HABITAT STRUCTURE AND PRODUCTIVITY IN RED-TAILED HAWKS

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Recent studies on populations of Red-tailed Hawks (*Buteo jamaicensis*) in different parts of North America have revealed aspects of population dynamics such as predator-prey relationships (Luttich et al., 1970), reproductive success (Gates, 1972; Wiley, 1973), and competition with other raptors (Luttich et al., 1971; Houston, 1975). Although vegetation structure was often considered, it was never investigated as a dominant factor affecting productivity.

In the analysis of Holt's banding records from 1963 through 1975 for 53 nesting sites in Butler County, Ohio, productivity for 461 pairs averaged 1.2 (0.4–2.1) nestlings per resident pair. The sites are located in habitat characteristic for Red-tails nesting in southwestern Ohio—tree islands (woodlots) of different sizes surrounded by various types of agricultural land. Some of these sites were consistently high in Red-tail productivity, others consistently low.

Vegetational parameters of the woodlot and the surrounding agricultural land which might be important to the high productive sites may be absent or considerably different in the low productive sites. Thus, this pilot study was designed to investigate the relationship of the structure of the nesting woodlot and surrounding habitat to productivity.

METHODS

Two low and two high productive sites in Butler County, Ohio were selected in 1975 for vegetational analysis. From Holt's banding records, the number of nestlings per resident pair averaged 0.95 (0.9–1.0) for 24 pairs in the low, and 1.7 (1.4–2.0) for 22 pairs in the high productive sites. The number of nestlings (bandable young 2–5 weeks old) per successful nest averaged 1.4 (1.3–1.4) for the low, and 2.3 (2.2–2.4) for the high productive sites.

A hunting range radius of 0.75 mi (Craighead and Craighead, 1956), was drawn around each nest site which had been plotted on topographic maps. A circle connecting the outermost boundaries was transcribed to give an "extrapolated hunting range" for each site. Within each extrapolated range, estimates were made from topographic maps of the percentage of woodlot and agricultural land actively farmed or rotated (crop-pasture) or left fallow (fallow-pasture). To verify vegetational boundaries, field checks were made at each site and landowners were consulted.

The method of James and Shugart (1970) was modified to sample the woodlots quantitatively. The area of each woodlot was estimated from topographic maps to determine the number of 20 × 40 m quadrats necessary for sampling two to three percent of the vegetation (Mueller-

Dombois and Ellenberg, 1974). The low productive sites required 2 and 13 quadrats, the high productive sites 2 and 11 quadrats.

Several community parameters were measured in each quadrat for each woodlot. Tree heights were measured with a clinometer. Canopy cover and ground cover were measured every 10 m by using an ocular tube first pointed upward, and then to the ground. Sightings were scored positive if vegetation was present.

To determine the density of samplings per acre, two arm-length transects were made across each quadrat and the number and species of saplings 1 inch diameter breast height (dbh) were recorded.

For sampling the trees in each area, seven size classes were selected: size class 1, 1–3 inch dbh; size class 2, 3–6 inch dbh; size class 3, 6–9 inch dbh; size class 4, 9–15 inch dbh; size class 5, 15–21 inch dbh; size class 6, 21–27 inch dbh; and size class 7, 27–33 inch dbh. However, for the purpose of sampling the woods independent of size class, the nearest tree over 1 inch dbh along each transect was tabulated. This sample was intended to represent the total woodlot community.

To determine community structural differences in each productive site, tree species richness and importance values were computed. Tree species richness was the total number of tree species greater than 1 inch dbh sampled within each study area. Importance values were computed according to Cottam and Curtis (1965) by summing the relative density, the relative frequency, and the relative basal area.

To determine the significance of nesting trees to productivity, importance values were correlated with each species of tree used for nesting.

