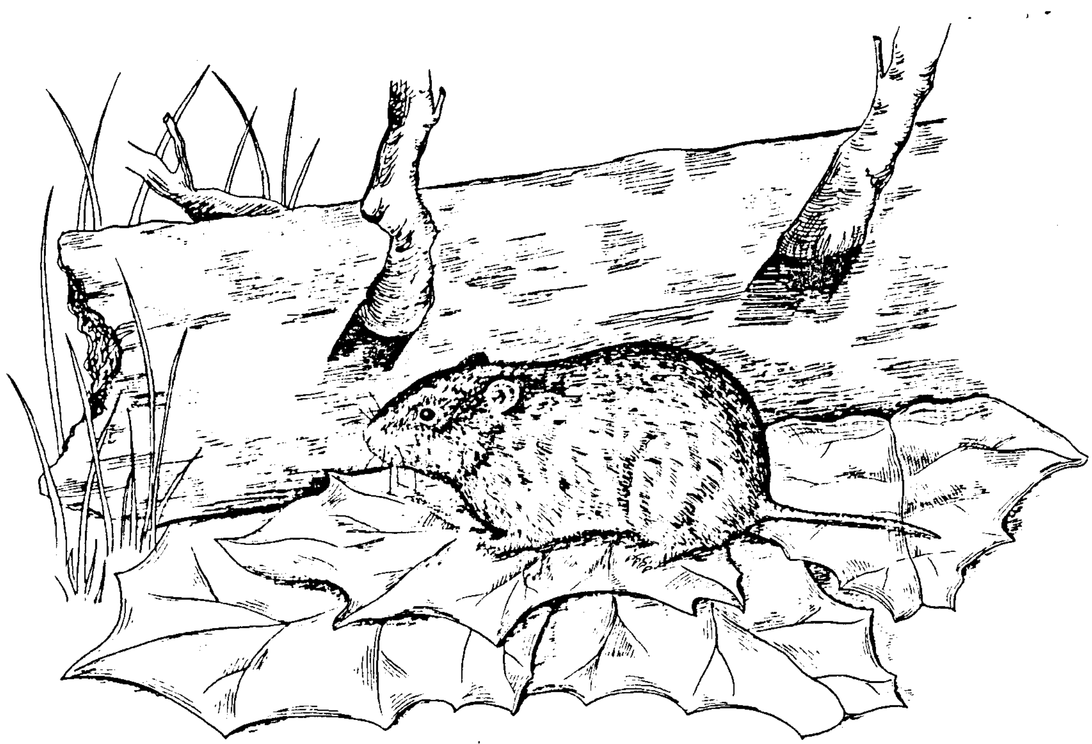
FWS/OBS-82/10.42
APRIL 1983

HABITAT SUITABILITY INDEX MODELS: SOUTHERN RED-BACKED VOLE (WESTERN UNITED STATES)



Fish and Wildlife Service

U.S. Department of the Interior

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: SOUTHERN RED-BACKED VOLE (WESTERN UNITED STATES)

by

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This report should be cited as:

Allen, A. W. 1983. Habitat suitability index models: Southern red-backec vole (Western United States). U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.42. 14 pp.

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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ACKNOWLEDGMENTS

Chris Maser, Forestry Sciences Laboratory, Corvallis, Oregon, and Douglas C. Ure, Department of Zoology and Entomology, Colorado State University, Ft. Collins, Colorado, provided valuable critiques of earlier drafts of the HSI model for the southern red-backed vole. Sara Johnson, U.S. Forest Service, Bozeman, Montana, also reviewed the HSI model and provided unpublished data pertaining to the southern red-backed vole. The comments and suggestions of these individuals added significantly to the quality of this HSI model, and their contributions are gratefully acknowledged. The cover of this document was illustrated by Jennifer Shoemaker. Word processing was provided by Carolyn Gulzow and Dora Ibarra.

SOUTHERN RED-BACKED VOLE (*Clethrionomys gapperi*)

HABITAT USE INFORMATION

General

The distribution of the southern red-backed vole (*Clethrionomys gapperi*) coincides closely with the boreal and montane forest biomes throughout North America (Merritt 1981). The species occupies a wide range of plant communities but tends to be most common in wooded cover types (Clark 1973). Red-backed voles generally do not inhabit fields, forest clearings, or other nanforested habitats unless an abundance of protective ground cover is present (Miller and Getz 1972).

