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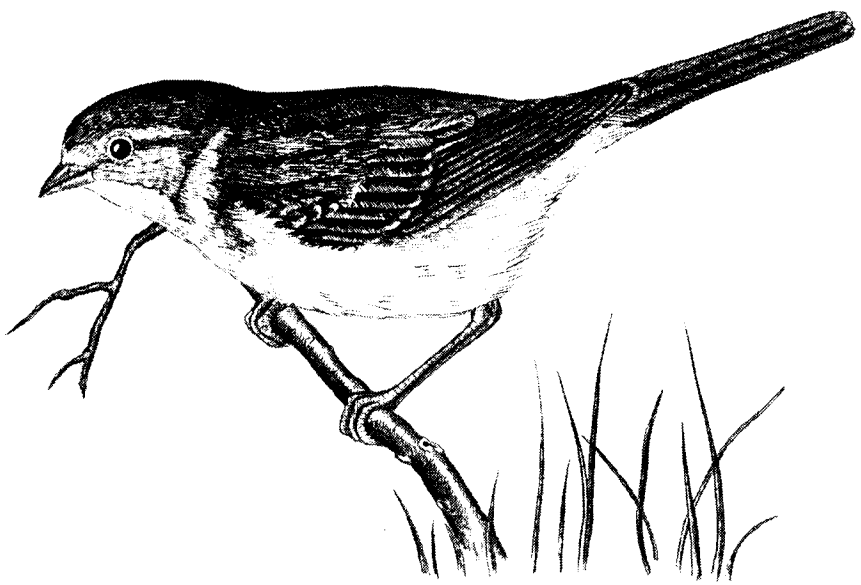
HABITAT SUITABILITY INDEX MODELS: FIELD SPARROW



Fish and Wildlife Service

U.S. Department of the Interior

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HABITAT SUITABILITY INDEX MODELS: FIELD SPARROW

by

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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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ACKNOWLEDGMENTS

Dr. Louis Best reviewed two earlier drafts of the HSI model for the field sparrow. His comments and suggestions added greatly to the quality of this model and his contributions are gratefully acknowledged. Dr. Best also participated in field validation efforts of the field sparrow HSI model conducted under the direction of Ms. L. Jean O'Neil, U.S. Army Corps of Engineers, Waterways Experiment Station. Results of the field validation efforts resulted in several improvements in the model. Ms. O'Neil's efforts in the field validation contributed significantly to the final structure of this model.

Word processing of this document was provided by Carolyn Gulzow and Dora Ibarra. The cover was illustrated by Jennifer Shoemaker.

FIELD SPARROW (Spizella pusilla)

HABITAT USE INFORMATION

General

The preferred habitat of the field sparrow (Spizella pusilla) is old fields with scattered woody vegetation (Best 1977b). Field sparrows are distributed primarily in the eastern United States, although they may breed as far west as Montana to eastern Texas (Walkinshaw 1968). They are resident species in much of their range.

Food

Field sparrows feed on a variety of plant and animal foods (Martin et al. 1961; Evans 1964; Best 1977a), and their food habits have been described as flexible (Allaire and Fisher 1975). Food is not considered to be limiting during the breeding season (Evans 1964; Best 1977a).

Field sparrows typically forage on or near the ground (Allaire and Fisher 1975; Hebrard 1978), although flycatching has also been observed (Hebrard 1978). Foraging perches, such as shrubs, brush piles, or barbed-wire fences, are often used to reach seeds (Allaire and Fisher 1975). Seeds account for 80% to 90% of the fall and winter diet, although vegetative material accounts for only 45% and 49% of the spring and summer diet, respectively (Martin et al. 1961). The spring diet of adult field sparrows is varied and includes insects and other arthropods, grass and forb seeds, and other vegetative material (Evans 1964).

The diet of nestlings is almost entirely insects [particularly larval forms of the order Lepidoptera, nymphal forms of the order Orthoptera, and adult forms of the order Homoptera (Best 1977a)] and spiders (Evans 1964; Best 1977a), although vegetative material and other animal forms have also been identified (Evans 1964). Adult field sparrows in Illinois were opportunistic foragers for their young and shifted their foraging habitats from wooded areas adjacent to the breeding habitat early in the spring to more open sites with low vegetation later in the breeding season (Best 1977a). The use of wooded areas for foraging was also reported in a Michigan study area (Evans 1964).

Water

No information on drinking water requirements was found in the literature.

