Snags (Wildlife Trees)

William A. Neitro, R. William Mannan, Douglas Taylor, Virgil W. Binkley, Bruce G. Marcot, Frank F. Wagner, Steven P. Cline

Introduction

Snags are an important structural component in forest communities. In forests of western Oregon and Washington, snags are used by nearly 100 species of wildlife of which at least 53 species (39 birds and 14 mammals) are cavity- dependent. Wildlife species that use cavities in partially live or dead trees for various life functions are referred to as cavity users or nesters, and include representatives from all classes of terrestrial animals. The dependency of these species on dead trees ranges from absolute to incidental, but for some species the presence of dead trees can spell the difference between local extinction and the perpetuation of existing populations. In forests, cavity-nesting birds may account for 30-45 percent of the total bird population (Jackman 1974a) Raphael and White 1984, Scott et al. 1980). Woodpeckers are dependent on snags and other dead wood for nesting, roosting, foraging, and other functions. Woodpecker nest cavities when abandoned are used by other animals (secondary cavity users) for nest sites. Some researchers believe that the use of cavities has allowed birds to become polygamous, nest earlier, have larger clutches, and fledge more young per nesting effort than noncavity-nesting birds (Nice 1957, Steinhart 1981).

The absence of suitable snags can be the major limiting factor for some snag-dependent wildlife populations (Haapanen 1965, Balda 1975). The abundance and diversity of hole-nesting birds are directly related to the dead and dying wood characteristics and general vegetation features of a forest. Morrison and Morrison (1983), in analyzing 30 years of Audubon Society Christmas bird count data, found that populations of three species--common (northern) flicker, hairy woodpecker, and downy woodpecker- -show a downward trend in the Pacific Northwest. They speculate that this may be the result of intensive forest management practices.

Some species decrease whereas others increase with changes in vegetation structure (Manuwal and Zarnowitz 1981). Hagar (1960) reported that logging could make an area as suitable as an unmanaged forest for some species of woodpeckers. Northern flickers and hairy woodpeckers actually increased after logging when snags were retained. From the 1940s through the early 1960s the Oregon Conservation Act of 1942 (repealed) inadvertently provided snags in managed young forests. This act required the replanting of harvested sites or the retention of seed trees. These old seed trees, many now dead or dying, often became snags (fig. 1).

Today, silvicultural practices are often aimed at producing even-aged forest stands with low vertical structural diversity (Wiens 1978). These single canopy stands usually have been "sanitized" by removal of snags, defective trees and salvageable cull logs (chip and peeler logs). As the practice of even-aged forest management extends to larger areas in Oregon and Washington, populations of cavity-nesting species are likely to be reduced (Manuwal and Zarnowitz 1981).

For example, Morrison and Meslow (1983) reported that breeding cavity-nesting species were rare on recent clearcuts (10 years old or less) studied in the Coast Ranges of Oregon. In older second growth managed forests with few trees suitable for cavity construction, intraspecific and interspecific competition among cavity-nesting species may be high (Jackson 1979, Manuwal and Zarnowitz 1981).

The basic conflict between hole nesters and commercial timber management relates to the systematic and maximum utilization of forest wood fiber and to the concern for fire control and safe working conditions (Franklin et al. 1981, Haapanen 1965, Jackman , Meslow 1978). Over the past two decades new technology and declining wood supplies have increased the utilization of lower quality forest trees and logging residues. Snags, cull trees and residue logs are often salvaged for wood chip products and firewood. In the future, logging debris may be used to generate electricity, thus posing an added threat to retention of snags for wildlife.

The objectives of this chapter are fourfold: 1) to describe the characteristics and dynamics of snag habitat in unmanaged and intensively managed Douglas-fir forests; 2) to describe the wildlife that use snags, and the role and importance of snag-dependent wildlife; 3) to estimate the snag requirements of hole-nesting birds in managed forests; and 4) to describe some techniques for snag management in managed forests.

Importance and Role of Snags in the Forest Ecosystem

Dead and partially dead trees are important to many species of wildlife and function in a variety of ways (table 1 Recognition of the importance of snags to wildlife dates back over 60 years when Grinnell and Storer (1924) recommended leaving dead trees for breeding, shelter, and food needs of wildlife. More recently, the importance of snags to wildlife has been investigated and described by many authorities (Bull 1978, Bull and Meslow 1977, Cline 1977, Mannan et al. 1980). Thomas et al. (1979) described a direct correlation between the abundance of snags and the abundance of cavity nesters. Mannan et al. (1980) confirmed this correlation with hole-nesting birds in western Oregon.

