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HABITAT USE AND PRODUCTIVITY OF SHARP-SHINNED HAWKS NESTING IN AN URBAN AREA

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ABSTRACT.—We measured productivity and vegetation parameters of habitat quality at 16 Sharp-shinned Hawk (*Accipiter striatus*) nests in and near the greater Montreal area in order to evaluate nesting habitat use and its possible relationship to reproductive success in an urban setting. Mean clutch size was 4.4 and hatching success was 3.8 eggs per nest. At least one egg hatched in 11 of 16 nests (68.8%), 10 (62.5%) pairs raised young to a bandable age (≥10 days old), and 8 (50%) pairs successfully produced at least one fledgling. Immature individuals comprised 33.3% of male and 38.5% of female breeders. Mean values in the habitat assessment included nest tree height, 14.0 m; tree density, 955/ha; total canopy cover, 88.1%; coniferous cover, 39.7%; mean dbh, 17.6 cm; and distance to the nearest forest opening, 19.7 m. Sharp-shinned Hawks nested in a range of forest types, from mature conifer plantations to young, almost purely deciduous stands, and this population exhibited considerable flexibility with respect to most of the habitat features that we measured. Their use of older stands with more deciduous cover than those used by conspecifics elsewhere may reflect regional differences in habitat availability as well as in the abundance of competitor species. Breeding in an urbanized area does not seem to be detrimental to Sharp-shinned Hawks, as evidenced by this population's relatively large proportion of immature breeders and normal productivity, which appeared to be independent of all the assessed parameters of habitat quality. *Received 13 March 2002, accepted 30 August 2002.*

Knowledge of the habitat requirements of Sharp-shinned Hawks (*Accipiter striatus*) is important for understanding their nesting ecology and developing recommendations for their conservation and management. As habitat fragmentation is the principal threat to the survival of most temperate zone species (Wilcove et al. 1986), efforts to understand how urban populations respond to the lack of large tracts of wilderness become especially pertinent.

Vegetation and structural characteristics are important cues for birds seeking nest sites (Reynolds et al. 1982). For accipiters, these features often reflect successional stage (Reynolds et al. 1982, Newton 1991). Younger tree stands appear to provide the appropriate environmental conditions for breeding Sharp-shinned Hawks: dense stands of small-diameter trees, with relatively thick canopies and a high proportion of coniferous cover (Reynolds et al. 1982, Moore and Henny 1983, Wiggers and Kritz 1991, Trexel et al. 1999, Bildstein and Meyer 2000).

These characteristics may influence the ability of Sharp-shinned Hawks to nest successfully. For instance, their typical nest structure would not appear to favor the use of primarily deciduous stands since they build broad, flat nests, usually on horizontal branches, close to or touching the trunk (Bildstein and Meyer 2000). Building materials consist almost entirely of coniferous twigs and branches, probably because their nodules grip each other and help hold the nest together (Newton 1991). Also, as the smallest North American accipiters, Sharp-shinned Hawks are vulnerable to predation by many larger raptors; thus, nesting in stands that offer some concealment and in which bigger birds may have difficulty maneuvering provides protection (Bildstein and Meyer 2000).

Altering vegetation cover may have major impacts upon animal populations (Morrison et al. 1998). Previous studies (e.g., Viverette et al. 1996) suggested that declines in counts of eastern migrating Sharp-shinned Hawks during the 1980s and early 1990s may reflect decreased productivity in eastern populations, and that this might be related to losses of suitable breeding habitat. The coincidental increase in migrant Cooper's Hawks (*A. cooperii*) counted at eastern watch sites may indicate that forest aging and urbanization are

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benefiting this larger accipiter, whose productivity may be unaffected by urbanization (Rosenfield et al. 1996), while reducing breeding opportunities for Sharp-shinned Hawks (Viverette et al. 1996).

Few studies of Sharp-shinned Hawk nesting habitat have been conducted previously in eastern North America and none of these examined habitat use by Sharp-shinned Hawks breeding in human-dominated landscapes, or attempted to find evidence that such habitat changes are reflected in a decrease in this species' reproductive performance. Newton (1991) observed that the closely related European Sparrowhawk (*A. nisus*) in English and Scottish cities nested in ''sub-standard'' sites. He concluded that those birds used nesting habitat according to what was available to them. Accordingly, urban Sharp-shinned Hawks also might be expected to differ from non-urban birds in their use of nesting habitat. Any costs related to urbanization might result in reduced reproductive success. We studied habitat use and productivity to investigate this issue for Sharp-shinned Hawks nesting in the Montreal area. Our goal was to compare vegetation features of their nest sites and reproductive parameters with those of non-urban populations described in the literature.

