

Woodpeckers as a keystone species

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Summary

This paper outlines the ecological importance of woodpeckers as a keystone species in a northern temperate zone forest ecosystem. As primary cavity excavators and nesters, woodpeckers create the majority of tree cavities which are frequently abandoned after initial use and then later used by many generations of secondary cavity nesting species. Primary and secondary Alberta cavity nesting birds are listed below with their respective common breeding habitats. Without the beneficial services of such tree cavity creators, the dependent woodland wildlife would have greatly reduced breeding success, survival rates and distribution due to much fewer secure nesting, denning and roosting sites in a cavity barren environment. The importance of wildlife trees to cavity nesting species is also discussed. A lack of suitable trees or cavities will result in a shifted forest food web, a subsequent increase in the insect population and a potentially unbalanced forest ecosystem.

Additional benefits provided by woodpeckers are also outlined. These include the provision of additional food sources for other species, greater control of insect populations, and potential increased fungal infection leading to accelerated forest decay and increased nutrient recycling. These added benefits significantly add to the role of woodpeckers as a critical keystone species within a forest ecosystem. Their presence and sustainability is therefore essential to successfully maintain adequate forest biodiversity.

What is a **keystone**?

- In architecture the often larger, trapezoidal-shaped center stone of a masonry arch which completes the construction of the arch and permits it to carry vertical loads. It is placed last at the top of the arch, which then locks the arch together and prevents its collapse.
- Something on which associated things depend for support.
- A species critical to the successful operation, sustainability and diversity of an ecosystem.

What is a **keystone species**?

- A plant or animal species group that many other organisms in a community or ecosystem depend on for survival and abundance. These species, often of a

predatory nature, which occupy a vital ecological niche in a specific location, enrich their ecosystem in unique and significant ways. This enrichment results from their uniquely important traits and attributes, and their activities, including preying on dominant species, causing disturbances, providing resources in times of scarcity, pollination, and supporting other keystone species. These resulting effects are significantly disproportionate to their numerical abundance than would normally be expected. The loss of a keystone species from the ecosystem can cause profound adverse affects on community structure, ecosystem process, and the diversity and abundance of other dependent species.

Origin of the **keystone species concept**

The keystone species concept has been a mainstay of the ecological and conservation biology literature since its introduction by University of Washington zoology professor Robert T. Paine in 1969. His seminal paper (*"The Pisaster–Tegula Interaction: Prey Patches, Predator Food Preference, and Intertidal Community Structure"*, Ecology, Vol. 50, Issue 6, November 1969, pp. 950–961) extended the conclusions of a marine field experiment originally published in 1966. The research resulting in the keystone species concept was done in the rocky intertidal zone at Mukkaw Bay along the Olympic Peninsula, outer northwest coast of Washington State. It involved the sustained removal of a single predator species, the carnivorous starfish *Pisaster ochraceus*, over a three-year period and careful documentation of the resultant changes. Paine found that this particular species played a key role in maintaining the balance of all other species in the entire intertidal community. He observed that if *Pisaster ochraceus* was removed from the community, the populations of two mussel species within the community grew unchecked. Without a predator to control their numbers, the mussels soon took over the community and crowded out other species, greatly reducing the community's diversity.

Keystone species are usually noticed when they are removed or they disappear from an ecosystem, resulting in dramatic and adverse changes to the rest of the community. The phenomenon has been observed in a wide range of ecosystems and for a wide range of organisms. Robert Paine's work, specializing in experimental ecology of rocky intertidal shores exposed to severe wave action along the outer coast of Washington State, has been cited by hundreds of researchers over the years, and it has been proposed as a foundation for management efforts to protect the biological diversity of the world's ecosystems. The ecological impact of a specific species group matters and protecting that key species group can stabilize and benefit an entire biotic community. Therefore to fully understand, manage and restore ecological assemblages, the role of specific species groups must be well understood.