Cover

Old fields with scattered woody vegetation (Best 1977b) and brushy fencerows (Walkinshaw 1968) provide the most suitable habitat for the field sparrow. Territories extend into grassland and forested cover types at times, but these habitats are less preferred (Best 1979). The field sparrow roosts in the dense foliage of small trees or bushes (Walkinshaw 1968). Field sparrows winter in a variety of forested or shrubby habitats (Emlem 1972).

Characteristics of habitats occupied during the breeding season are discussed in the following section.

Reproduction

Breeding habitat preferred by the field sparrow has been variously described as a shrub-grassland community (Best 1979); brushy stands with little or no overstory (Crawford et al. 1981); shrubby fields, forest borders, and roadsides (Johnston 1947); early successional stages (Shugart and James 1973); brushy fields or grasslands with a few larger trees (Kahl et al. 1981); and hillsides with shrubby growth, grassy meadows, pastures, and weedy fencerows (Walkinshaw 1936). The common habitat denominator in these studies is apparently the need for a mixture of shrubby and herbaceous vegetation. The field sparrow has also been considered a typical forest edge bird (Johnston 1947), and the presence of nearby wooded areas as an early spring foraging habitat may be an important factor in habitat suitability (Evans 1964).

The availability of suitable perches (e.g., shrubs, trees, and fences) has been suggested as a habitat factor that can limit field sparrow populations (Johnston 1947; Anderson 1979; Lanyon 1981). Factors related to habitat patchiness may also be limiting (Stauffer and Best 1980). Primary habitat factors in Missouri were identified as canopy height and stem density of woody vegetation less than 2.5 cm (1 inch) dbh (Kahl et al. 1981). Habitats with canopy height ranging from 2 to 8 m (6.6 to 26.2 ft) were occupied, although the preferred range was 2 to 4 m (6.6 to 13.1 ft). Optimum density of small diameter stems was reported as 350 to 700 stems/ha (142 to 283 stems/acre), although the range in occupied habitats was 25 to 1,050 stems/ha (10 to 425 stems/acre). Secondary habitat characteristics were stem density greater than 2.5 cm (1 inch) dbh and the percent vegetative ground cover. Optimum ranges for these variables were 25 to 50 stems/ha (10 to 20 stems/acre) and 95 to 100% ground cover. Ranges of the secondary variables in occupied habitat were 25 to 500 stems/ha (10 to 202 stems/acre) and 85 to 100%, respectively. Field sparrow populations in regenerating hardwood stands in Virginia decreased as canopy height of the stand exceeded 4.5 m (14.8 ft) (Crawford et al. 1981). Field sparrows were common on grasslands with shrubs following a transmission line corridor cut in Tennessee, but were expected to decrease as shrub density increased (Anderson 1979).

Field sparrows nest on the ground (Evans 1964; Fretwell 1969), in low herbaceous vegetation, or in low shrubs (Walkinshaw 1936; Best 1978). Only 1 of 145 field sparrow nests in a Pennsylvania study area was placed greater than 0.9 m (3 ft) above the ground (Preston and Norris 1947). Ten nests in a Scotch pine (Pinus sylvestris) Christmas tree plantation in Minnesota averaged

0.44 ± 0.07 m (1.4 ± 0.23 ft) above ground in trees that averaged 1.42 ± 0.08 m (4.66 ± 0.26 ft) tall (Buech 1982). Six of nine nests in an Iowa study area were located in shrubs, two were in evergreen trees, and one was in forb cover (Stauffer and Best 1980). Approximately 42% of 129 field sparrow nests in Illinois were located in standing grass litter, 19% were in forbs, and 39% were in trees and shrubs (Best 1978). However, a significant shift in nest placement from herbaceous to woody vegetation occurred through the breeding season. The average nest height increased from a low of 26 cm (10.2 inches) in May to 48 cm (18.9 inches) in August. A similar shift in nest placement through the nesting season has also been documented in Michigan (Walkinshaw 1936), Iowa (Crooks and Hendrickson 1953), and Indiana (Nolan 1963). Although this shift in nest placement has been considered to be correlated with leaf-out of woody vegetation (Nolan 1963), Best (1978) suggested that the shift results from unknown factors and not in response to leaf-out. Evans (1978) found a shift from ground nesting to tree and shrub nesting as plant succession progressed on an old field in Michigan. Fifty-six percent of all nests were located in junipers (Juniperus communis) even though junipers made up only a small portion of the potential nest sites, indicating a preference for this tree species as a nest site by field sparrows. Nests in junipers were significantly more successful than nests in other sites. Nest height alone was found to be an insignificant factor in nesting success in Illinois (Best 1978).

