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SEARING (2678)
RAPTORS

RAPTOR AND VOLE POPULATIONS AT AN AIRPORT[1]

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Abstract: Changes in numbers among overwintering populations of 4 species of raptors were studied in relation to changes in abundance of meadow voles (*Microtus pennsylvanicus*) on Toronto International Airport from October to April of 1974–75 and 1975–76. Data from small-mammal trapping, analysis of raptor pellets, and direct observations of prey hunted and captured by the raptors indicated that meadow voles were the major prey of all 4 raptor species. Rough-legged hawks (*Buteo lagopus*) and short-eared owls (*Asio flammeus*) exhibited a greater numerical response to changes in vole abundance than did red-tailed hawks (*Buteo jamaicensis*). Changes in snowy owl (*Nyctea scandiaca*) numbers were opposite those of the other raptors.

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Birds may create a serious hazard for aircraft, and considerable effort has been expended on developing effective methods of reducing bird populations at airports (Blokpoel 1976). More basic information is required if accurate predictions of how bird populations respond to various control procedures are to be derived. On Toronto International Airport, 4 species of raptors (red-tailed hawk, rough-legged hawk, snowy owl, short-eared owl) are common winter residents. Frequently these raptors become abundant and create hazards for aircraft traffic. Previous control measures, including shooting and livetrapping, have had limited success in reducing raptor numbers on the airport. Our study was undertaken to develop a management program that would reduce the raptor population of the airport. The objectives were to determine the prey used by the 4 raptor species, the response of these raptors to changes in prey abundance, and other variables that may cause changes in raptor abundance.

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STUDY AREA

Toronto International Airport is on the western perimeter of metropolitan Toronto, Ontario (43°41′N, 79°37′W). In addition to buildings and paved areas, the airport includes about 1,200 ha of farmland and grassland habitat, 827 ha of which comprised the study area. The airport is surrounded by industrial and urban areas and vacant land, the latter consisting of old-field communities. Within the airport there are 3 main runways and several associated taxiways and access roads.

Three major habitat types predominated: shortgrass, agricultural, and old-field. Shortgrass (*Poa* sp.) habitats (407 ha) were adjacent to runways, taxiways, buildings, and roadways, and were mowed to a height of 10 cm, usually 3 times/year. Agricultural land (273 ha) was further subdivided into 3 categories: pastures, plowed fields, and winter wheat fields. Pastures were grazed by cattle

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METHODS

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Short-eared owls were
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during all but the winter months. Plowed fields were left fallow over winter and wheat fields were planted in fall. The remaining areas were old-field habitats (147 ha), including abandoned farmlands (70%) and lands adjacent to streams (30%). Vegetation consisted largely of various forbs and grasses, with a few hawthorn (*Crataegus* spp.) shrubs.

METHODS

Raptor Populations.—Censuses of red-tailed hawks, rough-legged hawks, and snowy owls were conducted twice weekly from a vehicle traveling at 30 km/hour with 1 observer scanning both sides of a 12.8-km route. The widest area for observation along the route was 1 km and the average width was 0.5 km. At designated points along the route the vehicle was stopped to allow scanning of areas that could not be adequately observed while the vehicle was moving. All censuses were conducted between 1000 and 1430. Between 1 October and 15 April, 47 (1974–75) and 62 (1975–76) censuses were conducted.

Species and behavior of each raptor, and location and habitat that the bird was in or above were recorded for all raptors seen. The possibility of counting a bird more than once was minimized by noting variations in plumage color and missing wing and/or tail feathers, and by keeping records of birds flying out of an area being censused.

Short-eared owls were recorded when observed on censuses and were counted at their communal roosts (Clark 1975). Roosts were located by ground search, and each roost was periodically checked throughout the study. Occasional counts of foraging owls were made from fixed locations on the airport. Counting started about 1 hour before sunset and ended at dark.

Food Habits.—Food habits were assessed by pellet analysis (Errington 1932) and by observation of attempted and successful prey captures. Pellets were collected from roosts and perches used exclusively by a particular raptor species or were collected immediately after they were observed being regurgitated. Additional pellets collected at random from various parts of the airport were not assigned to a particular species. All pellets and prey remains at each location were collected.

Diet composition for each raptor species was calculated as the percentage of each prey species among the total number of prey animals in the pellets. For small mammals, each animal was counted as a single prey item. For larger animals, only 1 prey individual was counted if remains of that species were found in >1 pellet from a specific location in a collection period and if no identifiable parts were present more than once.

