Created Snag Monitoring on the Willamette National Forest[1]

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Abstract
Management agencies currently create snags from live trees and leave them in stands after cutting. Little information exists on the use of these snags by wildlife. This study had two objectives: to document whether created snags were used by wildlife, and if used, to elucidate stand and snag features associated with the use of these created snags by wildlife. We documented sign of woodpecker foraging and/or nesting or roosting use, along with snag and stand features in 55 systematically selected stands across the Willamette National Forest in Oregon. We found that woodpecker use was associated with created snag characteristics. Mainly, the status (live or dead) of the created snag was associated with the presence or absence of woodpecker foraging excavations. Management considerations are discussed, including the need to monitor wildlife use before and after created snags are killed and in subsequent years.

Introduction

Standing dead trees (snags) are important resources for vertebrate and invertebrate species worldwide and to forested ecosystems. They return essential nutrients to the soil and increase soil fertility. Throughout North America, over 85 species of birds use snags for nesting, foraging, or drumming (Raphael and White 1984, Scott and others 1977). In the Douglas-fir *(Pseudotsuga menziesii)* and western hemlock *(Tsuga heterophylla)* forests of the Pacific Northwest, over 100 vertebrate species utilize snags for some part of their life cycle (Neitro and others 1985, Thomas and others 1979). Approximately 20 percent (34 species) of all bird species in the Pacific Northwest depend on snags for nesting and feeding (Carey and others 1991, Lundquist and Mariani 1991). Furthermore, the abundance of snag-dependent birds has been shown to be correlated with the density of suitable snags (Carey 1995, Scott 1979, Stribling and others 1990, Zarnowitz and Manuwal 1985). Also populations of northern flying squirrel *(Glaucomys sabrinus),* the primary prey item of the threatened northern spotted owl *(Strix occidentalis caurina)* reach their highest densities in forests with large snags (Carey 1995).

Despite current widespread understanding of their importance for wildlife, and their prevalence in natural forested systems (Carey and others 1991, Ohmann and others 1994, Spies and Franklin 1991, Spies and Thomas 1988, Tyrrell and Crow 1994a, 1994b), snags have been systematically eliminated from managed landscapes

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for several decades (Carey 1995, Zarnowitz and Manuwal 1985), due to concerns about the role that snags may have in creating conditions suitable for fires, insect outbreaks, and as hazard trees. Within the past 15 years, however, most State and Federal and some private land management agencies have devised strategies to maintain, and in some cases enhance, snag abundance on their lands (USDA and DOI 1994).

Ways to enhance habitat for snag dependent wildlife are being tested by blasting or sawing the tops off of living trees; girdling live trees; inoculating live trees with fungus; and inducing bark beetle attacks. During the past 15 years, management plans on the Willamette National Forest (WNF) in western Oregon have required that varying levels of natural and artificially created snags be retained in units that are harvested for timber (USDA and DOI 1994). While snags have been artificially created by all three methods on the WNF, the vast majority have been artificially created by blasting and sawing off tree tops. At this time, however, very little information exists on the use of these artificially created snags by wildlife (Chambers and others 1997), or on the decay and fall-down rates of artificially created snags.

To address this lack of information, we began a long-term monitoring project in the summer of 1997. The objectives of this project were to establish a stratified sample of snags across the Willamette National Forest to be repeatedly sampled over time and to elucidate factors that are associated with the use of snags by wildlife (primarily bird) species.

In this report, we provide summary statistics of 1,267 snags (96 percent were artificially created, 4 percent natural) that we monitored during 1997 and 1998. In addition, we report the results from statistical analyses that addressed the question: Was total woodpecker use of created snags associated with structural characteristics of the snag and the stand?

Methods

Study Area

The study occurred on the Willamette National Forest (WNF) in Marion, Linn, and Lane counties, Oregon in west central Oregon in the Cascade Mountains.

Criteria for Selecting Stands with Created Snags

We surveyed a sample of stands that was stratified by elevation, year of snag creation, and WNF Ranger District. The initial pool of stands subsampled was developed using the WNF's stand treatment database (STD). This database contains details on all management activities for each stand on the WNF. We first queried STD for all stands containing created snags. Because we intended to collect data on every created snag within a stand, we chose stands that contained only as many snags as we thought we could survey during one working day (40 or less). We therefore shortened the initial list by selecting only those stands that contained from 10-40 created snags.

