Pileated woodpecker nest and roost trees in Montana: links with old-growth and forest "health"

B. Riley McClelland and Patricia T. McClelland

Abstract The pileated woodpecker (*Dryocopus pileatus*) is of special interest to wildlife managers; it requires large trees for nesting, and its abandoned excavations are used by many birds and other small animals for nesting, roosting, hiding, and feeding. Prior to our study, little had been published on pileated woodpecker habitat in the northern Rocky Mountains. From 1973 through 1995, we located nest and roost trees of pileated woodpeckers in northwestern Montana forests dominated by western larch (*Larix occidentalis*) and Douglas-fir (*Pseudotsuga menziesii*). Nests (113 in 97 trees) were in western larch (n=52), ponderosa pine (*Pinus ponderosa*, n=18), black cottonwood (*Populus trichocarpa*, n=15), trembling aspen (*Populus tremuloides*, n=7), western white pine (*Pinus monticola*, n=3), grand fir (*Abies grandis*, n=1), and Douglas-fir (n=1). Nest-tree diameter-at-breast-height averaged 73 cm, and height averaged 29 m. Roost trees (n=40) were similar to nest trees, but had more cavity entrances and higher basal area of surrounding forest. Nest trees and roost trees typically were snags (81% and 78%, respectively) with broken tops (77% in both). Old-growth stands containing western larch were common nesting sites for pileated woodpeckers. Old-growth ponderosa pine, black cottonwood, and trembling aspen were locally important, but their distribution was more restricted. Compared to other nest-tree species in Montana, undecayed larch wood is hard, making excavation difficult for woodpeckers. Heartwood decay, which softens the wood, becomes more prevalent as a forest matures and was characteristic of western larch nest trees. In the northern Rocky Mountains, the pileated woodpecker has been used too broadly and simplistically as a management indicator of old growth. A more realistic strategy would nurture western larch old growth, defined ecologically, as an indicator of high-quality nesting habitat for pileated woodpeckers. Large trees, logs, snags, carpenter ants (*Camponotus* spp.), and heartwood decay are intrinsic components of "healthy" old growth that sustains pileated woodpeckers.

Key words *Dryocopus pileatus,* forest health, indicator species, nest trees, pileated woodpecker, roost trees, western larch

In Montana, the range of the pileated woodpecker (*Dryocopus pileatus*) is mainly west of the Continental Divide (Montana Bird Distribution Committee 1996) and similar to the distribution of western larch (*Larix occidentalis*, Schmidt et al. 1976). In the Rocky Mountains, the ranges of the pileated woodpecker and western larch do not extend south of Montana. Description of pileated woodpecker ecology from the northern Rocky Mountains has been reported only as preliminary results (McClelland and Frissell 1975, McClelland 1979, and McClelland et al. 1979). An evaluation of

---

Authors' address: School of Forestry, University of Montana, Missoula, MT 59812 , USA. Authors' present address: Box 366, West Glacier, MT 59936, USA.

pileated woodpecker habitat in the northern Rocky Mountains is important because the species has been used by the United States Forest Service as an old-growth indicator. The species also deserves special attention because it is a "pathfinder" (Kneitz 1961). Via its abandoned cavities, the pileated woodpecker creates nesting, roosting, hiding, and feeding sites (pathways) used by other birds, small mammals, reptiles, amphibians, and invertebrates (McClelland 1979, Bull and Jackson 1995). Our objectives were to characterize nest and roost trees and to deduce conservation implications for western larch forests. We recognize that nest and roost trees are only part of the specific resources that comprise pileated woodpecker habitat. In referring to pileated woodpecker "habitat quality," we imply the definition of Hall et al. (1997:178): "...the ability of the environment to provide conditions appropriate for individual and population persistence."

Study area

Our work focused on western larch forest types in the Coram Experimental Forest (CEF) in the Flathead National Forest, and in Glacier National Park (GNP), 8 km north of the CEF. CEF (3,019 ha) was established to study western larch ecology and management (Shearer 1998). CEF annual precipitation averaged 89 cm, and elevation ranged from 1,067 m to 1,920 m. About 70% of the CEF forest had not been logged and was classified as mature or old (H. Trechsel, United States Forest Service, personal communication). Old growth was dominated by Douglas-fir (*Pseudotsuga menziesii*) and western larch, many of which were 300 years old and some 500 years old (United States Forest Service 1979). GNP encompasses 410,000 ha, including approximately 40,000 ha of western larch and Douglas-fir forest (C. Key, geographer, National Park Service, personal communication) similar to the CEF old-growth stands. Nearly all of GNP has never been logged.

The western larch-Douglas-fir forests where we worked had varying components of subalpine fir (*Abies lasiocarpa*), grand fir (*Abies grandis*), Engelmann spruce (*Picea engelmannii*), western white pine (*Pinus monticola*), lodgepole pine (*Pinus contorta*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Ponderosa pine (*Pinus ponderosa*) existed as isolated individuals or small enclaves. Black cottonwood (*Populus trichocarpa*) and paper birch (*Betula papyrifera*) occurred primarily in riparian areas. Trembling aspen (*Populus tremuloides*) groves were scattered and isolated within the western larch-Douglas-fir stands.

Methods

To find active nests and roosts of pileated woodpeckers during 1973-1995, we searched forests where western larch was a major component. We systematically searched the entire uncut portion of the CEF. In GNP and nearby national forest lands, we hiked roads, trails, and cross-country routes selected to maximize area covered. We recorded active roost trees in all seasons. We used auditory cues: sounds of nest-cavity excavation, persistent localized high calls or drumming (Kilham 1959), or vocalizations from young in the nest. Occasionally, we were led to an active pileated woodpecker nest by alarm "cuks" from adult pileated woodpeckers reacting to sharp-shinned hawks (*Accipiter striatus*) near the nest tree (Kilham 1958, Smith 1983). Unweathered chips at the base of a tree confirmed current year excavations. We recorded a cavity as an active nest only if we confirmed incubation or presence of young. We located most roosts by tracking loud "cuking" vocalizations during evening roost flights or by listening for the first "high call" in the morning (Hoyt 1957, Kilham 1974). We recorded a cavity as an active roost if full entrance of an adult was observed.

