Ovenbird Habitat Capability Model for an Oak-Hickory Forest

James M. Sweeney, *North Central Forest Experiment Station, 1-26 Agriculture Building, University of Missouri, Columbia, MO 65211*

William D. Dijak, *North Central Forest Experiment Station, 1-26 Agriculture Building, University of Missouri, Columbia, MO 65211*

Abstract: A pattern recognition (PATREC) habitat capability model for the ovenbird (*Seiurus aurocapillus*) was tested and refined on the Mark Twain National Forest (NF) in the Missouri Ozarks. Breeding bird surveys were conducted on 48 stands in 1983, 31 different stands in 1984, and 26 different stands in 1985. The literature-based PATREC model in use on the forest was used as an operational hypothesis to guide stand selection. Habitat data were obtained from the timber management and wildlife management information system data bases maintained by the Mark Twain NF. Stepwise (Wilks selection criterion) and direct multivariate discriminant analyses were used to determine which habitat variables best separated stands where ovenbirds were observed from those where no ovenbirds were observed. The best discriminant function for the 1983 data set included 5 habitat variables: forest type, stand condition, total basal area, percent overstory crown cover, and percent ground cover. The best discriminant functions for the 1984 data set and the pooled 1983-1984 data set included the same 5 habitat variables. These 5 variables and the survey data from the 79 stands in the pooled data set were used to develop a PATREC habitat capability model. In an empirical test of this PATREC model on the source data set, the model correctly classified 85% of the stands used by ovenbirds as ovenbird habitat. When applied to the 1985 data set in a separate field trial, the PATREC model correctly classified 94% of the stands used by ovenbirds as ovenbird habitat.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:430–438

The National Forest Management Act (1976) and subsequent regulations require the USDA Forest Service to use management indicator species in land and resource management planning. These species theoretically indicate the welfare of other species with similar habit requirements or indicate conditions of special habitats such as snags and riparian areas. The ovenbird was selected as a management indicator species for the Mark Twain National Forest in Missouri because it is commonly abundant in the breeding bird communities of mature mixed hardwood forests (Hann 1937, Shugart et al. 1978, Freedman et al. 1981) and shows a progressive decline in abundance with increasing intensity of timber harvest (Webb et al. 1977, Stauffer and Best 1980, Crawford et al. 1981).

Breeding habitat of the ovenbird in the northeast is usually mature, deciduous or mixed (pine/hardwood) forests, although pines may be used. Preferred forests are commonly open with little underbrush and an abundance of rocks, logs, and fallen leaves (DeGraaf et al. 1980). Collins et al. (1982) listed the distinctive features of ovenbird habitat in north central Minnesota as moderate ground and shrub cover and >75% canopy cover in mixed coniferous-deciduous vegetation. In a study of ovenbird territories in eastern Tennessee, Smith (1981) concluded that ovenbirds select stands with sparse understory and shrub layers and with a closed canopy dominated by large mature trees. In a study of songbirds in central Appalachian hardwoods, Crawford et al. (1981) included the ovenbird as a "closed-canopy-obligatory species," but concluded that ovenbirds were more abundant when the greatest portion of the total basal area was composed of trees <70 cm dbh. Bond (1957) and Shugart and James (1973) classified the ovenbird as a moist-forest species, and Smith (1977:816) narrowed that to an "obligatory moist-forest species." Hamel et al. (1982:352), however, indicated that ovenbirds "favor rather dry deciduous forests . . ." as primary breeding habitat.

Biologists on the Mark Twain NF have been using a first-generation Pattern Recognition (PATREC) model (Williams et al. 1977) to evaluate present and future habitat for the ovenbird. The model was developed through cooperation with wildlife research biologists of the Missouri Department of Conservation and was based on literature and expert opinion. However, because of the scarcity of detailed information on habitat selection by ovenbirds and apparent conflicts in published reports, the model had only 3 parameters: percent of the forest in non-forest habitat, percent of oak-hickory/oak-pine pole timber with >80% canopy closure, and percent of oak-hickory/oak-pine sawtimber with >80% canopy closure. As a result, model sensitivity has been poor.

