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Use of Conifer Stumps in Clearcuts by Bats and Other Vertebrates

Abstract

Although conifer stumps can constitute a large proportion of the volume of wood remaining in clearcuts, the amount and pattern of use of conifer stumps by bats and other vertebrates is poorly known. We made 18,168 observations of conifer stumps in four clearcuts to examine use of bark crevices on conifer stumps in clearcuts in western Oregon. Use of bark crevices by vertebrates did not exceed 1.5% of the stumps searched during any survey with upper 95% confidence intervals not exceeding 5%. Ten species of vertebrates were observed using bark crevices, with the western fence lizard most often detected. Use of stumps by bats was primarily limited to long-eared myotis. Most stumps used by vertebrates were relatively large Douglas-fir stumps located in open areas. Although bark crevices on conifer stumps in clearcuts provide habitat for some species of vertebrates they do not provide the breadth or long-term value as habitat for bats and other vertebrates as snags. Management of roost structures for bats, including the long-eared myotis, should focus on maintaining present and future availability of snags in an area.

Introduction

Dead wood is widely recognized as an important habitat component for wildlife and provides foraging, nesting, and roosting habitat for many species of amphibians, birds, mammals, and reptiles (Harmon et al. 1986, Maser et al. 1988, Bull et al. 1997, McComb and Lindenmayer 1999). Cavity-nesting birds and forest-dwelling bats are the two primary groups of species that depend extensively on snags (Bull et al. 1997, McComb and Lindenmayer 1999, Hayes 2003) and populations of some cavity-nesting birds are reduced if snags are not present or removed from an area (Mannan et al.1980, Zarnowitz and Manuwal 1985, Schreiber and deCalesta 1992, Sholwalter and Whitmore 2002). Although it is likely that abundance of many species of forest-dwelling bats are similarly linked to snag abundance, response of populations of forest-dwelling bats to removal of snags in coniferous forests has not been demonstrated empirically.

The removal of snags and decadent trees during forest management using standard logging, safety, and site establishment methods reduces the abundance of snags in a stand (Harmon et al. 1986, Spies and Cline 1988) and limits the availability of roosts for bats. As a consequence of the removal of dead wood during logging, conifer stumps often constitute a significant proportion of the wood remaining in a stand (Rolstad et al. 1998). Although some species of amphibians, cavity-nesting birds, forest carnivores, reptiles, and small mammals use highly decayed stumps in forested habitats (Steventon and Major 1982, Morrison et al. 1983, Spencer 1987, Bull and Holthausen 1993, Butts and McComb 2000, McCay 2000), use of conifer stumps with relatively little decay in young clearcuts has rarely been documented and our understanding of the importance of conifer stumps in young clearcuts as potential habitat for bats and other vertebrates that use snags is limited (Vonhof and Barclay 1997).

Vonhof and Barclay (1997) first documented use of bark crevices on conifer stumps in young clearcuts by non-reproductive male and female long-eared myotis (*Myotis evotis*) using visual searches (15 roosts in 14 stumps). Using radio telemetry, Waldien et al. (2000) found that reproductive female long-eared myotis often used conifer stumps, especially in areas primarily managed for timber production with little older forest. These data, combined with no evidence of use of stumps from telemetry work on other species of forest-dwelling bats (Campbell et al. 1996; Vonhof

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and Barclay 1996, 1997; Brigham et al. 1997; Ormsbee and McComb 1998; Waldien et al. 2000), suggest that conifer stumps offer regular roosting opportunities only for long-eared myotis, especially in intensively managed areas with limited numbers of snags. If stumps provide regular roosting habitat for long-eared myotis, then long-eared myotis should be frequently observed using stumps given their use of stumps (Vonhof and Barclay 1997, Waldien et al. 2000) and the availability of stumps in intensively managed areas. However, our understanding of the importance of conifer stumps as potential roosts to all species of forest-dwelling bats and the extent and pattern of use of stumps by the long-eared myotis remains limited.

