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GOSHAWK STATUS AND MANAGEMENT: WHAT DO WE KNOW, WHAT HAVE WE DONE, WHERE ARE WE GOING?

DOUGLAS A. BOYCE, JR., RICHARD T. REYNOLDS, AND RUSSELL T. GRAHAM

Abstract. Although the Northern Goshawk (*Accipiter gentilis*) is not listed as a threatened or endangered species in the US, five of nine regions of the USDA Forest Service have designated the goshawk as a sensitive species. The Nature Conservancy (TNC) believes goshawks are secure but some TNC state offices believe the species to be rare. A recent literature review found no strong evidence for a range-wide population decline (Kennedy 1997). The vastness of the North American forests and the elusiveness of goshawks prevent a reliable estimate of the number of breeding goshawks. In Alaska alone, the size of the boreal forest exceeds the size of the states of Oregon and Washington combined. In the continental US, the number of known breeding areas breeding documented at least once has been tallied for years and is estimated to exceed 3,000. However, habitat change is believed to have reduced the number of breeding goshawks by degrading the structural character of forests used for nesting and foraging. Forest fragmentation is known to have caused goshawk declines in Europe, and extensive forest cutting in the 18th and 19th centuries probably caused goshawk declines in the northeastern US. Habitat quality and availability are also important for supporting the diverse array of goshawk prey species. Goshawks nest and hunt in many forest types. However, in the western US, 78% of the known nesting areas are in ponderosa pine forests (*Pinus ponderosa*) and Douglas-fir forests (*Pseudotsuga menziessi*). Awareness of the potential effects of habitat change on goshawks has increased among land managers responsible for these and other forest types. Important changes in management have taken place since the 1970s as a result of increased understanding of essential goshawk resources and the extent of spatial and temporal scales that require simultaneous consideration for long-term management of goshawks. A conservation strategy that restores and sustains forest ecosystems to support goshawks has been implemented throughout the southwestern US. The concepts in the southwestern goshawk conservation strategy are used extensively to manage goshawks, and they are complementary to regional management strategies such as the Northwest Forest Plan and the Sierra Nevada Forest Plan Amendment.

Key Words: *Accipiter gentilis*, habitat management, habitats, management, Northern Goshawk, status.

ESTADO Y MANEJO DEL GAVILÁN: QUÉ SABEMOS, QUÉ HEMOS HECHO, A DÓNDE VAMOS?

Resumen. A pesar de que el Gavilán Azor (*Accipiter gentilis*) no está enlistado como una especie amenazada o en peligro en los Estados Unidos, cinco de nueve regiones del USDA Servicio Forestal han designado al gavilán como una especie sensible. De The Nature Conservancy (TNC) cree que los gavilanes están seguros, pero algunas oficinas de TNC estatales, consideran a la especie como rara. Una reciente revisión bibliográfica mostró evidencia poco fuerte en la declinación de la población de amplio rango (Kennedy 1997). La inmensidad de los bosques de Norte América y lo esquivo de los gavilanes, impiden un estimado confiable de los gavilanes reproductores. Solamente en Alaska, el tamaño del bosque boreal excede el tamaño de los estados de Oregon y Washington combinados. En EU continental, el número de áreas de reproducción (reproducción documentada al menos una vez) ha sido cuantificado por años, y se estima que excede 3,000. Sin embargo, se cree que el cambio del hábitat ha reducido el número de gavilanes reproductores, al degradar las características estructurales de los bosques utilizados para la anidación y forrajeo. Se sabe que la fragmentación del bosque ha causado decaimientos del gavilán en Europa, mientras el corte excesivo del bosque durante los siglos 18 y 19, causó probablemente el decaimiento en el noreste de EU. La calidad y la disponibilidad del hábitat son también importantes para soportar el diverso acomodo de las especies presa del gavilán. Los gavilanes anidan y cazan en varios tipos de bosque. Sin embargo, en el oeste de EU, 78% de las áreas de anidación se encuentran en bosques de pinos ponderosa (*Pinus ponderosa*) y bosques de abeto douglas (*Pseudotsuga menziessi*). La conciencia sobre los efectos potenciales en el cambio de hábitat ha incrementado entre los administradores de la tierra, responsables de estos tipos de bosque. Cambios importantes en el manejo han tenido lugar desde los finales de la década de los setenta (1979), como resultado del incremento en el entendimiento de los recursos esenciales del gavilán, y la magnitud de las escalas temporales y espaciales que requieren consideración simultánea para el manejo de los gavilanes a largo plazo. Una estrategia de conservación, la cual restaura y sustenta los ecosistemas forestales para soportar al gavilán, ha sido implementada por todo el suroeste de EU. Los conceptos en la estrategia de conservación del suroeste, son utilizados extensivamente para manejar a los gavilanes, y son complementarios a estrategias regionales de manejo, tales como el Plan Forestal del Noroeste y el Plan Enmienda Forestal de Sierra Nevada.

Extensive harvesting of mature and old trees during the 1960s and 1970s created concern for the welfare of species inhabiting older forests. The issue continued to grow through the 1980s and early 1990s as old forests disappeared or became highly fragmented. Numerous administrative appeals and lawsuits were filed in whole or in part over concern for the welfare of the Northern Goshawk (*Accipiter gentilis*). During the past decade, managers began to turn their focus away from individual species needs to address emerging concerns about managing ecosystems, and more recently to concerns about forest health. One catalyst for change was the increased number, size and devastation of wildfires that have destroyed much of the remaining old forests (Graham et. al. 2004). More than 80 yr of fire exclusion resulted in a population explosion of small trees, creating fuel ladders for surface fires to ignite forest canopies. The increased frequency and devastation of catastrophic wildfires focused the nation's attention on forest health problems as indicated by the emphasis and funding placed on it by the U.S. Congress. Increases in tree density and warming weather have allowed forest destruction by insects. For example, the spruce beetle (*Dendroctonus rufipennis*) killed 80% of all standing spruce trees on the Kenai Peninsula in Alaska (USDA Forest Service 2000b). A principle management tool to improve forest health is tree-thinning (Graham et al. 1999a). However, as forests are thinned, managers have become concerned about forest-dependent species that may be affected by these treatments, including the Northern Goshawk. The loss of old-forest structure, regardless of the cause, is a major concern.

We begin with a discussion of goshawk population status from the perspective of a federal regulatory agency, the USDI Fish and Wildlife Service (USFWS), a federal land management agency, the USDA Forest Service (USFS), a non-profit environmental organization, The Nature Conservancy (TNC), and two published reviews of existing information on goshawk ecology and populations (Kennedy 1997; Andersen et. al. 2004, 2005). We then discuss the distribution and abundance of breeding goshawks followed by a brief description of their use of habitat. From this we move into a description of goshawk management prior to 1990 followed by post-1990 forest management. Trends in habitat management are described followed by a concluding section on what we think the future holds. We describe several landscape-scale management plans in the western US, one of which was developed for goshawks specifically and others that were developed for other species which may affect goshawks. We focus, however, on the conceptual strength of a management plan developed specifically for southwestern forests which addresses goshawk nest and foraging habitats and the habitats of plants and animals in the goshawk food web.