For each nest or roost tree, we recorded: species, diameter-at-breast-height (dbh), height, condition (intact-top snag, broken-top snag, broken-top live, dead-top live, or intact-top live [all standing dead trees were classed as snags]), fire scar present or absent, conk present or absent, percentage of bark remaining, terrain slope, slope aspect, elevation, percentage canopy cover, basal area of the surrounding forest, nest height, and orientation of the nest opening. If bark was absent at the base of a nest or roost tree, we adjusted dbh to include bark thickness.

We did not sample vegetation around nest trees. As a rough measure of pileated woodpecker nest-tree selection between western larch and Douglas-fir, we compared nest trees from the entire study area with availability based on a United States Forest Service complete inventory of trees on plots totaling 33 ha on the CEF (data from R. Benson, United States Forest Service, personal communica-

Table 1. Number and condition of pileated woodpecker nest and roost trees in northwestern Montana, 1973–1995.

Tree species	Tree condition: Intact-top snag	Broken-top snag	Broken-top live	Dead top live	Intact-top live	Totals(%)
Western larch						
nests	9	28	4	3	7	51 (53)[a]
roosts	3	14	3	4	2	26 (65)
Douglas-fir						
nests	1	0	0	0	0	1 (1)
roosts	1	0	0	0	0	1 (2)
Ponderosa pine						
nests	2	15	1	0	0	18 (19)
roosts	1	3	0	0	0	4 (10)
Western white pine						
nests	2	1	0	0	0	3 (3)
roosts	0	0	0	0	0	0 (0)
Grand fir						
nests	0	1	0	0	0	1 (1)
roosts	0	0	0	0	0	0 (0)
Black cottonwood						
nests	1	14	0	0	0	15 (16)
roosts	2	7	0	0	0	9 (23)
Aspen						
nests	3	0	1	0	3	7 (7)
roosts	0	0	0	0	0	0 (0)
Total no.(%)						
nests	18 (19)	59 (62)	6 (6)	3 (3)	10 (10)	96 (100)[a]
roosts	7 (18)	24 (60)	3 (7)	4 (10)	2 (5)	40 (100)
trees	25 (18)	83 (61)	9 (7)	7 (5)	12 (9)	136 (100)

[a] Condition description missing on one nest tree.

tion). For this analysis (Neu et al. 1974, Byers et al. 1984), we used only sample plot trees with dbh ≥38 cm, the smallest used as a pileated woodpecker nest or roost tree in our study. Although the United States Forest Service considered the CEF forest typical of northern Rocky Mountain western larch–Douglas-fir forests (Barger 1979), results of this analysis should be extrapolated with caution because of geographic site differences. To determine whether nest-cavity wood was sound, we collected excavation chip samples from the ground below cavities. Chips were inspected for visual evidence of decay. Specific gravity of the chips was calculated by the volume-displacement method. We compared continuous nest-tree and roost-tree characteristics using *t*-tests after testing equality of variances and normality (SAS Institute Inc. 1988). We used Chi-square contingency tables for categorical variables (Everitt 1992).

Results

We found 113 active nests in 97 trees and 51 active roosts in 40 trees. Fifty-six percent of the nest and roost trees were in the CEF or GNP, whereas the others were on nearby national forest or private land. Fifty-seven percent of nest and roost trees were western larch; only one nest and one roost were in Douglas-fir. Most nest trees (81%) and roost trees (78%) were snags (Table 1).

Nest-tree characteristics

Pileated woodpeckers selected western larch over Douglas-fir for nest trees (χ^2=595, df=9, $P \leq 0.001$). Broken-top western larch snags were the major contributors to this distinction (Figure 1), equally so in the CEF and the remainder of the study area. Compared with intact-top nest snags (all species), broken-top nest snags were larger (t=-1.51, df=75, P=0.13; 78-cm dbh and 70-cm dbh), shorter (t=6.31, df=75, P=0.001; 24 m and 37 m), and had less bark (t=2.62, df=66, P=0.01; 27% and 51%). Nest trees where an active nest was documented in only one year (n=83) averaged smaller dbh (t=-2.09, df=95, P=0.04) and more bark (t=2.33, df=85, P=0.02) than trees with multiple year use (n=14). Nests in 2 of the 3 smallest dbh trees, a 39-cm-dbh grand fir and a 41-cm-dbh trembling aspen, failed during incubation.

The 18 ponderosa pine nest trees were in groves composed almost entirely of ponderosa pine and Douglas-fir. Canopy coverage and forest basal area at nest trees illustrated the differences between comparatively open ponderosa pine old growth and the denser western larch old growth (Table 2). In riparian forests, composed primarily of black cottonwood, white spruce (*Picea glauca*), Engelmann spruce, western red cedar, Douglas-fir, and paper birch, we found nests only in large black cotton-

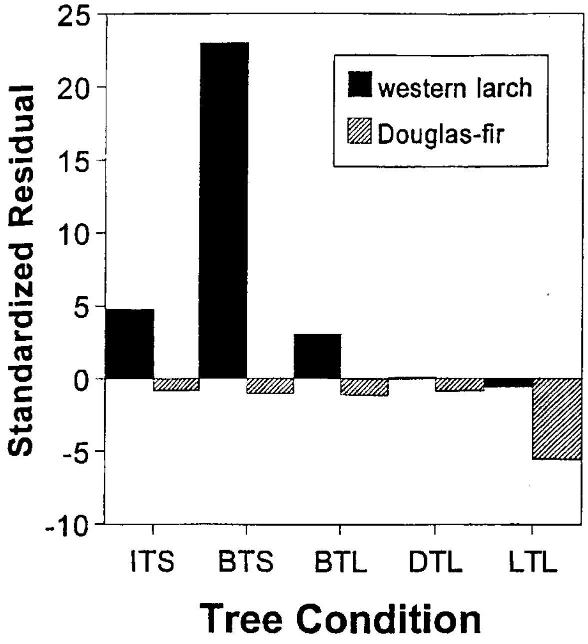

Figure 1. Standardized residuals (Everitt 1992) from chi-square goodness-of-fit test of western larch and Douglas-fir (≥38-cm dbh) availability compared to nest-tree selection by pileated woodpeckers in Montana, 1973-95. Tree conditions shown are: intact-top snag (ITS), broken-top snag (BTS), broken-top live (BTL), dead-top live (DTL), and live-top live (LTL).

wood snags (*n*=15). All aspen nest trees were in monospecific groves of aspen.

