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LANDSCAPE EFFECTS ON COWBIRD OCCURRENCES IN MICHIGAN: IMPLICATIONS TO RESEARCH NEEDS IN FORESTS OF THE INLAND WEST

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Abstract. We evaluated cowbird distributions relative to landscape-level conditions in northern Michigan. We located 113 study sites in mature, northern hardwood forests with varying stand conditions and land-uses in the surrounding landscape, characterized out to a radius of 3 km. The probability that a cowbird would occur at any given site was 3–3.5 times greater when agricultural lands were present within 3 km of a study site. Intra-stand structural diversity and surrounding habitat heterogeneity were important predictors of cowbirds when agriculture was present within 3 km. Without the presence of agriculture, cowbird occurrence was low, regardless of surrounding habitat heterogeneity. The distribution of cowbirds in forested landscapes of the inland forests of the western U.S. is poorly understood. Studies similar to that described for Michigan need to be conducted to determine landscape and stand factors influencing cowbird occurrences, and their potential negative effects on breeding success of passerines. Complicating this possible experimental design is the open ranges of this region, and the widespread distribution of cattle. Until data on breeding success of passerines and landscape influences on this success are available, questions concerning fragmentation of western forests will remain.

Key Words: agriculture, brood parasitism, cowbirds, forest management, habitat fragmentation, habitat analysis, landscape effects, *Molothrus ater.*

Studies have implicated parasitism by Brown-headed Cowbirds (*Molothrus ater*) as a significant negative influence on the breeding success of bird populations (Mayfield 1965, Payne 1977, Airola 1986, Robinson et al. 1995b). Fragmentation of forested landscapes has been documented to increase cowbird parasitism rates (Robinson et al. 1995b). Brittingham and Temple (1983) found that cowbird parasitism in Wisconsin decreased from 65% to 18% for nests located 100 m and 300 m from an opening, respectively. This led to the generalized recommendation that creation of forest edges should be avoided (Alverson et al. 1994) in order to provide for forest interior species.

We investigated the influences of landscape characteristics, including the proximity of edges, on the probability of occurrence of cowbirds in northern hardwood stands in northern Michigan. We evaluated our results in relation to concerns about forest fragmentation. Finally, we evaluated the implications of our findings in Michigan to research needs in forested landscapes in the western United States.

STUDY AREAS

Research was conducted in the Huron National Forest (Alcona County) of northeastern lower Michigan, Pigeon River Country State Forest (PRCSF) (Cheboygan, Otsego, and Montmorency Counties) of north-central lower Michigan, Hiawatha National Forest (Delta County) in the central upper peninsula of Michigan, and the Huron Mountain Club (HMC) (Marquette County) in the northwestern upper peninsula of Michigan. Multiple landuse activities including timber harvesting, farming, prescribed burning, and recreational activities occurred at varying levels throughout these regions (Lantz 1976, Beyer 1987). Climatic conditions within each of these regions are moderated by the Great Lakes with mean annual temperatures of 5.8 C and total annual precipitation ranging from 71–81 cm (Michigan Weather Service 1974, U.S. Department of Commerce 1979, Simpson et al. 1990).

Agricultural lands and urban-suburban development were interspersed with forested lands throughout the Huron National Forest study sites. The PRCSF was a relatively contiguous state forest (33,590 ha) with agricultural lands and urban-suburban development adjoining its boundaries. The Hiawatha National Forest has a limited number of agricultural lands within its boundaries, and a small amount of urban-suburban areas. Agricultural lands were present on the southern portions of the Hiawatha National Forest, but not in the northern portions. The HMC is a privately owned reservation. Since its inception in 1889, the HMC has grown to include over 7200 ha of contiguous, mature-old growth forest. With the exception of a 20% selective cut for white pines (*Pinus strobus*) in the 1890's and some peripheral clearcuts of hemlock (*Tsuga canadensis*), sugar maple (*Acer saccharum*), and yellow birch (*Betula alleghaniensis*) from 1939–1950's, HMC has received little silvicultural treatment (Simpson et al. 1990).