Examples of keystone species in different habitats include salmon, sea otters, grizzly bears, beavers, woodpeckers, prairie dogs, coyotes, wolves and elephants. Beavers are considered a keystone modifier, by modifying their habitat with dams which then alter hydrological processes, channel geomorphology, biogeochemical pathways and community productivity. The re-introduction of wolves as the top predator into

Yellowstone National Park since 1995–96 has dramatically impacted the local ecosystem and quickly restored the park's natural ecological balance. Elephants are classified as keystone herbivores, as their foraging causes drastic habitat modification with the removal of trees, thus preserving the African savannah grasslands and its numerous dependent species.

Woodpeckers as a keystone species

Woodpecker activities, especially of the larger pileated woodpecker, benefit other species through the provision of foraging opportunities, accelerated forest decay processes, increased nutrient recycling, control of insect populations, and facilitated inoculation by heart-rot fungi (*Phellinus tremulae*), an ecologically important disturbance agent. Woodpecker created wounds into the heartwood of healthy trees may provide an invasion pathway for airborne heart-rot fungi spores if the wound is not flushed out and quickly sealed with tree sap. Heartwood decay produces hollow chambers in live trees and the resulting softened wood is essential for nest-cavity excavation by most woodpeckers, chickadees and nuthatches.

Woodpeckers are often classified as keystone habitat modifiers, ecosystem architects or tree surgeons because of their creation of cavity sites in hard snags and decadent live trees. Cavity creation typically results from three processes; excavation of nest cavities and cavity-starts, excavation of openings into roost cavities, and foraging excavations. Many species of birds, mammals and invertebrates, known as secondary cavity users, subsequently benefit from the use of abandoned woodpecker cavities for use as nesting, denning, roosting and food storage sites often in mid- to late-successional forests. Natural cavities created by weathering and decomposition are usually in short supply compared to woodpecker excavated cavities, which have the added attraction of being designed to provide maximum security and shelter. As most woodpeckers excavate new nesting and roosting cavities for themselves every year, they constantly provide new habitat for the secondary cavity users. This ongoing resupply of cavities is essential, as existing cavities are regularly lost as old wildlife trees decay and fall, and as nests become unusable due to excess accumulation of nesting material.

Nest site selection follows the defining of territorial boundaries and the cementing of pair bonds. Cavity excavation follows the courtship ritual and pair bonding of most woodpeckers, which is why the strong cavity excavators rarely reuse nest holes from previous years or use nest boxes. Each woodpecker species constructs a slightly different style of nesting cavity in terms of the size of the cavity, diameter of the entrance hole and height above the ground. The typical woodpecker nest has a short horizontal tunnel leading to a vertical chamber within the tree trunk with an enlarged nest chamber at the bottom. The size and shape of the chamber depends on the specific species, and the entrance hole is typically only as large as is needed to allow access for the adult birds. Downy woodpeckers always select dead or dying wood and create a circular hole about 1" (2.5 cm.) in diameter. The slightly larger hairy woodpecker prefers live decaying wood and makes oblong holes about 2.5" (6.4 cm.) high and 1.5" (3.8 cm.) wide. The

larger northern flicker prefers live wood and makes a 3" (7.6 cm.) hole, 8 to 25 feet (2.4–7.6 meters) above the ground.

The orientation of a cavity entrance affects its internal temperature. In more northerly or high-elevation regions, which have cool summers and cold winters, woodpeckers often orient the cavity opening to take full advantage of solar heating and shelter from the chilling effect of prevailing winds. Small to medium-sized woodpeckers often orient their cavities so that the opening is on the underside of a branch or on a leaning trunk, thus sheltering it from the rain. (Backhouse, 2005, p. 70)