Our objectives were to document the extent of the use of bark crevices on conifer stumps by bats and other vertebrates (amphibians and reptiles) in clearcuts harvested 6-10 yr earlier and to determine if amount of use changed during the summer. Furthermore, we were interested in determining if characteristics of stumps were associated with use by vertebrates that could be expected to use bark crevices on conifer stumps in this region.

Methods

We conducted the study on the west slope of the Cascade Mountains in Lane County, Oregon, between 44°30' and 43°58' north latitude and 123°50' and 122°30' west longitude. Climate in the study area is mild with average minimum temperatures of -2 to -5°C in January and average maximum temperatures of 24 to 29°C in July (Franklin and Dyrness 1988). Study sites were within the western hemlock (*Tsuga heterophylla*) zone (Franklin and Dyrness 1988).

The study area encompasses three major drainage systems: Fall Creek, Little Fall Creek, and South McKenzie River (Waldien 1998). Douglas-fir (*Pseudotsuga menziesii*) was the dominant overstory species in these areas; western hemlock and western redcedar (*Thuja plicata*) were minor components in many stands. Clearcuts were generally replanted with Douglas-fir after harvest. The Fall Creek watershed had relatively little timber harvest and is generally characterized by large blocks of forests >80 yr old. The Little Fall Creek watershed and the South McKenzie River area are primarily under private ownership and have been managed for high timber yield; these areas are generally dominated by younger forests (<80 yr) with a few small areas of older forests remaining.

We identified all clearcuts in Little Fall Creek watershed and the South McKenzie River area that were 6-10 yr old and were located within 2.4 km of open water. Clearcuts with these characteristics are typical of those used by long-eared myotis in the study area (Waldien et al. 2000). We randomly selected four stands (Booth Kelly, Coopers, Wader, and Little Fall) from the population of available stands; Coopers stand was known to have been used in 1996 by female long-eared myotis. Selected stands were ≥4.0 km apart. The Booth Kelly stand (22.9 ha, 670 saplings/ha), was harvested in 1989, was located on an easterly aspect, and was ca. 1.5 km from a pond. Forest stands in the immediate vicinity generally were closed canopy forests <80 yr old with some younger clearcuts interspersed. The Coopers (easterly aspect, 32.8 ha, 1640 saplings/ha) and Wader (northerly aspect, 46.5 ha, 885 saplings/ha) stands were located within 0.2 km of ponds and were harvested in 1989 and 1988. Forest stands in the immediate vicinity of both stands were generally younger clearcuts; there was an area of older, closed canopy forests >80 yr old downslope from the Wader stand. The Little Fall stand (21.0 ha, 820 saplings/ha) was harvested in 1988, was located on relatively level terrain with a slight westerly aspect, and was immediately adjacent to Little Fall Creek. Forest stands in the immediate vicinity generally were closed canopy forests <80 yr old with some younger clearcuts interspersed.

We paired stands for sampling based on physical proximity and road access for logistical reasons. We surveyed one pair of stands every other week between 7 May and 18 August 1997. Surveys at each pair of stands generally were completed on the same day except for surveys prior to 10 June and one survey during the week of 14 August when only one stand was surveyed in a day. Prior to 10 June, we searched 200-400 stumps per stand per day. Starting 10 June, we surveyed 600 stumps per stand and two stands per day, except on 14 August when we searched all stumps in the Little Fall stand.

For surveys conducted between 10 June and 18 August, we divided each stand into three areas of equal size and randomly identified two starting points in each area. We examined the first 100 conifer stumps with top diameters ≥10 cm encountered within a 6 m wide belt transect oriented along a randomly selected compass bearing from the starting point. A new direction was selected if a transect intercepted the edge of the stand. Individual stumps could be resampled during different surveys.

