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HABITAT SUITABILITY INDEX MODELS: PILEATED WOODPECKER

Fish and Wildlife Service

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This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

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HABITAT SUITABILITY INDEX MODELS: PILEATED WOODPECKER

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents a habitat model and information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The application information includes descriptions of the geographic ranges and seasonal application of the model, its current verification status, and a listing of model variables with recommended measurement techniques for each variable.

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

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PILEATED WOODPECKER (Dryocopus pileatus)

HABITAT USE INFORMATION

General

The pileated woodpecker (Dryocopus pileatus) inhabits both coniferous and deciduous forests, but is restricted to areas containing mature, dense, productive stands (Bock and Lepthien 1975). These woodpeckers are widely distributed in eastern forests, but are confined in the West to Washington, Oregon, and northern California and, in the Rocky Mountains, to northern Idaho and northwestern Montana (McClelland 1979). Their absence in the central and southern Rocky Mountains is due to a lack of dense, highly productive forests with rapid maturation and decay (Bock and Lepthien 1975).

The critical components of pileated woodpecker habitat are large snags, large trees, diseased trees, dense forest stands, and high snag densities (Bull 1975).

Food

Pileated woodpeckers depend heavily on carpenter ants (Camponotus spp.) and other wood-boring insects for food (McClelland 1979; Bull 1981). A study of the stomach contents of 80 pileated woodpeckers from across the United States, and over the entire year, showed that animal foods comprised about 73% of the diet and vegetable food the remainder (Beal 1911). Over one-half of the animal food was ants, with beetles the next most abundant food item. The majority of the vegetable food was wild fruits.

Pileated woodpeckers in Oregon fed by excavation (subcambial penetration) approximately two-thirds of the time, and by scaling bark, in search of insects, the remainder (Bull 1981). Woodpeckers in Virginia fed primarily by pecking (no subcambial penetration) and excavating during the breeding season, but used excavation techniques more than 70% of the time during the winter months (Conner 1979a). This seasonal variation and narrowing in breadth of foraging techniques is due to the availability and location of prey items during winter months (Conner 1979a, 1981).

Pileated woodpeckers choose foraging habitats that contain high densities of logs and snags, dense canopies, and tall shrub cover (Bull and Meslow 1977). They forage on snags, stumps, and logs that exceed 18 cm (7 inches) in diameter (Bull and Meslow 1977), although they prefer logs greater than 25 cm (10 inches) in diameter and greater than 15 m (49 ft) in length (Bull 1981).

Bull (1981) reported that pileated woodpeckers in Oregon spent 36% of their feeding time foraging on logs, 35% on live trees, and 29% on snags. Foraging sites on the ground were in dead and decayed material, most of which had less than 25% of the bark, branches, and needles remaining. The majority of snags used for foraging were greater than 51 cm (20 inches) dbh, while only 46% of live trees used for foraging exceeded that diameter. Pileated woodpeckers in this study fed mostly on carpenter ants, which were more abundant in larger diameter dead wood.

Pileated woodpeckers in Virginia foraged mostly on dead wood in mature forest habitats (Conner 1980). Pileated woodpeckers foraged extensively on fallen logs in a recently burned pine forest in Mississippi (Schardien and Jackson 1978). Tree stumps greater than 0.3 m (1 ft) in height are used extensively as foraging sites in the East and West (Conner, pers. comm.). Use of snags for foraging increased during the winter months in Montana, as logs and stumps became snow covered (McClelland 1979). Winter food supply was probably the limiting factor for pileated woodpeckers in this northern study area. However, Bull and Meslow (1977) noted, in their Oregon study area, that feeding habitat was probably not as critical as nesting habitat.

Water

Pileated woodpeckers have been observed to drink water before roosting for the night (Kilham 1959). Pileated woodpeckers in Virginia did not nest farther than 150 m (492 ft) from water, and most nests were within 50 m (164 ft) of water (Conner et al. 1975). The average distance between water sources in this study area was 600 m (1,969 ft). The distribution of pileated woodpeckers in this area may have been due to the fact that mesic environments produce more large trees at a faster rate than xeric sites.

Cover

Cover requirements of the pileated woodpecker are very similar to their reproductive requirements. Therefore, cover requirements are included in the following section.