Trembling aspen trees house more woodpecker cavities than any other tree species in North America. It is the continent's most widely distributed tree species and it has numerous attributes that make it eminently suitable for woodpecker purposes. Aspens have relatively soft sapwood that is easy for woodpeckers to excavate into when the tree is alive; they produce little sap when wounded; they are susceptible to a type of decay fungus (*Phellinus tremulae*) that produces an ideally soft core; they can remain standing for years after they die; and their bark retains its integrity even when wood decay is well advanced, a significant advantage for weak excavators. Aspens also offer relatively good security because they have very smooth bark and few branches on the main trunk. (Backhouse, 2005, p. 71)

Woodpeckers also fill a key role in controlling insect populations through direct consumption as they are well adapted to access insect prey that other avian predators cannot reach. Indirect effects include altering insect microhabitats, increasing parasite densities, and exposing remaining prey to consumption by both vertebrate and invertebrate predators. Woodpeckers are important biological control agents of bark beetles and wood-boring beetles. As most woodpeckers are non-migratory, they are the primary avian insectivores during the winter months.

Pileated woodpeckers

As the strongest excavators, pileated woodpeckers are the only species that excavates extensively into sapwood and heartwood for invertebrate prey. Other woodpeckers are relatively weak excavators that typically locate prey by ground foraging, surface gleaning, scaling bark, or pecking substrates without penetrating the sub cambial tree layers. Consequently, pileated foraging excavations enables other woodpeckers and species to prey on invertebrates that would otherwise be unavailable to them, including downy and hairy woodpeckers, northern flickers and house wrens.

Pileated woodpeckers directly and indirectly accelerate wood decomposition and, ultimately, nutrient recycling by physically breaking apart sound and decaying wood as they excavate the largest nest and roost cavities, and forage for invertebrate prey by exposing wood in live trees, snags, and logs to fungal infection. Nest cavities and cavity-starts excavated by pileated woodpeckers typically provide more protection from

potential predators, have greater longevity, and provide habitat for secondary users over a longer time period than those excavated by other woodpeckers. For these ecological impacts, pileated woodpeckers are the most significant of the strong cavity excavators and therefore the most important keystone species.

Pileated woodpecker pairs excavate new nest cavities each year following their courtship ritual and pair bonding, and exhibit a strong preference for nest trees on the basis of tree diameter and the structural quality of the wood. They generally select very sound trees, which are not easily toppled or broken by wind and may stand for many years or even decades after their initial occupancy. Trees with sound wood but in the early stages of decay from heart-rot fungi (*Phellinus tremulae*) are preferred, presumably because soft wood in advanced decay cannot support large nest cavities. The pileated woodpecker chips out rectangular or oval entrances up to 5" (12.7 cm.) high and 15 to 70 feet (4.6–21.3 meters) up the tree trunk. Several field studies have indicated that nest cavities located high off the ground may reduce the incidence of nest predation. As the pileated creates nesting cavities larger than the other woodpeckers, requiring a cavity with a minimum diameter of at least 18" (45 cm.), it likely provides the majority of suitable tree cavities for the larger birds and mammals. These larger cavities with generally thicker walls provide less thermal conduction and greater heat retention, resulting in slower temperature changes and reduced temperature variation, particularly in live wood, as compared to dead wood which has greater temperature extremes, being hotter in the day and colder at night. These favorable tree characteristics also increase the structural integrity of the cavity and reduce the likelihood that the tree will break at the cavity location. In addition, such cavities surrounded by a thick shell of sound sapwood provide better protection from predators, such as raccoons and black bears that often climb trees and break open nest cavities.

Red-naped Sapsuckers — dual keystone species

An investigation during the 1991 breeding season in a Rocky Mountain subalpine ecosystem in Gunnison County, Colorado (Daily et al., 1993), showed subtle species interdependencies where red-naped sapsuckers play two distinct keystone roles. They excavate nest cavities in heartwood fungus-infected aspens that are required as nest sites by tree and violet-green swallows. They also drill sap wells into spruce, aspen and shrubby willows. The willow sap constitutes a major portion of the Sapsucker's diet during the summer breeding season, and is stolen by over 40 species, including hummingbirds, other woodpeckers, warblers, white-breasted nuthatches, ruby-crowned kinglets, white-crowned sparrows, pine siskins, common goldfinches, mountain chickadees, house wrens, chipmunks, squirrels, wasps, bees and butterflies. The sap wells provide a vital dietary supplement in late summer, especially for the warblers, when the availability of insects and flower nectar begins to decline.

