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**A FIELD STUDY OF THE RED-TAILED HAWK
IN EASTERN KANSAS**

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ABSTRACT

Road counts of the Red-tailed Hawk in the eastern one-third of Kansas indicated a breeding population density of one per 16.5 km² (one nest per 37 km²). Counts in winter indicated a population density 1.4 to 2.2 times as great. Most nests were in American elms, cottonwoods and sycamores in that order of preference but fifteen other species of trees were used for nest sites. Average height of all nests was 13.3 m and successful nests averaged slightly higher than those that failed. Of 195 nesting attempts, 126 failed; approximately two-thirds of the failures were caused by weather, mainly high winds. The 69 nests that fledged young had 25 percent mortality of nestlings. In 10 of 18 instances of predation, the raccoon was the predator implicated. Among forty prey items identified at nests and 2720 identified from pellets picked up under nests, the prairie vole was most frequent, the black rat snake second and the Eastern cottontail third. In terms of biomass, Eastern cottontail, black rat snake and prairie vole, in that order, were the principal prey species (90 percent), with many other kinds of small mammals, lizards and snakes (and a few birds and insects) each making up relatively small parts of the total. *Trans. Kansas Acad. Sci.*, vol. 81:1, 1978.

INTRODUCTION

Our field study of the Red-tailed Hawk in eastern Kansas was undertaken in order to compare certain aspects of its ecology there, and in other regions and communities where this widespread raptor has been studied. Our observations pertain specifically to nesting, population

density as indicated by road counts, survival of young, causes of nestling mortality and food of nestlings. Our records were based on many nests over an extensive area in a four-year period. These records, obtained in the early 1960s, should have increasing significance as a basis for comparison with later studies, when changes in human populations, land use and conservation practices have further altered the ecology of the area.

METHODS, MATERIALS AND STUDY AREA

Nests were found by scanning the terrain in the course of extensive driving on highways and country roads, in April, when incubation was occurring and trees were still bare.

When a nest was found to be in current use it was not revisited for many weeks to avoid possible disturbance by the investigators in the critical stages. However, late in the nesting season each was visited one or more times to determine whether young had been reared, and to collect pellets and other material for food habits study. The information gained from individual nests was usually meager, but the composite samples were large. Relatively small amounts of data were collected from 1955 to 1959; most records were obtained in 1960, 1961, 1962 and 1963. The study was concerned chiefly with food habits until the last two seasons, when interest focused on survival of the nestlings. Field procedures, extent of area covered (Fig. 1), and amounts of data obtained varied slightly from year to year.

Our food habits study was based both on discarded fragments of prey items in and beneath nests and on pellets, but more than 98 percent of individual items identified were from pellets. Errington (1932) and Glading, Tillotson and Selleck, (1943) have thoroughly discussed the shortcomings of hawk pellets as a basis for food-habits study. In brief, some kinds of prey leave no hard parts in pellets, and the epidermal structures such as hair, scales, and feathers that make up most pellets provide no information about the number of prey individuals eaten. Furthermore, residues from a meal may appear in several pellets, and a pellet may contain material from several meals.

Nevertheless pellets have the advantage that they can be collected in relatively large numbers, and they do provide a crude indication of the relative biomass of different kinds of prey involved. In our study the pellets collected were found on the ground beneath the nests scattered over areas of many square meters, and presumably were those of the young hawks in the late stages of growth, after they had begun feeding themselves from prey animals brought by adults.

Our study area, situated in the broad ecotone between eastern deciduous forests and grasslands of the Great Plains, was in the eastern one-third of Kansas, and was broadly oval, with greatest radius approximately 120 km, and included 22 counties or parts of them. Lawrence, Kansas, was our base of operations, hence field work was most concentrated near there in Douglas County in the northeastern part of the area.