Definition of Snags as Wildlife Trees

For a snag to be suitable as a cavity site for wildlife, its diameter must be large enough to accommodate cavity users. Most hole nesting birds have been shown to prefer snags with a diameter greater than 15 inches and to select specific stages of snag decomposition for feeding and nesting (Gale (1973, Mannan et al. 1980, Raphael 1980). Conner (1978) further described the visual indicators of a tree having potential for nest sites to include the presence of fungal conks, rotting dead branch stubs, old wounds, scars and existing woodpecker cavities. In this chapter snags will be defined as any dead, partially-dead or defective (cull) tree at least 10 inches in diameter at breast height (d.b.h.) and at least 6 feet tall. Smaller diameters may be useful to some species for feeding. The term 11 green" wildlife tree is used to identify trees that could be designated future snag habitat.

Other definitions of snags are generally concerned with forestry practices, potential safety, and fire prevention.

Snags as a Component of Wildlife Habitat

Snags are a vital component of the forest ecosystem (Bull 1978) providing habitat for many species of wildlife (Franklin et al. 1981) (appendix 18). The hardness of a snag is an important characteristic in determining its value for nesting or foraging. Soft and rotten snags are most used by cavity-nesting wildlife. Mannan et al. (1980), however, found that woodpeckers in the Douglas-fir forests of western Oregon often selected "hard-remnant snags" for nesting while species such as the chestnut-backed chickadee used "soft-remnant snags" (fig. 2).

Another important role of snags is the production of a rich source of foods (White & Raphael 1975). Snags are used extensively as foraging substrates by birds and mammals. Evans and Conner (1979) identified three foraging substrates provided by snags: external surface of the bark, the cambium layer, and the heartwood of the tree (fig. 3). Raphael and White (1984) found that use of snags as foraging substrate varied among wildlife species. Hairy woodpeckers and blackbacked woodpeckers fed in snags 70 percent and 79 percent of the time respectively, but red-breasted nuthatches were not observed foraging in snags. As a snag decomposes, texture and moisture content of wood fibers change, which in turn affects suitability of the snag as. insect habitat.

A number of avian and mammalian species use snags as food storage sites. The American kestrel, some owls, and a variety of mammals use dead trees to cache prey and other food items. Woodpecker occurrence can be limited by the absence of habitat features other than nesting snags. For example, in Monterey County, California, Swearingen (1977) found islands of suitable acorn woodpecker habitat that were not fully occupied, apparently because of a shortage of potential granary and anvil sites.

Natural cavities and those constructed by primary excavators in snags provide thermally-regulated enclosures for nesting and overwintering animals. Beebe (1974), Conner (1979a), and McComb and Noble (1981a), pointed out that snags provide cooler nesting substrates during hot weather periods than did open nests and artificial nest boxes. The thick walls of natural cavities moderate temperature fluctuations. This may result in increased animal survival and higher production when compared with species that nest in the open (Beebe 1974, Jackman 1974a).

Cavity-nesting species characteristically roost overnight in holes during stormy weather and during the winter (Bent 1964, McClelland 1979). Roosting in cavities may reduce winter mortality and allow a species to occur farther north than it could otherwise (Jackman 1974a). Von Haartman (1968) demonstrated that this adaptive behavior has enabled many cavity nesters to become year-round residents in a generally unfavorable winter climate. HE also found that a high percentage of the permanent resident species were cavity users.

The role of snags in courtship and reproductive phases of the avian life cycle is not well documented. Bent (1964), Bull (1975) and Jackman (1974a) postulated that drumming by woodpeckers on snags or trees with dead tops is a part of some species' social behavior. Drumming was theorized to be an indispensable ritual in courtship and territorial defense and snags may be an important component in the establishment of a woodpecker's territory.

