Nongame Session

Relationships Between Land Cover and the Abundance of Breeding Birds Recorded Along Florida's Breeding Bird Survey Routes

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Abstract: A map of land cover derived from Landsat Thematic Mapper data was used to quantify land cover characteristics around Florida Breeding Bird Survey Routes. Abundances of 54 species of birds were compared with land cover characteristics. Approximately 15 species showed biologically meaningful correlations, and in some cases the variation explained by land cover characteristics was quite large (e.g., >40%). There were also several anomalous correlations. Although Landsat data can be used to identify the habitat features sought by some species, more detailed information is needed for many species of nongame birds. Developing standardized procedures for collecting and processing habitat information along Breeding Bird Survey routes should be a top priority.

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The Breeding Bird Survey (BBS) is one of the primary tools available for monitoring populations of nongame birds in North America (Bystrak 1981, Robbins et al. 1986). These roadside counts are organized by the U.S. Fish and Wildlife Service and are designed to monitor bird populations across broad geographic areas (Robbins et al. 1986). However, data collected along BBS survey routes are also useful to state agencies interested in detecting declining species, assessing the recovery of populations following population declines, and monitoring the expansion of exotic species (Robbins et al. 1986).

Changes in the numbers of birds observed along BBS routes stem from observer effects, normal year-to-year population fluctuations, changes in habitat, and other factors (Sauer and Droege 1990). To quantify the changes in habitat that occur along survey routes over time, some authors (Robbins et al. 1986, Dawson unpubl.) have recommended using satellite imagery. However, for satellite imagery to be useful in this regard, it must be capable of identifying habitat features required by avian species along a survey route. In this paper, I use a recent map of Florida land cover derived from satellite imagery (Kautz et al. 1993), data collected along Florida BBS routes, and Geographic Information Systems (GIS) technology to evaluate relationships between land cover classifications derived from satellite imagery and bird abundances reported along Florida BBS routes.

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Methods

The land cover map was developed from Landsat Thematic Mapper data collected from 1987–1989. The minimum pixel size for Landsat TM data is 0.09 ha, and the map includes 22 cover types that correspond to general plant community descriptions found in Davis (1967), Hartman (1978), and Soil Conservation Service (1979). Complete descriptions of the cover types, accuracy, and classification procedures are provided in Kautz et al. (1993).

Maps of Florida BBS routes were obtained from the U.S. Fish and Wildlife Service, transcribed onto Florida Department of Transportation county road maps (1:126,720), and digitized. A GIS was used to create a 500-m buffer surrounding each survey route. This distance approximates the area within which BBS observers are allowed to record species seen or heard (Robbins et al. 1986). Cover types within this 500-m buffer were isolated, and area calculations were performed to characterize the land cover surrounding each BBS route. Calculation of land cover variables in this manner provides information on the broader landscape through which individual BBS routes pass. Estimation of land cover surrounding the individual sampling points along BBS routes was not meaningful because BBS data were encoded by 10-stop intervals.

Data collected from the 1987–1989 BBS were used in the analyses since these dates corresponded with the dates of the satellite imagery. The use of survey data spanning multiple years should improve on the predictive ability of statistical models (Rice et al. 1981). Fifty-four species were selected from the Florida BBS data based on 2 criteria: (1) a species had to occur along a route in each of the 3 years 1987–1989; (2) a species had to occur on a minimum of 7 (ca. 10%) of the 75 Florida routes surveyed in all 3 years. These selection criteria did not bias results by selecting only common species that might be tolerant of a broad range of land cover and habitat conditions.

Statistical analyses were performed using SYSTAT software (Wilkinson 1988). For each species selected, the average number of individuals observed along BBS routes for the 3-year period was determined. Pearson correlations were calculated using these 3-year averages and the area of specific cover types surrounding each route. Only those correlations with an absolute r value ≥ 0.50 are included below. Depending on the number of routes used to calculate these correlations, this minimum r value corresponds to P values ranging from approximately 0.2–0.01 if only a single correlation were computed. Owing to the many correlations involved (>350), it is difficult to estimate *P* values accurately (Salsburg 1985).

