNG model to synthesize local knowledge of goshawks, their prey, and vegetation types into desired habitats (Reynolds et al. 2006*a*).

REVIEW OF STUDIES CITED BY GREENWALD ET AL.

Goshawk Selection for Stand Structure

Greenwald et al. (2005) asserted that new information in the 17 post–1992 studies warranted a revision of the MRNG. Our review of the studies showed that only 7 (41%) appeared in science journals (others were theses and annual reports) and, therefore, much of the new information was not peer-reviewed and, contrary to Greenwald et al. (2005), 2 of the studies (Fischer 1986, Crocker-Bedford 1990) appeared before 1992 and were cited in the MRNG. Nonetheless, Greenwald et al. (2005:120, 125) reported that goshawks in 9 of the 12 telemetry studies selected stands in the home range with the "structural characteristics of mature to old-growth forests such as large trees and high canopy closure" and that the "consistency of results [among the reviewed studies] demonstrated goshawk selection for late-successional forest structures," including "high canopy closure, larger trees for forest type, canopy layering, and abundant coarse woody debris." Based on the 9 studies, Greenwald et al. (2005:125) concluded that goshawks were "habitat specialists with respect to forest structure." Greenwald et al. (2005:127) then argued that, because goshawks are specialists for late-successional forest structures, the desired landscape mix of VSS described in the MRNG is detrimental to goshawks because goshawks "avoid open areas and early seral forests, that logging reduces goshawk occupancy and productivity," and that there is "a lack of evidence that creating openings or young forest through logging benefits goshawks." Yet, Greenwald et al. (2005:125) failed to note the abundant evidence in the reviewed studies that did not support their conclusion of "consistency of results." Stephens (2001), for example, found no selection for canopy cover, tree size, or tree density; Hargis et al. (1994) found that home ranges had higher vegetation diversity, seral diversity, and greater interspersion of these diverse conditions then did random sites; Bloxton (2002) reported that diversity of vegetation used by goshawks reflected diversity of types available; and Beier and Drennan (1997:568) wrote that "for all parameters sampled, the range of sites used by goshawks was impressively broad, and comparable to the range found in contrast plots." Although Greenwald et al. (2005:125–127) occasionally noted evidence contradictory to their claim of "consistency of results," they often discounted this evidence with statements such as "more study may be necessary," "inferences to populations should be made cautiously," and "some other factor besides stand structure is driving avoidance in this case." Greenwald et al. (2005) also ignored statements such as Beier and Drennan's (1997:570) that "goshawks exhibit flexible hunting strategies and probably would use a variety of microsites even if dense stands of large trees were more widely available."

Another example of the failure of Greenwald et al. (2005) to disclose the full range of vegetation structure used by goshawks was their lumping of pinyon–juniper (*Pinus* spp.–*Juniperus* spp.) woodlands with tall coniferous and deciduous forest types, each used by goshawks in the reviewed studies (the caveat "large trees for forest type" of Greenwald et al. [2005:125] to account for large differences in tree sizes among forest types is inadequate and misleading). There are few structural similarities between the pinyon–juniper woodlands used by goshawks in Stephens (2001) and Drennan and Beier (2003) and, for instance, coastal temperate rain forests used by the goshawks in Titus et al. (1996), Pendleton et al. (1998), and Bloxton (2002). Pinyon–juniper woodlands have small (<12 m in ht), widely spaced trees (open canopies) whose crowns typically extend to the ground (little or no subcanopy space and no canopy layering), with little large-diameter woody debris, whereas coastal temperate rain forests contain large (to 58 m in ht and 100 cm in diam) trees with fully closed, multilayered canopies and considerable wood biomass on the forest floor (Franklin and Dyrness 1973, Brown 1982, Alaback and Juday 1989, Franklin et al. 2002). Further compromising their claim of consistent selection for large trees and high canopy cover was at least one (possibly 2, see below) telemetry studies missed by Greenwald et al. (2005). Younk (1996) and Hasselblad (2004; the latter may have appeared too late for Greenwald et al. [2005]) documented extensive use of open shrub or shrub-steppe vegetation by hunting goshawks. Goshawks in these studies nested in patches of trees (quaking aspen [*Populus tremuloides*] or mixed aspen and conifer) and hunted in surrounding open shrub communities for ground squirrels (Younk and Bechard 1994, Younk 1996, Hasselblad 2004). For example, 37–55% of telemetry locations were in open shrub vegetation in Nevada, USA, and open shrub-steppe vegetation comprised a mean of 49% of home ranges of successfully breeding goshawks in Idaho, USA (Younk and Bechard 1994, Younk 1996, Hasselblad 2004). Shrub or tundra vegetation surrounded several goshawk nests in riparian cottonwood (*Populus* spp.) stands in Colorado and Utah, USA, and one nest was in a 5-m-tall willow (*Salix* sp.) stand 145 km north of the Alaskan tree line (White et al. 1965, Swem and Adams 1992).

