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SPECIALIZED HABITAT CONSIDERATIONS FOR NONGAME BIRDS

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National Wildlife Federation

SNAG MANAGEMENT

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Abstract.--Thirty-six of the 85 North American cavity nesting bird species occur in the north-central and north-eastern forests. Species richness and density are influenced by the quality and quantity of available snags. Snag abundance is influenced by many land use options including timber operations. We have calculated the snag needs for 9 primary excavators and have related these needs to management options.

Only recently have wildlifers expressed great concern for animals that depend on the dead and dying tree (snag) component of the forest--especially for avifauna classified as cavity nesters. These birds evolved in unmanaged forest stands where snags occur naturally and are dependent on snags for at least a portion of their life requirements. Since 90 percent of the trees present in an upland hardwoods stand at age 20 will die during the next 60 years (Gingrich 1971), there are many standing dead and dying trees found in naturally developing forests.

Each resource discipline views the snag component of forests differently. Foresters know that growth can be increased and mortality decreased by periodically thinning forest stands. Thinning a forest selects against subdominant, low-vigor, silviculturally defective and low-quality trees--trees that have the highest potential to become suitable snags. Snags and potential snags are often referred to as "ugly" by the landscape architects, and "hazards" by the forest protection and safety divisions. Although these concerns are occasionally valid, across the board condemnation is unwarranted.

The objectives of this paper are to (1) identify bird species that depend on snags, (2) discuss the specialized requirements of these bird species, (3) relate snag attributes to management options for bird species, (4) calculate the number of snags required, and (5) make management recommendations.

EXPLANATION OF TERMS

Snag

A snag is a standing dead or partially dead tree. Snag attributes and the requirements of birds depending on these attributes vary greatly. Generally, the value of a snag increases as its size increases. Snags less than 10 cm d.b.h. and/or less than 2 m tall have little value for feeding and nesting birds. The snag characteristics of primary interest are natural cavities and a condition that makes a snag suitable for cavity excavation (fig. 1).

Hard and Soft Snags

The classification of a snag as "hard" or "soft" is somewhat subjective. Generally, hard snags are dead or partially dead trees with at least some limbs remaining and with fairly sound wood. Soft snags are in advance stages of decomposition and rarely have limbs.

Natural Cavity

A space hollowed out of a tree by a force other than a bird. These holes are commonly created by fungal rot, insects, fire, or the breakage of the wood fiber.

Primary Excavator

A bird species that excavates or hollows out a space within a snag for nesting or roosting. The woodpeckers are the major group of primary excavators. Their habit of excavating partial or complete cavities in excess of their needs provides the major supply of cavities for secondary users.

Secondary Users

A bird species that nests or roosts in a natural cavity or a cavity excavated by a primary excavator. Certain species, such as the black-capped chickadee, can be both a primary excavator and secondary user.

Bark Cavity

A space created by loose bark. These spaces are used by insects, reptiles, amphibians, mammals, and birds, e.g., brown creepers.