Food

Eastern subspecies of the red-backed vole are more dependent on herbaceous vegetation and insects as a food source than western subspecies, which are highly dependent on fungi, primarily hypogeous ectomycorrhizae (Maser et al. 1978a, b; Ure and Maser 1982). Vascular vegetation accounted for over 64% of the food of red-backed voles in North Carolina (Linzey and Linzey 1973). Fungi comprised 0.2% of the diet of the red-backed vole. Lichens and epigeous fungi (mushrooms and puffballs) accounted for 80 to 89% of the diet of the red-backed vole in Ontario (Martell 1981). Lichens are a major food source of western subspecies of the red-backed vole (Ure and Maser 1982; Maser, pers. comm.). Red-backed voles will climb trees and tunnel upward through the snow column to gain access to lichens growing on tree boles and limbs. The seeds of coniferous trees are also an important component of the diet of the red-backed vole on an annual basis (Merritt and Merritt 1978; Ure, pers. comm.).

A major food source for western subspecies of the red-backed vole is hypogeous fungi (truffles and false truffles) (Ure and Maser 1982). Truffles are the sporocarps, or reproductive bodies, of soil fungi (mycorrhiza). Ectomycorrhizal fungi form a sheath around plant rootlets and are essential for the successful growth of many tree species because they provide increased nutrient and water absorption, rootlet longevity, and rootlet protection from pathogens (Maser et al. 1978b; Spurr and Barnes 1980). The presence of mycorrhizae is essential for successful growth of tree species on drought and nutrient poor sites (Spurr and Barnes 1980). Pines (*Pinus* spp.) typically grow on nutrient poor sites, are particularly dependent on ectomycorrhizal fungi, and will not grow normally without the association. Red-backed voles play a positive role in the western coniferous forest ecosystems because they disperse the mycorrhizal inoculum that is necessary for the establishment and successful growth of conifers (Maser et al. 1978a).

Water

Information pertaining to the dietary water requirements of the red-backed vole were not found in the literature. However, the lack of soil moisture has been reported to be a critical factor in limiting the distribution of the red-backed vole (Butsch 1954; Hoffman 1960; Miller 1970; Kirkland and Griffin 1974). An absence of moisture in upland habitats in Connecticut restricted red-backed voles to moist, lowland habitats (Miller 1970). The species was most abundant in Connecticut at sites within 60 m (65.6 yd) of standing water or saturated soils (Miller and Getz 1973). Clark (1973) reported that the species inhabited the drier sites in peripheral areas of mesic communities sampled in Wyoming. Mesic forest sites allow hypogeous fungi to fruit for longer periods of time, thereby providing a more permanent and dependable food source for western subspecies of the red-backed vole (Maser, pers. comm.). Red-backed voles in Wyoming were significantly more abundant in mesic unlogged and selectively cut forest stands than in xeric forest stands (Campbell and Clark 1981). Soil xerification, resulting from logging activities, was believed to be the cause of a decrease in red-backed vole density. Clearcutting of western coniferous forests results in the severe reduction, or elimination, of red-backed voles due to the loss of ectomycorrhizal fungi (Maser et al. 1978a; Ure and Maser 1982). Scott et al. (1982) recorded no significant change in red-backed vole abundance when 36% of a 40 ha (100 acres) subalpine forest stand was harvested in 12 circular clearcuts, each 1.2 ha (3 acres) in size. Water provided by food may furnish sufficient moisture to allow distribution of the red-backed vole in drier, upland habitats (Miller and Getz 1973).