The strength of correlations and effects of combinations of different land cover variables on species abundance were estimated using linear regression techniques. Stepwise multiple regression was performed to identify a subset of land cover variables that correlated with abundance. An alpha value of 0.15 was used to determine inclusion or exclusion of specific variables at each step (Bendel and Afifi 1977). Adjusted *r*-square values were then derived using the subset of land cover variables obtained from stepwise procedures.

Results and Discussion

Positive and negative correlations between various land cover variables and the abundances of different species (Table 1) may include several spurious correlations given the *r*-value used for inclusion. However, among these correlations are several that appear to have an underlying biological basis. For example, the relationships between the abundance of killdeer (*Charadrius vociferus*) and the area of grass and agricultural land cover fits with the habitat preferences of this species. Figure 1 presents a bivariate plot of killdeer abundance and area of grass and agricultural land cover to demonstrate the strength of this relationship. This variable accounts for 70% of the variation in killdeer abundance. Based on my personal field experience and habitat relationships discussed in Dickson et al. (1980), Conner et al. (1983), and Hamel (1992), other species whose correlations appear to have an underlying biological basis include cattle egret (*Bubulcus ibis*), red-shouldered hawk (*Buteo lineatus*), common nighthawk (*Chordeiles minor*), eastern kingbird (*Tyrannus tyrannus*), fish crow (*Corvus ossifragus*), blue-gray gnatcatcher (*Polioptila caerulea*), European starling (*Sturnus vulgaris*), yellow-throated vireo (*Vireo flavifrons*), prothonotary warbler (*Protonotaria citrea*), common yellowthroat (*Geothlypis trichas*), and eastern meadowlark (*Sturnella magna*). However, in some cases the land cover variables do not account for a large portion of the observed variation in abundance (e.g., eastern kingbird).

Many of the correlations in Table 1 must be viewed with caution. For example, the correlation between Bachman's sparrow (*Aimophila aestivalis*) abundance and shrub swamp is meaningless given the preference this species has for open pine forests and early successional habitats (Hamel 1992). The strength of this correlation is based on a single observation (Fig. 2). When the BBS route with the largest average abundance of Bachman's sparrows was removed, there was no correlation between sparrow abundance and any of the other land cover variables.

This problem likely occurs with other species and may lay at the heart of some of the correlations that appear to lack a biological basis. The effects of a few observations may also explain the greater number of positive correlations

Table 1. Sample number (*N*), Pearson product-moment correlations (positive and/or negative), and adjusted *r*-square for comparison of species abundance with different land cover variables. A land cover variable had to have an absolute *r*-value ≥ 0.50 to be included under the heading of positive or negative correlations. Acronyms under positive and negative correlation are: BA, barren lands; BH, bottomland hardwoods; CY, cypress swamp; DP, dry prairie; GR, grass and agriculture; HH, hardwood hammock; HS, hardwood swamp; MS, mangrove swamp; OW, open water; PF, pine forest; SB, shrub and brush; SM, salt marsh; and SS, shrub swamp. The adjusted *r*-squared values were calculated using multiple linear regression and a subset of variables determined using a stepwise regression procedure (see text).