From this shortened list, we stratified the sample by median elevation (915 m), median year of snag creation (1993), and seven WNF ranger districts to obtain a diversity of tree species, wildlife using the trees, and tree decay levels (obtained from sampling trees killed in different years). In one of the WNF's Ranger Districts

(Lowell), there were no stands above 915 m that met our criteria. We used the median values as breaking-points and randomly sorted all the stands from the shortened list into the appropriate categories, and then randomly selected stands within each cell using Microsoft Excel's random number generator *(table 1)*.[4] For each of the randomly selected stands, we intended to locate and monitor all of the created (but not natural) snags in the stand, but this did not always occur.

Table 1—*The initial sampling regime for the study. For each of the cells shown in this table, four stands were randomly selected from the entire list of stands in the WNF's STD that contained from 10-40 created snags. In the Lowell Ranger District, there were no stands above 915 m that met these criteria, so two of the cells (denoted by "NA" in the table) in the sampling regime were empty. There were a total of 55 stands sampled. These were evenly distributed between each of the Ranger Districts, elevations, and age classes.*

	Elevation ≤ 3,000 feet		**Elevation > 3,000 feet**	
Ranger District	**Snag created ≤ 1993**	**Snag created > 1993**	**Snag created ≤ 1993**	**Snag created > 1993**
Detroit				
Sweet Home				
McKenzie				
Blue River				
Rigdon				
Oakridge				
Lowell			N/A	N/A

Logistical Problems Altered the Sampling Design

The trees that we selected for snag creation did not represent an unbiased, random sample of trees with or without prior wildlife use because of three major problems:

- Problem 1—Inaccessibility: Several of the stands that were selected at random were not accessible due to road closures (e.g., from mudslides or extensive tree fall-down over roads). When these road closures occurred > 1 mile from our randomly selected stand, we omitted the stand from the study. When this occurred, we substituted the nearest accessible stand in the same cell in our sampling design as the omitted stand.
- Problem 2—Stands without created snags: All of the stands that were selected at random were reported, in the stand treatment database (STD) to contain between 10-40 created snags. However, when we arrived at several of the stands, we were unable to locate any created snags. When this occurred, we substituted the nearest accessible stand in the same cell in our sampling design *(table 1)* as the omitted stand.
- Problem 3—Stands with more than 40 created snags: A third problem we encountered was that the actual number of created snags in a stand far exceeded the number reported in the STD. When we encountered stands with

[4] Trade names or products are mentioned for information only and do not imply endorsement by the U.S. Department of Agriculture.

> 40 created snags, we arbitrarily chose a starting point within the stand (usually near the landing) and sampled the first 40 trees that we encountered.

Finally, in addition to the stands that we selected and surveyed for the first time, we also re-surveyed 311 natural and artificially created snags that had been monitored in 1995 following a nonrandom selection process (Shope 1995).

Features of Created Snags That Were Recorded

We marked each created snag with a unique number on two aluminum tags (to facilitate relocating the snag in the future) and recorded its position (latitude, longitude, and elevation) with 1-m accuracy using a global positioning system (Trimble Pathfinder Pro XL) with differential correction (Trimble Pathfinder Office, version 1.1). We also recorded all the features at each created snag *(table 2)* and a stand level variable called "lscape" that we created.

Table 2—*Description of features recorded at each created snag.*

Snag Feature	Units	Methods
Species	Species code	Visual assessment of snag species
Year killed	Year	Year snag created. Obtained from Stand Treatment Database at the Willamette National Forest Supervisors Office, Eugene, Oregon
DBH	Inches	Used a diameter tape to measure diameter at breast height of snag.
Height	Feet	Used a clinometer and rangefinder to measure current height of snag.
Decay class	1, 2, 3	Visual estimation of decay class (Parks and others 1997).
Elevation	Meters	Obtained from GIS coverage listing the mean elevation of all harvested stands on the WNF
Pct bark	0-100 pct	Visual assessment
Status	Live or dead	Live snag was one with at least one branch with green needles Dead snag was one with no branches with green needles
# limbs	Count	Visual assessment of # dead and live limbs > 0.91 m long that extend from bole
# green branches	Count	Visual assessment of # green limbs. Green limbs are limbs that have at least one green leaf.
Treatment	Natural, sawed, blasted, inoculated, girdled, unknown, other	Visual assessment
Damage type	Lightning, conch, logging, insect, list others	Visual assessment for lightning scars, fungal conchs, logging damage, insect damage, wind damage, etc.
Pct damage	0-100 pct	Visual assessment of percentage of tree with specific damage types.
Fire scar	Yes, No	Visual assessment of fire scars.