Cover

The red-backed vole most frequently inhabits mesic areas within coniferous, deciduous, and mixed forests that contain an abundance of debris cover (Merritt 1981). The species normally avoids nonforested situations (Miller and Getz 1972), although winter use of grassland habitats has been reported (Iverson and Turner 1972). Western subspecies of red-backed voles are more restricted in terms of their habitat requirements than are their eastern counterparts (Ure, pers. comm.). The southern red-backed vole is generally restricted to coniferous forest habitats in western North America because western deciduous forests do not support enough ectomycorrhizal fungi. In western North America, the red-backed vole inhabits forests of western redcedar (*Thuja plicata*), hemlock (*Tsuga* spp.), Douglas fir (*Pseudotsuga menziesii*), spruce (*Picea* spp.), fir (*Abies* spp.), and krummholz and willow (*Salix* spp.) communities (Merritt 1981). Ponderosa pine (*Pinus ponderosa*) stands, characteristically xeric in nature, are not usually inhabited by red-backed voles (Maser, pers. comm.; Ure, pers. comm.). Rickard (1960) reported that red-backed voles were associated with coniferous forests in Washington and Idaho and were most often captured in the more dense portions of the understory, particularly near fallen logs. The highest densities of southern red-backed voles in a Colorado study were in coniferous, subalpine forest containing a forb and shrub (*Vaccinium* spp.) understory (Armstrong 1977). Red-backed voles usually inhabit western coniferous forest cover types with shrub understories of *Vaccinium* (e.g., blueberry and whortleberry) (Maser, pers. comm.). Forests with understory vegetation of grasses and sedges (*Carex* spp.) supported the lowest densities of red-backed voles. Johnson (1982) found the greatest number of red-backed voles in an Idaho study in ungrazed riparian vegetative communities with forb understories. No red-backed voles were captured in ungrazed riparian communities where grasses were the major constituents of the understory vegetation. Clark (1973) reported that the greatest numbers of red-backed voles in habitats dominated by quaking aspen (*Populus tremuloides*) were captured where there was a closed tree canopy and an understory of shrubs and herbs.

Several studies have reported a positive correlation between the abundance of red-backed voles and an accumulation of debris, consisting of downfall, rotting logs, brush piles, stumps, root wads, and loose litter (Williams 1955; Gunderson 1959; Miller and Getz 1973; Beach 1975; Lovejoy 1975; Maser et al. 1978b; Merritt 1981). There is a direct positive relationship between the number of rotting logs and red-backed vole abundance (Maser et al. 1981). Communities with a debris cover greater than 25% were reported to support three times as many red-backed voles in Vermont as sites with less ground cover (Miller and Getz 1973). Logs not only provide shelter for the red-backed vole, but may also serve as beds for the establishment and growth of mycorrhizal fungi (Ure, pers. comm.). The organic components of soil in a mature Douglas-fir/larch (*Larix occidentalis*) forest type in Montana were the most important substrates for ectomycorrhizae formation (Harvey et al. 1976). Sixty-six percent of all active ectomycorrhizae were associated with humus, while 21% and 8% were in decayed wood and charcoal, respectively. Mineral soil contained only 5% of all active ectomycorrhizae. Martell (1981) attributed a decline in red-backed vole numbers in clear cut areas of northern Ontario to reduced vegetative cover, extremes in daily temperatures, and soil xerification. These changes in microhabitat characteristics were believed to result in the species becoming rare to absent within 2 to 3 years following timber harvest due to a reduction in the availability of lichens and fungi. Maser et al. (1978a) and Ure (pers. comm.) attributed the disappearance of western subspecies of red-backed voles after clearcutting to the absence of an adequate food source. Red-backed voles are absent from clearcut areas until hypogeous fungi begin fruiting again as the trees reach the pole-sapling stage (Ure, pers. comm.). However, eastern subspecies may reinvade clearcut areas within 3 years, because they are more dependent on herbaceous vegetation than fungi as a food source.

Reproduction

The reproductive requirements of the red-backed vole are assumed to be identical with its cover requirements, as described above.

Interspersion

The mean home range size for the red-backed vole in Colorado varied from 0.01 to 0.5 ha (0.02 to 1.25 acres) (Merritt and Merritt 1978). Maximum and minimum home ranges for the species in Michigan were 1.4 ha (3.56 acres) and 0.20 ha (0.49 acre), respectively (Blair 1941). The home ranges of both males and females overlapped the ranges of other individuals of both sexes.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model has been developed for application in the geographic ranges of western subspecies of the southern red-backed vole (Fig. 1).

