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CORRELATION OF RED-SHOULDERED HAWK ABUNDANCE AND MACROHABITAT CHARACTERISTICS IN SOUTHERN OHIO

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Abstract. We measured an index of Red-shouldered Hawk (*Buteo lineatus*) abundance along streams in southern Ohio and related differences in abundance index to landscape-scale habitat characteristics within the surveyed areas. Fifteen study sites, each a 5.8-km reach of a permanent stream, were surveyed four times using broadcasts of Red-shouldered Hawk calls and Red-tailed Hawk (*Buteo jamaicensis*) calls. We determined the landcover types in a corridor surrounding each surveyed area using a GIS landcover data grid, and counted the number of small ponds within each corridor. We calculated hawk response rate for each species as the mean number of visual or aural detections per survey. Red-shouldered Hawk response rate was inversely correlated to Red-tailed Hawk response rate ($r = -0.52$, $P < 0.04$), and was positively correlated to the number of small ponds within each stream corridor ($r = 0.77$, $P < 0.01$), suggesting that the number of small ponds was an important factor associated with Red-shouldered Hawk abundance.

Key words: Buteo jamaicensis, Buteo lineatus, *habitat, Red-shouldered Hawk, Red-tailed Hawk, survey.*

Correlación entre la Abundancia de *Buteo lineatus* y Características de Macrohábitat en el Sur de Ohio

Resumen. Calculamos un índice de abundancia de *Buteo lineatus* a lo largo de varios arroyos en el sur de Ohio y relacionamos las diferencias en este índice con características del hábitat a escala del paisaje de las áreas censadas. Trabajamos en 15 sitios (cada uno comprendiendo 5.8 km alrededor de un arroyo permanente), que fueron censados cuatro veces reproduciendo vocalizaciones de *B. lineatus* y *B. jamaicensis*. Determinamos el tipo de uso de la tierra en un corredor alrededor de cada área censada utilizando un sistema de información geográfica y contamos el número de pequeños estanques al interior de cada corredor. Calculamos la tasa de respuesta de las dos especies de gavilanes como el número promedio de detecciones visuales o auditivas por censo. La tasa de respuesta de *B. lineatus* se correlacionó negativamente con la tasa de respuesta de *B. jamaicensis* ($r = -0.52$, $P < 0.04$) y positivamente con el número de estanques dentro de cada corredor ($r = 0.77$, $P < 0.01$). Los resultados sugieren que el número de estanques es un factor importante asociado a la abundancia de *B. lineatus.*

In many areas of eastern North America, habitat around Red-shouldered Hawk (*Buteo lineatus*) nests consists of mature, mesic forest (Morris and Lemon 1983, Preston et al. 1989) located in riparian bottomlands (Bednarz and Dinsmore 1981, Woodrey 1986) or near wetlands or other surface water (Titus and Mosher 1981, Armstrong and Euler 1983, Dykstra et al. 2000). Nest sites are often reported to be relatively distant from human activities and residences (Bednarz and Dinsmore 1982, Johnson 1989, Bosakowski et al. 1992).

The apparent preference of breeding Red-shouldered Hawks for mature, continuous forest located near surface water, together with their observed diet, which includes amphibians, snakes, and crayfish (Bednarz and Dinsmore 1985, Welch 1987, Howell and Chapman 1998), suggest that Red-shouldered Hawk abundance may be correlated to the presence of mature woods or surface water. Conversely, Red-tailed Hawks (*Buteo jamaicensis*) inhabit areas that are more open and more upland than those used by Red-shouldered Hawks (Bednarz and Dinsmore 1982, Moorman and Chapman 1996). In addition, in younger, fragmented, or logged habitats, Red-shouldered Hawks may be replaced by Red-tailed Hawks (Bednarz and Dinsmore 1982, Bryant 1986); thus it is possible that Red-shouldered Hawk abundance is also limited by or related to Red-tailed Hawk abundance.

Our objective in this study was to measure an index of Red-shouldered Hawk abundance in stream corridors and to relate differences in abundance to landscape-scale habitat features (macrohabitat characteristics) and to Red-tailed Hawk abundance.

METHODS

STUDY SITES

The study took place in the Interior Plateau ecoregion of southwestern Ohio, as defined by Omernik (1987) and Ohio EPA (Larsen et al. 1988). The Interior Plateau in Ohio is approximately seven counties in the southwestern corner of the state, with the city of Cincinnati located in the southwestern corner of the ecoregion. Unglaciated in the last glacial period, this region is moderately hilly with many large and small streams that have carved valleys and ravines. About 18% of the region is urban, 35% is cropland, and 25% is forest, with much of the forest located along the

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terraces of the Ohio River, in riparian corridors, and in isolated woodlands (Peterjohn and Rice 1991). Native forests are dominated by second-growth oak-hickory (*Quercus* spp., *Carya* spp.) and beech-maple (*Fagus grandifolia, Acer saccharum*) associations, with lowland, riparian forests characterized by sycamores (*Platanus occidentalis*) and beech.

