AN ABSTRACT OF THE THESIS OF

Dorothy G. Wilson for the degree of Master of Science in Wildlife Science presented on November 28, 2001. Title: Validating Songbird Habitat Relationship Models.

Abstract approved: W. Daniel Edge

W. Daniel Edge

Models are commonly used to assess and predict wildlife response to management practices. Model validation is essential if managers are to use them with confidence. Fifteen forest bird-habitat relationship models were developed by biologists using data collected from private forestland in southwest Washington. These models predict species' probability of occurring in a stand based on structural habitat variables, such as shrub cover and canopy height. In the spring/summer of 1998 and 1999, I collected data from private and Bureau of Land Management (BLM) forestland in the vicinity of Cottage Grove, Oregon to test or validate these models. Thus, I tested the models' ability to be generalized to a different time and place.

I used 3 approaches to test or validate the models: 1) accuracy of prediction; 2) trend analysis; and 3) variable coefficient comparisons. Four of the 15 models performed well in at least 2 of the 3 tests. Four of the models that performed well at predicting species occurrence also had a positive relationship between the probability of occurrence output from the model and species' abundance. However, this relationship was weak for species that had low detectabilities or low densities because of large territories. Models that performed well at predicting habitat also were more likely to have variable coefficients that were comparable between the Washington (WA) models and models I produced with the same variables using my data. Finally, because few of the models performed well, I created new models using my 1998 data and tested them with my 1999 data. These models generally performed better than the WA models; there were some similarities between variables, especially with the better performing WA models.

I tested whether point count duration effects bird abundance and/or presence/absence and, thus, model performance. Point count surveys were conducted along forest roads, so there was the additional concern that surveys conducted on roads

were not representative of the stand. I tested to see if there was a difference in relative abundance or species' presence/absence for on and off road surveys. I found a difference in abundance for most species between 5- and 8-minute point count surveys. Also, there were differences in presence/absence of species between the 2 counts, which had an affect on model performance. There was no difference in abundance of modeled species between on-road and off-road point count surveys except for the western tanager (*Piranga ludoviciana*), which was more abundant at on-road than off-road survey points. There were a few differences in presence/absence of species for on and off roads, but the differences in model performance were minimal.

The models that performed well may be used to make management decisions that will affect the landscape for years to come, and thus, their accuracy needs to be continually monitored and the models adjusted accordingly. The survey length for future monitoring efforts should be 8 minutes because presence/absence of species can be more accurately accessed with this longer survey length. Survey locations should accurately depict the entire habitat to which inferences are made.

Validating Songbird Habitat Relationship Models

by

Dorothy G. Wilson

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APPROVED:

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Dorothy G. Wilson, Author

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CONTRIBUTION OF AUTHORS

Dorothy G. Wilson collected and analyzed the data, reported and interpreted the results. W. Daniel Edge supervised the research and edited drafts of this document.

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Chapter 1

Introduction

Commercial forest managers are faced with the challenge of maintaining biological diversity on land primarily managed for commodity production as society and regulatory agencies increasingly demand effective strategies balancing multiple uses (Hansen et al. 1993). In Oregon, managed forests make up more than 8.5 million hectares (Oregon Department of Forestry 1995). Forest-dwelling migratory songbirds are of special concern because of population declines during the 1980s (Saab and Rich 1997). The need to incorporate songbirds and other wildlife into forest management has resulted in extensive landscape-scale planning efforts requiring the development of models that assess and predict landscape conditions and evaluate wildlife response to management. Habitat relationship models have been developed by biologists in Southwest Washington for the orange-crowned warbler (*Vermivora celata*), Bewick's wren (*Thryomanes bewickii*), black-throated gray warbler (*Dendroica nigrescens*), black-headed grosbeak (*Pheucticus melanocephalus*), brown creeper (*Certhia americana*), evening grosbeak (*Coccothraustes vespertinus*), gray jay (*Perisoreus canadensis*), hairy woodpecker (*Picoides villosus*), hermit warbler (*Dendroica occidentalis*), red-breasted nuthatch (*Sitta canadensis*), rufous hummingbird (*Selasphorus rufus*), song sparrow (*Melospiza melodia*), Stellar's jay (*Cyanocitta stelleri*), warbling vireo (*Vireo gilvus*), and western tanager (*Piranga ludoviciana*). The hermit warbler and rufous hummingbird are listed as high priority species for Washington by the western working group of Partners in Flight; the orange-crowned warbler is listed as a high priority species for Oregon (Saab and Rich 1997).

Statistical models, developed using multiple logistic regression, correlate structural habitat features with the presence and absence of a species. Structural habitat features are biologically important to birds and can be manipulated by forest managers through management prescriptions. Most previous modeling efforts of wildlife in forest habitats have focused on coarse-scale variables, such as seral stage or vegetation type, but, in general, these models have not performed well for forest management objectives. Poor model performance may be partly influenced by the choice of coarse-scale variables that are not as biologically meaningful to wildlife as fine-scaled variables. Fine-scaled variables are more likely to produce better performing models than those using coarse-scale variables (Irwin 1994).

The purpose of these songbird habitat relationship models is to provide a basis for both habitat assessment and diagnosis. These models will be linked with forest growth and management models in a Geographic Information System (GIS) to plan and achieve multiple objectives in managed forests. Because these models will be used by forest managers to influence prescription development, it is necessary that their performance be known. Only when managers have confidence in the models' abilities will they feel comfortable in using the models in the context for which they were designed. Model validation is thus an essential step because it establishes how well the models work according to specific criteria.

We conducted a study to test songbird habitat relationship models. We were also interested in whether survey length or survey location significantly affected survey results and thus, model performance. There is interest in using a shorter time period for point count surveys for subsequent monitoring so we wanted to determine how survey time may affect bird abundance results. Some researchers have found that longer counts are more advantageous when species have low detectability and may lower observer bias (Dawson et al. 1995; Buskirk and McDonald 1995). However, longer point counts increase standard error, which may decrease power and make it less likely to detect a difference when there is one (Smith et al. 1998). Longer counts may also increase the chance of double-counting (Dawson et al. 1995).

Most of our point count stations were located on forest roads. Because forest roads are not randomly placed throughout the landscape and may be associated with edge habitat, we were interested in testing whether on-road surveys affected study inferences. If forest roads are narrow and not heavily traveled, they may have little influence on bird abundance (Hutto et al. 1995). However, Miller et al. (1998) found that bird species composition was altered adjacent to trails in forest ecosystems in Colorado.

My objectives were to determine:

1) how well models developed in southwest Washington were able to predict species presence/absence in west-central Oregon;
2) whether model output is linearly related to relative bird abundance and frequency of occurrence at the stand level;
3) if model performance differed between 5- and 8-min point count surveys; and,
4) if model performance differed between on- and off-road point count surveys.

This thesis is presented in 2 papers prepared for journal submission. Chapter 2 entitled Validating Songbird Habitat Models, will be submitted to *Ecological Applications*. This chapter presents the results of the model validation, linear regression between the model output and abundance, variable coefficient comparisons, and model building. Chapter 3, entitled Effect of Survey Length and Location on the Performance of Songbird Habitat Relationship Models, will be submitted to *The Wildlife Society Bulletin*. This chapter presents model performance as a function of survey effort and/or location.

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Chapter 2

Validating Songbird Habitat Models

Dorothy G. Wilson and W. Daniel Edge

Abstract

Models are used extensively in forest management today as managers and biologists try to incorporate the needs of songbirds and other wildlife into management plans. Fifteen forest bird-habitat relationship models were developed by biologists using data from private forestland in southwest Washington. These logistic regression models predict the probability of a species occurring in a stand based on structural habitat variables, such as shrub cover and canopy height. These models were to be used with forest growth and management models to plan and achieve multiple objectives across forest landscapes. In order for these models to be used with confidence by forest managers, their reliability needs to be known. Thus, in the spring/summer of 1998 and 1999, we tested these models using data collected from private and Bureau of Land Management (BLM) forestland in the vicinity of Cottage Grove, Oregon. Thus, we tested the models' ability to be generalized to a different time and place.

We used 3 approaches to test the models: 1) accuracy of prediction; 2) trend analysis; and 3) variable coefficient comparisons. Five of the fifteen models performed well in at least two of the three tests. Validation requires an *a priori* level of performance to be determined; a determination that the models' user should make. If the model will be used for habitat assessment and diagnosis then a conservative, accurate model may be more desirable than if the model is to be used purely for furthering our understanding of a species. Models that performed well at predicting species' occurrence also had positive relationships between the probability of occurrence output from the model and species' abundance ($r^2 \geq 0.07$, $P \leq 0.05$). However, these relationships were not as strong for species with low detectability or low densities because of large territory size. Those models that performed well at predicting species occurrence also were more likely to have variable coefficients that were comparable between the Washington (WA) models and models with the same variables but coefficients produced with our data. Finally, because few of the models performed well, we created new models using our 1998 data and tested them with our 1999 data. These models tended to perform better

than the WA models, however, there were similarities among variables, especially with the better performing WA models.

The majority of the WA models did not perform well perhaps because of regional variation in habitat, scale of habitat selection, and variables important to a species not being represented. The new models we created should be tested with a different dataset to see whether they are plausible substitutes for some of the WA models. Because models are simplifications of a complex system, they need to be part of an adaptive management scenario where their predictions are continually monitored and adjustments made to the models when predictions are less than accurate.

Introduction

In the 1970s Congress passed several laws that dramatically affected the management of fish and wildlife species in our nation's forests. Since then there has been an increase in the use of modeling and models as forest managers and biologists sought rapid and reliable techniques to determine and predict species and habitats on forestland (Berry 1986). Also, over the last several decades there has been increasing interest in birds in forest environments as many species have experienced widespread declines. Thus, forest birds have become the subject of numerous modeling attempts.

Wildlife habitat relationship (WHR) models are used extensively in ecology (Bunnel 1989, McComb 1992) and are useful tools to address the challenges of preserving biodiversity. Morrison et al. (1992:221) state that the main objectives for developing WHR models are to "formalize our current understanding about a species or an ecological system, understand which environmental factors affect distribution and abundance of a species, predict future distribution and abundance of a species, identify weaknesses in our understanding and generate hypotheses about the species or system of interest." WHR models incorporate habitat variables correlated with a species' abundance or presence/absence and are used to predict that species' occurrence under varying habitat conditions. However, there are several weakness with models. First, they are simplifications of reality; abstractions of real processes and relations (McComb 1992), and therefore managers must recognize their inherent assumptions and weaknesses and use them with caution. Second, the habitat variables are correlated with the species' presence or abundance and usually not nesting success, survival or other demographic parameters. As Van Horne (1983) warns, density is often a poor indicator of habitat quality; without demographic parameters we do not know whether "suitable" stands are population sources or sinks (Pulliam 1988). Third, models are rarely tested or validated (Berry 1986, Wolff 1995). However, if models become a part of an adaptive management feedback loop where there is regular feedback between biologists and managers on the model's predictive ability, then models can be useful tools (Conroy 1993).

The importance of testing models cannot be overstated. One of the purposes of developing models is to increase our understanding of complex systems. If we assume our models to be correct without sufficient testing we are not adding to our understanding, but our misunderstanding. A model is an intellectual tool, not a fail-safe predictor (Starfield and Bleloch 1986). If managers are using untested models to make management decisions, these decisions may be flawed and the wildlife these models represent may be put at risk. Starfield and Bleloch (1986) warn validation in the formal sense is impossible, replaced instead by an iterative process where models are continuously tested and revised due to management's evolving perception of the problem as well as the collection of new data.

Fifteen forest bird-habitat relationship models were developed by biologists using data from private forestland in southwest Washington. These logistic regression models predict a species' probability of occurring in a stand based on structural habitat variables, such as shrub cover and canopy height. Forest managers in Cottage Grove, Oregon hope to use these bird-habitat relationship models, other WHR models and forest growth and management models in a GIS modeling effort to plan and achieve multiple objectives across the landscape. These models have not been validated or tested in this area and need to be so that forest managers can use them with confidence.

The objective of our study was to determine whether: 1) models developed in southwest Washington would be able to predict species occurrence in west-central Oregon; and 2) model output is linearly related to bird abundance and/or frequency of occurrence at the stand level. We predicted that well-performing models would have a positive linear relationship between the model's output (probability of occurrence) and the species' relative abundance and/or frequency of occurrence.

Study Area

The study was conducted on private and BLM forestland on the western slopes of the Cascades Range in the vicinity of Cottage Grove, Oregon. The area lies within the Row River and Sharps and Mosby creeks watersheds, and is located in the Western Cascade physiographic province, characterized by older volcanic flows and pyroclastics laid down during the Oligocene and Miocene (Franklin and Dyrness 1988). The vegetation and climate are characteristic of the western hemlock (*Tsuga heterophylla*) zone (Franklin and Dyrness 1988). Elevations range from 300-1,000 m. Precipitation averages 120-150 cm annually. The forest community is dominated by conifers, primarily Douglas-fir (*Pseudotsuga menziesii*), western hemlock, and western redcedar (*Thuja plicata*), except in areas of recent disturbance or along riparian areas where hardwoods such as red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and golden chinkapin (*Castanopsis chrysophylla*) are common. The private forest unit was chosen because it has vegetation and timber management practices similar to that of PeEll, the area in western Washington where these models were parameterized.