The breeding distribution of the closely related yellow-bellied sapsucker appears to determine the northern breeding range limits of both the ruby-throated and rufous hummingbirds (Daily et al., 1993, also Miller, R. S. & Nero, R.W., 1983, Canadian Journal of Zoology, 61, p. 1540–1546). These two hummingbird species have the longest

migration routes and the most northerly breeding distribution for all hummingbirds. There is strong evidence that the timing of these hummingbirds' spring arrival, often before flowers are in bloom, and the northern limits of their breeding range are determined by the sapsuckers' migratory schedule and distribution (Backhouse, 2005, p. 107). Tree sap is very similar in both sucrose content and viscosity to the nectar of flowers favored by hummingbirds. The Sapsuckers thus make available a rich resource to numerous species when they are reproducing.

The importance of wildlife trees

Excavated nesting holes and natural cavities resulting from decay are usually found in dead or decaying trees. These trees are commonly called hollow trees, roost trees, senescent trees, cavity trees, den trees, snags or more recently *wildlife trees*, in recognition of their enormous value to birds and other wildlife. In forest ecology a *snag* is defined as a standing tree which is partially or completely dead, often missing its top or most of its smaller branches. Tree mortality caused by old age, lightening, wildfire, storm breakage, disease, insects, lack of sunlight, or poor growing conditions is a natural occurrence in forests, so snags are a normal part of a mature forest, with coniferous snags generally standing longer than deciduous snags.

There is a direct relationship between the number of snags in an area and the numbers of cavity nesting birds present. Also, the more snags of various sizes that are present in a community, the larger and more diverse will be the population of cavity users. Consequently, keeping these trees in a forest ecosystem is a significant step towards enhancing wildlife habitat and diversity. Suitable snags, preferably 20 feet (6.1+ meters) or greater in height, require early identification and tagging to meet current and future local wildlife habitat needs. These mature trees, often perforated with multiple cavities, eventually become multi-level condominiums for a variety of birds, mammals and invertebrates. Numerous species of raptors, which are typically open nesters (large, open, cup-shaped or platform style stick nests supported by large branches, sturdy treetops, or a forked tree trunk) also require snags as resting and hunting perches.

Hollow chambers in snags and live trees, which are created by the process of heartwood decay and woodpecker excavation, are important to a wide variety of bird and mammal species for nesting, roosting, denning, and resting. The size, shape and location of cavities determine how wildlife species use them, as each snag dependent cavity nesting species has its own unique criteria in determining which snag it will use. These criteria can include tree species, height, diameter, stage of decay, snag distribution in the area, and the successional stage of the plant community in the area. The snag diameter can be a dominant parameter, with larger birds requiring larger cavities and smaller birds preferring smaller cavities. Larger diameter cavities provide habitat for more species than small cavities. Most cavity nesters generally require a minimum diameter of 10" (~25 cm.) and a height of 20 feet (~6 meters). Nest or den cavities are used for nesting, rearing young and food storage. Escape or roost cavities are used for roosting, temporary shelter from inclement weather, protection from predators and if large enough, for hibernation.

Wildlife trees also play an essential role in woodpecker acoustical communications, especially during the breeding season. The resonating qualities of recently dead trees or the dead tops of live trees make them important as drumming stations to produce loud, low frequency sound for optimum long distance transmission. From these sites, both male and female woodpeckers broadcast messages related to mate attraction, courtship, maintenance of pair bonds and the establishment of territorial boundaries.