Western larch, ponderosa pine, and black cottonwood nest trees were nearly identical in mean dbh (≥75 cm). Fire scars were present on ≥50% of western larch, ponderosa pine, and aspen nest trees, but on only 1 black cottonwood nest tree. Conks, primarily from *Phomitopsis officinalis* or *Phellinus pini* heartwood decay (identified by A. Harvey, forest pathologist, United States Forest Service), were observed on 26% of larch nest trees. In 72% of excavation chips (*n*=42), evidence of decay was easily visible to the unaided eye. The specific gravity of western larch nest excavation chips ranged from 0.15 to 0.38 ($\bar{x}$=0.28, SE=0.02, *n*=13). This was outside the 95% confidence interval reported for undecayed western larch (0.48, Panshin and deZeeux 1970). Thus, each of the chip samples had been substantially altered by decay.

Cavity reuse

Pileated woodpecker nesting reuse of a cavity is rare (Bent 1939, Bull and Jackson 1995). We documented reuse in 2 nest trees. In a broken-top western larch snag (91-cm dbh), the same cavity was used successfully in 1975, 1976, and 1990. A cavity excavated in a broken-top black cottonwood snag (48-cm dbh) was a successful nest in 1978, 1979, 1980, and 1983. The surrounding forest at both nest trees provided many other apparently usable trees, so cavity reuse did not appear to be the result of a lack of alternatives. After the black cottonwood snag fell in 1984, the pair nested in a live western larch (58-cm dbh) 300 m away.

Concurrent use of nest trees

Eight snags, all broken-tops, were used as nest sites concurrently by pileated woodpeckers and other species: 4 northern flickers (*Colaptes auratus*), 2 red-breasted nuthatches (*Sitta canadensis*), and 1 mountain chickadee (*Peocile gambeli*). An osprey (*Pandion haliaetus*) nested on top of a large broken-top larch snag containing an active pileated woodpecker nest. A cottonwood snag was used simultaneously by a roosting common flicker, a roosting hairy woodpecker (*Picoides villosus*), and a nesting pileated woodpecker. We document-

Table 2. Characteristics of pileated woodpecker nest trees in Montana, 1973–1995.

Variable		Tree species: Western larch (*n*=52)	Ponderosa pine (*n*=18)	Black cottonwood (*n*=15)	Aspen (*n*=7)	*F*	*P*
dbh	$\bar{x}$	77	76	75	48	5.65	0.001[a]
(cm)	range	46–104	59–124	46–120	38–66		
	SD	14.2	20.4	25.1	9.6		
Height	$\bar{x}$	30.7	25.8	23.4	24.0	4.28	0.007[b]
(m)	range	12.2–50.6	12.2–39.0	11.9–34.8	12.8–30.5		
	SD	9.3	7.1	6.7	7.2		
Canopy cover	$\bar{x}$	49	29	30	48	5.29	0.003[b]
(%)	range	10–90	0–50	0–90	35–60		
	SD	18.8	15.6	28.7	10.4		
Basal area	$\bar{x}$	33.8	21.0	29.4	31.6	2.39	0.075[c]
(m^2/ha)	range	5.7–82.6	3.4–45.9	0–105.6	18.4–55.1		
	SD	15.7	10.5	25.2	12.9		

[a] Based on Fisher's LSD (α=0.05), aspen different from other three.

[b] Western larch different from ponderosa pine and black cottonwood.

[c] Western larch different from ponderosa pine.

Table 3. Characteristics of pileated woodpecker nest trees[a] compared to roost trees[b] in Montana, 1973–1995.

	Nest trees (*n*=89)			Roost trees (*n*=32)			Differences in means		
Variable	Mean	Range	SE	Mean	Range	SE	*t*	df	*P*
Tree dbh (cm)	73.4	38.0–124.0	1.9	76.1	47.0–109.0	3.0	-0.73	119	0.46
Tree height (m)	29.0	11.9–50.6	1.0	30.4	12.8–57.9	1.9	-0.70	119	0.48
Cavity height (m)	15.9	5.5–29.9	0.6	16.3	7.3–37.2	1.1	-0.35	117	0.73
% bark remaining	50	0–100	4.6	49	0–100	8.0	0.06	106	0.96
% canopy closure	41	0–90	2.7	51	0–90	5.4	-1.79	86	0.08
Basal area (m^2/ha)	30.8	0–105.6	1.9	40.6	6.9–91.8	3.7	-2.57	112	0.01
% slope	11	0–33	1.1	8	0–35	1.8	1.35	106	0.18
Aspect (degrees)	145	1–360	13.2	114	1–358	20.5	1.24	113	0.21
No. nest holes	2.1	1–9	0.2	3.4	1–11	0.4	-3.32	107	0.00

[a] Trees for which only nesting was documented.

[b] Trees for which only roosting was documented.

ed use of abandoned pileated woodpecker nest cavities by Vaux's swift (*Chaetura vauxi*), northern saw-whet owl (*Aegolius acadicus*), western screech owl (*Otus kennicottii*), American kestrel (*Falco sparverius*), flying squirrel (*Glaucomys sabrinus*), red squirrel (*Tamiasciurus hudsonicus*), and pine marten (*Martes americana*).