Snag Feature	Units	Methods
Pct fire scar	0-100 pct	Visual assessment.
Sapsucker use	Yes, No	Visual observation of linear rows of small holes in trunk or limbs (Bent 1964).
New pileated foraging excavations	Count	Count of rectangular-shaped, approximately 5 cm deep and lighter in color than the surrounding wood, or with fresh wood shavings at the base (Bent 1964).
Old pileated foraging excavations	Count	Count of rectangular-shaped, approximately 5 cm deep and the same color as the surrounding wood (Bent 1964).
New woodpecker foraging excavations	Count	Count of foraging excavations that are not rectangular in shape, approximately 5 cm deep, lighter in color than the surrounding wood, or with fresh wood shavings at base, but are not rows of small holes.
Old woodpecker foraging excavations	Count	Count of foraging excavations that are not rectangular in shape, approximately 5 cm deep, same color as the surrounding wood, but are not rows of small holes.
New nest cavities	Count	Count of foraging excavations that appear very round or elliptical in shape and appear to be hollow in the interior. Also, the foraging excavation appears to a lighter color than the surrounding wood and/or fresh wood shavings at the base.
Old nest cavities	Count	Count of foraging excavations that appear very round or elliptical in shape and appear to be hollow in the interior. Also, the foraging excavation appears to the same color as the surrounding wood.
Other use	Yes, No	Visual assessment of other wildlife use. For example, bear scratches or current use by a chipmunk, squirrel, or bird. Record in notes.

We classified foraging excavations (holes in the bark, not scalings) and nest/roost cavities in the created snags as new or old. New foraging excavations and cavities were those that were a lighter color than the surrounding wood and/or had fresh wood shavings at the base. Old foraging excavations and cavities were the same color as the surrounding wood and did not have fresh wood shavings at the base. The new foraging excavations were potentially the more reliable observations for addressing use of created snags because they were obviously done after the snag was created. Although old use may have occurred after snag creation, it may also have been present before the snag was created. Hereafter, foraging excavations and nest cavities in the created snags will be referred to as new or old.

Pileated woodpecker *(Dryocopus pileatus)* foraging excavations were distinguished from all other types of foraging excavations by their rectangular shape and depth between 3 cm and 1 m deep (Bent 1964). Sapsucker foraging excavations were not classified as new or old but were distinguished from all other foraging excavations by their unique pattern of deeply cut holes, less than 0.5 cm in diameter and usually arranged in horizontal lines around the trunk (Bent 1964). Nest or roost cavities were distinguished from foraging excavations by their round or elliptical shape typical of certain woodpecker species such as pileated woodpecker and Northern flicker *(Colaptes auratus),* which were common in the study area.

Creation of Landscape Variable

We used geographic information systems (GIS) to create a stand level variable for the regression analyses called "lscape": the amount of late-successional forest in the adjacent landscape (i.e., within 500 m of the stand). Below we briefly outline the series of steps taken in GIS to create this variable.

The "lscape" variable was created by first identifying the predominant size-class of the trees within 500 m of each stand of created snags using ARC INFO, GIS software. We then calculated the percent of area in each stand's 500 m buffer that consisted of size classes typical of late successional forest on WNF. The size classes in the Veg6 GIS data layer that most closely fit this criterion are codes 6.0 through 7.1, which correspond to large (83-121 cm dbh) and giant (> 121 cm dbh) trees. In addition, the Veg6 data layer contains one size-class category (class 5.5) that includes both medium (53-82 cm dbh) and large trees. For the purposes of this analysis, we class 5.5 to be large trees.