Cline et al. (1980) and Franklin et al. (1981) described the role of snag decay in nutrient recycling. Snags also act as nurture sites for trees and other vegetation (fig. 4). Snags are of primary importance in the formation of down-log habitat in streams and on the ground (see chapters 8 and 10) (Franklin et al. 1981, Juday 1978). Cline et al. (1980) stressed that the complete ecological role of snags in the forest is unclear, and that management strategies must remain flexible to ensure that future management options are not lost.

Ecological Role of Cavity Users
Holes (cavities) in trees are formed in two ways: through natural decay and through excavation by woodpeckers. Both of these processes may depend on the tree being infected with fungi.

An important ecological function of woodpeckers in the forest is their role as excavators. Primary excavators are those species that actually construct nesting and foraging cavities in snags. Secondary cavity users use either natural cavities or cavities constructed by other species. McClelland (1979) indicated woodpecker hole excavation annually includes several false-start cavities that are abandoned. Some of these initial excavations, as well as the final nest cavity, provide nesting and roosting habitat for many animals. Seventeen excavator species occur in western Oregon and Washington (appendix 19).

Analysis of the Snag Resource

Snag densities, sizes, and species that occur within a forest will vary depending on the age and species composition of the stand and physical, chemical and soil factors that affect productivity of the site (e.g., aspect, elevation) (Cline et al. 1980, Manuwal and

Zarnowitz 1981). These processes operate during natural development in all forest communities. Thus, characteristics and dynamics of snag occurrence often exhibit a general pattern regardless of the community in which they occur. Recognizing these patterns and understanding the processes that create them are necessary before snags can be managed successfully. In the following analysis, patterns and processes relating to snag occurrence in unmanaged Douglas-fir forests in western Oregon and Washington will be examined.

Douglas-fir forests were chosen for the analysis because information was available on snag occurrence in this type. Also, Douglas-f ir forests make up a large portion of the land base in western Washington and Oregon and are scheduled for intensive, even-aged timber management (Beuter et al. 1976). As such, they illustrate the need for workable snag management programs.

The Snag Resource in Unmanaged Douglas-fir Forests

Development of Snags

The rate of development of snags, or the rate of tree mortality, varies considerably among stands of similar age, but generally decreases with increasing age (Cline et al. 1980). In healthy, young forests (stands up to 80 years old), such as those following wildfire, the development of snags is caused primarily by suppression. This results in high densities (80-320 per ac.) of small snags, usually less than 12 inches d.b.h. Suppression causes some mortality even in mature forests (80 to 200-yearold stands), but in many cases the specific cause of mortality is difficult to pinpoint. Some trees are obviously weakened prior to death by heart rot infections of the bole and/or roots (Roth, 1970), while other previously healthy trees are broken off or crushed by falling trees. These mortality factors are less size-specific than suppression; therefore, all sizes of snags may be represented in mature forests. In oldgrowth forests (200+ year-old-stands), suppression is again the dominant agent of mortality in understory trees, but the mortality factors mentioned above are primarily responsible for development of the large snags and fallen trees found in old-growth forests.

Snags are also created when an old forest is converted to a young forest. Prior to the beginning of commercial logging, wildfire, insects and disease outbreaks were primarily responsible for eliminating existing forests and provided a critical link between old and new stands. As a result, young, unmanaged stands often have a variable number of large "remnant" live trees and snags (Cline et al. 1980).

Decomposition of Snags

Deterioration of snags is caused by the interaction of insects, fungi, bacteria, and weather over time (Kimmey and Furniss 1943). Five stages of deterioration of Douglas-fir snags were described by Cline et al. (1980) (fig. 5, table 2). Important trends characterizing the process of decay are (1) deterioration from top to bottom resulting in a decrease in height and sloughing of needles, branches, bark, and wood as decay advances, and (2) a general deterioration from sapwood to heartwood causing hard snags to become soft snags.

The rate of deterioration of snags depends primarily upon the size and species of the snag (Graham 1981). The process of decay is similar for large and small snags except that small snags (less than 12 in. d.b.h.) often decay and break near or below groundline (Cline et al. 1980). Because large snags require more time to decay than small snags, large snags generally remain standing longer (Cline et al. 1980, Graham 1981, Raphael and White 1984).