Interspersion

Field sparrows are territorial during the breeding season (Walkinshaw 1968; Best 1977b; Evans 1978). Reported territory sizes range from a low of 0.30 ha (0.75 acre) in Iowa (Crooks and Hendrickson 1953) to a high of 2.4 ha (6 acres) in Michigan (Walkinshaw 1968). Mean territory sizes are typically less than 0.8 ha (2 acres) (Nolan 1963; Best 1977b; Evans 1978). Average territory sizes in a Michigan study area decreased from 0.63 ha (1.56 acres) in 1956 to 0.36 ha (0.89 acre) in 1975, apparently in response to an increase in the number of junipers (Evans 1978). Territories in a grassland type in Illinois were significantly larger than in nongrassland types (primarily the preferred shrub-grassland type) (Best 1977b). The difference in territory size may have resulted from the low food potential of the grassland or from the opportunity to expand territories outward because the grassland type was on the periphery of the preferred shrub-grassland cover type. Field sparrows in western Virginia were infrequently found in areas of regeneration following clearcutting that were less than 2 ha (4.9 acres) (Crawford et al. 1981).

Special Considerations

Suitable breeding habitat for the field sparrow may be created by activities such as fire, cutting, or scarification following clearcutting (Crawford et al. 1981). Fire can be used to maintain suitable shrub-grassland and edge conditions. However, too frequent burning may eliminate desirable woody vegetation, and infrequent burning may result in the closure of the woody canopy (Best 1979). The length of time that habitat is suitable for field sparrows following clearcutting depends on the growth rate of woody regeneration (Crawford et al. 1981). Habitats on fast growing sites may remain suitable for only 3 to 5 years, while those on slow growing sites may remain

suitable for 10 to 15 years. Old field successional habitats on fallow farmlands on Long Island were attractive to field sparrows as nesting habitat from about 2 to 16 years following cultivation (Lanyon 1981). The field sparrow does not tolerate habitat disturbance well, particularly the removal of woody vegetation (Stauffer and Best 1980). An increase in the patchiness of shrubby vegetation will likely result in an increase in field sparrow populations.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This HSI model was developed for use throughout the breeding range of the field sparrow (Fig. 1). The breeding range of the field sparrow is "... from northwestern and southeastern Montana, northern North Dakota, central Minnesota, north-central Wisconsin, north-central Michigan, southern Ontario, southwestern Quebec, southern Maine and southern New Brunswick south to northeastern Colorado (possibly), western Kansas, western Oklahoma, central and southern Texas (west to Irion County), the Gulf Coast (east to northern Florida) and southern Georgia; also in southern Manitoba (Winnipeg)" (American Ornithologists' Union 1983:701).