Greenwald et al. (2005) also ignored individual goshawk variation in use of vegetation structures within studies. Although there was an overall selection for mature and old forests by pooled goshawks, our review showed considerable individual goshawk variation in use of vegetation types. Pendleton et al. (1998, fig. 2) documented that, although goshawks in Alaska demonstrated a pooled selection for old forests, not all individuals showed strong selection for old-growth forests; many goshawks showed moderate selection, whereas about one-third actually avoided old forests. Of the reviewed studies, 7 others also documented individual variation in use of vegetation types and structures (Austin 1993, Hargis et al. 1994, Beier and Drennan 1997, Good 1998, Stephens 2001, Bloxton 2002, and Drennan and Beier 2003). Austin (1993) reported that, although 9 pooled goshawks showed selection for mature and old forests, one bird showed a trend of avoidance of mature and old forests, and mature and old forests were not found in a sample of random locations of another. Hargis et al. (1994) reported that 8 of 10 goshawks used areas with increased vegetation diversity; 3 of these used riparian areas, 2 used pumice-flat edges, one used young forest, and one used a baseball diamond. Stephens (2001) reported that 4 goshawks hunted in mixed conifer, 4 hunted in pinyon–juniper woodlands, and one hunted in lowland riparian adjacent to salt-desert scrub.

Our review suggested several likely sources of variation in goshawk use of vegetation structures. Among-study variation resulted from the diverse geographic regions in which the studies were conducted (e.g., AZ, CA, WY, MN, AK). First, these regions have widely different physical and climatic settings resulting in different forest types with sometimes widely different vegetative compositions and structures. By virtue of occupying the range of forest types, use of a diversity of tree sizes, tree densities, and canopy layers by goshawks was expected. Second, because the composition of suites of prey and their respective habitats varies among the geographic regions, goshawks in each region were likely to have incorporated different prey habitats into their daily movements (Reynolds et al. 2006*a*, *b*). Among-individual variation likely had 2 sources. Goshawk home ranges can be large (e.g., $\bar{x} = 6,376$ ha/pair; Boal et al. 2001), and, because large areas typically have diverse vegetation types, no 2 goshawk home ranges were likely to be the same. Although different availabilities of vegetation types within ranges likely contributed to individual variation, a portion surely stemmed from among-individual preferences for certain habitats and prey.

