PILEATED WOODPECKER WINTER HABITAT

HABITAT SUITABILITY INDEX MODEL

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1. INTRODUCTION

Habitat Suitability Index (HSI) models predict the suitability of habitat for a species based on an assessment of habitat attributes such as habitat structure, habitat type and spatial arrangements between habitat features. This HSI model for the pileated woodpecker (*Dryocopus pileatus*) applies to habitats of the Foothills Model Forest (FMF) in west-central Alberta. The intended use is to predict habitat suitability at landscape scales and over long-time periods. The model will be used to determine potential changes in pileated woodpecker habitat area and carrying capacity throughout an entire forest management cycle (200 years). The model was developed using literature review and preliminary information from a habitat ecology study of pileated woodpeckers in the FMF, and will be evaluated using data from the study.

2. SPECIES DESCRIPTION AND DISTRIBUTION

The pileated woodpecker is the largest North American woodpecker species. Adults are "crow-sized" (40-49 cm long), with average mass of 240-341 g, and males are 5-10% heavier than females (Short 1982, Bull and Jackson 1995). Body and upper wing feathers are black to very dark charcoal grey, and there is an oval white patch on the underside of the wings. Both sexes have prominent red crests (larger in the male), and a prominent white line that extends from the base of the bill down each side of the neck to the shoulders. The bill is long and chisel-shaped. In addition to other characteristics, malar coloration visibly distinguishes the sexes (red in males, black in females). Adults have reached the age of 11 years in the wild (Hoyt 1952). The most common calls are a series of loud "cuks" and a higher, rolling series of cuks fairly similar to the call of a northern flicker, but shorter and less mechanical sounding. Both sexes drum using a distinctive "slow sonorous drum-roll" (Ellison 1992).

Pileated woodpeckers occur in forests of North America from northern British Columbia to northern California in the west and Nova Scotia to Florida in the east (Short 1982, Bull and Jackson 1995). In Alberta, pileated woodpeckers are mainly in the Boreal Forest, Foothills, and Rocky Mountain Natural Regions. Pileated woodpeckers were recorded in 15.3% of 2206 100 km^2 areas surveyed for the Alberta Breeding Bird Atlas (Semenchuk 1992). It is probable that pileated woodpeckers occupy most forested habitat in Alberta (Bonar unpublished data).

Pileated woodpeckers are generally associated with mature and old forests (McClelland 1979, Bull 1987, Renken and Wiggers 1989, Mellen et al. 1992). They are non-migratory (Hoyt 1957, Bock and Lepthien 1975) and have a fairly low reproductive rate (2-3 young/pair/year) (Bull and Jackson 1995). Life-mated pairs have large home ranges that are defended all year against other pileated woodpeckers (Kilham 1976, 1979). Pileated woodpeckers excavate a new nest cavity each year in large trees, roost at night in tree cavities, and feed primarily on carpenter ants (*Camponotus* spp.) and other insects obtained by excavating into dead and living wood (Hoyt 1957, Bull 1987).

Tree cavities which the pileated woodpecker excavates each year are in turn used by other cavity-using forest wildlife species. In an Idaho study, 18 of 19 cavities used by nesting boreal owls (*Aegolius funereus*) were originally excavated by pileated woodpeckers (Hayward et al. 1993). Pileated woodpecker cavities in Alberta are used by at least 18 other species (Bonar in review). In northern forests, where natural cavities are uncommon, a continuous supply of old pileated woodpecker cavities are probably important for maintaining populations of large cavity-using wildlife species that cannot get into cavities made by smaller woodpecker species (Bonar in review).

3. FOOD

Wood-dwelling insects are the primary diet of pileated woodpeckers throughout the year, and carpenter ants are a major food in all seasons (Bent 1939, Hoyt 1957, Beckwith and Bull 1985, Bull et al. 1992a). Carpenter ants are particularly important in winter, when they form the bulk of the diet. Other ant species (especially thatching ants (*Formica* spp.), and seasonally abundant insects obtained from soft wood are eaten in spring, summer, and fall (Hoyt

1957, Bull et al. 1992a). Thatching ants comprised approximately 60% of the summer diet in an Oregon study (Bull et al. 1992a).