The species of snag is also an important factor determining longevity. Cline (1977) found that in the Oregon Coast Ranges, conifers generally lasted longer than hardwoods, and of the species of conifers examined, western redcedar and Douglas-fir were most persistent. Other factors determining the rate of deterioration are cause of death, presence or absence of heart-rotting fungi prior to death, and specific site conditions (Thomas et al. 1979). Those snags that remain standing the longest potentially provide the most benefit to wildlife, and are easiest to manage because they do not need to be replaced as frequently.

Patterns of Snag Abundance
Snag abundance in a given stand is the result of interaction between live tree mortality and snag deterioration rates. Environmental factors that affect stand development and productivity indirectly affect snag abundance, resulting in considerable variation from site to site. Cline et al. (1980) observed changing patterns of snag abundance and characteristics as a Douglas-fir forest matured; they included (1) a decrease in snag recruitment and density, (2) an increase in average and maximum sizes of snags, and (3) an increase in the variety of snag sizes, species, and stages of deterioration. Similar patterns probably occur in other unmanaged coniferous forest types in the Pacific Northwest.

The Snag Resource in Managed Douglas-fir Forests

Much of the Douglas-fir region is programmed for intensive timber production. Timber management practices such as clearcut logging, periodic thinning, salvage, and short harvest rotation periods (less than 100 years) dramatically reduce or eliminate the potential of the forest to produce or retain the types of snags needed by many species of wildlife (Mannan et al. 1980, Manuwal and Zarnowitz 1981).

Unless management programs for snags are designed and implemented, stands under intensive timber management will contain very few snags, most of which will be too small for use by snag-dependent wildlife.

Silvicultural practices such as clearcut logging and salvage cutting often reduce or eliminate remnant snags, thereby creating a substantial gap in the supply of large snags in plantations and young forests (fig. 6). These potential conflicts can be reduced, however, by silvicultural practices that are carefully planned and implemented in coordination with snag management objectives. This section demonstrates how to predict effects of intensive silvicultural management on snag numbers through time, and discusses how one may plan for retaining snags with the size and decay characteristics needed for wildlife habitat. Although the focus will be on snag management in even-aged stands of Douglas-fir, the concepts will apply to most other conifer or conifer-hardwood forest types undergoing intensive silvicultural treatment. The following section will present a method of determining snag requirements of cavity-excavating wildlife species. Also included is a method for integrating their requirements in assessing snag numbers.

Predicting Snag Numbers Under Even-Aged Silvicultural Management
The density, spacing, and distribution of snags by size and decomposition stage will change through time in forests undergoing even-aged silvicultural management. These changes are predictable given the forest management techniques to be applied. The number of snags present in a forest changes as a function of gains and losses (fig. 7). Gains result from suppression and natural mortality (fire, insects, disease) and purposeful creation of snags (girdling, topping, injection). Losses are from natural falling rates, salvage and safety cutting, and firewood cutting. Standing snags change through time in terms of decomposition characteristics, height, and bark cover (table 2). Estimating rates of gains, losses, and changes allows prediction of snag numbers by size and decay stage throughout the life of the managed stand.

Management procedures discussed involve even-aged management of stands for wood-volume production. The stand growth model DFSIM (Douglas-Fir SIMulator, Curtis et al. 1982) is used. DFSIM generates yield tables for a variety of possible management regimes, including precommercial thinning, commercial thinning, and fertilization. The model can be used to guide stocking control and to estimate probable yields of future managed stands. Output from DFSIM includes mean d.b.h. and numbers per acre of live trees and trees dying, by five-year increments.

For demonstration purposes, assume a site index of 125, a rotation age of 100 years, a stand that will be precommercially thinned to 400 trees per acre, and commercial thinnings that will be conducted periodically (derived from table 9c, pp. 107-109, in Curtis et al. 1982). The first step in estimating snag numbers requires summarizing "gains" of snag numbers. **Table 3** presents rates of snag "recruitment" from mortality by one-and five-year periods taken from the DFSIM tables. For this illustration it is assumed that snags created by means other than suppression add little to snag numbers. Suppression is the major source of snag creation in unmanaged, even-aged stands resulting from fire or regeneration harvests (Cline et al . 1980). Cline et al. (1980) reported that windthrow or uprooting accounted for less than one percent of annual tree mortality in stands less than 120 years old. Graham (1981) similarly reported that an average of seven percent (range 3-12 percent) of tree mortality in small, successional Douglas-fir was from windthrow, whereas 93 percent of tree mortality, on the average, resulted from suppression or other factors which left a standing snag.