Given the extent of individual variation in use of vegetation, the breadth of diversity in vegetation types used in the reviewed studies would likely have been even greater had samples of radiotagged goshawks been larger. Although Greenwald et al. (2005:125) acknowledged that "some studies suffered from small sample sizes or relatively short sampling periods," they included these as if sample size did not matter. More than half of the studies included ≤ 10 goshawks and one included only 2 (Greenwald et al. [2005, table 1] contains several errors in no. of goshawks sampled by study). Rather than the narrowly portrayed selection of "large trees and high canopy closure" by Greenwald et al. (2005:120), our review identified abundant evidence, both among studies and among individuals, of use of a wide range of tree sizes and canopy closures. The apparent opportunistic use of vegetation types by goshawks argues that managing for diverse MRNG vegetation structural stages, as both goshawk and prey habitats, will likely not be at the expense of habitat structures suited to goshawk foraging and should not decrease goshawk occupancy rates as suggested by Greenwald et al. (2005). Diverse vegetation supports a diversity of prey species and several of the reviewed studies suggested that the use of diverse habitats by goshawks resulted from goshawks entering habitats of their prey (Austin 1993, Hargis et al. 1994, Good 1998, Boal et al. 2001, Stephens 2001). Indeed, the use of openings by goshawks in the Younk (1996) and Hasselblad (2004) studies was related to abundance of ground squirrels there. If food limits goshawk reproduction, as increasing evidence suggests (see below), then a food web approach would better conserve goshawks than would managing for only those forest structures suited for goshawks (Reynolds et al. 2006*a*, *b*).

Goshawk Selection for Stand Diversity, Openings, Logged Forests, and Edge

Despite admitting that "there was great variation in stand vegetation diversity among the studies," Greenwald et al. (2005:123) concluded that goshawk selection for diversity of vegetation types was "inconclusive." Our review showed this conclusion to be untenable. Of the 12 telemetry studies, 3 reported that goshawks used vegetation types such as openings, edges, and seral stages in proportion to their availability within home ranges (Austin 1993, Bright-Smith and Mannan 1994, Lapinski 2000). Although half of the reviewed studies showed goshawks avoiding openings (Fisher 1986, Bright-Smith and Mannan 1994, Titus et al. 1996, Pendleton et al. 1998, Lapinski 2000, Boal et al. 2001, Bloxton 2002), 3 showed use of openings (Austin 1993, Good 1998, Stephens 2001), and one found no differences in presence of openings on used versus random plots (Beier and Drennan 1997). Of telemetry studies not included in Greenwald et al. (2005), both Younk (1996) and Hasselblad (2004) showed extensive use by goshawks of openings and edges. Finally, in a nontelemetry study of goshawk occupancy and home range conditions, Daw and DeStefano (2001) reported that odds of occupancy increased 2.5 times with the presence of openings in home ranges. Goshawks in each of the latter 3 studies hunted openings for Belding's ground squirrels (*S. beldingi*).

Perhaps symptomatic of their failure to recognize the diversity of vegetation types used by goshawks, Greenwald et al. (2005) appeared to equate forest structural stage with successional stage. Throughout, Greenwald et al. (2005) used old forest and late-successional forest interchangeably and appeared to also do the same with young and early seral forests. Structural stage and successional stage are not synonymous; a late-successional forest may not always have old-forest structures whereas an early seral forest can. Quaking aspen is often seral to ponderosa pine, Douglas-fir (*Pseudotsuga menziesii*), or subalpine fir (*Picea engelmannii*) forests, and these seral aspen forests often have old-forest structures and are frequently used by goshawks (Mueggler 1985, Squires and Reynolds 1997). The claim by Greenwald et al. (2005:125) that the "consistency of results demonstrates goshawk selection of late successional forest structures" is also inconsistent with their summary of Boal et al. (2001): "a variety of successional stages and ages of hardwoods and conifer forest types" (Greenwald et al. 2005, table 1). The VSS classification in the MRNG describes the range of forest structural stages as they mature irrespective of seral stage; any seral stage may include a full range of VSS (Thomas et al. 1979, Oliver and Larson 1990, Hann et al. 1997).