Pileated woodpeckers show a seasonal change in foraging methods and diet that appears to be related to the availability of arthropod food (Hoyt 1957, Conner 1979, 1981, Bull and Holthausen 1993). In winter, the main foraging method is deep excavation into relatively sound wood to access carpenter ant colonies. Pileated woodpeckers take opportunistic advantage of bark beetle outbreaks and may temporarily shift much of their foraging to scaling bark from trees to access bark beetle larvae (Kroll and Fleet 1979, Bull 1987). In summer, excavations into sound wood are mostly replaced by excavations into softer wood, surface gleaning, and probing. The variety of arthropod foods used increases in summer, but ants are still the dominant food item. Pileated woodpeckers opportunistically exploit seasonally abundant food sources such as western spruce budworm (*Choristoneura occidentalis*) larvae (Bull et al. 1992a), berries, nuts, and fruits of many species (Hoyt 1957, Bent 1939).

The seasonal change in foraging methods is accompanied by a seasonal change in foraging substrates, which also appears to be related to food availability. Summer food is abundant at or near the wood surface so birds do not need to expend energy in deep excavations through sound wood to obtain food. Winter food is only obtainable by deep excavation or scaling, and many of the foraging substrates used in summer such as stumps and logs may be covered by snow. This is particularly true in areas with deep and extensive winter snow cover (McClelland 1977).

Pileated woodpeckers do not use habitat randomly at the stand-level of selection. Selection appears to be related to the availability of food (Conner 1979, Renken and Wiggers 1989, Mellen et al. 1992, Bull and Holthausen 1993). Food is primarily obtained from dead wood, and forest characteristics related to the availability of dead wood are correlated with pileated woodpecker home range size (Renken and Wiggers 1989) and use of forest stands (Mellen et al. 1992, Bull and Holthausen 1993). Density and characteristics of foraging substrates vary among stand types.

4. COVER AND ROOSTING

Cover is associated with both food and predator avoidance. Pileated woodpeckers are closely associated with tree cover for nesting, roosting, and foraging. In spring, summer, and fall they forage in both open and closed canopied areas. In winter, logs and stumps are mostly unavailable due to snow cover, particularly in open areas, and as a consequence use of open areas declines. Tree cover is also important for predator avoidance, particularly from avian predators. Pileated woodpeckers foil avian predation attempts by dodging around tree trunks (Lima 1993, R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997). The major predator of pileated woodpeckers appears to be the northern goshawk (Bull et al. 1992b, Bull and Jackson 1995, R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997).

Pileated woodpeckers roost at night in tree cavities that reduce predation risk and offer protection from poor weather (Bull et al. 1992b). Members of mated pairs usually have separate roost trees, although they occasionally occupy different cavities in the same tree. Some roost cavities are used by both birds, but never at the same time. Each bird uses several roost trees, and birds disturbed after they have entered a roost fly directly to an alternate tree. Roost cavities include cavities excavated and used previously as nests (Hoyt 1957, Kilham 1979, McClelland 1979, Bull 1987, Mellen 1987), natural cavities (hollow trees) with entrances excavated by the birds (Bull et al. 1992b), and natural cavities with entrances not excavated by the birds (Aubry and Raley 1992). Roost trees often have two or more entrances that connect an internal hollow (Bull et al. 1992b).

5. REPRODUCTION

Eggs are laid in late April or early May and hatch after a 14-18 day incubation (Short 1982, Bull and Jackson 1995). The parents brood the young for the first few weeks and both adults carry food which is fed to the young by regurgitation. When the nestlings are about 12 days old, they climb to the nest entrance and the parents feed them from there instead of going inside. By this stage, the young make the typical woodpecker “churring” sound when the parents are at the nest, and most will fledge within another 2 weeks. Fledged young remain with the parents for most of the summer and disperse from the parent’s territory in August or September.