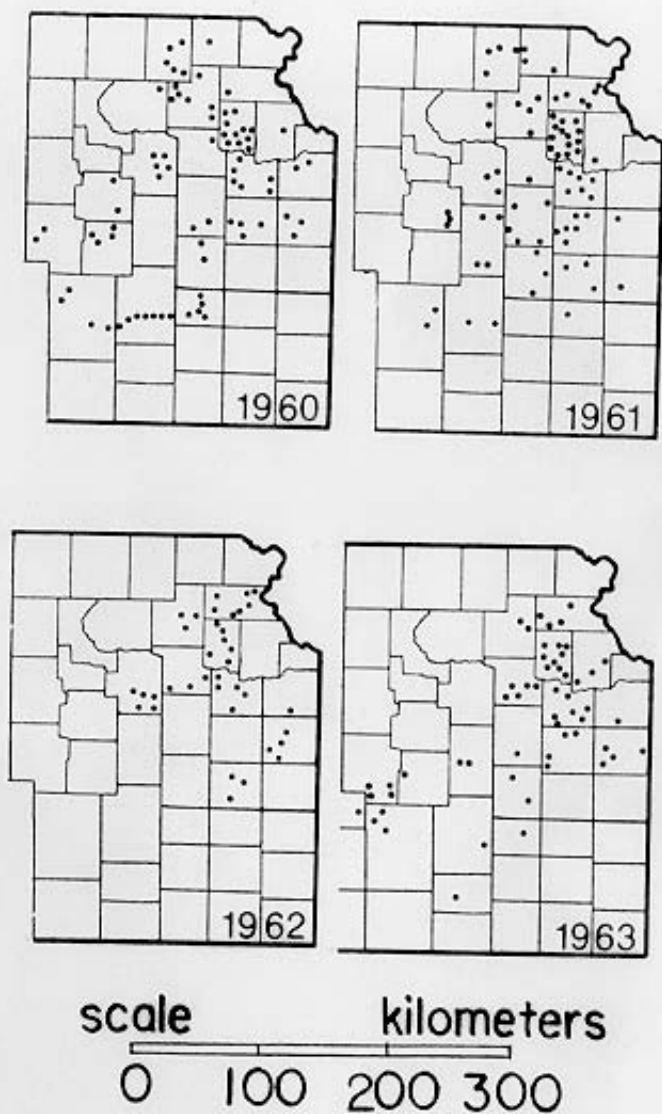


Fig. 1. Maps of eastern Kansas showing counties, and locations of Red-tailed Hawk nests found in four different years.

RESULTS

Habitat. — Throughout the study area, which was mostly open land, trees were present growing singly, in lines along gullies or field edges, or in more extensive groves along streams or in farm woodlots. The trees present included cottonwood (*Populus deltoides*), elm (*Ulmus americana* and *U. rubra*), black walnut *Juglans nigra*, red oak (*Quercus borealis*), hackberry (*Celtis occidentalis*), white oak (*Quercus alba*), ash (*Fraxinus americana*), sycamore (*Platanus occidentalis*), hickory (*Carya ovata*), maple (*Acer* sp.), willow (*Salix* sp.) and basswood (*Tilia americana*) in that order of importance (J. K. Strickler, pers. comm.). There was a trend toward fewer and smaller trees from northeast to southwest. In the northeastern part of the study area, land was 9 per cent woodland, 31 per cent cultivated, and the remaining 60 per cent chiefly pasture (Dobbs, 1970; Peeples, 1970). In the southwestern part, the Flint Hills of Marion, Chase, Lyon and Morris counties, there was 3 per cent woodland, 18 per cent cultivated land and 71 per cent cattle range.

Population density. — We found 172 nests of Red-tailed Hawks in 6400 km of driving (37 km per nest), and 23 additional nests were found on trips when distance was not recorded. Figure 1 shows that most nests found were within .5 km of the road; presumably those at greater distances were liable to be overlooked unless they were in unusually conspicuous situations. It is estimated that each kilometer of driving represents roughly 1 km² effectively scanned, hence the nest density represents about one to 37 km².

During the 6400 km of spring driving 387 adult hawks were seen (many of them associated with the nests), an average of one per 16.5 km. Table 1 compares this population density with the densities found by several other investigators in various parts of the United States and Canada. Most recorded densities were higher; especially in near-optimum habitat of pine-oak woodland, in the Sierra Nevada foothills of Madera County, California, Fitch, Swenson and Tillotson, (1946) found a breeding population much denser than that in eastern Kansas.

In the area of our study, winter densities are markedly higher than those in spring. In 6820 km of winter driving (1953-1963) in the counties where our study was made, H. A. Stephens (pers. comm.) counted 584 Red-tailed Hawks, one per 11.7 km. In 6850 km of driving in five areas of eastern Kansas participants in the Kansas Ornithological Society's Christmas Bird Count from 1950 to 1961 recorded 910 hawks, one per 7.54 km. These high winter counts suggest that from one-third to half of the winter population may consist of migrants from farther north.

