Appendix B. Habitat Use Information and HSI Model for the Red-tailed Hawk

B.1 Introduction. HSI models should be adequately documented so that the HSI estimates can be properly interpreted. This appendix provides an example red-tailed hawk model with documentation as described in 103 ESM 3.4. Section B.2 below provides documentation of habitat use information, and B.3 describes the HSI model, including model assumptions and limitations. Section B.4 contains information for applying the model.

B.2 Habitat use information

A. General. The red-tailed hawk (*Buteo jamaicensis*) inhabits all of the continental United States (Brown and Amadon 1968). In more northern parts of its range, it is quite migratory, although breeding pairs were found to be year-round residents in areas as far north as Wisconsin (Petersen 1979) and Michigan (Craighead and Craighead 1956). Commonly used habitat consists of woodlots, scattered trees, or tracts of mature woodland, often interspersed with, or adjoining, large expanses of open fields (Brown and Amadon 1968). Red-tailed hawks are rare in areas characterized by extensive unbroken forest. The red-tailed hawk has the widest ecological tolerance and geographic distribution of any buteo in North America. This species has not suffered the detrimental eggshell thinning observed in many other raptors, due to its predominantly mammalian diet (Hickey and Anderson 1968; Petersen 1979).

B. Food requirements. The red-tailed hawk is an opportunistic predator, feeding primarily on prey species which are locally common (Bohm 1978). It feeds on a variety of animals, but mostly small and medium-sized rodents, rabbits, and other mammals (Brown and Amadon 1968). Other important food items include medium-sized birds, large insects, and reptiles. Both adults and juveniles will feed on carrion (Errington and Breckenridge 1938). A winter diet of red-tailed hawks in Wisconsin averaged 44% cottontail rabbits (*Sylvilagus* spp.), 28% microtines (*Microtus* spp.), and 10% pheasants (*Phasianus colchicus*) (in percent biomass) (Petersen 1979).

Red-tailed hawks commonly hunt from perches overlooking open areas and by soaring above fields (Tyler and Saetveit 1969; Bohm 1978). Schnell (1968) found that red-tailed hawks prefer to hunt from tree perches, allowing the raptor to strike down on ground dwelling prey. Foraging sites in southern Michigan were open areas such as grassland and abandoned and cultivated fields (Craighead and Craighead 1956). In Wisconsin, lowland pastures with scattered trees were heavily used by hunting red-tailed hawks, whereas cover types without trees for hunting perches were seldom used (Petersen 1979). Results from an Ohio study suggest that red-tailed hawk productivity may be partially related to the percent of hunting territory in fallow pasture (Howell et al. 1978). Highly productive sites typically had over twice as much fallow pasture (69% average) around them as low productive sites. Hunting areas in New York were recently abandoned fields with matted, grassy cover (Bart 1977). Grassland and corn stubble were equally utilized as winter foraging sites in Illinois (Schnell 1968). Plowed fields were avoided. A comparison of cover types comprising home ranges of red-tailed hawks in Wisconsin suggests selection for predominantly graminoid cover of pastures and grasslands (Petersen 1979). Areas with grass less than 10 cm (4 in) high were generally preferred, but adults occasionally hunted over much taller vegetation. Pastures with abundant grasses were preferred.

Red-tailed hawks have been known to nest and hunt in woodlots (Luttich et al. 1970) and in extensive, unbroken forests (Titus and Mosher In press). Due to the lower availability of food (chipmunks, mice, and squirrels) and the natural obstacles presented by standing timber, these extensively forested regions probably cannot support as many red-tailed hawks as more open areas characterized by a woodlot-field mix (Mosher pers. comm.). Compared to random samples of surrounding habitat, red-tailed hawks nesting and feeding in extensive forests in Maryland were found on sites with a higher number of large trees [≥ 50 cm (20 in) dbh] and a lower percentage of tree canopy cover (Titus and Mosher In press).

C. Water requirements. Water does not appear to be limiting to the red-tailed hawk (Bartholomew and Cade 1962). Most water is supplied by the metabolic process of digesting food.