The objective of this study was to test and refine the PATREC habitat capability model for the ovenbird on the Mark Twain NF. Inherent to this objective was the clarification of distinct habitat use parameters for the ovenbird in an oak-hickory forest.

The authors would like to thank personnel of the Mark Twain National Forest for their cooperation in data collection. James D. Wilson and Richard Clawson, Missouri Department of Conservation, are thanked for their assistance in conducting pre-survey field training sessions. The authors also thank Ron McRoberts, Richard DeGraaf, and James Dickson (of the North Central, Northeastern, and Southern Forest Experiment Stations, respectively) and Richard Clawson for their critical review of this manuscript.

Methods

Study Area

The Mark Twain NF is located in southern Missouri. Breeding-bird surveys were conducted by Forest personnel on 10 of 13 districts: Doniphan, Fredricktown, Houston, Poplar Bluff, Potosi, Rolla, Salem, Van Buren, Willow Springs, and Winona. Except for the Cedar Creek Ranger District and a small part of Fredricktown Ranger District (not included in the study), the Mark Twain is located within the Ozark Natural Division of Missouri. Because of its great age and physiographic diversity, the Ozark Natural Division has 1 of the most diverse plant and animal communities in the region (Thom and Wilson 1980). Timber cover types include 15% shortleaf pine (*Pinus enchinata*); 20% oak-hickory-pine (*Quercus* spp.—*Carya* spp.—*P. enchinata*); 35% mixed oak-hickory with white oak (*Q. alba*) predominating in 5%, scarlet oak (*Q. coccinea*) predominating in 10%, black oak (*Q. velutina*) predominating in 15%, and post oak (*Q. stellata*) predominating in 5%; 25% mixed oak (nothing predominating); and 5% other deciduous (Roger Kirkman, pers. commun.).

Stand Selection

A stand is the basic management unit on a National Forest. On the Mark Twain NF, stand boundaries conform with the boundaries of ecological land types (Miller 1981). As a result, it is an identifiable ecological unit and an identifiable forest inventory unit, and was therefore selected as the study unit.

Forty-eight stands were surveyed during 1983, 31 in 1984, and 26 in 1985. Stands were selected through a stratified-random sampling of all possible stands. Strata were based on the parameters in the existing PATREC model, using it as an operational hypothesis. In 1983, the sample pool was first stratified along canopy closure to ensure selection of stands with >80%, about 80% and <80% crown closure. A secondary stratification ensured sampling within seedling-sapling, pole, and sawtimber stands. Study stands were randomly selected from all candidate stands in each cell of the resultant 2-way matrix. The same procedure was used to select study stands in 1984, but strata were based on the refined habitat capability model following analysis of the 1983 data. To provide an independent test of the 1983 discriminant function, 1984-stand selection was limited to unsurveyed stands.

Stands surveyed in 1985 were chosen to meet the needs of a parallel study on wood thrush (*Hylocichla mustelina*). The breeding bird survey was conducted in the same manner to permit use of this data set as a field test of the refined ovenbird PATREC habitat capability model. Stands surveyed in 1985 were not surveyed in 1983 or 1984.

The random selection of stands from the pool of all candidate stands within a given stratum cell was constrained by the following practical limitations: 1) An equal number of study stands were assigned to (chosen from) each participating district to ensure an equitable work load distribution and to provide a good geographic distribution of study stands throughout the Mark Twain NF, and 2) for each district, after the first stand was randomly selected, all subsequent stands were randomly selected from available stands within the same or adjacent compartments. This was done to minimize time and expense in travel.

