INFLUENCE OF POINT COUNT LENGTH AND REPEATED VISITS ON HABITAT MODEL PERFORMANCE

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Abstract: Point counts are commonly used to monitor bird populations, and a substantial amount of research has investigated how conducting counts for different lengths of time affects the accuracy of these counts and the subsequent ability to monitor changes in population trends. However, little work has been done to assess how changes in count duration affect bird-habitat models developed from point count data. In this paper, we present an empirical comparison of the performance of bird-habitat models, which were developed via logistic regression analyses based on point count data from 3-. 5-, 10-, and 20-min counts. We also investigated the effect of the number of visits to each survey point on model performance. We assessed model performance on the basis of R^2-values and percent concordant pairs. A positive relation behveen model performance and count duration was most apparent for species with relatively low detection probabilities, whereas performance of models for species with relatively high detectability was fairly consistent or even decreased as count duration increased. Our results suggest that while some improvement in bird-habitat models for species with low detection rates can be achieved via longer point counts, the modest gains in model performance should be weighed against the increased time and effort required to conduct longer counts. Models based on data from a single visit to each point did not performed as well as models based on multiple visits. However, we found little or no improvement in model performance when the number of visits per point increased from 2 to 3. We suggest that current recommendations on point count durations (5 or 10 min) will provide adequate data for modeling bird-habitat relations.

Key words: bird-habitat models, logistic regression, model performance, point count, southern Appalachian Mountains, Tennessee.

Considerable attention has been given to the use of point counts as a means of monitoring birds, with 2 special symposia held in the last 20 years dedicated to various topics related to this survey method (Ralph and Scott 1981, Ralph et al. 1995b). Much of the point count research has focused on using this sampling method to monitor population trends, although point counts are also used to collect data on bird-habitat relations. One frequently investigated topic deals with how varying count duration influences data accuracy and how these data affect the results of subsequent analyses, with the goal of determining the optimal duration for point counts. Based on empirical studies, 50–70% of the total detections from long counts (e.g., 20 min) can be recorded during the first 3–5 min of a point count (Scott and Ramsey 1981, Fuller and Langslow 1984, Gates 1995). The assumption is often made that monitoring for changes in populations does not require a complete census of all the individuals present, and the statistical power to detect these changes often depends on rather large sample sizes (Johnson 1981, Thompson and Schwalbach 1995). Optimizing the number of detections per unit time has been suggested as an approach for determining the appropriate duration for point counts used to monitor population trends (Vemer 1988). However, Barker et al. (1993) point out that the optimal allocation of point count sampling effort depends on the goals of the study (e.g., estimating population size, estimating population trends), the statistical tests being used, and the underlying population characteristics and detection probabilities of the animals being counted. Detection rates vary among species (Mayfield 1981, Dawson et al. 1995), habitat types (Emlen 1971, Reynolds et al. 1980. Schiek 1997), seasons (Best 1981, Best and Petersen 1985). and times

of the day (Robbins 1981, Lynch 1995). Hence, if not controlled for in the experimental design or corrected for in the analyses, variable detection rates can lead to biased results and misinformed conclusions about population trends (Barker et al. 1993, Pendleton 1995).

Although considerable research has focused on determining appropriate durations for point counts used in assessing population trends, much less consideration has been given to this same topic in regard to investigating bird-habitat relations with point count data. Longer count durations might be appropriate when studying bird-habitat associations, because of the potential negative implications of failing to accurately record the presence or absence of a given species at a location (Petit et al. 1995, Thompson and Schwalbach 1995). However, little work has been done to investigate whether longer counts actually provide more reliable information for describing bird-habitat relations. Fuller and Langslow (1984) found strong correlations *(r > 0.80)* between their assessments of bird community composition based on 5-min and 20-min counts for 6 different habitats, but they did not construct formal habitat models. Logistic regression is a technique frequently used in modeling bird-habitat relations (Capen et al. 1986, Green and Stowe 1993, Pearce 1996), but the effects of point count duration on such models have not be tested. In this paper, our main objective is to provide an empirical evaluation of whether the performance of logistic regression models of bird-habitat relations developed from point count data changes as count duration changes. We also investigate the effect of repeated visits to the same points on the performance of these bird-habitat models.