The private forestlands are managed primarily for sustainable production of wood and other forest products (Weyerhaeuser Company 1996, unpublished report). Intensive high-yield forestry has been practiced here since the mid-1960s; timber management includes site preparation, hand planting of genetically selected seedlings of primarily Douglas-fir, control of competing vegetation, fertilization, pre-commercial and commercial thinning, and clear-cutting on 45-60 year rotations. Bureau of Land Management lands are managed for multiple objectives, which include recreation, fish and wildlife habitat, late successional reserves, as well as timber production (U.S. Forest Service and Bureau of Land Management 1994). Bureau of Land Management lands are less intensively managed than the private lands.

We sampled 50 stands covering a range of site classes, densities, and ages. The majority of stands sampled had densities of 558 to 1,112 stems/ha, and site classes 2 and 3 (King 1966) were the most common. The mean age of the private forest stands was 19 years (SE = 1.9) and ranged from 6-58 years. The mean size of the stands was 44.7 ha (SE = 2.4) with a range from 28.6-81 ha. The mean age of the BLM stands was 39 (SE = 2.0) with a range of 24-49 years. BLM stands averaged 38.5 ha (SE = 3.2) in size, with a range of 28.3-75 ha. Habitat characteristics of the stands covered a range of conditions (Appendix A).

Methods

Fifty forest stands from the two ownerships served as experimental units. Eighteen BLM stands within the same or nearby watersheds as the private stands met our criteria of being ≥28 ha and received no cutting or herbicide spraying for the 2 years of the study. Thirty-two private stands that met the same criteria were randomly selected from those available.

Point count surveys and habitat sampling followed protocols used in developing the models (Weyerhaeuser Company 1996). Point count surveys were conducted between 13 May and 3 July 1998 and 18 May and 30 June 1999 in all 50 stands. Habitat data was collected from 27 May to 20 August 1998 and 6 May to 28 August 1999, and combined with forest inventory data.

Bird Surveys

We used point count surveys to determine presence/absence of modeled species, relative abundance and frequency of occurrence. Surveys followed the methodology of Ralph et al. (1995) and the protocol established in developing the models. Each stand had 5-7 points located along roads throughout the stand; some points (≤ 3/stand) were located off-road in order for them to be ≥75 m from the stand edge or ≥200 m from adjacent points. We used roadside counts for their efficiency and because future monitoring of bird populations (especially modeled species) on these timberlands will use roadside counts. Following the recommendations of Hutto et al. (1995), we used secondary and tertiary forest roads whenever possible. We randomly located the first point in the stand along the road, 75-150 m from the edge of the stand. The rest of the points were 200-300 m apart, depending on the stand size and road distribution within the stand. Surveys began ≤15 minutes before sunrise and lasted until approximately 4 hours after sunrise. Surveys were conducted only on rainless days with low (< 12 km/hr) wind. Point counts lasted 8 minutes. Each observer carried a stopwatch and recorded when each detection was made. All birds seen or heard within a 75-m radius of the point-count center were recorded. Birds outside the 75-m radius and birds flying above the canopy and not using the stand being sampled, were recorded but not included in the analysis.

All observers were experienced birders; however, to help decrease observer bias, all observers participated in an intensive 4-day bird training seminar prior to the start of the field season. Two of the surveyors participated during both years of the study. Each of 5 observers surveyed 2 stands/day for a total of 50 stands/week. Subsequent visits to each stand alternated between early and late morning periods. Each observer surveyed every stand once; thus, each stand received 5 visits.

Bird abundance was calculated as the average detections/point/visit. The frequency of occurrence is the number of point-visits for which a species was detected per total number of point-visits in a stand.

Habitat Measurements

We sampled habitat following the same methodology used in the development of the models (Austin 1995). We randomly located 20- x 200-m belt transects throughout each stand so that approximately 10% of the area of each stand was sampled. The belt transects served as the frame work for other transects; at one end of the belt transect we established a 30.5-m line intercept with a 5-m^2 circular plot at each end (Figure 2.1). Within the 20- x 200-m belt transect, we tallied and measured snags (≥ 25.4 cm dbh and ≥ 3 m in height), stumps (≥ 76 cm in diameter and 0.3-3.0 m in height), root wads (≥ 91 cm wide by ≥ 91 cm in height), and debris piles (≥ 3 m long by ≥ 3 m wide by ≥ 2 m in height). We measured diameter (stumps) or dbh (snags) to the nearest centimeter and height to the nearest meter. Species of stumps and snags was determined if bark remained. We determined the total number of snags and stumps in a stand by summing all the snags or stumps within all the transects and then multiplying this number by 10 (the belt transect represented approximately 10% of the area of the stand). This number was then divided by the size of the stand to get the density. We classified snags and stumps as hard (decay classes 1 and 2) or soft (decay classes 3, 4, and 5) and determined density of snags and stumps for each class.

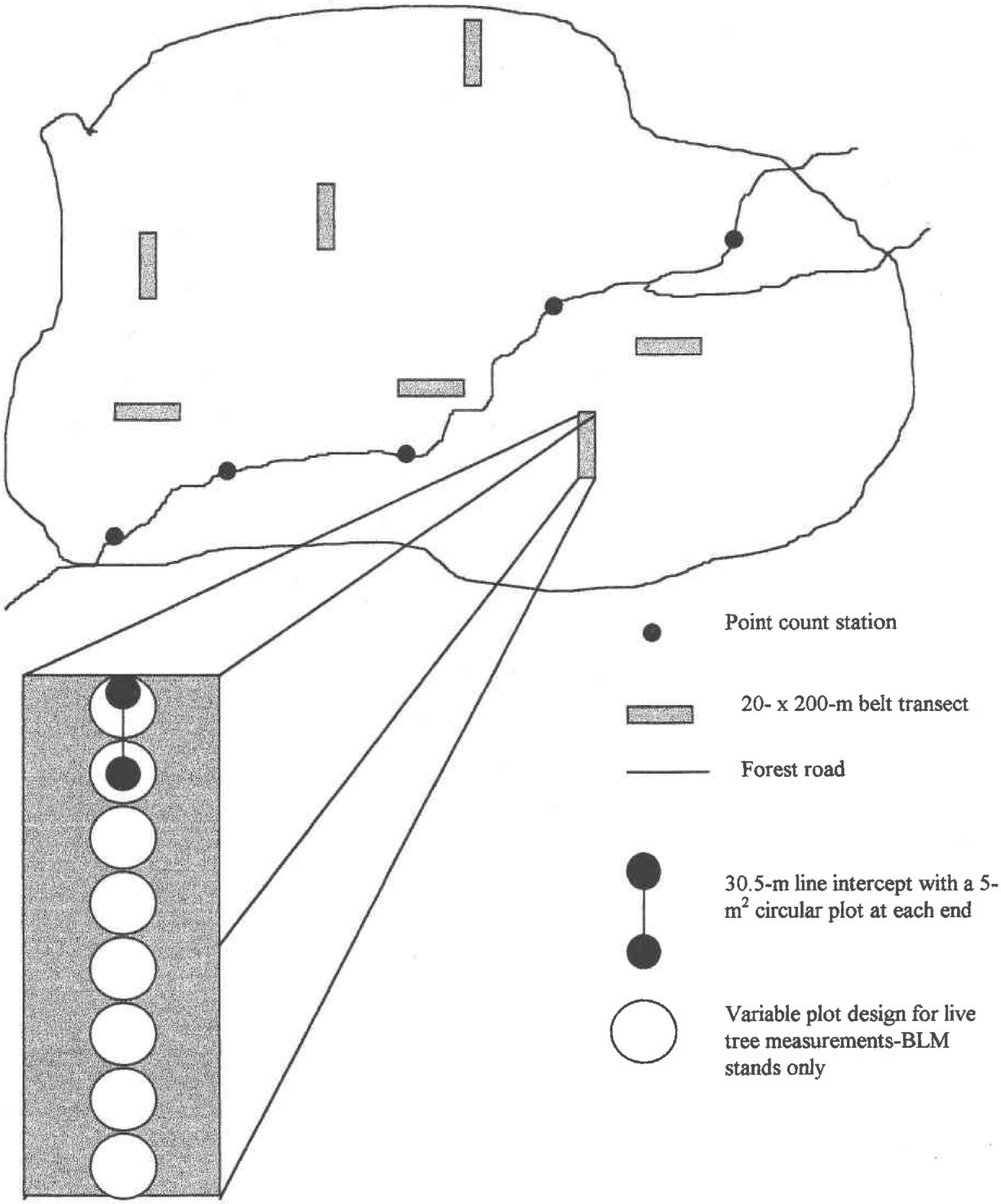

Figure 2.1. A stand showing point count stations and the layout of habitat transects for songbird model validation study, Cottage Grove, Oregon, 1998-99.

We measured length, width, and height to the nearest meter for root wads and debris piles and used those data to calculate volume. The rootwads and debris pile volumes were then totaled for each transect and averaged for each stand. This average was then multiplied by 10 and divided by the size of the stand to get the volume per hectare.

We tallied shrubs and logs along the 30.5-m line intercept. For each shrub species, we recorded total line intercept as a measure of percent cover. Shrubs were categorized by species as tall or short. We measured the vertical and horizontal diameters, and length of logs >30.5 cm in diameter at the smallest end. We categorized each log into 1 of 5 decay classes (Maser et al. 1979), and determined species, if possible. We further categorized logs as hard (decay classes 1 and 2) and soft (decay classes 3, 4, and 5). Density of logs was determined by summing the number of logs over all the transects and multiplying by 10; this number was then divided by the size of the stand.

We visually estimated percent cover of herbaceous vegetation within each of the 2 5-m^2 circular plots located at each end of the line intercept (Daubenmire 1959). Ground cover was categorized into 6 groups; (1) ferns and fern allies; (2) forbs; (3) graminoids (grasses, sedges, rushes); (4) mosses, liverworts, and lichens; (5) litter; and (6) other (which included soil and bare rock). For modeling, categories 1 through 4 were combined into a herbaceous cover category. Maximum height of herbaceous vegetation within these plots was also recorded. We estimated the canopy height and lift (height to the bottom of the live crown) of a tree, representative of the stand, nearest plot center with a clinometer. We used a moosehorn to determine percent canopy closure at plot center and we recorded the number of canopy layers within a 11-m radius of plot center.

The variable plot method (Grosenbaugh 1952) was used to determine stem density, species composition, basal area, and average dbh of live trees (≥ 8.9 cm) for the BLM stands because this information was not available from BLM forest inventories. The 20- x 200-m belt transect served as a framework. At the beginning of each belt transect, a 6.5-m radius circle was established. All trees over 8.9 cm dbh were counted.

The circle was then expanded to 8 m and the additional trees counted. If the number of trees in the larger radius plot was ≥1.5 times (± 1 tree) the number of trees in the smaller plot then the large plot (8 m radius) was used to tally trees along the entire transect, otherwise, the small plot was used. Also, if the number of trees counted in the smaller plot was <8, the larger plot was used automatically. If the 6.5-m radius plot was used, 12 equidistant plots were established along the belt transect. If the 8-m radius plot was used, 8 equidistant plots were established. Within each of these plots, all live trees (deciduous and conifer) ≥8.9 cm were identified to species and dbh was measured.

Average slope, aspect, and elevation were determined with a GIS for the private stands. For the BLM stands, percent slope was measured with a clinometer and aspect was determined by compass readings at each circular plot. Elevation was determined from a topographic map of the area.

Statistical Methods

We used 3 approaches to evaluate the models: 1) accuracy of prediction; 2) relationship between the predicted probability of occurrence and observed abundance and frequency of occurrence at the stand level, and; 3) whether the variable coefficients resulting from building the same models with our data fell within the confidence intervals of the WA models' coefficients.

The accuracy of prediction was determined by the percent of stands correctly identified as being either suitable or unsuitable habitat for the modeled species.

$$\% \text{ Correct} = \frac{(\text{\# of stands correctly predicted suitable} + \text{\# of stands correctly predicted unsuitable})}{(\text{total \# of predicted suitable stands} + \text{total \# of predicted unsuitable stands})}$$

The suitability of a stand for a particular modeled species was determined by output from the logistic regression model:

$$\Pr(\text{Occurrence}) = \frac{e^{\beta_0 + \beta_1 \text{Var}_1}}{1 + e^{\beta_0 + \beta_1 \text{Var}_1}}$$

"Pr(Occurrence)" represents the predicted probability of occurrence, or presence of a species. Based on model output, stands were classified as suitable ($1.0 \geq$ Pr(Occurrence) ≥ 0.75), marginal ($0.75 >$ Pr(Occurrence) ≥ 0.25), or unsuitable (Pr(Occurrence) < 0.25). Marginal stands were not included in the model evaluations. We chose these classifications because they are conservative and we felt that a conservative approach was necessary because managers plan to use these models for habitat assessment and diagnosis. A conservative approach establishes a stronger link between habitat and birds. For analysis, each stand was classed as either "present" for a species if that species was detected at least once, and "absent" if the species was not detected.

The second and third approaches were based on hypotheses we had about well-performing models. Our hypotheses were:

1) H_o: Predicted occurrence of modeled bird species and observed relative abundance or frequency of occurrence are not correlated at the stand level.

We predicted that the probability of occurrence of modeled species output from well-performing models would be linearly related to abundance or frequency of occurrence at the stand level.

2) H_o: For well-performing models the variable coefficients created with our data would not differ from those of the WA models.

We predicted that well-performing models would have more variable coefficients that fell within the WA models' variable coefficients' 95% confidence intervals than poor performing models.