Roost-tree characteristics and use

Nest trees and roost trees differed in number of nest holes and basal area of the surrounding forest (Table 3). Male pileated woodpeckers, which did most of the nest-cavity excavation, typically began roosting in the new cavity when it was complete. They invariably roosted in the nest cavity during incubation and brooding, whereas the female roosted in a different tree. Outside the nesting season, both members of a pair occasionally roosted in the same tree. On successive evenings one winter, we saw 3 pileated woodpeckers (2 males, 1 female) roost in the same broken-top black cottonwood snag (74-cm dbh). Each bird entered a different hole that we had seen excavated and used as a nest. We did not observe any young return to its nest cavity after fledging. Although nest cavities tended to favor easterly directions, roost holes did not (Table 4); differences between nest and roost hole orientation were not significant (χ^2=4.87, df=3, *P*=0.182).

Discussion

Nest-tree differences

Although large western larch and Douglas-fir were about equally represented in our study areas, pileated woodpeckers rarely used Douglas-fir as a nest tree. Decay characteristics of western larch make it more durable than Douglas-fir as a nest tree for strong excavators such as the pileated woodpecker. In western larch nest trees, heartwood softened by decay is surrounded by more slowly decaying sapwood, producing a protective shell of relatively sound wood around a cavity. Sapwood in Douglas-fir decays more rapidly; in most beetle-killed Douglas-fir, the sapwood is essentially destroyed in 4 years (Wright and Harvey 1967). However, the value of large Douglas-fir should not be minimized. We frequently observed pileated woodpeckers excavating carpenter ants (*Camponotus* spp.) in Douglas-fir snags. The significance of the broken top in larch nest trees may be its role as a point of entry for the most common heartwood decay organisms found in western larch (Boyce 1930, Hepting 1971).

Although most of our nest trees were in upland forests, riparian sites supporting large cottonwoods

Table 4. Orientation of pileated woodpecker nest holes (*n*=111)[a] and roost holes (*n*=51) in Montana.

Cavity opening direction	Quadrant	No. of nests (%)[b]	No. of roosts (%)[c]
Northeast	>0 through 90°	33(30)	11(22)
Southeast	>90 through 180°	36(32)	15(29)
Southwest	>180 through 270°	22(20)	8(16)
Northwest	>270 through 0°	20(18)	17(33)

[a] Data missing for 2 nests.

[b] Analysis of nest orientation distribution, χ^2=6.8, 3 df, *P*=0.079.

[c] Analysis of roost orientation distribution, χ^2=3.82, 3 df, *P*=0.282.

Young pileated woodpeckers peering from nest cavity in a western larch snag.

provided nesting habitat for pileated woodpeckers and other cavity nesters. Because we did not investigate tree-species availability other than for western larch and Douglas-fir, we cannot evaluate pileated woodpecker preference comparing larch and ponderosa pine, black cottonwood, or aspen. However, in northwestern Montana, even if the latter species are equally serviceable as pileated woodpecker nest sites, they are far less common than larch. Soils, water, and climate factors limit their distribution. The ranges of ponderosa pine, black cottonwood, and aspen extend south of the pileated woodpecker's distribution in the Rocky Mountains. In southern areas, these otherwise appropriate tree species must lack associated forest characteristics necessary to support pileated woodpecker territories. We found only 3 pileated woodpecker nests in western white pine, but there were few specimens in our area. We suspect that where the species is more abundant (e.g., northern Idaho), large western white pine snags are important nest sites. Large spruce, common in riparian and other bottomland sites, were not observed as nest or roost trees.

Comparisons with other studies

The similarity between nest and roost trees in Montana (Table 3) contrasts with northeastern Oregon, where Bull et al. (1992) found that roost and nest trees differed in species, condition, dbh, slope position, forest type, and number of entrance holes. Lawrence (1970), Rumsey (1970), and Bull et al. (1992) reported roosting cavity excavation in fall, but we observed no cavity excavation outside spring. Although many of our roosts were in snags with multiple entrances and hollow interiors, we believe the interior hollowing developed after years of use as a nest tree rather than by pileated woodpeckers selecting hollow snags in which to excavate roost cavities. In northeastern Oregon, although pileated woodpeckers nested primarily in ponderosa pine and western larch, they selected hollow grand fir in which to excavate roost entrances (Bull et al. 1992). Grand fir was uncommon in our study area. We found many old, unused pileated woodpecker nest cavities in larch, ponderosa pine, black cottonwood, and aspen. Although some of these cavities were used by other species, we believe that unoccupied cavities were sufficiently abundant to make pileated woodpecker excavation of distinct roost cavities unnecessary.

Along the foothills east of the Continental Divide in northern Montana and in the aspen parklands in Alberta, Canada, aspen often is the only tree species that reaches sufficient size for pileated woodpecker nesting. In Alberta, Bonar (1994) found 17 of 18 nests and roosts in aspen. In British Columbia, Harestad and Keisker (1989) found pileated woodpeckers nesting in live aspen with heartwood decay. In western Montana, there are few aspen large enough to hold a pileated woodpecker nest. Where other functional nest tree species are missing, availability of large aspen makes the difference between presence and absence of nesting pileated woodpeckers.

Tree growth in the Rocky Mountains generally is much slower than in many other parts of the pileated woodpecker's range (e.g., the Pacific Northwest and the East). Thus, in the northern Rocky Mountains, older forest stands and legacies from former stands are needed to provide trees large enough for pileated woodpecker nests. Because specific resources that compose high quality pileated woodpecker habitat vary geographically, generalizations and extrapolations among areas are of limited value.

Management considerations

Nest-tree size

Managers often apply minimum size standards for wildlife resource goals that conflict with exploitable resources, e.g., timber. Thus, the smallest recorded nest-tree dbh may be adopted as a size standard. This approach ultimately could lead to extirpation of the pileated woodpecker in affected areas. Alternatively, Conner (1979) recommended that managers provide optimum quality trees for

Figure 3. Adult female pileated woodpecker feeding young in nest cavity in a western larch snag.

woodpeckers, focusing on mean rather than minimum values. He also stressed providing optimum levels of other specific habitat features. For example, important habitat resources include logs and trees that sustain ants (*Camponotus* spp. and *Formica* spp.), primary prey of pileated woodpeckers (Bull et al. 1995).

