Use of Artificially Created Douglas-Fir Snags by Cavity-Nesting Birds

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ABSTRACT: *In western Oregon, we created snags by sawing tops off live Douglas-fir* (Pseudotsuga menziesii) *(n = 821) trees and monitored their condition and use by cavity-nesting birds. We created snags in three silvicultural treatments: modified clearcut stands, two-story stands, and small-patch group-selection stands. We used two snag patterns: clumped and scattered. Created snags averaged 3.8/ha in density, 17 m in height, and 75 cm in diameter. Chainsaw-topped snags were used by cavity nesters within 5 yr of creation. Abundance of excavated cavities increased in all silvicultural treatments (P = 0.0001) and was higher in two-story and clearcut stands than in small-patch stands (P ≤ 0.0004). We did not, however, find that snag pattern (clumped v. scattered) affected use by cavity-nesting birds based on abundance of excavated cavities (P > 0.6). We observed excavated cavities in five hardwood species indicating that hardwoods represented an important resource for cavity-nesting birds. Creating conifer snags by topping and retaining hardwoods may retain or increase populations of cavity nesters in areas with low natural snag density. West. J. Appl. For. 12(3):93–97.*

Dead standing trees (snags) are a natural component of forests. They are created by wind (stem breakage), fire, lightning, insects, drought, flooding, disease, and the natural death and decay of a tree (Bull 1986, Adkisson 1988, Morrison and Raphael 1993). Snags are an essential habitat component for many species of primary and secondary cavity-nesting birds (Thomas et al. 1979, Brown 1985).

Density of cavity-nesting birds is associated with snag density (Thomas et al. 1979, Bull and Meslow 1977, McClelland et al. 1979, Zarnowitz and Manuwal 1985, Schreiber and deCalesta 1992). Snag density often is lower in managed than unmanaged stands in the Pacific Northwest (Bull and Partridge 1986, Zarnowitz and Manuwal 1985, Ohmann et al. 1994) because snags are removed during timber harvest for fiber or for safety concerns (Snellgrove and Fahey 1977). In addition, rotation lengths (e.g., 40 to 80 yr) are too short to produce snags of adequate size for use by some cavity-nesting birds (Brown 1985).

Developing and implementing a snag management plan may be costly and time consuming. It may involve preharvest surveying, protecting existing snags, artificially creating snags, and marking live tree replacements. A snag management plan also may involve monitoring snag densities throughout the rotation to ensure snag densities sustain desired populations of cavity nesters (Bull et al. 1980, Hicks 1983, Stysel 1983). Knowledge of the best methods for creating suitable snags, optimal spatial configuration, and density can reduce costs.

We created snags as part of a project designed to silviculturally recreate structural attributes similar to those resulting from natural disturbances of differing intensity. We used three silvicultural treatments (small-patch group selection,

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two-story, and modified clearcut) to simulate disturbances. We used a modified clearcut treatment to simulate a high-intensity disturbance such as a crown fire. Our two-story treatment (green tree retention treatment) simulated a moderate- to high-intensity disturbance such as windthrow. We used small-patch group-selection to simulate a small-intensity disturbance such as root disease (Chambers 1996). Imposed on each silvicultural treatment were two snag patterns: snags arranged as scattered individuals or in clumps.

In western Oregon, we found no information documenting use of artificially created snags by cavity-nesting birds. We found no information about effects of snag spatial arrangement on cavity-nesting bird populations. Our objectives were to describe changes in condition and use of snags topped with a chainsaw after 5 yr and to determine whether spatial arrangement (clumped or scattered) influenced use by cavity nesters.

Methods

Study Sites

We selected 26 stands in Oregon State University's McDonald-Dunn Forest located on the eastern edge of the Coast Range, north and northwest of Corvallis. Replicates consisting of 6 to 10 stands each were located at (1) Lewisburg Saddle: T11S, R5W, Sec. 4, 8, 9, 16, 17; (2) Peavy: T10S, R5W, Sec. 25, 35, 36; and (3) Dunn: T10S, R5W, Sec. 14, 22, 23, 27. Elevation ranged from 120 to 400 m.