The second approach used simple linear regression to determine if there was a linear relationship ($P \leq 0.05$) between the abundance or frequency of occurrence of a modeled species and its predicted probability of occurrence, "Pr(Occurrence)," over all 50 stands. This is similar in principle to the trend analysis used by Dedon et al. (1986) to test their models' performance. Models that are the best predictors should have a significant linear relationship between the stands' probability of a species presence and the abundance of that species.

The third approach assessed the models' variables individually by developing models with the same variables using our data. We determined if the variable coefficients attained from our data fell within the 95% confidence interval of the coefficients in the WA model. By evaluating the models' performance in all three tests forest managers can determine which models provide the level of accuracy they need.

Finally, in an attempt to learn more about what habitat features forest songbirds in Oregon are responding to and how these differed from those same species in Washington, we created our own models. We used the first year's data to create the models and the second year's data to test the models. We screened potential variables by submitting them to a univariate logistic regression analysis for each bird species (the same 15 species in the WA models)(Hosmer and Lemeshow 1989). Variables that had a Wald statistic P-value of ≤ 0.25 were then entered into a Stepwise Logistic Regression with a P-value to enter of 0.20 and a P-value to stay of 0.15. To avoid multicolinearity, we performed a correlation analysis and those variables with a Spearman Rank Correlation of ≥ 0.60 were not included together in a model. The "best" models were chosen based on a combination of Wald statistic P-values, AIC values, performance with 1999 data, and biological and ecological relevance.

Results

Bird Surveys

We had >12,600 total detections of 94 bird species within and beyond the 75-m fixed radius plots in 1998. Within a 75 m radius of each point we had 7,816 detections of 84 species. In 1999, we had >14,000 total detections of 88 bird species within and beyond the 75-m fixed radius plots and 8,354 detections of 73 species within the 75-m radius plot. The most commonly detected species both years of the study were the Swainson's thrush (*Catharus ustulatus*), winter wren (*Troglodytes troglodytes*), willow flycatcher (*Empidonax traillii*), chestnut-backed chickadee (*Poecile rufescens*), spotted towhee (*Pipilo maculatus*), orange-crowned warbler (*Vermivora celata*), MacGillivray's warbler (*Oporornis tolmiei*), dark-eyed junco (*Junco hyemalis*), golden-crowned kinglet (*Regulus satrapa*), and song sparrow (*Melospiza melodia*). The average abundance of all species was 1.7 detections/stand (SE = 0.3; range = 0.02-14.8) in 1998 and 2.3 detections/stand (SE = 0.4; range: 0.02-20.4) in 1999. Average species richness over all 50 stands in 1998 was 27 species (SE = 0.44), with a range from 21-35 species and 28 species (SE = 0.51) with a range from 21-38 species in 1999.

Model Performance

Accuracy of Prediction

Four of the fifteen models performed above 70 % both years of the study (Table 2.1). Five other models performed above 70 % 1 year but not the other (hairy woodpecker [*Picoides villosus*]: above in 1998; gray jay [*Perisoreus canadensis*], hermit warbler [*Dendroica occidentalis*], Bewick's wren [*Thryomanes bewickii*] and song sparrow [*Melospiza melodia*]: above in 1999). Our study was not an adequate test for 4 of the models (red-breasted nuthatch [*Sitta canadensis*], rufous hummingbird [*Selasphorus rufus*], Stellar's jay [*Cyanocitta stelleri*], and western tanager [*Piranga ludoviciana*]) because less than half of the stands were considered suitable or unsuitable habitat for these models.

Linear Regression

The predicted probability of occurrence was positively correlated to relative abundance (Table 2.2) and frequency of occurrence for seven species (Table 2.3). To achieve the best fit to a linear model we used a natural log transformation of relative abundance. Thus, for most of the species the relationship between probability of occurrence and relative abundance and frequency of occurrence was an asymptotic curvilinear relationship.

Probability of occurrence for 6 species (Bewick's wren, brown creeper [*Certhia americana*], hermit warbler, orange-crowned warbler, rufous hummingbird, and song sparrow) was positively related to abundance both years (Table 2.2). Probability of occurrence for 2 species (evening grosbeak [*Coccothraustes vespertinus*] and red-breasted nuthatch) was positively associated with abundance only 1 year. Probability of occurrence for 5 species (gray jay, hairy woodpecker, Stellar's jay, warbling vireo [*Vireo gilvus*], and western tanager) were not correlated with abundance either year. Black-throated gray warbler (*Dendroica nigrescens*) abundance was negatively related to probability of occurrence both years of the study. The results of the correlation between probability of occurrence and frequency of occurrence were similar (Table 2.3).

Variable Coefficient Comparisons

Most models created with Oregon data that predicted species occurrence well had variable coefficients (not including the intercept) that fell within the 95% confidence intervals for the WA model coefficients (Table 2.4). All of the evening grosbeak model's coefficients in 1999 fell within the WA model's 95% confidence intervals. The brown creeper model had all of its variable coefficients and the song sparrow had 3 of 4 of its variable coefficients fall within the WA model's 95% confidence intervals both years of the study. The orange-crowned warbler model, however, performed poorly in this test. Only 1 of 2 of the variable coefficients fell within the WA model's 95% confidence intervals in 1998 and neither of the variable coefficients fell within the 95% confidence intervals in 1999. The hermit warbler model had 3 of 5 of its variable coefficients fall within the WA model's 95% confidence intervals in 1998 and 4 of 5 in 1999. Models that performed poorly in the other 2 tests performed poorly in this comparison as well. The western tanager and black-throated gray warbler model had no variable coefficients fall within the WA model's 95% confidence intervals. Only one of the warbling vireo variable coefficients fell within the WA model's 95% confidence interval for the 2 years.

Model Building

Most of our models were much simpler (≤ 2 variables) than the WA models (Table 2.5). Also, all of the models had a positive linear relationship between the probability of occurrence and abundance. Again, those species with large territories (hairy woodpecker and gray jay) had a weaker linear relationship due to lower abundance values than those species with small territories. The WA models that performed the best (orange-crowned warbler, evening grosbeak, song sparrow, brown creeper, and hermit warbler) had variables that were the same or highly correlated with the variables in our models for the same species. For instance, in the WA orange-crowned warbler model, canopy height was negatively correlated with the species presence, whereas in our model average dbh was negatively correlated with species presence. Canopy height and dbh are highly correlated variables.

In both song sparrow models, canopy height was negatively correlated with species presence. In a competing model to the one we chose for the brown creeper, presence was positively related to canopy height, whereas average dbh was positively correlated with the species presence in the WA model. In those models that performed poorly, there were few similarities between models we created and the WA models. In the hairy woodpecker models, for instance, species presence was negatively correlated with herbaceous cover in our model and positively correlated with herbaceous cover in the WA model.

Table 2.1. The percentage of stands correctly classified as suitable or unsuitable habitat in 1998 and 1999 for songbird model validation study, Cottage Grove, Oregon.

Species	Number of stands correctly classified (suitable/unsuitable)		Number of suitable/unsuitable stands	% Correct[a]	
	1998	1999		1998	1999
Bewick's wren	11/11	16/12	25/13	57.9	73.7
Black-headed grosbeak	13/5	15/0	18/14	56.2	46.9
Black-throated gray warbler	16/0	18/0	26/16	38.1	42.8
Brown creeper	NA/39	NA/37	0/50	78.0	74.0
Evening grosbeak	0/47	1/44	1/47	97.9	93.7
Gray jay	NA/19	NA/27	0/30	63.3	90.0
Hairy woodpecker	NA/41	NA/33	0/50	82.0	66.0
Hermit warbler	11/8	11/16	11/22	57.6	81.8
Orange-crowned warbler	34/2	35/2	35/2	97.3	100
Red-breasted nuthatch	0/NA	1/NA	1/0	0.0	100
Rufous hummingbird	NA/5	NA/2	0/7	71.4	28.6
Song sparrow	19/10	19/13	19/20	74.3	82.0
Stellar's jay	NA/0	NA/1	0/1	0.0	100
Warbling vireo	7/14	11/8	15/25	52.5	47.5
Western tanager	2/1	4/1	6/3	33.3	55.5

[a](correctly predicted suitable + correctly predicted unsuitable)/ (total suitable + total unsuitable)

Table 2.2. Relationship between probability of occurrence and relative abundance of modeled species, songbird model validation study, Cottage Grove, Oregon 1998-1999

	1998		1999	
Species	r^2	*P*-value	r^2	*P*-value
Bewick's wren	0.10	0.02	0.32	< 0.0001
Black-headed grosbeak	0.06	0.09	0.01	0.41
Black-throated gray warbler	0.27	< 0.0001	0.16	0.004
Brown creeper	0.11	0.02	0.07	0.05
Evening grosbeak	N/A[a]	N/A	0.14	0.008
Gray jay	0.04	0.14	0.05	0.11
Hairy woodpecker	0.04	0.14	0.05	0.11
Hermit warbler	0.45	< 0.0001	0.42	< 0.0001
Orange-crowned warbler	0.54	< 0.0001	0.60	< 0.0001
Red-breasted nuthatch	0.004	0.65	0.21	0.0009
Rufous hummingbird	0.21	0.0008	0.13	0.01
Song sparrow	0.54	< 0.0001	0.51	< 0.0001
Stellar's jay	0.004	0.64	0.07	0.06
Warbling vireo	0.01	0.49	0.06	0.07
Western tanager	0.02	0.37	0.03	0.25

[a] no evening grosbeaks were detected in 1998

Table 2.3. Relationship between probability of occurrence and frequency of occurrence of modeled species, Songbird Model Validation Study, Cottage Grove, Oregon 1998-1999

	1998		1999	
Species	r^2	*P*-value	r^2	*P*-value
Bewick's wren	0.12	0.01	0.31	< 0.0001
Black-headed grosbeak	0.06	0.09	0.02	0.33
Black-throated gray warbler	0.28	< 0.0001	0.17	0.003
Brown creeper	0.12	0.01	0.09	0.03
Evening grosbeak	N/A[a]	N/A	0.16	0.004
Gray jay	0.005	0.62	0.06	0.07
Hairy woodpecker	0.04	0.16	0.05	0.11
Hermit warbler	0.42	< 0.0001	0.40	< 0.0001
Orange-crowned warbler	0.54	< 0.0001	0.62	< 0.0001
Red-breasted nuthatch	0.01	0.52	0.14	0.01
Rufous hummingbird	0.21	0.0008	0.14	0.01
Song sparrow	0.57	< 0.0001	0.51	< 0.0001
Stellar's jay	0.005	0.62	0.08	0.04
Warbling vireo	0.01	0.46	0.07	0.06
Western tanager	0.02	0.37	0.02	0.27

[a] no evening grosbeaks were detected in 1998.

Table 2.4. Comparisons of variable coefficients between original Washington models and models created with Oregon data, Songbird Model Validation study, Cottage Grove, Oregon, 1998-99.

Species	Oregon model coefficients			Washington model 95 % CI	Oregon coefficients fall within Washington's CI?	
	Variable [a]	1998	1999		1998	1999
Bewick's wren	intercept	-3.1025	-0.2199	(-3.58, 10.60)	yes	yes
	CANOPYHT	0.1585	-0.0801	(-0.6166, 0.2312)	yes	yes
	SHORTSHRUB	5.4086	2.5291	(-0.3144, 4.6088)	no	yes
	C*S [b]	-0.5192	-0.1173	(-0.3172, 0.021)	no	yes
Black-headed	intercept	1.0869	-3.4901	(-30.0398, 0.009)	no	yes
grosbeak	SOFTSNAG	0.3025	2.5617	(-1.4719, -0.1153)	no	no
	HARDSNAG	-0.3996	-2.8371	(0.064, 1.9256)	no	no
	SITEIND	0.0969	0.1714	(0.0882, 0.9832)	yes	yes
	ELEV	-0.0051	-0.003	(-0.0244, -0.0056)	no	no

Table 2.4 continued

Species	Variable	Oregon model coefficients 1998	Oregon model coefficients 1999	Washington Model 95 % CI	Oregon coefficients fall within Washington's CI? 1998	Oregon coefficients fall within Washington's CI? 1999
Black-throated gray	intercept	-6.4800	-7.0915	(7.2222, 55.3834)	no	no
warbler	HERB	0.0367	0.0360	(-0.3614, -0.0314)	no	no
	CANOPYLYR	3.6713	3.1086	(-16.9931, -0.3245)	no	no
	TALLSHRUB	4.6312	5.4521	(0.0835, 0.4207)	no	no
	SHORTSHRUB	-3.1892	0.7397	(-0.211, -0.0382)	no	no
	SOFTSTUMP	0.0306	-0.0024	(-0.2891, -0.0355)	no	no
Brown creeper	intercept	-3.6352	-2.8315	(-66.3236, -5.3468)	no	no
	HERB	-0.0068	-0.0061	(-0.0116, 0.1002)	yes	yes
	SITEIND	-0.0885	-0.0319	(-0.1036, 1.248)	yes	yes
	DBH	0.2561	0.1564	(0.0738, 0.7234)	yes	yes