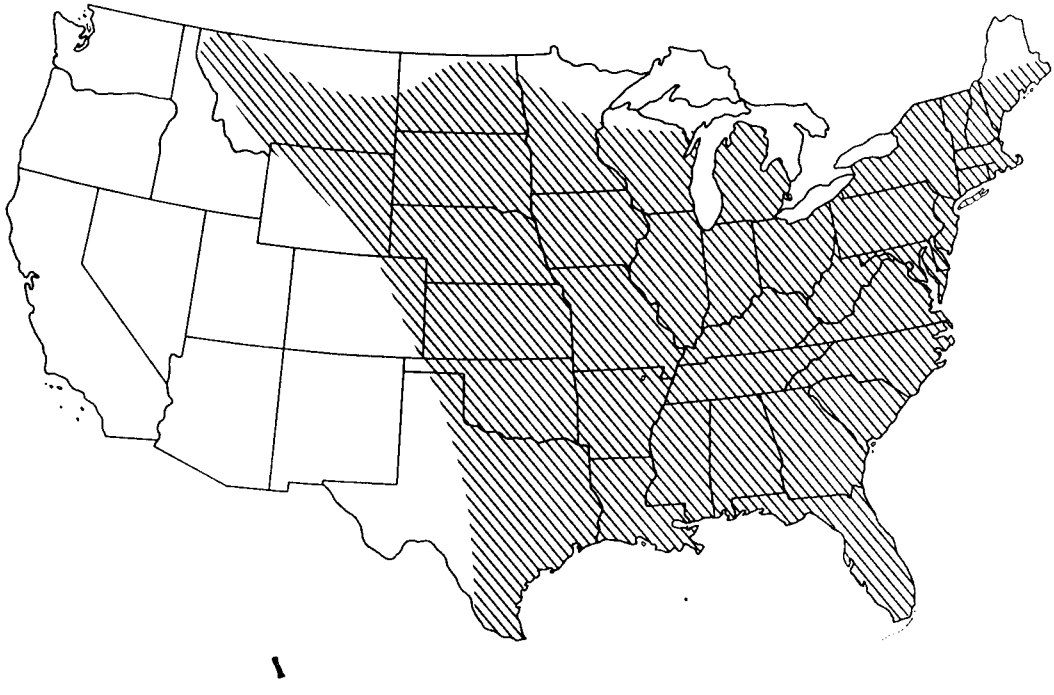


Figure 1. Geographic applicability of the field sparrow HSI model within the United States (adapted from a map prepared by D. B. Inkley and C. M. Raley, Wyoming Coop. Fish. Wildl. Res. Unit, Laramie, from American Ornithologists' Union 1983).

Season. This model was developed to obtain an HSI for habitat used by the field sparrow during the breeding season (spring through summer).

Cover types. The field sparrow is associated with early successional habitats with shrubby and herbaceous vegetation during the breeding season and may use any of the following cover types (terminology follows that of U.S. Fish and Wildlife Service 1981): Evergreen Shrubland (ES); Deciduous Shrubland (DS); Evergreen Shrub Savanna (ESS); Deciduous Shrub Savanna (DSS); Grassland (G); and Forbland (F).

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. The field sparrow does not usually inhabit areas of forest regeneration smaller than 2 ha (4.9 acres) (Crawford et al. 1981). It is assumed in this model that a minimum of 2 ha of habitat must exist or the HSI will equal 0.0.

Verification level. This HSI model provides habitat information for impact assessment and habitat management. The model is a hypothesis of species-habitat relationships and does not reflect proven cause and effect relationships.

Earlier drafts of this model were reviewed by Dr. Louis Best, based on his knowledge of the habitat requirements of the field sparrow in old field-tallgrass prairie habitats of Illinois and Iowa. Many of his review comments have been incorporated into the current model, with the belief that Dr. Best's perceptions of field sparrow habitat quality are appropriate throughout the range of the species.

An attempt at field validation of the model was conducted on 20 sites at Oak Ridge, Tennessee (O'Neil, pers. comm.). Comparisons between outputs of several versions of the model and site ratings by Dr. Best resulted in several changes to the original version of the model. Results of the comparison between Dr. Best's ratings and the HSI model described below were a product-moment correlation coefficient (r) of 0.53 ($p < 0.05$) and a Spearman's rank correlation coefficient (r_s) of 0.55 ($p < 0.05$) (O'Neil, pers. comm.). The following major assumptions must be considered in interpreting these results: (1) that the expert's perceptions of habitat quality for the field sparrow are valid throughout the breeding range of the species, even though these perceptions were developed over a limited portion of the range; and (2) that the expert ratings are highly correlated with actual habitat quality, i.e., that the expert ratings were a suitable surrogate measure of habitat quality.

Model Description

Overview. This model uses the reproductive habitat needs of the field sparrow to determine overall habitat quality. It is assumed that cover needs are met by reproductive habitat needs and that neither food nor water will be more limiting than the field sparrow's cover/reproductive needs. All of the life requirements of the field sparrow can be provided within each cover type in which it occurs, although the presence of nearby wooded areas may add to the suitability of the habitat.

In order to evaluate the cover and reproductive suitability of a habitat, it is necessary to characterize the habitat in terms of the needs of the field sparrow. The following section identifies important habitat variables, describes suitability levels of the variables, and describes the relationships between variables. The relationships between habitat variables, life requisites, and cover types used in this model and an HSI value for the field sparrow is shown in Figure 2.