STATUS

A species status is determined in a review of available information on trends in the populations, reproduction, survival, threats to populations, and trends in its habitats. For the USFWS, status is a formal designation with legal consequences. For non-profit organizations such as TNC, a species' status helps prioritize the importance, i.e., for funding, of the species relative to others. For state wildlife management agencies, the status of a species helps prioritize the agency's management attention.

USDI Fish and Wildlife Service

In July 1991, believing goshawk populations were declining due to forest cutting and habitat loss, a petition was filed with the USFWS (USDI Fish and Wildlife Service 1992a) to have the goshawk protected as endangered in Arizona, Colorado, New Mexico, and Utah under provisions of the Endangered Species Act (1973). In a review of the petition, the USFWS determined that the species in the four-state area was not a distinct population and therefore could not be listed. The USFWS noted that evidence existed to suggest the species may be declining and placed the goshawk, including the Queen Charlotte subspecies (*Accipiter gentilis laingi*), on its category II species list (USDI Fish and Wildlife Service 1991). Category II species were those that the USFWS determined required protection under the Endangered Species Act (ESA), but for which conclusive data regarding its population status and threats to its habitat were insufficient to support a proposed rule. By placing the goshawk on the category II list, the USFWS by-passed the petitioner's request for listing until more data were gathered. An amendment to the petition was submitted shortly thereafter (26 September 1991) asking for protection of the goshawk west of the 100th meridian. The USFWS considered the amended request a separate petition.

In January 1992, the USFWS began a status review of the goshawk, a process to acquire and analyze information about a species in an attempt to determine its current status and threats. Since

the goshawk breeds across the continent, one issue turned on the term species. Species, as defined in the ESA (16 U.S.C 1532(16)), includes subspecies and any distinct population segment that interbreeds when mature. On 16 June 1992, the USFWS found that the new petition was not warranted because the petitioner failed to demonstrate that goshawks in the petitioned region may be a population segment distinct from other populations in its North American range. The USDI Fish and Wildlife Service (1992b) turned down the listing request stating that, "Our present knowledge of goshawk movements, and potential gene flow, suggest that although movement of goshawks may be limited, there is opportunity for genetic interchange. Goshawk habitat and populations are virtually continuous from the petitioned region into Canada and Mexico, and across Canada to the goshawk population in the eastern US." The USFWS based its decision, in part, on the lack of genetic evidence that demonstrated the petitioned population was distinct from adjacent populations. Following this ruling, the petitioner filed a lawsuit in U.S. District Court arguing that the USFWS was arbitrary and capricious in its determination. The district court agreed with the petitioner, finding that the USFWS made several post-1978 listing decisions using several contradictory policies. The district court required the USFWS to use its most recent evaluation policy and revisit the petition to list the goshawk as endangered. In 1994, the USFWS vacated its 1992 finding replacing it with a new finding with the same determination, listing not warranted (USDI Fish and Wildlife Service 1994).

Using the new distinct population segment policy (USDI Fish and Wildlife Service 1996), the USFWS reasoned that organisms in a population are members of a single species or lesser taxon, and that taxons were equivalent to subspecies (USDI Fish and Wildlife Service 1996). Since the petition requested protection for goshawks west of the 100th meridian, an area that included three goshawk subspecies (*A. g. atricapillus*, *A. g. laingi*, *A. g. apache*), the USFWS found that the goshawk was not a listable entity. The petitioner filed another lawsuit challenging the ruling and the court ruled once more that the USFWS acted arbitrarily and capriciously. In a re-evaluation of the petition, the USFWS determined that a status review was needed.

During attempts to list goshawks in the continental US, a separate petition to list the Queen Charlotte subspecies as endangered in southeast Alaska was received by the USFWS on 9 May 1994. On 26 August 1994, the USFWS announced that the petitioner presented information suggesting the petition may be warranted. On 29 June 1995, after reviewing the best commercial and scientific information available, the USDI Fish and Wildlife Service (1995a) published their finding that listing the Queen Charlotte Goshawk was not warranted. Continuing legal challenges and a court order required the USFWS to reconsider their listing decision which is underway (USDI Fish and Wildlife Service 2005).

In late 1997, the USFWS determined in a 90-d finding that enough information existed to suggest that listing goshawks west of the 100th meridian may be warranted (USDI Fish and Wildlife Service 1997). In 1998, the USFWS completed their status review of the goshawk west of the 100th meridian and determined that its distribution did not appear to have changed from its historical range and that the available information did not show a decline in goshawk populations. The USFWS also determined that 78% of goshawk habitat was on federal forest lands and that many regional management strategies focused on retention or restoration of older forest. Therefore, the goshawk did not require protection under the ESA (USDI Fish and Wildlife Service 1998b). The Center for Biological Diversity and 18 other organizations filed a federal lawsuit claiming the USFWS was arbitrary and capricious in its finding. The U.S. District Court ruled on 28 June 2001 affirming the USFWS decision. The goshawk, therefore, has not been protected under provisions of the ESA. However, it is protected under provisions of the Migratory Bird Treaty Act (1918).

USDA Forest Service

Sensitive species

The USFS is responsible for managing the nation's national forests, plants, and wildlife habitat. The National Forest Management Act (NFMA 1973, NFMA 1982 implementing regulations at 36 CFR 219.19) provides for maintenance of vertebrate species viability in the planning area. To help meet this responsibility, the USFS has a threatened, endangered, and sensitive species management program. Sensitive species are those whose populations are sensitive to habitat-altering management activities. The USFS (USDA Forest Service 1988b) requires that every sensitive species in a management area undergo a biological evaluation (BE) documenting the probable effects of the proposed management on the species.

During the 1980s and early 1990s, the goshawk was added to regional sensitive species' lists in the Pacific

Southwest Region (California, 1981), Southwestern Region (Arizona, New Mexico, 1982), Intermountain Region (southern Idaho, Nevada, Utah, and western Wyoming, 1992), Rocky Mountain Region (Colorado, South Dakota, eastern Wyoming, 1993), and the Alaska Region (1994). The Pacific Northwest Region (Oregon, Washington) and the Northern Region (northern Idaho, North Dakota, Montana) do not list the goshawk as sensitive, and only some national forests within the Eastern Region list the goshawk as a sensitive species, while others designate the goshawk as a management indicator species.

Management indicator species

The management indicator species (MIS) concept assumes that certain species are not only sensitive to habitat change but are indicators of population changes of other species in a community. Theoretically, monitoring a few MIS reduces the difficulty of managing ecosystems by focusing limited funding on species that are representative of others. Thirty-seven of 104 national forests designated the goshawk as a MIS. The USFWS status review (USDI Fish and Wildlife Service 1998b) concluded that the goshawk was not a good MIS because it is difficult to locate and its habitat use is too general.