METHODS

Research was conducted at a total of 113 study sites during spring, 1992 and 1993, with 57 sites surveyed for both years. Study sites were located in mature northern hardwood forest stands, no less than 4 ha in size, at least 50 years old, and surrounded by a variety of forest stand conditions and land use activities. Maximum stand size occurred in the HMC, where approximately 85% of this 7200 ha area was northern hardwoods with inclusions of other cover types. No stands containing mean tree sizes < 8 cm diameter at breast height (dbh), streams > 3 m in width, clearings (> 1.0 ha in area and having < 50% canopy cover), human dwellings, or similar disturbances within 100 m of a sampling point were selected. Study sites were selected based on current geographic information system (GIS) coverage, U.S. Forest Service vegetation maps, and ground truthing.

The avifauna at each study site was censused using 20-min, unlimited-radius point counts according to Indice Ponctuel d'Abondance (IPA) protocol (Blondel et al. 1981). The approximate center of each forest stand (study site) served as the IPA census station. In the HMC area, 20 point counts were distributed throughout the 7200 ha area, without attempting to locate individual stands or stand centers, but were placed > 100 m from an edge. Characteristics of each point, the stand it occurred in, and the surrounding landscape were measured, and treated as independent samples in the analysis. Presence of any cowbirds was recorded during its breeding season (early May–mid July). Each study site was censused three times during the breeding season, once in mid-May, once in early–mid June, and once in late June–early July.

The vegetation structure and composition of each forest stand was sampled in the immediate vicinity of the census station. Sapling density (woody stems < 8 cm dbh and > 1.5 m tall) was measured in two, 2-m × 40-m perpendicular belt transects centered upon each census point and oriented to the four cardinal directions. The line intercept method (Gysel and Lyon 1980) was used to determine the percent vertical cover within each of three height strata (0–1 m, 1–7 m, and > 7 m) along a 20-m transect that extended 270 degrees (randomly selected) from each census station. Horizontal cover was measured in four height intervals (0–0.3 m, 0.3–1 m, 1–2 m, and 2–3 m) using a profile board. Mean forest canopy height and mean basal area were measured using a Haga altimeter and tubular gauge at the center and end points of the sapling belt transect array. The point-centered quarter method (Cox 1990) was used to estimate the tree species composition and density within each surveyed stand at five points positioned every 50 m along a 200-m transect, oriented east-west and centered on the census station.

Landscape patterns were quantified using an acetate dot-grid overlay in tandem with collages of U.S. Forest Service vegetation maps and recent aerial photos. A percent measure of the area occurring as agricultural, grassland, and mixed opening (upland and lowland brush, seedling-sapling stage forests, and/or selectively cut forests with < 50% canopy coverage) vegetation types was calculated within 0.5-km, 1.0-km, 2.0-km, and 3.0-km radii of each study site. Distances from each census station to the nearest edge and opening were measured (in meters) from the collage base maps using a metric ruler. Edges were defined as areas in early successional stages, at least 12 m wide, with no trees > 8 cm dbh (e.g., primary and secondary roads, transmission line corridors, shorelines, openings). Openings were defined as areas > 0.4 ha with > 50% open canopy (e.g., grasslands, agricultural fields, and mixed openings).

Logistic regression using the variable selection method (Hosmer and Lemeshow 1989) was used to assess which habitat variables (covariates) were important predictors of cowbird occurrence at census stations. For sites that were sampled in both 1992 and 1993, only one year's sampling was used in the analysis, the year being chosen randomly. Exceptions were any sites that underwent silvicultural treatment between years, which were then assumed to be independent observations. We did not analyze each year individually as we wished to focus our analysis on the overall landscape characteristics affecting cowbird distribution and occurrence rather than short term temporal dynamics of cowbird populations.