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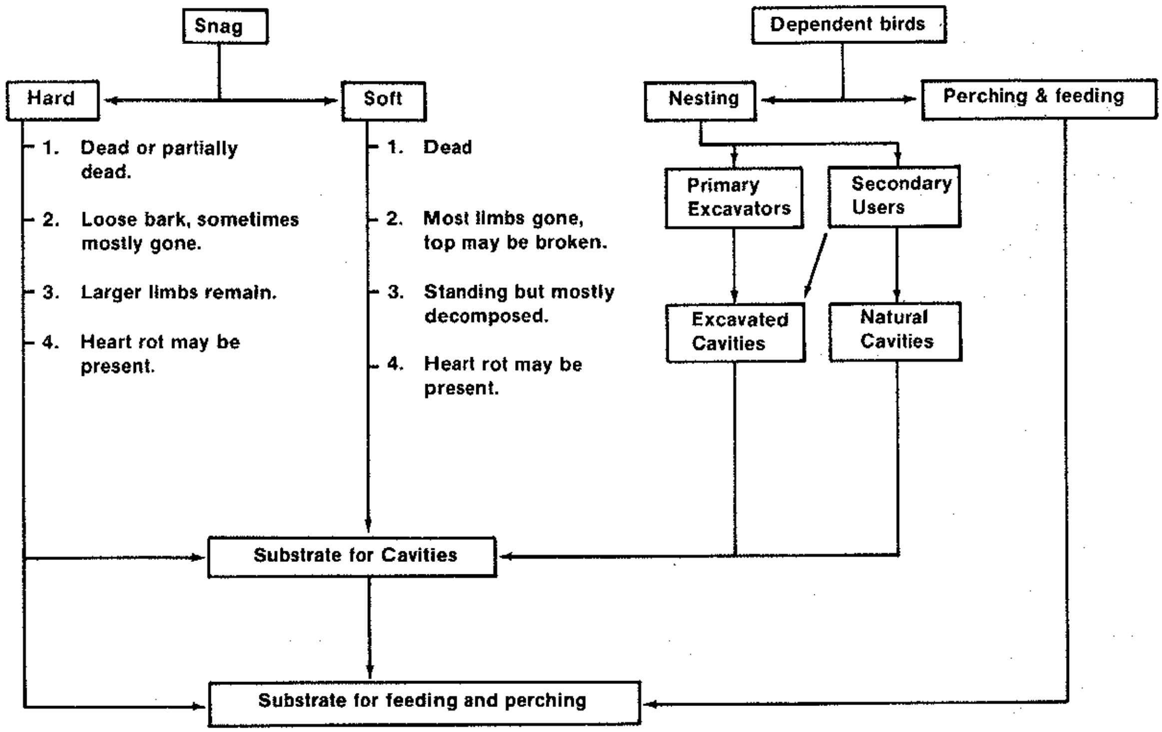

Figure 1.--*Diagram of snag types and generalized use patterns.*

Usually formed after a tree or tree limb has died.

Woodpecker Territories

Disagreement exists in the literature as to what type of territories different species of woodpeckers defend. Lawrence (1966) reported that several species in Ontario defended nesting and mating territories (type B) (Nice 1941). Brenowitz (1978) and others have noted that sizes of defended areas for many species varied within species depending on the species intruding; thus, a pair may defend nesting, mating, and foraging territory (type A) when interacting with one species, and Type B territory when interacting with another.

The values used for sizes of woodpecker territories in this paper include the area used by pairs for nesting, mating, and foraging--a type A territory using the code developed by Nice (1941). Also, for some of the woodpecker species examined in this paper, the word "range" may be more scientifically correct than the word "territory".

DEPENDENT BIRD SPECIES

Some 85 species of North American birds nest and/or roost in dead or deteriorating trees (Scott *et al.* 1977). These species either excavate cavities, use cavities created by decay or breakage, or use cavities constructed by other species. The snag-dependent species--hole nesters--make up 20 percent of the bird species encountered on the breeding bird survey routes in Missouri (Evans and Dawson 1976). Most of these species are insectivorous, and may help control insect populations that damage timber. The winter bird populations in the northeast consist of an even higher percentage of cavity-dependent birds. Bock and Lepthien (1974) found that the average Christmas bird count for the northeast contained 40 species of birds. The list of birds we are considering in this paper (table 1) contains 26 species that winter in the area.

Although the hole nesters have some common characteristics and requirements, they are a diverse group. They range in size from 11-1500 grams and utilize territories from less than 1 ha to over 140 ha (table 1). Management options must be equally diverse. We have simplified the management proposals by (1) concentrating our comments on the primary excavators, and (2) considering only the snag component of their life requirements. If suitable numbers and sizes of snags are provided for primary excavators, the snag requirements of secondary users hopefully will be attained.

SUITABILITY OF HARDWOOD AND PINE SNAGS AS CAVITY SITES

Recently, the importance of snags in forests and lumbered areas has become widely recognized

Table 1.--*Characteristics of cavity-nesting birds of the northeastern United States*

