The Application of FIA-based Data to Wildlife Habitat Modeling: A Comparative Study

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Abstract.—We evaluated the capability of two types of models, one based on spatially explicit variables derived from FIA data and one using so-called traditional habitat evaluation methods, for predicting the presence of cavity-nesting bird habitat in Fishlake National Forest, Utah. Both models performed equally well, in measures of predictive accuracy, with the FIA-based model having estimates of model sensitivity. The primary advantage of using the FIA data is the ability to convert the modeled relationships to spatially explicit depictions of bird habitat.

The conservation and management of animal populations depend, in part, on accurate and parsimonious habitat models capable of identifying key components of an organism's habitat. Organisms are assumed to select a habitat that will maximize survival and reproductive success, and determining these habitat associations is essential to the understanding of the factors underlying species distribution and the maintenance of biodiversity.

The inability of small, single-scale studies to adequately explain and predict species presence, the recognition that patterns and processes are often fundamentally scale-dependent, and the desire to minimize the need for intense field sampling have all resulted in the introduction of landscape-level and hierarchical investigations into habitat selection (Lawler 1999, Lawler and Edwards 2002, Mitchell *et al*. 2001, Morris 1987, Turner *et al*. 1989, Wiens 1989, among others). Habitat selection by an individual in a population is influenced by the composition and configuration of the surrounding landscape matrix (Wiens and Milne 1989), and the incorporation of the "landscape-level" concept and technological advances allowed for habitat selection to be examined at multiple spatial scales and varying hierarchical levels (Bergin 1992, Gutzwiller and Anderson 1987, Lawler 1999, Mitchell *et al*. 2001, Saab 1999, Wiens *et al*. 1987).

Ecologists have suggested that to maximize predictive capability, habitat models need to incorporate a range of scales (Knick and Rotenberry 1995). In a management context, however, landscape-level habitat modeling is a desirable alternative to microhabitat sampling since microhabitat field sampling is often not spatially explicit, and it can be time consuming and labor intensive (Mitchell *et al*. 2001). Landscape-level modeling also allows for the study and management of the environment across large areas and in remote areas. This is a desirable goal for broad-scale wildlife management; however, these models must be applied with caution. Landscape-level habitat models must predict species presence beyond a desired accuracy, or if maximum predictive capability is the goal, landscape models must predict species distribution similarly or better than a microhabitat model or combined landscape/microhabitat model to *alone* suffice for wildlife habitat modeling.

Here we evaluate the efficacy of FIA-based data and derived information in wildlife habitat modeling. Specifically, we use FIA-derived, spatially explicit maps of several variables assumed related to the presence of wildlife. The obvious advantage of the FIA-based variables is their ability to be used in spatial extrapolation. These predictor variables are compared against more traditionally collected habitat variables (after James and Shugart 1970; hereafter "traditional model") having, perhaps, better ecological linkage to species ecology but lacking in the capability for spatial extrapolation. We test the simple hypothesis that FIA-based habitat models perform equally as well as traditional models in predictive capability. Our test species is a guild of cavity-nesting birds.

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Methods

Our study area was the Fishlake National Forest in southern Utah at the southern extent of the Wasatch Mountains. The study area encompasses sections of four ranger districts (Richfield, Loa, Fillmore, and Beaver) spread over three general mountain ranges. The Richfield Ranger District is located on Monroe Mountain and the Eastern Ranges, the Loa Ranger District is located on the southern portion of the Eastern Ranges, and the Fillmore and Beaver Ranger District are both located on the Pahvant and Tushar Ranges, respectively (hereafter the Western Ranges). This region of Utah is characterized by high mountains (~2,000 to 4,000 m) consisting of broad, rolling plateaus, large alpine meadows, and considerable amounts of aspen (*Populus tremuloides*) forest. The winters are long and cold, and the summers are warm with frequent afternoon mountain storms and summer monsoons.

Our study species included all members of the cavity nesting bird community found to nest in aspen forests of Fishlake National Forest, Utah. The species included six primary cavity nesting birds: red-naped sapsuckers (*Sphyrapicus nuchalis*), northern flickers (red-shafted) (*Colaptes auratus*), hairy woodpeckers (*Picoides villosus*), downy woodpeckers (*Picoides pubescens*), three-toed woodpeckers (*Picoides tridactylus*), red-breasted nuthatches (*Sitta canadensis*), and six secondary cavity nesting birds: tree swallows (*Tachycineta bicolor*), violet-green swallows (*Tachycineta thalassina*), mountain chickadees (*Poecile gambeli*), mountain bluebirds (*Sialia currucoides*), western bluebirds (*Sialia mexicana*), and house wrens (*Troglodytes aedon*).

We systematically surveyed the study region for active nests of cavity nesting birds from late May until early July. A nest was considered active if it exhibited evidence of incubation, presence of eggs, presence of young, and/or feeding behavior. Due to the lack of inference available from the nest building stage, we did not include evidence of nest building as a sign of activity. If a nest was in the building stage, however, we returned to the site later to determine whether or not the nest became active. To mark the active nests, we flagged a tree that was at least 10 m away from the nest tree and recorded the distance and azimuth to the nest tree from the flagged tree. In addition, we recorded the UTM coordinates at each nest site using a global positioning system (GPS).