Douglas-fir basal area averaged 38 m^2/ha in each stand prior to harvest; grand fir (*Abies grandis*) basal area averaged 1 m^2/ha. Hardwoods, including bigleaf maple (*Acer macrophyllum*), Oregon white oak (*Quercus garryana*), Pacific madrone (*Arbutus menziesii*), Pacific dogwood (*Cornus nuttallii*), red alder (*Alnus rubra*), Oregon ash (*Fraxinus latifolia*), and bitter cherry (*Prunus emarginata*) comprised the remaining basal area (14 m^2/ha). Live tree densities (trees ≥ 20 cm dbh) averaged 537 trees/ha for conifers and 165 trees/ha for hardwoods. The study stands were 80 to 120 yr old and had regenerated naturally following Euro-American settlement and the subsequent elimination of prairie and hillside burning by Native Americans. Stands averaged 5 to 18 ha in size with snag densities (hardwood and/or conifer snags ≥ 30 cm dbh) of ≤ 1.9 snags/ha prior to treatment.

Each replicate included ≥ 1 stand per silvicultural treatment and snag spatial arrangement (Table 1). Treatments were (1) small-patch group-selection (approximately one-third wood volume removed in 0.2 ha circular patches) with clumped snags, (2) small-patch group-selection with scattered snags, (3) two-story (approximately three-quarter volume removed leaving 20 to 30 green trees/ha distributed uniformly throughout the stand) with clumped snags, (4) two-story with scattered snags, (5) modified clearcut (1.2 green trees/ha retained) with clumped snags, and (6) modified clearcut with scattered snags (Figure 1). Harvesting began in fall 1989 and was completed by early spring 1991.

Following harvest, Douglas-fir basal area averaged 29 m^2/ha in small-patch stands, 12 m^2/ha in two-story stands, and 1 m^2/ha in modified clearcuts. Hardwoods averaged 9 m^2/ha in small-patch stands, 3 m^2/ha in two-story stands, and 1 m^2/ha in clearcuts. Grand fir was absent. Conifer density (trees ≥ 20 cm dbh) averaged 441 trees/ha in small-patch stands, 130 trees/ha in two-story stands, and 18 trees/ha in clearcut stands. Hardwood density (trees ≥ 20 cm dbh) averaged 146 trees/ha in small-patch stands, 19 trees/ha in two-story stands, and 6 trees/ha in clearcut stands (Chambers 1996). Snags were created at an average density of 3.8 snags/ha. In small-patch group-selection stands, snags were created in the remaining forest matrix rather than in the harvested patches. Snags were topped within 6 months of harvest.

We created snags by sawing tops off 821 live Douglas-fir trees at a height of ≥15 m. Average height of these snags was 17

Table 1. Number of stands for each silvicultural treatment and snag arrangement by replicate. Silvicultural treatments were small-patch group selection (n = 14), two-story (n = 6), and modified clearcut (n = 6). Snag arrangements were clumped (CL) and scattered (S). Replicates were located on McDonald-Dunn Research Forest, Corvallis, Oregon between 1989 and 1991.

	Silvicultural treatment					
	Small patch		Two-story		Clearcut	
Replicate	CL	S	CL	S	CL	S
Lewisburg Saddle	3	3	1	1	1	1
Peavy	3	3	1	1	1	1
Dunn	1	1	1	1	1	1
Total	7	7	3	3	3	3

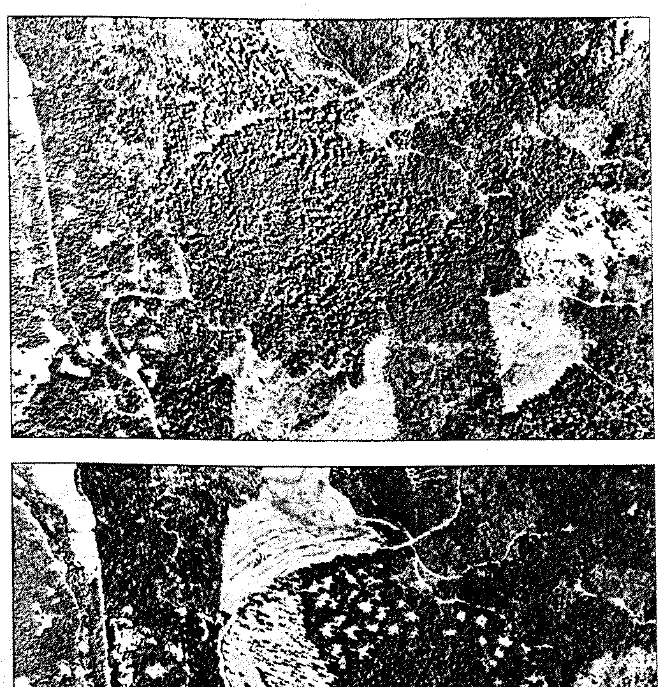

Figure 1. Layout of Lewisburg Saddle replication in the McDonald-Dunn Research Forest, Corvallis, Oregon before (top) and after harvesting.

m and average diameter was 75 cm. A numbered aluminum tag was nailed to each conifer snag. Baseline data for all snags were collected within 3 months of snag creation in 1990 and 1991. We revisited each snag in 1995 to monitor condition and use by cavity nesters. We used number of excavated cavities per Douglas-fir snag as an indicator of cavity-nester use.