Conner (1979) urged special attention for endangered and sensitive species. We believe the pileated woodpecker should be considered a sensitive species in the northern Rocky Mountains, for reasons outlined in this paper. Therefore, on multiple-use lands, we recommend that pileated woodpecker nest and roost tree optimum size (dbh) be described as the mean plus one standard deviation: 77–91 cm for western larch, 76–96 cm for ponderosa pine, and 75–100 cm for black cottonwood. This range would acknowledge stochasticity in the decay process and allow time for nest trees to attain appropriate size and condition. This goal is more likely to achieve the objective of long-term viability and the values would more closely match the "safe minimum standard" discussed by Toman and Ashton (1996). Broadening the goal range to one standard deviation below the mean would foster the same problem that initially elicited Conner's (1979) concern: when left with a range of choices in which timber and wildlife values conflict, managers usually opt for the minimum for wildlife.

Although we focused on the pileated woodpecker in this study, exclusive emphasis on the quality of habitat for a single species is ecologically unsound. For example, a diversity of tree and snag sizes is essential to support other cavity nesters. Some woodpecker species in our study area rarely nested in large snags. Three-toed woodpeckers (*Picoides tridactylis*) used nest trees with dbh $\bar{x}$=30 cm (n=31) and black-backed woodpecker (*P. arcticus*) nest trees were $\bar{x}$=28 cm (n=10). Trees and snags of this small size are easily provided. Trees even larger than the recommended optimum tree size for pileated woodpeckers are increasingly uncommon. They should be nurtured not only for a wider range of choice for pileated woodpeckers, but for other wildlife (e.g., black bear [*Ursus americanus*] dens) and for their intrinsic aesthetic values (Blocker 1995). Thus, a management plan needs to perpetuate forest diversity, not simply a tree size that fits the paradigm of a single species.

The pileated woodpecker as an old-growth indicator species

Using the pileated woodpecker as a management indicator for old growth has been questioned because of concerns about excessive reliance on a single species (Landres et al. 1988) and because pileated woodpeckers often forage in younger forest stands (Mellen et al. 1992, Bull and Jackson 1995). We observed pileated woodpeckers foraging in forest stands other than old growth, and territories usually were not confined to the old-growth nesting site (McClelland 1979). However, nesting and roosting sites in our study were limited to large, old trees in old-growth stands or occasionally legacies from former stands. We occasionally saw pileated woodpeckers at suet feeders near homes and perching or foraging on trees and power poles in rural areas. These observations generally were confined to the non-nesting seasons, especially autumn and winter, when young pileated woodpeckers dispersed from natal territories. These foraging areas outside of old-growth nest sites are not functional territories by themselves. Perpetuation

Adult male pileated woodpecker excavating a nest cavity in a black cottonwood snag.

of the pileated woodpecker and many other forest values depends on relationships and interactions among stands. Forest ecosystems are not simply aggregates of stands. "The whole functions differently than the sum of its parts . . .forest ecosystems need to be seen as a nested set of structures embracing the stand, the watershed, and the physiographic region" (Toman and Ashton 1996:375).

The pileated woodpecker's role as an indicator species (McClelland 1979) has been too broadly applied in some areas as a single-species management panacea for old growth and for the cavity-nesting guild. However, we should expect indicators and models to be experimental and tentative, always in need of refinement (Christensen et al. 1996). Although monitoring protocols for pileated woodpeckers have been available (Bull et al. 1990), application by the United States Forest Service in the northern Rocky Mountains has been sporadic, inconsistent, and short-term, not designed to reveal long-term population trends. Rather than using the pileated woodpecker as an indicator of old growth in western Montana forests, western larch, ponderosa pine, and black cottonwood old growth could be used as indicators of high-quality nesting habitat for pileated woodpeckers (Graul and Miller 1984). The pitfall with this approach is the penchant for defining old growth politically, in a way that maximizes harvest potential. To be biologically honest and useful for management, old growth must be defined ecologically, on a site-specific basis, based on: 1) floral and faunal composition, 2) vegetative structure (including snags and logs) and canopy layers, and 3) minimum stand size (Thomas et al. 1988). Monitoring old-growth status (i.e., degree of change in age structure and composition) then would be comparatively straightforward. Monitoring the long-term status of pileated woodpecker populations (rather than documenting mere existence) would require a great priority for wildlife in agency funding and time-consuming effort by well-trained personnel. Despite concerns about the indicator species concept, the pileated woodpecker should be considered a sensitive species. The pileated woodpecker warrants that concern because of its key role in the cavity-nesting guild and its dependence on large trees and old growth that are commercially valuable as timber or firewood.

The pileated woodpecker's link with forest "health"

In western larch forests of Montana, the pileated woodpecker is closely associated with forest values often considered characteristic of an "unhealthy" forest: fire, insects, and disease. Yet, these agents have been major factors in forest development in the northern Rockies (McClelland 1968, Monnig and Byler 1992). Many scientists consider the concept of forest health or ecosystem health ecologically inappropriate (Wicklum and Davies 1995). Nevertheless, on many western forests, perceived forest-health problems have continued to focus narrowly on tree health (DellaSala and Olson 1996). This perception of forest health has been used as a rationale to increase removal of dead, dying, and diseased trees (DellaSala et al. 1995, Lombardi 1996) and as a surrogate to increase harvesting to save timber-dependent communities (MacCracken 1996).