Reproduction

Pileated woodpeckers are primary cavity nesters that require large snags for their nest site (Bull 1981). In Oregon, these woodpeckers selected nest snags from groups of snags in areas of dense forest (Bull and Meslow 1977). They excavate a new cavity each spring and, therefore, need a continual supply of new snags (Bull 1975). Pileated woodpeckers have the strongest year-round pair bond of any North American woodpecker (Kilham 1979), and pairs appear to occupy the same location in successive years (Kilham 1959).

Pileated woodpeckers nest tree search image in Montana was summarized by McClelland (1979:291, 294) as: "a broken top snag [Western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*), or black cottonwood (*Populus trichocarpa*)] at least 60 cm (24 inches) dbh, taller than 18 m (59 ft) (usually

much taller), with heartwood substantially affected by decay, within a forest with an old growth component and a basal area of at least 23 m^2/ha (100 ft^2/acre)".

Pileated woodpeckers are strong excavators and can excavate in sound dead wood (Bull 1981). Most nest trees in Bull's Oregon study were dead at least 10 years, but showed little evidence of decay at the nest site.

Pileated woodpeckers require large, tall snags because their nest cavity is large and located high in the snag (Bull 1981). A summary of nest tree snag measurements from four studies is presented in Table 1. A dbh of 51 cm (20 inches) is considered to be the minimum size tree suitable for nesting in Oregon (Bull and Meslow 1977) and Montana (McClelland 1979). Forest stands in Virginia with trees 38 to 46 cm (15 to 18 inches) dbh would provide adequate nest sites if some trees were decayed (Conner et al. 1975). However, management for only minimum-sized trees may produce a suboptimum habitat, leading to low nesting success (Conner 1979b). Management to provide conditions in the range between the mean and one standard deviation below the mean of habitat variables is desirable for species such as pileated woodpeckers (Conner 1979b, pers. comm.). Snags used for roosting have similar diameters and heights as snags used for nesting (McClelland 1979).

Table 1. Nest tree and basal area measurements from four study areas.

Type of measurement	Study area and reference			
	Oregon (Bull 1981)	Montana (McClelland 1979)	Virginia (Conner et al. 1975)	Oregon (Mannan et al. 1980)
Mean DBH of nest tree, cm (inches)	76 (30)	74.9 (29.5)	54.6 (21.5)	78 (31)
Mean height of nest tree, m (ft)	28 (92)	28 (92)	20.3 (66.6)	
Mean height of nest hole, m (ft)	15 (49)	15.2 (49.9)	13.6 (44.6)	
Basal area, m^2/ha (ft^2/acre)		25.1 (109.4)	31.5 (137.3)	

The majority of nest trees in Oregon had less than 25% of their original limbs and bark remaining (Bull 1981). Thirteen of eighteen nest trees in Virginia were dead, one had a living cambium but decayed inner core, and four nests were in dead parts of live trees (Conner et al. 1975). Pileated woodpeckers in Virginia were apparently able to detect the presence of heart rot in trees, and selected such trees as nest sites, thus reducing the energy expenditure required for excavation (Conner et al. 1976).

Several researchers have estimated the number of snags needed to support maximum pileated woodpecker populations. Bull and Meslow (1977) reported that optimum habitats in Oregon should contain sound snags greater than 51 cm (20 inches) dbh at a density of 0.35 snag/ha (0.14 snag/acre). Their estimate was based on the following assumptions: (1) a density of two pairs of pileated woodpeckers per 2.59 km^2 (1.0 mi^2); (2) a need for three snags per year per pair, one for nesting and two for roosting; and (3) a need for a reserve of 15 snags for each snag used because not all snags are immediately acceptable. Thomas et al. (1979) stated that optimum pileated woodpecker habitat contained snags greater than 50.8 cm (20 inches) dbh and taller than 9.5 m (31 ft) at a density of 0.32 snag/ha (0.13 snag/acre). This estimate assumes a territory size of 122 ha (300 acres). Optimum pileated woodpecker habitat in the northeastern United States has been characterized as containing snags 45 to 65 cm (18 to 26 inches) dbh and 12 to 21 m (39 to 69 ft) tall at densities of 0.6 snag/ha (0.24 snag/acre) (Evans and Conner 1979). This estimate assumes the following: (1) a territory size of 71 ha (175 acres) per pair of pileated woodpeckers; (2) a need for four snags per year per pair; one for nesting, two for roosting, and one for fledged young; and (3) a need for a reserve of 10 snags for each snag used to account for unusable snags, replacements, feeding habitat needs, and a snag supply for secondary users.

