THE DIETS AND BREEDING BIOLOGY OF RED-TAILED HAWKS IN BOULDER COUNTY:
1985 NESTING SEASON

By: Daniel T. Blumstein
September 1986
ACKNOWLEDGMENTS

A study of this magnitude, for a beginning biologist, could not have been done without the help of many. Steve Jones tickled my interest in red-tailed hawks in Boulder County, and introduced me to many others interested in raptors, including Mike Figgs and Nan Lederer, who provided me with invaluable information collected by members of the Boulder County Nature Association and Boulder County Audubon Society. The landowners, especially Ricky Weiser and the Getmans, I thank for the permission to use their land and for stimulating and supportive discussions. Gerald Craig, of the Division of Wildlife, was especially helpful in directing me to other State and Federal authorities for additional information and for being a sounding board for some of my wild ideas. Robert Tully, also of the Colorado Division of Wildlife, provided considerable information on the history of red-tailed hawk management in Colorado. The City of Boulder Mountain Parks and Open Space Rangers were helpful in suggesting areas to look for nests on their land. Scott Wait was especially helpful. My housemates, who put up with my “weird habit of sorting pellets on the kitchen table at 9 AM,” are thanked for not screaming too loudly! Mike Mooring, Chris Hold, Scott Wait, Joe Strauch, and Alison Ruch assisted with the tedious habitat analyses. Alison kept me going during a time when I needed to keep going. Joe kindly identified bird remains. Url Lanham made sense of the bug names in the literature. Bonnie Gilbert insanely volunteered to help me with the pellet analysis. Virtually everyone in Hunter Building, especially Rick Adams and Scott Pedersen, was accosted and asked to identify pellet parts! Marc Bekoff graciously employed me in a job that also allowed me time to study hawks. My parents supported “our son who likes to chase hawks around and look at their droppings” in innumerable ways, including financially. Jones Drugs provided a discount on necessary optics. Jackson Dairies, Denver Colorado, generously supplied hundreds of pint ice cream containers and lids used in pellet analysis. The E.P.O.B. and E.C. honors committees (especially Carl Bock and David Greenland) are thanked for their advice. This study would not have been
completed without the guidance, suggestions, encouragement, and witty comments of David M. Armstrong. To Dave especially, and everyone who I have and have not mentioned, thanks! Despite all of this help, any and all errors are mine alone.
# Table of Contents

ACKNOWLEDGMENTS .......................................................... 1

TABLE OF CONTENTS ...................................................... iii

ABSTRACT ........................................................................ 1

INTRODUCTION ................................................................. 2
  Status ............................................................................ 2
  Life History .................................................................... 2
  Diet ............................................................................... 4
  Food Studies ................................................................... 5
  Habitat ............................................................................ 7
  Human Attitudes Toward Raptors ................................. 9

MATERIALS AND METHODS .............................................. 15

RESULTS ........................................................................ 18
  Nests ............................................................................ 18
    Nest #1 ....................................................................... 18
    Nest #2 ....................................................................... 19
    Nest #3 ....................................................................... 19
    Nest #4 ...................................................................... 20
    Nest #5 ...................................................................... 20
    Nest #6 ...................................................................... 20
    Nest #7 ...................................................................... 21
    Nest #8 ...................................................................... 21
    Nest #9 ...................................................................... 21
    Nest #10 .................................................................... 22
    Nest #12 ..................................................................... 22
  Food Habits ..................................................................... 22

DISCUSSION .................................................................. 23
  Productivity .................................................................... 23
  Habitat Analyses ............................................................ 25
Prey Items and Methods ................................................................. 26
Future Studies and Management ...................................................... 31

FIGURES
Figure 1—Pellet mass classes .......................................................... 34
Figure 2—Number pellets collected ................................................. 35
Figure 3—Pellets with fur ................................................................. 36
Figure 4—Pellets with feathers ....................................................... 37
Figure 5—Pellets with scales ............................................................. 38
Figure 6—Pellets with bones or teeth .............................................. 39
Figure 7—Identified bones ............................................................... 40
Figure 8—Multiple food items ......................................................... 41

TABLES
Table 1—Nesting chronology and productivity ................................... 42
Table 2—Habitat analyses ................................................................. 43
Table 3—Number pellets in mass classes ......................................... 44
Table 4—Gross pellet contents ......................................................... 45
Table 5—Species identified ............................................................... 46
Table 6—Species identified from each nest ...................................... 48

LITERATURE CITED ............................................................................. 51

APPENDICES
Appendix I—Data used to calculate averages .................................... 59
Appendix II—Definitions of HSI variables ......................................... 61
Appendix III—Animals attributed to diets of red-tailed hawks ............... 62
ABSTRACT

I studied red-tailed hawks in Boulder County, Colorado during their 1985 nesting season. The purposes of this project were to study red-tailed hawk breeding biology and nesting-season diets and then to make management recommendations based on these results and an understanding of past raptor management.

Numbers of red-tailed hawks winter and nest in Boulder County, Colorado. Boulder County also has five major ecosystem-types (Marr, 1984). The study was designed to be less interventive than many previous studies of raptor food habits had been. Pellet contents and other remains, collected beneath nests, were identified. Red-tailed hawks have been said to consume at least 247 species of animals. At least 31 mammalian and six avian species were identified by pellet analysis to be consumed by red-tailed hawks in Boulder County.

Nine nests in three of the five habitat-types (Plains Grassland, Lower Montane, Upper Montane) were studied. One to 1.7 juvenile hawks fledged per nest.

The evolution of human attitudes and management practices about raptors (specifically red-tailed hawks where possible) were surveyed. Red-tailed hawks and other raptors have been persecuted for years. The 1972 Migratory Bird Treaty Act provided protection for raptors by requiring permits before handling them. Red-tailed hawks are commonly used by falconers. In Colorado, young red-tailed hawks can be removed from a nest to be used for falconry. The falconer must have a proper permit and must leave two young in the nest.

I outline possible future studies which could be conducted by volunteers. The use of strychnine and other secondary poisons, used for prairie dog control and could then indirectly kill raptors, should be discontinued. Finally, I suggest that the Colorado Division of Wildlife monitor red-tailed hawk nests to assure two young are left in the nest by falconers.
INTRODUCTION

Food habits and the breeding ecology of free-living red-tailed hawks (*Buteo jamaicensis*) have been studied extensively. Despite the plethora of studies, no major study has been conducted in Colorado. Olendorff (1973) studied diets of other nesting raptors, but largely ignored the red-tailed hawk because it was not abundant on the Pawnee National Grassland.

The purposes of this study were to provide some information on the 1985 nesting-season diets of red-tailed hawks in Boulder County in different ecosystems. These results, and an understanding of past raptor management, would be used in formulating management recommendations.

This section of the paper provides information about the status, life history, and diet of red-tailed hawks that is helpful in understanding the methods chosen. A brief survey of various methods of raptor food study is presented. Habitat selection and some methods of habitat analysis are discussed as are human attitudes about raptors.

Status

Red-tailed hawks are common diurnal raptors in North America (Brown and Amadon, 1968). Red-tailed hawks probably are the second most common raptor in Colorado (Gerald Craig, pers. comm.). Red-tailed hawks winter and nest in Boulder County, Colorado. In 1972, Henny reported that populations of red-tailed hawks were stable throughout their range. Red-tailed hawks have suffered the effects of egg-shell thinning that have afflicted many species of raptors, but to a lesser degree than many other kinds (Anderson and Hickey, 1972; Braun et al., 1977; Henny, 1972; Henny and Wight, 1972; Hickey and Anderson, 1968; Seidensticker and Reynolds, 1971). This may be due to a smaller proportion of fish in the diet (Peterson, 1969).

Life History

Red-tailed hawks exhibit sexual dimorphism in size. Adults are between 560 and 635 mm long (Beebe, 1974). Males weigh around 1000 g, whereas females weigh
around 1200 g (Beebe, 1974; Brown and Amadon, 1968). Differences in size influence food requirements and may be important in niche partitioning and expanding the prey base of the pair (Andersson and Norberg, 1981; Craighead and Craighead, 1956).

Red-tailed hawks vigorously maintain hunting and nesting territories. A pair (generally mated for life) controls the territory which commonly has a radius of approximately 1.7 km (APPENDIX I). Perches, which provide a good overview of the surrounding area, are an important feature of a territory (Fitch et al., 1946). Territorial defense varies in form and intensity, declining as the season progresses (Craighead and Craighead, 1956). Territories may be re-occupied in subsequent years if the hawks are migratory (Hagar, 1957). Gates (1972) observed red-tailed hawks wintering in areas that later became nesting territories. These observations helped locate nests and determine potential hunting areas.

Old nests usually are modified and reused in successive years (Bailey, 1918; Fitch et al., 1946; Luttich et al., 1971; Orians and Kuhlman, 1956). The pair may maintain or build several nests early in the nesting season to be used in case of harassment or early nesting failure (Fitch et al., 1946). It is easiest to locate old nests in deciduous trees during the winter when the leaves are absent (Craighead and Craighead, 1956; Hagar, 1957; Orians et al., 1956). Behaviors, such as defensive displays and vocalizations, are another good indicator of a local nest (Craighead and Craighead, 1956). These observations initially focused the search for nests in the present study.

Nest construction sometimes begins as early as late January, but may begin later. Nevertheless, incubation does not begin that early (Fitch et al., 1946; Hagar, 1957; Orians et al., 1956). In the western United States, nest construction has been observed between 6 February and 25 March (Call, 1978). Green twigs are found in occupied nests (Beebe, 1974; Bennett and Rudersdorf, 1980; Call, 1978; Hamerstrom and Hamerstrom, 1951; Himberger, 1984). "Whitemash" is visible beneath nests (Johnson, 1975).
Beebe (1974:82) noted that egg-laying began "... as early as February in Mexico and across the southern United States, by March or early April in the region of Puget Sound, by mid-April across mid-Canada, and as late as early June in the extreme north." In the western United States, eggs have been observed to be laid from 8 March to 17 April. The red-tailed hawks' breeding season (from laying to fledging) is approximately 112 days long (APPENDIX I).