Snags have often been considered undesirable by forest and recreation management due to a lack of esthetics, harboring forest insect pests, fire or safety hazards, and conflicts with other forest management practices. Harvesting large dead or dying trees will have significant adverse ecological effects on many important bird species, especially woodpeckers, nuthatches, owls, swallows and wrens. Loss of nesting sites in specific locations (Arizona ponderosa pine forest) has resulted in documented reductions of 50% to 90% of specific bird species populations (Coveside Bird Houses, 2004, www.coveside.biz/cavity-nesting-birds.htm). Because cavity nesters require older mature trees and snags for nesting, roosting, feeding and territorial displays, their habitat requirements often conflict with optimized commercial timber production.

The removal of logs and slash on the forest floor is also detrimental to numerous forest species. Cavity nesting birds often use this downed debris as food sources, lookout posts, drumming sites, dusting sites, winter shelter and as nesting and cover sites. Downed logs also act as nurseries for new plants and provide shelter and denning sites for forest mammals, amphibians and reptiles.

Sustainable forest management practices and the successful maintenance of existing biodiversity require;

- frequent monitoring and periodic reviews of current forest management practices,
- integration with individual wildlife species physical habitat requirements following completion of a wildlife biophysical inventory survey or the use of existing legacy baseline inventory data,
- updated species–habitat models that accurately reflect the needs of different wildlife species, and
- ongoing research on rare, endangered, sensitive and harvested species.

Common classification of cavity nesting species

Cavity nesting species are classified into the following categories or guilds;

Primary cavity excavators – the term used for birds (primarily woodpeckers) that excavate their own holes by chiseling into standing live or dead trees for their nesting and roosting needs.

Secondary cavity users – the term used for birds and mammals that require either natural cavities or those made by primary cavity excavators.

Facultative secondary cavity nesters – those species (e.g. northern flicker, chickadees and nuthatches) that are capable of excavating their own cavities, but typically use existing cavities created by primary cavity excavators.

Obligatory secondary cavity nesters – those species that cannot excavate their own cavities and depend on existing cavities created by either primary or facultative secondary cavity nesters.

Cavity nesting birds

Birds build nests or use existing ones to protect themselves, their eggs, and their young from predators and from adverse weather. Although other animal species also build nests, birds do so in a greater variety of forms (burrow, cavity, cup, mound, pendant, platform, saucer, scrape, sphere), from a greater variety of materials, and on a greater variety of sites. Nests are often lined with wood chips, bark, twigs, rootlets, leaves, weed stems or pine needles, or soft materials such as feathers, grass, moss, lichen, hair, wool, down or fur.

Approximately 85 species of North American birds are cavity nesters. Cavity nesting birds build their nests in tree cavities or holes, which can be natural resulting from decaying wood, or excavated, usually by woodpeckers following their annual courtship ritual. Both primary and secondary cavity nesting birds will use artificial cavities (nesting boxes, bird houses), although most woodpeckers will not. Those species most receptive to using boxes include ducks, tree swallows, bluebirds and wrens.

The majority of cavity nesting birds are insectivorous, typically making up a large proportion of the forest-dwelling bird population (Scott et al., 1997, www.na.fs.fed.us/spfo/pubs/wildlife/nesting_birds/) and are effective biological control agents for beetles, budworms, caterpillars, moths, sawflies and weevils. Consequently, they play an important role in maintaining a healthy forest ecosystem through the control of forest insect pests.

Alberta breeding cavity nesting birds

Listed below are the Alberta breeding cavity nesting wild birds. This list consists of 35 species of which 13 are primary excavators and the remaining 22 are secondary users (**R** = Resident, **M** = Migratory). The Alberta primary cavity excavator guild comprises 8 members of the woodpecker family, 3 chickadee species and 2 nuthatch species. Members of this guild are classified as either strong or weak excavators. Chickadees and nuthatches are the weak excavators and require decay-softened wood for successful excavations.