D. Cover requirements. Red-tailed hawks wintering in Iowa used open wooded areas along stream bottoms to satisfy cover requirements (Weller 1964). Winter perches in Illinois were in groups of trees > 9 m (30 ft) tall (Schnell 1968). Both upper and midcanopy portions of trees are used for daily activities and night roosting (Dunstan and Harrell 1973). Dense timber, particularly conifers, is frequently used for night and winter roosts (Brown and Amadon 1968). The availability of suitable cover does not appear to be limiting to the red-tailed hawk as long as suitable reproductive habitat is available.

E. Reproductive requirements. Red-tailed hawk nests are generally located in mature trees and are found more frequently in open woodlots and woodland edges rather than in closed dense woodlots or woodland interiors (Orians and Kuhlman 1956; Gates 1972; Misztal 1974 cited by Howell *et al*. 1978). Groves used by nesting red-tailed hawks in Wisconsin were generally less than 0.4 ha (1 ac) in size (Gates 1972). The size of the tree and the height at which the nest may be placed is more important in site selection than the degree of concealment afforded by the surrounding timber (Bailey 1918).

Nest trees in Michigan were large, averaging 23.6 ± 3.3 m (77.8 ± 10.9 ft) tall and 52.3 ± 15.0 cm (20.9 ± 6 in) dbh (Belyea 1976). The average dbh of nest trees was 58 cm (23 in) [range 41 to 71 cm (16 to 28 in)] in southeastern Minnesota (Le Duc 1970) and 64 cm (25 in) [range 38 to 127 cm (15 to 50 in)] in Ohio (Misztal 1974 cited by Howell *et al*. 1978). The importance (relative frequency) of any one tree species may affect nest site selection, but appears to have no direct relationship to productivity (Howell *et al*. 1978). Nests are often re-used year after year (Brown and Amadon 1968).

F. Special habitat requirements. The availability of adequate perches is vital. During nonbreeding periods, red-tailed hawks commonly perch conspicuously on dead snags (Brown and Amadon 1968) and lone trees (Schnell 1968). Red-tailed hawks occasionally nest in isolated trees along fencelines and ditchbanks (Gates 1972); however, isolated trees are used mainly as hunting lookout posts.

G. Interspersion requirements. Red-tailed hawk home ranges in Wisconsin containing large amounts of woodland were larger than home ranges enclosing small, scattered woodlots (Petersen 1979). Austing (1964) concluded that red-tailed hawks occupying "fringe" habitat maintained larger home ranges in order to find sufficient prey. Data from an Ohio study suggests a correlation between the amount of woodland-forest comprising a study area and breeding density and breeding success (Howell *et al*. 1978). In this study, highly productive red-tailed hawk nest sites had an average of 8.1% of the home range in woodlot, whereas sites with low productivity had over twice as much (20.8%) wooded area.

While it is generally accepted that the availability of nest sites is critical to breeding red-tailed hawks, the optimum mix of habitat types needed to provide sufficient amounts of both nest sites (woodlots, forested areas, isolated trees) and hunting areas remains unclear. Data from recent population studies of red-tailed hawks suggest that study areas comprised of large percentages of woodland-forests support lower breeding population densities than study areas that are comprised of approximately 10% woodland. Study areas that are composed of very small percentages of habitat types that provide potential nest sites also support low densities of breeding red-tailed hawks (Table B-1). Austing (1964) characterized a study area in Ohio composed roughly of 70% river valley (pasture-grassland-cropland) and 30% woodland as prime habitat.