Pileated woodpecker densities in Illinois were positively correlated with the number of large trees [greater than 56 cm (22 inches) dbh] (Graber et al. 1977). Woodpecker densities were highest when there were about 50 large trees/ha (20/acre), and the approximate average dbh was 29 cm (11.5 inches). Woodpecker densities were lowest when there were only about 12.5 large trees/ha (5/acre) and the approximate average dbh was 27 cm (10.5 inches). [Note: Average dbh figures were estimated from graphics in Graber et al. (1977), using the median value of the size classes provided.] Conner (pers. comm.) stated that optimum suitability exists when habitats contain 30 or more trees greater than 51 cm dbh/0.4 ha (20 inches dbh/1.0 acre).

Pileated woodpeckers in Virginia preferred to nest in mesic stands near streams with the following characteristics: greatest basal area [27.1 m^2/ha (118 ft^2/acre)], greatest stem density [475.3/ha (1,174/acre)], and highest crown canopy height [24.2 m (79.4 ft)] available (Conner and Adkisson 1976). Favored nesting habitat in Montana and Oregon was dense forests containing old growth western larch or ponderosa pine (McClelland 1979; Bull 1981). Douglas-fir (Pseudotsuga menziesii) was seldom used in either study, probably due to the fact that its sapwood decayed very rapidly (McClelland 1979; Bull, pers. comm.).

Interspersion

The minimum forest size needed to support pileated woodpeckers is partially dependent on the availability of food (McClelland 1979). A minimum of 200 ha (494 acres) is probably needed in northern Rocky Mountain areas. Nesting pairs in Oregon ranged over 130 to 243 ha (320 to 600 acres), and a minimum requirement of 130 ha (320 acres) has been suggested (Bull and Meslow 1977). The winter foraging range of a pair of pileated woodpeckers in the southeastern United States was 70 ha (173 acres) (Kilham 1976).

Special Considerations

The pileated woodpecker is a key indicator species for the retention of a complete community of hole nesting birds (McClelland 1979), and it is likely that, if the habitat needs of the pileated woodpecker are met, other woodpeckers also would benefit (Bull and Meslow 1977).

Habitat for the pileated woodpecker in the Rocky Mountains is diminishing as old growth forests are cut (McClelland 1979). Silvicultural thinning may negatively affect these woodpeckers due to a loss of decayed trees that provide woodpecker nest sites and habitat for carpenter ants (Conner et al. 1975). Pileated woodpecker habitat may also be threatened by intensive forest harvesting practices (Conner 1980). A cutting rotation in Eastern forests of 80 years would probably provide adequate foraging habitat (Conner 1980), but a 150 year rotation may be needed for nesting habitat (Conner 1978).

Unmanaged, mature stands usually have adequate numbers of snags for resident woodpeckers (Bull et al. 1980). In managed forest stands, snags can be maintained by killing trees or by leaving trees to die, and woodpeckers can then be managed at selected population levels.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for application within the entire range of the pileated woodpecker with different variables included for snag diameters for the eastern and western portions of the range.

Season. This model was developed to evaluate the year-round habitat of the pileated woodpecker.

Cover types. This model was developed to evaluate habitat quality in the following cover types: Evergreen Forest (EF); Deciduous Forest (DF); Evergreen Forested Wetland (EFW); and Deciduous Forested Wetland (DFW) (terminology follows that of U.S. Fish and Wildlife Service 1981).

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before a species will occupy an area. It is assumed that a minimum of 130 ha (320 acres) of habitat must exist or the HSI for the pileated woodpecker will equal zero.

Verification level. Previous drafts of this model were reviewed by Evelyn Bull and Richard Conner, and their comments were incorporated into the current draft (Bull, pers. comm.; Conner, pers. comm.).

Model Description

Overview. The food, cover, and reproductive habitat needs of the pileated woodpecker are very similar. Large snags provide a source of food, cover, and nest sites. Mature, dense forest stands contribute to both the food and cover needs of the pileated woodpecker. Therefore, this model combines food, cover, and reproduction into a single component. It is assumed that the presence of water is related to the variables used to assess food, cover, and reproduction. Pileated woodpeckers use different size snags in the eastern and western portions of their range, and this model includes specific variables for each area.

The relationship between habitat variables, life requisites, cover types, and the HSI for the pileated woodpecker is illustrated in Figure 1.

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the pileated woodpecker in order to explain the variables that are used in the HSI model. Specifically, these sections cover the following: (1) identification of variables used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationship between variables.