Figure 1. Geographic applicability of red-backed vole HSI model.

Season. This model was developed to evaluate the potential quality of year-round habitat for the southern red-backed vole.

Cover types. This model was developed to evaluate the potential quality of southern red-backed vole habitat in the following cover types (terminology follows that of U.S. Fish and Wildlife Service 1981): Evergreen Forest (EF); Deciduous Forest (DF); and Evergreen Shrubland (ES).

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is-required before an area will be occupied by a species. Information on the minimum habitat area for the southern red-backed vole was not located in the literature. However, red-backed vole home range size has been reported to vary from 0.01 ha to 1.4 ha (0.02 to 3.56 acres). Based on this information, it is assumed that at least 2.0 ha (5 acres) of potentially suitable habitat must be present before an area will be occupied by the species. If less than 2.0 ha (5 acres) of forested habitat is present, the HSI for the red-backed vole is assumed to be 0.0.

Verification level. An earlier draft of this model was reviewed by Sara Johnson, U.S. Forest Service, Gallatin National Forest, Bozeman, Montana; Chris Maser, Forestry Sciences Laboratory, Corvallis, Oregon; and Douglas C. Ure, Department of Zoology and Entomology, Colorado State University, Fort Collins, Colorado. Improvements and modifications suggested by these reviewers were incorporated into this model.

Model Description

Although other cover types may be inhabited at low population 'densities, optimum year-round habitat requirements of western subspecies of the southern red-backed vole are met only within evergreen forests. It is assumed that food and cover requirements are interdependent characteristics of the vole's habitat. It is also assumed that the spatial distribution of resources within evergreen forests is not an important consideration in evaluation of habitat for the southern red-backed vole.

The following sections provide a documentation of the logic and assumptions used to translate habitat information for the red-backed vole to the variables and equations used in the HSI model. Specifically, these sections cover: (1) identification of variables; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationships between variables. Figure 2 illustrates the relationships of habitat variables, life requisites, and cover types used in this model to a habitat suitability value for the western subspecies of the southern red-backed vole.

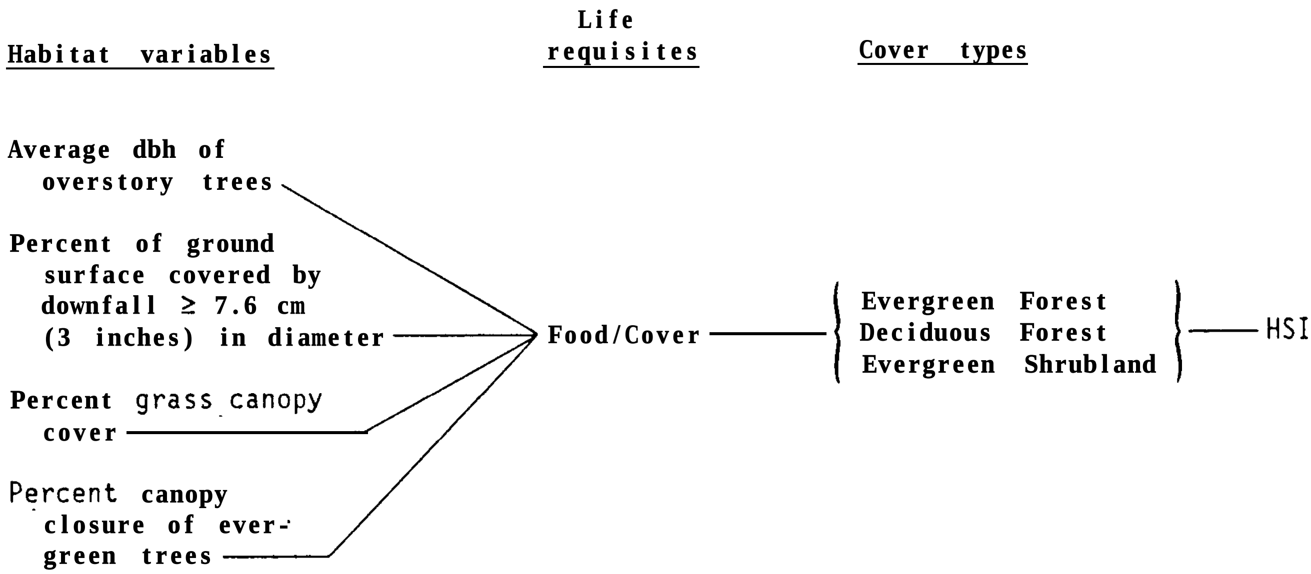


Figure 2. Relationships of habitat variables, life requisite and cover types in the southern red-backed vole model.