We selected fifteen study sites, each a reach of a permanent stream with adjacent habitat that was at least 50% forested, based on observers' field estimates. Generally, only one reach per stream was selected for inclusion in the study, but three reaches of the Little Miami River (separated by 17 km and 26 km) were included because of the variation in land-use along this river. One additional study site, along Monday Creek, in the Western Allegheny Plateau ecoregion, was also studied in 1998.

INDEX OF RED-SHOULDERED HAWK ABUNDANCE

We established fifteen survey routes in 1997, and surveyed them for Red-shouldered Hawks and Red-tailed Hawks between 20 February and 21 March 1997, and between 15 February and 16 March 1998. Survey dates were chosen such that most Red-shouldered Hawks would be in the courtship phase of the breeding season. Survey routes were 5.8-km long, with 10 survey stations spaced at 0.65-km intervals, as measured along the stream. (If a stream meandered such that two subsequent stations would have been separated by <0.5 km on the ground, stations were adjusted to 0.65 km apart.) Survey stations were accessed by vehicle or on foot. We surveyed each stream route once during the first two weeks of the survey period and again during the last two weeks of the survey period in each year. The direction of each survey was downstream. Responses of both Red-shouldered and Red-tailed Hawks were measured.

We conducted two or three surveys daily between 08:00 and 16:00 Eastern Standard Time. No streams were surveyed if wind speed was greater than 12–19 km hr^{-1}, if precipitation was constant, or if visibility was <1 km (McLeod and Andersen 1998). The second run of each survey in each year was conducted at a different time of the day (morning, midday, or afternoon) than the first run.

Survey protocol followed techniques described by Iverson and Fuller (1991) and used by McLeod and Andersen (1998). A 20-sec Red-shouldered Hawk call followed by a 40-sec listening period was broadcast six times; then a 20-sec Red-tailed Hawk call followed by a 40-sec listening period was broadcast six times, for a total survey time of 12 min. Calls used were recorded from the Peterson Field Guide to Bird Songs of Eastern and Central North America (Peterson Field Guide Series 1990). Calls were broadcast using a customized Fanon 10S megaphone linked to a waterproof Sony Sports Walkman (Wildlife Callers, Bellevue, Washington).

The observer recorded raptor responses, their behaviors, time elapsed since beginning the broadcast, and species of responding raptor. Response by two or more hawks of one species at a survey station was counted as a single response for statistical purposes (Balding and Dibble 1984). The same observer (CRD) conducted all surveys. We tallied response data as the number of responses of each hawk species per survey.

At most sites, we made no attempt to locate nests near stations where Red-shouldered Hawks responded. However, for three streams in 1998, we made extensive nest searches before trees were fully leafed by walking in lines approximately 75–100 m apart throughout all the wooded areas within 0.5 km of the stream survey site. By comparing the number of nests found at these three sites to our index of abundance, we were able to gauge the reliability of our index.

MACROHABITAT CHARACTERIZATION

We determined the landcover types in a 0.5-km-wide corridor surrounding the surveyed reach of each stream. We conducted landcover analysis with the ESRI ArcView operation with the Spatial Analyst Extension. Landcover types were classified using a LANDSAT Multi-Resolution Land Cover (Anderson Level 2 classification, 30-m resolution) data grid. Eight major landcover types were present within the stream corridors: residential, deciduous forest, coniferous forest, pastures/hayfields, cropland, lawns and parks, open water and wetlands, and other. The number of pixels associated with each landcover type was summed separately.

We determined the number of small ponds within each stream corridor using 1:24 000 black-and-white aerial photographs (USGS High Altitude Photography Program, ERDS Data Center, Sioux Falls, SD) taken in 1994. We verified the status of each pond <4 ha by a ground check. Three small lakes (4 to 11 ha) and two gravel pits filled with water were not included in the total number of small ponds.

STATISTICAL ANALYSES

The percentages of each landcover type within the stream corridor were log-transformed to account for non-normality. The numbers of Red-shouldered Hawk responses per survey in relation to the (log-transformed) percent coverage of different landcover types and the number of ponds were assessed with Pearson correlations. The number of Red-tailed Hawk responses per survey was similarly analyzed.

Results are presented as means ± SE. *P*-values < 0.05 were considered significant. All statistical tests were performed with SYSTAT (Wilkinson 1988).