METHODS

Study area.—Our approximately square 15,625-km^2 study area was centered at 45.52 N, 73.57 W in southwestern Quebec, in the St. Lawrence lowlands, which is characterized mainly by deciduous trees. The dominant geographical feature of the study area is the city of Montreal (population of 3.5 million in 1999), which, with its suburbs, covers a total area of 4,024 km^2 (Linteau 2000) or 26% of the study area.

The area was mostly forested prior to settlement, although more than 75% of it since has been cleared. The remaining woodlots, tree rows, and remnant stands do not support much of the wildlife that once lived there. In terms of green space, Montreal has 4,000 land parcels; 91% of these are $<$10 ha and 46% are $<$1 ha, with only 10% of the green space being wooded (Government of Canada 1996).

Nest searches.—We obtained historical nest card records from the Canadian Museum of Nature in Ottawa, and current reports of incidental sightings of Sharp-shinned Hawks from birdwatchers and wildlife technicians working in municipal and provincial parks. If we were able to determine that observers had made their observations in the course of random bird watching and not systematic nest searches, we used their information to locate potential nest sites.

Starting in late April at these locations, we searched a minimum 200-m radius area in all forest types on foot, using imitations of the territorial call of the Barred Owl (*Strix varia*) to elicit defensive responses from Sharp-shinned Hawks, if present. We also used visual evidence of nesting activity, such as whitewash, pluckings, or molted Sharp-shinned Hawk feathers to locate nests.

Data collection.—At each nest we identified the putative parents as immature (second year) or mature (after second year) based upon plumage. We counted eggs during late May, past the time when Sharp-shinned Hawks nesting at this latitude normally have begun to incubate (Bildstein and Meyer 2000, EAJ and L. Semo unpubl. data). To minimize disturbance, we used a pole-mounted mirror whenever possible.

At this latitude, Sharp-shinned Hawk eggs generally hatch in mid-June (EAJ unpubl. data), so we started checking nests for hatched eggs in early June, returning every few days until hatching was completed. We expressed hatching success as the percentage of hatched eggs per clutch. We could not assess clutch size and hatching success at six nests because of inaccessibility or because the nest had failed before we confirmed clutch size. Chicks $\geq$10 days old were considered bandable; three inaccessible nests were excluded from our calculation of bandable young per active nest (a nest in which eggs were laid, n = 13, or at which we observed a female in incubating posture, n = 3). Sharp-shinned Hawks leave the nest at 21–32 days of age and for the next few days tend to remain in the nest tree and other nearby trees (Bildstein and Meyer 2000), at which time they are counted easily. We had expected the chicks to fledge at about 27 days (EAJ unpubl. data), but many fledged earlier, making accurate fledgling counts impossible. We therefore report nesting success as the percentage of active nests that produced at least one fledgling.

After the young had fledged, we collected habitat data within 0.04-ha circular plots centered on each nest tree, following the technique of James and Shugart (1970) as modified by Titus and Mosher (1981). We ensured that all sites were independent according to the criteria of Rosenfield and Bielefeldt (1992, 1996). We identified the nest tree species and four most numerous canopy species using Rouleau (1990). We measured habitat variables (see Table 1) as in Trexel et al. (1999). Whenever possible, we determined stand age by consulting the landowner.

We compared several studies of Sharp-shinned Hawk nesting habitat with respect to the dispersion (standard deviations or standard errors) associated with selected habitat variables, expecting our urban population to exhibit relatively flexible habitat use. The most appropriate measure of dispersion for comparing variables from different populations with different sample sizes and means is the coefficient of variation (CV), which we calculated from SE and SD values (Freund and Wilson 1997).

TABLE 1. Habitat characteristics for 16 Sharp-shinned Hawk nests in the Montreal area of Quebec, Canada, 1999–2001, demonstrating high variability for most habitat features, low variability for some.