RESULTS

High productive sites were surrounded mostly by fallow pasture, and had less than 10% of the extrapolated range in woodlot (Table 1). Low productive sites had about twice as much woodlot and were bounded by crop-pasture. Thus, the amount of woodlot within a Red-tail's territory may not be as important to productivity as is the type and extent of surrounding vegetation.

The structure of the woodlot, in terms of percentage canopy cover and ground cover, was consistently higher in the low productive sites, and is apparently related to productivity as interpreted by the non-overlapping ranges (Table 1). Height of the canopy was similar in both high and low sites, although low productive sites had a greater range. Low productive sites averaged over twice as many saplings per acre than did the high productive sites, although again, low productive sites had a much greater range than high. Low productive sites also averaged nearly twice as many trees whose dbh was less than 6 inches (Table 2). Basal areas for the two sites were highly variable from size class to size class and showed no distinct pattern (Table 2). Greatest differences were found for trees ranging from 27 to 33 inches dbh. In this size class, basal areas of the high productive sites were twice that of the low productive sites.

TABLE 1

Average values of several woodlot parameters and average percent of vegetation types for Red-tailed Hawk nesting sites.[1]

Productive sites	Woodlot structure				Vegetation types			
	% Canopy cover	% Ground cover	Canopy height (ft)	Saplings per acre	Woodlot	Crop pasture	Fallow pasture	Other
Low	96.3 (95.8–96.7)	93.8 (91.7–96.0)	63.9 (59.8–68.0)	2,220 (697–4,370)	20.8 (12.8–28.9)	51.1 (50.6–51.6)	27.0 (19.4–34.7)	1.82
High	90.5 (87.0–93.9)	88.2 (87.0–89.4)	68.6 (66.8–70.5)	961 (500–1,422)	8.1 (6.7–9.5)	23.2 (9.8–37.1)	68.6 (53.3–85.8)	—

[1] Ranges are in parenthesis.

TABLE 2

Average density and basal areas of trees of different size class for two low and two high productive Red-tailed Hawk nesting sites.[1]

	Diameter size class	Trees per acre and basal area (ft^2) per acre by diameter size class in inches						
		1–3	3–6	6–9	9–15	15–21	21–27	27–33
LOW	Trees/acre	94 (47–142)	61 (37–85)	11 (10–12)	7 (5–9)	3 (2–4)	1 (0–3)	1 (0–2)
	Basal area/acre	3.8 (1.9–5.7)	6.1 (3.0–3.7)	3.3 (3.0–3.7)	5.5 (4.0–7.0)	5.6 (4.5–7.0)	4.7 (0.0–9.4)	6.1 (0.0–12.2)
HIGH	Trees/acre	59 (14–105)	29 (16–42)	12 (0.0–25)	7 (5–10)	0.5 (0–1)	0.0 —	0.0 —
	Basal area/acre	2.3 (0.5–4.2)	2.9 (1.6–4.2)	5.6 (3.7–7.6)	3.9 (0.0–7.9)	5.7 (2.4–9.0)	1.4 (0.0–2.8)	12.2 (0.0–24.5)

[1] Ranges are in parenthesis.

No relationship is evident between productivity and tree species number (Table 3). Tree species richness (number of tree species greater than 1 inch dbh) for the two low productive sites ranged from 12 to 19 species as compared to 15 and 18 species for the high productive sites.

Importance values for the top five tree species of each woodlot are summarized in Table 3. No distinct patterns existed in importance values between low and high productive sites; the most important species were different for each woodlot. Slippery elm ranked first for one high productive site, and second for one low productive site. Sugar maple ranked first for one high productive site as compared to a fourth ranking in a low productive site. White ash was the only species to have high importance rankings for both of the high productive sites, and in addition had the topmost rank in one of the low productive sites. In general, each woodlot exhibited a gradually declining set of dominant top canopy species.