Common Name**Common Breeding Habitat****Primary cavity nesters:**

Yellow-bellied Sapsucker (M)
(Summer resident)

usually in live trembling aspen or balsam polar with heart-rot fungus, at forest edge adjacent to water bodies or other openings, uses the same tree perennially but not the same hole

Red-naped Woodpecker (M)
(Summer resident)

live hardwoods (aspens, birch, poplar, cottonwood, willows) with heart-rot fungus, a new cavity is excavated each year often in the same tree

Downy Woodpecker (R)

deciduous and mixed forests in dead or dying hardwoods nearly always infected with advanced heart-rot, a new cavity is excavated annually, occasionally in the same tree

Hairy Woodpecker (R)

on mature woodland edges in live or dead hardwoods with decayed heartwood, often in trembling aspens, a new cavity is usually excavated each year

American three-toed Woodpecker (M)
(Winter resident)

usually dead or live woodland deciduous or conifer with heart-rot, prefers spruce, usually near or in open places, a new cavity is usually excavated each year

Black-backed Woodpecker (M)
(Winter resident)

conifer forests usually in dead wood, often near or in open areas, nearly always excavates a new cavity annually

Northern Flicker (R)

moderately open, sparsely-wooded areas or forest edges, deciduous, conifer or mixed, sometimes in dead wood, more often in live wood, requires weakened sapwood and extensive heartwood decay, will reuse old nest cavities more than most other woodpeckers, will also use nest boxes

Pileated Woodpecker (R)

forests with large diameter dead or dying conifer or deciduous mature trees often with heart-rot, holes often face east or south often

	on bark-free surfaces, excavates a new nest annually
Black-capped Chickadee (R)	deciduous and conifer riparian woodlands or forest edges, with soft, rotting wood in advanced decay stage
Mountain Chickadee (M) (Altitudinal migration, lower elevations during winter)	open conifer mountain forests, especially old-growth spruce and fir forests with soft, rotting wood, will reuse nest cavities and pre-existing cavities
Boreal Chickadee (R)	moist and open spruce and fir forests in soft, rotting wood, often on habitat edges and near bogs or muskegs, will use woodpecker and natural cavities
Red-breasted Nuthatch (R)	usually mature spruce, fir, pine or mixed forests with soft heartwood in moist riparian areas and shady, north-facing slopes, will reuse cavities including woodpeckers
White-breasted Nuthatch (R)	mostly uses natural cavities, woodpecker's or excavates in mature conifers or aspen with decay
Secondary cavity nesters:	
Wood Duck (M) (Summer resident)	large, mature hardwoods in woodlands near quiet, fresh and shallow waterways (lakes, beaver ponds, sloughs and streams) with large willows and cottonwoods
Bufflehead (M) (Summer resident)	wooded areas with poplars, very near small lakes and ponds with vegetated margins and open water
Common Goldeneye (R)	in mature woodlands near standing or slow-moving water with marshy shores and adjacent deciduous trees
Barrow's Goldeneye (M) (Winter resident)	open late-seral forest edges near lakes, ponds, streams and sloughs with dense submerged vegetation and adjacent to mixed forests with large and dead trees