The chi-square test of independence (Ott 1988:249–258) ($\alpha < 0.1$) was used to analyze the occurrence of cowbirds at sites possessing specific a priori defined conditions: (1) census stations in mature (> 50 years old) hardwood forest stands with > 90% canopy coverage > 400 m from an edge, as defined above; (2) census stations in forested regions (4 sections [2.59 km^2/section] in size) where > 80% of the area was comprised of forest stands having > 50% canopy cover of trees > 8 cm dbh; and (3) census stations in selectively harvested forest stands having a mean basal area > 16 m^2/ha.

Two-sample t-tests and F-tests were performed on all variables measured in sites having cowbirds versus those lacking cowbirds. A variable was considered for inclusion in the logistic regression model if its t-test P-value was < 0.25. This liberal P-value served to include potentially

important interaction terms. The F-tests were used in selecting the appropriate t-test for equal or unequal variances. Correlation analysis of the variables provided insight as to which variables met the independence assumption in logistic regression. Those variables that correlated significantly ($\alpha = 0.05$) with relative cowbird abundance and were independent or potentially biologically significant, and had a significant t-test result, were used in the saturated logistic regression model. An examination of the Wald statistic as well as each variable's estimated coefficient within the saturated model and the model with only that variable were compared. Those variables exhibiting significance ($P < 0.10$) were noted and remained in the model.

Quantile analyses on variables remaining in the model were implemented to ascertain the correct scaling for the covariates (Hosmer and Lemeshow 1989). Estimated quantile coefficients (β) exhibiting a quadratic or U-shaped pattern required an appropriate design variable to be used in the model given that these functions tend to exhibit a non-significant zero slope. Upon completion of this analysis, any variable having a non-significant Wald statistic was removed except for potential biologically relevant parameters (based on prior investigations from the literature and a priori selected land use variables). These remaining covariates represented the main effects model.

RESULTS

Cowbirds occurred in all of the four general locations examined except for the HMC. Mean relative cowbird abundance was 5.6% (number of cowbirds as a percentage of total birds observed) for Huron National Forest sites, 0.7% for both PRCSF and Hiawatha National Forests sites, and 0.0% for HMC sites. The proportion of study sites with cowbirds present was 0.701 for Huron National Forest sites, 0.487 for PRCSF sites, 0.207 for Hiawatha National Forest sites, and 0.0 for HMC sites.

The logistic regression analysis indicated that cowbird occurrence in northern Michigan hardwood forest stands could be predicted (91.6% concordance) based on five habitat variables: occurrence of agriculture within 3.0 km of a census station, total percent of non-agricultural openings within 0.5 km of the census station, percent vertical cover in the 1–7 m stratum, percent vertical cover in the 0–1 m stratum, and mean canopy height in meters (Table 1). The most influential variable in the logistic regression model in terms of cowbird predictions was the presence or absence of agriculture within 3 km of a study site (Stribley 1993). Further analysis indicated that cowbirds were 3–3.5 times more likely to occur in a forest stand when agriculture was present in the surrounding landscape (3 km). However, the probability of finding cowbirds at a study site dropped appreciably when the nearest agricultural lands were no closer than 2 km.

TABLE 1. LOGISTIC REGRESSION MODEL (CONCORDANT = 91.6%, TIED = 0%, DISCORDANT = 8.4%) FOR PREDICTING COWBIRD OCCURRENCE IN NORTHERN MICHIGAN HARDWOOD FOREST STANDS, 1992–1993

Variable	β[a]	SE[b]	Wald χ^2	Prob > χ^2
Intercept	4.182	2.435	2.950	0.0859
Height[c]	−0.4009	0.1226	10.70	0.0011
Ver Cover1[d]	5.654	1.583	12.76	0.0004
Ver Cover2[e]	2.591	1.159	4.997	0.0254
Ag Pres[f]	1.564	2.360	2.880	0.0172
Openings[g]	4.005	0.657	5.671	0.0897

[a] Estimated coefficient.
[b] Standard error of estimated coefficient.
[c] Mean canopy height (m).
[d] Percent vertical cover in the 0–1 m stratum.
[e] Percent vertical cover in the 1–7 m stratum.
[f] Occurrence of agriculture within 3.0 km of a study site.
[g] Total percent of non-agricultural openings (primary and secondary roads, ≤ 20 year-old clearcuts, selective cut areas with < 50% canopy closure, grassland areas, upland and lowland brush) within 0.5 km of a study site.