Importance values were also correlated with each tree species used by the Red-tails for nesting. Overall, 11 of 19 (58%) of Red-tail nestings were in sycamore, white ash, red oak, and American beech trees, all of which were ranked in the top five importance values (Table 4). In one low productive site, sycamores, which had the highest ranked importance value, were always selected for nesting. In the other site, the two top ranked species (white ash and red oak) were selected 2 of 4 times (50%). Thus, overall, tree species among the top five importance values were selected as nest trees 7 of 9 times (78%) in the low productive sites, and 4 of 10 times (40%) in the high productive sites. Trees with low ranking importance values (greater than 5) were selected as nesting trees only once in the low productive sites, as compared to their selection 6 of 10 times (60%) in the high productive sites. Thus, the importance (dominance) of a tree species may play a role in nest site selection, but appears to have no direct relationship to productivity.

DISCUSSION

Results of this study suggest that Red-tail productivity may be related to the structure of the woodlot, and percent of hunting territory in fallow pasture. Low productive sites are characterized by a greater percentage of ground cover and canopy cover as well as twice as many saplings and trees less than 6 inches dbh. Such community parameters more accurately measure the degree of openness of the community.

In previous studies, more Red-tail nests were found in open woodlots than in closed or dense woodlots. Of 89 Red-tail nests in Wisconsin, 64% were in open stands, 26% on edges, and 10% within dense woods (Orians and Kuhlman, 1956). More recently, Gates (1972) in eastcentral Wisconsin found only 4 of 31 (13%) Red-tail nests located in closed canopy woodlots; 58% were in open woodlots and 29% were in isolated trees along fencelines and ditchbanks. Misztal (1974), in six study sites in western Ohio, found 78% of all Red-tail nests in woodlots with an

TABLE 3

Three community parameters for Red-tailed Hawk nesting woodlots (dbh > 1 inch).[1]

Species	Relative density (A)	Relative frequency (B)	Relative basal area (C)	Importance value (A + B + C)
	Low productive sites			
	Site 1			
Sycamore *Platanus occidentalis*	10.3	5.8	35.2	51.3
Box Elder *Acer negundo*	17.2	5.8	8.5	31.6
Cottonwood *Populus deltoides*	4.1	3.9	15.4	23.4
Sugar Maple *Acer saccharum*	11.7	6.9	3.6	22.2
Ohio Buckeye *Aesculus glabra*	8.3	6.9	3.5	18.7
TOTAL SPECIES RICHNESS (19)	51.6	29.3	66.2	147.2
	Site 2			
White ash *Fraxinus americana*	23.1	9.5	65.0	97.6
Slippery Elm *Ulmus rubra*	18.3	9.5	5.0	32.8
Washington-thorn *Crataegus phaenopyrum*	17.7	9.5	4.4	30.6
Red Oak *Quercus borealis*	9.2	9.5	1.1	25.8
Honey Locust *Gleditsia triacanthos*	10.0	9.5	5.3	24.8
TOTAL SPECIES RICHNESS (12)	78.3	47.5	80.8	211.4
	High productive sites			
	Site 1			
Slippery Elm *Ulmus rubra*	54.4	9.5	12.9	76.8
White Ash *Fraxinus americana*	2.9	9.5	27.3	39.7
Basswood *Tilia americana*	1.5	4.8	26.8	33.1
Blue Ash *Fraxinus quadrangulata*	5.9	4.8	10.8	21.5
Hop Hornbeam *Ostrya virginiana*	5.9	9.5	1.5	16.9
TOTAL SPECIES RICHNESS (18)	70.6	38.1	79.3	188.0

		Site 2		
Sugar Maple *Acer saccharum*	31.3	20.2	19.0	70.5
Tulip *Tulipa sylvestris*	17.3	14.1	30.2	61.6
American Beech *Fagus americana*	6.0	8.0	17.9	31.9
Hackberry *Celtis occidentalis*	11.3	8.0	4.6	23.9
White Ash *Fraxinus americana*	5.3	8.0	5.3	18.6
TOTAL SPECIES RICHNESS (15)	71.2	58.3	77.0	206.5

[1] Only the top five dominant trees of each site are listed.

open canopy. In addition, woodlots that were grazed had the largest number of nesters.