STUDY AREA

Our study area was the Tellico Ranger District of the Cherokee National Forest, in Monroe County, Tennessee (Fig. 1). The 49,928-ha Tellico District has elevations ranging from 244 to 1,668 m above sea level (based on 7.5-min topography maps) and lies directly southwest of the Great Smoky Mountains National Park in the southern Appalachian Mountains. The Tellico District is composed of predominately even-aged stands (managed primarily through clearcutting) of several major forest types, including southern yellow pines (*Pinus* spp.) at lower elevations, oak-hickory and cove hard-
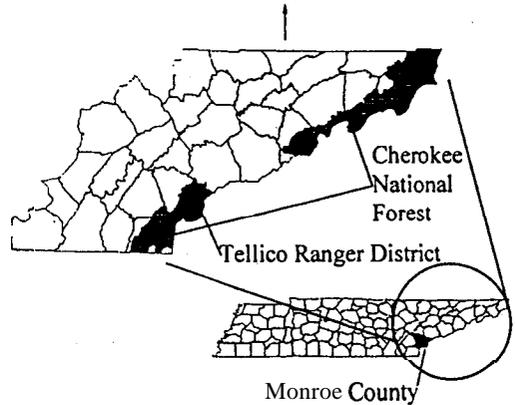

Fig. 1. Location of Tellico Ranger District, Cherokee National Forest, where the point count surveys for this study were conducted from 1992 to 1994.

wood types at middle elevations, and northern hardwoods at the highest elevations. The age distribution is skewed toward mature forest stands, with 65% being ≥70 years old and <10% being ≤20 years old.

METHODS

Sampling Methods

Forest Type and Condition Class Categories.—Using the U.S. Forest Service's Continuous Inventory of Stand Condition (CISC) database, we grouped all stands in the Tellico District into 6 major forest type categories: yellow pine, mixed hardwood-yellow pine, oak-hickory, eastern hemlock (*Tsuga canadensis*)–white pine (*P. strobus*), cove hardwood, and northern hardwood. The stands within each forest type were subdivided into 3 condition class (or size class) categories based on the U.S. Forest Service tree diameter classification scheme: seedling-sapling, poletimber, and sawtimber.

Our goal was to randomly select 30 stands from those available in each of the 6 major forest types, stratified evenly into the 3 condition classes. In several cases, 10 stands were not available on the Tellico District within a given forest type-condition class combination. In these cases, we located 2 or more point count sites in a single stand. In several cases, the actual location of a point count site, based on Global Positioning System (GPS) technology, was in a different forest stand than originally thought when the site was established. For these cases, we changed the forest type, condition class, or both for the site. Thus, sample sizes among forest types were slightly unequal

Table 1. Detection probabilities and general habitat preferences for the 6 species modeled in this study. The detection probabilities were calculated as the complement of the survivor function from the Kaplan-Meier method as applied to our complete dataset (3 visits to each of 215 survey points).

Species[a]	Habitat preference	Count length (min)			
		3	5	10	20
INBU	Early-successional	0.503	0.601	0.720	0.912
CSWA	Early-successional	0.576	0.621	0.533	0.955
WEWA	Mature forest	0.367	0.483	0.625	0.917
SCTA	Mature forest	0.435	0.551	0.696	0.942
YBCU	General	0.283	0.391	0.652	0.902
REVI	General	0.568	0.674	0.801	0.964

[a] INBU = indigo bunting; CSWA = chestnut-sided warbler; WEWA = worm-eating warbler; SCTA = scarlet tanager; YBCU = yellow-billed cuckoo; REVI = red-eyed vireo.

(38 yellow pine, 39 mixed hardwood-yellow pine, 29 oak-hickory, 35 eastern hemlock-white pine, 40 cove hardwood, 34 northern hardwood), with a range of 6-16 stands/condition class category within each forest type, for a total of 215 stands surveyed during the 3-year study. We used compass bearings and pacing to locate the randomly selected stands by navigating from known locations with U.S. Forest Service stand maps, and we established the point count sites prior to avian surveys. Point count sites were placed in the interior of each selected stand, ≥ 100 m inside the outer edge of the stand to eliminate edge-ecotone effects. We visually verified CISC forest type and condition class characterizations during establishment of the sites.