Food/cover/reproduction component. Dense, mature forest stands with an abundance of logs and stumps, and large decayed snags provide food and cover for the pileated woodpecker. This model assumes that either the availability of dense, mature forests or the abundance of snags can be the limiting factor in determining habitat values for pileated woodpeckers.

The density and maturity of forest stands can be assessed by measuring the tree canopy closure, abundance of large diameter trees, and abundance of fallen logs and stumps. Pileated woodpeckers prefer dense stands, and it is assumed that optimum habitats have 75% or greater tree canopy closures and that stands with less than 25% canopy closure will have no suitability. Pileated woodpeckers are most abundant in forest stands with many large diameter trees. It is assumed that optimum habitats contain 30 or more trees greater than 51 cm dbh/0.4 ha (20 inches dbh/1.0 acre). Habitats with less than three such large trees per 0.4 ha (1.0 acre) are assumed to have no suitability. Optimum pileated woodpecker habitats contain an abundance of fallen logs and stumps, while habitats with no fallen logs or stumps may provide moderate suitability if other resources are available. It is assumed

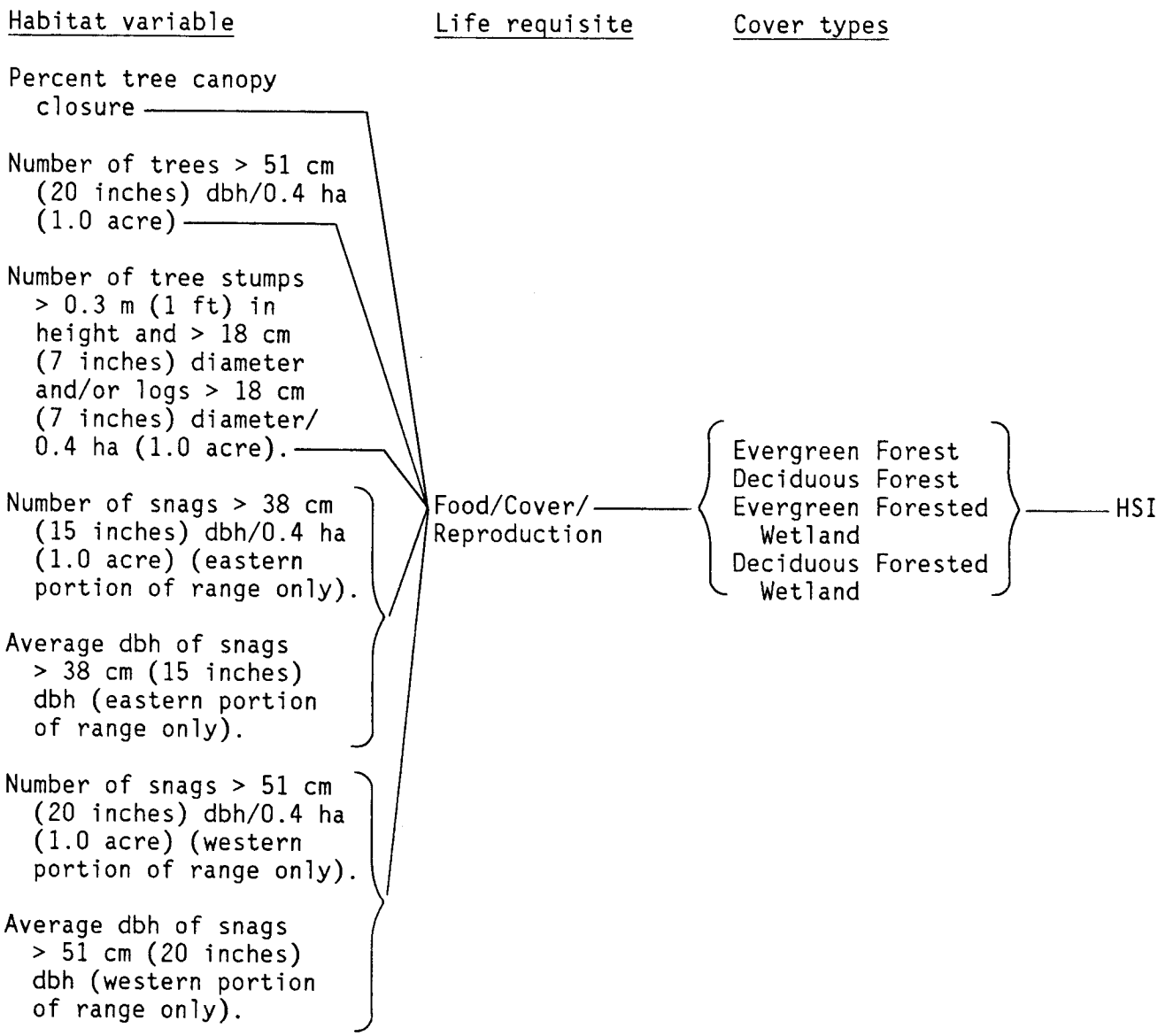


Figure 1. Relationship of habitat variables, life requisites, and cover types in the pileated woodpecker model.