THE NATURE CONSERVANCY

The Nature Conservancy maintains a national biotic database in collaboration with state governments known as the Natural Heritage Program (NHP). One function of the NHP is to describe the status of plant and animal species at several spatial scales—global, national, and state. The NHP developed a ranking system to describe how secure a species is on a scale of one–five: one being species at high risk, such as those listed under the ESA, and five being species of little concern. The ranking criteria are based on the number of documented populations and number of individuals in those populations. TNC currently ranks the goshawk as globally secure (G4). The New Mexico NHP, for example, ranks the goshawk as relatively rare either as a breeder or non-breeder within the state (S2; Table 1). Because the goshawk is considered either abundant, a non-resident species, a non-breeder, or it does not occur at high enough numbers in the winter to be of concern, many states do not rank the goshawk, or if they do, they rank it as S3 or higher (Table 1).

In Canada, *A. g. atricapillus* it is not considered to be at risk in the boreal forest, but *A. g. laingi* is considered threatened in western British Columbia by the Canadian government (Cooper and Stevens 2000, Cooper and Chytyk 2000, COSEWIC 2000, SARA 2002). The USFWS is currently reviewing the need to protect *A. g. laingi* (USDI Fish and Wildlife Service 2005). In Mexico, *A. g. apache* is informally considered threatened (Squires and Reynolds 1997). The Apache subspecies is not recognized by the American Ornithologists' Union (1998) because it is not distinctly different from *A. g. atricapillus*, but others believe it is a distinct subspecies (van Rossem 1938, Phillips et al. 1964, Wattel 1973, Hubbard 1992, Whaley and White 1994).

PUBLISHED REVIEWS OF GOSHAWK STATUS

Kennedy (1997) reviewed the literature regarding the status of goshawk populations in North America and evaluated the available evidence supporting or refuting population declines including contraction in geographic range, decreases in numbers of goshawks, and trends in their reproduction and survival. Kennedy (1997) found no strong evidence supporting a population decline but noted that studies she reviewed had not been designed to detect population change making her review problematic. Kennedy was subsequently criticized for not using the information provided to the USFWS by the petitioner in her evaluation (Peck 2000).

In 1999, The Raptor Research Foundation and The Wildlife Society established a technical committee to review the status of the goshawk. They determined that existing data were inadequate to assess population trends or to genetically differentiate among recognized subspecies using DNA analytical techniques and, that basing the status of goshawks solely on the distribution of late-successional forests is not appropriate (Andersen et al. 2004).

BREEDING LOCATIONS IN THE UNITED STATES

When estimating the status of goshawk populations, it is important to understand their breeding distribution. To appreciate the nuances of determining goshawk distribution requires knowledge of the components and sizes of goshawk home ranges. Goshawk home range has been estimated to be about 2,000–3,000 ha (Eng and Gullion 1962, Reynolds 1983, Reynolds et al. 1992, Kennedy 1990, Boal et al. 2003). For the purpose of managing goshawk breeding habitat, breeding home ranges have been partitioned into foraging area (FA), post-fledging family area (PFA), and nest area(s) (NA) (Reynolds et al. 1992). Each home range may include one or

TABLE 1. THE 2003 STATUS OF NORTHERN GOSHAWKS (*ACCIPITER GENTILIS ATRICAPILLUS*) AS REPORTED BY THE NATURE CONSERVANCY (NATURAL HERITAGE PROGRAM [NHP] STATE RANKINGS FROM THEIR BIOLOGICAL CONSERVATION DATABASE) AND THE STATE GAME AND FISH AGENCIES (STATE ENDANGERED [E] OR THREATENED [T]).

State	NHP-ranking[a]	State classification T or E?[b]	Falconry permitted?	Comments
Alabama	S3B, S4N	No	Yes	Accidental in state.
Alaska[c]	S4	No	Yes	Abundant in state.
Arizona	S3	No	Yes	Harvest being considered.
Arkansas	SA	No	Yes	Accidental in state.
California	S3	No	Yes	Review underway.
Colorado	S3B, SZN	No	Yes	1–6/yr. resident only.
Connecticut	S4B, SZN	No	No	Possession permit only.
Delaware	SZN	No	Yes	Winter visitant only.
District of Columbia	SA	No	Yes	No regulations.
Florida	S?	No	Yes	Extremely rare in winter.
Georgia	SA	No	Yes	Very rare transient in state.
Hawaii	Not tracked	No	No	Exotic species not allowed.
Idaho	S4	No	Yes	No out of state permits issued.
Illinois	SZN	No	Yes	Accidental in state.
Indiana	SZN	No	Yes	Rare winter visitor.
Iowa	SZN	No	Yes	Rare winter visitor.
Kansas	SZN	No	Yes	Non-breeding.
Kentucky	SZN	No	Yes	Follow federal regulations.
Louisiana	SA	No	Yes	Accidental in state.
Maine	S3?B, S3?N	No	Yes	few taken.
Maryland	S1B, SZN	Endangered	No	Conflicting laws.
Massachusetts	S3	No	No	Uncommon.
Michigan	S3		Yes	No take allowed.
Minnesota	SU		Yes	Sensitive species.
Mississippi	SA	No	Yes	Accidental in state.
Missouri	Not tracked	No	Yes	
Montana	S3S4	No	Yes	
Nebraska	S?N	No	Yes	No take allowed.
Nevada	S3	No	Yes	Take allowed (10).
New Hampshire	S4	No		On watch list.
New Jersey	S1B, S4N	Threatened	Yes	Take passage birds only.
New Mexico	S2B, S2N	No	Yes	Take allowed (6).
New York	S4B, S3N	No	Yes	Take allowed.
North Carolina	SUB, SZN	No	Yes	Follow federal regulations.
North Dakota	S?	No	Yes	Follow federal regulations.
Ohio	S?	No	Yes	None breeding.
Oklahoma	S2N	No	Yes	Infrequent visitor.
Oregon	S3	No	Yes	Take allowed (12).
Pennsylvania	S2, S3B, S3N	No	Yes	Take allowed (7).
Rhode Island	S1B, S1N	No	Yes	No take allowed.
South Carolina	S?	No	Yes	Accidental—one record in 50 yr.
South Dakota	S3B, S2N	No	Yes	Take allowed.
Tennessee	SPB, S2N	No	Yes	No breeding.
Texas	Not tracked	No	Yes	Accidental.
Utah	S3	No	Yes	Take allowed.
Vermont	S3, S4B, SZN	No	Yes	Take allowed.
Washington	S3B, S3N	No	Yes	Take allowed.
West Virginia	S1B, S1N	No	Yes	No state ESA.

TABLE 1. CONTINUED.

State	NHP-ranking[a]	State classification T or E?[b]	Falconry permitted?	Comments
Wisconsin	S2N, S2B	No	Yes	Take allowed.
Wyoming	S2, S3B, S4N	No	Yes	Take allowed.