Territory size is affected by the degree of interspersion of cover types (Petersen 1972, 1979). In Michigan, the size of red-tailed hawks' winter range was inversely proportional to the food supply (Craighead and Craighead 1956). Red-tailed hawks generally maintain circular or oval home ranges which vary spatially according to various habitat variables (Fitch et al. 1946). Red-tailed hawks in an area of Wisconsin with significant amounts of cropland and pasture had year-round territories averaging 119 ha (298 ac), whereas territories without these two cover types averaged 154 ha (384 ac) (Petersen 1972). The average home range size of red-tailed hawks in another Wisconsin study was 137 ha (338 ac) with the largest home range being reported in fall [390 ha (963 ac)] (Petersen 1979). Breeding territories in southeastern South Dakota and northwestern Iowa averaged 256 ha (640 ac) (Tyler and Saetveit 1969). Craighead and Craighead (1956) reported a hunting range radius of 1.19 km (0.75 mi). The average home range of nesting red-tailed hawks in southern Wisconsin was 3.75 km^2 (1.5 mi^2) with an average maximum diameter of 3.2 km (2 mi). A maximum diameter of a red-tailed hawk's home range was reported to be 4 km (2.5 mi).

H. Special considerations. The red-tailed hawk is more tolerant of civilization than most raptor species (Jackman and Scott 1975). Nonetheless, Michigan red-tailed hawks did not nest within 370 m (411 yd) of occupied human dwellings (Belyea 1976). Nest desertion in four out of seven cases in Wisconsin was attributed to human interference (Petersen 1972).

B.3 Habitat Suitability Index (HSI) model for the red-tailed hawk (*Buteo jamaicensis*)

A. Model applicability

(1) Geographic area. This model was developed primarily for the entire eastern half of the United States, classified by Bailey (1978) as the humid temperate domain.

Table B-1. Comparison between habitat composition and breeding density of red-tailed hawks.

Source and Study Area	Density of Active Breeding Red-tailed Hawks in km² per pair	Composition of Study Area in Cover Type Percentage	
Gates (1972) (Wisconsin)	10.6	Cropland-Pasture	85%
		Lakes, Marshes	10%
		Forest-Woodland	.3%
Hager (1957) (New York)	7.9	Cropland-Pasture approximately	50%
		Forest-Woodland approximately	50%
McInvaille and Keith (1974) (Central Alberta)	7.6	Cropland-Pasture approximately	41%
		Forest-Woodland approximately	34%
Luttich et al. (1970) and (1971) (Central Alberta)	7.0	Cropland-Pasture	50%
		Lakes, Marshes	5%
		Forest-Woodland	45%
Petersen (1979) (Wisconsin)	4.7	Cropland-Pasture	71%
		Lakes, Marshes	16%
		Forest-Woodland	8%

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(2) Season. This model will produce HSI values based upon breeding habitat needs for the red-tailed hawk.

(3) Cover types. The red-tailed hawk is an adaptable, opportunistic raptor that utilizes a wide variety of cover types. Since this model is a prototype, cover type consideration has been limited to the following two types: Grassland (G) and Deciduous Forest (DF).

(4) Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous suitable habitat that is required for a species to successfully live and reproduce. This information was not found in the literature for the red-tailed hawk. If local information is available to define the minimum habitat area, the HSI for the species will be zero if less than this amount of area is available.

(5) Verification level. This model was critiqued by James Mosher, University of Maryland, who concluded it was as reasonable as can be expected given the variety of habitat types encompassed in the applicable range. His review comments have been incorporated into the current model. No field tests have been conducted.

B. Model description

(1) Graphic overview. This HSI model for the red-tailed hawk considers the quality of the life requisites found in each cover type and interspersion of life requisites when the habitat is composed of two or more cover types. Figure B-1 shows how the HSI is related to cover types, life requisites, and specific habitat variables. Food and reproduction are the only life requisites considered in this model. It is assumed that cover needs are met by adequate reproductive habitat and that water is not limiting.

(2) Life requisite components

a) Food. Food suitability for the red-tailed hawk is related to the abundance and accessibility of suitable prey. This relationship is based upon the premise that optimum conditions for prey do not necessarily reflect optimum conditions for the predator. For this reason, coupled with the fact that many species fall into the broad category of "prey", a general approach to modeling food suitability for this predator is presented.