Nest sites and timing of nesting. — Johnston (1965:16) summarized nesting habits of the Red-tailed Hawk in Kansas as follows: "Eggs laid February to first week of April, peak March 1-10; single-brooded." "Nests placed in crotches 15-65 feet high, of cottonwood, elm, oak." Table 2 summarizes the stages of development of the young at the nests that were relocated in late spring.

Of 261 nests in identified trees, 37.1 percent were in American elms, 32.7 percent were in cottonwoods, 18.0 percent were in sycamores, 3.1 percent were in black walnuts, and the rest were divided among fourteen tree species. Nesting success (at least one young fledged) was 33.8 percent in cottonwoods, 33.8 percent in American elms, 43.4 percent in sycamores and 37.5 percent in miscellaneous other trees of eleven species. The sample included 195 nests for which the kind of tree was recorded and success or failure was observed. Accessibility to predators was influenced by height, type of trunk, texture of bark and site of the tree. Many nests, especially those in sycamores, were directly over streams, so that the feces, pellets, and scraps of food dropped into the water removed some of the cues by which predators might find the nest. Ground heights of 261 nests ranged from 5.5 to 30.5 m (mean = 13.3 m); with more than three-fourths between 11 and 17 m. Average height of all successful nests was 13.6 m, and the height of those that failed to produce young averaged 12.8 m.

Freemyer (1966:15) reported on 22 nests found in the spring of 1965 in Lyon County, Kansas, in the southwestern part of our study area. He found cottonwood, American elm, and sycamore to be the most frequent nest trees, and the nests averaged 12.2 m (6.1 - 21.4) in height.

Although two of the nests that we found were in towns and a few were as little as 100 m from buildings, the hawks tended to avoid man. Individual hawks must differ greatly in their experiences with humans; they exhibited striking differences in behavior and approachability. Also, humans varied in their attitudes toward the hawks. While many, including landowners, recognized the hawks as beneficial, some of the traditional hostility toward raptors persisted to the extent that shooting was probably the one most important mortality factor in the population studied. Wariness, developed from a combination of individual experience and genetic selection, must play an important part in the survival of Red-tailed Hawks in Kansas.

Nesting success. — Of 276 April nests found in our four seasons of field work, 70 could not be relocated later in the season. Of the 206 that were revisited, 69 were successful in producing at least one fledgling, 126 apparently failed, and 11 were of indeterminate status. Of the 195 nests for which fates were known, 64.6 percent failed and 35.4 percent produced one or more fledglings (1.54 per successful nest, and .51 for all the nests, including those that failed). Of the nests in which young fledged, 41 produced a single fledgling, 23 produced two, four produced three each, one produced four, and one had either three or four. Johnston (1965) indicated an average of 2.6 eggs in 20 nests in Kansas. In Lyon County, Kansas, Freemyer (1966:16) found an average of 1.95 for egg clutches and nestlings, combined, in 22 nests. As the population present in the breeding season consists of some immatures from the previous year and some unmated wandering adults in addition to those that are nesting, the .51 young fledged per observed nest probably constituted

Table 1. Population Densities of Red-tailed Hawks in the Nesting Season

² km per hawk	Source of information	Area
29.6	Freemyer, 1966	Lyon County, Kansas
16.5	Present study	Eastern Kansas
3.9	Orians and Kuhlman, 1956	Wisconsin in 1955
3.2	Luttich et al., 1970	Alberta
3.15	Orians and Kuhlman, 1956	Wisconsin in 1954
.64	Fitch, Swenson and Tillotson, 1966	Madera County, California

Table 2. Seasonal Timing of Development in Young Red-tailed Hawks

Condition of young	May 22-28	May 29 to June 4	June 5-11	June 12-18	June 19-25	June 26 to July 3	July 4-10	July 11-17
Small and downy	3	1	1	2				
Approximately half grown	1	5	1					
Partly feathered	7	3	3	3	2			
Almost ready to fly		2	-	3	-	2		
Flushed from nest by climber		1	3	5	2	1		
Already fledged			2	3	9	-	3	1

somewhat less than 25 percent of the postbreeding population in late summer.

Our records suggest that about two-thirds of the nest failures could be attributed to weather, mostly to violent spring thunderstorms and accompanying high winds in which young could be blown from the nest. More frequently the nest was damaged or destroyed and the young were eliminated as a result. In 73 such instances the nest was blown down (18), collapsed (22), or seriously damaged (33). Nests were seriously damaged in several other instances when one or more well-grown young were still present; one nest was tipped to nearly 30 degrees from the horizontal because part of its support had given away. Hail also possibly caused nest failure.