[a] S1 = 1–5 occurrences; S2 = 6–20 occurrences; S3 = 21–100 occurrences; S4 = 100 or more occurrences, taxa is widespread, abundant and apparently secure, but cause for long-term concern; S5 = demonstrably widespread, abundant, and secure; B = breeding, N = non-breeding; A = abundant; U = uncommon; Z = zero occurrences in state.

[b] The goshawk is officially designated by the state as threatened or endangered.

[c] In Alaska, *Accipiter gentilis laingi* is ranked as S2B (NatureServe 2005).

more NAs (about 12 ha) generally located within the PFA (Reynolds et al. 1992). Prior to 1985, <500 nesting sites were known in the US, but no systematic effort had been made to find or monitor nest sites (USDI Fish and Wildlife Service1998). Until 1992, no coordinated west-wide attempt by the USFS to monitor nests existed except in the Southwest Region (Arizona and New Mexico). Searching for nests consisted of visiting suitable nest habitat within or adjacent to planned tree cutting units. In 1990, a protocol for systematically surveying large areas for breeding goshawks was developed (Kennedy and Stahlecker 1993) and later refined (Joy et al. 1994). This technique which used sampling stations at fixed distances on transects from which goshawk vocalizations are broadcast with tape recorders, increased the efficiency of searching for goshawks in large areas. During the 1990s, many national forests began inventorying project areas for nesting goshawks using this technique.

Since the early 1980s, the number of documented goshawk nest sites on USFS lands has steadily increased (Fletcher and Sheppard 1994). In response to a 1992 questionnaire sent by one of us (DAB) to all USFS regions with breeding goshawks, a total of 1,871 nest sites (1,722 nest sites for western US) on public lands were documented (Table 2). Because the eastern US contains little USFS land, and about three-quarters of America's private forests are in the eastern US (Stein et al. 2005), the number of nest sites on USFS lands in the eastern US was <10% of the known USFS nest sites (Table 2). It is unknown how many of these nest sites were visited in 1992, but 700 were reported as occupied (one or more goshawks present). It is difficult to estimate the total number of breeding goshawks in the US because of the wide variation among the USFS regions in the intensity of surveying and monitoring goshawk nests.

In 1998, the USFWS goshawk status review contained information on >2,900 occupied territories (breeding activity in ≥1 yr) in the western US (excluding Alaska) on private, state, and federal lands (95% of territories were on USFS land [USDI Fish and Wildlife Service 1998b]). The USDI report (USDI Fish and Wildlife Service 1998b) defined territory as a location where no other occupied nests were found within a 1.6 km radius from the previous nest site. If we assume a similar increase in known territories for the eastern US, then a conservative estimate in 2004 of the number of territories in the US would be about 3,200. If each territory was occupied in a given year (very dubious assumption), about 6,400 goshawks would be breeding in the continental US.

Goshawks also nest in Alaska, Canada, and northern Mexico. Numbers of breeding goshawks in Canada and Alaska fluctuate dramatically over years in response to large fluctuations in prey (McGowan 1975, Mueller et al. 1977, Doyle and Smith 1994, Squires and Reynolds 1997). Considering this, and the fact that the expansive boreal forest has the potential to contain many goshawks, it is difficult to describe the total population size for North America.

National forests generally do not have the budgets to apply the Kennedy and Stahlecker (1993) protocol to all forested lands. Thus, knowledge of goshawk breeding locations comes mainly from lands designated for commercial use and not from lands such as wilderness, national recreation areas, wild and scenic river corridors, experimental forests, and national parks. No formal monitoring protocol for goshawk populations has been established for national forests. However, Hargis and Woodbridge (*this volume*) have developed such a monitoring protocol. Limited funding typically results in biologists visiting historical nest sites on an opportunistic basis. Intensive monitoring of goshawk populations, such as documenting the re-occupancy rate of nest areas, nest success and productivity has been limited to a few research sites.

Although goshawks typically exhibit strong fidelity to territories (Detrich and Woodbridge 1994, Reynolds et al. 1994), a problem that confounds monitoring breeding goshawks is that a high

TABLE 2. NUMBER OF GOSHAWK NESTING AREAS LOCATED ON USDA FOREST SERVICE LANDS THROUGH 1992, DISPLAYED BY REGION AND FOREST COVER TYPE.

	USDA Forest Service regions[a]								
Forest type	R1	R2	R3	R4	R5	R6	R9	R10	Total
Northern hardwoods[b]	0	0	0	0	0	0	92	0	92
Red pine	0	0	0	0	0	0	16	0	16
Oak-pine	0	0	0	0	0	0	10	0	10
Mixed conifer	30	3	71	25	309	123[c]	0	0	561
Yellow pine	11	43	215	35	80	9	0	0	393
True fir	0	0	2	0	75	2	0	0	79
Douglas-fir	25	0	4	51	53	77[c]	0	0	210
Spruce-fir	0	5	0	15	0	0	0	0	20
Lodgepole pine	10	33	0	42	13	8	0	0	106
Aspen	3	45	2	125	1	0	13	0	189
Aspen-lodgepole	0	18	0	8	0	0	0	0	26
Mixed aspen-conifer-spruce-fir	1	15	0	15	0	0	0	0	31
Sitka spruce-hemlock	0	0	0	0	0	0	0	10	10
Misc. types[d]	9	0	2	1	2	0	0	0	14
Unrecorded	30	13	46	10	13	0		0	112
Total	119	175	342	321	546	219	131	4	1,857

[a] R1 = northern (ID, MT); R2 = Rocky Mountain (CO, SD, WY); R3 = southwestern (AZ, NM); R4 = intermountain (ID, NV, UT, WY); R5 = Pacific Southwest (CA); R6 = Pacific Northwest (OR, WA); R9 = eastern (IL, IN, MI, MN, NH, PA, VT, WV, WI); R10 (AK)

[b] Includes Allegheny hardwood forest type (N = 9) that contain 50% or more cherry trees (*Prunus* spp.). Includes northern hardwood-mixed conifer forest cover types (N = 9).

[c] Region six reported 136 nest areas located in Douglas-fir or mixed-conifer forest. We did not know the correct classification so we split them evenly between forest types (Gene Silovsky, pers. comm.)

[d] Miscellaneous types includes cottonwood (R1,1; R4, 1), pinyon-juniper (R3,2), subalpine fir (R5,2), western red cedar-hemlock (*Thuja plicata-Pseudotsuga heterophylla*) (R1,8)

percentage of pairs (up to 75%) change nest locations yearly and these nests can be as far as 2.4 km from a previously used nest (Reynolds et al. 2005). Because of shifting nest use, monitoring goshawks typically requires repeated searches over large areas to determine if the goshawks are breeding (Reynolds et al. 2005). A potential problem then is that many territories may be mislabelled as unoccupied because of insufficient sampling effort. If only a single annual visit is made to a nest site, roughly 35% of occupied goshawk nests can be misclassified as unoccupied by searchers who were testing three common search techniques (Boyce et al. 2005). Failure to search sufficiently regardless of the number of re-visits often leads to mislabelling territories as unoccupied (Reynolds et al. 2005). Watson et al. (1999) studied goshawk detection rates with the broadcast technique at three distances from known active nests (100, 250, and 400 m), and reported that five visits were needed at 100 m to attain 90% or higher detection rate, eight visits at 250 m from the nest, and 10 visits at 400 m. Boyce et al. (2005) provide guidance on the estimated number of re-visits needed to have confidence in verifying a nest area as occupied.