Generally, 90% of red-tailed hawk pairs lay on average 2.5 eggs. The remaining 10% do not lay eggs in a given year. Both sexes incubate the eggs (Bent, 1937) for approximately 32 days. Brood sizes average 2.1 young. Of those young that hatch, 64% survive to fledge (APPENDIX I). The parents actively defend their young. The surviving young have been observed to fledge between 16 May and 1 July (Call, 1978). Once fledged, the young may stay in the vicinity of the nest for several days (Fitch et al., 1946).

**Diet**

The diets of free-living red-tailed hawks have been studied extensively elsewhere, but never in Colorado (see Appendix III for a nearly complete list). The young are brought the same kinds of food that adults eat (small mammals, reptiles, amphibians, insects, fish, crustaceans, and birds). Initially, the adults tear up the prey into smaller pieces; later, entire carcasses are deposited in the nest for the chicks to feed on by themselves. At first, the chicks only eat the flesh and viscera. Because parents try to remove all uneaten prey from the nest within a day, it would be difficult to rely only on nest remains for an accurate food study.

Beebe (1974:78) identified a problem with food studies of red-tailed hawks when he noted that,

... studies of the food habits and hunting methods of this hawk made in a specific region, or even at a specific time of year, do not necessarily indicate the kind of prey taken, or the hunting methods used by the same...
species elsewhere, or even of the same birds in the same area at a
different time of the year. Their behavior and food habits are in fact so
variable that two individuals living close together in the region and at
the same time of year may have food preferences and hunting habits quite
as different as if they were two separate species.

Adamcik et al. (1979) noted that diet varies in response to fluctuations in
populations of prey species. During a snowshoe hare (Lepus americanus)
population decline, they observed the mean daily biomass of snowshoe hares in
the diet of red-tailed hawks decreasing while the mean daily biomass of other
prey species (ground squirrels, voles, mice, various birds) increased.

Food Studies

Various quantitative methods of determining diets of raptors have been
developed (Craighead and Craighead, 1956; Errington, 1932). They include field
observations, nest studies, stomach examinations, gullet examinations, pellet
analysis, tethering (reviewed by Errington, 1932), and the "cage nest" method,
discussed by Selleck and Glading (1943). This section will discuss these methods
and provide some background for the method chosen.

Some of these methods are more harmful to the bird than others. Stomach
examinations not only kill the bird, but they provide only limited data (based
upon stomach contents when shot). However, at one time this was the accepted
method and was used as recently as 1949 by Latham (1950). It was not uncommon to
find 22% of those stomachs examined to be empty (APPENDIX I). Yet, as Olendorff
(1973) has discussed for other aspects of raptor studies, "our current,
extensive knowledge...is in part, regardless of such detrimental effects,
the result of this research" (Olendorff, 1973:24). Therefore, while we do not
have to continue using these methods, we should not discard the data they
generated.

Gullet examinations, tethering, direct nest studies (i.e., regular nest-tree
climbing), and the "cage nest" method also are interventive. Although they do not usually kill the birds being studied, they undoubtedly produce unnecessary stress for the adults and young involved.

If man is going to continue to exercise the privilege of using non-human animals for research purposes, then he must realize that covert changes in an organism may be equally damaging to the animal as overt changes, although the former are not equally unpleasant to the human eye (Bekoff, 1976:31)

Field observations and pellet analysis are the least interventive methods of raptor food studies. Field observations include sign reading and nest observations. Red-tailed hawks regurgitate undigested prey remains (hair, feathers, scales, exoskeletons, and some bones) as pellets or "castings". These pellets can be collected under the nest-tree.

Field observations alone can be misleading (Errington, 1932). The advantages and disadvantages of pellet analysis for use in buteos have been discussed by a variety of authors: Brooks (1929); Duke et al. (1976); English (1934); Errington (1930, 1932); Fitch et al. (1946); Fitch and Bare (1978); Glading et al. (1943); Luttich et al. (1970); Orians and Kuhlman (1956); Phelan and Robertson (1978), and Seidensticker (1970). Fitch and Bare (1978: 5) observed that "many nests . . . were directly over streams, so that the feces, pellets, and scraps of food dropped into the water [which] removed some of the cues by which predators might find the nest." On the plains in Boulder County, red-tailed hawks nest in plains cottonwood trees (Populus sargentii) which are associated with water. Hence, food remains may be dropped into the water and lost for study.

Errington (1932:80) noted that "digestion of bones was especially pronounced in the Buteos, in fast-growing young hawks having high calcium requirements, and
in most cases where soft-boned juvenile prey was eaten." Furthermore, "since hawks digest the bones of their prey more thoroughly than do owls, a smaller amount of each meal would be retained at the time of ingestion of a new meal by hawks" (Duke et al., 1976:5). This might result in the "stockpiling" of meals, thereby preventing accurate quantitative analysis. However, by relying on the undigested remains, "... hawk pellets provide qualitative data that may reflect food habits" (Fitch and Bare, 1978:7).

Luttich et al. followed certain guidelines for their quantitative pellet analysis. For example, "not more than one individual of a species was credited to any one pellet, unless numbers of teeth and bones indicated otherwise" (1970:192). They also were careful not to double count remains and pellets. This is of little significance if remains and pellet contents are analyzed separately or qualitatively.

Brooks (1929:222) noted that birds might not show up in pellets because "... raptors pluck birds very carefully as a rule, or else strip the skin and feathers off together, eating the meat only." Field observations may provide additional data in this case. Page and Whitacre (1975) estimated the number of birds consumed by counting primary feathers.

Habitat

"The red-tailed hawk has the widest ecological tolerance and geographic distribution of any buteo in North America" (USFWS, 1981:B-1). It has gained this tolerance and distribution by adapting to utilize a broad spectrum of prey (Beebe, 1974). However, red-tailed hawks appear not to choose nesting sites and territories randomly.

Red-tailed hawks establish territories in habitats which support their prey base. Territories must be in areas which can provide nutritional support for adults and presumably their young. Adamcik et al. studied red-tailed hawks in Alberta and stated that "about 50% of all nesting losses were associated with food shortage" (1979:16). Fitch et al. (1946) and Seidensticker (1970:40)
observed that "...many red-tailed hawks hatched as young ground squirrels became available." Janes reported a high degree of fidelity to breeding territories and explained it by observing that, "even [a] relatively poor territory...presents an opportunity for reproduction and is therefore of considerable value" (1984:203).

In order to compare various nesting sites and territories, it is crucial to understand habitats. Any method of habitat analysis must measure variables which influence prey habitat, prey abundance, and prey vulnerabilities. Habitat models are not population-predicting models. The remainder of this section will discuss two methods for habitat evaluation.

The United States Fish and Wildlife Service has developed a procedure that provides a numerical index which "...represents the capacity of a given occurrence of habitat (e.g., a vegetative stand or stream reach) to support a selected terrestrial or aquatic wildlife species" (Crumpacker and Ervin, 1982:123-124). This number is called the Habitat Suitability Index (HSI). HSI values range between 0 (totally unsuitable habitat) and 1 (optimal habitat). Specific instructions for variable measurement are not provided in the HSI description. It is assumed that the more data collected on each variable, the "better" the habitat evaluation.

An HSI model was developed to model the relationship between habitat and red-tailed hawk success for the eastern United States (USFWS, 1981). This model assumes that red-tailed hawks hunt in grasslands and nest in deciduous forests. Remote sensing methods (e.g., U.S. Geological Survey topographic maps) may be used to estimate the relative percentages of the various broad types of habitat (e.g., forest versus grassland).

Variables in each habitat are measured (APPENDIX II). Values are calculated by weighing these variables by the amount of habitat available. The lower of these two values is HSI. This "limiting-factor-concept" is crucial for a habitat analysis in the East where both habitats are used by the hawks. This feature
"acknowledges" the importance of all critical variables. It prevents a habitat which lacks, or possesses limited amounts of, a crucial variable from being classified as "optimum" habitat. In Boulder County, red-tailed hawks nest in cottonwoods on the plains and in coniferous forests west of the plains. The relationship between grasslands for hunting and forests for nesting is not always present in Boulder County.

Noon et al. (n.d.) developed a method to evaluate habitat use by raptors which does not contain a limiting-factor-concept. They identified variables to be measured in forested habitats and nonforested habitats. They provided explicit instructions for its implementation. This comprehensive evaluation procedure is beyond the scope of this project and also interferes with some of the goals of this project. (It requires nest tree climbing to record certain variables. Therefore, this method is more interventive than HSI.)

Luttich et al. (1970:201) concluded "...that the red-tail is an extremely adaptable raptor, capable of effectively utilizing a wide variety of habitat types. Its skill as a predator...is evidently sufficient to permit occupation of both open and forest cover types with equal facility." Therefore, a modified HSI could be applied. This would remove the "limiting-factor-concept" while still providing a meaningful method of comparing the habitats around the nests.

**Human Attitudes Toward Raptors**

An understanding of human attitudes toward raptors (specifically red-tailed hawks) and how they have changed over time allows one to understand past and current methods of food habit study and also past and present management techniques. This section will discuss human attitudes towards raptors and how they have changed as documented by legislation involving raptors.