RESULTS

RESPONSES OF RED-SHOULDERED AND RED-TAILED HAWKS

Most Red-shouldered Hawks (80%) responded during the first six minutes of calls (i.e., the Red-shouldered Hawk calls), as did most Red-tailed Hawks (62%). The time to first detection of a response was 3.6 ± 0.3 min for Red-shouldered Hawks and 4.9 ± 0.3 min for Red-tailed Hawks (two-tailed *t*-test, $t_{251} = 3.1$, $P < 0.01$). Response type differed by species. Most Red-shouldered Hawks either called or responded aggressively (calling, approaching station), while most Red-tailed Hawks silently circled well above the station (Table 1; distribution of response types differed significantly, $\chi^2_6 = 93.0$, $P < 0.001$). For Red-shouldered Hawk responses, 40% of detections were aural only, 17% were visual only, and 43% were both visual and aural. For

TABLE 1. Types of responses of Red-shouldered Hawks and Red-tailed Hawks to call broadcasts along 15 streams in southwestern Ohio, all surveys combined, 1997–1998.

Type of response	Number of Red-shouldered Hawk responses	Number of Red-tailed Hawk responses
Flew over or circled silently	13	31
Approached station silently	8	44
Perched silently	3	7
Called	57	7
Flew over or circled and called	13	7
Approached station and called	15	8
Approached station, perched, and called	33	6
Unidentified response	0	1
TOTAL RESPONSES	142	111

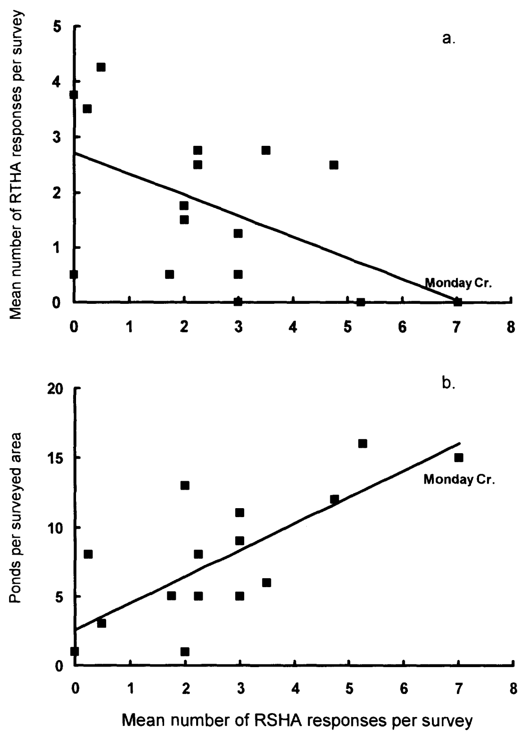

FIGURE 1. (a) Correlation of mean number of Red-shouldered Hawk (RSHA) responses per survey to mean number of Red-tailed Hawk (RTHA) responses per survey ($r = -0.52$). Each data point represents the average of four surveys conducted on one stream reach (except Wesselman Creek and Monday Creek, which were surveyed only twice each). Monday Creek is labeled because of its location in a different ecoregion. (b) Correlation between mean number of Red-shouldered Hawk responses and the number of small ponds per stream corridor ($r = 0.77$).

Red-tailed Hawks, these values were 6%, 74% and 19%, respectively ($\chi^2_2 = 87.7$, $P < 0.001$).

INDEX OF RED-SHOULDERED HAWK ABUNDANCE

The mean number of Red-shouldered Hawk responses per survey in 1997 did not differ from the mean in 1998 (paired *t*-test, two-tailed, $t_{14} = 1.3$, $P > 0.2$); nor did Red-tailed Hawk responses differ between years ($t_{14} = 0.2$, $P > 0.8$). Thus, the numbers of hawk responses in the four runs of each survey (two in 1997 and two in 1998) were averaged for statistical tests.

The mean number of responses per survey for Red-shouldered Hawks, 2.5 ± 0.5 responses per survey (range 0–7.0), did not differ from that for Red-tailed Hawks, 1.8 ± 0.4 responses per survey (range 0–4.3; paired *t*-test, $t_{15} = 1.1$, $P > 0.3$). The mean number of Red-shouldered Hawk responses per survey was inversely correlated to the mean number of Red-tailed Hawk responses per survey ($r = -0.52$, $P < 0.04$, $n = 16$, Fig. 1a).

At the three sites where we searched extensively for nests in 1998, we found eight occupied nests along Briarly Creek (compared to the survey mean of 5.3 responses), and four occupied nests along Polk Run (survey mean = 3.0 responses). These were likely all the nests within these stream corridors, because we never detected territorial pairs for which we did not know a nest location, despite extensive time spent at these sites. At Monday Creek, which was heavily forested, there were four occupied nests and two territorial pairs for which we found no nests, although such nests may have been present (survey mean = 7.0 responses).