Because of annual movement among alternate nests within territories, Reynolds et al. (2005) suggest that the appropriate scale for reporting occupancy is the territory, and that due to the difficulty of proving that territories are not occupied, territories should be classed as active if goshawks laid eggs, occupied if adult(s) are present in a nest area but no eggs are laid, and unknown if there is no (or insufficient) evidence of activity or occupancy. Habitat alternating management decisions are made daily based on varying degrees of uncertainty; having complete knowledge is almost never the case.

The extent of annual variation in the proportion of goshawk territories occupied by egg-laying pairs is known only in a few study areas (Doyle and Smith 1994, Reynolds et al. 2005; Keane and Morrison, *this volume*; Reynolds and Joy, *this volume*). Even in areas where nests are intensively monitored, estimates of population size or trend are difficult to attain because: (1) the proportion of territories with egg-laying adults (hence, their probability of detection) can be extremely variable year to year (7–87%; Reynolds et al., pers. obs.), (2) reproductive failure and nest abandonment may occur before breeding pairs can be detected, and (3) the high frequency of movement among alternate nests lowers their probability of detection (Reynolds et al. 2005; Reynolds and Joy, *this*

volume). Reynolds et al. (*this volume*) showed that about 60–80 territories require monitoring in good breeding years and >100 territories are required in poor breeding years for reliable estimates of nesting success. Mark-recapture of goshawks is the best method for estimating vital rates and population trends (Cormack 1964, Jolly 1965, Seber 1965). However, cost is prohibitive because a large number of goshawks must be marked and recaptured over many years before reliable estimates can be obtained (DeStefano et al. 1994b, Kennedy 1997, Reynolds et al. 2004; Reynolds and Joy, *this volume*). We believe that monitoring goshawks is valuable, but understanding the habitat needs of goshawks and their prey are also important. Habitat management can only improve if we have a clear understanding of goshawk habitat and the habitat of species in their food web.

GOSHAWK HABITAT

The Effect of Habitat Change

The extent of habitat change matters. Mid-aged to old forests are fundamentally important to goshawks and many of their prey (Reynolds et al. 1992), but they are also a valued timber resource for society. In the northeastern US, the number of nesting goshawks may have declined because of timber harvesting and severe wildfires over the past 200 yr (Speiser and Bosakowski 1984). However, goshawk populations appear to be expanding as those forests are recovering (Bull 1974, Speiser and Bosakowski 1984, DeStefano 2005). In Europe, it is believed that goshawk populations declined in areas where forests were clear cut (Ivanovsky 1995, Widén 1997). Today those boreal forests are highly fragmented and breeding goshawks there underwent a 50–60% decline in densities (Ivanovsky 1995, Widén 1997). Railroad logging at the turn of the century removed extensive areas of mature trees in much of the western US, but the effect of this on goshawks is unknown.

With the arrival of European settlers in the western US, the pace and extent of habitat modification was extensive. Human activities that altered goshawk habitat included tree harvesting (Crocker-Bedford 1990), fire exclusion (McCune 1983), livestock grazing (Lucas and Oakleaf 1975, Mueggler 1989), and road building (Speiser and Bosakowski 1987, Grubb et al. 1998). Fire exclusion across the western US allowed young trees to become established. In ponderosa pine forest, for example, the understory structure of open forest has been converted to a closed understory of dense trees beneath old pine trees (Covington and Moore 1994b).

In some areas, goshawk nest habitat is vulnerable to livestock grazing. In northern Nevada, for example, goshawks frequently nest in stands of quaking aspen (*Populus tremuloides*) in otherwise treeless landscapes (Lucas and Oakleaf 1975, Younk and Bechard 1994a). Aspen is a relatively short-lived tree (≈ 120 yr) and browsing by elk (*Cervus elaphus*), deer (*Odocoileus* spp.), and cattle (*Bos* spp.), retards its regeneration eventually leading to the loss of stands (Lucas and Oakleaf 1975). Grazing can also reduce herbaceous fuels that can stimulate aspen regeneration. Grazing can be particularly destructive because aspen stands often grow on level benches in swales and next to creeks where ungulates tend to concentrate.

In areas where extensive railroad logging did not occur, such as on the Kaibab Plateau in northern Arizona, a combination of light forest cutting (single-tree selection began in the 1920s) and intensive shelter-wood seed-cut harvests (between 1985–1991), was believed to have resulted in a goshawk decline from 260 pairs prior to tree harvests to 60 pairs by 1988 (Crocker-Bedford 1990). However, long-term research on the Kaibab Plateau goshawk population has shown that the Kaibab Plateau currently has the highest density of nesting territories reported for the species in a large area (Reynolds et al. 2005; Reynolds and Joy, *this volume*). Nonetheless, Crocker-Bedford (1990) findings resulted in a renewed focus on the effects of forest management on goshawks.

Most discussions of threats to goshawk populations suggest that forest management, especially tree harvesting, may be causing declines in goshawks (Reynolds et al. 1982, Moore and Henny 1983, Reynolds 1983, Crocker-Bedford 1990, Woodbridge and Detrich 1994). These arguments rest on the goshawk's affinity for mature and old forest and the effects of human and natural disturbance on that forest's structure. Although it is believed that extensive habitat modifications are detrimental, it remains unclear exactly how goshawk populations are responding to habitat modification because of inadequate study of the effects across a gradient of tree-harvesting intensities. Research is needed to examine how goshawks respond to light to intermediate tree harvesting and how their prey species respond to these harvests.

Goshawk Use of Habitat

An important conservation issue still argued is the relationship between goshawks and their

habitat, and the importance of mature to old-forest composition, structure, and pattern. Is the goshawk an old-growth obligate? The literature shows that goshawks prefer to place their nests in mature to old-forest settings (Reynolds et al., *this volume*). However, if mature to old-forest habitat is not available, goshawks will nest in younger forest (Reich et al. 2004). As the scale of consideration increases, the diversity of habitat used by goshawks provides a broader understanding of the adaptability of goshawks at regional and continental scales. Goshawks can adjust to environmental conditions and occasionally nest in essentially treeless areas (Swem and Adams 1992) or in areas with small patches of trees and hunt in open shrub-steppe habitats (Younk and Bechard 1994a).