"Birds of prey have been treated as enemies ever since European settlement began" (May, 1984:85). "Man's hostility toward hawks and owls probably began when he questioned their right to kill and consume grouse, ducks, or any other prey that might serve as food for himself" (Craighead and Craighead, 1956:201).
Farmers and ranchers frequently found themselves at odds with predators. In the late 19th century scientists, realizing the value of certain predators in rodent control, attempted to protect some species. Management of these species has always been related to the human costs and benefits derived from them. For example, Broadbent (1971) said that:

Historically wildlife managers have based their predator control programs on two tenets, neither of which is supported by the facts. The first is that all predators are bad and they decimate our wildlife... The next is that...[they], the purveyors of wildlife, have an innate responsibility to the livestock industry for any wildlife depredations on domestic animals (p. 51).

If a raptor species was said to eat chickens or game birds it was persecuted. If it ate agricultural pests, it was protected. Broadbent realized that we should value predators for other reasons (e.g., the call of a coyote is intrinsically beautiful). Now we realize that raptors can control agricultural pests, serve as indicator species, and that people value the aesthetic experience of simply seeing them fly around.

As early as 1930, McAtee and Stoddard called for protection of raptors because they claimed there was not enough data to define which raptors were beneficial and which were not beneficial. Meanwhile,

they are becoming rare enough throughout most of the United States already to need the special treatment we should have available when required for the protection of any species of wild life actually threatened with extermination. Regrettably, it is probable that before we have attained that evidence of civilization, the hawks and owls will be too far gone to profit by it (p. 19).
In 1893, Fisher (discussing red-tailed hawks) said:

...its inappropriate name 'Hen Hawk' stimulates an unceasing warfare against it. The farmers, who are chiefly benefited by it, are its most pronounced enemies, because of the erroneous belief that the Red-tailed Hawk is a persistent and destructive enemy of poultry (p. 48).

Later views on the benefits and costs of red-tailed hawks to humans have been along the same line of thought; red-tailed hawks do eat some chickens and game species, but they are generally a beneficial species because they eat considerable numbers of 'harmful pests' and should therefore not be persecuted (Bailey, 1910; Criddle, 1917; Errington, 1933; Fitch and Bare, 1978; Gloyd, 1925; Hornaday, 1913; Knight, 1902; Langenbach, 1939; May, 1935; McAtee, 1935; McDowell, 1949; Mendall, 1944; Miller, 1931; Munro, 1929; Pearson, n.d.; Sage et al., 1913; Stoddard, 1931; Taverner, 1934). Errington (1933) regarded "it as being one of our most valuable wild life [sic] species and one having too low a reproductive rate. . . to hold up under the terrific persecution it receives throughout the United States" (p. 28). He suggested non-lethal means of behavioral modification rather than outright killing of offending birds (e.g. if a red-tailed hawk was near your chickens--shoot in the air to scare the hawk away). In 1935, May observed that red-tailed hawks were effective rodent killers and stated that they should be protected because "it is one of the species which has diminished markedly in recent years over much of its range" (p. 33).

A problem with protection of select raptor species (e.g. red-tailed hawks) was identified by Orians (1955) who, when studying red-tailed hawks in Wisconsin, observed that none of the "...local residents were able to or cared to distinguish one species of hawk from another. All were unanimous in saying that hawks are shot whenever possible in their area. The attitude that the only
good hawk is a dead hawk still prevails" (p. 10). Therefore, he continued, 
legislation protecting certain species of hawks would be ineffective "...until 
public opinion is behind it." A possibility that Orrians did not consider would 
be to protect all raptors. There would be no mistaken identifications of hawks 
shot if no hawks were to be shot. Baldwin et al. (1932), prophetically 
realized this 23 years before when they noted that, "control measures designed 
to eliminate certain species and not others are distinctly and unquestionably 
inaudible" (p. 420). They based this statement by discussing the results of 
the 1929, five dollar bounty in Pennsylvania on goshawks. "Within one year after 
the law went into effect, 503 birds were taken into the office of the 
Pennsylvania Game Commission at Harrisburg in order to receive the $5.00 bounty. 
Out of this [sic] 503 birds only 76, or 15% were goshawks. Over 58% of all birds 
taken were of beneficial varieties" (p. 420).

Legislation concerning raptors has been at the local, state, federal, and 
international levels. Legislation has included: no protection, bounties on 
certain species, protection of some species, and protection of all species. The 
most infamous of all raptor legislation was the 1885 "scalp act" in 
Pennsylvania. Merriam (1886:228-229) described it well.

On the 23d of June, 1885, the legislature of Pennsylvania passed an 
act known as the "scalp act," ostensibly "for the benefit of 
agriculture," which provides a bounty of 50 cents each on Hawks, Owls, 
Weasels, and Minks killed within the limits of the State, and a fee of 20 
cents to the notary or justice taking the affidavit.

By virtue of this act about $90,000 has been paid in bounties during 
the year and a half that has elapsed since the law went into effect. This 
represents the destruction of at least 128,571 of the above-mentioned 
animals, most of which were Hawks and Owls.

Granting that five thousand chickens are killed annually in
Pennsylvania by Hawks and Owls, and that they are worth 25 cents each (a liberal estimate in view of the fact that a large proportion of them are killed when very young), the total loss would be $1,250, and the poultry killed in a year and a half would be worth $1,875. Hence it appears that during the past eighteen months the State of Pennsylvania has expended $90,000 to save its farmers a loss of $1,875. But this estimate by no means represents the actual loss to the farmer and the tax-payer of the State. It is within bounds to say that in the course of a year every Hawk and Owl destroys at least one thousand mice, or their equivalent in insects, and that each mouse or its equivalent so destroyed would cause the farmer a loss of 2 cents per annum. Therefore, omitting all reference to the enormous increase in the numbers of these noxious animals when nature's means of holding them in check has been removed, the lowest possible estimate of the value to the farmer of each Hawk, Owl, and Weasel would be $20 a year, or $30 in a year and a half.

Hence, in addition to the $90,000 actually expended by the State in destroying 128,571 of its benefactors, it has incurred a loss to its agricultural interests of at least $3,857,130, or a total loss of $3,947,130 in a year and a half, which is at the rate of $2,631,420 per annum! In other words, the State has thrown away $2,105 for every dollar saved! And even this does not represent fairly the full loss, for the slaughter of such a vast number of predaceous birds and mammals is almost certain to be followed by a correspondingly enormous increase in the numbers of mice and insects formerly held in check by them, and it will take many years to restore the balance thus blindly destroyed through ignorance of the economic relations of our common birds and mammals.

In 1899, 30 states had no legislation protecting any raptors (Phillips,
1949). As of 1949, at least 30 states protected "all hawks and owl, except the bird hawks--Cooper's, sharp-shinned, and goshawk--and the great horned owl" (Phillips, 1949:377). In 1972, "all species of raptors occurring in the wild in the United States and Mexico were given Federal protection under the Migratory Bird Treaty Act (16 U.S.C. 703-711)" (U.S.F.W.S., 1977:1). "Protection" means that if a human wants to trap, band, collect, kill, import, or export a raptor, a permit must first be obtained. Violations of the Migratory Bird Treaty "are punishable by fines of up to $500 and/or six months in prison, and revocation of permits if applicable. Sale or barter of raptors is a felony, punishable by a $2,000 fine and/or two years in prison" (U.S.F.W.S., 1977:5). There are stiffer fines related to bald eagles and endangered species. As with all laws, state laws do not take precedence over Federal laws unless the state law is more restrictive (U.S.F.W.S., 1977).

In Colorado, "turkey buzzards" were the only raptor protected in 1899 (Phillips, 1949). In 1903, all raptors were protected except sharp-shinned hawks (Accipiter striatus), Cooper's hawk (Accipiter cooperii), goshawks (Accipiter gentilis), duck hawks (Falco peregrinus), and great horned owls (Bubo virginianus) (C.S.A., Ch. 73, § 225, 231). According to Robert Tully (pers. comm.), even though most raptors were protected by law, there was little, if any, enforcement of the law. Raptors, including red-tailed hawks were routinely killed in Colorado until the 1960s.

"'Falconry' means the sport of taking quarry by means of a trained raptor" (50 C.F.R., § 21.3). Falconry was practiced in ancient Egypt. Falconry was very popular in the Middle Ages. The more "noble" species (e.g. falcons and eagles) were reserved for the aristocracy. Falconry was introduced to America in the early 20th century (Nye, 1966). Falconry has existed as a sport in Colorado since before the 1930s (Robert Tully, pers. comm.). In 1963, Colorado passed a law requiring permits for possession of raptors (Colorado Session Law, Ch. 142, 1963). This law was one of the first laws in the United States designed to
regulate falconry. Later, Colorado's falconry laws were stiffened and ultimately adopted into the Federal Regulation 50 C.F.R. 21--Migratory Bird Permits. State statutes 21.3, and 21.28-21.30, of 50 C.F.R. 21, deal specifically with raptors and falconry. It outlines a continuum of permits and levels of experience required before a falconer can obtain certain species. Wild red-tailed hawks can be taken by those falconers in the lowest class ("Apprentice"). Colorado Wildlife Commission Regulations (Chapter 6) also discusses requirements for falconry. Colorado's regulations are a little more restrictive than the Federal laws. Red-tailed hawks still can be taken by apprentice falconers.

Robert Tully (pers. comm.) said that once a falconry permit is obtained, the falconer can remove one eyas red-tail (2-3 week old juveniles are ideal) from a nest. "When a young raptor is removed from a nest at least two (2) live young raptors shall remain in the nest or aerie" (Colorado Wildlife Commission Regulations, Chapter 6, Article IIIb). In practice, there is little supervision by the Colorado Division of Wildlife. A falconer is supposed to report to the local Division officer that s/he is removing a raptor from a nest at a particular location. Once reported, they are allowed to capture the raptor without the officer checking the status of the nest.