Species[1]	Snag use				Hard snags	Soft snags	Secondary	Optimum d.b.h. (cm)				N. hardwood	Lowland hardwood	Aspen-birch	Oak	Pine	Upland conifer	Lowland conifer	Hole size	Box size			Territory size	Body weight
	Feed	Perch	Nest	Roost				10	20	30	50+									Length	Width	Height		
																			- - -	cm	- - -		ha	g
Wood duck			X				X				X		X						10	25	25	60		
Common goldeneye			X				X				X							X	10	30	30	60		
Hooded merganser			X				X				X		X					X	10	25	25	60		
Common merganser			X				X				X							X	12	25	25	90		
Turkey vulture		X	X				X				X	X	X	X	X	X								1500
Peregrine falcon		X	X				X				X	X		X			X							
Merlin		X	X				X				X			X	X		X							
American kestrel		X	X				X			X		X	X	X	X	X	X	X	8	25	25	40	142	115
Barn owl		X	X	X			X				X	X	X		X	X			13	33	38	40		500
Screech owl		X	X	X			X			X		X	X	X	X	X	X	X	8	20	20	30		178
Barred owl		X	X	X			X				X	X	X		X				20	33	38	40		800
Boreal owl		X	X	X			X			X							X	X	7					
Saw-whet owl		X	X	X			X			X				X	X	X	X		6	15	15	30	40	90
Chimney swift			X	X			X				X	X	X	X	X	X	X	X	Chimneys					
Common flicker	X	X	X	X	X	X	X			X		X	X	X	X				7	18	18	40	16	134
Pileated woodpecker	X	X	X	X	X	X					X	X	X		X	X			10				70	230
Red-bellied woodpecker	X	X	X	X	X	X				X		X	X		X	X							6	62
Red-headed woodpecker	X	X	X	X	X	X					X	X		X	X				5				4	66
Yellow-bellied sapsucker	X	X	X	X	X	X				X			X	X	X	X	X						4	47
Hairy woodpecker	X	X	X	X	X	X				X		X	X	X	X	X	X		4	15	15	35	8	44
Downy woodpecker	X	X	X	X		X			X			X	X	X	X	X	X	X	3	10	10	25	4	27
Black-backed three-toed woodpecker	X	X	X	X	X	X				X							X	X					30	
Northern three-toed woodpecker	X	X	X	X	X	X				X							X	X					30	
Great crested flycatcher		X	X				X			X		X	X	X	X				5	15	15	25		34
Tree swallow			X				X			X			X		X			X	4	12	12	15		20
Purple martin			X	X			X			X		X		X	X	X			6	15	15	15	3	43
Black-capped chickadee			X			X		X				X		X	X	X	X		3	10	10	25	1.5	11
Boreal chickadee			X			X		X						X			X	X	3	10	10	25		
Tufted titmouse			X	X			X			X			X		X				3	10	10	25		23
White-breasted nuthatch	X		X	X			X			X		X	X	X	X	X	X	X	3	10	10	25	0.8	20
Red-breasted nuthatch	X		X	X		X	X			X							X	X	3	10	10	25		
Brown creeper	X		X	X			X			X		X				X	X	X				25		9
House wren			X	X			X			X			X	X	X	X	X	X	3	10	10	20	0.5	11
Winter wren			X				X		X							X	X		3					9
Eastern bluebird		X	X	X			X		X			X		X	X				4	12	12	20	1.0	30
Prothonotary warbler			X				X		X				X										1.5	16

[1] Scientific names in Appendix A.

(McClelland and Frissell 1975, DeGraaf 1978, Scott 1978). Techniques to calculate the number of snags required by individual species appeared in Balda (1975), Bull and Meslow (1977), and Thomas *et al.* (1976). The snags provided should be suitable for nest cavity excavation. To be suitable for cavity sites, snags should be large enough in diameter and have decayed heartwood at a height appropriate for a bird species to excavate a nest cavity (table 2). Primary excavators prefer trees with heart rots because the soft, rotted wood facilitates cavity excavation (Conner *et al.* 1976).

Several states of decay are suitable for cavity excavation, but some are better "quality" for nest sites than others. The best quality nest site is a live tree with a "top rot", decayed heartwood in the upper trunk or main limbs of the tree. Such trees have a firm sapwood which is highly effective as a defense against predators (Kilham 1971, Conner 1977b). Top-rotted trees are often used by woodpeckers when nesting in hardwoods (Conner *et al.* 1975).

A less defensible nest tree is one having both heart and sap rotting fungi present at the site of the nest cavity. Sap rots infect the sapwood of trees, softening it and killing the affected tree or limb. If the sapwood is soft, predators can easily enlarge the cavity entrance tube and prey on young or adults. However, certain species that are not strong excavators (e.g., downy woodpeckers[2/]) may be partially dependent on snags with both heart and sap rots when they nest in trees with "hard" wood, e.g., oaks, hickories, etc. (Conner 1978).

Beetle-killed pines are an additional type of snag available for cavity nesters. These snags are often quite soft because invading beetles and broken branches have exposed most of the wood to fungal attack. Due to extensive decay in both sapwood and heartwood these snags often do not stand for long periods of time.