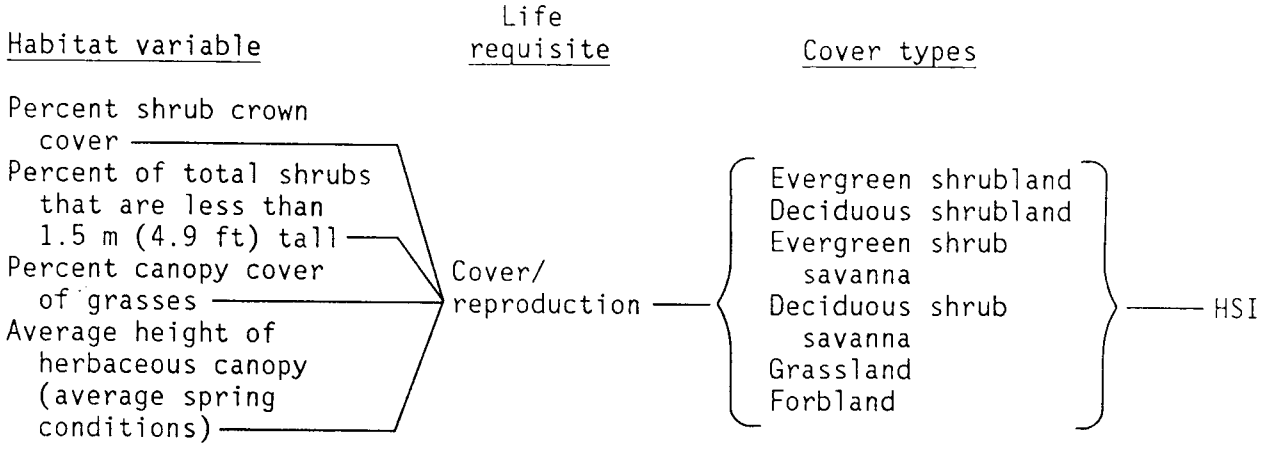


Figure 2. The relationships between habitat variables, life requisites, and cover types in the field sparrow model.

Cover/reproduction component. Reproductive suitability for the field sparrow is related to the height and density of both shrubs and herbaceous vegetation. Optimal habitats occur in old field areas with low to moderate densities of shrubs and dense, moderately tall grasses. Field sparrows use shrubs as perch sites and increasingly for nesting as the breeding season progresses. Since preferred habitat includes a mixture of shrubs and grassy vegetation, canopy cover of shrubs may serve as one variable to predict habitat quality. Grasslands with no shrubs are assumed in this model to be unsuitable for field sparrows, and habitats with greater than 75% shrub cover are considered to be too dense to be used by field sparrows. Shrub cover between 15 and 35% is considered to represent optimum conditions in this model. Although horizontal patchiness of shrubs may be an important variable influencing field sparrow habitat (Stauffer and Best 1980; Best, pers. comm.), an evaluation of horizontal patchiness of shrubs is not included in this model. It is assumed in this model that an estimate of shrub cover will, in most instances, address the question of shrub patchiness and distribution. It is also assumed that optimal shrub cover as described above will represent optimal interspersion of woody and herbaceous vegetation.

Field sparrows use relatively short shrubs for nesting and taller shrubs for song perches (Best, pers. comm.), and an estimate of average shrub height may not adequately reflect this condition. Since field sparrows usually nest

low in shrubs, it appears reasonable to assume that most shrubs should be relatively short in order to provide optimal nesting conditions. Habitats with 50 to 75% of the shrubs < 1.5 m (4.9 ft) tall are assumed to provide the optimum mixture of high and low shrubs. Habitats where all shrubs are < 1.5 m (4.9 ft) tall are assumed to provide less than optimal habitat due to a scarcity of preferred perch sites. Habitats with all shrubs > 1.5 m (4.9 ft) tall are assumed to provide relatively low quality habitat due to a scarcity of preferred nest sites. It is assumed in this model that a scarcity of low nest sites has a more significant impact on the suitability of shrubs to field sparrows than does a scarcity of perch sites (i.e., areas with all shrubs > 1.5 m are less suitable than areas with all shrubs < 1.5 m). The suitability levels corresponding to these conditions were based on field validation efforts of an earlier draft of this model (O'Neil, pers. comm.).

Overall shrub suitability for the field sparrow is a function of both shrub density and height distribution. It is assumed in this model that the shrub variable with the lowest suitability level will determine the overall shrub suitability level. This assumption is based on results of correlations of model outputs from several combination functions to expert ratings of 20 sites for field sparrows (O'Neil, pers. comm.).