Table 2.4 continued

Species	Variable	Oregon model coefficients 1998	Oregon model coefficients 1999	Washington Model 95 % CI	Oregon coefficients fall within Washington's CI? 1998	Oregon coefficients fall within Washington's CI? 1999
Evening grosbeak	intercept	N/A	-2.0555	(-7.4313, 0.2535)	N/A	yes
	HERB		-0.0766	(-0.0994, -0.0092)		yes
	DBH		0.1262	(0.0415, 0.3107)		yes
Gray jay	intercept	-1.1389	-2.1151	(-1.9105, 0.2055)	yes	no
	ASPECT	0.2367	-1.4763	(-3.939 - -0.6572)	no	yes
	HARDSNAG	1.4308	1.8791	(0.0764 - 0.8620)	no	no
Hairy woodpecker	intercept	-4.5871	-0.8524	(-7.7565, 1.6061)	yes	yes
	SOFTLOG	0.0636	0.2321	(0.0014, 0.0153)	no	no
	ORIGIN	0.3220	-0.6521	(0.0669, 5.5981)	yes	no
	HERB	0.0564	0.0033	(-0.1812, 0.0237)	no	yes

Table 2.4 continued

Species	Oregon model coefficients			Washington Model 95 % CI	Oregon coefficients fall within Washington's CI?	
	Variable	1998	1999		1998	1999
Hermit warbler	intercept	-2.6265	-0.0925	(-1.3136, 7.5006)	no	yes
	SOFTSNAG	-0.2269	-0.3964	(-1.721, 0.0336)	yes	yes
	HARDSNAG	-0.8750	7.2501	(0.0652, 1.8358)	no	no
	SLOPE	-0.0270	-0.0406	(-0.2439, -0.0221)	yes	yes
	HERB	0.0347	-0.0563	(-0.0927, 0.0033)	no	yes
	CANOPYHT	0.3968	0.3831	(-0.0002, 0.4404)	yes	yes
Orange-crowned	intercept	4.7605	11.5709	(1.305, 9.428)	yes	no
warbler	CANOPYHT	-0.1861	-0.6082	(-0.4503, -0.0909)	yes	no
	SHORTSHRUB	2.3797	14.8890	(0.025, 0.232)	no	no
Red-breasted nuthatch	intercept	-3.9709	-0.7817	(-1.3985, 1.4603)	no	yes
	SOFTLOG	0.6302	0.3418	(-0.0223, -0.0041)	no	no
	HARDSNAG	-0.0644	0.5147	(0.2353, 1.1945)	no	yes

Table 2.4 continued

Species	Oregon model coefficients			Washington model 95% confidence interval	Oregon coefficients fall within Washington's CI?	
	Variable	1998	1999		1998	1999
Rufous hummingbird	intercept	-0.1871	-1.5329	(-1.9593, 0.4765)	yes	yes
	HARDSNAG	-1.8526	-0.2958	(-1.7984, -0.0454)	no	yes
	SHORTSHRUB	2.5218	7.5471	(-0.0037, 0.0359)	no	no
Song sparrow	intercept	12.5718	4.7315	(3.5067, 17.9483)	yes	yes
	DBH	0.0842	0.0629	(-0.0375, 0.4063)	yes	yes
	ELEV	-0.002	-0.0008	(-0.0163, -0.0006)	yes	yes
	SOFTLOG	-0.3953	-0.2807	(-0.0159, 0.0014)	no	no
	CANOPYHT	-0.4854	-0.2328	(-0.959, -0.1812)	yes	yes
Stellar's jay	intercept	1.6107	4.8502	(-0.5822, 1.8462)	yes	no
	SOFTSNAG	0.0055	-0.5562	(-0.644, 0.0404)	yes	yes
	SHORTSHRUB	-0.4600	-1.7885	(0.0046, 0.1148)	no	no

Table 2.4 continued

Species	Oregon model coefficients			Washington model 95% confidence interval	Oregon coefficients fall within Washington's CI?	
	Variable	1998	1999		1998	1999
Warbling vireo	intercept	-0.8160	-0.4072	(-68.6950, -10.4994)	no	no
	HARDSNAG	-1.2987	-0.6109	(0.2725, 1.9173)	no	no
	SLOPESD	-0.2817	-0.1532	(0.2301, 1.1183)	no	no
	ORIGIN	2.3245	0.8932	(1.2219, 7.4469)	yes	no
	SITEIND	0.0602	0.0755	(0.1411, 1.5249)	no	no
Western tanager	intercept	-2.8421	-0.1451	(1.6435, 7.6987)	no	no
	SLOPE	0.0425	0.0203	(-0.1685, -0.0273)	no	no
	HERB	0.0475	0.0279	(-0.0727, -0.0037)	no	no

[a] Variable definitions: ASPECT- whether the stand was facing N/S or E/W; CANOPYHT- the height of canopy in meters; CANOPYLYR- the number (1-3) of canopy layers; C*S- the interaction between canopy height and short shrub cover; DBH- the average diameter at breast height of live trees; ELEV- the average elevation of the stand; HARDSNAG- the number of hard (decay class 1-2) snags per hectare; HERB- the percent cover of herbaceous plants; ORIGIN- whether the stand was naturally regenerated or planted; SHORTSHRUB- the percent cover of short shrubs; SITEIND- the site index in meters of the stand; SLOPE- the average slope of the stand; SLOPESD- the average slope standard deviation; SOFTLOG- the number of soft (decay class 3-5) logs per hectare; SOFTSNAG- the number of soft snags per hectare; SOFTSTUMP- the number of soft stumps per hectare; TALLSHRUB- the percent cover of tall shrubs.

[b] * designates an interaction between variables

Table 2.5. Logistic regression habitat relationship models for songbirds created using 1998 data, songbird model validation study, Cottage Grove, Oregon, 1998-99.

Species	Variable [a]	Coefficient	% of stands correctly predicted in 1999	Linear Regression w/ 1999 data	
				r^2	*P*-value
Bewick's wren	CANOPYCLSR [b, c]	-0.0333	84.8	0.49	< 0.0001
			(28/33)[d]		
Black-headed grosbeak	ELEV [e]	-0.005	92.6	0.11	0.02
			(25/27)		
Black-throated gray warbler	CANOPYCLSR [b, c]	0.1521	88.6	0.44	< 0.0001
			(39/44)		
Brown creeper	TALLSHRUB [b, c]	9.8616	84.2	0.34	< 0.0001
	TOTSNAG [b]	0.7967	(32/38)		

Table 2.5 continued

Species	Variable [a]	Coefficient	% of stands correctly predicted in 1999	Linear Regression w/ 1999 data	
				r^2	*P*-value
Gray jay	CANOPYHT [b, c]	0.0769	100	0.07	0.05
			(21/21)		
Hairy woodpecker	HERB [e]	0.1124	70.3	0.14	0.008
	SOFTSNAG [b, c]	0.7258	(26/37)		
	CANOPYCLSR [b, c]	0.0524			
Hermit warbler	DBH [b, c]	0.2427	80.9	0.35	< 0.0001
	CWD [b, c]	0.2763	(34/42)		
Orange-crowned warbler	DBH [b, c]	-0.6069	95.6	0.49	< 0.0001
			(44/46)		

Table 2.5. continued

Species	Variable	Coefficient	% of stands correctly predicted in 1999	Linear Regression w/ 1999 data	
				r^2	*P*-value
Red-breasted nuthatch	TOTSTUMP [b, c]	0.0854	N/A	N/A	N/A
Rufous hummingbird	HERB [b]	0.0955	91.2	0.30	< 0.0001
	CANOPYHT [b, c]	-0.2199	(31/34)		
Song sparrow	SHORTSHRUB [b, c]	10.39	84.6	0.33	< 0.0001
			(33/39)		
Stellar's jay	CANOPYLYR [b, c]	4.4923	91.2	0.13	0.01
	HARDSTUMP [b, c]	1.1863	(31/34)		
Warbling vireo	HERB [b]	-0.0807	66.7	0.15	0.005
	CANOPYHT [b, c]	-0.0916	(14/21)		
	TOTSTUMP [b]	-0.0559			

Table 2.5 continued

Species	Variable	Coefficient	% of stands correctly predicted in 1999	Linear Regression w/ 1999 data	
				r^2	*P*-value
Western tanager	TALLSHRUB [b]	4.1997	94.7	0.15	0.006
	ELEV [b, c]	-0.0038	(18/19)		

[a] see Table 4 for variable names

[b] variable not used in WA model

[c] variable correlated with variable used in WA model

[d](correctly predicted suitable + correctly predicted unsuitable)/ (total suitable + total unsuitable)

[e] variable used in WA model

Discussion

Forest managers must determine what level of accuracy is necessary based on how the models will be used. We presented the results of 3 tests performed on the models, but managers must decide which models work best for their needs. Of the 15 models tested, 5 (brown creeper, evening grosbeak, hermit warbler, orange-crowned warbler, and song sparrow) performed well in 2 of the 3 tests both years of the study. However, as Rykiel (1996) warns this does not mean that these models embody any absolute truth nor that they are the "best" models available, only that they have performed well under specified conditions. That is, they can be used by forest managers to make predictions of suitable/unsuitable breeding habitat in the watersheds from which the sample of stands was randomly drawn (i.e., the watersheds of the Row and Big River and Mosby and Sharps Creek).

Commission Versus Omission Errors

A trade-off exists between making a Type I error (error of commission) and making a Type II error (error of omission); as you decrease one the other increases. Researchers need to judge which error is most important. For our top 7 models, the Type II error rate was generally greater than the Type I error rate for models that predicted both suitable and unsuitable habitat. Thus, errors of omission were more common than errors of commission; we were more likely to find the species of interest in unsuitable habitat than not find the species in suitable habitat. Errors of commission are negatively associated with survey effort (Marcot et al. 1983) and our sampling effort (5 visits/stand) was relatively high (Smith et al. 1995). Errors of omission may have been reduced by limiting sampling to time when the species were more closely tied to suitable habitat (narrowing our point count survey time span even further or possibly deleting visit 1 and/or 5, thus decreasing our chance of detecting migrants). However, our survey time span from mid-May through 30 June is the accepted breeding survey time for our area. Also, setting minimum criteria for accepting presence (if a species was detected once it was considered present in our study) would decrease the chance of detecting birds not dependent upon the habitat. Another way to reduce the Type II error rate would be to lower the probability threshold (i.e., Pr(Occurrence) ≥ 0.75) for suitable habitat. However, this may lead to an over-estimate of suitable habitat. Finally, using ancillary information (proof of breeding/nesting) to supplement our point count surveys would ensure that our detected species were actually breeding in the habitat where they were detected (Marcot et al. 1983). Errors of commission may be reduced further by increasing survey effort, however as already mentioned our survey effort was already relatively high and therefore increasing survey effort even more probably would not have made any appreciable difference in the Type II error rate.

Probability of Occurrence Versus Abundance

Our hypothesis that well-performing models would have a significant positive linear relationship between the probability of occurrence and the species abundance and frequency of occurrence was generally supported by our data. We found positive linear relationships for 6 of the 15 models. The orange-crowned warbler, song sparrow, and hermit warbler models all had r^2>0.40. The evening grosbeak model, however, did not perform as well in this test. We detected no evening grosbeaks in 1998 so we could not test the relationship that year; in 1999 evening grosbeaks were detected in only 4 stands and at low numbers, producing a poor correlation ($r^2 = 0.14$, $P = 0.008$).

Not all the models that predicted occurrence well had positive correlations between the probability of occurrence and the species abundance. The gray jay and hairy woodpecker models, which had performed fairly well at predicting habitat (≥ 80% at least 1 year of the study) did not have a significant positive relationship between probability of occurrence and abundance. Those species both have large territories, which may exceed the size of a typical forest stand, and therefore, the number of detections were very low (Best and Stauffer 1986; Strickland and Quellet 1993). Species that have low to moderate detectabilities, such as the brown creeper, may not be detected in sufficient numbers to test the relationship between probability of occurrence and abundance. Detection rates decrease with increasing home range (territory) size and with decreasing observability (Marcot et al. 1983). Thus, we suggest that this relationship will not hold for well-performing models of species with large territories or low detectability.

Variable Coefficient Comparisons

Our hypothesis that coefficients produced from models developed using our data would be similar to the WA model coefficients of well-performing models, was generally supported. Most of the models that performed well in the other 2 tests performed well in the variable coefficient comparisons. However, this comparison was the least sensitive of the 3 methods we used. When there were annual changes in model performance in the other 2 tests, this method did not always exhibit a corresponding change. Also, the orange-crowned warbler model, which had performed well in the previous tests did poorly in this comparison. In our data canopy height and short shrub cover were highly correlated ($r = 0.74$, $P \leq 0.0001$), thus resulting in multicolinearity (Hosmer and Lemeshow 1989) when entered into a model together.

Model Building

Our models, in general, were simpler than most of the WA models. The Principle of Parsimony and Occam's Razor state that simple models are to be preferred over complicated ones. There is often a loss of precision when too many explanatory variables are included in models (Ramsey and Schafer 1997). It is often impossible to understand all relevant relationships between a species and its environment and therefore choosing a simple model over a more complicated one may be more practical (Starfield and Bleloch 1986). The WA models were developed using data from stands within a narrow range of older age classes than were our models. Thus, variables associated with stand age such as canopy height and average dbh would be less variable in the WA models and less likely to be significant. The models we created used data from stands with a wide range of ages, and therefore, variables associated with stand age were more common in our models than in the WA models. Our 5 best performing WA models, had 5 or fewer variables. Also, well-performing WA models often used the same variable or variables that were correlated with the variable(s) in our models. Variables in the WA models, except for the orange-crowned warbler model, had not been screened for biological significance, which may have resulted in the poor model performance (Doug Runde, Weyerhaeuser Company, pers. comm.).