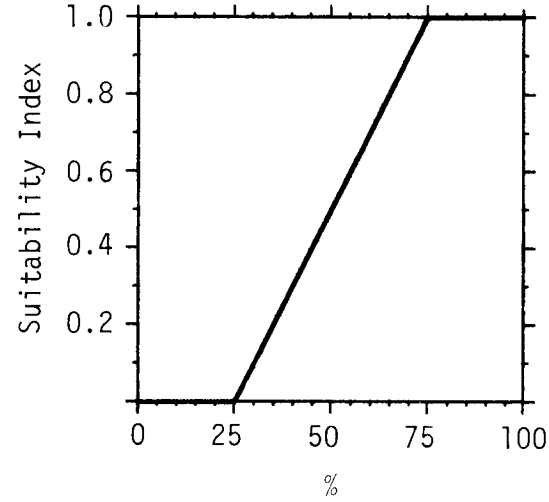
that maximum habitat values occur when there is a total of 10 or more logs greater than 18 cm (7 inches) diameter and/or stumps of the same diameter and greater than 0.3 m (1 ft) in height per 0.4 ha (1.0 acre). Overall suitability related to the density and maturity of forest stands is a function of the tree canopy closure, abundance of large trees, and abundance of logs and stumps. Tree canopy closure and large tree abundance are the most important variables, while log and stump abundance exerts less of an influence in determining habitat values.

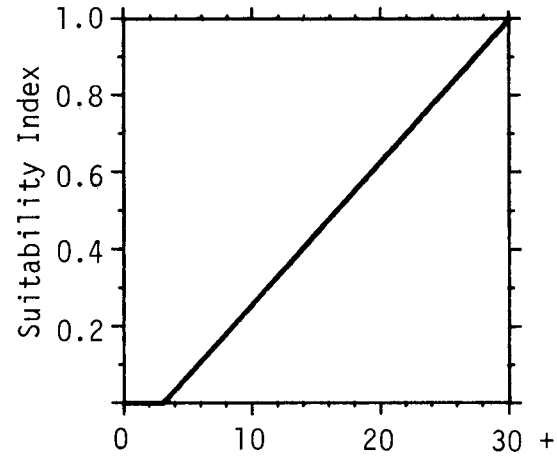
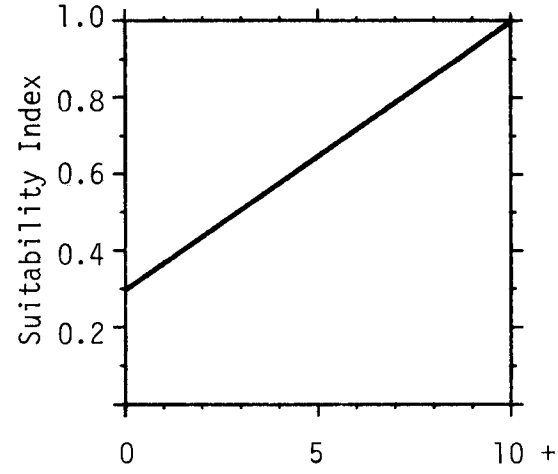
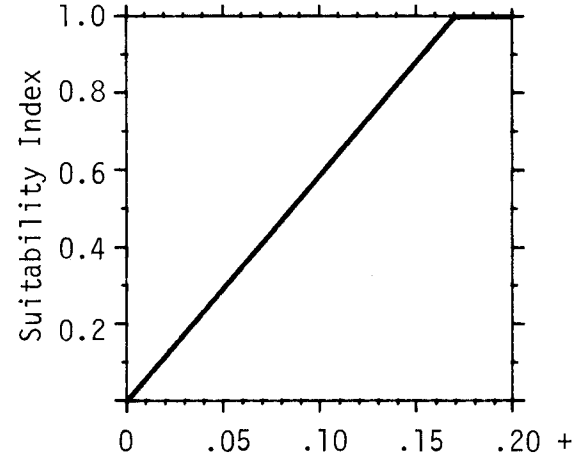
Snag suitability is assumed to be related to the abundance of large diameter snags. It is assumed that pileated woodpeckers, in the Eastern portion of their range, require snags greater than 38 cm (15 inches) dbh for nesting and, in the West, they require snags greater than 51 cm (20 inches) dbh. Maximum suitability in both the East and West exists when 0.17 or more suitably sized snags occur per 0.4 ha (1.0 acre). Habitats with no suitably sized snags provide no suitability. These snag sizes represent the minimum dbh for a useable snag. It is assumed that optimum conditions occur when the average dbh of all snags that meet the minimum size requirement is equal to the average dbh of snags actually selected by pileated woodpeckers for nest sites (see Conner 1979b). In the East, it is assumed that optimum conditions occur when the average dbh of all snags greater than 38 cm (15 inches) dbh is 54 cm (21 inches). In the West, optimum habitats exist when the average dbh of all snags greater than 51 cm (20 inches) is 76 cm (30 inches). Habitats in the East or West with an average snag diameter equal to the minimum suitable size will provide one-half of optimum habitat suitability.