Ten nesting failures were attributable to the raccoon (*Procyon lotor*). In three of these, chewed feathers of young hawks were found in or beneath nests; in two others, scats of raccoons were in the nest tree or at its base, and in another instance there were recent claw marks on the

tree trunk near the nest. In four other cases there were tracks of a raccoon in soft soil near the base of the tree.

In four other instances failure resulted from shooting of young in the nest or robbing of the nest by humans. In the remaining eight cases of suspected predation, no definite clue to the identity of the predator could be found. The Great Horned Owl (*Bubo virginianus*) is a suspected predator on hawk nestlings, and the Common Crow (*Corvus brachyrhynchos*) and Blue Jay (*Cyanocitta cristata*) are possible predators on the eggs.

Food of young. — Our data represent prey obtained mostly in the months of May and June from young that were near fledging. A relatively small number of prey items were found at the nests, and a much larger number of animals were identified from their residual indigestible parts in pellets. The trends in the two sets of records are somewhat different. At 18 nests there were 40 prey items that were represented by recognizable remains: 19 Eastern cottontails, 7 muskrats, 2 timber rattlesnakes, 2 blue racers, 2 unidentified snakes, and one each of prairie vole, pine vole, Eastern grey squirrel, Eastern mole, Western Meadowlark, rough green snake, Great Plains skink, and snapping turtle. Cottontail remains were found at 10 of the 19 nests, but no other kind of prey was found at more than two nests. Six of the seven muskrats were at one nest, suggesting that the resident pair of hawks was specializing on a muskrat diet. The two timber rattlesnakes found together in another nest were both halfgrown. In this sample there seemed to be bias in favor of the larger items which, even after being fed upon, were still present in the nests as identifiable remains such as the spinal columns and large limb bones of rabbits. In contrast, small items such as insects, lizards, shrews, mice, and voles (Table 3) were presumably eaten almost as soon as they were delivered, and therefore, were not seen in the nest by the investigator. The small sample of prey remains from nests was notable for including a snapping turtle and a rough green snake, two species that were not represented in the much larger sample from pellets.

Table 3 lists 23 species and ten other categories identified from analysis of 1322 Red-tailed Hawk pellets with a total of 2720 occurrences. Food residue in pellets consists mostly of fur, feathers, scales, and chitin fragments, and bony material is largely dissolved, providing no such information concerning the number of animals eaten as do the skeletal remains, almost unaffected by digestive processes, in owl pellets. Some kinds of small animals which lack hard epidermal structures — salamanders and frogs for example — may leave no trace in pellets, but in general, hawk pellets provide qualitative data that reflect food habits.

DISCUSSION

The present study of the Red-tailed Hawk, carried on near the center of this widespread raptor's breeding range, revealed ecological relationships that were mostly similar to those found in earlier studies else-

where, but with a few noteworthy exceptions. Breeding density was relatively low, less than one-fourth of those that have been found in Alberta and Wisconsin, and only one twenty-sixth of that found in near-optimum habitat in central California. Immediately to the west of our study area, the breeding density decreases abruptly to even lower levels and is low in the open terrain of central Kansas and the High Plains beyond. Winter counts indicated that from one-third to one-half the Red-tailed Hawks on our study area were migrants from farther north. Nesting success was found to be low with only about one young fledged for every two nests. Approximately two-thirds of all nests failed to produce any young and approximately two-thirds of these failures were caused by violent summer storms with high winds. The raccoon was identified as the chief predator, but weather caused more mortality than predation.