Construction of habitat relationship models is dependent on the range of conditions under which the data are collected (Best and Stauffer 1986; Fielding and Haworth 1995; Hansen et al. 1995). We did not construct models for a few of the species modeled in Washington. The stands in southwest Washington, where the models were parameterized, were on average older than the average Oregon stands, where the models were tested. Thus, some species associated with older stands were not as abundant in the Oregon stands. We did not construct an evening grosbeak model because this species was not detected the first year of the study and only detected in 4 stands at low numbers the second year. We constructed a red-breasted nuthatch model using '99 data instead of '98 data because red-breasted nuthatches occurred in 6 stands the first year and 27 the second year. Thus, we did not cross-validate the red-breasted nuthatch model.

The ability of some of our and the WA models to predict habitat may be improved if large-scale variables were included. The Stellar's jay, gray jay, and hairy woodpecker, and possibly other models may be improved with the inclusion of larger scale variables (Orians and Wittenberger 1991). These birds typically have large territories, much larger than the average size of our stands (41.6 ha), and are likely selecting habitat based on larger scale variables. Orians and Wittenberger (1991) found that yellow-headed black-bird (*Xanthocephalus xanthocephalus)* females preferred an end territory in a marsh segment, extensive channeling, moderate vegetation density, and medium marsh width. Thus, yellow-headed blackbird females select habitat from a number of different scales. Also, species-habitat relationships apparent at one scale do not necessarily hold at other scales (Wiens et al. 1987; Wiens 1989; Orians and Wittenberger 1991; Bergin 1992; McGarigal and McComb 1995). Wiens et al. (1987) found that bird-habitat relationships changed with every change in spatial scale on which the system was viewed. Species may be more selective of habitat at one scale than another (Orians and Wittenberger 1991; Bergin 1992). Birds are highly mobile animals and many of the species modeled are neotropical migrants, thus larger scales may be relevant (Bergin 1992, Saab 1999).

Poor Model Performance

Often when models are generalized to a different place and time they do not work well for a number of reasons (Fielding and Haworth 1995). Although we followed the same protocol for the bird and vegetation surveys and both studies used experienced and trained observers, some observer bias may have occurred, though none was documented. Regional variation in habitat and intraspecific variability in breeding habitat could account for poor model performance (Fielding and Haworth 1995; Hansen et al. 1995). Not only is vegetation structure important to many bird species, but other abiotic factors such as temperature and rainfall, not accounted for in this study may influence populations as well (Cody 1985; Gilbert and Allwine 1989; Irwin 1998). These models may be improved by use of smaller and larger scale variables. Some birds may select habitat at larger scales or even a number of scales not represented in our or the WA models. These models only used stand-scale variables. If variables had been measured within the 75 m radius of each point count station stronger associations might have been obtained between species presence and habitat variables. Song sparrows, for instance, are often associated with riparian areas, so a variable that represents distance to water may have been helpful in predicting occurrrence for this species (Hagar et al. 1995). Another factor which may have caused some of the models to predict species presence poorly is not including variables important to the species. Although we accounted for many variables we felt were biologically meaningful to most species, for logistical reasons we may not have adequately characterized habitat for every species. For instance, warbling vireos forage for insects on deciduous trees and are often associated with them, so a variable that accounted for this component may have been warranted.

In forest settings much of the bird identification is done by ear, and often there are difficulties in differentiating similar sounding species. The hermit warbler and black-throated gray warbler models may not have performed as well due to problems with identifying the birds by song. Our study site was at the edge of a hybrid zone between the Townsend's warbler (*Dendroica townsendi*) and the hermit warbler and 1 or 2 hybrids between the black-throated gray and hermit warbler have also been found, thus, many of the songs of these species are similar and even experts have trouble telling them apart (Guzy and Lowther 1997; Pearson 1997; Rohwer and Wood 1998).

Model Assumptions and Weaknesses

It is important that model assumptions and weaknesses be understood. Models are "abstractions of real processes and relations" (McComb 1992:377); they are simplifications of complex systems that lose resolution in attaining simplicity (Schamberger and O'Neil 1986). These models were constructed using data collected during the breeding season and thus, only predict species occurrence during that season;

habitat suitable for these species during other seasons may be different. Also, these models were tested with only 2 years of data and we documented temporal variability in the models' ability to predict habitat suitability. Wiens et al. (1987) and Diehl (1986) recommend that bird-habitat relationship studies be relatively long term in order to assess temporal consistency, to reduce the effects of local stochastic variation and time lags (where changes in habitat conditions may not produce an immediate "tracking" response in birds), and to examine the temporal dynamics of birds and their habitats. These models assume that used and unused stands were classified correctly. As we saw in comparing data between 1998 and 1999, a stand classified as unused one year may become used the next year and vice versa. Thus, the models' predictions should be monitored for as long as the models are used.

These models assume that species presence is associated with suitable habitat and species absence is associated with unsuitable habitat. Probability of occurrence output from these models was positively associated with species abundance. However, species presence/absence as well as density can be poor indicators of habitat quality (Van Horne 1983; Pulliam 1988; Morrison et al. 1992). Because we did not measure fitness parameters we do not know if abundance measures are associated with sources or sinks. When well-performing models are chosen and used by managers, their predictions need to be monitored. Model development and use must be linked; the relationship between model developer (biologist) and user (forest manager) need to be continuous and symbiotic, where management decisions and model predictions are reviewed on a regular basis and models are revised or replaced in light of what is learned (Conroy 1993; Starfield 1997).

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Chapter 3

Effect of Survey Effort and Location on the Performance of Songbird Habitat Models

Dorothy G. Wilson and W. Daniel Edge

Abstract

Survey effort and location are important considerations when monitoring bird populations for they effect the results obtained. Fifteen forest bird-habitat relationship models were developed by biologists using data from private forestland in southwest Washington. These logistic regression models use structural habitat variables to predict a species' probability of occurring in a particular stand. These models will be used with other wildlife habitat relationship models and forest growth and management models to plan and achieve multiple objectives across the forest landscape. A shorter survey duration may be used for future monitoring efforts, so we tested whether point count duration effects bird abundance and/or presence/absence and, thus, model performance. Point count surveys were conducted along forest roads, so there was the additional concern that surveys conducted on roads were not representative of the stand. We tested to see if there were differences in relative abundance or species' presence/absence for on- and off-road surveys. In the spring/summer of 1998 and 1999, we collected data from private and Bureau of Land Management (BLM) forestland in the vicinity of Cottage Grove, Oregon to test these models.

Differences in relative abundance and presence/absence between the 5- and 8-minute point count surveys were found for most species. Differences in presence/absence resulted in differences in model performance between the 2 counts. Also, most of the modeled species were not detected until the last 3 minutes in some stands at least 1 year of the study. During each year of the study, an average of 2 (range: 0-6; $P < 0.0001$) new species were detected per stand the last 3 minutes of the survey. There was no difference in abundance between on-road and off-road point count surveys except for the western tanager (*Piranga ludoviciana*), which was more abundant for on-road than off-road surveys. There was a difference in presence/absence and, thus, model performance for a few species on and off roads (song sparrow and warbling vireo, both years; Bewick's wren, black-throated gray warbler, brown creeper, hairy woodpecker, and orange-crowned warbler, 1 year).

The results of this study have important management implications. The primary role of the surveys should be considered in decisions regarding point count duration and location. Future surveys will be primarily used to assess presence/absence of modeled species such that a longer survey may be warranted to accurately assess bird-habitat relationships. The addition of some off-road points may help insure that the stand has been accurately classified. Longer counts and some off-road points can help ensure that the stands are accurately classified, thus rigorously testing models.

Introduction

Point-count surveys are used to assess presence/absence and abundance of birds. Point count duration and location can affect the information obtained from these surveys. For most species, the number of birds counted at a point is a function of the time spent counting (Dawson et al. 1995). Species that are inconspicuous because of their distance from the point or that sing infrequently are more likely to be detected with longer counts (Buskirk and McDonald 1995; Dawson et al. 1995). Also, longer counts may reduce observer bias, because observers with less hearing acuity, alertness, and/or experience would have more time to detect species. However, longer counts increase the chance of double-counting of birds (Dawson et al. 1995). If point count surveys are short (≤ 5 minutes) and the travel time between points is also short, then there is the potential to detect more individuals per field time (Burkirk and McDonald 1995). Also, changes in detection frequency found with shorter counts will more closely measure changes in abundance at individual points than will longer counts (Burkirk and McDonald 1995).

Because forest roads are not randomly located and contain edge habitat not normally associated with interior forest, counts conducted on roads may not be generalizable to entire stands (Hutto et al. 1995, Hanowski and Niemi 1995, Keller and Fuller 1995). More species may be detected on than off roads (Hutto et al. 1995, Hanowski and Niemi 1995, Keller and Fuller 1995). However, Hutto et al. (1995) found that roadside counts generated a bird list that was essentially the same as the list generated from off-road counts; species restricted to either on- or off-road areas were rare. Hanowski and Niemi (1995) found 24 species more abundant on than off roads and 5 species were more abundant off roads than on. Hutto et al. (1995) recommend selecting narrower secondary or tertiary forest roads that may have less habitat changes associated with them as transect routes for extrapolating results from on-road to off-road sites.

Survey duration and location are important considerations when monitoring bird populations and may affect the performance of bird-habitat relationship models. Presence/absence data may be especially sensitive. Fifteen forest bird-habitat relationship models were developed using data collected in southwest Washington. The purpose of these models was to provide forest managers with a basis for habitat assessment and diagnosis. We tested these models using independent data collected in the spring/summer of 1998 and 1999 in forests in the vicinity of Cottage Grove, Oregon. We used point-count surveys to assess presence/absence and abundance of modeled species. The objectives of our study were to determine if inferences regarding model validation differ between (1) 5- and 8-min point count surveys; and, (2) on- and off-road point count surveys.

Study Area

The study was conducted on private and BLM timberland on the western slopes of the Cascades Range in the vicinity of Cottage Grove, Oregon. The area lies within the Row River, Big River, Sharps, and Mosby creeks watersheds, and is located in the Western Cascade physiographic province, characterized by older volcanic flows and pyroclastics laid down during the Oligocene and Miocene (Franklin and Dyrness 1988).

The vegetation and climate are characteristic of the western hemlock (*Tsuga heterophylla*) zone (Franklin and Dyrness 1988). Elevations range from 300-1,000 m. Precipitation averages 120-150 cm annually. The forest community is dominated by conifers, primarily Douglas-fir (*Pseudotsuga menziesii*), western hemlock, and western red cedar (*Thuja plicata*), except in areas of recent disturbance or along riparian areas where hardwoods such as red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and golden chinkapin (*Castanopsis chrysophylla*) are common. The private forest unit was chosen because it has vegetation and timber management practices similar to that of PeEll, the area in western Washington where these models were parameterized.

The private forestland is managed primarily for sustainable production of wood and other forest products (Weyerhaeuser Company 1996, unpublished report). Intensive high-yield forestry has been practiced here since the mid-1960s; timber management includes site preparation, hand planting of genetically selected and improved seedlings of primarily Douglas-fir, control of competing vegetation, fertilization, pre-commercial and commercial thinning, and clear-cutting on 45-60 year rotations. Bureau of Land Management (BLM) lands are managed for multiple objectives, which include recreation, fish and wildlife habitat, late successional reserves, as well as timber production (U.S. Forest Service and Bureau of Land Management 1994). Bureau of Land Management lands are less intensively managed than the private lands.

Methods

Fifty forest stands from the 2 ownerships served as experimental units. Eighteen BLM stands within the same or nearby watersheds as the private forest stands met our criteria of being ≥28 ha and received no cutting or herbicide spraying for the 2 years of the study. Thirty-two private forest stands that met the same criteria were randomly selected from those available.

Point count surveys and habitat data collection followed protocols used in developing the models (Weyerhaeuser Company 1996). Point count surveys were conducted between 13 May and 3 July 1998 and 18 May and 30 June 1999 in all 50 stands. Habitat data was collected from 27 May to 20 August 1998 and 6 May to 28 August 1999, and combined with forest inventory data.

Bird surveys

I used point count surveys to determine presence/absence of modeled species, relative abundance and frequency of occurrence. Surveys followed the methodology of Ralph et al. (1995) and the protocol established in developing the models. Each stand had 5-7 points located along roads throughout the stand; some points ($\leq$ 3/stand) were located off-road in order for them to be $\geq$75 m from the stand edge or $\geq$200 m from adjacent points. There were a total of 31 off-road ($\geq$ 75 m off-road into the stand) points in 21 stands, which we used to test for differences in relative abundance and model performance between on-road and off-road surveys. Roadside counts were used because future monitoring of bird populations (especially modeled species) on these timberlands will use roadside counts. Following the recommendations of Hutto et al. (1995), we used secondary and tertiary forest roads whenever possible. We randomly located the first point in the stand along the road, 75-150 m from the edge of the stand. The rest of the points were 200-300 m apart, depending on the stand size and road distribution within the stand. Twenty-six points in 21 stands were located off roads for logistical reasons. Surveys began up to 15 minutes before sunrise and lasted until approximately 4 hours after sunrise. Surveys were conducted only on rainless days with low ($<$ 12 km/hr) wind. Point counts lasted 8 minutes. Each observer carried a stopwatch and recorded whether the detection was within the 0-5 minute or the 5-8 minute time period. All birds seen or heard $\leq$75 m of the point-count center were recorded. Birds $>$75 m of the point and birds flying above the canopy and obviously not using the stand being sampled, were recorded but not included in the analysis.