The chi-square test for independence indicated that cowbirds were significantly less likely to occur in forest stands that were > 300 m from an edge and had > 70% canopy cover. A comparison of the distance to the nearest edge with the distance to the nearest grassland or agricultural opening for those stands meeting the > 400 m and > 90% canopy closure requirements indicated the distance to the nearest opening was not significant, whereas the distance to the nearest edge was. Study sites with mean tree basal areas < 16 m^2/ha were significantly more likely to have cowbirds present than absent. Correlation analysis indicated, however, that mean tree basal area did not correlate significantly with relative cowbird abundance. Covariates that did correlate significantly with relative cowbird abundance included mean tree canopy height, percent vertical cover in the 0–1 m stratum, percent vertical cover in the 1–7 m stratum, percent agriculture within 3 km of a study site, and percent mixed openings within 0.5 km of a study site.

Results of the chi-square test of independence indicated that as much as 20% of a 4-section sized forested area can occur in open vegetation types while maintaining a significantly lower probability of cowbird occurrence than similar areas with > 20% in open vegetation types.

DISCUSSION

The distribution of Brown-headed Cowbirds in northern Michigan is clearly influenced by

landscape characteristics. Logistic regression identified five variables that influenced the occurrence of cowbirds in northern hardwood stands. The variable with the greatest influence was the presence of agricultural lands in within a 3-km radius of a northern hardwood stand. These findings are consistent with other studies that have identified the proximity of cowbird feeding sites as a major influence on the occurrence or abundance of cowbirds (Ankney and Scott 1980, Rothstein et al. 1984). The implication of this to northern Michigan landscapes is significant, with the HMC as a good example. Agricultural lands do not occur within 3 km of these study sites, and no cowbirds were detected. Christy (1925) reported the occurrence of cowbirds in the HMC at a time when the club maintained a horse stable and pasture area.

This relationship is further demonstrated in Delta County. Four study sites in the southern part of this county were interspersed with agriculture and urban-suburban areas, and all had cowbirds present. The remaining 21 sites were located further north and did not have agricultural lands within 3 km, and had (with one exception) no recorded cowbirds present, regardless of silvicultural activities or other landscape characteristics.

In landscapes with agriculture present, other factors then influenced the likelihood of cowbirds occurring in a northern hardwoods stand. The proximity of edges was found to increase the likelihood of occurrence in these landscapes. Census stations that were more than 300 m from an edge, as defined for this study, for stands having >70% canopy coverage had significantly lower occurrence of cowbirds. Similarly, if 80% of a 4-section sized area was maintained in closed canopy stands, the occurrence of cowbirds was significantly less.

Certain stand characteristics were also found to influence the occurrence of cowbirds once agricultural lands were in the surrounding area. Percent cover in the 0–1 m stratum was the most significant predictor of cowbird occurrence after the presence of agricultural lands. Cowbird probability of occurrence was also found to increase as the percent mid-story cover (1–7 m) increased. These relationships may have been caused by the increased availability of nesting sites for host bird species in stands with higher structural diversity, attracting cowbirds to these stands.

Our results differ from those of Robinson (1990), who reported that cowbirds were pervasive throughout the Shawnee National Forest of southern Illinois regardless of distance (> 400 m) from edges or agricultural lands. Robinson et al. (1993) proposed that cowbirds in this area of Illinois were so prevalent that the forests were simply saturated with cowbirds. The Illinois landscape differs from that of northern Michigan, the former being more of a mosaic of forest patches within an agricultural landscape while the latter is agricultural patches within a forested landscape. Coker and Capen (1995) conducted a similar study to ours that investigated cowbird occurrences in Vermont landscapes. They also found the presence of agriculture (livestock areas) significantly influenced cowbird occurrence.