For reproduction to occur, a territory must contain at least some trees suitable for nesting. With a few rare exceptions, pileated woodpeckers nest only in tree cavities that they excavate. New cavities are usually excavated each year, but a few instances of old cavity reuse have been reported (Hoyt 1957, Bull 1987, Bonar unpublished data). More commonly, new cavities are excavated in previously-used nest trees and nest-tree stands (Bull 1987, Bull et al. 1992b, Bonar in review). Cavity excavations are frequently started and then abandoned, and some of

these are completed in later years and used for nesting or roosting (Bull and Jackson 1995, R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997).

Cavities are almost always excavated in the main trunk of the tree. Only trees big enough to hold a large cavity relatively high above the ground are used for nesting. The largest available trees of suitable species seem to be preferred. To accommodate large cavities, the minimum dbh (diameter at breast height, 1.3 m) of trees used for nesting appears to be about 33 cm (Conner et al. 1976). In Alberta pileated woodpeckers have successfully nested in trees as small as 29 cm dbh (R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997).

Nest cavities are usually located at least 4 m from the ground, and are often much higher on the branch-free portion of the trunk (Bent 1939). Pileated woodpeckers may prefer high cavities to "hide" the nest from ground-based predators and also to make it harder for them to reach the nest. Branches may interfere with cavity excavation or movement of adult birds flying to and from the nest.

Pileated woodpeckers use many tree species for nest trees, with variation according to geographic location and available tree species composition. Hoyt (1957) reported nests in 12 different tree genera. In Virginia, nests were in oaks (*Quercus* spp.) and hickories (*Carya* spp.; Conner et al. (1976); in the interior coniferous forests of Oregon ponderosa pine (*Pinus ponderosa*), western larch (*Larix occidentalis*), and Douglas fir (*Pseudotsuga menziesii*) were the primary species used for nest trees (McClelland 1979, Bull 1987). In the coastal rain-forests of Washington, most nests are in western hemlock (Aubry and Raley 1992). In Alberta and north-eastern British Columbia, 113 of 115 nests were in living trembling aspen (*Populus tremuloides*), 1 was in a balsam poplar (P*opulus balsamifera)* snag, and 1 was in a white spruce (*Picea glauca*) snag (R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997).

Both living and dead trees are used for nesting, but dead trees are used more often in many areas (Hoyt 1957, Conner et al. 1976, McClelland 1979). However, it seems that the species of tree and whether the tree is alive or dead may be less important than the physical characteristics of the tree. Pileated woodpeckers are capable of excavating a cavity in sound, dense wood (Bull 1987), and nest trees almost always have sound sapwood at the cavity entrance. This lessens the chance that the tree will break at the cavity and makes it harder for predators to break into the nest.

Pileated woodpeckers show a preference for trees with fungal-softened heartwood at the cavity location (Conner et al. 1976, McClelland 1979, Bonar unpublished data). Soft hardwood is easier to excavate, and fungal respiration may heat the cavity (Conner et al. 1976). In boreal forests, aspen, balsam poplar, paper birch (*Betula papyrifera*), and balsam/subalpine fir (*Abies* spp.) are species where heartwood decay occurs high on the trunk.

6. HABITAT AREA

Pileated woodpecker pairs generally mate for life and actively defend their territories against other pileated woodpeckers throughout the year (Hoyt 1957, Bull and Jackson 1995). There have been only two studies that provide year-around territory size information. In Oregon, territory size of individual birds was 200-1586 ha, and pair territories were slightly larger than the territory of either partner (Bull and Holthausen 1993). The territories of birds in Alberta are considerably larger, ranging from approximately 1000-4000 ha and averaging more than 2000 ha (R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997).

Pileated woodpecker territories must contain foraging and nesting/roosting opportunities.

7. HSI MODEL DEVELOPMENT

7.1 MODEL APPLICABILITY

Species: Pileated Woodpecker (*Dryocopus pileatus*).

Habitat Evaluated: Nesting, roosting, and winter food habitat.