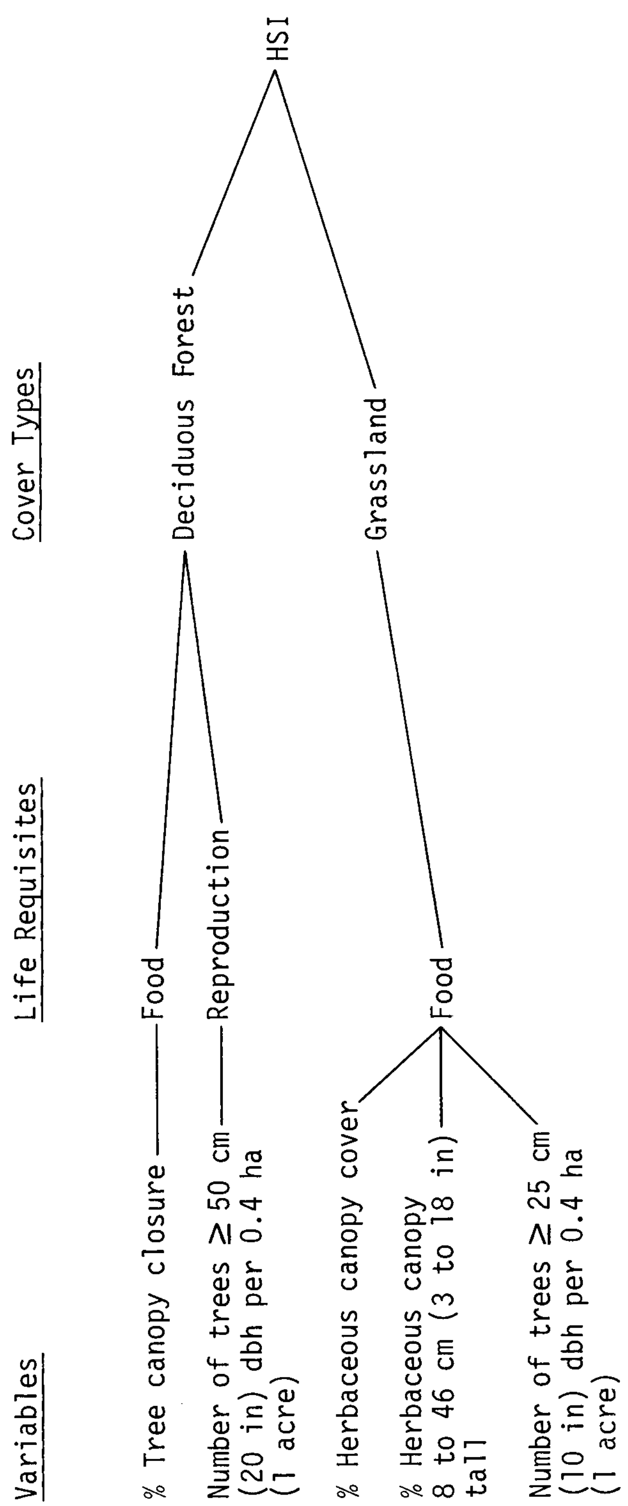


Figure B-1. Tree diagram showing relationship of habitat variables, life requisites, and cover types to the HSI for the red-tailed hawk.

It is assumed that the abundance of prey in grasslands is related to the structure of the herbaceous vegetation which can be estimated by measuring the density and height of herbaceous cover. The accessibility of prey is related to the level of concealment provided for prey by herbaceous vegetation and the degree of access by the hawk to all "huntable" areas. The accessibility of prey can be estimated by measuring the height of herbaceous vegetation and the availability of suitable hunting perch sites. It is assumed that moderately high to high densities of herbaceous vegetation will support dense populations of prey species. It also is assumed that dense stands of herbaceous vegetation will not dramatically reduce the success rate of prey capture by this opportunistic predator. Herbaceous vegetation between 8 and 46 cm tall is considered optimum. If a large proportion of all the herbaceous vegetation present in a grassland is in this height class, conditions will be optimum. Very short vegetation will limit the abundance of prey, whereas very tall vegetation will maximize concealment for prey and thereby limit prey accessibility. It is assumed that three or more suitable perch sites per 0.4 ha will provide optimum hunting conditions. The lack of suitable perch sites will not be completely limiting since red-tailed hawks will hunt by gliding over fields.