Snags

We collected data on 15 characteristics for each snag (Table 2) recording diameter prior to topping and collecting data for other variables after topping. Decay class was determined using Cline et al.'s (1980) descriptions of stages of decomposition.

We categorized bird use of snags as nesting habitat or foraging substrate. Nesting habitat included excavated and natural cavities. We defined an excavated cavity as (1) any circular opening that appeared to the observer on the ground to have adequate depth for the smallest cavity nester (house wren, *Troglodytes aedon*) to use as a nest site or (2) a rectangular opening created by a pileated woodpecker (*Dryocopus pileatus*). A natural cavity occurred at a limb break where an inclusion occurred.

Foraging substrate included foraging cavities. A foraging cavity was an irregular opening that appeared to be (1) on the surface of the snag, (2) too small for a house wren, or (3) ≥7.5 cm in diameter. Most foraging cavities were connected in a line along the bole or scattered at the base of the snag.

Statistical Analysis

We compared number of excavated, natural, and foraging cavities among silvicultural treatments and snag patterns. We monitored 376 scattered snags and 445 snags in clumps. The experimental design was a randomized complete block with a one-way treatment structure. We used analysis of covariance to determine if decay class, number of dead limbs, percent slope, and percent lean explained a significant proportion of the variation in cavity number. We used Fisher's protected LSD ($\alpha = 0.05$) to compare treatments. All variables were log transformed ($\log_{10}$[variable+1]) to meet the assumptions of equal variance and normally distributed residuals. Averages for density of excavated cavities and their standard errors (SE) are reported as untransformed values. We used logistic regression as a means of selecting variables that separated snags used by cavity nesters from unused snags.

Results

We found few excavated cavities in newly created snags. Three months after topping, there were 0.01 cavities/snag in clearcuts (SE = 0.15); 0.02 cavities/snag in two-story stands (SE = 0.19); and no cavities/snag in small-patch stands. Five years after topping, excavated cavities had increased significantly in all silvicultural treatments ($P = 0.0001$). Excavated cavaties per snag averaged 1.8 in clearcuts, 2.1 in two-story stands, and 0.6 in small-patch stands (Table 3). There was no detectable difference in the number of excavated cavities per snag between clearcut and two-story stands ($P = 0.5$). Number of excavated cavities per snag was significantly greater in two-story and clearcut stands than in small-patch stands ($P \leq 0.0004$) (Table 3).

Five years after topping, we found no difference among treatments in snag height, bark cover, scorch, number of dead limbs, or lean ($P > 0.10$). Snags averaged 18.8 m tall in clearcuts (SE = 0.4), 17.2 m in two-story stands (SE = 0.2), and 17.0 m in small-patch stands (SE = 0.1). Bark cover was 98.8% (SE = 0.3) in clearcuts, 98.9% (SE = 0.4) in two-story stands, and 99.2% (SE = 0.2) in small-patch stands. Percent scorch averaged 0.5 (SE = 0.2) in clearcuts, 0.2 (SE = 0.2) in two-story stands, and 0.0 (SE = 0.0) in small-patch stands. Number of dead limbs per snag averaged 1.7 for clearcuts (SE = 0.3), 2.1 for two-story stands (SE = 0.4), and 1.5 for small patch stands (SE = 0.3). Snag lean averaged 1.7° in clearcuts (SE = 0.2), 1.4 in two-story stands (SE = 0.2), and 1.9 in small-patch stands (SE = 0.2). Ground slope at each snag averaged 30% in clearcuts (SE = 1), 24% in two-story stands (SE = 1), and 24% in small-patch stands (SE = 1).

Table 2. Characteristics collected for snags, McDonald-Dunn Research Forest, Corvallis, Oregon.

Variable	Definition
Dbh	Snag diameter (cm) at 1.4 m height above ground
Height	Snag height (m)
Dead	Snag condition D = dead, A = alive (≥1 live branch present)
Bark cover	Percent of bole bark cover
Scorch	Percent of bole with scorch
Excav. cavities	Number of excavated cavities
Forage cavities	Number of foraging cavities
Natural cavities	Number of natural cavities
Dead limbs	Number of dead limbs >10 cm diameter, >30 cm length
% slope	Percent slope of ground averaged from 20 m upslope and down-slope from snag
Lean	Degrees of lean of snag from perpendicular to ground
Decay class	Decay class (see Cline et al. 1980)
Standing	Snag condition: standing or fallen

Table 3. Snag characteristics [mean (SE)] for Douglas-fir snags topped by chainsaw 5 yr after topping, McDonald-Dunn Forest, 1995. We did not detect a difference ($P > 0.10$) among treatments with the same letter.