Geographic Area: This model is applicable to the Foothills Model Forest in west-central Alberta.

Seasonal Applicability: This model was developed to evaluate year-round habitat.

Cover Types: This model applies to all forest and non-forest habitat areas of the Lower and Upper Foothills, Montane and Subalpine Natural Subregions of Alberta (Beckingham et al. 1996). The model should also be broadly

applicable to other habitat areas dominated by similar tree species, including boreal deciduous, mixedwood and coniferous forest types.

Minimum Habitat Area: Pileated woodpeckers have large territories and are highly mobile. There is no minimum habitat area for nesting, roosting, or foraging. It is assumed that birds will readily use a single tree, snag, or stub for these activities, regardless of the location.

Model Output: This model will produce Habitat Units (HU) for all cover types for their suitability as (1) nesting/roosting habitat; and (2) winter foraging habitat. HU are calculated by multiplying the HSI score with the area in hectares. The performance measure for the model is potential carrying capacity (pileated woodpecker pairs per hectare). Model output (HU) must be correlated to estimates of carrying capacity to verify model performance.

Carrying Capacity: Each pair of pileated woodpeckers is assumed to use a territory of at least 500 ha, so the number of pairs per hectare where HSI = 1.0 is 0.002.

Verification Level: This model is based on a review of the U.S. Fish and Wildlife Service HSI model (Schroeder 1983), literature review, and preliminary results from an ongoing research study on pileated woodpecker habitat ecology in the FMF (R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997). The model has been reviewed by several biologists but not by third-party recognized species experts. When available, data from the research study will be used to calibrate and improve the model. The verification is currently 4: local data used to develop model but model predictions have not been tested.

Application: This HSI model is designed to assess habitat suitability for relatively large forest landscapes using generalized species-habitat relationships and stand-level vegetation inventory. Its purpose is to predict relative changes in pileated woodpecker habitat supply at the landscape level over long time periods (200 years), for integration with forest management planning. The model is not designed to provide accurate prediction of suitability or use at the stand level. Approximate population size can be calculated by assuming linear habitat-population relationships, but the model is not designed to provide accurate population density estimates. Any attempt to use the model in a different geographic area or for other than the intended purpose should be accompanied by model testing procedures, verification analysis, and other modifications to meet specific objectives.

7.2 MODEL DESCRIPTION

Unless otherwise stated, all statements and assumptions used to develop the HSI model are based on preliminary results from the ongoing pileated woodpecker habitat ecology research (R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997; Bonar in review).

Forested habitat provides nest trees, roost trees, food, cover, and opportunities to escape raptor predation, which are assumed to be the major habitat needs of the pileated woodpecker. Food and cover needs are found to some extent in all forest types except very young stands that have little residual forest structure. Nest/roost trees are found only in stands which have trees or snags of the correct size, species, and decay characteristics. Food and nesting/roosting habitat are considered to be the limiting life requisites on which the HSI for the pileated woodpecker is based. Raptor escape opportunities are assumed to be present in all habitat that provides food and nesting/roosting opportunities.

7.2.1 Habitat Variables and HSI Components:

A. Nesting/Roosting

In Alberta, pileated woodpecker nest trees (N = 115) ranged in size from 29-60 cm and averaged 44 cm dbh (R. L. Bonar, Pileated woodpecker habitat ecology in boreal forests, 1996-1997 Progress Report, Foothills Model Forest, 1997). Roost trees have similar size characteristics. Although most nest and roost trees are in living trembling aspen, some dead trees were used, and cavities were also found in coniferous snags (lodgepole pine, white spruce, subalpine fir). The model assumes that the availability of suitable nest trees will provide suitable trees for roosting, and therefore availability of roost trees is not a limiting factor. Although pileated woodpeckers will nest in a stand with a single suitable tree, greater numbers of suitable trees will provide a continuing supply of nest trees for long-term use. Trees of suitable species and size do not necessarily provide suitable nest sites because of the association between heart-rot fungal decay and nest tree selection.