We visually located vertebrates in bark crevices on stumps by carefully pulling exfoliating bark away from the wood and visually inspecting the crevice (Vonhof and Barclay 1997). Flashlights, mirrors, and probes were used occasionally to inspect crevices. A probe was used to move bats to the opening of the crevice where they were carefully removed by hand. We attempted to extract only one bat from a roost for species identification to limit disturbance to the roost when more than one bat was observed within a crevice, and we assumed that bats remaining in the roost were of the same species. On several occasions, more than one bat was captured as it attempted to exit the roost. These observations supported our assumption that only one species simultaneously occupied individual roosts. Bats were identified to species and we determined their sex, age (Anthony 1988), and reproductive status (Racey 1988). Bats were individually marked with a tattoo punch (Boncorrosa and Smythe 1972) to allow identification of individuals in subsequent searches. All other vertebrates were extracted only if necessary for species identification. We did not attempt to distinguish among species of garter snakes (*Thamnophis* sp.). Although we occasionally observed western fence lizards (*Sceloporus occidentalis*), northern alligator lizards (*Elgaria coeruleus*), and garter snakes basking on stumps, these observations were not recorded because our objectives focused on use of bark crevices and because of potential sampling biases resulting from basking animals frequently fleeing upon our approach.

Although it is possible vertebrates were missed during searches of bark crevices, our estimate is a realistic estimate because <50% of the stumps sampled had any crevice that a vertebrate could enter and the vast majority of stumps with crevices were structurally simple with small crevices that were easily searched. Few stumps had large or complex bark crevices that would interfere with our ability to successfully detect individuals in a crevice.

We measured six habitat variables at all stumps used by vertebrates and at a subset of randomly selected stumps. During surveys prior to 10 June, we collected habitat data for all stumps searched. Starting 10 June, we randomly selected five of the six transects in a survey and measured habitat data on the first and last 10 stumps in each of the five transects (100 stumps) one time each month in each stand to increase the number of stumps searched in a stand during each visit. Each stump was identified to species and was classified as having or lacking a crevice under exfoliating bark with a minimum opening of 10 x 3 cm and a depth ≥10 cm (adapted from Waldien et al. 2000). We visually estimated the percentage of bark remaining on the stump (<5%, 5 to 40%, 41 to 75%, or >75%) and percent cover of vegetation or dead wood within 5 m that limited a bat from accessing the stump (≤50%, 51-75%, or 76-100%). We classified the height on the tallest side (0-25 cm, 26-100 cm, 101-200 cm, or >200 cm) and diameter (average of 2 perpendicular measures; 10-40 cm, 41-70 cm, 71-100 cm, or >100 cm) of each stump.

We used numerical methods (Leemis and Trivedi 1996) to construct exact 95% confidence intervals for the binomial proportion of stumps used on each sampling occasion. We tested the hypothesis that species used stumps independently of measured habitat characteristics using Fisher's exact test (Ramsey and Schafer 1997). However, since we found significant differences in all six characteristics of stumps among the four stands (Chi-square tests, all P-values <0.0001), we conducted tests on a stand-by-stand basis and restricted our analyses to used and available stumps that had crevices, and to species of vertebrates with ≥12 observations. Based on these criteria, we only tested for associations between stump use and habitat characteristics for the western fence lizard in one stand, and for the northern alligator lizard in two stands.

We made additional observations of vertebrates in conifer stumps in other stands in our study area during a contemporaneous study of long-eared myotis (Waldien et al. 2000). These observations are not included in analyses of extent of use or associations with characteristics of stumps, but are presented to provide a more complete documentation of use of bark crevices by bats and other vertebrates.

Results

We made 18,168 observations of conifer stumps during 32 systematic searches in four clearcuts (8 searches per stand; Table 1). We identified six species of vertebrates in bark crevices on 79 conifer stumps (81 observations) and detected four additional species during ancillary searches of conifer stumps in other stands (Table 1). Frequently a single species accounted for the majority of observations in a stand and no species was observed using stumps in all four stands (Table 1). Western fence lizards and northern alligator lizards were the most commonly observed species. Long-eared myotis was the only species of bat encountered during systematic surveys (7 roosts in 6 stumps) and was the species most often observed during ancillary searches in other stands (Table 1). California myotis (*Myotis californicus*), fringed myotis (*M. thysanodes*), and Yuma myotis (*M. yumanensis*) were observed infrequently using stumps during ancillary searches in other stands (Table 1). All were solitary adult males.