Finally, it was difficult to evaluate the importance of openings and edge to goshawks in the reviewed studies because none of the authors provided dimensional criteria defining an opening. However, from their descriptions (e.g., clear-cuts, open mountain slopes, pumice flats, alpine areas, open forests with <35% canopy closure, rock and ice, and nonforested areas), it appears that only goshawk use of large openings and associated edge was investigated. Further, detecting the importance of openings and edges to goshawks with telemetry, especially the fine-scale openings in the MRNG, is difficult because error polygons associated with both ground- and aerial-based telemetry are typically large (ground, 22–98 m [Bright-Smith and Mannan 1994, Beier and Drennan 1997, Stephens 2001]; aerial, 100–762 [Good 1998, Pendleton et al. 1998, Boal et al. 2001, Stephens 2001]), making it difficult to determine whether a goshawk was in an opening, on its edge, or in the forest interior. Also, failure to find selection for openings or edges does not mean that none exists. Although Greenwald et al. (2005:126) posited that openings may benefit goshawks by increasing food abundance, they wrote "given the history of clear-cutting in much of the western United States, we very much doubt that forest clearings are a limiting factor for the species." Equating the fine-scale MRNG openings to past clear-cuts underscores the misunderstandings of the MRNG by Greenwald et al. (2005). Implementing the MRNG restores the natural heterogeneity and interspersion of groups of trees and small natural openings that typified Southwestern conifer forests—openings that have filled with trees since fire exclusion (Covington and Moore 1994; Fulé et al. 1997; Reynolds et al. 2006*a*, figs. 2–4). Areas of past tree cutting (including clear-cuts) would be restored to the desired heterogeneity and interspersion of goshawk and prey habitats.

Goshawk Selection for Prey Abundance

Greenwald et al. (2005) reviewed 4 studies that investigated the importance of habitat structure versus prey abundance in goshawk habitat selection (Boal and Mannan 1994, Beier and Drennan 1997, Good 1998, Drennan and Beier 2003). Greenwald et al. (2005) questioned the adequacy of the MRNG because they claimed the 4 studies demonstrated that goshawks were either not limited by food or they selected home ranges on the basis of habitat structure and not food abundance. Greenwald et al. (2005) then posited that inclusion of prey habitats in the MRNG was unnecessary and would dilute the quality of goshawk foraging habitat. Greenwald et al. (2005) cite Boal and Mannan (1994) as evidence that food availability did not limit goshawk productivity. Yet, there is no evidence in Boal and Mannan (1994) that prey abundance was determined. The 3 other studies compared vegetation structure and prey abundance at sites where goshawks were assumed to have been hunting (based on transmitter pulse rates and direct observations), where prey remains were found, or where goshawks were observed feeding, to either randomly located sites or among prey-kill sites differing in frequency of revisits by goshawks (Beier and Drennan 1997, Good 1998, Drennan and Beier 2003). Beier and Drennan (1997) and Drennan and Beier (2003) concluded that goshawks selected habitat on the basis of structure and not on prey abundance because foraging sites had higher canopy cover, higher tree density, more large trees, and lower shrub cover than random sites and there were no differences in prey abundance among used versus random sites. Good (1998) found that goshawks returned more often to sites that were closest to nests, had more mature forests with large conifers, lower shrub cover, and had greater densities of small natural openings (within 1-km circles), and that goshawk use of kill areas was more frequently correlated with these habitat characteristics than prey abundance. A critique of assumptions and potential biases in these studies is in Reynolds et al. (2006*b*). Nonetheless, Greenwald et al. (2005) again missed or ignored studies reporting the use by Palearctic goshawks of habitats with higher prey abundance (Kenward and Widén 1989, Widén 1989, Younk 1996, Tornberg and Colpaert 2001, Sunde 2002). Moreover, food has been found to limit survival, reproduction, distribution, density, home range size, proportion of pairs breeding, and nest success of raptors including goshawks (Southern 1970; Galushin 1974; McGowan 1975; Sollien 1979; Lindén and Wikman 1980; Baker and Brooks 1981; Huhtala and Sulkava 1981; Doyle and Smith 1994; Keane 1999; Salafsky et al. 2005, 2007; Wiens et al. 2006*a*). In fact, Widén (1989) suggested that goshawk habitat preferences were probably based on different energetic profitability of habitats, which were determined by a habitat's prey abundance and the presence of habitat features that influence a goshawk's ability to hunt. In view of this, we argue that the MRNG's inclusion of both prey habitats and vegetation structures suited to goshawk nesting and foraging was a robust approach to goshawk conservation (Reynolds et al. 1992, 1996, 2006*a*, *b*).