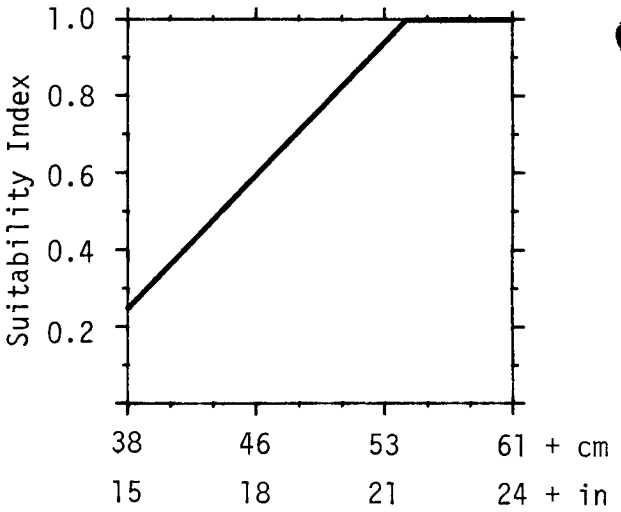
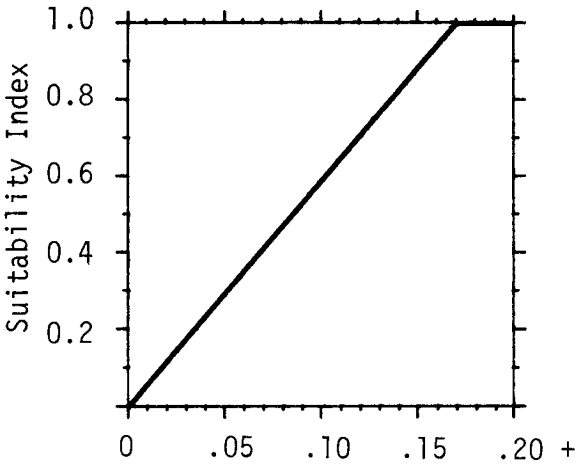
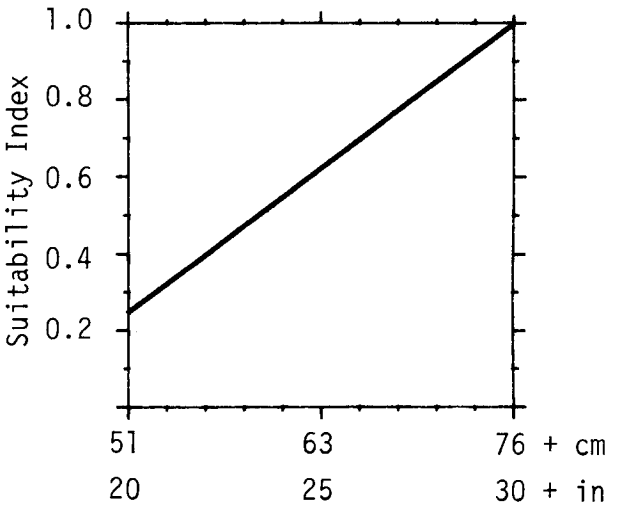
Overall habitat suitability for the pileated woodpecker is assumed to be limited by either the density and maturity of the forest or the abundance of snags.

Model Relationships

Suitabilty Index (SI) graphs for habitat variables. This section contains suitability index graphs that illustrate the habitat relationships described in the previous section.