Variable	Mean ± SE	Coefficient of variation (%)
Nest height (m)	9.5 ± 1.0	41.8
Nest tree height (m)	14.0 ± 1.3	38.5
Nest tree condition (%)	48.0 ± 9.0	74.0
Nest tree dbh (cm)	24.7 ± 2.6	42.1
Canopy height (m)	15.1 ± 1.4	37.3
Total canopy cover (%)	88.1 ± 2.2	10.1
Deciduous cover (%)	48.4 ± 7.0	57.8
Coniferous cover (%)	39.7 ± 6.2	62.0
Understory cover (%)	34.5 ± 7.4	86.1
Ground cover (%)	29.1 ± 4.7	64.1
Shrub density[a] (no. of tall shrubs/plot)	29.0 ± 9.0	100.0
Shrub index[a] (no. of low shrubs/plot)	55.0 ± 13.0	79.0
Tree density (trees/ha)	955.0 ± 155.0	65.0
Understory density[a] (trees/ha)	44.0 ± 18.0	135.0
Basal area of trees (m^2/ha)	28.7 ± 3.5	49.0
Mean dbh (cm)	17.6 ± 1.8	41.9
Distance to water[b] (m)	60.0 ± 22.3	111.7
Distance to opening (m)	19.7 ± 5.1	102.8
Stand age (years)[c]	44.0 ± 7.0	43.0

[a] Variable not assessed at five nests.
[b] Variable not assessed at seven nests where location of nearest water source was unknown.
[c] Variable not assessed at eight nests where age of stand was unknown.

RESULTS

Nesting.—Of the putative breeders for which age was determined, 38.5% of females and 33.3% of males were immature. Both putative parents were immature at 3 of 16 nests. Mean clutch size was 4.4 (range, 4–5; n = 10). The mean number of eggs hatched per active nest (n = 10) was 3.8 (range, 0–5) and mean hatching success was 77.7%. Ten of 16 pairs (62.5%) raised ≥1 chick to bandable age, but we counted bandable nestlings at only seven nests, where the mean number of bandable young was 3.9 (range, 2–5). The mean number of bandable young per active nest (n = 13) was 2.1 (range, 0–5), with 8 of the 16 nests successfully fledging ≥1 young.

Habitat.—All nests (n = 16) were in conifers, including four in white spruce (*Picea glauca*); two each in Norway spruce (*P. abies*), black spruce (*P. mariana*), jack pine (*Pinus banksiana*), white cedar (*Thuja occidentalis*), and eastern hemlock (*Tsuga canadensis*); and one each in white pine (*Pinus strobus*) and balsam fir (*Abies balsamea*). At all but two sites, conifers were well represented in the canopy. Thirteen stands were mixed, and none were monospecific. The species most commonly present in the surrounding canopy were red and sugar maple (*Acer rubrum* and *A. saccharum*); grey, paper, and yellow birch (*Betula populifolia*, *B. papyrifera*, and *B. alleghaniensis*); trembling poplar (*Populus tremuloides*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), red oak (*Quercus rubra*), and red pine (*P. resinosa*).

Mean stand age was 44 years (range, approximately 30–100 years). Means and coefficients of variation for the other habitat variables are given in Table 1.

Nesting success was not significantly correlated with either tree density (r = 0.18, n = 16, P = 0.51) or distance to nearest opening (r = 0.14, n = 16, P = 0.59).

DISCUSSION

The Sharp-shinned Hawks in and near Montreal nested closer to openings ($\bar{x}$ = 19.7 m) than conspecifics in Wisconsin ($\bar{x}$ = 58 m; Trexel et al. 1999) or Arkansas ($\bar{x}$ = 46 m; Garner 1999). In many cases, the nearest openings were areas of considerable human activity, including cycling or walking trails and a golf course. One nest, which was successful, was along a heavily used all-terrain vehicle trail and another, which failed, was a few meters from the main road in Montreal's Botanical Gardens. This close proximity to edges may reflect a relative scarcity of large tracts of forest in this study area.

Every Sharp-shinned Hawk nest we found was in a conifer, regardless of the type of stand. Trexel et al. (1999) reported a similarly disproportionate tendency for Sharp-shinned Hawks to use conifers in mixed forest. However, our population used stands with the least coniferous cover ($\bar{x}$ = 39.7%) and most deciduous cover ($\bar{x}$ = 48.4%) of all studies we examined (cf. 61.3% and 15.2%, respectively, in Trexel et al. 1999). This result may reflect regional differences in vegetation across North America. Our study area was in the deciduous forest vegetation zone (Rouleau 1990). Additional studies of habitat use by nesting Sharp-shinned Hawks elsewhere in this zone may elucidate whether this pattern is common among northeastern populations.

The mean age of stands used by this population was 44 years, similar to the finding in Oregon (25–50 years; Reynolds et al. 1982). However, stand structure presumably is more important than age with respect to its suitability for nesting Sharp-shinned Hawks. While the Douglas fir (*Pseudotsuga menziesii*), western hemlock (*T. heterophylla*) and ponderosa pine (*P. ponderosa*) of Oregon's forests are still young at 50 years old, many northeastern conifers are approaching maturity at this age (Burns and Honkala 1990).