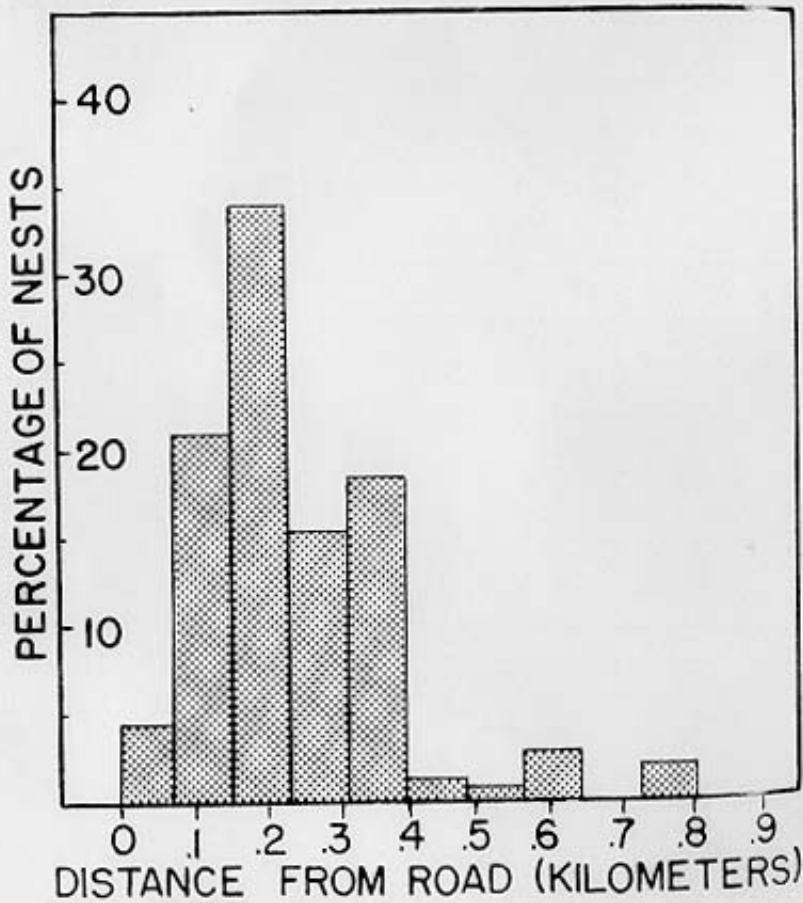


Fig. 2. Histogram showing distances from road of red-tailed Hawk nests found by driving and scanning terrain from car. Relatively few were found adjacent to the road or at distances greater than .5 kilometer.

The Red-tailed Hawk is known to prey upon various small vertebrates, but food samples from different regions have revealed some divergent trends. Our sample from eastern Kansas was noteworthy in two respects. Firstly, snakes make up nearly one-third of the total occurrences, whereas other investigators have found the prey to consist mainly of mammals and birds. Secondly, the most frequent prey animal, the prairie vole, was a remarkably small one with average weight only about three percent of the hawk's weight.

The snake occurrences in pellets were of at least nine species, including many records of the venomous copperhead and rattlesnake, but 72 percent were of the black rat snake. This large slow-moving snake was less numerous than most of the other kinds of snakes recorded; its frequency in the pellets was unexpected, and doubtless was correlated with its partly arboreal habits. The rat snake's food consists largely of birds' eggs and nestlings obtained by climbing in trees and bushes (Fitch, 1963). The snakes, prowling above ground level, are often scolded and harrassed by mixed groups of small birds which may attract the attention of larger predators such as the Red-tailed Hawk. This raptor probably learns to detect the snakes from such experiences, and becomes alert for the visual and auditory cues provided by the small birds.

In our study, as in others, the Red-tailed Hawk's feeding was found to have both beneficial and deleterious aspects from an economic viewpoint. Most of the rodents and rabbits eaten were potential agricultural pests, and the frequent predation on both venomous snakes and bird-eating snakes must also be considered positive. On the other hand, some of the hawk's predation involved fur-bearers, game mammals, insectivores, birds, lizards, and snakes that are themselves predators on pests.

In Wyoming, Craighead and Craighead (1956) found rodents and rabbits to make up most of the Red-tailed Hawk's food. In Alberta, Lutich, *et al.* (1970) found the chief foods to be ground squirrels, snowshoe hares, ducks, grouse, coots, voles, pocket gophers, red squirrels and muskrats. In Wisconsin, Orians and Kuhlman (1956) found the chief prey species to be pheasants, cottontails, domestic chickens, crows, voles, ground squirrels and blackbirds. Their sample was notable for the frequency of birds, which occurred nearly twice as often as mammals, with more species represented. Also it was notable for the occurrence of domestic animals including 20 chickens, two young pigs, two turkeys and one pigeon. In central California range land, Fitch, Swenson and Tillotson (1946) found the chief prey to be ground squirrels, cottontails, gopher snakes, pocket gophers and rattlesnakes in that order of importance.