The least desirable nest tree condition occurs when only the sapwood of a snag is rotted. When a nest cavity is excavated into just the sapwood, the cavity is quite vulnerable to predation, and possibly temperature extremes. The thickness of wood between the cavity and the outside of the tree is typically minimal in such cavities. Thus, the insulation value of the cavity (Kendeigh 1961) may be greatly reduced.

Possible Indicators of Suitable Snags

Snags with potential nest sites have many indicators (Conner 1978). Fungal conks, rotting dead branch stubs, old wounds or scars, existing woodpecker cavities, and dead portions on trees are some obvious characteristics indicating the possible presence of a suitable substrate. Coring snags with an increment borer and/or culturing fungi from these cores are more difficult methods to determine suitability of snags (Conner *et al.* 1976).

[2/] Scientific names in Appendix.

SNAGS AS FORAGING SUBSTRATES

In addition to their importance as nest sites, snags are used extensively by many birds as foraging sites. The surface of a live tree is a complex habitat. Crevices formed by the bark provide sites for spiders, ants, moths, and other invertebrates to hide. These invertebrates are the mainstay diet of the bark gleaning birds.

As a tree dies, it is invaded by many additional insects. Noteworthy of these are the numerous species of bark beetles that feed in the cambium of the tree. Larvae, pupae, and adults are a major food item of many woodpeckers (Otvos 1965). Woodpeckers extract the larvae of these insects after pecking small holes through the bark. Later in the beetles' life cycle woodpeckers need to make excavations to gain access to larvae that have gnawed a tunnel into the sapwood to pupate.

Additional prey are found in the heartwood of the snags. Carpenter ant (*Camponotus* spp.) and termite (Isoptera) colonies are rich food supplies for woodpeckers strong enough to penetrate the tree shell protecting the caverns (Conner 1977a).

CALCULATION, SIZES, AND DISTRIBUTION OF SNAGS REQUIRED

In this paper we have used the formula developed by the U.S. Forest Service (Bull and Meslow 1977) to calculate the number of snags required by species:

$$Y = A \times B \times C$$

Where: Y = number of suitable-sized snags required standing at any given time per 40 ha (100 acres).
A = maximum bird species density per 40 ha (100 acres).
B = number of snags used annually (or for a specific season).
C = snag reserve, some snags will fall and need replacement, some available snags will be unsuitable for cavity excavation, and some snags will be used as feeding but not nesting sites.

Table 2.--*References and characteristics of territories and nest trees needed to calculate snag densities for 9 species of woodpeckers common to the northeastern United States*

Species	When using territory	Territory size		Minimum no. of snags used	Average d.b.h. of nest trees		Average height of nest trees		Maximum pairs per: 100 ha (100 ac)		Literature
		ha	*(ac)*		*cm*	*(in)*	*m*	*(ft)*			
Downy woodpecker	All year	4	(10)	4	20	(8)	6	(20)	25	(10)	Allen (1928), Kilham (1962), Lawrence (1966), Conner *et al.* (1975, & unpublished data), Bull (1978)
Hairy woodpecker	All year	8	(20)	4	30	(12)	9	(30)	12.5	(5)	Kingsbury (1932), Kilham (1960, 1966, 1968), Lawrence (1966), Conner *et al.* (1975)
Pileated woodpecker	All year	70	(175)	4	55	(22)	18	(60)	1.4	.6	Becker (1942), Tanner (1942), Hoyt (1957), Kilham (1959, 1976), Conner *et al.* (1975), Bull (1978)
Common flicker	Breeding	16	(40)	2	37	(15)	9	(30)	6.3	(2.5)	Lawrence (1966), Conner *et al.* (1975), Bull (1978)
Red-bellied woodpecker	All year	6	(15)	4	45	(18)	12	(40)	16.7	(6.7)	Tanner (1942), Kilham (1958a), Boone (1963), Stickel (1964), Reller (1972), Conner (1973), Jackson (1976)
Red-headed woodpecker	Breeding	4	(10)	2	50	(20)	12	(40)	25	(10)	Kilham (1958b), Reller (1972), Conner (1976, & unpublished data), Jackson (1976)
	Winter	.1	(.3)	1	50	(20)	12	(40)	1000	(333)	
Black-backed three-toed woodpecker	All year	30	(75)	4	38	(15)	9	(30)	3.3	(1.3)	Bent (1939), Short (1974), Bull (1978),(Territory size assumed to be same as northern three-toed woodpecker)
Northern three-toed woodpecker	All year	30	(75)	4	35	(14)	9	(30)	3.3	(1.3)	Laing and Taverner (1929), Bent (1939), Gibbon (1966), Bull (1978), Thomas *et al.* (Unpublished manuscript)
Yellow-bellied sapsucker	Breeding	4	(10)	1	30	(12)	9	(30)	2.5	(10)	Howell (1952), Lawrence (1966), Kilham (1971, Personal communication), Bull (1978), Thomas *et al.* (Unpublished manuscript)