Estimated use of stumps by vertebrates (all species combined) ranged from 0 (95% CI = 0.0-0.6%) to 1.5% (95% CI = 0.5-4.3%) of the stumps searched (n = 0-20 stumps) during a given survey (Figure 1). Observations of vertebrates in bark crevices suggest seasonal shifts in use. Bats and reptiles were observed most often from June to September prior to the onset of fall rains, and clouded salamanders (*Aneides ferreus*) were observed most often after the onset of fall rains in September. Amphibians represented only 3.4% of the vertebrates observed in bark crevices from May through August (n = 88 vertebrates), but represented a much higher proportion of observations in September (n = 20 vertebrates; 30%) and October (n = 14 vertebrates; 64%). Conversely, bats and reptiles represented 96.4% of observations from May through August and relative observations of bats and reptiles decreased in September (70%) and October (36%).

We observed bats roosting in stumps on 24 occasions (systematic and ancillary searches combined). The majority of the roosts comprised single bats (17 of 24 roosts); four roosts had 2 bats each and each of three additional roosts had 4, 5, and 14 bats. The largest colony of bats (14 bats) we observed was in a high cut stump. Of the 24 bats extracted from roosts, we identified 12 adult (9 females, 3 males) and 8 juvenile (6 females, 2 males) long-eared myotis. We observed juvenile long-eared myotis roosting singly in stumps on four separate occasions.

TABLE 1. Observations of vertebrates in bark crevices during systematic surveys of conifer stumps in four stands in western Oregon, during May to August, 1997, and ancillary searches for vertebrates in conifer stumps, during July 1996 to September, 1997.

	Systematic Searches					
	Stands					
	Booth Kelly	Coopers	Wader	Little Fall	Total	Ancillary Searches
Stumps Searched	3,900	4,200	4,350	5,718	18,168	
Species						
California myotis	0	0	0	0	0	2
Long-eared myotis	0	2[a]	1	4[b]	7[a,b]	13
Fringed myotis	0	0	0	0	0	1
Yuma myotis	0	0	0	0	0	1
Clouded salamander	0	2	1	0	3	17
Pacific tree frog	0	0	0	0	0	1
Northern alligator lizard	12	9	0	1	22	5
Western skink	0	0	0	1[c]	1[c]	0
Western fence lizard	0	2	3	39[c]	44[c]	5
Garter snake	2	1	1	0	4	0
Total	14	16[a]	6	44[b,c]	81[a,b,c]	45

[a] one stump was a maternity roost of 14 bats.

[b] one stump was used on two different occasions by adult females and another stump was a maternity roost of two adult females.

[c] one stump was used simultaneously by a western skink and a western fence lizard in two separate crevices.

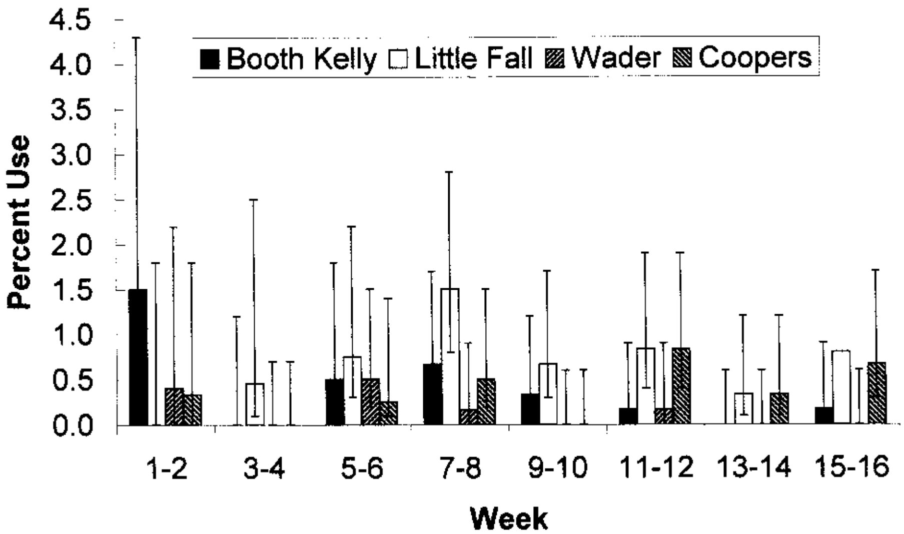

Figure 1. Patterns of detection of vertebrates in bark crevices on conifer stumps during systematic surveys in four stands in western Oregon, during May to August, 1997. The final survey in the Little Fall stand represents an inventory of stumps.