We measured vegetation variables within 0.04 ha surrounding active nest trees. This scale ensured complementarity of our data with the wealth of existing studies on avian habitat selection (James and Shugart 1970). Furthermore, this area is effective at characterizing the nest site since it is smaller than the average territory size for most small forest passerines (Noon 1981, Sedgwick and Knopf 1992). We measured a series of habitat measures including canopy cover, snag density, tree density, and shrub cover. These variables constituted our traditional models. FIA-derived variables were obtained from maps developed using emerging techniques (e.g., Frescino *et al*. 2001) that convert FIA data to spatially explicit representations. Variables modeled included canopy height (m), number of snags, number of live trees, and average tree height (m). Values were obtained from the FIA maps by intersecting the UTM coordinates of the nest sites with the digital FIA data. The result was two sets of observations for modeling purposes: one based on data collected within a 0.04-ha area surrounding active nest trees and the other extracted from the FIA-based maps.

We used stepwise logistic regression to model the probability of presence of nest sites based on traditional and FIA-based predictors. Although the number of nests varied depending on guild type and model type, we used all of the non-nest locations from 2001 in each habitat model. Models were evaluated using these criteria: (1) estimates of model fit based on model R^2 and the Somer's D statistic; (2) model predictive capability based on the 2001 training data; (3) predictive capability based on internal cross-validation; and (4) predictive capability based on the 2002 external model validation data. Measure of predictive capability included percent correctly classified (PCC), sensitivity, specificity, and the area under curve (AUC). The first three measures are considered threshold-dependent measures, and their values are dependent on a user-specified threshold. In our case we considered a threshold value of >0.5 to be indicative of nest site presence. AUC is threshold independent and is a measure of model predictive capability across the range of thresholds t, where $0<t<1.0$.

Results

A total of 227 nests were found during the 2001 and 2002 field seasons. Of these nests, 165 were found in 2001 and used for model building. The remaining 62 nests found in 2002 were used for model validation.

Model fit was relatively poor for both the traditional and FIA-based models (table 1), but differences between the two model forms were negligible. Percent correctly classified and AUC values were similar for both model forms for both training and cross-classified data (tables 2, 3). However, model forms differed in their sensitivity and specificity, with the FIA-based model having greater sensitivity but lower specificity. When tested with independent field data, the FIA-based model form had a somewhat lower PCC and AUC value (table 4). The same pattern in sensitivity and specificity found in the training and cross-validated data occurred in the independent data as well.

Table 1.—*Estimates of model fit for traditional and FIA-based habitat models of nest sites of cavity-nesting birds, Fishlake National Forest, Utah*

Model	R^2	Somer's D
Traditional	0.039	0.020
FIA-based	0.174	0.048

Table 2.—*Measures of model accuracy of training data for traditional and FIA-based habitat models of nest sites of cavity-nesting birds, Fishlake National Forest, Utah*

	FIA-based	Traditional
PCC	0.633	0.637
Sensitivity	.910	.593
Specificity	.239	.739
AUC	.600	.742

Table 3.—*Measures of model accuracy of cross-validated training data for traditional and FIA-based habitat models of nest sites of cavity-nesting birds, Fishlake National Forest, Utah*

	FIA-based	Traditional
PCC	0.633	0.637
Sensitivity	.910	.593
Specificity	.240	.740
AUC	.565	.720

Discussion

Forest wildlife management often requires not only understanding of the ecological reasons behind a species presence on landscapes, but also a depiction of the spatial distribution of the species. Variables suited for explaining *why* a species is found at specific locations are not necessarily the best for predicting *where* a species is located. Moreover, the types and kinds of variables associated with species presence (e.g., presence of fungal conks as an indicator of suitable trees for cavity nesting birds) are often difficult to model and map. Consequently biologists must often choose, based on management objectives, whether explaining the *why* of species presence location is more important than the *where* of species presence. Ideal models would simultaneously address both questions, but variables well suited for mapping are not the same as those suited for explanation. The results presented here indicate that habitat models for cavity nesting birds based on variables having less ecological explanatory value do as equally well in prediction as those with high ecological explanatory value. The added value to the FIA-based variables is the ability for spatial extrapolation. These spatially explicit maps can provide managers with much needed information on the spatial distribution of critical habitats.

However, use of maps of forest type and structure in wildlife management are only as accurate as the models that created the structural maps. There are several means of modeling or mapping forest structure across space, the first of which is statistical modeling. In the Uinta Mountains of Utah,

Table 4.—*Measures of model accuracy of independent data for traditional and FIA-based habitat models of nest sites of cavity-nesting birds, Fishlake National Forest, Utah*

	FIA-based	Traditional
PCC	0.557	0.703
Sensitivity	.790	.593
Specificity	.283	.830
AUC	.541	.755

Frescino *et al*. (2001) built and validated statistical models of forest presence, forest type, basal area, shrub cover, and snag density using remotely sensed imagery and a suite of environmental predictor variables (environmental gradients, temperature, precipitation, elevation, aspect, slope, and geology). The models for forest presence and forest type were 88 percent and 80 percent accurate, and an average of 62 percent of the predictions for basal area, shrub cover, and snag density fell within ~ 15 percent deviation of field values (Frescino *et al*. 2001). Such levels of accuracy are well within the margins of error for wildlife management.

The ability to predict where a species occurs and where it does not occur is vital to management decisions. Biologists must evaluate their habitat models using rigorous model validation to test the spatio-temporal accuracy of their predictions. Our results indicate, at least for the system studied here, that equally reliable models could be built using so-called traditional methods as well as new methods capable of translating FIA data into spatial representations. The advantage of latter is the clear ability to use these maps for spatial extrapolation for use in wildlife management.

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