That Sharp-shinned Hawks nested in structurally mature stands may be related to the status of the Cooper's Hawk (a predator and competitor of the Sharp-shinned Hawk) in the area. There are an estimated 60 breeding pairs of Cooper's Hawks in Quebec (Barnhurst et al. 1996, Bird 1999) and only 15 nest sites were found in our study area during the past 10 years. Many of the structurally older stands they ordinarily would inhabit are unlikely to contain breeding pairs (Barnhurst et al. 1996), leaving more areas for Sharp-shinned Hawks to nest.

Low Cooper's Hawk numbers similarly may explain the comparatively high deciduous cover for the nest sites of our Sharp-shinned Hawk population. The study by Trexel et al. (1999) is an interesting contrast: since Wisconsin delisted the Cooper's Hawk in 1989 (Rosenfield and Bielefeldt 1993), it may have become the most numerous forest hawk in that state (Bielefeldt et al. 1998). There, stands used by nesting Sharp-shinned Hawks were denser, with more coniferous cover than those used by Cooper's Hawks in the same region, or by Sharp-shinned Hawks in our study. If the Cooper's Hawk population also is increasing in Quebec (F. Shaffer and P. Fradette pers. comm.), revisiting this issue in the future might reveal different patterns of habitat use by nesting Sharp-shinned Hawks.

The fact that this population of Sharp-shinned Hawks nested in more open sites, with more large, deciduous trees than other populations, may suggest a link between urbanization and nesting habitat use. Yet, it is difficult to separate differences in forest type due to urbanization from those due to geography. It also is impossible to compare current patterns of habitat use by nesting Sharp-shinned Hawks in such an established urban environment with patterns they exhibited prior to development. Comparing the nest sites used by urban and rural populations in a single geographic area might provide a more accurate assessment of differential patterns of nesting habitat use as they relate specifically to urbanization.

Measures of dispersion may be important in assessing a population's flexibility with respect to nesting habitat and the ability to adapt to habitat change. Contrary to our expectation that this urban population would exhibit more plasticity than rural ones, our results suggest that this species may not have stringent requirements for the majority of habitat variables we measured. Despite their ability to nest in different forest types, Sharp-shinned Hawks generally may be restricted to well-covered stands. Whereas variation in most other variables was high, CV values for canopy cover ranged from 7.7% in Wisconsin (Trexel et al. 1999) to 35.5% in eastern Oregon (Reynolds et al. 1982), with a mean of 17.1% for all studies examined.

Mean clutch size in our study (4.4) was within the range (3–8 eggs, usually 4 or 5) reported for Sharp-shinned Hawks breeding in temperate climates (Bildstein and Meyer 2000). Mean clutch sizes were 4.3 in Utah (Platt 1976), 4.4 in Wisconsin (L. Semo et al. unpubl. data), 4.5 in Missouri (Wiggers and Kritz 1994), 4.6 in Oregon (Reynolds and Wight 1978), and 3.9 in North America overall (Apfelbaum and Seelbach 1983).

Mean hatching success (77.7%) and mean brood size (3.8) were within the range of previously reported values. Hatching success rates for Sharp-shinned Hawks were 70% in Oregon (Reynolds and Wight 1978) and 87% in New Brunswick (Meyer 1987). In Missouri, Wiggers and Kritz (1994) reported a mean brood size (number of young in nest on first visit after hatching) of 3.5 chicks. The North American mean was 2.7 nestlings per nest (Apfelbaum and Seelbach 1983), but it is unclear whether this figure refers to hatching success or brood size (Bildstein and Meyer 2000). Our mean number of nestlings that reached a bandable age (3.9) was similar to that found by EAJ (3.6; unpubl. data) during 13 years in Wisconsin.

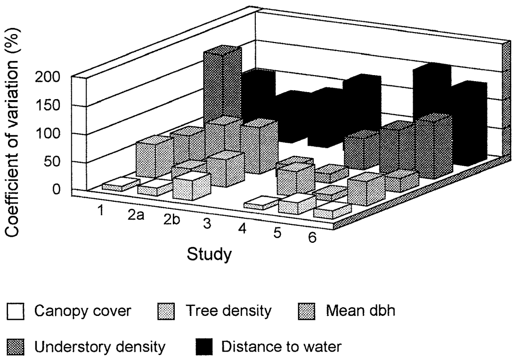

FIG. 1. Variation in habitat characteristics of 16 Sharp-shinned Hawk nest sites in the Montreal area from 1999–2001, and at nests of other populations, demonstrating flexibility with respect to most habitat variables (high CV values) and relative stringency with respect to canopy cover (low CV values). The studies were conducted in (1) Quebec, the present study; (2a) northwestern Oregon, Reynolds et al. 1982; (2b) eastern Oregon; Reynolds et al. 1982; (3) northeastern Oregon, Moore and Henny 1983; (4) Missouri, Wiggers and Kritz 1991; (5) Arkansas, Garner 1999; and (6) Wisconsin, Trexel et al. 1999.