Avian Surveys.—We conducted unlimited-radius, 20-min point counts to survey breeding bird populations from mid-May until early July in 1992 through 1994. The point counts were subdivided at 3-, 5-, and IO-min increments, and detections were noted as either ≤ 50 or > 50 m from the point. We used only the 550-m data for the analyses reported in this paper. All counts were done between 0600 and 1000 EST. To eliminate potential seasonal sampling biases associated with forest type, condition class, elevation, species-specific life histories, or all these factors, we scheduled approximately 3 point counts within each forest type-condition class category for survey every 10 days of the 6-week monitoring period. Counts began immediately upon arrival at a point, and all birds seen or heard were recorded in their respective time interval. Counts were not conducted during periods of precipitation or high winds. Birds detected while walking to or from a point but not during the count were also recorded for purposes of calculating detection probabilities.

Each point was visited 3 times, once per year from 1992 to 1994.

Statistical Methods

Model Development and Comparison.-We selected 6 species to represent birds associated with several general habitats types. Two species were selected for each of 3 general habitat guilds: (1) birds associated with early-successional habitats (indigo bunting [*Passerina cyanea*]—species code: INBU; chestnut-sided warbler [*Dendroicu pensylvanica*]—CSWA), (2) birds associated with mature forest habitats (scarlet tanager [*Pirunga olivacea*]—SCTA; worm-eating warbler [*Helmitheros vermivorous*]—WEWA), and (3) habitat generalists (red-eyed vireo [*Vireo olivaceus*]—REVI; yellow-billed cuckoo [*Coccyzus americanus*]—YBCU). For each pair, 1 species had a relatively high probability of detection (CSWA, SCTA, REVI; Table 1), and 1 had a relatively low probability of detection (INBU, WEWA, YBCU; Table 1). We calculated detection probabilities as the complement of the survivor function from the Kaplan-Meier method using the Lifetest procedure (SAS Institute 1989), which was the method used by Dawson et al. (1995).

We used the Logistic procedure (SAS Institute 1989) to build logistic regression models for predicting the likelihood of species' occurrence based on 4 CISC-based variables (major forest type, stand age, condition class, site index) and elevation. For each species, models were developed for 0–3-, 0–5-, 0–10-, and 0–20-min data based on (1) the first visit only, (2) the first 2 visits, and (3) all 3 visits to each point. Thus, a total of 12 models representing each possible combination of count duration-visitation level was developed for each species. For

the models based on 2 visits and 3 visits, we classified a stand as occupied by a given species if that species was detected during at least 1 of the visits to that stand. We used a best subset selection process, beginning with all variables in the model, to find the models resulting in the lowest Akaike Information Criterion (AIC) value (SAS Institute 1989) and a P-value ≥ 0.05 for the Hosmer-Lemeshow goodness-of-fit statistic (large P-values indicate models fit the data well; Hosmer and Lemeshow 1989:140–145). For each set of 4 models representing the different count durations (i.e., 3, 5, 10, 20 min) for a given visitation level, we held the number of terms in the final model constant to eliminate the effect of number of variables on the R^2-value. The continuous variables (stand age, site index, elevation) were assessed for linearity in the logit (Hosmer and Lemeshow 1989) for all the final models. If linearity in the logit was not confirmed for any continuous variable in a final model, we divided that variable into 4 groups, coded it as a categorical variable, and then replaced the continuous variable with the categorical variables in the final model. We assessed P-values (as a measure of the variability explained by a model) and the percentage of concordant pairs (as a measure of predictive ability) to compare the performance of the models developed from different count durations and levels of visitation for the same species.

RESULTS

Relative Sampling Effort.-Our survey points were selected at random from all possible stands throughout the Tellico District, without consideration of accessibility; thus, travel time between points was often lengthy. The average travel time between points was about 40 min, which meant 1 observer was able to complete an average of 4 20-min counts/day. At this level of effort, 54 observer-days were required to make 1 visit to all 215 of our survey points. In comparison, the relative effort to complete 1 visit to all 215 points would have been 43 observer-days for 10-min counts, 36 for 5 min, and 36 for 3 min. Thus, with an average travel time between points of 40 min, 20-min counts required 1.5 times the effort to complete 1 visit to all the points as compared to what would have been required for 3- or 5-min counts.