MATERIALS AND METHODS

Red-tailed hawk nests were located in early 1985. The methods of Call (1978) and Craighead and Craighead (1956) were used to locate nests. I began searching for nests on 16 January and continued until late July. Historical nests were re-checked for occupancy. Areas where there were sightings of red-tails during the nesting season were checked carefully for nests.

Once the nests were identified, regular visits were made until the young fledged or disappeared. Those nests that were easily accessible received more visits than those which required substantial hiking or driving to reach. The visits were as brief, and as far from the nest as possible to limit disturbance.
of the adults and/or juveniles. During the visits, observations were made on the presence or absence of adult(s); sex of adults; nest defense; hunting; feeding; young; etc. Furthermore, once the young could be seen, ages were estimated (where possible) based on comparisons with photographs in Bent (1937); Call (1978); Craighead and Craighead (1956); Finley (1905); Fitch et al. (1946); Orians and Kuhlman (1956); and Sumner (1929).

Habitat analyses were conducted following the fledging of the young. A modified Habitat Suitability Index (HSI) for the red-tailed hawk was applied to all nests where juvenile red-tailed hawks were seen. Four \( (N, S, E, W) \) 25 m line transects extended from the nest tree to measure \( V_1 \) and \( V_2 \) (Appendix II) in those areas in which the red-tails nested in "grassland" (as interpreted from U.S.G.S. topographic maps). In those areas in which red-tails nested in "forests" (U.S.G.S. map interpretation) \( V_4 \) was measured on four \( (N, S, E, W) \) 25 m line transects extending from the nest tree. \( V_1 \) and \( V_2 \) were measured by two "X's", each with 25 m "arms" in grassy habitats. Additional data were collected while measuring HSI variables: diameter at breast height (dbh) of nest tree; height of nest tree; species of nest tree; height of nest; slope of ground around the nest; and distance from the nest to nearest water. This mainly provided a means of comparing nest sites. Comparisons of the entire area utilized by a given red-tailed hawk family would have required additional transects and specific knowledge about home ranges.

Pellet analysis and the identification of nest remains were supported by unintrusive nest observations from the ground to provide information on diets during the nesting season. Pellets and nest remains were collected beneath the nests soon after the young birds fledged. Approximately one hour per nest was spent searching in and around the "white-wash" zone. Each pellet was placed in an individually labeled polyethylene bag. If few pellets and/or remains were located, and nest tree climbing was feasible, the nest tree was climbed and Pellets were removed from the nest surface.
Pellets and other remains were frozen for one month to kill associated invertebrates. The pellets were then placed in individual pint ice cream containers and were allowed to reach room temperature prior to analysis.

Pellet analysis consisted of numbering, weighing, and measuring each pellet. Gross morphology was described (color, texture, the presence or absence of fur, feathers, scales, bones/teeth, odor, and moisture). The contents were then identified.

Content identification was based on the identification of fur, feathers, bones, and teeth. Useful keys and guides included: Armstrong (1972); Armstrong and Freeman (1982); Brown (1942); Gilbert (1980, 1981); Hausman (1920); Hoffmann and Pattie (1968); Mathiak (1938); Moore et al. (1974); Nason (1948); Stains (1958); Williams (1938). Road-killed small mammals were collected for comparative purposes. Zoological collections of the University of Colorado Museum were also used for comparison. Expert judgment of specialists affiliated with the University of Colorado was relied upon for identification of some contents.

Specifically, a set of comparative hair slides of locally collected specimens (when possible) was made for hair analysis. If a nest had fewer than 20 pellets, hair was identified in all of the pellets. If a nest had more than 20 pellets, hair was identified in 20 randomly selected pellets. Five percent of those pellets analyzed for hair were re-analyzed to obtain a measure of precision (* correctly re-identified/# re-identified).

Feathers were analyzed, in all pellets containing them, by Joe Strauch (an expert associated with the University of Colorado Museum). Identifications were made when possible. Scales and chitinous remains were not identified. Bones and teeth were identified when possible. Direct comparisons with the mammalian skull collection were made frequently.

Pellets were placed in one of seven mass classes (0-0.49 g, 0.5-0.99 g, etc. to >3.0 g). Pellets were also analyzed based on their kinds of contents (fur,
feathers, scales, bones/teeth, more than one kind, and identifiable bones/teeth).

A list of food items of the red-tailed hawk and their source in the literature was developed. Certain criteria were followed when assembling the list. Primary sources were located. Species were listed only when it was clear exactly which species were being reported (common names confused the process). Technical and common names of mammals followed Jones et al. (1982). Hall (1982) was useful in tracking down obscure mammalian names. The A.O.U. checklist (1983) was used for common and scientific names of birds. The 1957 checklist was helpful in tracking down synonyms. Names of amphibians and reptiles follow Collins et al. (1978). Fish names follow Robins et al. (1980). Numerous sources were used to organize the invertebrates. This list was supplemented with the list generated from pellet analysis.

RESULTS

Nests

Over 6,000 miles were driven searching for and monitoring nests. Nine nests were located in 1985. Eleven additional areas were searched intensively for nests. Nesting results are summarized on Table I. Once nests were located to determine progress, I made more than 113 visits (range 1-26) to the nesting areas. Ninety percent of the observed pairs of hawks laid eggs. Incubation began as early as March (Nest #4). The young fledged from late May (Nest #4) to mid-July (Nest #6). Nine to fifteen juvenile red-tailed hawks fledged (an average of 1-1.7 hawks per nest). Descriptions of the nests and their approximate locations follow. Life requisite values of each of the nests and the species of the nest tree are summarized on Table II.

NEST # 1—WILD BASIN-84 (40°13'N, 105°32'W)

This nest was a few hundred meters NE of Wild Basin-85. It was approximately 2550 m above sea level in an Upper Montane forest (Marr, 1964). Because no young were seen in it, a habitat analysis was not conducted. The habitat was similar
NEST # 2--BOULDER VALLEY RANCH-85 (40°04'N, 105°15'W)

This nest was located 12.5 m up a plains cottonwood tree in a large, gently rolling (angle <5°) horse pasture at Boulder Valley Ranch. The horse pasture formerly contained a substantial prairie dog colony. The colony was poisoned in 1981 with strychnine. Neighboring (less than 1 km away) prairie dog towns remain. A few prairie dogs were seen within 100 m of the nest in June. The hawks built this nest in 1984 (Jones, pers. comm.). From at least 1982 until 1984, the hawks nested over Farmers Ditch, about 250 m from this nest. There was an active great horned owl (Bubo virginianus) nest about 1 km away from the 1985 nest. The nest tree was approximately 1630 m above sea level in the Plains Grassland region (Marr, 1964). The nest was approximately 215 m from the nearest water source (Farmers Ditch). The tree was 26.2 m high and had a dbh of 1.17 m. The HSI of the area, calculated from four "grassland" transects, which measured food variables, on 16 August 1985, was 0.61.

NEST # 3--41st & OXFORD (40°07'N, 105°15'W)

This nest was built in 1985 following a successful theft of the 1984 nest by great horned owls. The usurped nest was in the same small woodlot, less than 75 m away from the active hawk nest. The elevation of the nest tree was 1646 m also in the Plains Grassland region (Marr, 1964). The nest was directly above an irrigation ditch and next to a small irrigation pond. Mostly overgrazed cow pastures surround the nest. The unflooded pasture below the nest contained a small prairie dog colony. Red-winged blackbirds (Agelaius phoeniceus) nested around the pond. The hawk nest was 17.6 m high up a 22.4 m tree with a dbh of 0.55 m. The HSI of the area was calculated by measuring "grassland" and "forest" variables since the woodlot was identifiable on a U.S.G.S. map. The life requisite values were 0.1 (food), and 1.0 (reproduction) measured, in both the "forest" and the "grassland," on 20 August 1985. Without the "limiting-factor-concept", the HSI was 1.0.
This nest was one of several red-tailed hawk nests in the immediate area, presumably constructed by the same pair (Heiser, pers. comm.). It was located on the edge of a flat woodlot, above an irrigation ditch, less than 1 km from Boulder Creek. A large, uncontrolled prairie dog colony was less than 1 km from the nest. The woodlot was surrounded by well-managed cow and horse pastures. In the horse pasture, prairie dogs were controlled by shooting and by having their holes filled in. The nest was about 1.5 km from nest # 8 (White Rocks). The neighboring Boulder Creek riparian zone was managed by removing beavers and keeping people out. The nest was 14.9 m up a 19.9 m plains cottonwood with a dbh of 0.88 m. The nest tree elevation of about 1550 m placed it in Marr’s (1964) Plains Grassland Region. The life requisite values, calculated by measuring food variables in the grassland, was 0.97 on 21 August 1985. The HSI was 0.97.

This nest was located 19.6 m up a 26.9 m tall lodgepole pine, 2725 m above sea level in an Upper Montane forest (Marr, 1964). The ground was sloped at 7° around the nest. The nearest clearing was the intersection of State Road 72, and County Road 103. A small stream flowed beside Route 72. The nest was 0.2 km from this water source. There was much evidence of pine squirrel (Tamiasciurus hudsonicus) activity in the forest around the nest. The grassy areas surrounding the intersection contained sign of montane voles. An active great horned owl nest was less than 1.5 km SE of the red-tailed hawk nest. The dbh of the nest tree was 0.53 m. The life requisite values based on food (0.0) and reproduction (0.24) were measured in both the “forest” and the “grassland” on 28 August 1985. Ignoring the “limiting-factor-concept,” the HSI was 0.24.