We conclude that the occurrence of cowbirds in northern hardwood forests of northern Michigan is most limited by the presence of agricultural lands, which provide feeding areas for cowbirds (Rothstein et al. 1984, Thompson 1994). Those forest stands occurring within 3 km of an agricultural field had the highest probability of cowbird occurrence. In the presence of agricultural influences and, we assume, other potential feeding areas (e.g., bird feeders, horse corrals), habitat heterogeneity and intra-stand structural diversity become important factors in determining where cowbirds will occur.

Management Implications in Michigan

Direct effects of cowbird parasitism on reproductive success of bird populations in northern hardwood stands in northern Michigan have not been extensively researched. Studies conducted in other parts of the Midwest (Brittingham and Temple 1983, Robinson 1990) have found that cowbirds can have significant influences on populations of breeding birds. These findings have raised concerns about fragmentation as a contributor to cowbird parasitism rates throughout the Midwest. Our results indicate that more specific factors than a general description of fragmentation are important in understanding potential cowbird influences on bird populations in northern Michigan. When agricultural lands (or other major cowbird feeding areas) are not present in the surrounding landscape, the heterogeneity of stand types or structures, and the presence of edges or openings, will not have a major influence on cowbird occurrence. We think that only when agricultural lands or other major feeding areas are within 2–3 km of a site does the influence of fragmentation by forest edges have significance for cowbird occurrence, and thus parasitism. In northern Michigan, through further analysis of landscape conditions, it may be found that the limited extent of agricultural lands leave sufficient areas that are not close to agriculture so that overall concerns with cowbirds may be negligible.

Our results also indicate that if cowbird parasitism continues to be a concern in northern

Michigan, then two different strategies may be used to address these concerns. In areas with limited numbers or amounts of agricultural lands, one strategy might be to remove these lands from agriculture through land purchases or conservation easements. While this is contrary to many government programs designed to maintain agricultural activities, the implications to native species of maintaining limited amounts of agricultural practices in marginal agricultural areas may need reevaluation. In areas lacking agricultural lands, other potential foraging areas (e.g., certain bird feeders, campgrounds, horse paddocks) may need to be identified and managed to minimize cowbird utilization if cowbirds are to be kept from occurring. Where agricultural activities will continue to be a major activity in a landscape, the second strategy would strive to maintain stand and landscape characteristics to reduce cowbird occurrences in specified locations.

Implications for Inland Forests of the Western United States

Based on findings from studies conducted in other regions of the country, concerns about habitat fragmentation have been raised about forestlands in the inland area of the western United States (DellaSala et al. 1995). Increased densities of cowbirds in National Forests in the Pacific Northwest have been identified as a concern (Sharp 1995). However, no data have been reported on the effects of cowbirds on breeding populations of birds in this region (Sharp 1995). Sharp (1995) did report, based on work by Rothstein et al. (1980), Verner and Ritter (1983), and Airola (1986), that cowbirds were congregating near cattle in the Sierra Nevada. Sharp (1995) also reported that in the Umatilla National Forest cowbirds were associated with riparian zones where cattle occurred, and found low cowbird numbers in "fragmented" conifer forests.

These studies reveal that little empirical information exists about cowbird distributions or effects on breeding bird populations in the inland forests of the West, but that relationships seem to exist with cattle. This points to the need to conduct further landscape level research to determine the influence of parameters, such as the proximity of agricultural lands, on the distribution of species such as the cowbird. As our work in northern Michigan demonstrates, general assumptions about effects of habitat fragmentation or other factors may not apply to all landscapes. Haufler (1998) discussed a strategy for bird research to address information needs for bird conservation in forested ecosystems of the western United States.

A complicating factor for landscape level studies on cowbirds in the western United States is the open range laws of many states. Cattle occur throughout most areas of both private and public lands as free-ranging animals. The implication of this to the distribution of cowbirds has not been investigated, and designing replicated research projects is difficult. Effective studies may require collaborative efforts of agencies, ranchers, and other private landowners. Only through such well-designed studies that generate empirical data on land management questions will controversies be minimized and supportable conservation strategies identified.

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