Effects of Count Duration.--For species with relatively low detection rates (INBU, WEWA, YBCU), R^2-values for the logistic regression

models tended to increase moderately (increases of as much as 0.14) as count duration increased from 3 to 20 min for all visitation levels (Table 2), although these increases were not related to count duration in a strictly linear fashion in some cases (e.g., INBU, WEWA). For these low-detection species, the concordance values generally indicated slight to moderate increases in the predictive ability of the models (3–6%) with increased count duration for the 3-visit models. However, for the 1-visit and 2-visit models, generalizations about the results were not as easy to make, because the 3-min and 10-min models tended to have relatively high concordance values compared to 5-min and 20-min models.

For 2 of the species with relatively high detection rates (CSWA, SCTA). R^2-values and concordance values tended to decrease slightly (decreases of 0.027-0.08 for R^2, 3.0–7.6% for concordance) with increased count duration for 2- and 3-visit models (Table 2). This relation was again not strictly linear with count duration, especially for SCTA, which had higher values for the 20-min models than the 5- or 10-min models. The 1-visit models for both of these species produced the largest R^2-values for the 20-min models, but 3-min models produced the next highest values, and 5-min models the lowest values. Concordance for the 1-visit CSWA models varied minimally across count durations, while concordance was largest for SCTA at 20 min and smallest at 5 min. For all visitation levels, R^2-values for the REVI models tended to increase slightly (increases of 0.02-0.05) with longer count duration, although all of the 5-min models had lower values than the 3-min models (Table 2). Concordance values for the REVI models generally increased in a linear fashion with count duration for all 3 visitation levels (increases of 3.4–6.0%).

Effects of Repeated Visits.-For all species, models developed from a single visit to each point produced the lowest R^2-values and concordance values for a given count duration (Table 2). Also, 1-visit models produced R^2-values and concordance values that tended to be larger for longer duration counts than for shorter counts for most of the species, regardless of detection probabilities. The R^2-values for the 1-visit models were anywhere from 0.008 to as much as 0.170 less than the values for the 2-visit models, with differences of ≥0.10 being common. Differences in concordance values

Table 2. Performance of logistic regression models of bird-habitat relations developed from point counts of different lengths and with different numbers of visits per point. All models fit the data acceptably well (P > 0.05) based on the Hosmer-Lemeshow goodness-of-fit test.

Species	1-visit models				2-visit models				3-visit models			
	3 min	5 min	10 min	20 min	3 min	5 min	10 min	20 min	3 min	5 min	10 min	20 min
Indigo hunting												
No. of detections[a]	30	34	40	48	62	71	80	97	70	79	91	106
R^2-value	0.157	0.170	0.236	0.222	0.279	0.331	0.404	0.372	0.255	0.286	0.377	0.398
% concordance	73.2	73.0	76.9	75.1	77.3	79.5	81.3	80.2	75.5	77.3	80.7	81.3
Variables[b]	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa, si	elev, ft, cc, si	elev, ft, cc, si	elev, ft, cc, si	elev, ft, cc, si	elev, ft, sa, si	elev, ft, sa, si	elev, ft, sa, si
Worm-eating warbler												
No. of detections	19	23	28	45	29	38	49	71	36	47	58	81
R^2-value	0.152	0.123	0.133	0.170	0.156	0.139	0.163	0.208	0.190	0.197	0.195	0.287
% concordance	73.0	70.0	71.1	68.8	73.0	70.7	71.4	71.6	74.8	73.5	71.1	75.3
Variables	elev, ft, sa	elev, ft, sa	elev, ft, si	elev, ft, sa	elev, ft, si	elev, ft, si	elev, ft, si	elev, ft, si	elev, ft, si	elev, ft, si	elev, ft, si	elev, ft. si
Yellow-billed cuckoo												
No. of detections	2	5	8	11	8	11	17	24	13	15	23	31
R^2-value	c	c	0.238	0.241	0.289	0.228	0.282	0.335	0.169	0.174	0.227	0.329
% concordance			84.4	82.8	87.0	82.3	85.1	85.9	78.3	79.2	80.0	84.0
Variables			elev, ft, si	elev, ft, si	elev, ft, si	elev, ft, si	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa
Chestnut-sided warbler												
No. of detections	12	13	16	18	20	22	25	26	21	24	26	27
R^2-value	0.656	0.639	0.649	0.687	0.761	0.748	0.746	0.710	0.796	0.765	0.765	0.716
% concordance	97.2	96.9	96.5	97.2	98.0	97.7	97.8	96.7	98.4	97.8	98.0	96.8
Variables	elev, sa	elev. sa	elev, sa	elev, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa, si	elev, ft, sa, si	elev, ft, sa, si	elev, ft, sa. si
Scarlet tanager												
No. of detections	23	30	34	40	49	55	66	85	55	66	76	93
R^2-value	0.119	0.105	0.128	0.187	0.204	0.144	0.159	0.175	0.206	0.184	0.178	0.187
% concordance	64.7	60.8	64.7	68.1	73.4	68.6	70.6	70.3	73.8	70.3	70.4	70.5
Variables	ft, si, cc	ft, si cc	ft, si, sa	ft, si, sa	elev, ft, cc, si	elev, ft, cc, si	elev, ft, si, sa	elev, ft, si, sa	elev, ft, cc, si	elev, ft, cc, si	elev, ft, si, sa	elev, ft, si. sa
Red-eyed vireo												
No. of detections	74	81	99	114	128	139	150	164	134	144	152	166
R^2-value	0.165	0.163	0.199	0.242	0.332	0.315	0.337	0.352	0.319	0.313	0.316	0.331
% concordance	69.8	69.9	71.3	74.7	78.5	78.4	80.4	84.5	77.7	78.3	79.3	81.1
Variables	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa	elev, ft, sa