Analyses

Descriptive Statistics

We calculated descriptive statistics using Microsoft Excel.

Regression Analyses

We used logistic regression to analyze the relationship of woodpecker use of created snags associated with snag and stand characteristics using S-Plus software version 4.5 from MathSoft, Inc. The presence or absence of new woodpecker foraging excavations on a created snag was the response variable in the models, and the variables listed in *table 2*, along with Universal Transverse Mercators, "lscape," and elevation, were the explanatory variables representing snag and stand characteristics.

The regression models were constructed using two data sets, one with 1,267 snags (96 percent created snags) excluding the explanatory variable, "snag age" (years since tree killed), and another with 1,223 records that included the explanatory variable "snag age." Two data sets were used because snag age was an additional characteristic that might have to be associated with bird use. The different sample size in each data set was due to some missing data on the year of snag creation for certain stands.

Results, Discussion, and Recommendations

Descriptive Statistics

Types of Snags Monitored

We monitored 1,267 snags in 55 harvested stands on seven districts of the Willamette National Forest over 1997 and 1998. The elevation of the created snags ranged from approximately 333 m to 1,848 m. Approximately 85 percent of the snags were artificially created by blasting or saw topping, 11 percent by girdling or inoculating, while 4 percent were natural. The blasted and sawtopped snags were all over 27 m in height. The blasted snags ranged in dbh from 38 to 191 cm; the saw-top snags ranged from 40 to 183 cm dbh; the one girdled tree was 62 cm dbh; and the natural snags ranged from 53-172 cm. Eighty-seven percent were Douglas-fir *(Pseudotsuga menziesii),* 38 percent were still partially alive with green branches, and 95 percent were in the first two stages of decay (decay classes follow Parks and others [1997] in which class 1 represents those trees that died recently and retain most of their bark and branches with their top intact; class 2 represents those snags that have been dead at least several years and have lost some branches and some bark; and class 3 represents those snags dead a long time and lack branches and bark).

We report only new bird use below because we cannot be certain that old bird use was not done before the snag was created.

- Foraging use by sapsuckers and pileated woodpeckers: Only 1.5 percent of the snags had new foraging excavations by pileated woodpeckers. Sapsucker use was present on 1.5 percent of the snags.
- Foraging use by other birds: Nearly half of the created snags monitored (49 percent) had new foraging excavations from other woodpeckers and other unidentified excavators.
- Nest/Roost cavities in created snags: New cavities were present on 1.2 percent of the snags. Of the 17 snags with new cavities, 2 were naturally created; 1 was girdled; 1 was unknown; and the rest were blasted or saw-topped. Also, of these 17, 2 had class 1 decay, 2 were class 3 decayed, and the rest were class 2 decay. The majority of these 17 snags had 80 percent of their bark remaining with 7 having 60 percent of their bark remaining.
- Use by species other than birds: Evidence of use by species other than birds on the created snags was present on 1.8 percent of the snags. Detecting use by other species was difficult since they did not always leave obvious signs. However, we did observe an unidentified species of bat leaving one created snag and a chipmunk climbing up another.

There were few created snags in this project with foraging use by pileated woodpeckers and sapsuckers. The majority of created snags that we monitored were recently killed (within the last 10 years), had little decay, and therefore, may not house carpenter ant colonies, one of the major prey items of the pileated woodpecker (Bent 1964). The low level of use by these species could also reflect their limited abundance in the forests surrounding the harvested stands we surveyed. We did not conduct bird abundance studies in the harvested stands that we monitored.

Nearly half of the created snags had new foraging excavations by woodpeckers and other unidentified excavators, indicating that one or more species that occur in the elevation range of our project (e.g., hairy woodpecker *[Picoides villosus],* downy woodpecker *[Picoides pubescens],* or red-breasted nuthatch *[Sitta canadensis])* were using these snags for foraging.

There were few created snags in this project with nesting or roosting cavities. The majority of created snags that we monitored had little decay and therefore may not have been soft enough for cavity foraging excavation by some birds. The low level of cavities could also reflect the limited abundance of cavity excavators in the forests surrounding the harvested stands we surveyed.