Species	*N*	Positive correlations	Negative correlations	Adjusted *r*-square
White ibis (*Eudocimus albus*)	7	HH,CY,GR,SB	SM,MS,BA	0.00
Little blue heron (*Egretta caerulea*)	7	GR,HH,DP	—	0.82
Cattle egret (*Bubulcus ibis*)	25	GR	HS	0.54
Green-backed heron (*Butorides striatus*)	11	—	—	0.00
Killdeer (*Charadrius vociferus*)	10	GR	—	0.41
Turkey vulture (*Cathartes aura*)	18	DP,GR	—	0.52
Black vulture (*Coragyps atratus*)	7	HH,GR	OW	0.97
Red-shouldered hawk (*Buteo lineatus*)	20	HS	—	0.40
Northern bobwhite (*Colinus virginianus*)	24	—	—	0.48
Mourning dove (*Zenaida macroura*)	28	—	—	0.46
Common ground-dove (*Columbina passerina*)	17	SM	—	0.92
Yellow-billed cuckoo (*Coccyzus americanus*)	15	CY	OW	0.65
Chuck will's widow (*Caprimulgus carolinensis*)	19	—	—	0.12
Common nighthawk (*Chordeiles minor*)	12	BA	—	0.27
Chimney swift (*Chaetura pelagica*)	24	—	—	0.47
Downy woodpecker (*Picoides pubescens*)	10	SM,HS,HH	—	0.68
Pileated woodpecker (*Dryocopus pileatus*)	19	—	—	0.13
Red-bellied woodpecker (*Melanerpes carolinus*)	41	—	—	0.31
Eastern kingbird (*Tyrannus tyrannus*)	8	BA,GR	—	0.00
Great-crested flycatcher (*Myiarchus crinitus*)	29	—	—	0.19
Purple martin (*Progne subis*)	24	BA	—	0.27
Blue jay (*Cyanocitta cristata*)	27	—	—	0.00
American crow (*Corvus brachyrhynchos*)	22	—	—	0.12
Fish crow (*Corvus ossifragus*)	24	SM,OW	—	0.76
Tufted titmouse (*Parus bicolor*)	24	HH	—	0.61
Carolina chickadee (*Parus carolinensis*)	14	SM	—	0.73
Carolina wren (*Thryothorus ludovicianus*)	30	PF,HH	BA	0.55
Blue-gray gnatcatcher (*Polioptila caerulea*)	9	HH	—	0.81
Eastern bluebird (*Sialia sialis*)	12	BA	—	0.89
Northern mockingbird (*Mimus polyglottos*)	27	—	—	0.29
Brown thrasher (*Toxostoma rufum*)	16	HH	—	0.36
Loggerhead shrike (*Lanius ludovicianus*)	15	GR	—	0.69
European starling (*Sturnus vulgaris*)	20	BA	PF	0.41
Red-eyed vireo (*Vireo olivaceus*)	8	—	—	0.00
Yellow-throated vireo (*Vireo flavifrons*)	8	CY,HS	BA	0.97
White-eyed vireo (*Vireo griseus*)	28	—	—	0.25
Prothonotary warbler (*Protonotaria citrea*)	7	CY,HS,SS	GR,BA	0.39
Northern parula (*Parula americana*)	24	HH,CY	—	0.58
Pine warbler (*Dendroica pinus*)	26	—	GR,BA	0.56
Common yellowthroat (*Geothlypis trichas*)	18	SS	—	0.82
Yellow-breasted chat (*Icteria virens*)	7	HS,SS	SM	0.99
Summer tanager (*Piranga rubra*)	13	—	—	0.00
Blue grosbeak (*Guiraca caerulea*)	9	—	—	0.00

Table 1. (*continued*)

Species	*N*	Positive correlations	Negative correlations	Adjusted *r*-square
Indigo bunting (*Passerina cyanea*)	13	HH	—	0.99
Northern cardinal (*Cardinalis cardinalis*)	31	—	—	0.27
Rufous-sided towhee (*Pipilo erythrophthalmus*)	29	—	—	0.15
Bachman's sparrow (*Aimophila aestivalis*)	13	SS	—	0.42
Brown-headed cowbird (*Molothrus ater*)	16	SM	—	0.32
Red-winged blackbird (*Agelaius phoeniceus*)	25	—	PF	0.50
Eastern meadowlark (*Sturnella magna*)	19	GR,DP	PF,HS	0.87
Orchard oriole (*Icterus spurius*)	8	GR,SB,BA,BH	—	0.03
Common grackle (*Quiscalus quiscula*)	38	BA	PF	0.70
Boat-tailed grackle (*Quiscalus major*)	11	BA,SM	PF	0.63
House sparrow (*Passer domesticus*)	12	SM	SB	0.77