The second step is to summarize "losses" of snag numbers through time. Assume that losses arise from natural rates of falling, although intentional cutting of snags is easily added to the calculations. Cline et al. (1980) presented curves showing survival rates of Douglas-fir snags as a function of snag diameter and age. Applying their falling rates to the snags "recruited" to the forest (**Table 3**) effectively creates a "life table" of snag numbers, as shown in **table 4**. A snag life table traces "cohorts" of snags through time, thus allowing one to predict snag numbers at any point along the stand growth cycle.

The first of the snag "cohorts" shown in **table 4** illustrates the approach. **Table 3** shows that 662 snags per 100 acres averaging 3.7 inches d.b.h. were created by suppression during the five years of stand ages 20-24. Cline et al.'s (1980) estimates of falling rates of small diameter snags suggested that after five years, about 75 percent of the original 662 snags, or 497 snags per 100 acres, would still be standing; after ten years, about 20 percent would still be standing, and so on. Thus, the fate of a snag .1 cohort" can be followed through time, as shown by the diagonal arrows in **table 4**. When the stand reaches 25-29 years old, the next set of snags (435 per 100 acres, averaging 4.6 inches d.b.h.) becomes "recruited" into the snag population. A time increment of five years was used for clarity of presentation and ease of calculation.

The third step in calculating snag numbers, once the "life table" has been established, is to estimate rates of snag decomposition. **Table 2** presents Cline et al.'s (1980) estimates of snag decay rates. The stages of decay, as shown in parenthesis on the right side of each age class column in **table 4**, may be superimposed over the snag life table cohort sequences. Thus, reading across a row in a snag life table gives a detailed picture of snag numbers at a given age of the stand by snag diameter and decay stage. For example, in **table 4**, the stand at age 65-69 years contains a total of 541 snags per 100 acres averaging 12.7 inches d.b.h.; 68 snags per 100 acres are in decay stage 1; 260 + 142 = 402 snags per 100 acres are in decay stage 2; and 71 snags per 100 acres are in decay stage 3. Furthermore, out of the 541 snags per 100 acres total, 473 snags (260 + 142 + 71) are in the 10-15 inch diameter class, and 68 snags are in the 16-20 inch diameter class. These numbers may be compared between different snag management alternatives, and compared with estimates of different wildlife species' needs.

Effects of Even-Aged Management on Snag Numbers

The snag life table developed above may be plotted on a graph to further illustrate the effects on snag numbers from intensive, even-aged management (**fig. 8**). From such a graph, as from the life table, one may estimate snag numbers by diameter and decay stage at any stand age. Although this example has focused on a specific site class and management prescription, some general effects on snag numbers may be described.

First, snags induced by suppression mortality alone in a relatively short rotation (100 years or less), even-aged silvicultural system are mostly under 20 inches d.b.h. As **figure 8** shows, there may be no snags over 10 inches d.b.h. during the first half of the rotation.

Second, commercial thinnings act to reduce rates of suppression mortality. While this effect may be a positive silvicultural objective, it acts to reduce snag "recruitment" in a stand otherwise unmanaged for snags. figure 8 shows how snag recruitment from suppression mortality (the appearance of new snag cohorts) markedly decreases following each entry. The retention of existing snags within a stand will be determined by the design of yarding corridors and safety requirements. A benefit of thinning, however, may result from accelerating tree growth to provide larger snag sizes at an earlier stand age (see chapter 14).

Third, rotation age may profoundly affect the number of large diameter (over 20 inches d.b.h.) snags present in an intensively managed stand. If final harvest is conducted at 80 years rather than 100, no large diameter snags will be present at any point in the rotation cycle (fig. 8).

Finally, snags created by suppression mortality will consistently be of smaller average diameters than the average size live tree in an even-aged stand (Cline et al. 1980). Whether this is significant for snag-using wildlife depends on each species' requirements and actual snag diameters.