Pileated woodpecker feeding excavations in a western larch snag

The short-term effects of silvicultural prescriptions such as regeneration cuts, fuel-load reduction, and "salvage" cutting in old-growth stands may not be indicative of long-term impacts on pileated woodpeckers (Bull et al. 1995). Short-term documentation can lead to mistaken inferences because territorial fidelity is strong in most woodpeckers (Lawrence 1967). At 4 of our pileated woodpecker nest trees, the

anecdotal

Conk (fruiting body from heartwood decay) at the base of a western larch nest tree. Field assistant Laddie poses for scale.

territory was not abandoned until several years after the surrounding old growth was logged. Short-term fidelity (mere presence) often is construed as evincing adaptability of a bird and lack of impact from logging. Longer-term effects are the important concerns, and they may be distinctly negative (Ruggiero et al. 1988). Forest management that emphasizes restoring forest health through routine cutting of dead, dying, and diseased trees and fire suppression can eliminate essential characteristics of old-growth western larch. According to DellaSala et al. (1996), low elevation, old-growth forests in western Montana have declined 80-90% since European settlement. A concomitant decrease in pileated territories was evident from the absence of nests in young even-age stands that have replaced logged old-growth larch in our study area.

Fire's role in western larch forests. Fire has played a key role in the evolution of several forest types that support pileated woodpeckers in the northern Rockies, e.g., western larch and ponderosa pine (Habeck 1990). Perpetuation of western larch, an exclusively seral, shade-intolerant species, historically has depended on recurring fire (Arno and Fischer 1995). Primeval fire regimes in some western larch forests of GNP included mean intervals of 140-340 years for stand-replacement fires (Barrett et al. 1991). The thick bark at the base of western larch endows it with exceptional fire tolerance, allowing large specimens to survive even intense fire while other species are killed. Because of its longevity (maximum >900 yrs), larch are often present as relicts (legacies) in stands of various ages (Fiedler and Lloyd 1995). Thus, old larch trees may survive fires over centuries, isolated or in groups or stands, providing nest and roost sites for pileated woodpeckers.

Heartwood decay. Although the historic role of fire in western forests now is widely recognized by managers, the essential roles of natural diseases and decay generally have not received similar comprehension (Christensen et al. 1996). "Forest land managers . . . generally view pathogens not as essential to ecosystem function, but rather as nuisances that interfere with management objectives" (Castello et al. 1995:22-23). In general there is a positive correlation between forest age and amount of wood decay (Smith 1970). The importance of decay in woodpecker nest trees has long been known (Shigo and Kilham 1968, Conner et al. 1976, Harris 1983). Pileated woodpecker dependence on heart rot in potential nest trees may depend on the tree species and geographical area. Conner et al. (1976) concluded that pileated woodpeckers selected nest trees with heart rot in the oak-hickory forests of Virginia. Harestad and Keisker (1989) found that heartwood decay was the most important factor in

Western larch snag with multiple pileated woodpecker nest holes and an osprey nest on top. The snag is within an old-growth western larch forest.

nest-tree (primarily aspen) selection by all woodpeckers, including pileateds, in British Columbia. However, Bull (1987) concluded that decayed wood was not necessary for pileated woodpecker nest-tree excavations in northeastern Oregon. Although some of her nest trees were larch, most (73%) were ponderosa pine, the undecayed wood of which is softer (specific gravity=0.38) than western larch (specific gravity=0.48). Other nest-tree species in our area have even softer (lower-specific-gravity) undecayed wood, e.g., grand fir=0.36; aspen=0.35; and black cottonwood=0.34 (Panshin and deZeeux 1970). However, they are less common and the first two seldom reach the large dbh achieved by western larch. In our study, where western larch was the most commonly observed nest-tree species, analysis of excavation chips showed that heartwood decay was an important nest-tree characteristic. Because western larch has comparatively hard wood, pileated woodpeckers selected larch with heartwood softened by decay.

Conclusion

On a landscape scale, fire and heartwood decay organisms are both essential elements in a healthy forest, if healthy connotes a complete assemblage of ecosystem processes and components (Harvey 1994). Deep fire scars at the base of western larch are common points of entry for heartwood decay organisms (Boyce 1930, Shigo 1969). Emphasizing individual tree health subverts the goal of ecosystem integrity and long-term sustainability of forests and their myriad biotic components such as the pileated woodpecker.

"In recent years sustainability has become an explicitly stated, even legislatively mandated, goal of natural resource management agencies. In practice, however, resource management approaches have often focused on maximizing short-term yield and economic gain rather than long-term sustainability" (Christensen et al. 1996:665). In the northern Rocky Mountains, tree decay, native insects, and fire are integral components of a healthy forest. Decaying and dead trees are essential components for the long-term presence of pileated woodpeckers in western larch forests. "Both quality and sustainability can be used as broad descriptors of ecosystem management goals, with more specific objectives set on an ecosystem-specific basis" (Wicklum and Davies 1995). In this context, quality in western larch forests should focus on ecosystem completeness, not on subjective health criteria.

Acknowledgments. We dedicate this paper to Jack Whitney, consummate naturalist and intrepid outdoorsman, who freely shared his knowledge of pileated woodpeckers. We thank R. L. Barger, R. E. Benson, D. Biggins, R. Blodnick, J. K. Brown, E. L. Caton, B. Cooper, J. S. DeSanto, M. Donofrio, D. Elliot, C. E. Fiedler, W. C. Fischer, S. S. Frissell, J. R. Habeck, C. H. Halvorson, G. Halvorson, M. A. Harris, J. J. Hasbrouck, R. Hensler, A. N. Lester, K. S. McClelland, T. M. McClelland, R. F. Muth, B. W. O'Gara, W. C. Schmidt, J. A. Schmidt, R. C. Shearer, J. K. Smith, R. Trembath, W. Weydemeyer, G. Wilson, P. L. Wright, and R. E. Yates for assistance with the project. R. E. Bennetts helped with statistical analyses. A. E. Harvey consulted on tree decay. R. N. Conner, J. K. Smith, R. E. Bennetts, and an anonymous reviewer made helpful suggestions on earlier drafts. Funding was provided by the United States Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; McIntire-Stennis Grants through the Montana Forest and Conservation Experiment Station; the School of Forestry, University of Montana; and the United States Department of Interior, National Park Service.