Cover type	Variable		Suitability graph
EF,DF, EFW,DFW	V_1	Percent tree canopy closure.	

EF,DF, EFW,DFW	V_2	Number of trees > 51 cm (20 inches) dbh/0.4 ha (1.0 acre).	
EF,DF, EFW,DFW	V_3	Number of tree stumps > 0.3 m (1.0 ft) in height and > 18 cm (7 inches) diameter and/or logs > 18 cm (7 inches) diameter/ 0.4 ha (1.0 acre).	
EF,DF, EFW,DFW	V_4	Number of snags > 38 cm (15 inches) dbh/0.4 ha (1.0 acre).	

EF,DF, EFW,DFW	V_5	Average dbh of snags > 38 cm (15 inches) dbh.	
EF,DF, EFW,DFW	V_6	Number of snags > 51 cm (20 inches) dbh/0.4 ha (1.0 acre).	
EF,DF, EFW,DFW	V_7	Average dbh of snags > 51 cm (20 inches) dbh.	

Equations. In order to determine the life requisite value for the pileated woodpecker, the SI values for appropriate variables must be combined through the use of equations. A discussion and explanation of the assumed relationship between variables was included under Model Description, and the specific equations in this model were chosen to mimic these perceived biological relationships as closely as possible. The suggested equations for obtaining the food/ cover/reproduction value are presented below.

Life requisite	Cover type	Equation
Eastern portion of range: Food/cover/reproduction	EF,DF,EFW,DFW	Lower of $(V_1 \times V_2 \times V_3)^{1/2}$ or $(V_4 \times V_5)^{1/2}$
Western portion of range: Food/cover/reproduction	EF,DF,EFW,DFW	Lower of $(V_1 \times V_2 \times V_3)^{1/2}$ or $(V_6 \times V_7)^{1/2}$

HSI determination. The HSI for the pileated woodpecker is equal to the life requisite value for food/cover/reproduction.

Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 2. Note that V_4 and V_5 are to be measured only in the eastern portion of the range of the pileated woodpecker, and V_6 and V_7 in the western portion of the range.

Variable (definition)		Cover types	Suggested technique
V_1	Percent tree canopy closure [the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation taller than 5.0 m (16.5 ft)].	EF,DF,EFW, DFW	Line intercept

Figure 2. Definitions of variables and suggested measurement techniques.

Variable (definition)		Cover types	Suggested technique
V_2	Number of trees > 51 cm dbh/0.4 ha (20 inches dbh/1.0 acre) [actual or estimated number of trees that are greater than 51 cm (20 inches) diameter at breast height (1.4 m (4.5 ft) per 0.4 ha (1.0 acre)].	EF,DF,EFW, DFW	Quadrat
V_3	Number of tree stumps > 0.3 m (1.0 ft) in height and > 18 cm (7 inches) diameter and/or logs > 18 cm (7 inches) diameter/ 0.4 ha (1.0 acre) [the actual or estimated number of tree stumps greater than 0.3 m (1.0 ft) in height and greater than 18 cm (7 inches) in diameter, and/or logs greater than 18 cm (7 inches) in diameter present per acre. Log diameter should be measured at the largest point].	EF,DF,EFW, DFW	Quadrat
V_4	Number of snags > 38 cm (15 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, that are greater than 38 cm (15 inches) diameter at breast height (1.4 m/4.5 ft), and that are at least 1.8 m (6 ft) tall, per 0.4 ha (1.0 acre). Trees in which at least 50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].	EF,DF,EFW, DFW	Quadrat

Figure 2. (continued).

Variable (definition)		Cover types	Suggested technique
V_5	Average dbh of snags > 38 cm (15 inches) dbh [the average diameter of all snags that exceed 38 cm (15 inches) diameter at breast height (1.4 m/ 4.5 ft)].	EF,DF,EFW, DFW	Quadrat; Biltmore stick or diameter tape
V_6	Number of snags > 51 cm (20 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, that are greater than 51 cm (20 inches) diameter at breast height (1.4 m/4.5 ft), and that are at least 1.8 m (6 ft) tall, per 0.4 ha (1.0 acre). Trees in which at least 50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].	EF,DF,EFW, DFW	Quadrat
V_7	Average dbh of snags > 51 cm (20 inches) dbh [the average diameter of all snags that exceed 51 cm (20 inches) diameter at breast height (1.4 m/4.5 ft)].	EF,DF,EFW, DFW	Quadrat; Biltmore stick or diameter tape

Figure 2. (concluded).