Small-mammal Populations.—Population estimates were based on 4- to 10-day sessions on livetrapping plots and by using standard capture/mark/recapture methods (Davis 1956). Overall trends in abundance of small mammals were derived from data from 2 plots in shortgrass and 1 plot in an old field. Estimates were based on the Schnabel census (Schnabel 1938), using Overton's (1965) modification for known removals. To verify estimated population size, the minimum number of animals known to be alive (MNA) was also tabulated (Krebs 1966).

On each plot, 55 folding Sherman live traps baited with raisins were set 1/station at 10-m intervals. Pieces of plywood (15 × 30 cm) were placed over the traps, allowing a 7-cm projection over the open end, and Fortrel cotton was placed in the traps. Traps were set within 1 m of grid stakes and beside active vole runways. Captured voles were weighed, toe-clipped, and released at point of capture. Trapping sessions were conducted in July, November, and December 1974; March, April, May, and October 1975, and February and March 1976. Data on small-mammal populations between October 1974 and May 1975 were obtained from Steele (1977). Snow depth data were obtained at an Environment Canada weather station on the airport.

Data Analysis.—Changes in numbers of red-tailed hawks and rough-legged hawks were examined within and between years. Each year was divided into 3 seasons: fall (1 Oct–15 Dec), winter (16 Dec–15 Feb), and spring (16 Feb–15 Apr). These seasons corresponded to the fall and spring migration periods and a winter period with little or no migratory movements (Craighead and Craighead 1956).

All data were transformed using a $\log(n + 1)$ transformation. A 2-way ANOVA compared changes in numbers within and between years. Factors were seasons and years, and replication was by censuses within each season. Means were compared using Scheffe's test. Snowy owl numbers were compared between the 2 years using Student's t test for unpaired data.

RESULTS

Raptor Populations.—Seasonal changes in mean numbers of red-tailed hawks from fall to spring had a similar pattern each year. No differences ($P > 0.05$) in numbers of hawks occurred among seasons within either year, except for an increase ($P < 0.05$) in mean number of red-tailed hawks in spring vs. winter 1975–76 (Fig. 1). Comparisons of mean numbers of red-tailed hawks for the same and different seasons between years showed

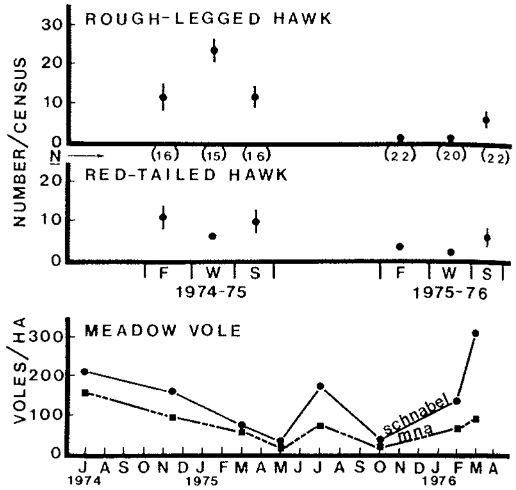

Fig. 1. Seasonal changes in numbers of rough-legged hawks, red-tailed hawks ($\bar{x} \pm 2$ SE), and meadow voles. Both Schnabel and minimum number of animals (MNA) estimates are shown. F = Fall (1 Oct–15 Dec), W = Winter (16 Dec–15 Feb), S = Spring (16 Feb–15 Apr). N = number of censuses.

there were more ($P < 0.05$) red-tailed hawks on the study area in fall 1974–75 than in fall or winter 1975–76, and in winter 1974–75 than in winter 1975–76 (Fig. 1).

Numbers of rough-legged hawks changed ($P < 0.05$) during both years, with dissimilar patterns between years. There was a greater ($P < 0.05$) mean number of rough-legged hawks in winter than in fall and spring of 1974–75. During 1975–76, spring had a greater ($P < 0.05$) mean number than fall or winter. All other comparisons were not different ($P > 0.05$) (Fig. 1). Comparisons between years showed that means in all 3 seasons of 1974–75 were greater ($P < 0.05$) than those of the corresponding seasons of 1975–76. All other comparisons between years showed differences ($P < 0.05$), except fall 1974 vs. spring 1976 (Fig. 1).