Although we did not systematically monitor individual stumps for repeated use, we did observe use of one stump on two occasions by different female long-eared myotis. We also observed stumps previously used as roosts by female long-eared myotis (Waldien et al. 2000) being used by other bats or other species of vertebrates on nine occasions (two clouded salamanders, one western fence lizard, one Yuma myotis, and five long-eared myotis). Two of the stumps used repeatedly by long-eared myotis contained at least one adult female in reproductive condition, two contained solitary juveniles, and one contained an adult male long-eared myotis. Based on distinct punch-marks given to bats when they were originally captured night-roosting together, one juvenile may have been offspring of the female long-eared myotis previously tracked to the stump using telemetry.

Forty-seven percent of the stumps searched had bark crevices with a minimum opening of 10 x 3 cm and a depth ≥10 cm. The general pattern of observations of vertebrates in stumps reflected the availability of stumps, with most observations in Douglas-fir stumps 26-100 cm tall, 10-70 cm in diameter, and with ≤75% cover (Table 2). We found evidence that northern alligator lizards were associated with stump height, bark remaining, and cover but the pattern was inconsistent between the two stands. In the Coopers stand, alligator lizards were associated with taller stumps ($P = 0.002$) and stumps with low levels of cover ($P = 0.01$), but stump height ($P = 0.50$) and cover ($P = 0.20$) did not appear to influence their use in the Booth Kelly stand. In both the Booth Kelly and Coopers stands, alligator lizards were detected more frequently than expected in stumps with 5-40% bark and less frequently than expected in stumps with 41-75% bark (Booth Kelly $P = 0.06$, Coopers $P = 0.02$). In Booth Kelly, alligator lizards were also detected more frequently than expected in stumps with >75% bark (Booth Kelly $P = 0.06$). Height, diameter, and cover were related to use of stumps by western fence lizards, which were most frequently detected using taller stumps ($P = 0.004$) and stumps with little cover ($P < 0.0001$). Western fence lizards were detected more frequently than expected in stumps with a diameter of 10-40 cm and less than expected in stumps with a diameter of 71-100 cm ($P = 0.03$).

Discussion

Conifer stumps likely provide limited habitat for some species of forest-dwelling bats in clearcut forest stands in western Oregon. Our data demonstrate that a small proportion of the available stumps are used for roosting at any given time, and the vast majority are likely never used, despite

TABLE 2. Habitat characteristics of 2229 random stumps and 79 stumps used by vertebrates during systematics searches in 4 clearcuts in western Oregon, summer 1997. One observation of a western skink is not included.

Variable	Random	Long-eared Myotis	Clouded salamander	Northern alligator lizard	Western fence lizard	Garter snake	All Species
Crevice							
Present	981	6	3	22	44	4	79
Not Present	1248	0	0	0	0	0	0
Species							
Douglas-fir	1747	4	3	14	37	3	61
Western Hemlock	446	1	0	8	5	1	16
Western Redcedar	36	1	0	0	2	0	2
Bark (%)							
<5%	142	0	0	0	0	0	0
5-40%	326	0	2	9	10	0	21
41-75%	662	4	0	2	14	1	21
>75%	1099	2	1	11	20	3	37
Diameter							
10-40 cm	1175	3	2	7	23	0	35
41-70 cm	873	2	0	11	19	1	33
71-100 cm	133	1	1	3	1	2	8
>100 cm	48	0	0	1	1	1	3
Height							
0-25 cm	69	1	0	1	4	0	6
26-100 cm	1837	4	2	11	33	2	52
101-200 cm	277	0	1	7	7	2	17
>200 cm	46	1	0	3	0	0	4
Cover							
≤50%	383	4	0	9	27	1	41
51-75%	478	2	1	7	10	3	23
76-100%	1368	0	2	6	7	0	15