Bird Use Associated with Created Snag and Stand Characteristics

New Woodpecker Foraging Excavations

We conducted regression analyses to investigate whether new woodpecker foraging excavations were associated with snag and stand characteristics. This analysis was based on the null hypothesis that new woodpecker foraging excavations were random events.

The data set used in the analysis contained 1,267 created snags with the response variable presence/absence of "new woodpecker foraging excavations" and the explanatory variables listed in *table 2* (excluding snag age). Data was analyzed using the following steps:

- First**,** presence/absence of new woodpecker foraging excavations was statistically tested against all explanatory variables using logistic regression for binary responses. Stand differences were found to be statistically different. Stand-level variables, such as "lscape" and elevation, were not found to be significantly associated with stand differences in the response variable.
- Next, the same logistic regression model was rerun with the 1,267 snags and this time corrected for stand differences. This means that, within the regression model, the stand average count (total count in that stand divided by the number of created snags in that stand) was subtracted from each individual snag count. This put all of the snags on an even basis, as if they all were from the same stand. Obviously, this eliminated all stand-level differences. We did this only after checking all stand-level variables for significance (and finding none), and only when "stand," as a categorical variable, was significant.

This second model provided convincing evidence that the status (live or dead) of the created snag was associated with the presence/absence of new woodpecker foraging excavations (p-value <0.00004). Specifically, the odds of the presence of new woodpecker foraging excavations on dead created snags was estimated to be 2.3 times the odds of the presence of new woodpecker foraging excavations on created snags that were still living (95 percent Confidence interval: 1.5 times to 3.4 times) *(table 3).* Many of the foraging excavations were deep (greater than 5 cm) into the cambium, where the woodpeckers may have been foraging for insects. Insect colonies may be more abundant in dead trees than in live. This inference may be useful in selecting a preferred method of snag creation and/or post-creation treatments.

We did not randomly select which trees within each of the harvested stands were to be converted to snags, therefore this project was observational. Stronger inferences about the association of bird use with created snag characteristics may be gained by instituting experimental controls in future snag creation efforts.

Table 3—*Coefficients and equation for the logistic regression model providing convincing evidence that the status (live or dead) of the created snag and the presence of old woodpecker foraging excavations were associated with the presence/absence of new woodpecker foraging excavations (p-value <0.00004).*

Equation: $\log\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \sum_{i=1}^{55}\left(\beta_i s \tan d_i\right) + \beta_1 + \varepsilon$ where π is the proportion of new woodpecker foraging excavations, "$stand_i$" is an indicator variable for each stand (correcting for between stand differences), β_1 is a binary, categorical variable with a value of 0 if the created snag is dead and a value of 1 if the created snag is still alive, and ε is error. The sample size is 1,267 created snags, null deviance is 1,736.93 on 1,266 degrees of freedom, and residual deviance is 1,141.67 on 1,211 degrees of freedom.

Coefficient	Interpretation of coefficient	Standard error	p-value
β_0 0.458401	Intercept	0.874047	0.60000
β_1 -0.82203	Categorical variable 0=dead created snag 1=live created snag	0.197628	0.00003

Future Monitoring

The created snags in this project should be monitored over several years to observe current bird foraging and nesting during the spring breeding season when the actual birds, rather than just their foraging sign, can be documented. This could provide evidence on which species were not using these snags in the harvested stands, as well as information on what density and placement of created snags was associated with more frequent bird use. This may provide evidence that species such as the red-breasted nuthatch, identified as the primary cavity excavator and upon which several Willamette National Forest post-harvest snag retention rules are based (USDA Forest Service 1994), were utilizing the snags for nesting or roosting. Also, more studies should be initiated to monitor wildlife use of created snags before and after the snag is killed and in subsequent years. Wildlife use could also be compared between blasted, sawed and fungus and insect inoculated snags to learn more about the effect of each of these kill methods on wildlife use. Features monitored at each created snags should include insect use, because insects attract birds and other wildlife. In addition, fall down rates should be monitored as the snags age. This information will assist Willamette National Forest land managers with compliance with the Pacific Northwest Regional Forest Planning regulations (USDA Forest Service 1990, 1994) regarding selection and monitoring of snags left in harvested stands.

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