Whether considered at the home-range, population, or the regional scale, goshawks are not restricted to one forest environment. The literature does not support the notion that the goshawk is an old-growth obligate (Reynolds et al., *this volume*). However, though they do not depend on a single forest age class for nesting, they often prefer mature and older forests for nest sites (Reynolds et al. 1982, Crocker-Bedford and Chaney 1988, Hayward and Escano 1989). McGrath et al. (2003) found that plots within nest areas contained more mature to old trees then plots within random sites 83 ha in size; a similar finding noted by others (Bartlet 1974, Reynolds et al. 1982, Saunders 1982, Hall 1984, Lang 1994, Siders and Kennedy 1994, Desimone 1997, Patla 1997, Daw et al. 1998). Goshawk home ranges during the breeding season are variable, but typically large (about 26 km^2; Reynolds et al. 1992, Boal et al. 2003). Radio-telemetry studies indicate that, while foraging goshawks prefer mature forest, they also use younger forests as well as edges and openings (Fisher 1986, Hargis et al. 1994, Bright-Smith and Mannan 1994; Reynolds et al., *this volume*).

Prey Habitat

A key to raptor survival and reproduction is an adequate supply of food (Newton 1979a, 1986). Goshawk foraging areas need to provide abundant and accessible prey. Widén (1997) concluded that forest management may degrade hunting habitat and prey populations and was the prime factor behind the goshawk decline in Fennoscandia. Goshawk habitat use may in part reflect the habitat of the prey. This was supported in an analysis of habitat use of major goshawk prey species in southwestern US forests (Reynolds et al. 1992). Reynolds et al. (1992) also observed that although the entire range of forest vegetative structural stages was used by goshawk prey, the older vegetative structural stages and small openings were of higher value to the greatest number of prey species. This resulted in a recommendation to have the maximum sustainable amount of old forest with interspersed small openings in a southwestern goshawk landscape.

Kenward and Widén (1987), Reynolds et al. (1992), and Beier and Drennan (1997) suggested that accessibility of prey to goshawks is influenced by forest structure. In pre-settlement (circa 1900) ponderosa pine forests, historical photographs and accounts describe the forest as park-like with forest floors being open (Cooper 1960), a condition where prey are easier to detect and pursue by hunting goshawks. Now, due mostly to fire exclusion, livestock grazing, and road building, forest structure and pattern has been altered with forests being much denser in many areas of the western US (Covington and Moore 1994b, Graham et al. 2004). This population of small trees has filled in the sub-canopy space where goshawks do much of their hunting. Management practices that improve goshawk hunting by reducing the density of young trees should improve the quality of hunting habitat. How goshawk and prey habitat are changed by forest management is a critical issue for the long-term welfare of goshawks.

The Diversity of Forests Used

In 1994, we surveyed each national forest nationwide to determine the forest types used by goshawks and the known number of goshawk nests in each (Table 2). Two forest types, Douglas-fir and ponderosa pine, contained 78% of the known nest areas in the western US. The trend in forest structure and pattern of these two forest types is important for predicting the status of goshawk populations. In the East, hardwood forest was used extensively for nesting and to the north, use of boreal forests have been well documented.

The winter ecology of goshawks is poorly known, but habitats used during winter show a wider variation than during the breeding season as adults and juveniles move down in elevation from spruce-fir (*Picea engelmannii-Abies lasiocarpa*) forests, mixed conifer forests, or ponderosa pine forests to pinyon-juniper (*Pinus edulis-Juniperous* spp.) forests to woodland and shrub communities (Reynolds et al. 1994, Squires and Ruggiero 1995, Stephens 2001, Sonsthagen 2002). Movement from boreal forests south is well known. In a Wyoming population, goshawks migrated over 160 km from breeding territories during winter months (Squires

TABLE 3. GOSHAWK NEST AREAS BY FOREST COVER TYPE IN THE WESTERN US THAT CONTAIN 99% OF THE KNOWN GOSHAWK NESTING AREAS WEST OF THE 100TH MERIDIAN (HECTARES × 1,000; DATA FROM USDI FISH AND WILDLIFE SERVICE 1998B).

Forest cover type	Number of goshawk nest areas (%)	Hectares of forest cover type (%)
Douglas-fir	2,771	15,474
	(55.4)	(24.3)
Spruce-fir	363	7,678
	(7.3)	(12.1)
Lodgepole pine[a]	356	11,744
	(7.1)	(18.5)
Ponderosa pine	1,130	22,089
	(22.6)	(34.7)
Western hardwoods	67	5,302
	(1.3)	(8.3)
Aspen-birch[b]	318	1,295
	(6.4)	(2.0)
Totals	5,005	63,583
	(100)	(100)

[a] *Pinus contorta*.
[b] *Betula* spp.

and Ruggiero 1995). Movement away from breeding areas during winter increases the scale of management consideration. Information is needed on habitat use of goshawks and their prey during the non-breeding season to improve our understanding of forest management options that might increase the likelihood of sustaining goshawks (Graham et al. 1999b).

MANAGEMENT

Numerous human-related activities potentially threaten goshawks population viability including shooting, poisons, and falconry (Reynolds 1989), but the primary threat appears to be modification of forest habitat caused by management and natural disturbance (Reynolds 1989, Crocker-Bedford 1990, Squires and Reynolds 1997). Natural factors such as disease, parasites, exposure, and predation affect individuals more than populations (Squires and Reynolds 1997; Reynolds et al., *this volume*).

MANAGEMENT PRIOR TO 1990

The effect of tree harvests in nest areas on goshawk reproduction has been a concern since the early 1970s (Reynolds 1971, Bartelt 1977, Hennessy 1978, Reynolds et al. 1982, Crocker-Bedford 1990). As a result, goshawk nest trees were the first component of goshawk habitat to be protected (Reynolds 1971). By the mid- to late 1970s, most national forests in the western US protected goshawk nest trees in management areas. Forest managers gradually began incorporating nest area management guidelines into their project designs. But from the early 1970s through the 1980s, most national forests did not have formal goshawk nest area management standards or guidelines.

As cutting of forests in the US accelerated, public concern escalated over the effects that timber harvesting was having on wildlife. Managers started to protect small areas around goshawk nests. However, because management guidelines for federal lands were unavailable, the size of the protected nest areas varied from 1–10 ha. By 1985, the USFS in California required 20-ha buffers around goshawk nests in all national forests, and in 1986 the state of California Department of Fish and Game recommended a 50.6 ha buffer around goshawk nests; a recommendation adopted by only a few national forests in California (B. Woodbridge, pers. comm.). During the late 1980s and early 1990s, concerns arose about the effects of tree cutting beyond protected nest areas (Reynolds 1989, Crocker-Bedford 1990, Reynolds et al. 1992, Bright-Smith and Mannan 1994, Hargis et al. 1994) where goshawks foraged. In particular, there were concerns about how tree harvesting was changing goshawk and prey habitat (Kenward and Widén 1989, Reynolds et al. 1992, Widén 1997).