Overall food suitability for red-tails in grassland habitats is related to the density and height of herbaceous vegetation and availability of perch sites. Herbaceous density is the most important factor in determining abundance of prey and thus, food quality. No food will be provided in habitats with either a total lack of herbaceous cover or herbaceous cover that is all too short or too tall.

Hunting strategies of the red-tailed hawk in forested areas have not been documented, and the relationships influencing the abundance of prey is unknown. It is assumed that red-tails will hunt in forests and that they feed upon both ground and canopy dwelling mammals. It is assumed that, in the forest, the most critical factor influencing food suitability for the red-tailed hawk is prey accessibility.

Dense stands of trees would likely interfere with the flight patterns of this large buteo, which is best suited for hunting from a lookout perch or soaring slowly over open fields. Conversely, an "open" forest would maximize utilization of all vegetative strata by the red-tailed hawk. It is assumed that prey accessibility can be estimated by measuring the canopy closure of trees, and that canopy closures of less than 50% provide the best prey accessibility and canopy closures of 100% provide poor accessibility (no suitability). It is further assumed that even the best forests provide limited prey availability for red-tailed hawks.

b) Reproduction. Reproductive value is related to the availability of suitable nest trees. It is assumed that the availability of suitable nest trees can be adequately assessed by measuring the density of large trees. It is assumed that a minimum of 10 trees per 0.4 ha (1.0 ac) greater than 50 cm (20 in) dbh are needed to provide optimal suitability, and that if no large trees are available, reproductive suitability will be absent. These statements are based upon the assumption that suitable cliff sites are not available for potential nest sites in the eastern United States.

Human disturbances may have a severe negative impact on nesting red-tailed hawks. The field user must assess each situation with respect to human interference during nesting and, if necessary, adjust the reproductive value accordingly.

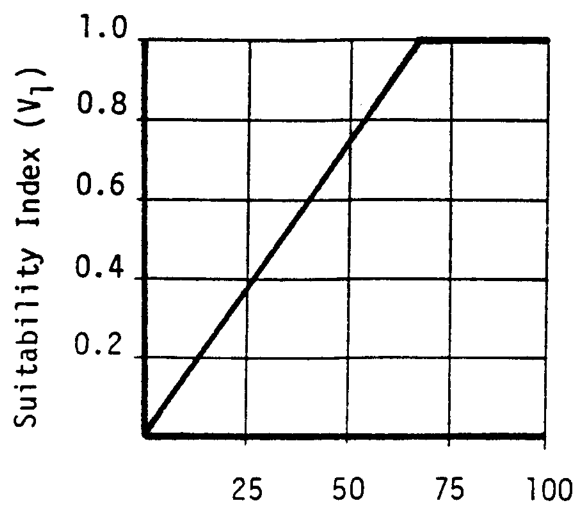
(3) Interspersion of life requisites. It is assumed that the best habitat for the red-tailed hawk contains high quality food over 70% of the habitat and high quality reproductive habitat over 15% of the area. These estimates are based upon data indicating that red-tailed hawks generally hunt over large portions of their home range but restrict reproductive activities to isolated and small woodlots and forested areas. High quality food is not required over 100% of the area because the effective hunting range is usually smaller than the home range, i.e., hunting activities are concentrated in areas where prey capture success rates are highest.

The effective amount of food and reproductive resources is determined by considering the distance between cover types which provide the resources. Since food and reproductive resources may be provided by different cover types, the distances between cover types can be used to determine the amount of useable area. It is assumed that the optimum distance between food and reproductive resources is equal to or less than 1.2 km. It is also assumed that if food and reproductive resources are distributed at three times this distance, or 3.6 km, then they exceed the distance that red-tailed hawks will fly during the breeding season to obtain them. These distance measurements were estimated using information in the literature pertaining to average home range size and maximum diameters of home ranges.