Literature cited

Arno, S. F. and W. C. Fischer. 1995. *Larix occidentalis:* fire ecology and fire management. Pages 130-135 *in* W. C. Schmidt and K. J. McDonald, compilers. Ecology and management of Larix forests: a look ahead. United States Department of Agriculture Forest Service General Technical Report INT-GTR-319, Ogden, Utah.

Barger, R. L. 1979. The forest residues utilization program in brief. Pages 7-24 *in* Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. United States Department of Agriculture Forest Service General Technical Report INT-90.

Barrett, S. W., S. F. Arno, and C. H. Key. 1991. Fire regimes of western larch-lodgepole pine forests in Glacier National Park, Montana. Canadian Journal of Forestry Research 21:1711-1720.

Bent, A. C. 1939. Life histories of North American woodpeckers. Dover, New York, New York.

Blocker, L. 1995. Aesthetics of larch forests. Pages 151-152 *in* W. C. Schmidt and K. J. McDonald, compilers. Ecology and management of Larix forests: a look ahead. United States Department of Agriculture Forest Service General Technical Report INT-GTR-319, Ogden, Utah.

Bonar, R. 1994. Habitat ecology of the pileated woodpecker in Alberta. Alberta Naturalist 24(1):13-15.

Boyce, J. S. 1930. Decay in Pacific Northwest conifers. Yale University. Osborn Botanical Laboratory Bulletin Number 1.

Bull, E. L. 1987. Ecology of the pileated woodpecker in northeastern Oregon. Journal of Wildlife Management 51:472-481.

Bull, E. L., Holthausen, R. S., and M. G. Henjum. 1990. Techniques for monitoring pileated woodpeckers. United States Department of Agriculture Forest Service General Technical Report PNW-GTR-269, Portland, Oregon.

Bull, E. L., Holthausen, R. S., and M. G. Henjum. 1992. Roost trees used by pileated woodpeckers in northeastern Oregon. Journal of Wildlife Management 56:786-793.

Bull, E. L., and J. E. Jackson. 1995. Pileated Woodpecker (*Dryocopus pileatus*) *in* A. Poole and F. Gill, editors. The Birds of North America, Number 148. The Academy of Natural Sciences, Philadelphia, Pennsylvania, and The American Ornithologists' Union, Washington, D.C.

Bull, E. L., T. R. Torgerson, A. K. Blumton, C. M. McKenzie, and D. S. Wyland. 1995. Treatment of an old-growth stand and its effects on birds, ants, and large woody debris. United States Department of Agriculture Forest Service General Technical Report PNW-GTR-353, Portland, Oregon.

Byers, C. R., R. K. Steinhorst, and P. R. Krausman. 1984. Clarification of a technique for an analysis of Utilization-availability data. Journal of Wildlife Management 48:1050-1053.

Castello, J. D., D. J. Leopold, and P. J. Smallridge. 1995. Pathogens, patterns, and process in forest ecosystems. Bioscience 45:16-24.

Christensen, N. L., A. N. Bartuska, J. H. Brown, S. Carpenter, C. D'Antonio, R. Francis, J. F. Franklin, J. A. MacMahon, R. F. Noss, D. J. Parsons, C. H. Peterson, M. G. Turner, and R. G. Woodmansee. 1996. The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. Ecological Applications 6:665-691.

Conner, R. N. 1979. Minimum standards and forest wildlife management. Wildlife Society Bulletin 7:293-296.

Conner, R. N., O. K. Miller, Jr., and C. S. Adkisson. 1976. Woodpecker dependence on trees infected by fungal heart rots. Wilson Bulletin 88:575-581.

DellaSala, D. A., and D. M. Olson. 1996. Seeing the forests for more than just trees. Wildlife Society Bulletin 24:770-776.

DellaSala, D. A., D. M. Olson, S. E. Barth, S. L. Crane, and S. A. Primm. 1995. Forest health: moving beyond rhetoric to restore healthy landscapes in the inland Northwest. Wildlife Society Bulletin 23:346-356.

DellaSala, D. A., J. R. Strittholt, R. F. Noss, and D. M. Olson. 1996. A critical role for core reserves in managing Inland Northwest landscapes for natural resources and biodiversity. Wildlife Society Bulletin 24:209-221.

Everitt, B.S. 1992. The analysis of contingency tables, Second Edition. Monographs on Statistics and Applied Probability 45. Chapman and Hall, New York, New York.

Fiedler, C. E. and D. A. Lloyd. 1995. Autecology and synecology of western larch. Pages 118-122 *in* W. C. Schmidt and K. J. McDonald, compilers. Ecology and management of Larix forests: a look ahead. United States Department of Agriculture Forest Service General Technical Report INT-GTR-319, Ogden, Utah.

Graul, W. D., and G. C. Miller. 1984. Strengthening ecosystem management approaches. Wildlife Society Bulletin 12:282-289.

Habeck, J. R. 1990. Old-growth ponderosa pine-western larch forests in western Montana: ecology and management. Northwest Environmental Journal 6:271-292.

Hall, L. S., P. R. Krausman, and M. L. Morrison. 1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25:173-182.

Harestad, A. S. and D. G. Keisker. 1989. Nest tree use by primary cavity-nesting birds in south central British Columbia. Canadian Journal of Zoology 67:1067-1073.

Harris, R. D. 1983. Decay characteristics of pileated woodpecker nest trees. Pages 125-129 *in* J. W. Davis, G. A. Goodwin, and R. A. Ockenfels, technical coordinators. Snag habitat management: proceedings of the symposium. United States Forest Service General Technical Report RM-99.

Harvey, A. E. 1994. Integrated roles for insects, diseases, and decomposers in fire dominated forests of the inland western United States: past, present and future forest health. Pages 211-220 *in* R. N. Sampson, D. L. Adams, and M. J. Enser, editors. Assessing forest ecosystem health in the Inland West. Food Products, New York, New York.

Hepting, G. H. 1971. Diseases of forest and shade trees of the United States. United States Department of Agriculture Forest Service, Agricultural Handbook 386.

Hoyt, S. F. 1957. The ecology of the pileated woodpecker. Ecology 38:246-256.