Suitable trees for nesting are defined as living deciduous trees or coniferous snags ≥ 35 cm dbh (Table 1). Although pileated woodpeckers will nest in smaller trees, the 35 cm dbh limit is set because smaller trees are less likely to have fungal infections and are more likely to break at the cavity site than larger trees.

B. Winter Food

In winter, pileated woodpeckers obtain most of their food by excavating at the base of living trees, snags, and stubs of all tree species to access carpenter ant colonies. Most carpenter ant colonies are found in trees that are ≥ 16 cm dbh. Snags and stubs are selected over living trees by both carpenter ants and pileated woodpeckers, and conditions are considered optimal when >8 snags/stubs >16 cm dbh are present per hectare. However, snags and stubs are not essential, because pileated woodpeckers also forage on living trees. Conditions are considered unsuitable when the average dbh of overstory trees is <10 cm dbh, and optimal when the average dbh is >16 cm dbh. The components S_2 and S_3 are defined to relate mean dbh and number of snags and stubs to winter food, respectively (Table 1). The fourth component (S_4) is set so that the model only provides food values in stands with a sufficient cover of trees, and it also decreases the suitability in very dense stands.

Table 1. Relationship between habitat variables and life requisites for the pileated woodpecker HSI model.

HSI Component	Life Requisite	Habitat Variable	Habitat Variable Definition
S_1	Nesting/ Roosting Cover	Deciduous Trees & Coniferous Snags ≥35 cm dbh/ha	Number of deciduous trees ≥ 35 cm dbh per hectare and number of coniferous snags ≥ 35 cm dbh per hectare.
S_2	Winter Food	Stand dbh (cm)	Mean dbh of canopy trees measured at 1.3 m height.
S_3	Winter Food	Snags and Stubs ≥ 16 cm dbh/ha	Number of dead and broken topped trees ≥ 16 cm dbh per hectare.
S_4	Winter Food	Tree Canopy Closure	Percent of ground covered by a vertical projection of tree crown areas onto the ground. Includes trees ≥ 8 cm dbh.

7.2.2 Graphical HSI Component Relationships

S_1 If no suitable deciduous trees or coniferous snags (≥ 35 cm dbh) are present, the nesting/roosting component, $S_1 = 0$. S_1 increases to 1 when there are 30 or more suitable trees or snags per hectare (Figure 1a).

S_2 The value of S_2 is 0 at all values up to and including 10 cm dbh, and then increases to 1 at 16 cm (Figure 1b).

S_3 Since snags are not the only potential food source, their absence cannot drive the food value to zero. The minimum value of S_3 is set at 0.2 and then increases to 1 at 8 snags/stubs per hectare (Figure 1c).

S_4 The value of S_4 is 0 for canopy closure classes < 10%, and becomes 1 at canopy closures ≥ 10%. The suitability in canopy closures > 70% is reduced to 0.75 to reflect observed reductions in pileated woodpecker use of very dense stands (Figure 1d).