MANAGEMENT SINCE 1990

Concerns about the effects of tree harvesting on goshawk reproduction and population viability continued into the 1990s (Crocker-Bedford 1990, Bright-Smith and Mannan 1994, Beier and Drennan 1997). Crocker-Bedford (1990) and Woodbridge and Detrich (1994) noted that the rate of re-occupancy of nest stands by goshawks was related to the size of the forest stand containing nests. Bühler and Oggier (1987) reported that goshawk nest density increased as the proportion of woodland in a landscape increased. Telemetry research on adult female and goshawk fledging movements (Kennedy 1989, 1990; Kennedy et al. 1994), made it clear that an area larger than the NA was also important and researchers turned their attention to developing recommendations for larger areas around goshawk nests. Reynolds et al. (1992) recommended that three 10–12 ha nest areas and three 10–12 ha replacement nest areas be managed per goshawk breeding territory, and that a PFA about 170 ha in size (excluding the nest areas) be managed based on the estimated size of the adult female core area that contained the goshawk nest (Kennedy 1990). The collective recommendation

was that the nest areas, replacement nest areas, and PFA total 243 ha per breeding home range. By 1994, the USFS in Oregon and Washington began protecting PFA habitat (DeStefano et al. 1994a).

Reynolds et al. (1992) developed habitat management recommendations for the Northern Goshawk (MRNG) that included available knowledge on goshawk nesting, fledging, and foraging habitats, and the foods and habitats of their important prey. The MRNG described sets of desired forest compositions, structures, and landscape patterns for three southwestern forest types (ponderosa pine, mixed conifer, and spruce-fir). Furthermore, the MRNG states that certain habitat elements—downed logs, woody debris, and snags—be present in landscapes, and suggested management prescriptions to attain the desired conditions (Reynolds et al. 1992). The focus of habitat management expanded from nest areas to PFAs, then foraging areas to landscapes, and finally to ecological function.

The MRNG were implemented on all national forests in the southwestern US on an interim basis in June 1991 (USDA Forest Service 1991b; amended [USDA Forest Service 1991c] to clarify public issues, 1992b; extended 1993a) and formally adopted on a permanent basis in June 1996 through an amendment of all forest plans. In addition, six national forests in Utah (USDA Forest Service 2000a), the Black Hills National Forest in South Dakota (USDA Forest Service 2001a), and the Tongass National Forest in Alaska changed their forest plans to incorporate the approach and concepts developed in Reynolds et al. (1992).

Management scale

Reynolds et al. (1992) recommended creating and sustaining goshawk and prey habitats at multiple landscape scales. Because of the overall importance of mid-aged, mature, and old vegetative structural stages to the goshawk and its suite of prey, the recommended goshawk landscape would have as much mid-aged-to-old structural stages as could be sustained. Because of vegetation growth, sustaining mid-aged to old structural stages required that all vegetative structural stages be present in the landscape. Vegetative structural stages were to be distributed in a fine-scale mosaic (Reynolds et al. 1992). In ponderosa pine forest, for example, the sustainable distribution approximated 10% of the area occupied by grasses, forbs, or shrubs, 10% by seedling-saplings, 20% by young trees, 20% by mid-aged trees, 20% by mature trees, and 20% by older trees (Reynolds et al. 1992, Bassett et al. 1994). Unlike many other wildlife habitat management plans, the MRNG is not a habitat-reserve approach where management within reserves is restricted or not allowed. Instead, active management is encouraged to develop or maintain the desired forest conditions (Reynolds et al. 1992). The pace and direction of change needed to attain the desired forest conditions is determined by the existing conditions.

Long-distance movement of goshawks away from their breeding areas during winter increases the scale of management consideration (Graham et al. 1999b). Habitat management recommendations for goshawk habitats have not been developed for non-breeding areas, but the desired breeding habitats identified in the MRNG were intended to provide for sufficient prey during winter to minimize the needs for goshawks to leave their breeding home ranges in search of food.

Trends in Habitat Management

Prior to 1900, tree harvests occurred first in valley bottoms near population centers. Once this source of trees was exhausted, harvesting activities moved upslope and away from populated areas. As the amount of old forests declined, conservationists began to oppose forest management practices that threatened the remaining old forests. A forest survey of the Southwest Region of the USFS in 1992, for example, found an abundance of young to mid-aged trees and a deficit in mature and old trees (Johnson 1994). The USFS Pacific Southwest and Pacific Northwest regions also reported decreasing trends in the amount of mature forest (Thomas et al. 1990). As a result, many believed that goshawk habitat had been degraded or destroyed. USDI Fish and Wildlife Service (1998b) concluded that considerable forest habitat modification had occurred which likely affected goshawks, but the effects had not been measured. However, in the northeastern US, the number of mature and old trees has increased from the time of early settlement (Nyland 2002).

WHERE ARE WE GOING?

Managing for the Future

In the western US, 78% of the habitat occupied by nesting goshawks is federally managed lands (USDI Fish and Wildlife Service 1998b). Therefore, the federal government alone can maintain well-distributed breeding goshawks throughout the western US. In their review (USDI Fish and Wildlife Service 1998b) the USFWS concluded that the MRNG model for the southwestern US (Reynolds et al. 1992) would

likely sustain goshawks. Since forests in the eastern US forests are largely privately owned, sustaining goshawk's there depends on the development of conservation strategies, prevailing attitudes about management of private forests, and ultimately a precautionary approach to management (O'Riordan and Cameron 1994). Prospects for improved future management depend on validating goshawk subspecies designations, determining the level and importance of dispersal in maintaining viable populations of goshawks, modelling climate change to understand how forests may change as temperatures increase in North America, continuing demographic investigations into factors limiting goshawk populations (habitat, food, predators, competitors, disease, and weather) and how these are affected by forest management, identifying suites of important goshawk prey by forest types, identifying habitats of prey and synthesizing these with forest ecology to develop forest type-specific desired forest conditions, and testing the effectiveness of food web and/or ecosystem-based conservation strategies for sustaining goshawks. Testing should include economic factors associated with implementation.

Northwest Forest Plan

An important question is what existing conservation strategy should managers implement? Several conservation plans that might benefit goshawks are available, but several of these were created for reasons other than to directly protect goshawks. The President's Northwest Forest Plan (NWFP) established a network of habitat conservation areas (HCA) to protect Spotted Owls (*Strix occidentalis*) in northern California, Oregon, and Washington. The NWFP is essentially a system of old-forest reserves; each large enough to accommodate 20 pairs of Spotted Owls and presumed to be large enough to provide self-sufficient habitat to sustain other organisms (Johnson et al. 1991, USDA Forest Service 1992a, Thomas et al. 1993). Low-elevation areas were not as well represented as higher-elevation reserves due to patterns of private and public land ownership. Connectivity among reserves is provided by a matrix of habitat, considered to be permeable by species, between reserves. Managed riparian corridors also offer connectivity.