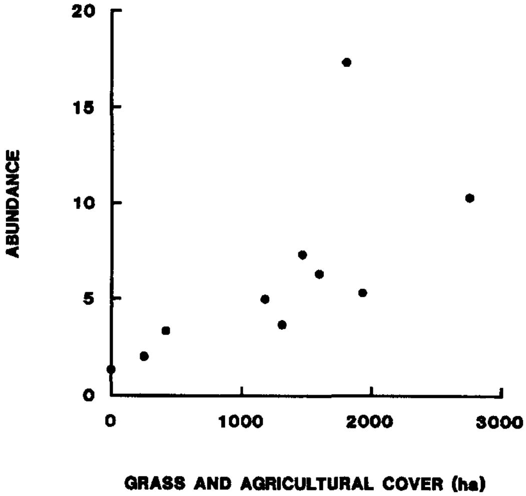

Figure 1. Mean abundance of killdeer along BBS routes in Florida versus the area (ha) of grass and agriculture land cover. Grass and agriculture land cover accounts for approximately 70% of the variation in killdeer abundance.

(56) versus negative correlations (20) in Table 1. Several of the species analyzed were more common on 1 or 2 BBS routes while having consistently lower numbers (e.g., only 1–2 individuals observed) on most other routes. Any land cover type that covers a large area along BBS routes where the species is most abundant may be assigned greater significance than it warrants. Based on a review of plots of average species abundance versus correlated land cover types, this problem appears responsible for the ambiguous correlations shown for Carolina chickadee (*Parus carolinensis*), brown thrasher (*Toxostoma rufum*), eastern bluebird (*Sialia sialis*), Bachman's sparrow, and indigo bunting (*Passerina cyanea*).

Several cover types appeared frequently in correlations with abundance while others did not (Table 1). Salt marsh, grass and agricultural, barren land, and hardwood hammock cover types were correlated with abundances of 8 species, while pine forest, cypress swamp, and hardwood swamp were correlated

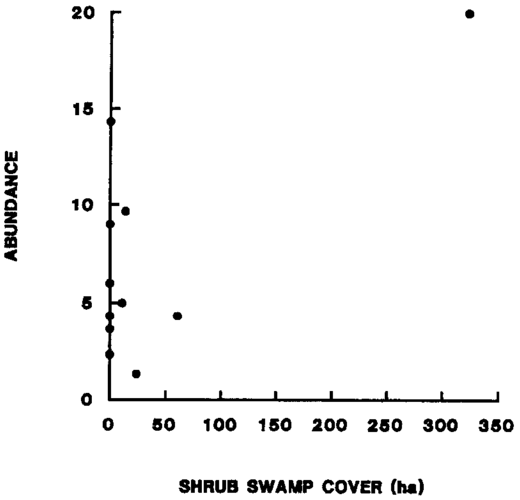

Figure 2. Mean abundance of Bachman's sparrows along BBS routes in Florida versus the area (ha) of shrub swamp land cover. The correlation between sparrow abundance and acreage of shrub swamps is heavily influenced by the route with the highest sparrow abundance.

with abundances of 5 species. Such results might occur if BBS routes sampled certain cover types in greater proportion than their occurrence throughout the State. Upland cover types are generally over-represented on survey routes, while wetland cover types are generally under-represented (Table 2). However, there is no general tendency for cover types to be correlated with species abundance following any general wetland-upland dichotomy (Table 1). Thus some other explanation is needed.

The data used here define the general surroundings within which a route occurs rather than the specific habitat variables important to determining the presence or absence of species. The number of strong correlations involving salt marsh reflects a tendency for species such as common ground-dove (*Columbina passerina*), fish crow, and boat-tailed grackle (*Quiscalus major*) to be more or less abundant along coastal BBS routes rather than a specific preference only for salt marsh habitat. Similarly, correlations with cover types such as barren land, grass and agriculture, hardwood hammock, and pinelands may indicate a general association with predominantly urban or predominantly rural survey routes rather than an association with these specific cover types. For example, the European starling increases in abundance with increasing area of barren lands (which largely corresponds to urban areas, Kautz et al. 1993) and decreases in abundance with increasing areas of pine forest, the most common forest cover type (Table 2, Kautz et al. 1993). However, a pine forest surrounded by a large area of barren land cover may contain starlings. The grass and agriculture, pine forest, barren land, hardwood hammock, and cypress swamp cover types were among the most abundant cover types mapped for Florida (Table 2, Kautz et al. 1993), and these probably serve as general indicators of "rural" or "urban" routes.