Breeding Bird Survey

Stands were surveyed between 15 May and 15 June in 1983, 1984, and 1985. Each stand was surveyed by walking a transect line through the entire length (major axis) of the stand on 5 separate mornings (7 of the 1983 stands were only surveyed 3 times). Investigators stopped for 3-minute listening periods approximately every 100 m (5 chains) along the transect. Ovenbirds were "observed" by sight and sound. Surveys were conducted during the first 3 hours following sunrise to take advantage of the peak calling period. The specific time a stand was surveyed each of the 5 mornings was varied within the 3-hour period to prevent a time bias. To ensure standardization in data collection and proper identification of ovenbirds, a 2-day field training session for all participating biologists and foresters was conducted before beginning the study.

Habitat Data Base

Habitat data were obtained from the Timber Management Information System (TMIS) and Wildlife Management Information System (WMIS) data bases maintained by the Mark Twain NF. The habitat stand variables available for analysis were acreage, age, total basal area, stem density, site index, average dbh, height and percent crown closure of the canopy, height and percent crown closure of the subcanopy, percent ground cover, understory vegetation type, forest type (timber type), vegetation type (subdivision of forest type), land surface form (mountains, breaks, hills, plains), geology (soil parent materials), ecological land type (combination of land form, slope, aspect, soils, and vegetation), animal habitat type (e.g., lake, grassland, immature coniferous upland, rock outcrop), land use class (e.g., grazing allotment, special wildlife zone, access problem, unproductive), and stand condition (e.g., sparse, low quality, mature) (Miller 1981; U.S. Dep. Agric., For. Serv. 1980, 1983).

Discriminant Analysis

Stepwise (using the Wilks selection criterion) and direct multivariate discriminant analyses (Nie et al. 1975) were used to identify the habitat variables that best separated surveyed stands into 2 groups—those in which ovenbirds were observed (designated O), and those in which no ovenbirds were observed (designated N). Variables that have been associated with ovenbird habitat use in previous studies or were highlighted in the stepwise procedure were used in various combinations of 3 to 6 variables for direct analyses.

The "best function" was defined as the discriminant function that maximized the correct classification of stands where ovenbirds were sighted as ovenbird stands, and when this classification result was equal, the discriminant function that also maximized the correct classification of all stands.

By classifying the cases used to derive the discriminant functions and comparing predicted group (ovenbird, non-ovenbird) membership with actual (observed) group membership one can empirically measure the success of discrimination by calculating the proportion of correct classifications (Nie et al. 1975). The results are a measure of the discriminant functions' ability to classify their own data sets, and not a measure of ability to discriminate other groups of stands.

Discriminant analysis is a multivariate approach to pattern recognition and interpretation; however, most ecological data do not support required multivariate statistical assumptions. There is evidence in the statistical literature that certain of these assumptions can be violated moderately without large changes in correct classification rates, but nothing is known of the effects on canonical variates (Williams 1983). Discriminant analysis was therefore used only as an exploratory tool to indicate, on the basis of classification rates, which habitat variables might prove useful as parameters in a habitat capability model.

Habitat Model Formulation

The classes (groupings) and associated probabilities conditional upon ovenbird status (O or N) for each variable were determined by direct examination of observed frequencies of ovenbird and non-ovenbird stands. While the final grouping was subjective, it was not arbitrary. For example, forest types 44, 53, 54, and 59 had a higher number of stands where ovenbirds were observed than stands where no ovenbirds were observed, type 79 was about evenly split (9 and 8), and type 72 had a higher number of stands where no ovenbirds were observed. Types 51 and 77, each represented by only 1 stand, were assigned to the group containing their closest community counterpart. The final division into these 3 classes (Table 1) was consistent with ecological grouping in that types 44 through 59 are all oak types, 79 is a mixture of lowland hardwoods, and 72 and 77 are more specific riparian types, river birch-sycamore (*Betula nigra—Plantanus occidentalis*) and green ash (*Fraxinus pennsylvanica*).