[a] Number of sites on which species was detected, out of 215 total sites.
[b] Variables selected for final models: elev = elevation; ft = forest type; sa = stand age; si = site index; cc = condition class
c The small number of detections was insufficient to develop a reasonable model.

between I-visit models and 2-visit models for a given count duration were of a similar magnitude (from 0.1 to 10.0%). However, only slight improvements (CSWA, SCTA, WEWA) or even decreases (INBU, REVI, YBCU) in model performance were produced by the 3-visit models in comparison to the 2-visit models (Table 2). Thus, for this study, the greatest improvement in model performance was seen by increasing the number of visits per point from 1 to 2, but little apparent benefit was found in visiting each point a third time.

DISCUSSION

Although numerous topics regarding point counts could be considered in relation to our study, we wish to focus the discussion on our main objective, which was to evaluate the changes in habitat model performance as count duration and number of repeat visits to each point increased. The bird species we chose for our analyses provided a diverse collection with regard to their abundances and detection rates, and thus the number of sites at which they were detected over time. Despite these complexities and the related diversity in the results, several important generalizations were suggested from our results.

First, for the kinds of forest songbirds observed in this study, the performance of logistic regression models (as measured by R^2-values and concordance values) is unlikely to improve *greatly* by increasing count duration. Only moderate increases in model performance were achieved through increased count duration, even for low-detectability species. The species with low detection probabilities were the ones for which improvements in model performance *were* the greatest with an increase in count duration, but our results suggest that even for these species, increases of >0.15 in R^2-values or $>10\%$ in concordance values are unlikely. The amount of variability explained by the models (as measured by R^2-values) for these low-detectability species increased with longer count durations, but overall predictive ability did not improve as much. Model performance for the high-detectability species was *even* less likely to increase substantially over time, and our performance measures indicated slight decreases with longer counts for several of these species.

Secondly, the amount of variability in the data explained by the single-visit models (as indicated by the R^2-values) was relatively low in comparison to models based on 2 and 3 visits, or so few detections were recorded during a single visit that validity of the models was questionable (e.g., YBCU). With the exception of CSWA, all 3- and 5-min models based on a single visit yielded R^2-values <0.20, while all 10- and 20-min models for a single visit produced R^2-values <0.25. These rather low R^2-values were likely due in part to our predictor variables not being sufficient to adequately describe strong habitat relations for these birds, although R^2-values ≥0.30 were achieved for 4 of the 6 species when 2- or 3-visit data were used. The predictive ability (as indicated by concordance values) of the single-visit models also tended to be somewhat lower than that of the 2- and 3-visit models. These results suggest the limited number of detections recorded from a single visit are less likely to provide sufficient data for adequately modeling bird-habitat relations than data from 2 or 3 repeated visits to each point. This conclusion agrees with Stauffer and Best (1986). who also suggested small datasets may not adequately represent relations between species and habitat variables.