This nest was 21.9 m up a 22.9 m tall ponderosa pine with a dbh of 0.7 m. The ground around the nest was steeply sloping (35°). The nest tree was approximately 2550 m above sea level in a thinly wooded, Upper Montane forest (Marr, 1964).
The valley below the nest contained the meandering North St. Urain Creek with its associated riparian ecosystems. The nest was approximately 0.4 km from the nearest body of water. Many bird species nested in the area around the creek. Abert (Sciurus aberti) and pine squirrels were common on the slopes around the nest. The life requisite values were calculated by measuring food (0.7) and reproduction (0.7) variables in both the "grassland" and the "forest" on 28 August 1985. The HSI was 0.7.

NEST # 7--MATRON (39°56'N, 105°17'W)

This nest was located east of the Matron, a rock formation about 2010 m above sea level. The nest was 15.8 m up a 19.9 m ponderosa pine with a dbh of 0.62 m. The Mesa Trail runs in the grassy valley east of the nest which was located in the Lower Montane Forest (Marr, 1984) adjacent to a large talus slope. The nest was 0.6 km away from the nearest water source (the creek running through Shadow Canyon). There was substantial vole activity in the grassy areas adjacent to timberline. The HSI of the area was calculated from the life requisite values for food (0.4), and reproduction (1.0), measured in the "forest" and in the "grassland" on 19 August 1985. Disregarding the "limiting-factor-concept," the HSI was 1.0.

NEST #8--WHITE ROCKS (40°03'N, 105°08'W)

This nest was less than 1.5 km east of nest # 4 (Weiser), 1545 m above sea level, in Marr's (1984) Plains Grassland Region. Large ponds, periodically rich with waterfowl, and cattle-grazed meadows surrounded this nest. It was 24.5 m up a 33.1 m plains cottonwood with a dbh of 1.19 m. The trunk of the nest tree was less than 6 m from a bend in Boulder Creek. The nest was less than 100 m from an expanding prairie dog town. An active great horned owl nest was less than 1 km S of the hawk nest. An HSI of 0.6 was calculated by measuring food requisites for the "grassland" surrounding the nest on 22 August 1985.

NEST # 9--35th & NIMBUS (40°06'N, 105°16'W)

This nest was located in a small stand of trees near an irrigation ditch, in
a lightly grazed cow pasture, 2010 m above sea level. Since no young were raised at this nest, no habitat analysis was conducted.

NEST * 10--OUREY (40°09'N, 105°13'W)

This nest was located in a small stand of trees near an irrigation ditch, about 1585 m above sea level. Cattle and horses grazed the pastures surrounding the nest tree. A habitat analysis was not conducted because the nest was abandoned.

NEST * 49th & LEFTHAND (40°06'N, 105°14'W)

This nest probably was located in a woodlot near Lefthand Creek. The meadows around it were frequently overgrazed. The meadow west of it, along Lefthand Creek, had a dense colony of prairie dogs living in it. A habitat analysis was not conducted as the nest never was located.

Food Habits

Food data were collected from nests 1-8. Pellets were collected beneath all nests except nest * 7 (Matron). The * 7 nest tree was climbed to reach the nest. About 30 minutes was spent inside the nest removing pellets and some remains from the top layer of material. The nest was not destroyed while gathering information. The breakdown of the pellets by mass group is presented in Table 3 and Figure 1. The numbers of pellets collected from each nest is illustrated in Figure 2. The number of pellets collected from each nest varied greatly (2 to 147). The kinds of contents in the pellets are presented in Table 4 and Figures 3-8. Most pellets contained fur (Fig. 3). Most nests had pellets containing feathers in fewer than 20% of the pellets collected. A notable exception was nest * 3 (41st & Oxford) which had feathers in 67% of its pellets (Fig. 4). Forty-eight percent of the pellets collected contained scales. The scales were not distributed evenly among the nests. Nest * 2 (BUR) had scales in none of its pellets, while nest * 7 (Matron) had scales in 69% of its pellets (Fig. 5). Bone and teeth remains in pellets also varied. Thirty-six percent of the pellets collected had bone, tooth parts, or fragments. However, nest * 4 (Heiser) had
bones or teeth in 74% of its pellets whereas nest # 2 (BUR) had them in none (Fig. 6). The more pellets containing bones or tooth parts collected from a given nest, the smaller the percentage of identified bones or tooth parts (figs. 2 and 7). Seventy percent of those pellets collected contained more than one kind of food item (Fig. 8). However, nest # 2's (BUR) pellets only contained one kind each while every pellet in nest # 1 (Wild Basin-84) contained at least two kinds of contents.

The results of the literature search for food habits of red-tailed hawks are listed in Appendix III. Thirty-nine orders, 176 genera, and at least 247 species have been said to be consumed by red-tailed hawks. In the present study, at least 31 species of mammals from four orders were identified by nest remains, hair, bone, or tooth analysis (Tables V and VI). Eighty-two percent of those hair samples analyzed were correctly re-identified. Seven of the species (Castor canadensis, Ochotona princeps, Cynocephalus ludovicianus, Gelotes bursarius, Microtus longicaudus, Reithrodontomys montanus, Tamias umbrinus) had never been reported to be consumed by red-tailed hawks. Six avian species were identified from feather analysis (Tables 5 and 6).

DISCUSSION

Productivity

The numbers of pairs of hawks laying eggs (90%, n = 10), compared favorably with what has been reported in the literature (90%, n = 650). Unlike the observations of Craighead and Craighead (1956), Hagar (1957), Luttich et al. (1971), and Seidensticker and Reynolds (1971), most (3/4) of those red-tailed hawk nests near (1.5 km) great horned owl nests produced at least 2 young per nest. It is possible that the BUR nest failed because of owl predation on the young.

Seidensticker and Reynolds (1971) listed several reasons why red-tailed hawk nests might fail to produce young. It is possible, but not probable, that my observations might have influenced nest successes. My visits did not include
nest tree climbing and were as brief as possible. However, other humans could have influenced nest failure. Gunshots were heard in the vicinity of nest #5 (103 & 72). A Boy Scout camp was nearby. Additionally, the nest was visible from the road. Visits could have attracted the attentions of others who might have removed or killed the young. A close investigation for signs of climbing spike use on nest #5 tree proved fruitless. Adamcik et al. (1979) noted that about 50% of the nesting losses of young red-tailed hawks was due to food shortages. Other natural effects leading to nest failure cannot be discounted. For example, nest #10 was blown out of a tree at least twice before being abandoned.

Henny and Wight (1972:245-246) estimated that "...1.79-1.89 young [red-tailed hawks] must be fledged per breeding-age female to maintain a stable population" south of the 42nd parallel. In Boulder County, 1.0-1.7 red-tailed hawks fledged from those located nests. These numbers seem low. However, all nests located were analyzed, not a random sampling of nests. Average success from hatching to fledging of hawks in Boulder County (50%, n = 10) compared favorably to that reported in the literature (64%, n = 123). This study was only one year long. Too few data were collected to allow definitive statements about population trends in Boulder County.

The lengths of the breeding seasons of red-tailed hawks in Boulder County seemed low (ca. 46 - ca. 83 days) compared to the approximately 112 days (range 79-141) reported in the literature. I had difficulties assessing the status of the nesting season from the distances that most nests were observed. Previous studies had used more interventive techniques (e.g., regular nest-tree climbing) and therefore had collected more precise data. However, nest #3 (41st and Oxford) was observed closely. A 46- to 49-day nesting season (incubation to fledging) was seen at this nest. Therefore, the possibility exists that those numbers reported in the literature are somewhat high, or that red-tailed hawks exhibit remarkable flexibility in length of breeding season.
Habitat Analyses

The fact that red-tailed hawks nested in areas with such variable HSI's, shows that my habitat assessment methods might be at fault or that the proper variables were not measured. Numerous samples over several years, not just a few samples on a given day, might have better described the habitats around the nests. Also, home range information would have allowed additional representative transects. However, preliminary generalizations can be made. Red-tailed hawks nest high up in large trees, fairly close to water, and sometimes above or near a concentrated food source (e.g., a prairie dog town). Height probably serves to avoid predators and also to gain a good overview of the surrounding area. (When I was in the Matron nest collecting pellets and remains, I could see for miles in most directions.) Water might be required for prey abundance or nest tree growth. Nests were only directly above a water source on the plains. Since cottonwood trees require water, this is not unusual. I do not think (as did Fitch and Bare, 1978) that red-tailed hawks choose nests above bodies of water "so that the feces, pellets, and scraps of food [are] dropped into the water [to] removed [sic] some of the cues by which predators might find the nest" (p. 5). I had few problems collecting pellets beneath nests. Nest sanitation (as Orians and Kuhlman, 1956, reported) is probably conducted by removing uneaten prey from the nesting area. Nesting above or near a concentrated food source probably reduces the costs of foraging.

While HSI is not a population predicting model, it is interesting to see the relationship between HSI and nesting success. When HSI's "limiting-factor-concept" was ignored, the results were less than telling. A relatively high life requisite value did not guarantee producing more young than a low value (nest #8, White Rocks, produced two young with a value of 0.6, whereas nest #3, 41st and Oxford, probably produced two young with a value of 1.0). The nest with the lowest value (nest #5, 103 & 72, value = 0.24) probably produced no young. These data showed little relationship between HSI and nesting
success although the sample size is too small to be predictive.

Prey Items and Methods

What a redtail [sic] or any other Buteo [sic] eats is largely a matter of what is to be had without too much trouble; what is conspicuous enough to be readily seen by a hungry bird; what is within the bird's power to capture and to handle; or what is already available in the form of a carcass beside a highway, along a lake shore, or in a field or a woodlot. The feeding of all mid-west Buteos upon rodents, snakes, invertebrates, and whatever else they may recognize as eligible food and can readily get claws on, reveals a conforming to ecological pattern that combines, as well as is controlled by, the elements of naturalness and necessity (Errington and Breckenridge, 1938:121).