Treatment	*n*	Dbh (cm)	No. of excavated cavities/snag[1]	No. of natural cavities/snag	No. of foraging cavities/snag	Decay class
Clearcut	205	94 (2)	1.8a (0.3)	0.6a (0.1)	3.7a (0.8)	2a (0)
Two-story	223	92 (3)	2.1a (0.3)	0.7a (0.1)	4.1a (0.8)	2a (0)
Small patch	393	75 (1)	0.6b (0.3)	0.6a (0.1)	2.3a (0.5)	2a (0)

[1] Significant difference among treatment means ($P = 0.0001$). We did not detect a difference ($P > 0.5$) between number of excavated cavities in treatments with the same letter.

We found no relationship 5 yr after harvest between number of excavated cavities and dead limbs, ground slope, or lean of snags. When we used decay class as a covariate and omitted silvicultural treatment, however, we did find a relationship between decay class and number of excavated cavities [significant difference between decay classes 1 and 2 for two-story (P = 0.009) and clearcut (P = 0.09) stands]. We found that snags with the highest probability of containing ≥ 1 excavated cavity were in two-story or clearcut stands, were dead (no live branches present), of large diameter, and had ≥ 1 natural cavity present.

We did not detect a relationship between snag pattern (clumped v. scattered) and number of excavated cavities in any silvicultural treatment (P = 0.6). Nor did we detect any relationships between number of natural or foraging cavities and dbh, height, dead limbs, bark cover, slope, lean, and decay class among silvicultural treatments (P > 0.1).

Discussion

Douglas-fir snags created from live trees were used by both primary and secondary cavity-nesting birds within 5 yr after topping. Some primary cavity nesters excavate cavities in relatively sound wood and might be expected to use hard snags (snags in decay class 1, 2, or 3) (Brown 1985). We found, however, primary cavity nesters that nest in more decayed snags [e.g., northern flicker *(Colaptes auratus)*] as well as secondary cavity nesters that use cavities created by primary cavity nesters (unpublished data). Their presence indicated that nest sites were available within a short time period following topping.

Snags in clearcut and two-story stands (open-canopy stands) contained more excavated cavities than snags in small-patch stands (closed-canopy stands). There were more species of primary and secondary cavity-nesting birds such as the red-breasted sapsucker *(Sphyrapicus ruber)*, hairy woodpecker *(Picoides villosus)*, northern flicker, black-capped chickadee *(Parus atricapillus)*, chestnut-backed chickadee *(Parus rufescens)* in open-canopy than in closed-canopy stands (red-breasted sapsucker, northern flicker, chestnut-backed chickadee) (unpublished data) which may have resulted in greater use of newly available snags.

Pileated woodpeckers are associated with mature or old-growth forest (Brown 1985) and might use snags in small-patch stands. Their home range size (120 to 240 ha) (Brown 1985), however, was larger than the size of our replicates (approximately 100 ha each) so they probably occurred at low densities in our study area. We did observe pileated woodpeckers using topped snags in clearcut and two-story stands for foraging and territorial calling but did not find pileated woodpecker nests in these stands. Presumably pileated woodpeckers nested in adjacent old-growth stands or were undetected in small-patch stands. The lower density of cavity nesters associated with mature forest may have contributed to the lower number of excavated cavities in small-patch stands.

Decay rates of created snags may have been higher in open-canopy stands than closed-canopy stands. We classified decay based on physical appearance of the snag rather than internal wood structure or insect abundance. Use of snags in open-canopy stands may have been higher than in closed-canopy stands if snags were decaying at faster rates or if insects were more abundant.