Despite the fact that Red-tails select predominantly open canopy or grazed woodlots, information is lacking on the degree of reproductive success of hawks nesting in these different habitats. Cornman (1973) found that although 90% of nesting Red-tails used open woods or woods edge, productivity was not significantly different from that of Red-tails nesting in deep woods. Also, northern or eastern facing nest sites, although selected less frequently, showed 100% nesting success. Of 76 Red-tails nesting in central Ohio, 73% preferred open woodlots or edges, but there was no significant difference ($P > .05$) between edge and center nest productivity (J. S. Kirkley and M. A. Springer, Ms). In contrast, the findings of this study suggest that Red-tail productivity may be related to certain parameters of woodlot structure and/or vegetation surrounding the nesting site. Perhaps the influence of vegetation structure is only indirectly related to productivity, as a function of cover for prey, for example. Red-tails in dense woods may be close enough to open fields to obtain rodent prey, or may simply choose alternate prey items, a more likely alternative given the opportunistic hunting behavior of the Red-tail.

Productivity was not related to importance values as each woodlot exhibited a different set of dominant top canopy species. Nor was productivity related to preference for a specific nest tree. The opinion that Red-tails do not choose particular nest trees except for size was expressed some 40 years ago (Bent, 1937). Misztal (1974) found that nest trees ranged from 15–50 inches dbh ($\bar{x} = 25$). Our results show that Red-tails prefer common top canopy trees for nesting. Other studies supporting our findings that Red-tails select common trees for nesting are Gates (1972), Cornman (1973), and Johnson (1975). The only exception was the study of Orians and Kuhlman (1956) during the pre-

TABLE 4

Importance values (IV) and preferred nesting trees of Red-tailed Hawks, 1964–1974.

Tree species	Importance value	IV Ranking	No. of times used as nest tree
	Low productive sites		
		Site 1	
Sycamore *Platanus occidentalis*	53.1	1	5
		Site 2	
White Ash *Fraxinus americana*	97.6	1	1
Red Oak *Quercus borealis*	25.8	4	1
Shagbark Hickory *Carya ovata*	12.8	9	2
	High productive sites		
		Site 1	
White Ash *Fraxinus americana*	39.7	2	3
Burr Oak *Quercus macrocarpa*	6.4	18	1
Shagbark Hickory *Carya ovata*	—	>18	1
		Site 2	
American Beech *Fagus grandifolia*	31.9	3	1
Black Cherry *Prunus serotina*	12.2	8	1
Shagbark Hickory *Carya ovata*	6.1	13	1
Black Locust *Robinia pseudoacacia*	3.2	15	1
Black Walnut *Juglans nigra*	—	>15	1

Dutch elm disease era. They reported that although elms were outnumbered by both sugar maples and white oaks, 52 of 90 (58%) of all Red-tail nests were in elms. They attributed this to the spreading branches of the elm which provided more nest cover and also many suitable sites for nest building materials.

The low percentage of woodlot in the high productive sites was not surprising since research shows that Red-tails nesting in open areas have often been highly productive (Gates, 1972; Holt, pers. comm.). High productive sites characteristically had over twice as much fallow pasture around them. Of five cover types studied by McInvaille and Keith (1974) in Alberta, 44% was in agriculture. Included in this cover-type was all land in cultivation, pasture, and forest clearing. Within a 0.75 mi radius of their hawk nest sites, average percentage of cover types over six years was 41% agricultural and 34% for forest cover. Hence, their Red-tails had hunting ranges enclosing more forest and less agricultural habitat than our Ohio Red-tails. In the Alberta sites the average number of young fledged per nesting attempt was 0.92%.