All observers were experienced birders; however, to help decrease observer bias, all observers participated in an intensive 4-day bird training seminar prior to the start of the field season, and 2 of the surveyors participated during both years of the study. Each of 5 observers surveyed 2 stands/day for a total of 50 stands/week. Subsequent visits to each stand alternated between early and late morning periods. Each observer surveyed every stand once; thus, each stand received 5 visits.

We calculated bird abundance as the average detections/point/visit--number of detections of a species/number of point-visits (number of points x number of visits). The frequency of occurrence is the number of point-visits a species was detected/total number of point-visits in a stand.

Habitat Measurements

We sampled habitat following the same methodology used in the development of the models (Austin 1995). We randomly located a series of 20- x 200-m belt transects throughout each stand so that approximately 10% of the area of each stand was sampled. The belt transects served as the frame work for other transects; at one end of the belt transect, we established a 30.5-m line intercept with a 5-m^2 circular plot at each end (Figure 3.1). Within the 20- x 200-m belt transect, we tallied and measured snags, stumps, root wads, and debris piles that met minimum size requirements. We tallied shrubs and logs along the 30.5-m line intercept.

We visually estimated percent cover of herbaceous vegetation within each of the 2 5-m^2 circular plots located at each end of the line intercept (Daubenmire 1959). Maximum height of herbaceous vegetation within these plots was also recorded. We estimated the canopy height and lift (height to the bottom of the live crown) of a tree, representative of the stand, nearest plot center with a clinometer. We used a moosehorn to determine

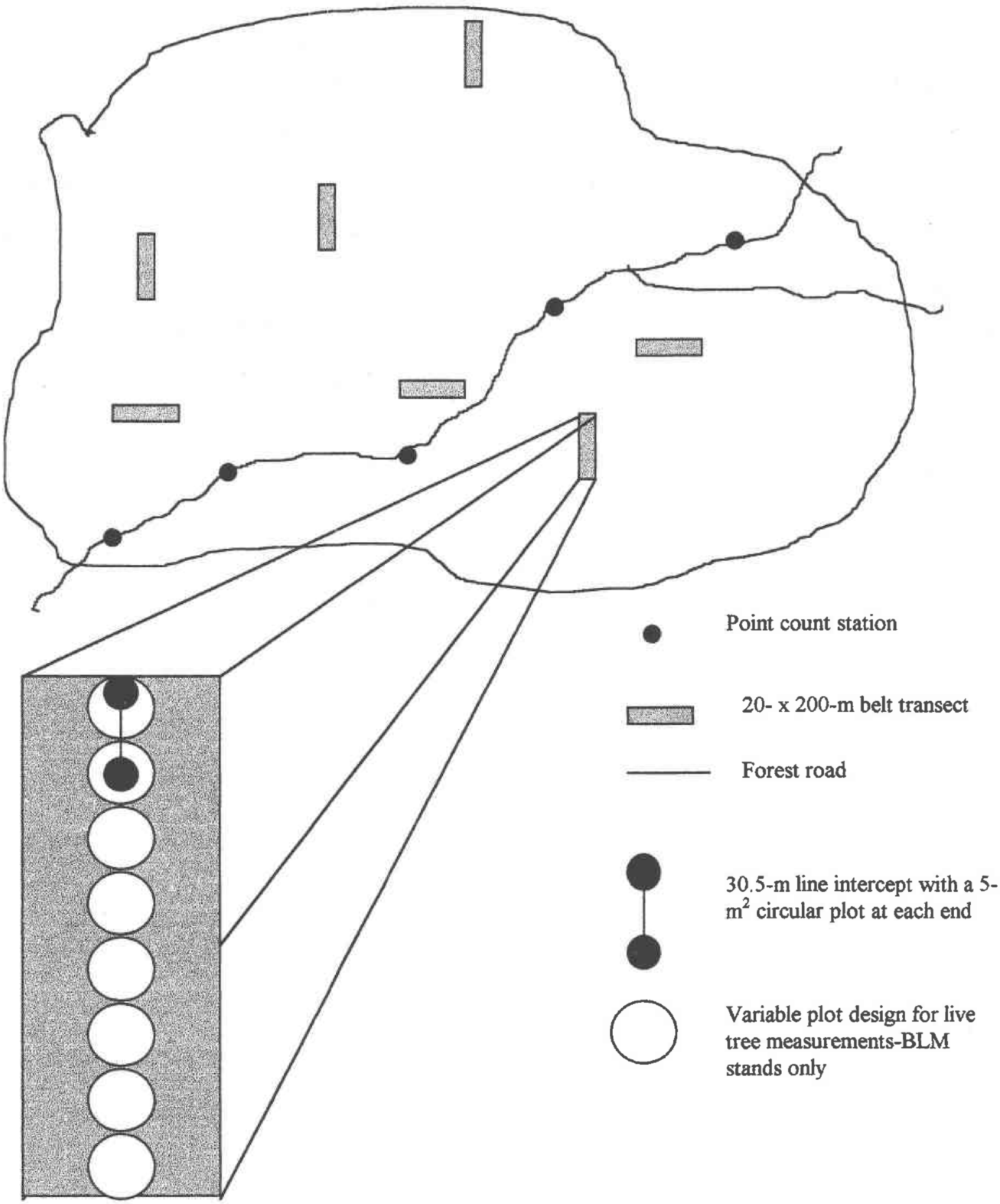

Figure 3.1. A stand showing point count stations and the layout of habitat transects for songbird model validation study, Cottage Grove, Oregon, 1998-99.

percent canopy closure at plot center and we recorded the number of canopy layers within a 11-m radius of plot center.

The variable plot method (Grosenbaugh 1952) was used to determine stem density, species composition, basal area, and average dbh of live trees (≥ 8.9 cm) for the BLM stands because this information was not available from BLM forest inventories.

Average slope, aspect, and elevation were determined with a GIS for the private forest stands. For the BLM stands, percent slope was measured with a clinometer and aspect was determined by compass readings at each circular plot. Elevation was determined from a topographic map of the area. A more detailed methodology can be found in Chapter 2.

Statistical Methods

One method we used to test the models was the accuracy of prediction. The accuracy of prediction was determined by the percent of stands correctly identified as being either suitable or unsuitable habitat for the modeled species.

$$\% \text{ Correct} = \frac{(\#\text{ of stands correctly predicted suitable} + \#\text{ of stands correctly predicted unsuitable})}{(\text{total }\#\text{ of predicted suitable stands} + \text{total }\#\text{ of predicted unsuitable stands})}$$

The suitability of a stand for a particular modeled species was determined by output from the logistic regression model:

$$\Pr(\text{Occurrence}) = \frac{e^{\beta_0 + \beta_1 \text{Var}_1}}{1 + e^{\beta_0 + \beta_1 \text{Var}_1}}$$

"Pr(Occurrence)" represents the predicted probability of occurrence, or presence of a species. Based on model outputs, stands were classified as suitable (1.0 ≥ Pr(Occurrence) ≥ 0.75), marginal (0.75 > Pr(Occurrence) ≥ 0.25), or unsuitable (Pr(Occurrence) < 0.25).

We chose these classifications because they are conservative and necessary because managers plan to use these models for habitat assessment and diagnosis. With a conservative approach we establish a stronger link between habitat and birds. For analysis, each stand was classed as either "present" for a species if that species was detected at least once, and "absent" if the species was not detected.

The presence/absence of each modeled species was compared between the 0-5 minutes and 5-8 minutes time periods. In particular, we were interested in seeing if there were modeled species that were only detected during the last 3 minutes of a survey. If we only used a 5-minute point count these stands would have been coded as observed-unsuitable instead of observed-suitable. We then determined if additional observations made a difference in model performance. The relative abundance of birds detected in 0-5 minutes was compared to the relative abundance of birds detected from 0-8 minutes using a paired t-test for each of the modeled species in the 50 stands. We used a 1-sided P-value of 0.05 as a significance level for these tests.

The presence/absence of modeled species was compared between on-road and off-road points. In particular, we were interested in seeing if there were any species that were detected off roads in a stand but not on roads. That is, if we used only on-road points, these stands may have been classed as "absent" instead of the actual "present". We then determined if this made a difference in model performance. The relative abundance of birds detected off roads was compared to the relative abundance of birds detected on roads for each of the modeled species in each stand that had both on- and off-road points using a paired t-test. Twenty-one stands had off-road points (mean number of off-road points = 1.2 ([SE = 0.12]); range: 1-3). We used a 2-sided P-value of 0.05 as a significance level for these tests.

Results

Bird Surveys

We had >12,600 total detections of 94 bird species within and beyond the 75-m fixed radius plots in 1998. Within a 75 m radius of each point we had 7,816 detections of 84 species. In 1999, we had >14,000 total detections of 88 bird species within and beyond the 75-m fixed radius plots and 8,354 detections of 73 species within the 75-m radius plot. The most commonly detected species both years of the study were the Swainson's thrush (*Catharus ustulatus*), winter wren (*Troglodytes troglodytes*), willow flycatcher (*Empidonax traillii*), chestnut-backed chickadee (*Poecile rufescens*), spotted towhee (*Pipilo maculatus*), orange-crowned warbler (*Vermivora celata*), MacGillivray's warbler (*Oporornis tolmiei*), dark-eyed junco (*Junco hyemalis*), golden-crowned kinglet (*Regulus satrapa*), and song sparrow (*Melospiza melodia*). The average abundance of all species was 1.7 detections/stand (SE = 0.3; range = 0.02-14.8) in 1998 and 2.3 detections/stand (SE = 0.4; range: 0.02-20.4) in 1999. Average species richness over all 50 stands was 27 species (SE = 0.44), with a range from 21 to 35 species in 1998 and 28 species (SE = 0.51) with a range from 21 to 38 species in 1999.

Length of Survey

Differences in relative abundance and presence/absence between the 5- and 8-minute point count surveys were found for most species. However, the differences in relative abundance were minimal averaging 0.03 birds/point-visit (or approximately 1 bird) in year 1 and year 2 (range: 0.004-0.07 in 1998; 0.007-0.06 in 1999) (Figure 3.2). Thus, although the differences in relative abundance were found to be statistically significant, they may not be biologically significant. Also, the extra 3 minutes of survey time did make a difference in the number of birds detected for each species. However, most of the modeled species were not detected until the last 3 minutes in some stands at least 1 year of the study. If the survey had been only 5 minutes long, the stands would have been classed as "absent" instead of "present", and would have resulted in 10 of the models performing better than they did with the 8-minute surveys at least 1 year (Table 3.1). However, performance declined for 5 models at least 1 year of the study when using a 5-minute survey. Also, we detected a significant number of new species the last 3 minutes of the survey. During each year of the study, an average of 2 (range: 0-6; $P < 0.0001$) new species were detected per stand the last 3 minutes of the survey.

Location

Overall, there were no species that were detected exclusively on roads or off roads, however, there were individual stands where some species were only detected either on or off the road. For most species, there was no difference in the relative abundance for on-road versus off-road surveys ($t \leq 1.9$, $P > 0.09$) (Figure 3.3). However, in 1999, more western tanagers were detected on roads ($\overline{x} = 2.8$, SE = 0.96) than off roads ($t = 2.9$, $P = 0.009$). Differences in detections on and off roads resulted in no appreciable difference in model performance for any of the modeled species (Table 3.2).

Discussion

An additional 3 minutes of survey time added significantly to the relative abundance for most species we examined. Also, significantly more species were detected/stand during the last 3 minutes of the 8-minute surveys. Detecting an average of 2 new species/stand may be important for species with low detectabilities or species of special interest or concern (Buskirk and McDonald 1995; Dawson et al. 1995).

Survey length may affect model performance. Many of the modeled species were not detected until the last 3 minutes in some stands at least 1 year of the study. Thus, if the survey had been only 5 minutes long, these stands would have been classed as "absent" instead of "present", resulting in most of the models performing better than with the standard 8-minute survey. Model performance improved because the model predicted that those species would not occur in particular stands and with a shorter 5 minute count these species were not detected. Thus, a longer count is more likely to give us an accurate picture of what species occur in a stand and a more accurate depiction of model performance. A longer count makes it more likely to detect all species that occur in a stand, more likely to detect species with low detectabilities, and decrease observer bias (Dawson et al. 1995; Buskirk and McDonald 1995). Observers with less hearing acuity or less experience have a better chance of detecting all species that occur in a stand with a longer count. However, longer counts increase the chances of double-counting birds (Dawson et al. 1995).

In general, the on-road points were representative of the stands that also contained off-road points. Most of the modeled species were detected equally on and off roads. There were a few species, however, that differed with detection location. The brown creeper and song sparrow were consistently more abundant off than on roads, but not significantly. The Bewick's wren, hermit warbler, and western tanager were consistently more abundant on roads than off roads, however, only the western tanager was significantly more abundant on roads. Miller et al. (1998) found that adjacency to trails affected bird abundance in forested ecosystems. Western tanagers prefer open forest habitat and are often associated with edge habitats (McGarigal and McComb 1995, Hudon 1999). This difference in abundance, however, produced no change in model performance either year of the study.