Wildlife Snag Requirements

Patterns of Use by Wildlife

Species of wildlife that frequently use snags for foraging, nesting, or perching are selective as to size, decomposition stage, and abundance of snags. Large diameter snags are used more frequently as nest sites and also show more evidence of woodpecker foraging than smaller snags (Bull and Meslow 1977, Mannan et al. 1980, Manuwal and Zarnowitz 1981, Raphael 1980). Consequently, greater numbers of cavity-nesting wildlife are present when large snags are available than where few or no large snags exist (Balda 1975, Haapanen 1965, Mannan et al. 1980, Raphael and White 1984, Scott 1979).

in western Oregon and Washington, trees grow rapidly to large diameters. Research conducted in this region has shown that both mean and minimum snag diameters selected by cavity excavators for nesting and foraging (Mannan et al. 1980, Manuwal and Zarnowitz 1981, Zarnowitz and Manuwal 1985), are considerably larger than those reported by Thomas et al. (1979). No studies from this region have documented bird use of smaller diameter snags if larger snags are not available. Consequently, minimum snag diameters recommended in this chapter, to meet the requirements of cavity excavators and secondary cavity users (appendix 19), are larger than those recommended by Thomas et al. (1979) for the same species. All minimum size recommendations are for snag diameters measured at breast height including bark thickness.

Stage of deterioration of snags also influences use by wildlife. Each stage differs in characteristics (fig. 5, table 2), and is used in different ways by different species. In stage 1, woodboring beetles become active and woodpeckers take advantage of this source of food (Cline et al. 1980, Mannan et al. 1980). Large limbs that persist in the 1st and 2nd stages of deterioration provide perches for raptors and other birds. Stages 2-5 provide many species of wildlife with potential breeding sites. For example, the red-breasted nuthatch frequently nests near the top of snags in the 2nd stage of deterioration, while northern flickers prefer snags in more advanced stages of decay (Mannan et al. 1980). Brown creepers and some bats roost or nest behind loose bark in the 3rd or 4th stages of snag deterioration. If the requirements of all snag-dependent species are to be met, snags in all stages of deterioration need to be maintained.

One characteristic that separates the 1st stage of deterioration from the remaining four is "broken tops" (fig. 5). Broken tops are important in the decay process of both living and dead trees. Raphael and White (1984) showed a correlation between broken tops, percent bark cover and tree diameter, and densities of cavity-using wildlife species. Broken tops provide an avenue for infection by heartrotting fungi, primarily in living trees, and expose an area of heart wood to weather and insects (McClelland and Frissell, 1975). The presence of decayed heartwood is an important factor in the selection of nest sites by primary hole-nesting birds (Conner et al. 1975, 1976).

Ability of woodpeckers to excavate in snags of different soundness is related to the species' morphological adaptations for drilling (Jackman 1974b, Raphael and White 1984). Relatively strong excavators such as pileated woodpeckers are able to excavate in harder snags than the Lewis' woodpecker, a weak excavator.

Cavity dwellers also differ in their use of successional stages and stand structure (Bull et al. 1980, Jackman 1974b, McClelland 1977, Mannan et al. 1980, Manuwal and Zarnowitz 1981, Raphael 1980, Thomas et al. 1979). For example, the northern flicker typically nests in open situations, while the red-breasted nuthatch utilizes densely forested stands. Other structural features, such as large snags or down logs containing carpenter ants, provide a winter forage substrate for pileated woodpeckers (McClelland 1977) (**fig.9**).

The importance of the species of snag with regard to use by wildlife varies with the plant community. For example, Douglas-fir snags may be used most frequently for nesting in one community (e.g., temperate coniferous forest dominated by Douglas-fir), but are of secondary importance in another community (e.g., mixed conifer forest consisting of ponderosa pine and Douglas-fir). Managers will need to determine which species of snags are most important in the forest communities under consideration.

Species-Specific Snag Requirements

To maintain populations of snag-dependent wildlife, the appropriate number, species, and size of snags in the proper stages of deterioration must be provided through space and time. Prescriptions for snag management must be handled differently for separate forest communities because the wildlife species that use each community and their specific snag requirements will be different (Thomas et al. 1979). Differences in animal species composition between the early and late stand conditions of a plant community indicates the need to provide snags in each successional stage. A procedure for calculating the snag requirements of individual species or entire communities is described below. The method builds upon the approach presented in Thomas et al. (1979) and helps the manager to select snag densities for desired population levels of snag-using species.

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