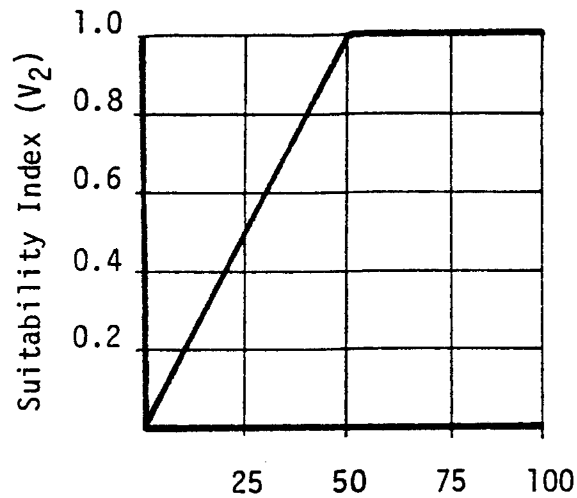
C. Model relationships. This section contains suitability index curves and equations to quantitatively describe the relationships discussed in the previous section. These curves and equations can be used to produce an HSI for the red-tailed hawk.

(1) Suitability index curves

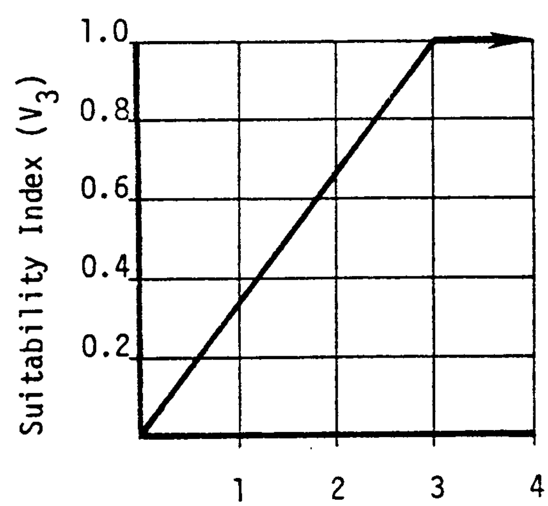
Cover Type	Variable	
Grassland	(V_1)	Percent herbaceous canopy cover.



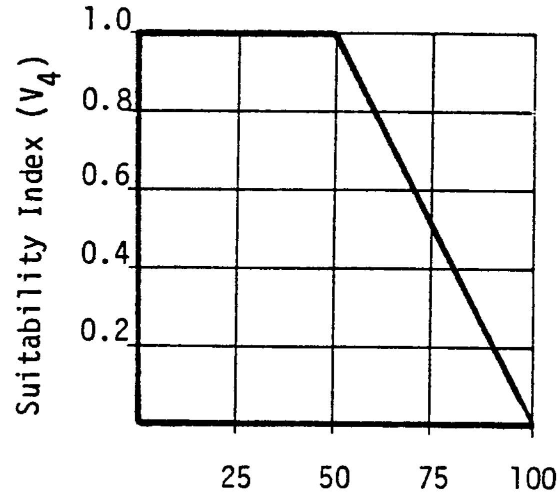
Grassland (V_2) Percent herbaceous canopy 8 to 46 cm (3 to 18 in) tall.