Food/cover component. The highest densities of western subspecies of the southern red-backed vole are reported in association with mature evergreen forests. The major food of this species appears to be hypogeous fungi with conifer seeds and lichens also appearing in the diet during some seasons. Several studies have described forest stand conditions that favor production of these food items. The availability of hypogeous fungi increases with increasing forest stand density and age, especially on more mesic sites. Downfall, or debris, also increases with forest age and an increase in debris is believed to be associated with increasing densities of red-backed voles and is a characteristic of microhabitats favoring hypogeous fungi growth. It is assumed that measurements of forest stand structure and composition can be aggregated to reflect the habitat conditions favoring the production of major food items and cover requirements of the southern red-backed vole.

The dbh of overstory trees, percent canopy closure of evergreen trees, percent of the ground surface covered by downfall, and the percent canopy closure of grass are assumed to be indicators of the ability of a forest stand to meet the food and cover needs of the southern red-backed vole. Relatively dense forest stands with large diameter evergreen trees potentially provide optimum habitat for western subspecies of the southern red-backed vole. Hypogeous fungi are most abundant in mesic forest communities with large diameter evergreen trees. These fungi are relatively uncommon in the early successional stages of forest communities. Hypogeous fungi are assumed to increase in abundance during the pole-sapling successional stage and become most abundant in mature and old growth stands. This model assumes that the diameter at breast height of dominant, or overstory, trees in a stand is correlated with successional stage. Forest stands with an average overstory dbh ≤ 5.0 cm (2.0 inches) are assumed to be shrub-seedling communities that have almost no value as southern red-backed vole habitat. The potential value of a forest stand as southern red-backed vole habitat is assumed to increase as the average dbh of overstory trees increases. Forest stands with an average overstory tree dbh ≥ 30.4 cm (12.0 inches) are assumed to be mature stands, indicative of optimum habitat conditions.

The percent canopy closure of evergreen trees is assumed to be the most influential characteristic of the potential of a forest stand to provide suitable conditions for western subspecies of the southern red-backed vole. Forest stands with optimum tree diameters ≥ 30.4 cm (12.0 inches), have greater potential as red-backed vole habitat as evergreen tree density increases. Sparse, open stands and stands dominated by deciduous trees are of minimum value as red-backed vole habitat, even when the mean dbh of the stand is optimum. Conversely, stands of small diameter trees have greater value as southern. red-backed vole habitat as tree density increases. Dense forest canopies tend to modify extremes in daily temperatures and maintain mesic microenvironments on the forest floor. It is assumed that optimum canopy closure of evergreen trees is ≥ 60%. Canopy closures of evergreen trees ≤ 20% have minimum value. Forest stands composed mainly of deciduous. tree species will be of little value as southern red-backed vole habitat, even though overstory tree dbh, the amount of downfall present and the canopy closure of grasses are of optimum value. As the proportion of a forest stand composed of evergreen trees increases, the potential of the stand to provide suitable food and cover for the southern red-backed vole will also increase.