In contrast, our nesting success (50%) was low compared to those found in Oregon (91.7%; Reynolds and Wight 1978), New Brunswick (95%; Meyer 1987), and Wisconsin (76%; L. Semo et al. unpubl. data). The mean number of young banded per nest attempt (2.1) in our study also was low compared to 2.7 in Wisconsin (L. Semo et al. unpubl. data). Weather conditions may have contributed to our high rate of nest failures. Inclement weather can reduce prey availability and hunting efficiency for raptors while increasing their energy requirements, resulting in elevated nestling mortality. Wet weather has been linked to reduced productivity in Ospreys (*Pandion haliaetus*; Odsjö and Sondell 1976), Black Eagles (*Aquila verreauxii*; Gargett 1977), and European Sparrowhawks (Newton 1991). In our study, all but one nest failure occurred during the summer of 2000, which arrived late and was unseasonably cold and rainy (A. Julien pers. comm.).

Other birds of prey, such as the Red-shouldered Hawk (*Buteo lineatus*), Eastern Screech-Owl (*Otus asio*), and Mississippi Kite (*Ictinia mississippiensis*), seem to be equally or more productive in urban areas than in rural areas (Dykstra et al. 2000, Gehlbach 1996, Parker 1996, respectively). Rosenfield et al. (1996) found that Cooper's Hawks breeding in an urban and suburban area of Wisconsin not only had relatively large clutch sizes and numbers of bandable young, but also nested at the highest nesting density ever recorded for this species.

We detected no relationships between productivity and parameters of habitat quality. For example, if forest fragmentation were impairing Sharp-shinned Hawk productivity, we would have expected pairs that nested closer to edges to perform comparatively poorly. Similarly, if forest aging were reducing the productivity of Sharp-shinned Hawks which, according to many studies (Reynolds et al. 1982; Moore and Henny 1983; Wiggers and Kritz 1991; Trexel et al. 1999; Bildstein and Meyer 2000), nest mainly in dense woods, breeders would tend to be less successful in more open stands. Larger sample sizes are required to adequately address these questions.

Our percentage of immature breeders (36%) was high, we found similar numbers of males and females among yearling breeders, and pairings between yearlings occurred at least 18.8% of the time. During 10 years in Scotland, 18% of fathers and 15% of mothers at European Sparrowhawk nests were immature, and few adult-immature pairs were observed. Productivity was lower for adult-yearling pairs than adult pairs, and lowest for yearling pairs (Newton 1991). In contrast, adult male-yearling female Sharp-shinned Hawk pairs in Wisconsin were no less productive than pairings between adults, and both performed better than pairs containing immature males. Immature females in Wisconsin also bred >2.5× more often than immature males (EAJ and L. Semo unpubl. data), while juvenile male sparrowhawks in Scotland bred only 1.2× more often than juvenile females (Newton 1991). Furthermore, only 4.6% and 6.3% of pairs in Wisconsin and Scotland, respectively, were between yearlings, and in Scotland, the highest percentage of yearling-yearling pairs reported in any one year was 13.5%.

A longer term study could examine whether our Sharp-shinned Hawk population consistently contains more immature breeders than other populations, and if so, what this reveals about environmental conditions and demographics in our area. Higher proportions of yearling breeders may be observed when environmental conditions are especially favorable for breeding (Newton 1979), or, alternately, when habitat is less than ideal and more suitable habitat elsewhere is occupied by more experienced, adult breeders (D. R. Trexel pers. comm.).

Cities tend to support a lower diversity of raptors, as do smaller parcels of woodland. However, this population bred successfully in these fragments, which were wooded and had well-covered canopies. As Montreal continues to develop outward, small fragments of forest are lost; their importance to local and regional wildlife populations may be unrecognized. We believe that remaining stands of forest should be considered as potential nest sites for Sharp-shinned Hawks and other raptors, and every possible effort should be made to protect them from being cleared.

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