Grasses are used much more frequently than forbs for nest sites and as a food source by field sparrows (Best 1978). Optimal grass density is assumed to be from 50% to 90% canopy cover in this model. These levels are assumed to provide adequate nesting substrate, an abundant food source, and no obstruction to movement through the grasses. Canopy cover < 50% is assumed to provide less than optimal nesting substrate and food sources. Canopy cover > 90% is assumed to provide optimal levels of nesting substrate and food resources, but less than optimal conditions for unrestricted movement through the vegetation. Optimal height of herbaceous vegetation during the period when nesting is concentrated in herbaceous vegetation (i.e., May-June) is assumed to be 16 to 32 cm (6.3 to 12.6 inches), and suitability is assumed to decrease as herbaceous height increases above 32 cm, due to increased difficulty in reaching ground level where most nests are located. Average herbaceous height greater than 40 cm (15.8 inches) during the May-June period is assumed to represent average suitability to nesting field sparrows. Herbaceous vegetation that averages less than 5 cm (2 inches) is assumed to provide inadequate concealment for field sparrow nests. Overall suitability related to the herbaceous component of the habitat is a function of both herbaceous height and density of grasses. It is assumed in this model that the final value of herbaceous vegetation to field sparrows will be determined by the lowest suitability level of the two variables related to herbaceous vegetation. This assumption is based on results of correlations of model outputs from several combination functions to expert ratings of 20 sites for field sparrows (O'Neil, pers. comm.).

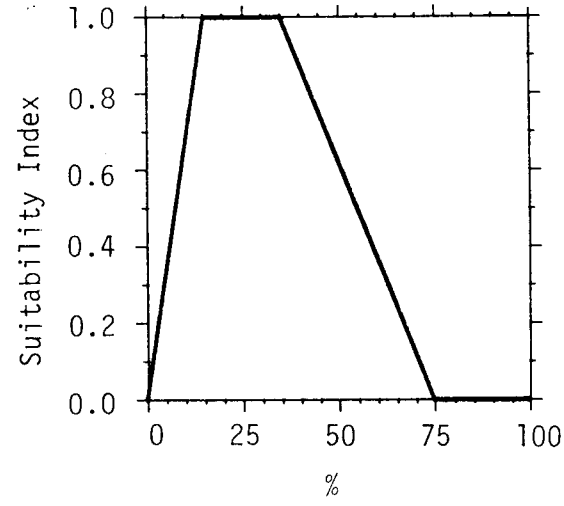
The overall cover/reproductive suitability during the breeding season is a function of both the shrub and herbaceous components of the habitat. It is assumed that shrubs and herbaceous growth are equally important and that optimal levels of both are necessary to provide optimal habitat conditions. Low levels of either component are assumed to be partially compensated for by

high values of the other component, except when either component provides no suitability for the field sparrow. If either the shrub or herbaceous component is absolutely unsuitable for field sparrows, then the entire habitat is assumed to be unsuitable. These assumptions suggest that a combination of suitability indices of the shrub and herbaceous components should include a multiplicative function.

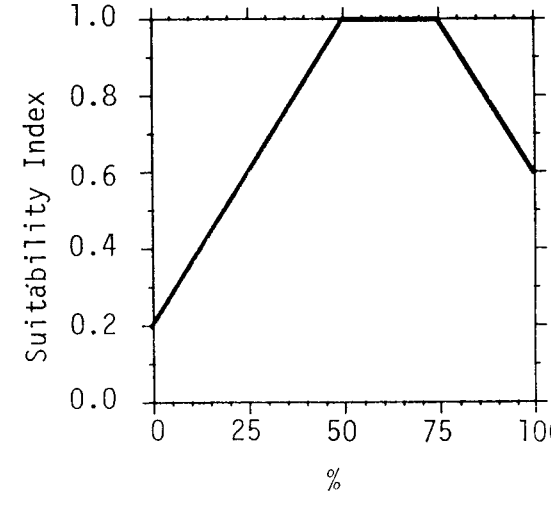
Model Relationships

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

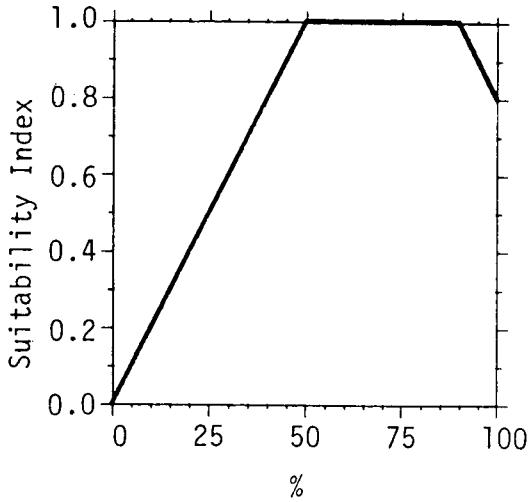
Cover type	Variable	
ES,DS, ESS,DSS, G,F	V_1	Percent shrub crown cover.