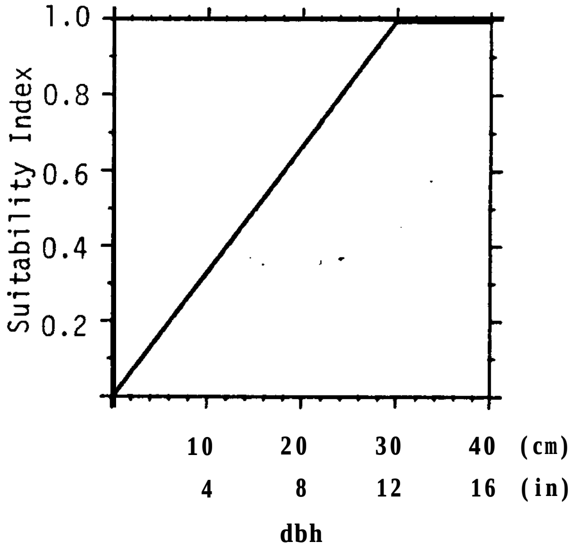
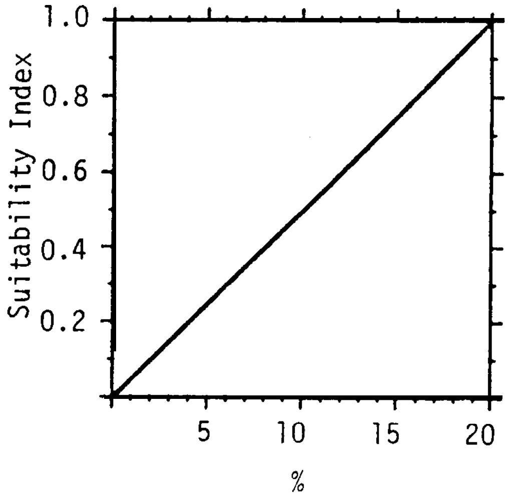
Woody debris on the forest floor provides southern red-backed voles with cover and is believed to provide concentrated sources of hypogeous fungi. It is assumed that optimum conditions occur when 20% or more of the forest floor is covered by downed woody material greater than 7.6 cm (3.0 inches) in diameter. Forest stands devoid of woody debris are of much lower value as southern red-backed vole habitat.

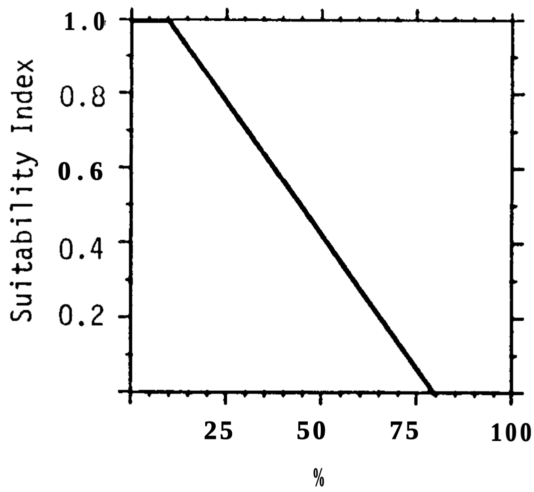
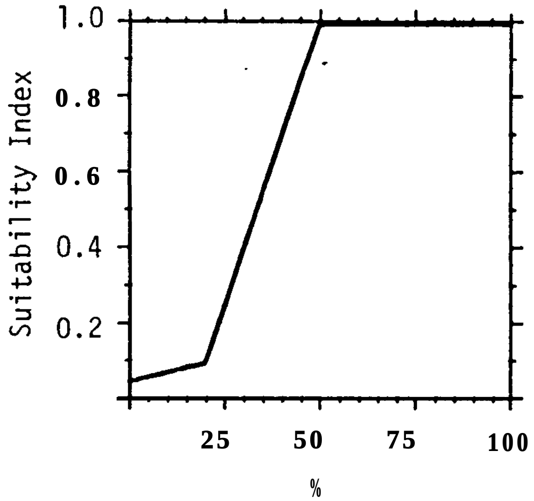
The review of the literature indicated that the southern red-backed vole inhabits forest stands with an understory of shrubs and/or forbs; however, the presence of grass characterizes less suitable habitat. It is assumed that there is an inverse relationship between grass density and habitat quality for western subspecies of the southern red-backed vole. A grass canopy closure of 10% or less is assumed to indicate optimum habitat for the species, while grass canopy closures of 80% or greater are assumed to represent unsuitable southern red-backed vole habitat.

Briefly, optimum habitat for western subspecies of the southern red-backed vole can be characterized as an evergreen forest stand of large diameter trees with a canopy closure in excess of 60%, an understory with little to no grass, and 20% or more of the forest floor covered by woody debris.