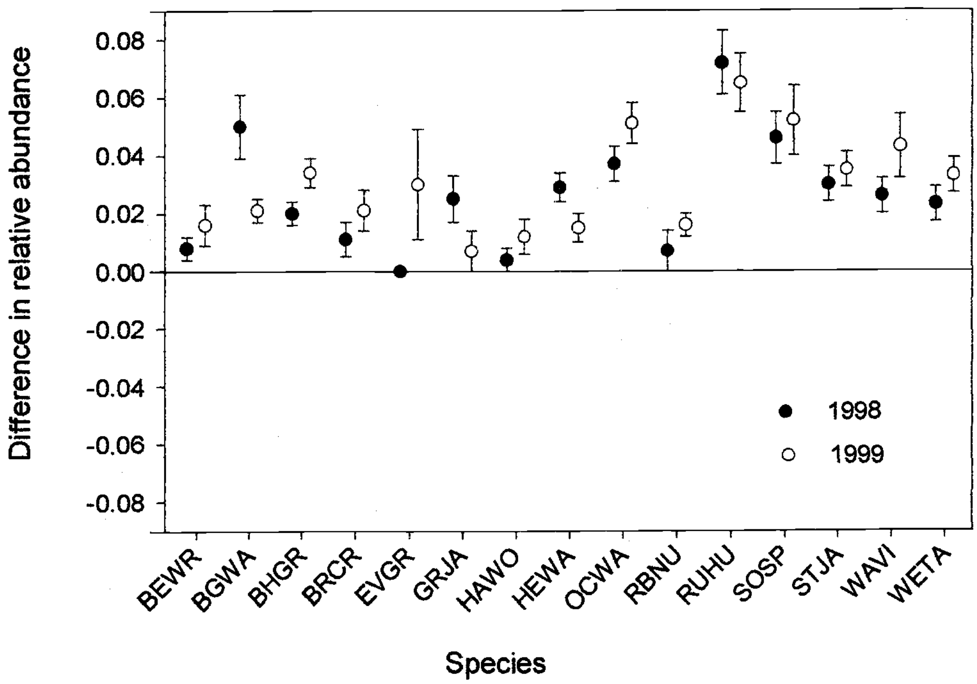

Figure 3.2. Difference (± SE) between relative abundance of birds detected on 5- and 8-minute surveys by year and species, 1998 and 1999, songbird model validation study, Cottage Grove, Oregon.
BEWR-Bewick's wren (*Thryomanes bewickii*), BGWA-black-throated gray warbler, BHGR-black-headed grosbeak (*Pheucticus melanocephalus*), BRCR-brown creeper (*Certhia americana*), EVGR-evening grosbeak (*Coccothraustes vespertinus*), GRJA-gray jay (*Perisoreus canadensis*), HAWO-hairy woodpecker (*Picoides villosus*), HEWA-hermit warbler (*Dendroica occidentalis*), OCWA-orange-crowned warbler, RBNU-red-breasted nuthatch (*Sitta canadensis*), RUHU-rufous hummingbird (*Selasphorus rufus*), SOSP-song sparrow, STJA-Stellar's Jay (*Cyanocitta stelleri*), WAVI-warbling vireo (*Vireo gilvus*), WETA-western tanager.

Table 3.1. Percent of correctly classified stands for 5- and 8-minute counts, 1998 and 1999, songbird model validation study, Cottage Grove, Oregon.

Species [a]	Survey Length			
	1998		1999	
	5-min	8-min	5-min	8-min
BEWR	60.5	57.9	68.4	73.7
BGWA	38.1	38.1	45.2	42.8
BHGR	53.1	56.2	50.0	46.9
BRCR	80.0	78.0	84.0	74.0
EVGR	97.9	97.9	93.7	93.7
GRJA	70.0	63.3	90.0	90.0
HAWO	82.0	82.0	72.0	66.0
HEWA	60.6	57.6	78.8	81.8
OCWA	94.6	97.3	100.0	100.0
RBNU	0.0	0.0	100.0	100.0
RUHU	71.4	71.4	42.8	28.6
SOSP	74.3	74.3	82.0	82.0
STJA	0.0	0.0	100.0	100.0
WAVI	52.5	52.5	50.0	47.5
WETA	44.4	33.3	33.3	55.5

[a] See figure 3.2 for species' names.

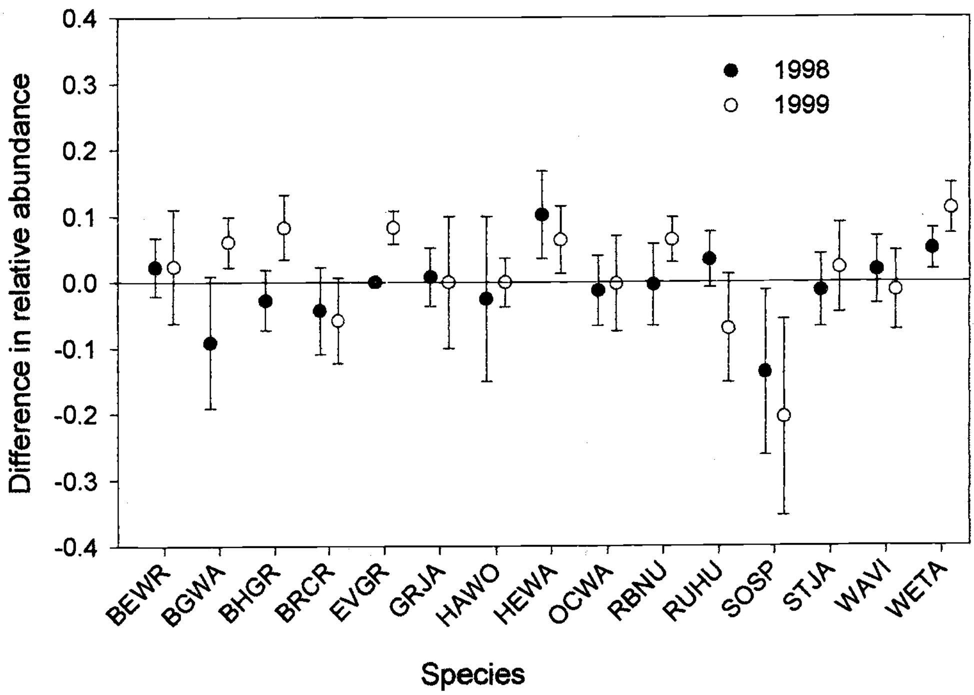

Figure 3.3. Difference between relative abundance (± SE) of birds detected on roads versus off roads by year and species, 1998 and 1999, songbird model validation study, Cottage Grove, Oregon. See figure 3.2 for species names.

Table 3.2. Percent of correctly classified stands by survey location, 1998 and 1999, songbird model validation study, Cottage Grove, Oregon.

	Survey Location			
	1998		1999	
Species [a]	on-road	off-road	on-road	off-road
BEWR	57.9	57.9	71.0	73.7
BGWA	35.7	38.1	42.8	42.8
BHGR	56.2	56.2	46.9	46.9
BRCR	78.0	78.0	76.0	74.0
EVGR	97.9	97.9	93.7	93.7
GRJA	63.3	63.3	90.0	90.0
HAWO	82.0	82.0	70.0	66.0
HEWA	57.6	57.6	81.8	81.8
OCWA	91.9	97.3	100	100
RBNU	0	0	100	100
RUHU	71.4	71.4	28.6	28.6
SOSP	76.9	74.3	84.6	82.0
STJA	0	0	100	100
WAVI	55.0	52.5	55.0	47.5
WETA	33.3	33.3	55.5	55.5

[a] See figure 3.2 for species names

The on and off road comparison had limitations in our study. Furthermore, most of the off-road points were ≤100 m off-road. It is possible that this was not far enough off-road to detect a difference if there was one. We only had 21 stands with on- and off-road points, and the modeled species had to occur in those stands in order for us to make a comparison. Thus, we had a limited number of stands on which to base model comparisons.

Management Recommendations

The determination of survey length requires an examination of study objectives for there are advantages and disadvantages to both short and long survey lengths. A significant difference in relative abundance of most species was found between the 5- and 8-minute counts for both years of the study. Also, some species were not detected in some stands until the last 3 minutes. If the survey had only been 5 minutes long these species would not have been detected in those stands, thus affecting model performance. We recommend that when the objective is to determine presence/absence of species in a stand that the longer survey time be used. Three additional minutes (15 minutes/stand) may be beneficial in detecting species with low detectability, as well as reducing observer bias. Problems with double counting are unimportant for objectives based on presence/absence of a species.

Further study of location as it affects model performance is warranted given the limitations mentioned above. Although only the western tanager was more likely to be detected on roads than off roads, a number of modeled species were detected only off roads in some stands. If off-road points had not been included in the survey these species may not have been detected in those stands. Thus, based on our observations, we recommend that when presence/absence of a species is the objective that some off-road points be included.

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Appendix

Table A.1. Means of habitat variables for 50 stands, Songbird Model Validation Study, Cottage Grove, Oregon, 1998 and 1999.

Stand no.	Shrub cover (%)		Downed log density (#/ha)		Percent cover							Maximum herbaceous height (cm)
	Tall	Short	Hard	Soft	Forbs	Grass	Ferns	Moss	Herb*	Litter	Other	
161062	24.0	127.2	0.2	2.3	7.9	12.9	15.0	9.6	45.4	62.5	2.5	117.4
161073	5.1	73.2	0.0	1.6	3.5	0.0	25.4	33.1	61.9	46.9	8.5	48.0
161077	1.2	90.1	0.0	1.9	11.4	2.8	8.7	17.6	40.5	39.5	23.6	59.7
161078	13.1	144.5	0.0	0.5	1.7	1.1	17.8	17.8	38.3	66.1	6.1	130.4
161079	17.9	160.8	0.3	0.6	7.5	2.5	11.9	26.2	48.1	58.1	3.1	119.5
164031	23.3	142.9	0.0	0.3	2.5	12.5	27.5	17.5	60.0	40.6	11.9	139.2
164050	20.3	137.0	0.5	1.0	22.2	10.5	10.5	6.7	48.7	48.9	7.2	168.9
820308	27.7	44.3	0.0	3.7	3.5	1.0	20.0	14.5	39.0	60.5	23.0	70.7
820332	63.6	73.0	0.0	2.2	1.7	0.0	9.4	33.3	44.4	61.7	14.4	63.5
820338	42.4	46.6	0.3	4.0	2.8	0.7	27.1	31.4	62.1	58.6	16.4	84.5
820355	33.9	44.0	0.0	3.4	2.5	0.0	11.9	35.0	49.4	66.2	14.4	65.9
820373	40.9	29.2	0.0	4.3	0.0	0.0	12.1	30.0	42.1	71.4	23.6	58.4
820374	32.3	22.0	0.0	1.4	3.6	0.0	18.6	31.4	53.6	82.1	8.6	64.9
820544	8.8	30.9	0.3	4.6	0.0	0.0	15.0	3.6	18.6	85.7	22.1	48.4
820557	50.0	34.1	0.0	3.7	0.7	0.0	25.7	32.8	59.3	70.0	11.4	79.8
820580	35.5	53.5	0.0	2.0	1.4	0.0	19.3	46.8	67.5	45.7	14.3	64.4
820584	49.2	43.0	0.0	2.9	0.5	0.0	12.1	31.6	44.2	64.5	17.6	58.9

Table A.1. (continued)

Stand no.	Shrub cover (%)		Downed log density (#/ha)		Percent cover							Maximum herbaceous height (cm)
	Tall	Short	Hard	Soft	Forbs	Grass	Ferns	Moss	Herb*	Litter	Other	
820607	33.0	88.2	0.0	2.9	5.0	3.3	17.2	22.2	47.8	53.9	20.0	76.9
820817	35.5	22.9	0.0	0.8	2.8	0.0	19.4	18.9	41.1	67.8	11.7	80.4
820819	65.2	47.7	0.0	3.0	0.4	0.0	8.2	23.6	32.3	74.1	10.9	60.3
821124	78.4	56.0	0.0	4.3	5.5	1.1	11.1	6.1	23.9	78.3	24.4	52.9
821237	18.7	61.5	0.0	5.2	11.2	2.5	7.5	18.7	40.0	43.1	30.0	55.4
821364	24.8	34.3	0.6	7.0	4.7	0.0	10.3	19.1	34.1	68.5	16.5	47.2
821384	42.7	48.3	0.0	3.4	1.4	0.0	1.4	36.4	39.3	49.3	24.3	22.3
822497	59.2	26.7	0.0	1.7	1.4	0.0	7.1	45.7	54.3	63.6	12.1	45.2
830154	28.5	53.2	0.0	1.7	7.2	0.5	16.7	22.8	47.2	64.4	12.8	48.8
831040	50.1	121.5	0.0	1.3	4.4	10.0	8.9	13.3	36.7	54.4	26.1	75.6
832051	23.1	62.0	0.0	0.3	1.4	0.7	7.8	9.3	19.3	42.8	37.8	37.2
832069	16.7	92.5	0.0	0.8	21.2	4.2	17.1	25.4	67.9	45.8	9.2	88.8
832070	27.7	20.4	0.2	3.9	2.1	0.0	9.0	6.8	17.9	69.3	13.2	41.4
833008	0.6	106.5	0.9	1.7	25.4	6.4	8.2	9.5	49.5	24.5	28.6	115.2
833036	14.4	76.3	0.0	2.4	0.0	0.0	10.6	31.2	41.9	72.5	13.7	73.3
833037	27.0	32.6	0.0	3.0	6.4	3.2	8.2	18.2	35.9	69.1	16.4	86.2
834016	14.6	70.1	0.0	2.4	8.3	0.3	20.0	23.3	52.0	50.3	13.3	111.8
834020	28.6	97.2	0.0	4.6	4.4	0.0	22.5	33.1	60.0	40.0	9.4	121.3
834031	26.0	43.1	0.0	3.7	2.8	3.9	10.0	16.7	33.3	54.4	15.0	83.1