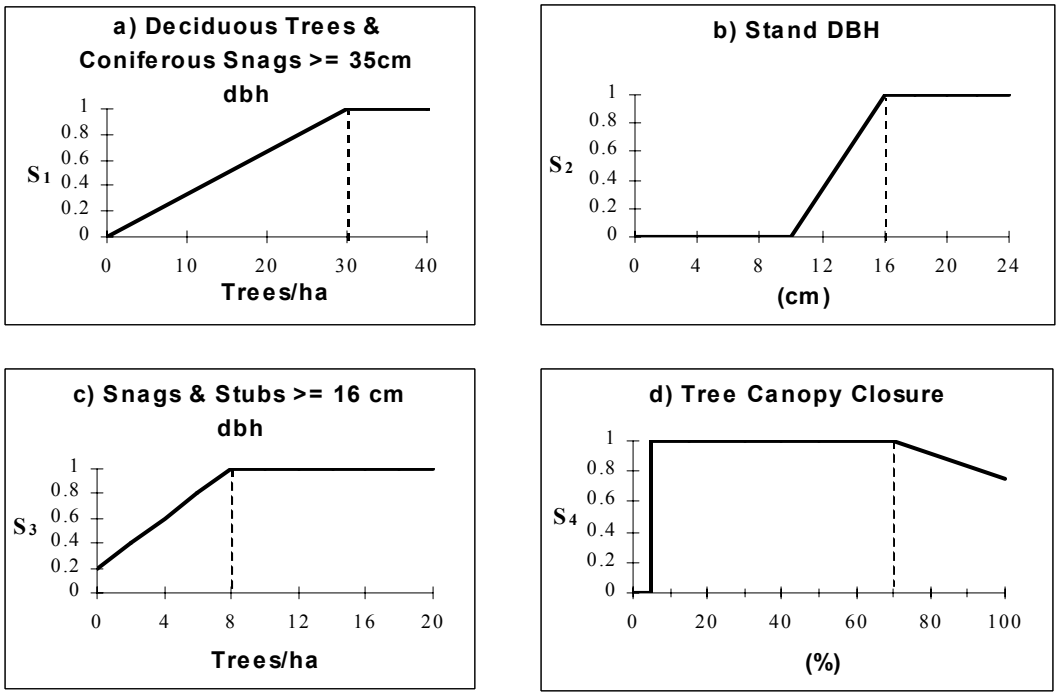

Figure 1. Graphical relationships between habitat variables and HSI components in the pileated woodpecker model.

7.3 MODEL ASSUMPTIONS

1. Winter is the limiting season, because food resources are more restricted than in summer. The territory used in winter includes the territory used in summer, so the model applies to year-around habitat.
2. All coniferous snags and large aspens have the same potential value for nest/roost cavity excavation. The availability of suitable nest trees is not normally a limiting factor in boreal forests because of large territory size and preferred use of relatively abundant living aspen with heart-rot fungal infection for nest trees.
3. Cover (predator avoidance) and water needs are provided by food and nesting habitat.
4. Roosting habitat needs are provided by nesting habitat.
5. Pileated woodpecker habitat use is not limited by proximity to human activities or roads or by the spatial arrangement of habitat.

7.4 EQUATIONS:

A. Nesting

HSI Nesting is the value of S_1 (the number of large deciduous trees or dead coniferous snags) determined for each stand. There is compensation built directly into the component since deciduous trees and coniferous snags can both serve as this resource.

HSI (Nesting) = S_1

B. Winter Food

The three HSI components S_2, S_3 and S_4 are considered equal and non-compensatory, so they are multiplied directly together. Only S_2 and S_4 can equal 0, so these are critical for determining suitability. S_3 is a modifying component and never decreases below 0.2.

HSI (Winter Food) = $S_2 \times S_3 \times S_4$

The model assumes that winter food is the limiting factor for pileated woodpeckers, provided that nesting opportunities exist within a territory. A circle with a radius of 2.5 km represents the size of an average pileated woodpecker territory in the study area. The model assumes that winter food is useful if it is within 2.5 km of nesting

habitat. It is expected that there will almost always be sufficient nesting opportunities within 2.5 km of winter food. If this is so, the equation for HSI (Winter Food) becomes the equation for pileated woodpecker HSI. A calculation should be performed to confirm this assumption. The value of HSI (Winter Food) is not changed if there are more than 10 HU of HSI (Nesting) within 2.5 km. If there is less than 10 HU of HSI (Nesting) the value of HSI (Winter Food) is multiplied by HU (Nesting)/10.

8. SOURCES OF OTHER MODELS

The United States Fish and Wildlife service developed the original HSI model for pileated woodpeckers (Schroeder 1983). This model has since been modified for use in other areas including Quebec (LaFleur and Blanchette 1993), Manitoba (Millar 1994), Ontario (Bush and Naylor 1996) and Saskatchewan (Anon. 1991). Kirk and Naylor (1996) provide a summary and comparison of these models.

Model History

All of the HSI models for the Weldwood Forest Management Area have undergone several revisions, and they will be revised again as new information becomes available. Contact Rick Bonar for information about the most current version.

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