For a given variable and a given ovenbird status, the conditional probability for each class is the number of stands in that class divided by the total for that ovenbird status. For example, the conditional probability of forest type 79 given ovenbird presence was $P(FT=79/O) = 9/48 = 0.19$ (Table 1). The classes within each variable and the conditional probabilities for each were all derived in this fashion.

PATREC models are based on Baye's Theorem (Williams et al. 1977), which

Table 1. Ovenbird use and conditional probabilities by forest type class on the Mark Twain National Forest, spring 1983 and 1984.

Forest Type	Number of Stands		Conditional Probabilities	
	Ovenbird	Non-ovenbird	Ovenbird	Non-ovenbird
44,51,53,54,59	37	14	0.77	0.45
79	9	8	0.19	0.26
72,77	2	9	0.04	0.29
Total	48	31	1.00	1.00

allows the incorporation of prior probabilities. The prior probability for ovenbirds was calculated as the number of stands where ovenbirds were observed in 1983 and 1984 divided by the total number of stands surveyed in 1983 and 1984, $P(O) = 48/79 = 0.61$. Similarly, the prior probability for non-ovenbird stands was $P(N) = 31/79 = 0.39$. The 1985 stands were not included in order to reserve that data set for a test of the PATREC model.

The model is used to evaluate a stand's ovenbird habitat capability by selecting the conditional probabilities (1 for ovenbird and 1 for non-ovenbird) associated with the stand's ranking in each parameter. The product of all ovenbird conditional probabilities $P(S/O)$ is calculated, as is the product of all non-ovenbird conditional probabilities $P(S/N)$. The expected status of a stand (ESS) being suitable habitat for ovenbirds is then calculated using Bayes' Theorem as follows:

$$ESS = \frac{P(O) \cdot P(S/O)}{[P(O) \cdot P(S/O)] + [P(N) \cdot P(S/N)]} .$$

The resultant value is the posterior probability that the stand is suitable ovenbird habitat, the proportion of similar stands that would be expected to be ovenbird stands. A stand is classified as suitable ovenbird habitat then, if $ESS > 0.5$.

Results and Discussion

The 48 stands surveyed in 1983 ranged in size from 2.8 to 27.9 ha; 26 of these stands were used by ovenbirds. In 1984, stands ranged in size from 1.6 to 27.5 ha; 22 of these 31 stands were used by ovenbirds. In 1985, stands ranged in size from 2.4 to 21.4 ha; 18 of these 26 stands were used by ovenbirds.

Discriminant Analysis

The best discriminant function for the 1983 data included the 5 habitat variables: forest type, stand condition, total basal area, percent overstory crown cover, and percent ground cover ($X^2 = 20.34$, $P < 0.01$) (Table 2). The best discriminant

Table 2. Classification results of multivariate discriminant functions for habitat use by ovenbirds on the Mark Twain National Forest, 1983 and 1984.

	Percent Correctly Classified		
Data Set	Ovenbird Stands	Non-ovenbird Stands	Overall
1983[a]	88.5	81.8	85.4
1984[a]	72.7	66.7	71.0
1983–1984 Combined[a]	79.2	77.4	78.5
1984[b]	68.2	77.8	71.0

[a]An empirical measure calculated by classifying the stands used to develop the discriminant function and comparing predicted group (ovenbird, non-ovenbird) membership with actual (observed) group membership.

[b]Classified by the discriminant function developed from the 1983 data set.

function for the 1984 data was made up of the same 5 variables, although its discriminating power was lower ($X^2 = 8.73$, $P = 0.12$). Likewise, the best discriminant function for the 2 years combined (1983 and 1984) was again the same 5 habitat variables ($X^2 = 28.83$, $P < 0.01$).

An indication of the discriminant ability of these 5 habitat variables on other areas was ascertained by using the 1983 discriminant function to classify stands in the 1984 data set. The 1983 function correctly classified 15 of the 22 stands used by ovenbirds as ovenbird habitat, and 7 of the 9 stands where no ovenbirds were observed as non-ovenbird habitat (Table 2).