Maximum Density

A maximum population density must be used in order to determine what number of snags are needed to support this density. Territory sizes and densities of pairs listed in table 2 are based on values found in the literature. In a few cases assumptions and adjustments were needed. Due to a lack of information, the territory size of black-backed three-toed woodpeckers was assumed to be similar to northern three-toed woodpeckers. Since the black-backed three-toed woodpecker is larger than the northern three-toed, it probably required a larger territory; thus our assumption may provide slightly more snags than the bird actually requires as a maximum.

Many population densities have been reported for pileated woodpeckers; the highest being one pair per 106 acres (Tanner 1942). However, this value was measured in southern United States where food may be more abundant for a longer portion of the year than in northeastern United States. Thus, we adjusted territory size to one pair per 175 acres to obtain what is probably a more realistic maximum for the Northeast. This value, 175 acres or 70 ha, is also the range size reported for pileateds by Kilham (1976).

Number of Snags Used Annually

Woodpeckers use cavities in trees for nesting and roosting. If all conditions are favorable, a pair of woodpeckers uses only one nest cavity annually. However, often predators and competitors cause a cavity to be unsuitable (Allen 1928, Balda 1975).

Ideally, only two roost cavities are needed annually. Field observations, however, indicate that several roost cavities per individual bird may be needed as both sexes frequently move to different roost cavities (Allen 1928, Hoyt 1957, Stickel 1964). Natural selection may have favored this behavior to reduce losses of roosting woodpeckers to nocturnal predators.

After fledging, young woodpeckers of most species require roost cavities, which adds at least one more cavity to the annual requirement. Thus, for most woodpeckers, pairs require a minimum of 4 suitable cavity trees (or snags) each year (table 2). Annual cavity requirements are different for the migratory woodpeckers, common flickers, yellow-bellied sapsuckers, and red-headed woodpeckers, as they need winter roosting sites in a different area than nesting sites.

Reserve of Snags

It is difficult, if not impossible to determine the percentage of snags in a forest that are suitable for cavity excavation. Thomas *et al.* (1976) reported that only one snag out of 17 in Oregon contained a nest cavity. This however, does not preclude the possibility that some of the 16 unused snags were suitable for cavity excavation. Availability of food, as suggested by McClelland (1979), may be a limiting factor that reduces woodpecker densities in the Pacific Northwest. Low population densities of cavity excavators and/or spacing of snags may cause some suitable snags to be unused. Variations in the percentage of snags that are suitable for cavity excavation will be influenced by site characteristics, geographical location, and the species of the tree involved. In addition, a reserve of snags is needed to replace cavity trees lost each year.

We have used the value 10 as an estimate of the number of snags needed to provide cavity substrate for each cavity required by a pair of woodpeckers. This value includes a margin for unusable snags, a reserve of snags for replacements, feeding habitat, and a supply for secondary users.

Snags Required to Support Percentages of Population Maximums

Once the number of snags required to support maximum densities of woodpecker species is determined (Y in the formula), various percentages of these values can be used to estimate the number of snags required to support percentages of population maximums (table 3). These values are estimates based on the best information currently available. If future research provides more accurate base data, the estimates of snags required should be recalculated and the new values used for habitat management projects in the field.

Snag Height and DBH

Thomas *et al.* (1976) and Bull (1978) mentioned the use of minimum heights and DBH's of snags when providing snags for cavity nesters. We discourage the use of minimum values.

The DBHs and heights of species' nest trees tend to be normally distributed, most observation falling near the mean and few at the "tails" of a normal distribution curve. Natural selection favors individuals nesting in trees with d.b.h.'s and heights close to the mean, and often reduces productivity of pairs nesting in trees with d.b.h.'s and heights at the minimum or maximum extremes.