Snowy owls did not arrive on the airport until November, and all had left by 31 March. During censuses from 1 November to 31 March, snowy owls were

Table 1. Percentage[a] of each prey sp

Species and year	
Red-tailed hawk	197
	197
Rough-legged hawk	197
	197
Snowy owl	197
	197
Short-eared owl	197
	197
Unidentified raptors	1974
	1975

[a] Approximate for small samples ($N < 26$).

observed 7 times in 1974–75 a
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Short-eared owls were foun
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Food Habits of Raptors.—
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Eastern cottontail rabbits (*Syl*
floridanus) were not found in pe
1974–75, but occurred as a sm

Table 1. Percentage[a] of each prey species in raptor pellets collected on Toronto International Airport, 1974–76.

Species and year		Pellets (*N*)	Meadow vole	Deer mouse	Ring-necked pheasant	Cottontail rabbit	Misc.
Red-tailed hawk	1974–75	65	100				
	1975–76	27	89	4	2	2	3
Rough-legged hawk	1974–75	90	98	2			
	1975–76	8	90	10			
Snowy owl	1974–75	11	100				
	1975–76	116	87	10	2		1
Short-eared owl	1974–75	180	98	1			1
	1975–76	9	100				
Unidentified raptors	1974–75	245	97				
	1975–76	21	95	5			3

[a] Approximate for small samples ($N < 26$).

observed 7 times in 1974–75 and 66 times in 1975–76. The mean number observed/census between 1 November and 31 March was 0.09 ± 0.13 (SD) in 1974–75, and 0.26 ± 0.07 in 1975–76 ($P < 0.001$). Patterns of numerical change were similar for both years, although timing of the changes varied.

Short-eared owls were found roosting at 2 locations on the airport in 1974–75. In 14 visits to these 2 roosts, 67 owls were flushed. In 1975–76, only 1 roost was found and only 6 owls were flushed on 6 visits throughout the winter. In 1974–75, 56 short-eared owls were counted during 8 observation periods, whereas in 1975–76 only 8 were counted in 8 observation periods.

Food Habits of Raptors.—Meadow voles predominated among prey items found in all raptor pellets during both years (Table 1). The smallest percentage of meadow voles in the pellets of any raptor species was 98% in 1974–75 and 87% in 1975–76. In 1975–76, there was an increase in the percentage of deer mice (*Peromyscus maniculatus*). Ring-necked pheasants (*Phasianus colchicus*) and Eastern cottontail rabbits (*Sylvilagus floridanus*) were not found in pellets in 1974–75, but occurred as a small percentage of the prey species in 1975–76 (Table 1).

Prey Species on the Airport.—During 14,105 livetrapping nights, 1,404 meadow voles and 32 individuals of 3 other species (25 deer mice, 5 ermine [*Mustela erminea*], 2 masked shrews [*Sorex cinereus*]) were captured. In 1974–75 and 1975–76, 97 and 98%, respectively, of all small mammals captured were meadow voles.

Observations of other potential prey at the airport were noted, but accurate estimates of their numbers were not obtained. Rock doves (*Columba livia*), house sparrows (*Passer domesticus*), and European hares (*Lepus capensis*) were commonly seen throughout the winter. Cottontail rabbits, muskrats (*Ondatra zibethicus*), and pheasants were occasionally observed. Between years, there was no noticeable change in the relative abundance of any of these species.

During both years, 241 attempted captures of small mammals by raptors were observed, of which 86 were successful. There were only 6 observations of attempted captures of prey other than small mammals, and none was successful.

Vole Populations.—Both methods of estimating the population indicated a

Table 2. Seasonal mean snow depths on Toronto International Airport during 1974–76.

Year	Mean snow depth (cm)		
	Fall	Winter	Spring
1974–75	0.8	2.5	3.0
1975–76	0.7	23.0	2.5

similar trend in vole population changes during the study (Fig. 1). In 1974–75, vole populations (Schnabel estimates) were highest in fall (175/ha), then declined over winter to a minimum level in spring (26/ha). During 1975–76, populations were low in fall (35/ha) and then increased over winter to a high level in spring (310/ha) (Fig. 1).

Snow Depth.—Patterns of change and amounts of snow were quite different between the 2 winters. In 1974–75, snow cover increased from fall through winter and spring, but the depth was not great (Table 2). In 1975–76, deep snow cover accumulated during winter, but then declined sharply in spring. Fall and spring seasons had similar mean snow depths in both years (Table 2).

DISCUSSION

Data from small-mammal trapping, analysis of pellets, and direct observations indicated that meadow voles were the primary prey of the 4 species of raptors. Red-tailed and rough-legged hawks, short-eared owls, and voles were all more numerous in the 1st year than in the 2nd, whereas snowy owls were more numerous in the 2nd year.