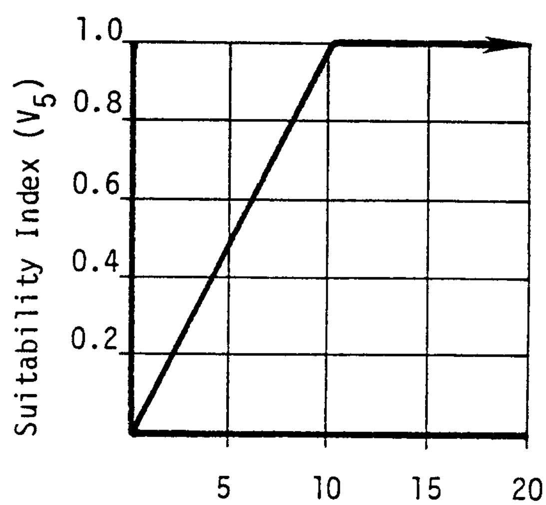
Grassland (V_3) Number of trees $\geq$ 25 cm (10 in) dbh per 0.4 ha (1.0 ac).



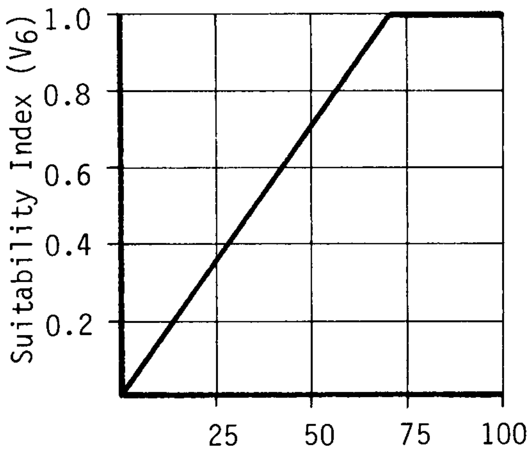
Deciduous Forest (V_4) Percent tree canopy closure.



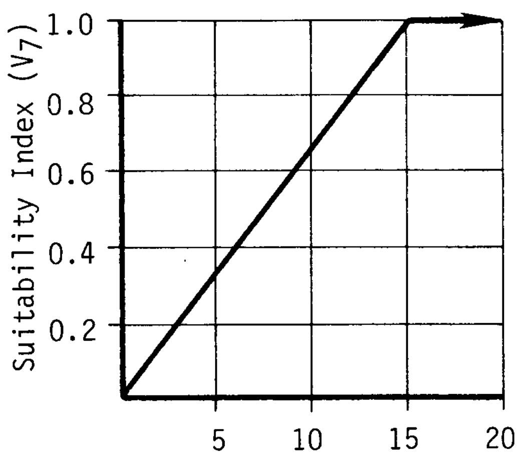
Deciduous Forest (V_5) Number of trees ≥ 50 cm (20 in) dbh per 0.4 ha (1.0 ac).



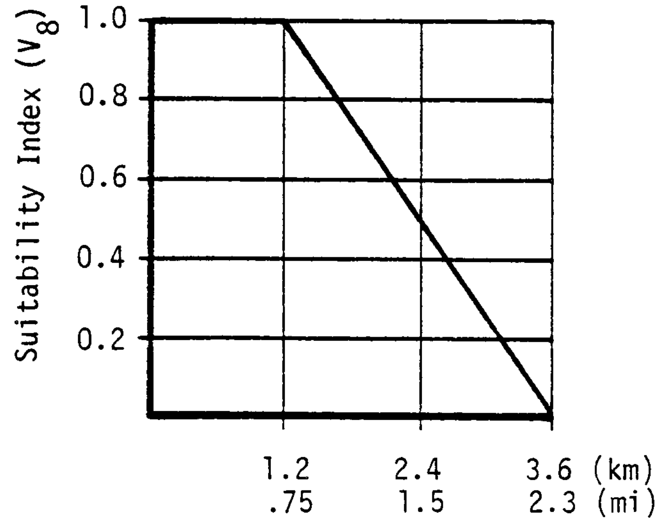
All (V_6) Percent area in equivalent optimum food.



All (V_7) Percent area in equivalent optimum reproduction.



All (V_8) Distance between cover types.



(2) Equations

a) Equations for food component. The following equations integrate index values for each variable to obtain a life requisite value for food in each cover type.

Cover Type	Equation
G	Food Value = $(V_1^2 \times V_2 \times V_3)^{1/4}$
DF	Food Value = $(V_4 \times 0.6)$

b) Equations for reproduction component.