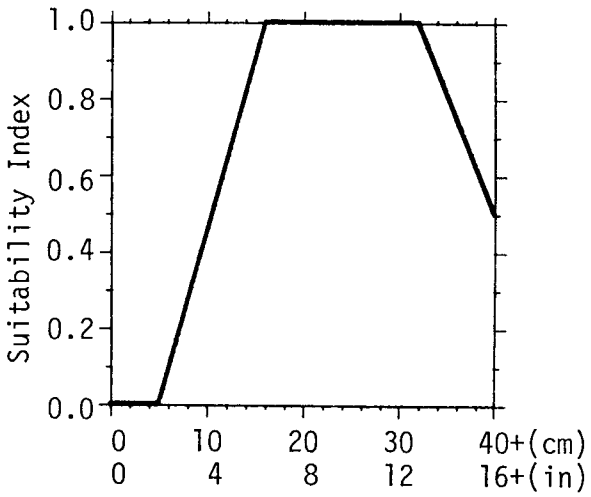
ES,DS, ESS,DSS, G,F	V_2	Percent of total shrubs that are less than 1.5 m (4.9 ft) tall.



ES,DS, ESS,DSS, G,F	V_3	Percent canopy cover of grasses.



ES,DS, ESS,DSS, G,F	V_4	Average height of herbaceous canopy (average spring conditions).



Equations. In order to obtain a cover/reproduction value for the field sparrow, the SI values for the 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. Also, the equation selected in this study provided the highest correlation with expert ratings of 20 sites in Tennessee for field sparrows (O'Neil, pers. comm.). The results of several other combinations of suitability indices were compared to expert ratings, including equations that gave greater importance to the shrub component of field sparrow habitat. However, these other combinations resulted in lower correlations than the equation selected for this model. The suggested equation for obtaining a cover/reproduction value in all cover types potentially used by the field

sparrow is the geometric mean of the minimum suitability levels of the shrub and herbaceous components. That is, the geometric mean of the lowest of the suitability indices for Variable 1 and Variable 2 and the lowest of the suitability indices for Variable 3 and Variable 4. This can be expressed mathematically as the following equation:

$$[\text{MIN}(V_1, V_2) \times \text{MIN}(V_3, V_4)]^{1/2}$$

HSI determination. Cover/reproduction was the only life requisite considered in this model, and the HSI for the field sparrow is equal to the life requisite value for cover/reproduction.

Application of the Model

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

Variable (definition)		Cover types	Suggested techniques
V_1	Percent shrub crown cover [the percent of the ground shaded by a vertical projection of the canopies of woody vegetation less than 5 m (16.5 ft) in height].	ES,DS,ESS,DSS, G,F	Line intercept
V_2	Percent of total shrubs less than 1.5 m (4.9 ft) tall.	ES,DS,ESS,DSS, G,F	Line intercept and graduated rod, or ocular estimate
V_3	Percent canopy cover of grasses (the percent of the ground shaded by a vertical projection of grasses).	ES,DS,ESS,DSS, G,F	Ocular estimation of cover

Figure 3. Definitions of variables and suggested measurement techniques.

Variable (definition)	Cover types	Suggested techniques
V_4 Average height of herbaceous canopy (average spring conditions) (the average vertical distance from the ground surface to the dominant height stratum of the herbaceous vegetative canopy during May-June, when nesting of field sparrows is concentrated in herbaceous vegetation).	ES,DS,ESS,DSS, G,F	Graduated rod

Figure 3. (concluded).

SOURCES OF OTHER MODELS

An HSI model for the field sparrow was developed by Cole and Smith (1983) for use on abandoned strip mines in West Virginia. Variables included in the model are percent cover and mean height of herbaceous vegetation, percent cover and mean height of shrubs, and percent cover and mean height of trees. Equations were developed by trial and error to obtain the highest correlation between model outputs and observed populations on 10 study sites. The selected equation resulted in a coefficient of determination (r^2) of 0.48 ($p < 0.05$) and a Spearman's rank correlation coefficient (r_s) of 0.71 ($p < 0.05$). The model by Cole and Smith (1983) was also used to calculate HSI values for 20 sites in Tennessee in conjunction with field validation of the current model (O'Neil, pers. comm.). Comparison of model outputs to site ratings by Dr. Louis Best resulted in a Spearman's rank correlation coefficient of -0.21. Possible explanations for the poor rank correlation include: (1) expert ratings of the Tennessee sites were not valid measures of habitat suitability; (2) data collection on the Tennessee sites did not precisely correspond to the data needs of the model of Cole and Smith (1983); or (3) the model developed by Cole and Smith (1983) was designed to provide the highest correlation with a given data set and is not intended nor appropriate for application outside the area of development.