Table A.1. (continued)

Stand no.	Shrub cover (%)		Downed log density (#/ha)		Percent cover							Maximum herbaceous height (cm)
	Tall	Short	Hard	Soft	Forbs	Grass	Ferns	Moss	Herb*	Litter	Other	
835010	18.2	88.3	0.0	3.9	8.1	2.7	6.5	24.6	41.9	40.8	21.5	77.1
835012	38.3	75.3	0.0	3.7	7.3	0.7	11.7	8.0	27.7	65.0	12.7	99.8
835018	21.6	45.7	0.0	1.7	3.0	1.0	10.0	13.0	27.0	51.0	24.5	64.1
860092	30.0	66.3	0.0	5.1	14.5	1.7	4.2	7.0	27.5	69.7	19.5	46.9
861156	8.6	92.5	0.0	1.5	16.9	5.0	6.2	11.9	40.0	32.5	34.4	77.5
862054	20.5	74.9	0.0	1.6	3.2	2.0	15.2	24.2	44.7	48.2	14.0	88.2
862068	52.7	59.4	0.0	2.1	7.7	4.6	20.4	30.0	62.7	52.7	10.8	91.2
862071	2.6	113.8	0.0	1.5	16.0	0.0	30.0	14.5	60.5	25.5	17.0	182.4
863001	31.9	14.8	0.0	7.0	20.7	0.0	9.3	24.4	54.5	41.6	8.1	28.7
863080	34.8	125.2	0.0	0.8	0.7	0.0	12.0	48.7	61.3	28.3	14.7	80.9
864062	13.1	112.4	0.2	1.9	5.6	0.6	15.6	11.9	33.7	71.2	13.1	148.9
864065	57.8	66.9	0.0	0.5	3.3	0.0	11.7	24.0	39.0	62.7	17.0	85.0
865008	10.9	235.7	0.0	0.3	2.5	4.4	14.4	3.7	25.0	46.9	28.1	117.6
865032	41.4	100.4	0.0	0.8	7.5	0.0	13.7	25.8	47.1	63.3	12.9	151.2

* Herb = Forb + Grass + Fern + Moss

Table A.2 Dead and downed wood mean densities and canopy measurements for Songbird Model Validation Study, Cottage Grove, Oregon, 1998 and 1999.

Stand no.	Snag density (#/ha)		Stump density (#/ha)		Root wad density		Debris pile density		Canopy height (m)	Canopy lift (m)	Canopy cover (%)	Canopy layers (#)
	Hard	Soft	Hard	Soft	(#/ha)	(m^3/ha)	(#/ha)	(m^3/ha)				
161062	0.2	4.0	1.2	34.3	6.9	103.9	0.2	25.6	9.1	1.7	66.5	2.0
161073	0.0	1.9	1.7	45.5	5.5	38.7	0.0	0.0	13.4	1.8	73.7	1.8
161077	0.0	1.2	1.9	27.7	9.1	63.3	0.0	0.0	7.1	2.2	61.0	1.4
161078	0.0	3.3	0.8	30.7	1.6	9.0	0.0	0.0	11.2	1.8	58.9	2.0
161079	0.0	1.3	0.6	28.4	0.6	2.8	0.0	0.0	8.1	1.2	59.5	1.9
164031	0.3	1.6	4.6	10.8	2.6	16.9	1.0	149.0	5.6	0.5	25.2	2.0
164050	0.3	3.4	1.6	28.2	5.5	41.2	2.9	402.8	2.6	0.3	9.5	1.1
820308	0.0	3.4	0.0	41.8	9.9	124.4	0.5	256.3	22.7	4.7	90.0	1.7
820332	0.0	2.0	0.0	43.8	7.0	64.0	0.0	0.0	19.6	7.2	87.8	2.2
820338	0.7	2.3	0.3	23.7	3.7	65.1	0.0	0.0	32.0	8.9	93.4	2.0
820355	0.0	0.9	0.0	39.8	8.3	79.6	0.0	0.0	23.3	6.7	93.0	1.9
820373	1.0	3.0	0.0	38.4	7.0	92.3	0.0	0.0	26.1	8.5	96.8	1.8
820374	0.0	0.0	0.0	39.7	4.9	108.2	0.0	0.0	22.6	7.5	99.1	1.8
820544	1.4	7.4	0.0	40.9	4.9	59.5	0.0	0.0	30.1	10.3	96.6	2.3
820557	0.0	0.7	0.3	32.7	2.7	42.6	0.0	0.0	25.3	10.1	97.4	2.1
820580	0.9	3.2	0.0	32.6	9.8	188.0	0.0	0.0	29.3	10.1	94.7	2.2
820584	0.5	1.1	0.0	31.5	2.5	40.6	0.0	0.0	28.5	10.5	91.8	2.0
820607	0.0	1.1	0.6	35.9	4.6	60.7	0.0	0.0	17.5	2.3	90.9	2.0
820817	0.0	0.6	0.0	28.9	3.6	27.4	0.3	28.6	29.1	9.5	93.8	2.0

Table A.2 (continued)

Stand no.	Snag density (#/ha)		Stump density (#/ha)		Root wad density		Debris pile density		Canopy height (m)	Canopy lift (m)	Canopy cover (%)	Canopy layers (#)
	Hard	Soft	Hard	Soft	(#/ha)	(m^3/ha)	(#/ha)	(m^3/ha)				
820819	0.7	1.2	0.0	30.5	2.6	27.9	0.0	0.0	32.2	12.2	93.1	2.1
821124	0.0	1.9	0.8	44.6	5.6	50.8	0.0	0.0	15.8	2.1	73.3	2.0
821237	0.0	2.6	5.5	39.3	7.1	47.2	0.0	0.0	11.4	0.8	31.0	1.6
821364	0.3	3.7	0.3	31.5	17.7	277.7	0.1	82.3	21.5	8.7	96.3	2.0
821384	0.0	2.4	0.0	43.9	3.1	20.0	0.0	0.0	17.0	1.7	92.8	2.0
822497	0.0	0.0	0.0	33.1	1.4	8.1	0.0	0.0	27.4	11.2	98.0	2.0
830154	0.0	2.3	3.1	21.3	1.7	11.8	0.3	54.3	4.6	0.3	20.0	1.0
831040	0.0	0.5	0.0	25.1	1.0	3.4	0.3	21.4	8.1	0.5	52.2	1.9
832051	0.0	0.0	14.9	25.9	3.5	29.3	0.3	70.6	10.9	1.8	44.6	1.9
832069	0.0	0.8	4.7	16.9	2.1	10.8	0.6	24.8	2.5	0.1	1.2	1.0
832070	3.9	3.3	0.3	56.3	10.9	104.5	1.0	1397.5	27.9	16.4	91.1	2.0
833008	0.0	0.6	3.5	39.4	19.7	92.7	0.6	49.0	1.8	0.2	0.0	0.9
833036	0.0	0.9	0.3	47.4	2.1	10.9	0.3	16.1	15.3	3.6	93.7	1.9
833037	0.0	0.5	0.2	31.4	3.9	17.0	0.2	16.9	12.5	1.7	87.1	1.8
834016	0.0	2.4	2.9	42.2	11.4	156.9	0.3	63.7	9.1	0.5	75.6	2.0
834020	0.0	0.3	2.3	36.1	0.6	3.4	2.0	347.0	14.2	2.9	54.2	2.0
834031	0.0	1.1	2.2	29.6	8.7	112.2	0.3	9.6	11.2	0.9	79.8	2.0
835010	0.0	0.7	6.9	41.1	11.3	93.8	0.6	50.2	12.6	1.6	52.5	2.0
835012	0.2	1.0	7.7	59.1	6.6	53.6	0.2	34.7	13.2	1.2	45.7	2.0
835018	0.2	1.2	8.5	41.6	4.3	34.0	1.2	134.5	10.8	1.8	79.4	1.9

Table A.2 (continued)

Stand no.	Snag density (#/ha)		Stump density (#/ha)		Root wad density		Debris pile density		Canopy height (m)	Canopy lift (m)	Canopy cover (%)	Canopy layers (#)
	Hard	Soft	Hard	Soft	(#/ha)	(m^3/ha)	(#/ha)	(m^3/ha)				
860092	0.1	1.7	0.0	70.3	3.0	27.1	0.0	0.0	13.6	1.3	88.4	1.9
861156	0.0	0.0	1.2	41.2	4.4	24.7	1.5	134.3	2.1	0.0	0.0	1.0
862054	0.0	1.2	2.9	21.1	3.9	29.7	0.2	30.3	10.8	2.4	85.8	1.8
862068	0.0	0.7	0.0	36.5	3.8	35.5	0.0	0.0	14.9	2.7	83.4	2.0
862071	0.0	3.0	4.0	23.3	0.5	0.8	1.0	109.7	4.8	0.7	27.0	1.2
863001	0.0	1.0	1.4	71.7	4.2	146.8	2.4	511.9	22.9	10.7	82.3	2.1
863080	0.0	0.0	0.6	21.9	1.1	2.3	2.5	709.6	13.1	4.1	84.5	2.0
864062	0.0	1.2	0.6	24.2	2.1	17.6	0.0	0.0	6.5	0.3	52.5	1.6
864065	0.0	0.2	0.0	15.5	0.2	0.7	0.0	0.0	11.4	2.4	85.6	1.9
865008	0.0	0.0	4.3	7.3	2.3	7.1	0.7	68.1	2.5	0.1	2.5	1.0
865032	0.0	1.1	0.6	11.3	3.2	15.9	0.4	21.9	7.5	0.9	67.0	2.0

Table A.3. Means of forest inventory data for all 50 stands, Songbird Model Validation Study, Cottage Grove, Oregon, 1998-1999.

Stand #	Site class (m)	Mean dbh (cm)	Origin [a]	Elevation (m)	Slope (%)	Slope sd [b]	Aspect
820338	32.0	28.4	3	522.1	20	9	S
820373	30.5	24.2	3	469.1	35	15	E
835012	32.3	18.4	3	1007.7	35	13	N/A
864065	30.5	19.8	3	361.2	40	15	N/A
833036	36.0	22.1	3	703.2	26	9	N/A
834020	35.4	17.9	3	682.8	30	14	N/A
835010	36.6	18.1	3	972.0	28	11	N/A
860092	39.9	22.1	3	1020.2	25	11	N/A
862068	37.5	19.3	3	426.4	23	10	N/A
161077	29.6	26.0	1	808.6	19	7	N/A
161079	29.6	25.9	1	779.7	14	6	N/A
820557	29.0	23.7	3	381.9	27	13	N
820580	29.3	24.1	1	453.8	29	10	N
820817	29.0	23.3	3	510.8	38	14	E
821364	29.0	22.9	3	678.8	27	11	N
822497	31.7	23.2	3	330.7	20	8	E
832051	32.9	19.0	3	793.7	46	13	N/A
863001	33.8	29.5	1	976.9	16	7	N/A
820308	30.5	21.7	3	658.4	41	11	S
820332	24.4	23.4	3	595.0	18	10	S
820355	31.1	24.3	3	470.0	28	8	E
820374	31.1	23.2	3	335.3	26	11	E
820544	30.2	32.9	3	786.1	38	19	E

Table A.3. (continued)

Stand #	Site class (m)	Mean dbh (cm)	Origin [a]	Elevation (m)	Slope (%)	Slope sd [b]	Aspect
820584	28.3	23.8	1	425.5	26	12	S
820607	24.4	21.8	3	668.4	29	11	W
820819	32.3	29.2	3	583.7	41	12	S
821384	24.4	19.4	3	754.4	54	12	S
821237	18.9	16.7	3	972.3	48	13	E
821124	22.3	17.6	3	1035.1	27	12	E
832069	35.1	1.6	3	444.1	26	16	N/A
861156	39.6	1.7	3	742.8	23	9	N/A
863080	37.5	20.6	3	426.4	35	13	N/A
865032	35.7	7.3	3	395.0	19	9	N/A
161073	30.5	14.1	3	775.4	19	7	N/A
161078	30.8	14.9	3	826.3	20	8	N/A
164050	32.9	1.6	3	631.5	26	9	N/A
831040	29.0	3.5	3	476.4	43	17	N/A
833008	32.9	1.7	3	672.4	29	9	N/A
834016	33.2	7.1	3	739.4	53	16	N/A
832070	28.7	28.8	1	863.5	41	17	N/A
161062	21.9	9.7	3	746.8	19	7	N/A
862071	36.3	5.2	3	580.0	27	9	N/A
864062	39.6	4.6	3	710.8	31	11	N/A
164031	31.7	4.5	3	441.0	22	7	N/A
833037	34.4	9.6	3	607.2	37	12	N/A
834031	31.1	7.7	3	520.6	41	16	N/A
830154	35.7	4.0	3	634.6	30	10	N/A

Table A.3. (continued)

Stand #	Site class (m)	Mean dbh (cm)	Origin [a]	Elevation (m)	Slope (%)	Slope sd [b]	Aspect
862054	39.6	8.7	3	549.2	27	10	N/A
835018	30.5	10.4	3	738.2	40	13	N/A
865008	31.4	2.4	3	494.1	31	9	N/A

[a] Origin codes: 1: naturally regenerated; 2: seeded; 3: planted

[b] Slope standard deviation