Cover Type	Equation
DF	Reproductive Value = V_5

D. HSI determination. The following calculations must be made to determine an HSI.

(1) Determine if all life requisites are provided at some level greater than zero, considering all cover types under consideration. If any life requisite is not provided, the HSI will equal zero and no further calculations are necessary.

(2) Compute the life requisite values for each cover type by collecting field data for each variable and entering this data into the proper suitability index curve and using the resulting index values in the appropriate life requisite equations.

(3) Determine the relative area (%) of each cover type within the study area as follows:

$$\text{Relative Area (\%) for Cover Type A} = \frac{\text{Area of Cover Type A}}{\text{Total Area of All Cover Types used by the Species}} \times 100$$

Be certain that only those cover types used by the species are considered in determining this percentage.

(4) Determine which cover types are not providing one or more life requisites. For each of these cover types, an interspersion index must be computed. This is accomplished as follows:

a) Select random points on a map in each cover type missing a life requisite and measure the distance to the edge of the nearest other cover type (or cover types, where two or more life requisites are missing) that provide(s) the missing life requisite(s).

b) Enter each of these distance measurements into the Suitability Index Curve titled "Distance between Cover Types", record the individual interspersion indices, and use these to calculate the average interspersion index for each cover type. Where two or more life requisites are missing from a cover type, use the lowest average interspersion index in the next calculation.

(5) Modify the relative area (%) of each cover type missing a life requisite by multiplying the relative area by the average interspersion index for that cover type. This determines the useable area (%) of each cover type. For those cover types that provide all life requisites the useable area (%) is the same as the relative area (%).

(6) To determine the % area in equivalent optimum condition for any life requisite, first multiply the useable area (%) for each cover type by the life requisite values for that cover type (from 2 above). Sum the products of this multiplication across all cover types for each life requisite. This sum for each life requisite is the equivalent percent of the area that provides that life requisite at optimum levels (this is actually an equivalent figure, i.e., 100% of the area at a 0.5 value is equal to 50% of the area at an optimum, 1.0 value).

(7) To determine overall life requisite values, enter the percent area for each life requisite (Step 6) into the appropriate life requisite composition Suitability Index Curve. The index value obtained is the overall life requisite value.

(8) The HSI is equal to the lowest of the overall life requisite values.

B.4 Application of the model. The level of detail needed for a particular application of this model will depend on time, money, and accuracy constraints. Detailed field sampling of all variables will provide the most reliable and replicable HSI values. Any or all variables can be estimated, in order to reduce the amount of time required to apply the model. Increased use of subjective estimates decreases reliability and replicability, and these estimates should be accompanied by appropriate documentation to insure that decisionmakers understand both the method of HSI determination and quality of the data used in the HSI model.

The measurement techniques in Table B-2 are suggested for the variables used in this model. A field form can be developed from this list.

Table B-2. Suggested measurement techniques and definition of habitat variables.

Variable (Definition)	Cover Types	Suggested Technique
(V_1) Percent herbaceous canopy cover [the percent of the ground surface that is shaded by a vertical projection of all non-woody vegetation (grasses, forbs, sedges, etc.)]	G	Line transect and Daubenmire plot frame
(V_2) Percent of herbaceous vegetation that is 8 to 46 cm (3 to 18 in) tall (self explanatory)	G	Line transect, Daubenmire plot frame, and meter stick
(V_3) Number of trees ≥ 25 cm (10 in) dbh per 0.4 ha (1.0 ac) (self explanatory)	G	Line transect and dbh tape
(V_4) Percent tree canopy closure (the percent of the ground surface that is shaded by a vertical projection of the canopies of all trees)	DF	Line intercept
(V_5) Number of trees ≥ 50 cm (20 in) dbh per 0.4 ha (1.0 ac) (self explanatory)	DF	Line transect and dbh tape

B.5 Sources of other models. No other habitat models for the red-tail were identified during the development of this model.

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