Kilham, L. 1958. Repeated attacks by a sharp-shinned hawk on a pileated woodpecker. Condor 60:141-142.

Kilham, L. 1959. Behavior and methods of communication of pileated woodpeckers. Condor 61:377-387.

Kilham, L. 1974. Loud vocalizations by pileated woodpeckers on approach to roosts or nest holes. Auk 91:634-636.

Kneitz, V. G. 1961. Zur frage Verteilung von Spechthölen und der Ausrichtung des Flugloches. Waldhygiene 4(3-4):80-120.

Landres, P. B, J. Verner, and J. W. Thomas. 1988. Ecological uses of vertebrate indicator species: a critique. Conservation Biology 2:316-328.

Lawrence, L. D. K. 1967. A comparative life-history study of four species of woodpeckers. Ornithological Monograph Number 5.

Lawrence, L. D. K. 1970. The apartment. Audubon 72:4-7.

Lombardi, L. 1996. Preserve natural ecosystems in the Inland Northwest. Wildlife Society Bulletin 24:176-177.

MacCracken, J. G. 1996. Forest health in the Inland Northwest: maintaining the focus. Wildlife Society Bulletin 24:325-329.

McClelland, B. R. 1968. The ecosystem, a unifying concept for management of natural areas in the national park system. Rocky Mountain High Plains Parks and Recreation Journal Occasional Paper Number 3, Part 2.

McClelland, B. R. 1979. The pileated woodpecker in forests of the Northern Rocky Mountains. Pages 283-299 *in* J. G. Dickson, R. N. Conner, R. R. Fleet, J. C. Kroll, and J. A. Jackson, editors. The role of insectivorous birds in forest ecosystems. Academic, New York, New York.

McClelland, B. R., and S. S. Frissell. 1975. Identifying forest snags useful for hole-nesting birds. Journal of Forestry 3:414-417.

McClelland, B. R., S. S. Frissell, W. C. Fischer, and C. H. Halvorson. 1979. Habitat management for hole-nesting birds in forests of western larch and Douglas-fir. Journal of Forestry 77:480-483.

Mellen, K. M., E. C. Meslow, and R. W. Mannan. 1992. Summertime home range and habitat use of pileated woodpeckers in western Oregon. Journal of Wildlife Management 56:96-103.

Monnig, E. and J. Byler. 1992. Forest health and ecological integrity in the Northern Rockies. United States Department of Agriculture Forest Service FPM Report 92-7, Northern Region.

Montana Bird Distribution Committee. 1996. P. D. Skaar's Montana bird distribution. Fifth edition. Special publication. Number 3. Montana Natural Heritage Program, Helena, Montana.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management 38:541-545.

Panshin, A. J. and C. deZeeux. 1970. Textbook of wood technology, third edition. Volume 1. McGraw-Hill, New York, New York.

Ruggiero, L. F., Aubry, K. B., Holthausen, R. S., Thomas, J. W., Marcot, B. G., and Meslow, E. C. 1988. Ecological dependency: the concept and its implications for research and management. Transactions of the North American Wildlife and Natural Resource Conference 53:115-126.

Rumsey, R. L. 1970. Woodpeckers attack on utility poles: a review. Forest Products Journal 20(11):54-59.

SAS Institute Incorporated. 1988. SAS/STAT User's guide. Release 6.03. SAS Institute Incorporated, Cary, North Carolina.

Schmidt, W. C., R. C. Shearer, and A. L. Roe. 1976. Ecology and silviculture of western larch forests. United States Department of Agriculture Forest Service Technical Bulletin 1520, Washington, D.C.

Shearer, R. 1998. Coram Experimental Forest: fifty years of research. Pages 20-23 *in* Interpreting the landscape through science. Papers from a symposium, 15-16 May 1998, Flathead Valley Community College, Kalispell, Montana.

Shigo, A. L. 1969. The death and decay of trees. Natural History 78(3):42-47.

Shigo, A. L. and L. Kilham. 1968. Sapsuckers and *Fomes igniarius* var. *populinus*. United States Forest Service, Northeast Forest Experiment Station, Research Note NE-84.

Smith, W. H. 1970. Tree pathology: a short introduction. Academic, New York, New York.

Smith, W. P. 1983. Cooperative harassment of a pileated woodpecker by juvenile sharp-shinned hawks. Murrelet 64:97-98.

Thomas, J. W., L. F. Ruggiero, R. W. Mannan, J. W. Schoen, and R. C. Lancia. 1988. Management and conservation of old-growth forests in the United States. Wildlife Society Bulletin 16:252-262.

Toman, M. A., and M. S. Ashton. 1996. Sustainable forest ecosystems and management: a review article. Forest Science 42:366-377.

United States Forest Service. 1979. Coram Experimental Forest. United States Department of Agriculture Forest Service GPO: 1979-680-765, Ogden, Utah.

Wicklum, D. and W. Davies. 1995. Ecosystem health and integrity? Canadian Journal of Botany 73:997-1000.

Wright, K. H., and G. M. Harvey. 1967. The deterioration of beetle-killed Douglas-fir in western Oregon and Washington United States Department of Agriculture Forest Service Research Paper PNW-50, Portland, Oregon.

Riley McClelland received B.S. and M.S. degrees from Colorado State University. His Ph.D., from the University of Montana, emphasized ecology of cavity-nesting birds. In 1993 he retired as professor, School of Forestry, University of Montana, after 20 years of teaching and research. He also retired from the National Park Service after 37 years (partly concurrent with University of Montana duties) in various naturalist, resource management, and research positions in Yellowstone and Glacier National Parks. ***Patricia McClelland*** received a B.S. in education from Ohio State University and an M.S. in wildlife biology from the University of Montana. Her bird studies have concentrated on a variety of species and on bald eagles in the United States and Canada. Pat has worked on research and natural resource projects in Yellowstone and Glacier National Parks for more than 40 years. Her current interests include local land-use planning issues.

Associate editor: *Bowman*