In the list of prey items found in pellets in Table 3, the relative numbers of different prey species do not express well the actual composition of the diet, because the largest vertebrates eaten are at least 100 times the bulk of the smallest and the occasional invertebrates taken may be even smaller. Relatively small prey animals may be taken frequently without making up much of the food. A realistic appraisal of the

Table 3. Prey Items Identified in 1922 Red-tailed Hawk Pellets.

Kind of prey	Number of Occurrences	Percentage of Occurrences	Weight of typical individual (grams)	Estimated percentage of biomass of sample
Prairie vole (<i>Microtus ochrogaster</i>)*	717	26.4	30	9
Black rat snake (<i>Elaphe obsoleta</i>)	636	23.4	200	33
Eastern cottontail (<i>Sylvilagus floridanus</i>)	431	15.8	400	38
"bird"	189	6.9	50	4
Cotton rat (<i>Signodon hispidus</i>)	104	3.8	50	2
Garter snake (<i>Thamnophis sirtalis</i>)*	100	3.7	50	2
Mole (<i>Scalopus aquaticus</i>)	79	2.9	90	2
"insect"	78	2.9	1	<.1
Fox squirrel (<i>Sciurus niger</i>)*	67	2.5	200	4
Blue racer (<i>Coluber constrictor</i>)	55	2.0	75	1
Copperhead (<i>Agkistrodon contortrix</i>)	47	1.7	100	2
White-footed mouse (<i>Peromyscus</i> sp.)**	41	1.5	20	<.1
"beetle"	37	1.4	1	<.1
Ringneck snake (<i>Diadophis punctatus</i>)	25	.9	5	<.1
Harvest mouse (<i>Reithrodontomys megalotis</i>)*	14	.5	10	<.1
Least shrew (<i>Cryptotis parva</i>)	14	.5	4	<.1
Glass lizard (<i>Ophisaurus attenuatus</i>)	13	.5	30	<.1
Bull snake (<i>Pituophis melanoleucus</i>)	12	.5	200	<.1
Wood rat (<i>Neotoma floridana</i>)	12	.5	100	<.1
Water snake (<i>Agrodis sipedon</i>)	10	.4	100	<.1

Table 3 (continued)

Kind of prey	Number of occurrences	Percentage of occurrences	Weight of typical individual (gram)	Estimated percentage of biomass of sample
Skink (<i>Eumeces obsoletus</i>)*	10	.4	25	<.1
Short-tailed shrew (<i>Blarina brevicauda</i>)	8	.3	15	<.1
Muskrat (<i>Ondatra zibethica</i>)	6	.2	400	< 1
"reptile"	4	.1	75	<.1
Other***	13	.5	---	

* May include occurrences of a similar less common or less available species (*Microtus pinetorum*, *Thomomys proximus*, *Sciurus carolinensis*, *Reithrodontomys montanus*, *Eumeces fasciatus*).

** Includes both *P. leucopus* and *P. maniculatus* in unknown ratio.

*** Includes two each of unidentified "mammal", *Oreodiporus sexlineatus*, and "crayfish", and 1 each of *Lampropeltis* sp., *Crotalus horridus*, *Mus musculus*, *Lepus hudsonius*, *Bufo* sp.

composition of the hawk's food must take into account the relative biomass of the prey species. Column 3 of Table 3 shows the weight considered most typical for each species (taking into account the fact that the largest kinds, rabbits, squirrels, rats and snakes, were often taken as immatures).

A large prey animal such as a rabbit, brought to a nest, might provide two or more meals for a nestling hawk, and might be fed upon by two or more nestlings resulting in its representation ultimately in several separate pellets. On the other hand a small prey animal would usually be bolted entire and its indigestible parts would appear mostly or entirely in one pellet. In order to allow for this difference the prey species were divided into five arbitrary size classes estimated to occur in from one pellet (smallest size class) to three pellets (largest size class) each. A 400 g cottontail thus would be expected in three pellets, and the 431 cottontail occurrences that we recorded in pellets are judged to represent 144 animals killed, whereas the 717 occurrences of prairie vole could represent that many individual animals. Estimated on this basis the figures in Table 3, column 4 indicate that in terms of biomass the hawk's food includes 40 percent cottontail, 36 percent rat snake, 10 percent prairie vole, 4 percent bird, and 4 percent fox squirrel, with all other species of minor importance. While the actual percentage figures may be questioned, we believe them to be rough approximations that reflect the correct order of importance of the main prey species.

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