The prey species identified from each nest were species expected to be found in the vicinity of each of the nests. Bent (1937:157-158) stated that "...the young [red-tailed] hawks are fed largely on [sic] mice and squirrels."

"Squirrel-sized" mammals seemed to be present as remains wherever they were found. Also, chipmunk- and mouse-sized mammals were consumed.

Bird remains were found in pellets at a low, but fairly consistent rate. Most feathers were not identifiable. "Flicker-sized" birds were represented from most nests although red-tailed hawks have been known to eat all but the largest species. No bird remains were found in nest #1 or #2. This could indicate those individuals not hunting birds or it might be an artifact of the small numbers of pellets collected from each of those nests. Bent (1937:157) noted that "probably most of the small birds are killed during the nesting season as food for the small young."

Reptiles and amphibians were not identified, but probably were preyed upon whenever possible. Hammerson (1982) listed amphibians and reptiles found in
Colorado and where they are found. Amphibians probably left few identifiable remains. None of the scales appeared to be fish scales. I do not think that scales in pellets represented individual prey items or individual meals. The large percentage of pellets containing scales was probably caused by the scales lying around the nest and either becoming attached to fresh prey items or becoming attached to the pellets after they were regurgitated. Another possible cause for the large numbers of pellets containing scales might be that scales are not regurgitated as easily as fur. This might produce a 'reservoir' of scales in a hawk's stomach which would be regurgitated along with other items (e.g., fur, feathers). Quantitative statements about predation of red-tailed hawks on reptiles and amphibians might be misleading.

Invertebrate remains were not noted or identified. Whereas red-tailed hawks may opportunistically prey on some invertebrates (e.g., grasshoppers), some invertebrates might become associated with a pellet after the hawk has regurgitated it. The list of invertebrates associated with red-tailed hawks should be considered in light of the fact that it is impossible to determine the origin of many invertebrates (the hawk may have eaten the invertebrate directly, or the invertebrate might have been inside the mouth or stomach of a vertebrate consumed by the hawk, or perhaps the invertebrate was eating a pellet).

Bone and tooth fragments were generally of no use in identifying remains. Entire jaws, when found, proved extremely helpful. Errington (1932) was correct when he observed buteos digest most bones.

These results illustrate the problems associated with quantitative studies of the food habits of red-tailed hawks which rely on pellet analysis. Pellet analysis is the least interventive method of raptor food study if pellets are collected following fledging or abandonment of nests. However, pellet contents may not reflect individual meals and few identifiable bones are regurgitated. Qualitative studies, such as this one, must provide information on food habits of red-tailed hawks.
Future investigators should be aware of the difficulties associated with hair analysis. Korschgen (1980:115) said that "attitudes and work habits of the investigator have great bearing on achievements from food-habits studies...[The investigator] must be thorough, patient, and persevering [sic]...". Some species' hair microscopically resembles other species'. Therefore, some measure of precision should be reported for hair analysis. By having a good idea of which mammalian species live in an area where pellets were collected, thus producing a subset of hair for comparison, considerable time can be saved. Red-tailed hawk pellet analysis would not be a good mammal sampling technique.

The following discussions are about those prey species never previously reported to be consumed by red-tailed hawks.

Pikas (*Ochotona princeps*) were identified in two nests. Pikas probably were never before reported as a prey item because no previous studies had nests near timberline in an area where pikas lived. Pikas are found only in alpine talus slopes. This suggests that hawks were travelling a considerable distance (perhaps as far as 10 km by nest #5's hawks) to hunt the pikas. Pika's elaborate alarm calling system would seemingly make them less vulnerable to aerial predation than some other diurnal small mammals.

Although Knight (1902) and Lloyd (1887) reported "prairie dogs" as part of the diet of red-tailed hawks in Wyoming and Texas, "black-tailed prairie dogs" (*Cynomys ludovicianus*) had never before been specifically reported. Full-grown prairie dogs might be too large for a red-tailed hawk to fly with, but juvenile prairie dogs would pose no such problem. Prairie dogs dispersed from their coteries in the summer and were killed (in mass) by cars. Red-tailed hawks could have been scavenging these remains (they have been known to scavenge before--in 1981, a red-tailed hawk was found dead near a prairie dog burrow in the BUR prairie dog town poisoned with strychnine--Jones, 1983). At least four nests were within 1 km of active prairie dog towns. Black-tailed prairie dog
remains were found in three of those nests. Clark et al. (1982) ran a large belt transect as part of a study of vertebrates associated with prairie dog colonies. In areas where black-tailed prairie dog ranges overlapped with red-tailed hawk ranges, they did not notice red-tailed hawk and black-tailed prairie dog associations. Yet, my data show that black-tailed prairie dogs are part of red-tailed hawk diets when found sympatrically (3/4 of nests which were sympatric with prairie dogs showed evidence of prairie dog predation).

The management implications of this are troublesome. Prairie dogs, considered agricultural pests, are controlled by poisoning and shooting. Secondary poisons, such as strychnine, have been used routinely. Lead shot can act like a secondary poison by ultimately or directly killing an animal (e.g., a raptor) which unsuspiciously eats an animal previously shot. Other poisons (e.g., phostoxin) are indiscriminate killers, killing everything living in a prairie dog burrow (e.g., burrowing owls, snakes, ferrets, badgers). The Boulder County Extension Office issues phostoxin (with the proper E.P.A. license), gas cartridges (containing sulphur and sodium nitrate—which also kill everything in the burrows), and strychnine (strychnine has not been sold for about two years since the other methods are more effective). Non-secondary, and directable poisons are available, e.g. zinc phosphide (Tietjen, 1976). The City of Boulder has used zinc phosphide successfully for several years and (as of early 1986) was trying to have it accepted by Boulder County as the official poison. The only problem with zinc phosphide is that its application is fairly labor intensive.

Beavers (Castor canadensis), another species never before reported, were only consumed in the mountains. Numerous beavers used to live around the Weiser/White Rocks nests (#4 and #8) and probably were consumed there too. Those beavers were trapped and killed because of their destruction of cottonwood trees along Boulder Creek. Small beavers fall within the size-range of prey of red-tailed hawks.

Northern pocket gophers (Thomomys talpoides) had been previously reported
as part of the diet of red-tailed hawks but plains pocket gophers (*Deomys bursarius*) had not. Plains pocket gophers were consumed at three of the plains nests in this study. All of the nests were in agricultural areas where irrigation and cultivation could have forced individual pocket gophers above ground, thus increasing their vulnerability to predation. Caldwell (1986) recently reported red-tailed hawks flying away from tractors plowing fields rather than staying around and hunting. Nevertheless, small mammals, including plains pocket gophers, are displaced by plowing and are therefore potentially more vulnerable to hawk predation.

Long-tailed voles (*Microtus longicaudus*) had never been previously reported to be consumed by red-tailed hawks. In this study, remains were identified at the Matron nest (#7). Armstrong (1972:240) noted, "the long-tailed vole occurs widely in the western United States and adjacent Canada. ... is the most euryecious of Coloradan microtines. ..." One might assume that such a wide-ranging species would be consumed by red-tailed hawks wherever they were found together. Perhaps since long-tailed voles are less dependent on grass runways than other microtines and may therefore live in forested areas (Armstrong, 1972), they are more difficult to locate and catch than other species.

Plains harvest mice (*Reithrodontomys montanus*) had never been previously reported to be consumed by red-tailed hawks. This nocturnal species occupies drier areas on the plains than western harvest mice (*Reithrodontomys megalotis*) (Armstrong, 1972). Plains harvest mouse remains were identified at the White Rocks nest (#8). As the habitats are similar, they also are probably consumed at the Weiser nest (#4).

Uinta chipmunks (*Tamias umbrinus*) were never before reported to be eaten by red-tailed hawks. In this study, Uinta chipmunks were consumed at the nest #5. Uinta chipmunks are found in lodgepole pine forests. Since other species of chipmunks have been reported to be consumed by red-tailed hawks, previous
studies of red-tailed hawks diets probably did not occur in lodgepole pine forests where the hawks' could have captured Uinta chipmunks.

**Future Studies and Management**

Red-tailed hawks are fairly common raptors in Colorado. This provides an opportunity to collect considerable baseline data, and to monitor their progress in the future. Future studies should note distribution and abundance, food habits, and breeding ecology. Since the Colorado Division of Wildlife has little non-game funding, volunteers could be utilized for this research. This section will outline a potential management plan for red-tailed hawks in Colorado.

A part-time volunteer coordinator from the DDW could be appointed. Duties would include stimulating interest among local Audubon Societies, nature associations, environmental groups, and university students. Data analysis, and writing regular reports to those involved in the project would also be done by this person.

Changes in Christmas bird count data over time could be compiled by those organizations which reported the data. The coordinator could then map the results to develop abundance patterns. Bock and Lepthien (1976) cautioned that since field identification is not always correct, maps, while not providing "exact distributional limits", could be used to depict "overall abundance patterns."

The same organizations responsible for the Christmas count data could stimulate members to participate in breeding season counts. These counts would provide information on potential nest locations. For example, the Boulder County Nature Association has identified at least 36 areas in Boulder County which may have red-tail hawk nests. Most of these areas were searched for the hawks and/or nests for this study. Undoubtedly, with more people searching, more nests would have been located. Therefore, potential nest areas could be investigated by diligent members of these organizations. Information on location of nests would be restricted to as few members as possible. An emphasis on non-interventive
methods would be stressed to all involved in this stage.

Once nests are located, several non-intervention checks could be made to determine nesting progress. Approximate fledging dates are easier to collect than hatching dates. Fledging dates would be particularly useful since they would “define” the nesting season.