Hooded Merganser (M) (Winter resident)	near still or slow-moving secluded fresh water, forest ponds and lakes, riverside swamps and streams with fish, emergent vegetation and forested shorelines
Common Merganser (R)	forested shores of clear lakes, large rivers or beaver ponds
American Kestrel (M) (Summer resident)	woodpecker hole or natural cavity at woodland edges or grasslands near watercourses with scattered trees for perching and nesting
Merlin (R)	conifer and mixed forests, sparse woodland bordering open areas primarily use abandoned hawk, crow, jay or magpie nests in woodlands or cliff ledges
Northern Hawk Owl (M) (Winter resident)	mainly natural cavities in black-spruce bogs and muskegs, old burns and conifer or mixed forests bordering cleared or open areas, also decayed woodpecker cavities
Northern Pygmy Owl (M) (Winter resident)	abandoned woodpecker holes in conifer, deciduous or mixed forests, often on steep slopes near openings and water
Barred Owl (R)	large and mature conifer and mixed forests near open areas and often in riparian areas
Boreal Owl (M) (Winter resident)	abandoned woodpecker nests and natural cavities in mature conifer and mixed forests, often adjacent to open meadows
Northern Saw-whet Owl (M) (Summer resident)	abandoned woodpecker cavities, conifers or hardwoods in mature, open, riparian forests, sparsely treed rangeland, marshes and bogs
Vaux's Swift (M) (Summer resident)	old-growth forests with mature conifer and deciduous trees using pileated roost cavities or hollow trunks

Tree Swallow (M) (Summer resident)	old woodpecker cavities usually near water edges of lakes, ponds, rivers and wet meadows, or grasslands and open aspen forests near foraging habitat
Violet-green Swallow (M) (Summer resident)	open mixed forests, near ponds and marshes
House Wren (M) (Summer resident)	old woodpecker, nuthatch or chickadee cavities in hardwood forests, farmland and human settlements, will use any structure offering a cavity
Winter Wren (M) (Summer resident)	moist and thick mature spruce and fir forests, often near water
Mountain Bluebird (M) (Summer resident)	abandoned woodpecker nests in semi-open to open habitats adjacent to open foraging habitat, including woodland, forest edges, burns, subalpine meadows, grasslands, lake shores, farmland, orchards and ranches
European Starling (R)	parks, suburbs, mature cottonwood aspen and balsam groves and cottonwood islands with dead snags for nesting
House Finch (R)	cultivated areas and around buildings, more rarely in trees, near water
House Sparrow (R)	usually near cultivated and urban areas, often nests communally

Primary and Secondary cavity species webs

(modified from Fenger et al., 2006, Figure 14, p. 32)

Primary Cavity Excavator, minimum tree diameter	Cavity entrance width, cm.	Secondary Cavity User
Pileated Woodpecker 40 cm.	8–10 by 10–15 (elliptical)	Wood Duck, Common Goldeneye, Barrow's Goldeneye, Northern Hawk Owl, Boreal Owl, Northern Saw-whet Owl,

		Vaux's Swift, Bats, Northern Flying Squirrel
Northern Flicker 30 cm.	6.5	Bufflehead, Hooded Merganser, American Kestrel, Northern Hawk Owl, Northern Pygmy Owl, Boreal Owl, Northern Saw-whet Owl, Mountain Bluebird, Northern Flying Squirrel, Tree Squirrels
Hairy Woodpecker 25 cm.	4.5	Northern Pygmy Owl, Northern Saw-whet Owl, Tree Swallow, Mountain Bluebird, Northern Flying Squirrel, Chipmunk
Sapsuckers & Downy Woodpecker 25 cm.	4	Tree Swallow, House Wren, Mice
Nuthatches 15 cm.	3–4	Nuthatches, House Wren
Chickadees 10 cm.	3.5	Chickadees, House Wren

Woodpecker nesting times (from Bannick, 2008, p. 192 & 194)

Yellow-Bellied Sapsucker	Early March through mid-July
Red-Naped Sapsucker	Mid-March through early August
Downy Woodpecker	Early April until late July
Hairy Woodpecker	Mid-March through July
Northern Flicker	Late April through early August
Pileated Woodpecker	Early May through mid-July

Other cavity nesting species

Numerous mammals are also secondary cavity users, including deer mice, voles, woodrats, chipmunks, tree squirrels, northern flying squirrels, bats, raccoons, striped skunks, pine martens, fishers, porcupines, mink, weasels, bobcats and black bears.

Insect users include honeybees, wasps, butterflies and carpenter ants.

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