If trees are too small in diameter, crowding may reduce the number of offspring that can fit in a cavity. Studies in Europe indicated that some cavity nesting species increase their clutch size with increases in nest box sizes (Karlsson and Nilsson 1977). This relationship may also exist in species nesting in natural or

Table 3.-- *Recommended numbers of snags to maintain selected densities of woodpecker populations in northeastern United States*

Species	Probable optimum d.b.h. ranges of nest trees		Optimum ranges of nest tree heights		Snags needed per 40 ha (100 acres) to maintain listed percentages of population maximums				
					Good		Fair		Poor
					100	80	60	40	20
	cm	*(in)*	*m*	*(ft)*	- - - - - - *Number* - - - - - - -				
Downy woodpecker	15-25	(6-10)	3-9	(10-30)	400	320	240	160	80
Hairy woodpecker	25-35	(10-14)	6-12	(20-40)	200	160	120	80	40
Pileated woodpecker	45-65	(18-26)	12-21	(40-70)	24	19	14	10	5
Common flicker	30-44	(12-18)	6-12	(20-40)	[1]50	40	30	20	10
Red-bellied woodpecker	36-53	(14-22)	9-15	(30-50)	270	220	160	110	55
Red-headed woodpecker	40-60	(16-24)	9-21	(30-70)	[1]200	160	120	80	40
					[2]3,330	2,660	2,000	1,330	670
Black-backed three-toed woodpecker	30-46	(12-18)	6-12	(20-40)	52	42	31	21	10
Northern three-toed woodpecker	30-40	(12-16)	6-12	(20-40)	52	42	31	21	10
Yellow-bellied sapsucker	25-35	(10-14)	6-12	(20-40)	[1]100	80	60	40	20

[1]Breeding season requirements.
[2]Wintering habitat requirements.

excavated cavities. As crowding increases, juvenile cavity nesters may kill siblings (Kilham[3/]). If nest trees provided are only of minimum height, predators may seriously reduce the reproductive success of populations using such snags (Holcomb and Twiest 1968, Dennis 1969). Thus, if we provide only minimum sized snags (DBH and height) we may eliminate a species by not providing the size of nest tree that natural selection favors.

Snags provided for woodpecker species should be within the appropriate DBH and height ranges required by the species (table 3), preferably, as close as possible to the mean DBH's and heights listed in table 2. By providing the average sized snags, the probability of meeting species requirements can be maximized.

Distribution of Snags Provided

When snags are provided for cavity nesters, snag distribution must not prohibit or reduce the chance of snags being used. Thus, a uniform distribution of snags may be the best in a forest situation. This distribution optimum may not always be possible, especially during early regeneration stages of clearcuts. In such cases, a belt of "old growth" along water influence zones or a good distribution of small clumps of older trees with abundant snags within younger forest stands would be of great value to cavity nesters.

MANAGEMENT OPTIONS

One concept should dominate designs of management programs--each wildlife species has an intrinsic value in the perpetuation of natural ecosystems. Therefore, effort should be directed toward achieving or maintaining self-sustaining population levels of all native species. Many current land use patterns in eastern forests maintain structural complexity and support a correspondingly diverse avifauna. Most breeding bird species in this area have a wide geographical range, are mobile, and in no current danger of being reduced to less than a self-sustaining population. Some species, especially those that tolerate only a narrow range of habitat variability or require a specialized habitat component, need a more specialized management program. Cavity nesters fit into this category.

Four broad management options are open to the forest manager, each with its own implications to avian habitat values. These options are exploitation, even-aged management, unevenaged management and preservation. Exploitation involves no silvicultural system. The silvicultural systems which might be employed to implement the even-aged management option include shelterwood, seedtree, and clearcutting systems. The selection system--either single tree or group selection--would be used in uneven-aged management. The preservation option includes active protection of a stand or the no-management, no-use, leave alone option. These were discussed in greater detail by Zeedyk and Evans (1975). How these options might affect nongame birds are as many and as varied as the bird species and forest types involved. The preservation option probably provides the best opportunity for an abundance of snags and corresponding populations of snag-dependent species. We are not recommending the preservation option for any large area because of the other values of a well-managed forest and the negative impacts on the many bird species that require an early successional stage.

[3/]Personal communication.