Pellets and other remains could be collected under nests after the young fledged or the nests were known to be abandoned. Pellets could be analyzed by biology students, with the help of their instructors, at universities. The analysis need not be that rigorous. Any information on species consumed would be useful.

There would be a considerable time-lag between data collection and analysis with this many volunteers involved. However, the data would still be collected and analyzed.

With this mass of data, concrete management plans could be developed. While the red-tailed hawk is just one predator, other species rely on their prey items too. Emphasis might be placed on eliminating the use of secondary poisons (e.g., used to control prairie dogs and coyotes). Falconers might be discouraged from removing eyases from certain areas and encouraged to remove young from other areas. With known numbers of young in a nest, Colorado Wildlife Regulation Chapter 5, Article 111b (which specified at least two young raptors remain in a nest where one was removed) might be able to be followed (In this study, only 2 of 6 productive nests might have fledged three young. If these data are representative for Colorado, the collection of red-tailed hawks for falconry might have to be severely limited). The habitats of red-tailed hawks and their prey could be monitored. This study has demonstrated that, in Colorado, red-tailed hawks nest in a variety of habitat types.

The data collected now, while the red-tailed hawk is still fairly common, could be useful in the future if and when it becomes threatened or endangered. Regardless of the future of the red-tailed hawk, long-term data are infrequently
collected because costs of collecting these data are great. This program would maximize the amount of data collected while minimizing the costs. (Of course once these data were collected management policies should be based on them. Presently, annual falconry reports are compiled, filed, and lost!) Additionally, public interest about wildlife might increase (thereby generating more non-game revenues) if the project received enough favorable publicity. The State of Colorado, and the Division of Wildlife would have a lot to gain and little to lose by embarking on such a project.
Figure 1. Number of pellets from each mass class collected at each of the nests. Number of pellets collected is plotted on the ordinate. Mass classes (Table 3) are plotted on the abscissa.
Figure 2. Number of pellets collected from each nest.
Figure 3. Percentage of pellets from each nest containing fur.
Figure 4. Percentage of pellets from each of the nests containing feathers.
Figure 5. Percentage of pellets containing scales from each nest.
Figure 6. Percentage of pellets from each nest containing bones or teeth.
Figure 7. Percentage of bones extracted from pellets from each nest, identified to genus and to species.
Figure 8. Percentage of pellets containing multiple food item-types from each nest.
Table 1. Summary of nesting chronology and productivity of red-tailed hawk nests in Boulder County during the 1985 nesting season.

<table>
<thead>
<tr>
<th>NEST (#)</th>
<th>INCUBATION</th>
<th>BROODING</th>
<th>FLEDGING</th>
<th>NUMBER FLEDGED</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUR (2)</td>
<td>&lt;7 April-29 May</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>41st + Oxford (3)</td>
<td>7 April-</td>
<td>28 June-1 July</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>49th + Lefthand (?)</td>
<td>&gt;14 May-</td>
<td>&gt;26 May</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Matron (7)</td>
<td>&lt;9 April-</td>
<td>19-27 June</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ouray (10)</td>
<td>20 March + 11 April</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>103/72 (5)</td>
<td>24 June-1 July</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>35th + Nimbus (9)</td>
<td></td>
<td></td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Weiser (4)</td>
<td>&lt;8 March</td>
<td>&lt;17 April</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>White Rocks (8)</td>
<td>&lt;9 April-</td>
<td></td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>Wild Basin (6)</td>
<td>&lt;5 June</td>
<td>15 or 16 July</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

1No activity seen on or around nest after 29 May. Nest presumably failed.
2Nest may have fledged three.
3Nest never found. Adults seen acting territorially on numerous occasions and two juveniles seen flying with adults on this date.
4Nest may have fledged two.
5Nest apparently blew out of tree twice; rebuilt first time but not second.
6Hawks seen in area 27 April. No new nest found.
7At least one downy juvenile head seen on 24 June and part of one head seen on 1 July. No hawks or activity seen after 1 July; nest presumably failed.
8Nest constructed late February and March; hawks seen in area through 5 April.
9No hawks or nesting activity seen after 5 April; nest presumably abandoned.
Table 2. Habitat analyses for red-tailed hawk nests in Boulder County, 1985.

<table>
<thead>
<tr>
<th>NEST #</th>
<th>&quot;grassland&quot;</th>
<th>&quot;forest&quot;</th>
<th>Nest Tree Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.61</td>
<td>-</td>
<td>Plains Cottonwood</td>
</tr>
<tr>
<td>3</td>
<td>0.1</td>
<td>1.0</td>
<td>Plains Cottonwood</td>
</tr>
<tr>
<td>4</td>
<td>0.97</td>
<td>-</td>
<td>Plains Cottonwood</td>
</tr>
<tr>
<td>5</td>
<td>0.0</td>
<td>0.24</td>
<td>Lodgepole Pine</td>
</tr>
<tr>
<td>6</td>
<td>0.7</td>
<td>0.7</td>
<td>Ponderosa Pine</td>
</tr>
<tr>
<td>7</td>
<td>0.4</td>
<td>1.0</td>
<td>Ponderosa Pine</td>
</tr>
<tr>
<td>8</td>
<td>0.6</td>
<td>-</td>
<td>Plains Cottonwood</td>
</tr>
</tbody>
</table>
Table 3. Number of pellets from each mass class collected at each nest. Pellet masses are in grams.

<table>
<thead>
<tr>
<th>Nest #</th>
<th>Pellet Mass Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-0.4 (g)</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>7</td>
<td>92</td>
</tr>
<tr>
<td>8</td>
<td>90</td>
</tr>
</tbody>
</table>

n (Σn=380) 228 57 52 13 8 7 15

n/Σn (g) 60.0 15.0 13.7 3.4 2.1 1.8 3.9
Table 4. Contents of red-tailed hawk pellets collected beneath Boulder County nests in 1985.

<table>
<thead>
<tr>
<th>NEST</th>
<th>%pellets</th>
<th>%fur</th>
<th>%feathers</th>
<th>%scales</th>
<th>%bones</th>
<th>%multiple contents</th>
<th>%identifiable bones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>19</td>
<td>18</td>
<td>4</td>
<td>7</td>
<td>14</td>
<td>15</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>30</td>
<td>27</td>
<td>6</td>
<td>11</td>
<td>12</td>
<td>19</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>36</td>
<td>5</td>
<td>10</td>
<td>18</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>132</td>
<td>129</td>
<td>18</td>
<td>92</td>
<td>14</td>
<td>95</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>147</td>
<td>147</td>
<td>9</td>
<td>58</td>
<td>74</td>
<td>109</td>
<td>34</td>
</tr>
</tbody>
</table>
Table 5. Mammalian and avian species consumed by red-tailed hawks in Boulder County, Colorado. Species marked with an asterisk had never previously been reported to be consumed by red-tailed hawks.

MAMMALS

ORDER INSECTIVORA
  Sorex spp.

ORDER LAGOMORPHA
  Lepus californicus
  Ochotona princeps*
  Sylviagus audubonii* (found only by bones, not hair)
  Sylviagus nuttalli
  Sylviagus spp.

ORDER RODENTIA
  Castor canadensis
  Cynomys ludovicianus*
  Geomys bursarius*
  Marmota flaviventris
  Microtus longicaudus* (found only by bones, not hair)
  Microtus ochrogaster* (found only by bones, not hair)
  Microtus pennsylvanicus
  Ondatra zibethicus
  Peromyscus maniculatus
  Peromyscus spp.
  Reithrodontomys megalotis
  Reithrodontomys montanus*
  Sciurus aberti
  Sciurus niger
  Sciurus spp.
  Spermophilus lateralis
  Spermophilus tridecemlineatus
  Tamias minimus
  Tamias umbrinus*
  Tamias spp.
  Tamiasciurus hudsonicus
  Thomomys talpoides
  Thomomys princeps
Table 5, continued.

ORDER CARNIVORA
   *Mephitis mephitis*
   *Procyon lotor*

**BIRDS**

ORDER PICIFORMES
   *Colpatus auratus*

ORDER PASSERIFORMES
   *Cyanocitta stelleri*
   *Pica pica*
   *Piranga ludoviciana*
   *Sturnus vulgaris*
   *Turdus migratorius*
Table 6. Mammalian and avian species found in red-tailed hawk pellets or nest remains in Boulder County, Colorado. Species with a bold asterisk had never been reported previously to be consumed by red-tailed hawks.

<table>
<thead>
<tr>
<th>NEST *</th>
<th>NAME</th>
<th>HAIR</th>
<th>BONES/TEETH</th>
<th>FEATHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>WILD BASIN 1984</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Marmota flaviventris</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Tamiasciurus Hudsonicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Microtus longicaudus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BUR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cynomys ludovicianus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Microtus pennsylvanicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>41st &amp; OXFORD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Geomys bursarius</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Lepus californicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Peromyscus maniculatus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Peromyscus</em> spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Spermophilus tridecemlineatus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Sylvilagus nuttallii</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cynomys ludovicianus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sturnus vulgaris</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>WEISER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Cynomys ludovicianus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Microtus pennsylvanicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Ondatra zibethicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Reithrodontomys megalotis</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Sciurus niger</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Spermophilus tridecemlineatus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Sylvilagus</em> spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Geomys bursarius</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Microtus</em> spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Microtus ochrogaster</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Microtus pennsylvanicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Ondatra zibethicus</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6, continued.