Habitat Capability Model

A PATREC habitat capability model (Table 3) was constructed using the 5 habitat variables defined above. When applied to all 79 stands in the combined 1983-1984 data set, this model correctly classified 85% of the stands used by ovenbirds as ovenbird stands, and 61% of the stands where no ovenbirds were observed as non-ovenbird stands for an overall correct classification of 76%. This, however, is also an empirical analysis as the stands classified were the same stands used to construct the model.

In an applied test of the model on a separate (1985) data set, the model correctly classified 17 of the 18 stands used by ovenbirds as ovenbird habitat. However,

Table 3. Ovenbird pattern recognition habitat capability model for oak-hickory forests of Missouri.

Habitat Parameter	Conditional Probabilities	
	Ovenbird	Non-ovenbird
1. Forest Type[a]		
A. Oak-pine, Oak-hickory (44,51,53,54,59)	0.77	0.45
B. Mixed lowland hardwood (79)	0.19	0.29
C. River birch, sycamore, ash (72,77)	0.04	0.26
2. Stand Condition[a]		
A. Sparse (2)	0.15	0.03
B. Low quality (3)	0.37	0.16
C. Mature, Immature (4,5)	0.48	0.81
3. Total Basal Area in sq. ft./acre (m^2/ha)[b]		
A. ≤40 (≤3.72)	0.17	0.32
B. 50 to 70 (4.65 to 6.50)	0.44	0.52
C. ≥80 (≥7.43)	0.39	0.16
4. Overstory Density (Percent crown closure)[b]		
A. ≤50	0.29	0.45
B. 60 to 70	0.50	0.29
C. ≥80	0.21	0.26
5. Percent Ground Cover[b]		
A. ≤10	0.31	0.13
B. 20 to 40	0.38	0.39
C. ≥50	0.31	0.48
Prior Probabilities	0.61	0.39

[a]Forest survey types and stand condition codes according to USDA Forest Service (1980).
[b]Data collected in increments of 10.

it only classified 2 of the 8 stands where no ovenbirds were observed as non-ovenbird habitat, for an overall correct classification rate of 73% (19 of 26).

A higher degree of mis-classification may be acceptable on the non-ovenbird side because there are various reasons, other than habitat, why ovenbirds might not be observed in a given stand. The most obvious is that the stand may have actually been used by ovenbirds, but the survey failed to detect ovenbird presence. Surveying a stand 5 separate mornings might not have been sufficient to detect low level use. Dickson (1978) showed wide variations in breeding bird detection as the number of separate counts in a census were increased. Another reason for non-detection of ovenbirds is that all suitable habitat may not have been occupied. As a result, any of the 6 "mis-classified" non-ovenbird stands could have been suitable ovenbird habitat, and as such were correctly classified as ovenbird habitat by the PATREC model. The model therefore may have functioned better than was indicated by the classification results.

Conclusions

This study demonstrates the utility of combining discriminant function analysis and pattern recognition modeling to develop a useable habitat suitability model. Discriminant function analysis serves well as an exploratory procedure providing fruitful insights into the data. However, because biological data usually cannot meet the necessary assumptions of multivariate normality and homogeneous dispersion, the mathematical structure of the linear discriminant functions may have little ecological meaning (Williams 1983). It is therefore unwise to use the discriminant function as the final habitat capability model. The PATREC model, however, is based on direct observation of frequencies within the data, and does not suffer the same statistical liabilities. The insight gained from the discriminant function analysis allows one to select meaningful habitat parameters for the PATREC model.

This study also indicates that a reasonably accurate habitat capability model can be developed using vegetation data readily available in existing forest inventory data bases. This is a very important consideration in the economical day-to-day use of the model by land managers. Finally, this study is an example of what can be accomplished under restricted budgets when research and management cooperate to meet a common objective.

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