The 500-m buffers used here also encompass large areas that might not be

Table 2. Proportion of 22 land cover types throughout Florida (statewide) and within 500 m of Breeding Bird Survey Routes (BBS). Upland and disturbed cover types are generally over-represented on BBS routes while wetland cover types are under-represented.

Cover type	BBS proportion	Statewide proportion
Upland cover types		
Coastal strand	0.001	0.000
Dry prairie	0.024	0.035
Pineland	0.181	0.167
Sandpine scrub	0.008	0.006
Sandhill	0.025	0.022
Xeric oak scrub	0.006	0.005
Mixed hardwood-pine	0.014	0.014
Hardwood hammock	0.062	0.059
Tropical hammock	0.004	0.000
Wetland cover types		
Coastal salt marsh	0.010	0.012
Freshwater marsh	0.057	0.069
Cypress swamp	0.034	0.042
Hardwood swamp	0.040	0.049
Bay swamp	0.003	0.004
Shrub swamp	0.008	0.017
Mangrove swamp	0.012	0.014
Bottomland hardwood	0.000	0.002
Open water	0.073	0.160
Other cover types		
Grass and agriculture	0.186	0.104
Shrub and brush	0.123	0.106
Exotic plant	0.001	0.001
Barren	0.128	0.109

important to species with small home ranges. For some species, more meaningful correlations may have occurred if the land cover information were compiled around specific stopping points. However, it would be very difficult to relate such information to the encoded BBS data. BBS data are encoded in 10-stop intervals that span a distance of approximately 7 km. Compiling data from specific stopping points would require an expensive and time-consuming data entry effort.

Dawson (unpubl.) developed an experimental habitat classification procedure that BBS observers could use to define land cover conditions along routes. This procedure was used to collect land cover data on >70% of the routes surveyed in 1981 and 1982. These data were then analyzed in a manner similar to that performed here (Dawson unpubl.). As in this study, land cover data collected by BBS observers often proved effective in identifying variables that influenced the presence of some bird species, but there were also some anomalous or ambiguous results. In general, the predictive power of land cover variables used by Dawson (unpubl.) was weaker than the variables used here. This difference may be attributable to the GIS-based approach taken here, but it may also stem in part from the broader geographical scope of the study performed by Dawson (unpubl.), inconsistent estimates of land cover variables by volunteer observers, as well as use of slightly different statistical computations.

Outside of the experimental work reported in Dawson (unpubl.), the U.S. Fish and Wildlife Service has not proposed a systematic procedure for collecting habitat information along BBS routes. BBS observers appear willing to collect such information (Dawson unpubl.), and although land cover and habitat data may not always provide clear insights into changes in numbers of bird species along routes, it may be useful in many situations. For example, if land cover data were collected periodically (e.g., every 5–10 years), it might be used to develop more detailed evaluations of observed changes in avian numbers. The existence of land cover data spanning several years may enable researchers to assess the relative importance of habitat changes along survey routes versus some other causal mechanisms for some declining species.

In lieu of BBS observers collecting habitat information, satellite imagery may provide a coarse assessment of habitat features along BBS routes. These analyses produced some strong and seemingly meaningful correlations between average avian abundances and land cover area, and stronger relationships might emerge if either the land cover data or BBS data were organized around individual stopping points along survey routes. In addition, several states have completed or are in the process of producing vegetative cover maps similar to the one developed by Kautz et al. (1993), and this may enable broad geographic analyses to be considered once BBS routes and land cover data are linked.

However, the production of land cover maps using satellite imagery is time consuming and costly. Furthermore, such maps may not be developed on a recurring basis by all the states and provinces covered by the BBS. Land cover maps developed from satellite imagery also do not provide information on vegetation structure or height that many birds may use when selecting habitat. Only a handful of the 54 species analyzed here appeared to have biologically meaningful correlations with land cover, but there were numerous ambiguous correlations. For these reasons, I believe that land cover data collected by BBS observers or professional biologists may ultimately be more useful than satellite imagery. Given the increased emphasis placed on nongame species by state and federal wildlife agencies, professional biologists may be able to assist periodically in quantifying land cover features along BBS routes. Development of procedures to collect and process such information should be a priority for BBS organizers.

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