Seasonal changes in numbers of red-tailed hawks were similar in both years: numbers were higher in fall and spring than in winter. Vole numbers declined from a high in fall 1974 to a low level in spring 1975, and showed a reverse trend from fall 1975 to spring 1976. Therefore, seasonal patterns for red-tailed hawks must have been influenced by factors other than vole density. Although many red-tailed hawks in the Toronto area are breeding residents, large numbers of migrants move through the area in spring and fall (Haugh and Cade 1966). These migrants account for the observed pattern of seasonal change in numbers. However, the decrease in numbers of red-tailed hawks between fall 1974 and fall 1975 was likely a numerical response to a corresponding decline in vole abundance, especially as there was no similar decline in the number of fall migrants (Goodwin 1975, 1976). The lower red-tailed hawk numbers in winter 1975–76 compared to the same period in 1974–75 again coincided with the lower vole numbers at the beginning of the winter season, but may also have been influenced by other factors, such as differences in snow cover. However, there was no difference between numbers of red-tailed hawks during spring 1975 and spring 1976, even though vole numbers were much higher in the latter period. Hence, increases in red-tailed hawk numbers in spring seemed independent of vole density.

Changes in numbers of rough-legged hawks between seasons corresponded closely to seasonal changes in abundance of voles. Between years, rough-legged hawks were more numerous in fall and winter 1974–75, when vole densities were high, than in fall and winter 1975–76, when vole densities were low. However, in spring 1975 voles were less numerous than in spring 1976, whereas the reverse was true for numbers of rough-legged hawks.

Short-eared owls tend to overwinter in areas where fall populations of voles are high (Clark 1975). On the airport, large numbers of these owls overwintered when voles were abundant in fall 1974, whereas relatively few owls overwintered when vole populations were low in 1975.

The increase in numbers of snowy owls in 1975–76 over those in 1974–75 contrasted with the decline in numbers of the other 3 raptors during the same period. Numbers of snowy owl migrants supposedly correspond to a reduced food supply in the Arctic, and the numbers overwintering in southern Ontario vary from year to year (Gross 1947). The number of fall migrants (Goodwin 1975, 1976) and the number of snowy owls observed on Christmas counts (Rupert 1975, 1976) were similar in both years. However in 1975–76, snowy owls did not increase on the airport until January, which was after these independent estimates were completed. Therefore, the higher numbers in the 2nd year may have been simply the result of increased numbers of snowy owls moving into southern Ontario after January.

Deeper snow cover may have reduced vulnerability of voles to predation in 1975–76 and contributed to the decline in numbers of buteos and short-eared owls on the airport, even though vole abundance increased in late winter and early spring of 1976. Of the 4 raptor species, only snowy owls were observed to capture or even attempt to capture voles under the snow. Snowy owls may be better adapted than the other raptors to hunt small mammals in snow, and hence may have been able to forage more successfully for the high vole numbers in winter 1975–76.

The results of our study are comparable to those from 2 others conducted on overwintering raptor populations. In a 2-year study in Michigan, rough-legged hawks and short-eared owls declined in numbers concomitantly with a decline in abundance of meadow voles (Craighead and Craighead 1956). However, numbers of red-tailed hawks remained stable, which suggests that this species could switch to available alternate prey, such as ring-necked pheasants and cottontail rabbits, whereas the other 2 raptors could not because they lacked sufficient size and strength.

On a simple, island habitat in southern Ontario where meadow voles were the major source of prey, overwintering populations of red-tailed hawks, rough-legged hawks, snowy owls, and short-eared owls all showed a numerical response to changes in abundance of meadow voles, perhaps because of a lack of available alternate prey species (Phelan and Robertson 1978).

Potentially, many variables could affect responses of raptors to changes in prey abundance. However, our data show that at high or low density of voles, all 4 species of raptors were strongly dependent on voles for food, and furthermore, that the abundance of these raptor populations can be minimized by managing prey abundance, regardless of other variables. Raptor numbers in late fall and winter would be minimized if prey abundance is low prior to fall migration. On the airport, vole abundance corresponded with particular structural aspects of the vegetation (Steele 1977). Therefore, we recommend reduction of vole populations by habitat management. Specifically, old fields should be eliminated, and mowing and agricultural practices should minimize habitat quality for voles by reducing cover and vegetation height. Such manipulation should proceed with caution as some alternatives may increase suitability of the area for other bird species that cause hazards at airports. Anyone contemplating management of bird hazard problems should consider long-term studies at the community level to derive optimum solutions.

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