SOURCES OF OTHER MODELS

Conner and Adkisson (1976) have developed a discriminant function model for the pileated woodpecker that can be used to separate habitats that possibly provide nesting habitat from those that do not provide nesting habitat. The model assesses basal area, number of stems, and canopy height of trees.

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A review and synthesis of existing information was used to develop a habitat model for the pileated woodpecker (Dryocopus pileatus). The model is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for areas of the continental United States. Habitat suitability indexes are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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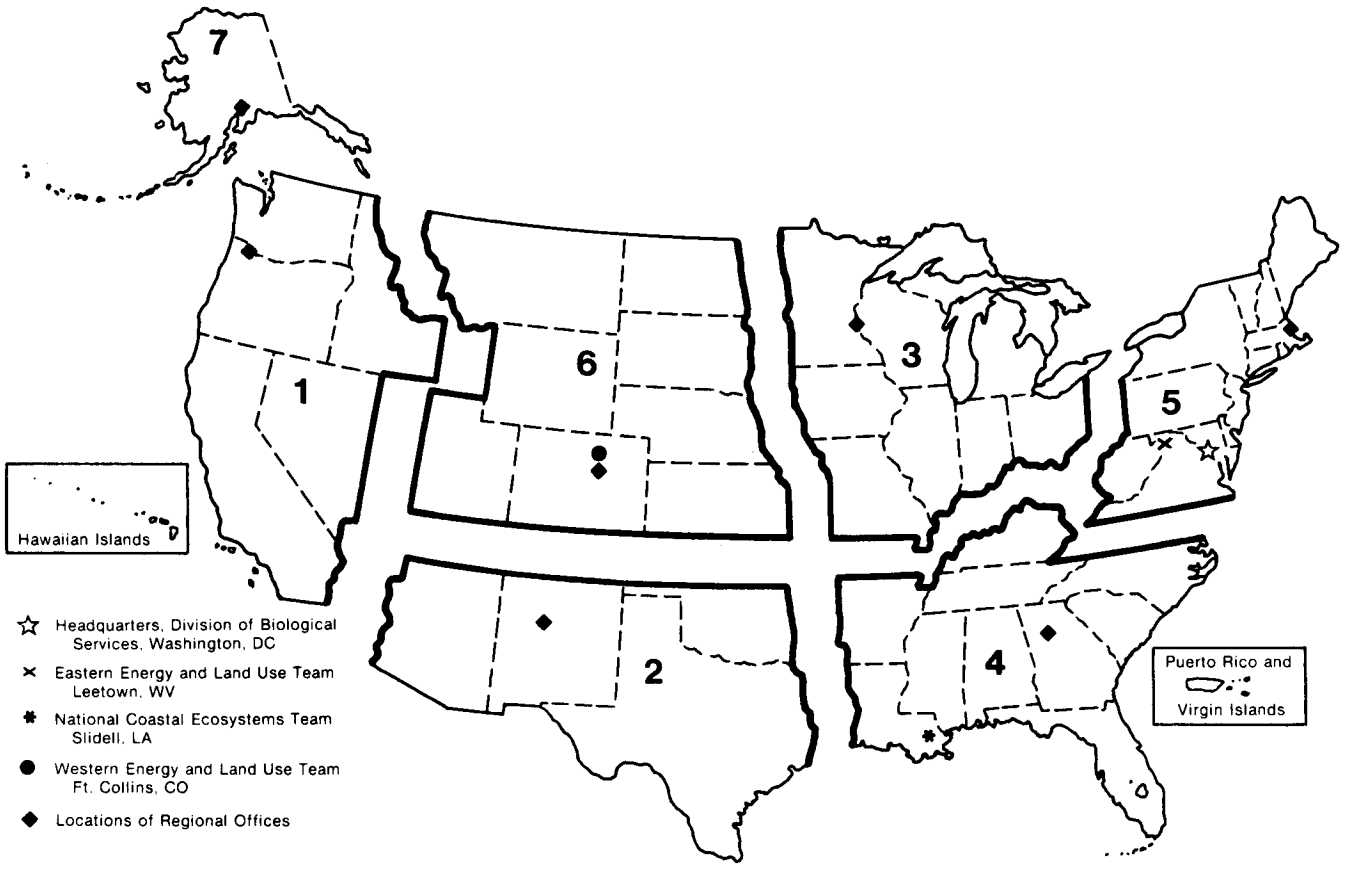

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