Condor 83:42–47

DISTRIBUTION PATTERNS OF RAPTORS IN RELATION TO DENSITY OF MEADOW VOLES

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ABSTRACT.—Densities of overwintering Red-tailed Hawks (*Buteo jamaicensis*) and Rough-legged Hawks (*Buteo lagopus*) were examined in relation to densities of meadow voles (*Microtus pennsylvanicus*) on six habitat types. Generally, densities of both raptor species were greater in habitats that had higher densities of meadow voles. However, not all habitats with high numbers of voles had high numbers of the raptors. The amount and distribution of cover also appeared to influence the distribution of the raptors. Hence, patches that support high densities of prey may not be profitable foraging sites for predators because other factors may reduce availability of prey.

Optimal foraging theory predicts that animals should maximize their net rate of energy intake (Krebs 1973, Pyke et al. 1977). For example, when the food of a predator is distributed unevenly in space, the predator would be expected to spend more time on those patches yielding greatest net gain of energy (MacArthur and Pianka 1966, Krebs 1973, Smith and Sweatman 1974, Zach and Falls 1976a, Pyke et al. 1977, Bobisud and Voxman 1979, Waage 1979). Several studies have shown that predators do concentrate their search efforts in areas of high prey density (Goss-Custard 1970, Simons and Alcock 1971, Smith and Dawkins 1971, Hassel and May 1974, Smith 1974, Smith and Sweatman 1974, Hartwick 1976, Zach and Falls 1976a, b, c). Royama (1970, 1971) hypothesized that predators learn to use the most "profitable" patches where profitable is defined in terms of biomass of prey taken by a predator per unit of hunting time, rather than strictly on the basis of prey density.

Few field studies, however, have investigated whether predators concentrate their foraging efforts on the most profitable sites. In the present study, we examined the profitability hypothesis of Royama (1970) by measuring responses of raptors to different densities of meadow voles (*Microtus pennsylvanicus*). On Toronto International Airport, meadow voles constitute more than 85% of prey items in the diets of overwintering Red-tailed Hawks (*Buteo jamaicensis*) and Rough-legged Hawks (*B. lagopus*; Baker 1977). From November to March these hawks devote most of the day to foraging and might be expected to be most numerous in areas where voles are abundant.

STUDY AREA AND METHODS

Toronto International Airport is on the western perimeter of Metropolitan Toronto, Ontario (79°37'W, 43°41'N). In addition to buildings and paved areas, it includes about 1,200 ha of farmland and assorted grasslands. The airport is surrounded by industrial and urban areas and by flat old-field communities that are largely devoid of trees and shrubs. On the basis of access roads and runways, we chose a study area of 827 ha so as to permit a total census of the raptors on the study area.

The study area was divided into six habitat types according to vegetation composition and type of land management. *Shortgrass* habitats (407 ha) were mowed and treated with herbicides regularly by airport personnel so that the average vegetation height was about 10 cm and the dominant plant species was bluegrass (*Poa* sp.). Agricultural land (273 ha) was classified into four habitat types. *Pastures* (49 ha) were grazed by cattle except in winter. By early fall, little cover remained on pastures except around clumps of weeds avoided by the cattle. *Plowed fields* (100 ha) were farmed during summer, then were plowed in early fall and left fallow over winter. *Winter wheat* (69 ha) was sown in September, and harvested the following July. There was little cover on winter wheat fields over winter. *Straw* habitats (55 ha) occurred only in 1974–75 when straw from the harvested winter wheat was left in rows in the fields over winter. The straw provided good winter cover for voles. *Old fields* (147 ha) were largely abandoned farm fields (70%) and unmanaged areas near streams and lowlands (30%). They were densely covered by perennial grasses, forbs and hawthorn (*Crataegus* spp.) seedlings. More detailed description of these habitat types is in Steele (1977).

Vole populations were estimated on the basis of live-trapping plots using standard capture/mark/recapture methods (Davis 1956). Estimates were based on the Schnabel (1938) method, using Overton's (1965) modification for known removals. The minimum number of voles known to be alive (MNA) was also tabulated (Krebs 1966). One live-trapping plot was set on each habitat type, with no plot less than 50 m from the habitat boundary, and no plot within 400 m of any other. Each plot was a 0.4-ha grid with one trap set every 10 m for a total of 55 traps per plot. Each plot was trapped every three months and at each sample period the traps