For the production of high quality sawtimber and veneer trees in the oak-hickory forests, even-aged management is recommended (Sander 1977, Roach and Gingrich 1968). This objective can best be attained with clearcutting or some form of shelterwood. The time required to grow trees to a given diameter can be greatly reduced and the forest yield substantially increased if thinnings are initiated early in the life of a stand (Sander 1977). When management prescriptions call for thinning to begin at age 20 and occur at 10-year intervals, the effect on cavity-nesting species could be disastrous. Gingrich (1971) reported that at age 20 an unthinned upland hardwood stand will contain from 3,400 to 6,200 trees per hectare, and during the nest 60 years, without thinning, 90 percent of these will die. These dead and dying trees are essential habitat components for at least 26 cavity-nesting species of birds in the oak-hickory forest (Hardin and Evans 1977).

Condition of currently available forest stands and rotation age plays an important role in the management of hole nesting species. Over 50 percent of the 116 billion trees in the northeast are less than 5 cm (3 in) d.b.h. (U.S. Department of Agriculture Forest Service 1977). Nearly all of the primary cavity excavations require a snag of 23 cm (9 in) d.b.h. for their nesting hole. Only 8 percent of the hardwood trees in the northeast are 23 cm d.b.h. or larger (table 4). The situation is even worse for the softwoods of the northeast--less than 6 percent are over 23 cm (9 in) d.b.h. Out of 116 billion trees in the northeast 8 billion are 23 cm d.b.h. or greater. Observing the number of live trees per unit area provided a base for snag management considerations (table 5). This illustrates two concerns, (1) only a small percentage of the living trees are large enough to provide suitable cavity substrate and (2) in a managed forest these large trees are not likely to be left for snags.

Table 4.--*Percent of live hardwoods by d.b.h. classes in various regions*[1]

D.b.h.		North	Minnesota	Missouri
in	*cm*	- - - *Percent*	- - -	
1	2.5	[2]100	100	100
3	7.6	48	48	39
5	12.7	25	26	19
7	17.8	14	12	11
9	22.9	8	5	6
11	27.9	5	2	4
13	33.0	2	1	2
15	38.1	1	0.6	1
17	43.2	0.1	0.3	0.5
19	48.3	0.003	0.13	0.3
21	53.3	0.002	0.06	0.14

[1]Source: USDA Forest Service (1977).

[2]Percent of trees of this d.b.h. and larger.

Table 5.--*Number of live trees per 40 ha (100 acres) on commercial timberland in the northeast*[1]

D.b.h.		Live trees per 40 ha (100 acres) Hardwood	Softwood
in	*cm*	- - *Number*	- -
1	2.5	[2]49,062	19,061
3	7.6	23,453	9,741
5	12.7	12,347	4,832
7	17.8	6,726	2,306
9	22.9	3,676	1,076
11	27.9	1,997	499
13	33.0	1,099	235
15	38.1	591	112
17	43.2	316	54
19	48.3	171	26
21	53.3	93	13
29	73.7	11	1

[1]Source: USDA Forest Service (1977).

[2]Number of trees of this d.b.h. and larger.

We won't discuss the wide variety of generalized snag management options that have previously been discussed (Conner 1978, Evans 1978). The one obvious factor is that under an even-aged management system, most of the stands will be too young to provide adequate size snags; we need to protect some areas from regeneration cuts. Zeedyk and Evans (1975) recommended leaving a 0.1 ha clump of trees within each 2 ha of regeneration (0.25 acre within each 5 acres of harvest area). Although each area would be different, this would provide between 830 (site index 75) and 1,210 (site index 55) trees left standing after clearcutting per 40 ha (100 acres). For upland hardwood stands the dominant trees on site index 55, at age 80, will average about 30 cm (12 in) d.b.h., whereas the dominant trees on site index 75, at age 80, will average 45 cm (18 in) d.b.h. (Gingrich 1971).

Although additional research would be required to evaluate this management proposal, a 5 percent trade-off in timber growing space would probably provide some of the smaller cavity nesting species adequate habitat during later stages of timber regeneration. This would not be true for larger woodpeckers such as the pileated, and possibly hairy woodpeckers which require more extensive areas of continuous forest. The arrangement of these clumps could be somewhat flexible. Combining 4 of these clumps together could provide a 0.4 ha (1 ac) mature forest in each 8 ha (20 ac) of young (regenerating) timber. These islands would provide limited foraging and nesting sites immediately following clearcutting and be of value for a long period of time.