Forest management is restricted in the NWFP Spotted Owl reserves but is permitted in the matrix between the reserves. The idea is to provide enough reserves well-distributed in the landscape to sustain the owl and other species that are old-growth dependent. It remains uncertain if the NWFP strategy can sustain goshawks, in particular whether the number and sizes of the reserves, as well as the composition and structure of the matrix, are sufficient to support viable populations of goshawks. A similar forest habitat reserve plan is being used in Alaska to accomodate other species such as the marten (*Martes americana*). Conservation strategies dependent on reserves may not recognize the dynamics of forests and the needs of species that are dependent on those dynamics for survival. Sustaining goshawk's in managed forests depends on management plans that incorporate the ecological dynamics of each forest type.

Sierra Nevada Forest Plan and 2004 amendment

The California Sierra Nevada Forest Plan (SNFP; USDA Forest Service 2001b) as amended (USDA Forest Service 2004) provides protection for goshawk activity centers (PAC), surrounding all known goshawk nests in national forests located in the Sierra Nevada Mountains. The PACs are defined as the largest contiguous patch of at least 81 ha of forested habitat near known or suspected goshawk nests. Surveys are required prior to management activities to establish nest or activity centers when management is planned in or adjacent to a PAC. PACs are to be maintained regardless of goshawk occupancy status unless the habitat is rendered unsuitable by stand-replacing events.

The SNFP clearly addressed the nest-area requirements of goshawks, but was silent on goshawk PFAs, foraging habitats, and prey habitats. The NWFP has no explicit direction for the goshawk and we could not find a clear discussion in either the NWFP or the SNFP of the habitat of goshawk prey. Nonetheless, both the SNFP and NWFP incorporated information on species that comprise the goshawk food web as well as extensive analyses of other plant and animal species. Lacking a specific goshawk and prey analysis, the capability of the SNFP and NWFP to sustain goshawks remains unknown. However, the management approaches in the SNFP and NWFP provide a suitable framework for applying other conservation plans, such as the MRNG (Reynolds et al. 1992); the MNRG, which describes forest stand and landscape attributes that are suitable for the goshawk and its prey species, could be implemented in the matrix between Spotted Owl reserves and goshawk PACs.

Goshawk management in southwestern forests

The MRNG (Reynolds et al. 1992) has been the focus of numerous critical reviews. USDI Fish and Wildlife Service (1998b) identified the MRNG as

a management plan that would likely sustain goshawks. In their review, the Committee of Scientists (U.S. Department of Agriculture 1999) highlighted the process used to develop the MRNG as the first example of a food-web based bioregional assessment for a large-scale conservation strategy. The Wildlife Society and the American Ornithologists' Union concluded that the scientific basis of the MRNG was sound and that management of a food web is an important step towards keeping goshawks from becoming threatened or endangered, and provides the basis for adaptive management that strives for a naturally functioning ecosystem (Braun et al. 1996). One review focused on whether the desired conditions in the MRNG were sustainable in southwestern forests (Long and Smith 2000). Long and Smith (2000) wrote that "With the adoption of the goshawk guidelines in 1996, the FS embarked on a truly ambitious restoration effort. The guidelines mandate nothing short of fundamentally restructuring southwestern ponderosa pine forests at a regional scale. The underlying management strategy, while superficially another example of a narrow, single-species focus, is in fact a coarse filter approach that includes a mosaic of age and structural classes intended to provide habitats and food chains for a broad spectrum of wildlife species, including goshawk prey species. This landscape-scale mosaic will be created and maintained under an uneven-aged silvicultural system intended to approximate the composition, structure, and landscape patterns existing in southwestern ponderosa pine forests before fundamental changes in natural disturbance regimes and forest structure."

Other reviews of the MRNG were negative. These include a FWS review (USDA Forest Service 1992a), a State of Arizona review (Arizona Game and Fish Department 1993), and a petition filed to correct the MRNG under Public Law 106-554 §515 (Federal Data Quality Act 2001) by Olsen et al. (2003a, b). In 1992, the Regional Director of the USFWS in New Mexico listed the agency's concerns as: (1) the MRNG would fragment forests which is deleterious to goshawks, because goshawks need large tracts of mature closed-canopy forests for foraging, (2) goshawks are adapted to closed physical environments and opening forests allows competitors and predators to invade, (3) goshawks are limited by habitat structure not food, (4) prey abundance is a function of forest structure, (5) important prey species in the Southwest are not known, (6) goshawks are prey generalists, and specific information on habitat of prey is not known or presented, (7) using minimum values for nest areas, PFAs, and foraging areas is not recommended, and (8) no data exist to support managing PFA habitat as a transition between nest area and foraging habitat.

Similarly, the State of Arizona (Arizona Game and Fish Department 1993) was concerned about: (1) the degree to which forest structure in goshawk foraging habitat would be opened and fragmented, (2) implementing the MRNG in lands allocated as old growth or unsuitable for timber production, (3) the cumulative effects of past and future timber harvest activities, (4) existing forest conditions are already below minimum thresholds identified in the MRNG, (5) a replacement of existing land and resource management plan standards and guidelines by the MRNG, and (6) implementation of the MRNG at the landscape scale.

Olsen et al. (2003a) used the FDQA to petition the USFS to remove the MRNG publication from circulation and set-aside management decisions based on the MRNG throughout the western US. In response to the Olsen et al. (2003a) petition, the USFS (USDA Forest Service 2003) conducted an in depth review of the petition and found it to be without merit. The USFS also contracted with the Ecological Society of America to provide three blind reviews of the Olsen et al. (2003a) petition. The Ecological Society of America concluded that MRNG meets the requirements of federal information quality guidelines and is accurate, clear, transparent, and unbiased. Olson et al. (2003b), disagreeing with the USFS finding, requested reconsideration from the USDA. In response, a specially convened USDA panel reviewed the case and denied the petitioner's request for further reconsideration.

The MRNG was published in 1992 and it has withstood over 13 yr of reviews and criticisms. During these years managers have learned through adaptive implementation how to create the desired goshawk habitats. The desired forest conditions are within the range of natural variability (i.e., forest composition, structure, and pattern); therefore, confidence in the strategy's ability to sustain the desired conditions is increased. Thus, the MRNG is a cautious and conservative approach for managing southwestern forests (Long and Smith 2000). An added value of the MRNG is a reduction of unnaturally high tree densities and the return of naturally frequent, low-intensity surface fires. Implementing the MRNG provides forest managers with the opportunity to simultaneously recreate healthy forests, restore diversity, sustain food webs and ecological processes, and allows managers to reduce fire fuel loads that lead to the destruction of homes and loss of life. The MRNG remains a compelling forest management strategy.

Barriers to implementing ecosystem-based conservation plans include: (1) difficulties associated with increasing management complexities as spatial and temporal scales increase, (2) integration of management knowledge across disciplines and collaboration among professionals representing the disciplines, (3) not carefully reading and understanding complex documents, (4) competition among conservation plans slows the acceptance, implementation, and testing of the strategies, (5) pressures to accept locally developed solutions first, regionally developed solutions second, and nationally developed solutions last, (6) emerging issues, such as healthy forests, turn the focus of policymakers away from existing management plans, and (7) inadequate funding.

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