the large number of stumps potentially available in an area following harvest. In addition, our observations are consistent with previous work suggesting that only the long-eared myotis uses stumps on a semi-regular basis (Vonhof and Barclay 1997, Waldien et al. 2000). Observations of little brown myotis (*Myotis lucifugus*) (Kalcounis and Hecker 1996), Yuma myotis (Table 1; Vonhof and Barclay 1997), southwestern myotis (*M. auriculus*) (Bernardos 2001), fringed myotis (Table 1), and California myotis (Table 1) roosting in stumps appear to represent infrequent occurrences. Although female long-eared myotis regularly roost in stumps in areas with limited snags (Waldien et al. 2000), relatively few female long-eared myotis or other bats are captured at sites with low densities of snags within 2.5 km of the capture site (E. B. Arnett, Oregon State University, Corvallis, unpublished data). This is consistent with the hypothesis that limited snag resources in an area may limit populations of forest-dwelling bats, even long-eared myotis that is known to roost in stumps.

Use of bark crevices on conifer stumps by vertebrates is likely influenced by weather and varies seasonally among species. Use by bats and reptiles is greatest during warm and dry periods when stumps in open areas offer higher temperatures (Vonhof and Barclay 1997). Wet and cool conditions that likely occur in bark crevices on stumps during spring and fall rains in western Oregon are likely to be unfavorable for bats and reptiles because they would negatively impact their ability to thermoregulate effectively. Conversely, use of bark crevices by clouded salamanders was greatest during the fall and use of bark crevices by amphibians may be largely restricted to cool and moist periods. These data suggest that habitat value and patterns of use of stumps varies seasonally, and that seasonal influences vary among taxa.

Use of bark crevices on stumps in clearcuts appears to be further limited by the phenology of bark exfoliation and decay of stumps, and by the timing of plant succession and stand development in the clearcut. Previous research demonstrated that use of stumps by bats is largely restricted to a period of a few years between the time crevices form and surrounding vegetation covers the stump (Waldien et al. 2000). Similarly, we observed that western fence lizards were associated with tall stumps with little vegetative cover. This observation is consistent with previous observations of western fence lizards using stumps for basking and foraging (Adolph 1990, Chase 1998). Stumps in areas with little vegetative cover experience higher temperatures (Vonhof and Barclay 1997) and may offer sites where fence lizards and other species can thermoregulate effectively (Lillywhite and North 1974). Thus, it appears that use of stumps by reptiles is also strongly influenced by development of the surrounding vegetation, and that use by reptiles is greatest during the first few years following timber harvest. In contrast, crevices in stumps likely offer habitat for amphibians until crevices are filled with debris or the bark fully exfoliates. Increasingly cool and moist microclimatic conditions in a stand as overstory development proceeds are likely to create increasingly favorable conditions for amphibians through time.

Our observations of 10 species of vertebrates in bark crevices in conifer stumps, in conjunction with observations that several species of cavity-nesting birds have been observed to use stumps (Morrison et al. 1983), suggest that stumps do provide some habitat for vertebrates in clearcuts, particularly when other sources of dead wood are scarce or lacking (Rolstad et al. 1998, Waldien et al. 2000). However, we contend that stumps only provide a fraction of the habitat value of large snags because of the limited time period they are available for use. Further, although several species of bats and other vertebrates can use stumps (Vonhof and Barclay 1997, Rolstad et al. 1998, Waldien et al. 2000), most species select for larger snags (Morrison et al. 1983) and many more species of vertebrates use snags than those that can use stumps. Large, moderately decayed, conifer snags are the primary roost structures for long-eared myotis and other forest-dwelling bats (Campbell et al. 1996, Vonhof and Barclay 1996, Brigham et al. 1997, Ormsbee and McComb 1998, Waldien et al. 2000, Weller and Zabel 2001, Hayes 2003) and management of roosting habitat for bats, including the long-eared myotis, should focus on maintaining present and future availability of snags.

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