Goshawk Winter Habitat Selection

Greenwald et al. (2005:124) cited Stephens (2001), Drennan and Beier (2003), and Titus et al. (1996) as supporting their view that wintering goshawks continued to occupy ponderosa pine, mixed conifer, and coastal temperate rain forests with "statistically higher canopy closure than random sites" and continued to be habitat specialists during winter. Despite this statement, Greenwald et al. (2005) noted Stephens' (2001) and Drennan and Beier's (2003) descriptions of winter goshawk movements to lower elevation pinyon–juniper woodlands from higher elevation conifer forests. We already identified the structural dissimilarities between canopied conifer forests and pinyon–juniper woodlands. Although some goshawks occupy their breeding habitats during winter (Speiser and Bosakowski 1991, Doyle and Smith 1994, Reynolds et al. 1994, Boal et al. 2001), some studies missed by Greenwald et al. (2005), as well as others published after 2004, documented winter goshawk movements to nonforested shrublands and agricultural areas (Reynolds et al. 1994, Squires and Ruggiero 1995, Stephens 2001, Sonsthagen 2002, Wiens et al. 2006*a*). Although none of these studies determined why goshawks moved to more open, lower elevation habitats, we think that Drennan and Beier's (2003:183) suggestion that the winter movements to pinyon–juniper forests were "in response to reduced diversity and abundance of prey in ponderosa pine habitats in winter" is correct (this statement is counter to their conclusion that "goshawks selected foraging sites based on forest structure rather than prey abundance"). The MRNG's focus on sustaining goshawk and prey habitats in the breeding home range minimizes the likelihood that lack of food would cause wintering goshawks to move to open habitats where they can suffer increased predation (Squires and Ruggerio 1995).

Goshawk Occupancy and Productivity Related to Landscape Features

Greenwald et al. (2005) reviewed 5 studies that investigated the relationships between forest conditions in landscapes surrounding goshawk nests and rates of nest occupancy and reproduction. Greenwald et al. (2005) reviewed Crocker-Bedford (1990, 1995) for effects of different levels of tree harvests on nest occupancy and reproduction, Ward et al. (1992) for effects of varying canopy closure on nest occupancy (active, inactive nests), Patla (1997) for effects of different forest ages (mature, young, seedling) on nest occupancy, and Finn et al. (2002) for effects of different forest attributes (nonforest cover, late-seral forests) on nest occupancy and nesting success. Based on these, Greenwald et al. (2005) concluded that greater goshawk occupancy and reproduction was consistently related to more closed-canopy forests with large trees in home ranges. These nontelemetry studies have several potential limitations. First, nontelemetry studies are correlative. Although occupancy (or reproduction) and some defined habitat condition in the home range (e.g., old forest) may co-vary, it can not be said that occupancy is a function of that habitat condition because habitat use was not directly measured. Second, due to the difficulty of unequivocally determining occupancy or reproductive status of goshawks on home ranges due to their elusive behavior, the extent of error associated with correctly classifying reproductive status of goshawks on territories can be problematic. The potential for error was demonstrated in a 17-year study of color-banded goshawks in Arizona in which temporal and spatial variation in egg-laying was shown to be extensive (7–86% of goshawks laid eggs in a yr, none laid eggs every yr, and some territorial goshawks skipped breeding for 7 consecutive yr), non-breeders had much lower detectabilities than breeders, and there were frequent movements among alternate nests (55–75% of egg-laying goshawks/yr moved to an alternate) that were as far apart as 2.4 km (Reynolds et al. 2005; R. T. Reynolds, Rocky Mountain Research Station, personal observation; see Woodbridge and Detrich 1994, Siders and Kennedy 1996, and Keane et al. 2006 for similar temporal variation in breeding and distances among alternate nests). To minimize classification error, Reynolds et al. (2005) used 3 nest-searching protocols within a 1,600-m radius around home range centers that required $\geq$10-person-days per year per home range. Further, because it is difficult to prove a negative in such large forested areas, home ranges in which goshawks were not found were classified as unknown, not unoccupied as in other studies (Boyce et al. 2005, Reynolds et al. 2005).