Model Relationships

Suitability Index (SI) graphs for habitat variables. This section provides graphic representations of the relationship between various conditions of habitat variables and habitat suitability. The identification of variables and a written summary of the logic and assumptions used in defining suitability levels were described in the Model Description section.

Cover type	Variable		
EF,DF,ES	V_1	Average dbh of overstory trees.	
EF,DF,ES	V_2	Percent of ground surface covered by downfall ≥ 7.6 cm (3 inches) in diameter.	

EF,DF,ES	V_3	Percent grass canopy cover.	
EF,DF,ES	V_4	Percent canopy closure of evergreen trees.	

Equations. In order to obtain the food/cover value for the red-backed vole, the SI values for appropriate variables must be combined with the use of an equation. A discussion and explanation of the assumed relationships between variables was included under Model Description and the specific equation in this model was chosen to mimic these perceived biological relationships as closely as possible. The suggested equation for obtaining a food/cover 'value for the southern red-backed vole in western evergreen and deciduous forests is as follows:

$$(V_1 \times V_2 \times V_3)^{1/3} \times V_4$$

HSI determination. Because other life requisites are assumed to be met and food/cover is the only life requisite considered in this model, the HSI equals the food/cover value.

Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 3.

Variable (definition)		Cover types	Suggested technique
V_1	Average dbh of overstory trees [the average diameter at breast height (1.4 m/4.5 ft) of those trees ≥ 80% of the height of the tallest tree in the stand].	EF,DF,ES	Cruise for tallest tree in stand. Sample with optical range finder and Biltmore stick on strip quadrat.
V_2	Percent of the ground surface covered by downfall ≥ 7.6 cm (3 inches) in diameter [the percent of the ground surface covered by dead woody material: including tree boles, stumps, limbs, or root wads, ≥ 7.6 cm (3 inches) in diameter].	EF,DF,ES	Line intercept, ocular estimation of cover
V_3	Percent grass canopy cover [the percent of the ground surface shaded by a vertical projection of grasses and/or sedges (<u>Carex</u> spp.)].	EF,DF,ES	Line intercept, ocular estimation of cover
V_4	Percent canopy closure of evergreen trees [the percent of the ground surface that is shaded by a vertical projection of the canopies of coniferous woody vegetation taller than 5.0 m (16.5 ft).]	EF,DF,ES	Line intercept, remote sensing

Figure 3. Definition of variables and suggested measurement techniques.

SOURCES OF OTHER MODELS

No other habitat models for the southern red-backed vole were located.

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50272 -101

REPORT DOCUMENTATION PAGE	1. REPORT NO. FWS/OBS-82/10.42	2.	3. Recipient's Accession No.
4. Title and Subtitle Habitat Suitability Index Models: Southern Red-Backed Vole (Western United States)			5. Report Date April 1983
			6.
7. Author(s) Arthur W. Allen			8. Performing Organization Rept. No.
9. Performing Organization Name and Address	Habitat Evaluation Procedures Group Western Energy and Land Use Team U.S. Fish and Wildlife Service Drake Creekside Building One 2627 Redwing Road Fort Collins. CO 80526		10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address	Western Energy and Land Use Team Division of Biological Services Research and Development Fish and Wildlife Service Washington, DC 20240		13. Type of Report & Period Covered
			14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

Habitat preferences of the southern red-backed vole (Clethrionomys gapperi) are described in this publication, which is one of a series of Habitat Suitability Index (HSI) models. A review and synthesis of the literature is followed by *development of a model of the species-habitat requirements of the southern red-backed vole. Habitat suitability indexes are designed for use with ttabitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

Mathematical models
Wildlife
Habitability

b. Identifiers/Open-Ended Terms

Habitat Suitability Indexes (HSI)
Southern red-backed vole
Clethrionomys gapperi

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release Unlimited	UNCLASSIFIED	14
	20. Security Class (This Page)	22. Price
	UNCLASSIFIED	

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

U.S. GOVERNMENT PRINTING OFFICE 1983 - 679 527 302 REGION NO 8

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving thsenvironmtntal and cultural values of our national parks and historical places, and providing for the enjoyment of life thmugh outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.