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Habitat preferences of the field sparrow (Spizella pusilla) are described in this report, which is one of a series of Habitat Suitability Index (HSI) models. A review and synthesis of the literature is followed by the development of a habitat model for the field sparrow throughout its breeding range in the United States. HSI models are designed to be used in conjunction with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

Mathematical models
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Habitability
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b. Identifiers/Open-Ended Terms

Habitat Suitability Index
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Spizella pusilla

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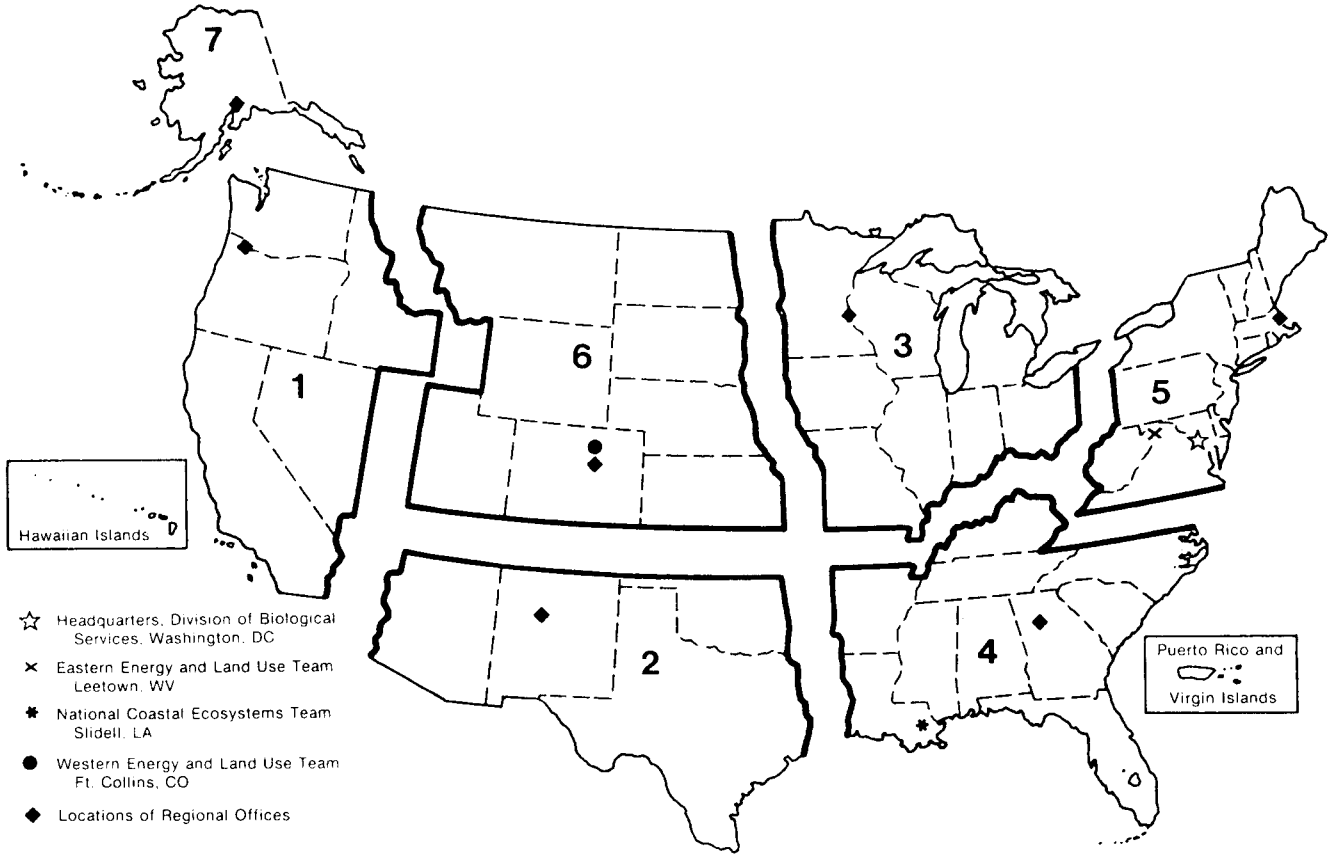

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