Our review of sampling efforts used in the landscape features and occupancy studies reviewed by Greenwald et al. (2005) showed that Crocker-Bedford (1990:263) did not report radius of areas searched but that nest searches "typically involved 2 person-days (range = one-half to 10 person days)," Ward et al. (1992) did not describe their sampling efforts, Finn et al. (2002) searched 3 years in areas previously known to have goshawk nests but only within 1 km of nests, and Patla (1997, 2005) used within- and among-year sampling efforts close to those in Reynolds et al. (2005). Thus, with the exception of Patla (1997, 2005), it was difficult to evaluate the reliability of estimates of occupancy and reproduction in the reviewed studies. Nonetheless, the review of Greenwald et al. (2005) again missed a number of studies of landscape habitats and goshawk occupancy and reproduction. La Sorte (2001) and La Sorte et al. (2004) measured forests conditions around goshawk nests and found that, although nests were associated with mature forests, beyond 0.8 km from nests forest structure became increasingly fragmented and resembled forests at randomly located sites. Joy (2002) compared forests around nests in high- and low-quality territories ranked on total reproduction over a 10-year period. Joy (2002) did not detect differences in forest conditions between high- and low-quality territories but found that both had fewer openings within 0.6 km of nest plot centers than did random plots. 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. Clough (2000) surveyed 70% of an area of extensively managed forest for goshawks and measured vegetation around 18 nests she located. Clough (2000) reported that occupied areas had been heavily influenced by tree harvests, roads, and grazing relative to more interior forests where there were no nesting goshawks. Daw and DeStefano (2001) measured forest landscapes within plots of increasing radii around 22 active nests and 44 randomly located sites and found more old forest within smaller circles (12 ha and 24 ha) than around random sites, but differences between used and random sites diminished as size of the circle increased. Odds of occupancy by goshawks increased 2.5 times with presence of dry openings (Daw and DeStefano 2001). McGrath et al. (2003) measured landscapes around 82 active goshawk nests and 95 randomly located sites and found the ability to distinguish goshawk sites from random sites decreased beyond 83 ha around nests. In a study published too late for Greenwald et al. (2005), Desimone and DeStefano (2005) revisited 46 nests to determine reproductive status and measured forest age classes and canopy cover in 1-km circles around nests and found that 15 nests were reoccupied in the study year and had significantly more mid-aged closed forests and late-successional forest than had unoccupied sites. Finally, all of these studies, including those reviewed by Greenwald et al. (2005), were conducted in forests with some prior tree harvests.