MACROHABITAT CHARACTERISTICS AND HAWK ABUNDANCE

Macrohabitat characteristics in the corridors surrounding each stream varied widely. Forested land (total of deciduous, coniferous, and mixed forests) within the stream corridors averaged 65 ± 4% (range 40–94%), residential and lawn habitats averaged 10 ± 4% (range 0–46%), open water and wetlands averaged 3 ± 1% (range 0–12%), and most of the remaining habitat was pastures/hayfields or cropland. Mean number of ponds per stream corridor was 7.4 ± 1.2 (range 1–16).

Mean Red-shouldered Hawk response was positively correlated with the number of small ponds within the stream corridor ($r = 0.77$, $P < 0.01$, $n = 16$, Fig. 1b), but not with any other landcover variable. Mean Red-tailed Hawk response was not correlated to any landcover variable, although there was a trend indicating a positive relationship with the percentage of pasture ($P < 0.08$). Similar results were obtained when the single site located in a different ecoregion (Monday Creek) was excluded from analyses.

DISCUSSION

Our survey protocol, though not providing a measure of hawk density, appeared to be adequate for indexing abundance along streams. Although response rates on individual stream reaches varied somewhat from survey to survey, they were reliable enough to allow us to classify sites as high abundance, medium abundance, or low abundance. Hawk response rate correlated fairly well with nest density at the three sites where we searched thoroughly for nests. Elsewhere, response rates of Red-shouldered Hawks to owl broadcasts was highly correlated to number of resident pairs (Mosher and Fuller 1996).

However, in order for hawk responses to adequately index abundance, it may be necessary to conduct surveys only during the pre-laying, courtship phase. After eggs are laid, response rate decreases (Fuller and Mosher 1981, Johnson and Chambers 1990, McLeod and Andersen 1998). A possible difficulty in correctly timing such surveys might be that migratory birds may not be present in their breeding areas when surveys begin; however, this problem did not affect our study, because adult Red-shouldered Hawks were nonmigratory in southwest Ohio (13 of 13 radio-marked hawks remained in their breeding areas all year, Dykstra and Hays, unpubl. data).

Red-shouldered Hawks may be replaced by Red-tailed Hawks as habitats are logged, fragmented, or converted to agriculture (Bednarz and Dinsmore 1982, Bryant 1986). In comparative habitat studies, Red-tailed Hawks inhabited areas that were more upland and more open than those occupied by Red-shouldered Hawks (Bednarz and Dinsmore 1982, Moorman and Chapman 1996). Our results are consistent with the hypothesis that Red-tailed Hawks replaced Red-shouldered Hawks, but they do not necessarily indicate that this occurred. Breeding hawks of both species are highly territorial, and may defend their territories from intruders of either species; hence, there is space enough for only a finite number of hawks of any species.

The only macrohabitat feature correlated to Red-shouldered Hawk abundance, the number of ponds within the stream corridor, explained 51% of the variance in Red-shouldered Hawk abundance. Because Red-shouldered Hawks in southwestern Ohio acquired a minimum of 24% of their prey items from aquatic sources (Dykstra and Hays, unpubl. data), it is logical that they would nest in areas with numerous food sources (small ponds). If water were a significant determinant of abundance, one might predict that the percentage of open water within a stream corridor might also be correlated to hawk abundance. However, the percentage of water as a land cover category in each survey corridor was very small (<10%), and large portions of that water represented areas that likely were not useful to foraging Red-shouldered Hawks, such as the deep-water centers of lakes and rivers, and water-filled gravel pits.

No other landcover variables were correlated to hawk abundance. There are two possible interpretations of the lack of further relationships. (1) Much of the variance in hawk abundance was attributable to the number of ponds, and hawk abundance may truly have been unrelated to any other macrohabitat features in southwestern Ohio. (2) The landcover database may have been too coarse to distinguish habitat differences important to hawks; for example, we were unable to distinguish mature and young forest, and hawk abundance may have been correlated to the proportion of mature forest in a corridor, rather than to overall forest proportion.

The association of Red-shouldered Hawks with ponds in our study was consistent with conclusions from other studies. In Georgia, home ranges of radio-marked Red-shouldered Hawks contained beaver ponds or other temporary or permanent pools (Howell and Chapman 1997). Additionally, nest sites of Red-shouldered Hawks have been found to be associated with wet woods, wetlands, riparian areas, and other surface water (Bednarz and Dinsmore 1981, Bosakowski et al. 1992, Dykstra et al. 2000, McLeod et al. 2000). The previous studies were in undisturbed areas, whereas this study was in a developed area. Most of the ponds in our study were anthropogenic, and the presence of numerous ponds seemed positively related to suburban or rural development, ($r = 0.42$). Despite the difference in disturbance level, Red-shouldered Hawks were associated with the presence of ponds in all instances.

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