Models for all count durations based on 3 visits/point produced either minor improvement, or no improvement at all, in model performance when compared to the 2-visit models. Our results suggest that for studies of forest songbirds with design parameters similar to ours, the performance of 2-visit models is likely to be somewhat better than single-visit models, but conducting a third visit per point may yield limited improvement in model performance. For our study, the small additional benefits gained in model performance probably were not worth the extra effort of conducting a third visit. However, decisions on how to allocate sampling effort are most appropriately made on the basis of pilot data collected before a study begins. Such decisions should also consider the intended use of the models and the desired level of model performance. For example, Hurley (1986) suggested managers typically are comfortable using models that can predict with 75-80% accuracy, and Chalk (1986) indicated that researchers also tend to consider 75–80% accuracy as a reasonable goal for habitat models. However, Morrison et al. (1992258262) cautioned that even good habitat models typically account for $\leq50\%$ of the variation in species occurrence or population density. For any study, consideration should be given to the tradeoffs

between the costs (time, resources) and benefits (potential increase in model performance) associated with increasing the sampling effort per point (e.g., longer counts or increased number of visits).

We acknowledge that potentially different detection rates among the various habitat types, across years, and between observers could have resulted in biased estimates of habitat occupancy for a given species (Barker et al. 1993, Dawson et al. 1995, Petit et al. 1995) and thereby resulted in biased habitat models. However, our survey methods and experimental design followed the recommended guidelines for point counts, including the establishment of points and timing of the actual counts during the day and within the season (Ralph et al. 1995a), which should have reduced differences in detection rates and the associated biases (Pendleton 1995). Despite the biases that may have been present due to detection rate differences, the variables chosen for the final models were quite consistent among different point count durations and even across visitation levels. This result suggests the underlying bird-habitat relations upon which the models are based must be fairly robust. Additionally, the models seemed to be fairly robust to differences in the overall abundance and distribution of the species we analyzed. Although we looked at species that ranged from uncommon (e.g., YBCU was detected on only 31 sites for 20-min counts) to very common (e.g., REVI was detected on 166 sites for 20-min counts), the relative occurrence of a species did not have a noticeable effect on how model performance changed with count duration or number of visits.

The current recommendations for point counts suggest using a count duration of 10 min when travel time behveen points is >15 min (Ralph et al. 1995a), which was the case in our study. For the species we analyzed, models developed from the 10-min data consistently provided relatively high performance across species. Our study supports a conclusion that following the current point count recommendations (i.e., 5 or 10 min counts, depending on the travel time between points) will likely provide data for the development of bird-habitat models for forest songbirds that perform as well or nearly as well as models developed from longer counts (i.e., 20 min), especially for species with high detection rates. These results were similar in nature to those reported by Fuller

and Langslow (1984), who found their assessments of bird community composition in relation to different habitat types to be very similar when using data from 5-min and 20-min counts. The results from our study provide some evidence that longer counts may not provide a great advantage over shorter counts in assessing bird-habitat relations, despite the deficiency short counts might have in accurately portraying the presence and absence of a given species across habitat types. However, we remind readers to consider that we have presented results for only 6 species and from only 1 location. Drawing broad generalizations from this study would be unwarranted. We also urge other authors who have similar sets of point count data to conduct similar analyses so as to provide more information for the debate on these issues.

MANAGEMENT IMPLICATIONS

Our results suggest short-duration point counts may provide data for developing bird-habitat models for forest songbirds that perform as well or nearly as well as models developed from longer counts. Such results should help relieve concerns that the shorter-duration counts recommended for monitoring population trends (Ralph et al. 1995a) may not be long enough to provide data for developing good habitat models. Particularly for species with high rates of detection, longer counts do not appear to provide any advantages in model performance compared to shorter counts. Increased performance of habitat models will likely be achieved for species with low detectability as count duration increases, but our results suggest these increases will be moderate (i.e., about 10%) at best. Even for low-detectability species, the tradeoff between the modest increases in model performance and the additional time and effort required to conduct the longer counts should be considered when designing habitat modeling studies based on point counts. Our data indicate the current recommendations (Ralph et al. 1995a) for point count durations are adequate for developing bird-habitat models and for monitoring population trends. The current point count recommendations also suggest conducting only 1 visit/point, but we found that models developed from 2 visits/point consistently performed somewhat better than single-visit models across all count durations and species. We concluded that con-

ducting 2 visits/point will likely result in habitat models that perform better than models developed from a single visit. However, as with count duration, the potential benefits of increased model performance should be weighed against the additional costs in time and resources required to complete extra visits to each point.

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