Greenwald et al. (2005) cited Crocker-Bedford's (1990, 1995) 3-year study (1985–1987) on the Kaibab National Forest (KNF) in Arizona as documenting significantly lower nest occupancy and productivity of goshawks in areas that had been twice selectively harvested versus those that had been only selectively harvested once. Although Greenwald et al. (2005:127) cited the Crocker-Bedford (1990, 1995), Ward et al. (1992), Patla (1997), and Finn et al. (2002) studies as demonstrating that "removing forest cover in the home range . . . reduced productivity because there were fewer breeding territories," we point out that the desired conditions in the MRNG are not at all like the residual forest conditions following "selection harvesting" such as occurred on the KNF. Nonetheless, although it is unclear whether Crocker-Bedford's (1990) sampling efforts were sufficient to reliably estimate goshawk occupancy and reproduction, our 17-year (1991–2007) study of goshawks on as many as 123 goshawk territories on the Kaibab Plateau has identified extensive temporal and spatial variation in goshawk reproduction (Reynolds et al. 2005; Reynolds and Joy 2006; R. T. Reynolds, unpublished data). The variation was closely associated with inter-annual variation of prey abundance, which was, in turn, associated with inter-annual fluctuations in forest productivity (e.g., conifer cone production) driven by El Niño–La Niña wet and dry periods (Salafsky et al. 2005, 2007; Wiens and Reynolds 2005; S. R. Salafsky, Rocky Mountain Research Station, unpublished data). Our Kaibab study is demonstrating that inter-annual variation in food abundance, high annual fidelity to breeding territories, extensive variation in the breeding life spans of goshawks, and direct weather effects on reproduction can all act synergistically to produce large variations in total reproduction on and among territories (Wiens and Reynolds 2005; Reynolds et al. 2006*b*; Wiens et al. 2006*a*; R. T. Reynolds, unpublished data). Each of these factors confounds our search for the true effects of tree harvests on goshawks; unless habitat changes approach a catastrophic level (high severity fire, extensive clear-cutting), it is clear that short-term studies (<7 yr) are not likely to identify the effects of tree harvests on goshawks (Reynolds et al. 2006*b*).

CONCLUSION

We believe that the suggestion of inadequacy of the MRNG by Greenwald et al. (2005) was faulted for several reasons. First, Greenwald et al. (2005) ignored the extent to which individuals and populations of goshawks used diverse vegetation types and, hence, the extent of their opportunistic use of habitat. Second, Greenwald et al. (2005) misunderstood goshawk and prey habitats described in the MRNG. Third, Greenwald et al. (2005) failed to understand the extent to which food can limit goshawk populations. Fourth, Greenwald et al. (2005) failed to recognize how forest dynamics constrain the sustaining amount of mature and old-forest habitats in landscapes. Fifth, the literature review by Greenwald et al. (2005) missed many studies with similar objectives and methods as those they reviewed. We found no evidence in any of the post-1992 studies that the MRNG are inadequate for protecting goshawks. On the contrary, many of the studies supported the approach used in the MRNG. Our review showed that goshawk breeding is often limited by food abundance and that, in most North American areas occupied by goshawks, the measure of food abundance should be the combined abundance of all species in a suite of prey—no one or two species are likely to support goshawk breeding in a majority of years. Our review also showed that foraging goshawks are adept at using a wide range of vegetation structures when foraging. Thus, goshawks are probably less limited by vegetation structure beyond the nest area than by food abundance. The MRNG showed that the structural stages most important for supporting populations of forest-dependant prey are mid-aged, mature, and old forests, that these structural stages are also best suited for goshawk foraging, and that small openings intermixed with these structural stages are habitat for other primary prey that goshawks can hunt from older trees. It was for these reasons that an entire home range (or landscapes) described in the MRNG was comprised of the diversity and intermixture of habitats that supported a full suite of prey. That the desired diversity and interspersion of habitats were ecologically sound was suggested by the fact that these conditions were well within the historical range of variability of Southwestern forests. Implementation of the MRNG in Southwestern forests should increase goshawk occupancy by increasing their reproduction and survival by lowering the likelihood that food and forest structure will limit goshawks. Advocating management of forests for goshawks according to the Greenwald et al. (2005) one-size-fits-all criteria of big trees, closed and multilayered canopies, and abundant woody debris is ecologically unsound because landscapes comprised of these conditions cannot be sustained in all of the forests and woodlands occupied by goshawks.

ACKNOWLEDGMENTS

We thank T. Jain, R. King, and B. Linkhart, S. DeStefano, and 2 anonymous reviewers for comments on drafts of this manuscript.

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Associate Editor: Chamberlain.