Each stand would probably have a drainage system that needed to be protected or a partially inaccessable area. These areas could also be left uncut to provide mature forest area for forest cavity nesters with large home range requirements. We recommend that an uncut area of of 20 times the stream width, not to exceed 50 m, be left on both sides of water courses. These buffer strips will provide habitat for both game and nongame species in addition to greatly reducing erosion and stream siltation. The resulting canopy cover over streams will also prevent stream warming which negatively affects desired fish species.

THE VALUE OF MATURE FORESTS AND INSECTIVOROUS BIRDS

Economic advantages of providing areas with mature forest habitat for cavity nesters may at first seem remote. However, evidence suggests that long term advantages may exist. Most cavity nesters are insectivorous and many studies have demonstrated their effectiveness in reducing populations of insect pests that attack and destroy trees (Baldwin 1958, Knight 1958, Otvos 1965, Shook and Baldwin 1970, Koplin 1972). When woodpeckers forage on insect infested trees there are secondary benefits. Typically, they chip bark off while foraging which increases the effectiveness of insects that parisitize the insects that are attacking the tree (Otvos 1965).

In order for insectivorous birds to buffer insect epidemics, they must be maintained at sufficient population densities. Providing enough snags to maintain bird populations in mature forest habitat is crucial, especially for primary excavators.

Insectivorous birds that are secondary users of nest cavities will often nest in artificial nest boxes. Providing nest boxes for such birds can increase avian population densities greatly while concurrently decreasing densities of insects (Bruns 1960, Tichy 1963, Campbell 1968). Table 1 provides nest box and entrance hole dimensions for selected species.

If insect outbreaks occur when insectivorous bird populations are at sufficient densities, the birds can concentrate in areas of outbreaks and buffer, contain, or possible eliminate the insect infestation, thus possibly reducing economic losses. Concentration of insectivorous birds at insect infestation does occur and has been documented (Blackford 1955, Yeager 1955, Morris *et al.* 1958, Koplin 1969).

Additional benefits can be derived if natural predators are used to control insect pests. Biological control may eliminate or reduce the expense, "pesticide resistance" problems, and environmental dangers of pesticide applications.

Recommendations

1. Manage for maximum feasible rotation age.
2. Consider old growth a high priority option. Select stands for deferred cutting as early as possible--age 20 is optimum.
3. Leave a 0.1 ha clump permanently uncut in each 2 ha of regeneration cut.
4. Discontinue removal of dead, dying, and decayed trees for use as materials or firewood in areas where nest cavity sites are limited.
5. Consider management techniques such as providing artificial nest boxes and boring holes in suitable sized trees when cavity availability is limited.
6. Consider leaving permanent uncut buffer strips on both sides of streams.

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APPENDIX

Wood duck	*Aix sponsa*
Common goldeneye	*Bucephala clangula*
Hooded merganser	*Lophodytes cucullatus*
Common merganser	*Mergus merganser*
Turkey vulture	*Cathartes aura*
Peregrine falcon	*Falco peregrinus*
Merlin	*Falco columbarius*
American kestrel	*Falco sparverius*
Barn owl	*Tyto alba*
Screech owl	*Otus asio*
Barred owl	*Strix varia*
Boreal owl	*Aegolius funereus*
Saw-whet owl	*Aegolius acadicus*
Chimney swift	*Chaetura pelagica*
Common flicker	*Colaptes auratus*
Pileated woodpecker	*Dryocopus pileatus*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-headed woodpecker	*Melanerpes erythrocephalus*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Hairy woodpecker	*Picoides villosus*
Downy woodpecker	*Dendrocopus pubescens*
Black-backed three-toed woodpecker	*Picoides arcticus*
Northern three-toed woodpecker	*Picoides tridactylus*
Great crested flycatcher	*Myiarchus crinitus*
Tree swallow	*Iridoprocne bicolor*
Purple martin	*Progne subis*
Black-capped chickadee	*Parus atricapillus*
Boreal chickadee	*Parus hudsonicus*
Tufted titmouse	*Parus bicolor*
White-breasted nuthatch	*Sitta carolinensis*
Red-breasted nuthatch	*Sitta canadensis*
Brown creeper	*Certhia familiaris*
House wren	*Troglodytes aedon*
Winter wren	*Troglodytes troglodytes*
Eastern bluebird	*Sialia sialis*
Prothonotary warbler	*Protonotaria citrea*