The amount of fallow pasture surrounding nesting sites may be indicative of more prey habitat. Productivity apparently is related to the availability and cycling of specific prey within the hunting range (McInvaille and Keith, 1974). They found the relationship of percent biomass of Richardson's Ground Squirrels (*Spermophilus richardsoni*), a prairie species, to the percentage of agricultural cover-type strongest (r^2 = 0.56) in 1970 when ground squirrel populations were highest. Consumption of Snowshoe Hares (*Lepus americanus*), a forest species, was directly related to the proportion of forests and brush cover around nests (r^2 = 0.52–0.61). Both were the main prey of Alberta Red-tails.

Red-tail productivity in our sites also may be related to the cycling of small mammal populations. The mammalian diet of Red-tails in central Ohio is varied, consisting of mice, voles, and shrews (39%), Eastern Chipmunks, *Tamias striatus*, (19%), and Cottontail Rabbits, *Sylvilagus floridanus*, (17%) (J. S. Kirkley and M. A. Springer, Ms). According to unpublished trapping records, 1969 was a peak year for small open-field mammals (e.g., *Microtus*), in southeastern Ohio, whereas 1971 was a very low year. In 1969, 12 of 21 (57%) of our Red-tail sites had a maximum brood size of three, and only 5 of 30 (17%) had no successful nests. In 1971, the year of low rodent numbers, only 14% (3 of 21) had a maximum brood size of three, whereas 43% (13 of 30) had no successful nests.

Although our sample size was small, we believe this study provides useful information on the relationship of vegetational structure to Red-tail productivity. The approach was unique in that our investigation on productivity was in terms of viewing the long-term reproductive success of a community from the analysis of banding records. Several community parameters were found important in explaining differences between high and low productive sites. The relationship of vegetational structure, productivity and prey cycling was examined in the light of fluctuating rodent populations. We feel similar studies on hawks nesting in different habitats would be fruitful in ascertaining the degree of intra-populational reproductive success as related to community structure and land use.

SUMMARY

This study was designed to examine the productivity of Red-tailed Hawks in relationship to the vegetation structure of the nesting area.

Two low and two high productive sites were determined from analysis of banding records. High productive sites were characterized by over twice as much fallow pasture, less than one half as much crop pasture, and less than one half the amount of woodlot, factors perhaps indicative of more prey habitat and prey availability. Low productive sites had a greater percentage of canopy cover and ground cover, and averaged nearly twice as many trees with dbh less than 6 inches. No relationship was found between productivity and canopy height, saplings per acre, tree basal areas, and tree species number, although low productive sites had a greater range in canopy height and saplings per acre. Importance values appeared to be unrelated to productivity, although tree species dominance may be related to nest site selection. This study is unique in its approach of using banding records analyses to investigate the productivity of an avian species.

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REQUEST FOR PARTICIPANTS

INTERNATIONAL SHOREBIRD SURVEYS 1978

A cooperative International Shorebird Survey scheme has been organized by the Canadian Wildlife Service and the Manomet Bird Observatory since 1974 to obtain information on shorebird migration and to identify and document areas of major importance. This scheme has been highly successful, with much valuable information on shorebird distribution and migration coming from contributors throughout eastern Canada and the U.S.A., the Caribbean Islands, and Central and South America. Information from the scheme will be valuable in assessing requirements for the future protection and conservation of the birds and their habitats. It is planned to make 1978 the fifth and final year of the project. Any observer who can participate in regular counts of shorebirds during spring and autumn migration periods, as well as during the winter in shorebird wintering areas, is asked to contact one of the undersigned. Occasional counts from observers visiting shorebird areas on an irregular basis would also be most welcome. For areas in Canada: DR. R. I. G. MORRISON, *Canadian Wildlife Service, 2721 Highway 31, Ottawa, Ontario Canada K1G 3Z7*. For areas in U.S.A., Caribbean Islands, Central and South America: BRIAN A. HARRINGTON, *Manomet Bird Observatory, Manomet, MA 02345*.