Although Douglas-fir snags are an important resource for many cavity nesters, hardwoods also provide nesting opportunities. Some birds (e.g., house wrens) use natural cavities in hardwood snags. Other birds excavate cavities in dead or dying branches of living hardwoods (e.g., red-breasted sapsuckers). Incidental to monitoring created snags, we found excavated cavities in five hardwood species. Bigleaf maple (187 trees with cavities, dbh = 33.0 to 41.7 cm, height = 14.3 to 17.9 m) and Oregon white oak (140 trees with cavities, dbh = 39.4 to 59.0 cm, height = 11.0 to 14.2 m) were the most abundant hardwoods containing excavated cavities. Pacific madrone, Oregon ash, and bitter cherry represented only 2% of hardwoods containing excavated cavities (Pacific madrone: 3 trees, dbh = 45.0 to 61.0 cm, height = 10.7 to 19.8 m; Oregon ash: 2 trees, dbh = 35.8 cm, height = 16.8 m; bitter cherry: 1 tree, dbh = 31.0 cm, height = 16.8 m). We also found 9 of 18 red-breasted sapsucker nests in dead branches of live bigleaf maples and hairy woodpeckers and northern flickers nesting in hardwood snags (unpublished data).

Natural cavities are usually more abundant in hardwood snags and live hardwood trees with dead branches than Douglas-fir trees and snags (Gumtow-Farrior 1991). Many hardwood species decay at faster rates than Douglas-fir, so birds that nest in soft conifer snags (decay class 4 and 5) may use hardwoods for nesting in the absence of conifers. We rarely observed birds using natural cavities in our created Douglas-fir snags, nor were natural cavities readily available. Five years after we created snags, the number of natural cavities per Douglas-fir snag was only one-third the number of excavated cavities.

We did not detect a difference in number of excavated cavities between the two spatial arrangements of snags. We used number of excavated cavities, however, as an index of snag use rather than active nest sites. Although we detected increases in number of cavities in all silvicultural treatments, we did not document bird species creating or using these cavities. Some species that use large home ranges may exclude other individuals. Clumping snags may reduce bird densities if clumps are not adequately spaced to account for territoriality, although some species nested in adjacent snag clumps (100- to 200 m apart) (e.g., we observed three pairs of red-breasted sapsuckers nesting in adjacent snag clumps in a two-story stand).

Management Recommendations

Creating snags may retain or increase populations of cavity nesters in areas with low natural snag densities. In westside Oregon Douglas-fir forests, cavity nesters used snags topped with chainsaws within a short time period (within 5 yr of creation). When we used number of excavated cavities as an indicator of use, we did not distinguish differences based on snag spatial pattern. Since we did not document actual nest locations with regard to spatial pattern we cannot recommend a snag arrangement: both appeared effective. Clumping snags probably offers some economical advantages since it is easier to locate, monitor, and operate equipment around clumps. Scattered snags, however, may allow higher densities of highly territorial species to persist since snags are widely distributed across the landscape. A combination of both spatial arrangements may be optimal since both are observed in unmanaged forests. If only one arrangement can be selected, identifying home range sizes and territory sizes of species of interest may help in selecting spatial arrangement.

Bull and Partridge (1986) found that topping with a chainsaw yielded the best cost/benefit results in northeastern Oregon. Snags died immediately, had a low fall rate, and were used more frequently by cavity-nesting birds than snags created by other techniques. Cost of topping snags in our study was relatively low. Snag topping averaged $30 per tree. This technique was acceptable to adjacent landowners and helped us avoid problems related to creating snags with dynamite.

We created snags that were ≥ 53 cm in diameter (average diameter was 75 cm). Although we selected 53 cm as a minimum snag size based on snag sizes used by cavity-nesting birds in western Oregon, snags as small as 28 cm may be used by some cavity-nesting birds (Brown 1985). Topping smaller trees (< 53 cm) may limit use since fewer animal species can use small snags for nesting (Brown 1985), and small snags do not persist as long as large snags (Morrison and Raphael 1993).

Knowing which trees or snags will remain standing longest and be used most by cavity nesters can provide guidance in developing a snag management plan. There are several models available to predict current and future snag densities and pre- and post-harvest snag densities (Bull 1978, Bull et al. 1980, Morrison and Raphael 1993). Most of these models require a previous knowledge of species decay rate. Cline et al. (1980) assigned five stages of decay for Douglas-fir in the Pacific Northwest. These stages depend on the amount of deterioration of the needles, branches, bark, sapwood, and heartwood from a snag. Other considerations are the cause of death and diameter. Independent of silvicultural treatment, decay classification was the strongest predictor of number of excavated cavities in our study. Excavated cavities were more abundant in snags with ≥ 1 natural cavity. Natural cavities may be indicators of decay, and their presence may aid in selecting snags to be retained or live trees to be topped.

We recommend monitoring snag condition every 5 yr to determine fall rate, decay rate, and use by cavity-nesting species. Conducting surveys of cavity nesters during the breeding season to document population trends can help determine types of snags that are most effective in maintaining cavity-nester populations.

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