<table>
<thead>
<tr>
<th>5</th>
<th>103 &amp; 72</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Castor canadensis</strong>&lt;sup&gt;*&lt;/sup&gt;</td>
<td><strong>Peromyscus maniculatus</strong></td>
</tr>
<tr>
<td><em>Marmota flaviventris</em></td>
<td><em>Sylvilagus audubonii</em>&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>Microtus pennsylvanicus</em></td>
<td><em>Sylvilagus nuttallii</em></td>
</tr>
<tr>
<td><em>Ochotona princeps</em>&lt;sup&gt;*&lt;/sup&gt;</td>
<td><em>Sylvilagus spp.</em></td>
</tr>
<tr>
<td><em>Sciurus spp.</em></td>
<td><em>Piranga ludoviciana</em></td>
</tr>
<tr>
<td><em>Sorex spp.</em></td>
<td><em>Sturnus vulgaris</em></td>
</tr>
<tr>
<td><em>Tamias minimus</em></td>
<td></td>
</tr>
<tr>
<td><em>Tamias umbrinus</em>&lt;sup&gt;*&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><em>Tamias spp.</em></td>
<td></td>
</tr>
<tr>
<td><em>Tamiasciurus hudsonicus</em></td>
<td></td>
</tr>
<tr>
<td><em>Microtus spp.</em></td>
<td></td>
</tr>
<tr>
<td><em>Thomomys talpoides</em></td>
<td></td>
</tr>
<tr>
<td><em>Colpotes auratus</em></td>
<td></td>
</tr>
</tbody>
</table>

6 WILD BASIN 1985

**Castor canadensis**<sup>*</sup>

*Nephtis mephitis*

*Microtus pennsylvanicus*

*Ochotona princeps*<sup>*</sup>

*Sciurus aberti*

*Spermophilus lateralis*

*Tamiasciurus hudsonicus*

*Zapus princeps*

*Thomomys talpoides*

*Colpotes auratus*

7 MATRON

*Marmota flaviventris*

*Microtus pennsylvanicus*

*Sciurus aberti*

*Thomomys talpoides*

*Microtus longicaudus*<sup>*</sup>
Table 6, continued.

<table>
<thead>
<tr>
<th>Sciurus spp.</th>
<th>Cyanocitta stelleri</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pica pica</td>
</tr>
<tr>
<td></td>
<td>Turdus migratorius</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8</th>
<th>WHITE ROCKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Microtus pennsylvanicus</td>
</tr>
<tr>
<td></td>
<td>Peromyscus maniculatus</td>
</tr>
<tr>
<td></td>
<td>Procyon lotor</td>
</tr>
<tr>
<td></td>
<td>Reithrodontomys montanus*</td>
</tr>
<tr>
<td></td>
<td>Geomys bursarius*</td>
</tr>
<tr>
<td></td>
<td>Microtus ochrogaster</td>
</tr>
<tr>
<td></td>
<td>Microtus pennsylvanicus</td>
</tr>
<tr>
<td></td>
<td>Microtus spp.</td>
</tr>
<tr>
<td></td>
<td>Ondatra zibethicus</td>
</tr>
<tr>
<td></td>
<td>Sylvilagus spp.</td>
</tr>
<tr>
<td></td>
<td>Colopatus auratus</td>
</tr>
<tr>
<td></td>
<td>Sturnus vulgaris</td>
</tr>
</tbody>
</table>
LITERATURE CITED


CAMERON, E.S. 1907. The birds of Custer and Dawson counties, Montana. Auk, 24:241-270.


DIXON, J. 1906. Land birds of San Onofre, California. Condor, 8:91-98.


JONES, J.K., Jr., D.C. CARTER, H.H. GENOWAYS, R.S. HOFFMANN, and D.W. RICE.


LANO, A. 1927. Western red-tail (Buteo borealis calurus) in Arkansas. Auk, 44:249.


Miller, J.P. 1931. The red-tailed hawk (Buteo borealis [Gmelin]) in relation to the control of the Columbian ground squirrel (Citellus columbianus [Ord]). Murrelet, 12:46-49.


APPENDIX I

Published data used to calculate averages in the text. (The inspiration for this appendix and some of the categories are from Nader, 1978).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Data</th>
<th>Location</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average territory radius (km): 1.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td></td>
<td>Michigan, Wyoming</td>
<td>Craighead and Craighead, 1956</td>
</tr>
<tr>
<td>2.4</td>
<td></td>
<td>Michigan</td>
<td>English, 1934</td>
</tr>
<tr>
<td>0.85</td>
<td></td>
<td>California</td>
<td>Fitch et al., 1946</td>
</tr>
<tr>
<td>1.8</td>
<td></td>
<td>Utah</td>
<td>Smith and Murphy, 1973</td>
</tr>
</tbody>
</table>

| Approximate length of breeding season (laying -> fledging) in days: 112 |       |                  |                                 |
| 81       |       | Utah             | Hardy, 1939                     |
| 118      |       | Arizona          | Mader, 1978                     |
| 139      |       | Utah             | Smith and Murphy, 1973          |
| 79       |       | Ohio             | Springer and Kirkley, 1978      |
| 141      |       | California       | Wiley, 1975                     |

| Average number of pairs laying eggs % (n): 90 (650) |       |                  |                                 |
| 90 (212) |       | Alberta          | Adamcik et al., 1979            |
| 100 (19) |       | Michigan, Wyoming| Craighead and Craighead, 1956   |
| 90 (153) |       | Montana          | Johnson, 1975                   |
| 86 (66)  |       | Alberta          | Luttich et al., 1971            |
| 89 (107) |       | Alberta          | McInwaile and Keith, 1974       |
| 90 (67)  |       | Wisconsin        | Orians and Kuhlman, 1956        |
| 81 (26)  |       | Utah             | Smith and Murphy, 1973          |

| Average clutch size (n): 2.5 (757) |       |                  |                                 |
| 2.18 (191) |       | Alberta          | Adamcik et al., 1979            |
| 2.0 (8)    |       | California       | Fitch et al., 1946              |
| 1.9 (33)   |       | Kansas           | Freemyer, 1966                  |
| 2.79 (476) |       | USA, Canada      | Henry and Wight, 1972           |
| 1.9 (30)   |       | Alberta          | Luttich et al., 1971            |
| 2.89 (19)  |       | Utah             | Smith and Murphy, 1973          |

| Average incubation period in days: 32 |       |                  |                                 |
| 32       |       | Alberta          | Adamcik et al., 1979            |
| 30       |       | British Columbia| Beebe, 1974                     |
| 28       |       | North America?   | Bent, 1937                      |
| 35       |       | Utah             | Hardy, 1939                     |
| 35       |       | Arizona          | Mader, 1978                     |
| 30       |       | Utah             | Smith and Murphy, 1973          |
Average brood size \((n)\): 2.1 (213)

<table>
<thead>
<tr>
<th>State/Region</th>
<th>Average</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>2.09 (191)</td>
<td>Adamcik et al., 1979</td>
</tr>
<tr>
<td>New York</td>
<td>1.9 (22)</td>
<td>Hagar, 1957</td>
</tr>
</tbody>
</table>

Average success from hatching to fledging \%(n)\): 64 (123)

<table>
<thead>
<tr>
<th>State/Region</th>
<th>Success</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan, Wyoming</td>
<td>76 (29)</td>
<td>Craighead and Craighead, 1956</td>
</tr>
<tr>
<td>California</td>
<td>59 (27)</td>
<td>Fitch et al., 1946</td>
</tr>
<tr>
<td>Utah</td>
<td>67 (12)</td>
<td>Platt, 1971</td>
</tr>
<tr>
<td>Utah</td>
<td>58.9 (55)</td>
<td>Smith and Murphy, 1973</td>
</tr>
</tbody>
</table>

Stomachs empty \%(n empty/n examined): 22 (361/1630)

<table>
<thead>
<tr>
<th>State/Region</th>
<th>Stomachs</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>24 (16/68)</td>
<td>Bailey, 1918</td>
</tr>
<tr>
<td>USA</td>
<td>16 (89/562)</td>
<td>Fisher, 1893</td>
</tr>
<tr>
<td>Alabama</td>
<td>0 (0/1)</td>
<td>Howell, 1924</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>44 (23/52)</td>
<td>Langenbach, 1938</td>
</tr>
<tr>
<td>Arkansas</td>
<td>0 (0/1)</td>
<td>Lano, 1926</td>
</tr>
<tr>
<td>Arkansas</td>
<td>100 (1/1)</td>
<td>Lano, 1927</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>34 (161+)</td>
<td>Luttringer, 1935</td>
</tr>
<tr>
<td></td>
<td></td>
<td>106 more that were &quot;unfit&quot; for analysis/468</td>
</tr>
<tr>
<td>Maine</td>
<td>5 (1/20)</td>
<td>Mendall, 1944</td>
</tr>
<tr>
<td>Ohio</td>
<td>27 (28/102)</td>
<td>Pearson, 1933</td>
</tr>
<tr>
<td>Connecticut</td>
<td>20 (1/5)</td>
<td>Sage et al., 1913</td>
</tr>
<tr>
<td>Florida</td>
<td>0 (0/7)</td>
<td>Stoddard, 1931</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>38 (12/32)</td>
<td>Sutton, 1928</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>9 (29/311)</td>
<td>Warren, 1890</td>
</tr>
</tbody>
</table>
APPENDIX II
Definitions of the Habitat Suitability Index variables for the red-tailed hawk model (USFWS, 1981: 8-17). Variables $U_1$, $U_2$, and $U_3$ are measured for grassy cover types. Variables $U_4$, and $U_5$ are measured for forested cover types.

$U_1$: Percent herbaceous canopy cover (the percent of the ground surface that is shaded by a vertical projection of all non-woody vegetation (grasses, forbs, sedges, etc.))

$U_2$: Percent of herbaceous vegetation that is 8 to 46 cm (3 to 18 in) tall (self explanatory)

$U_3$: Number of trees $\geq$ 25 cm (10 in) dbh per 0.4 ha (1.0 ac) (self explanatory)

$U_4$: Percent tree canopy closure (the percent of the ground surface that is shaded by a vertical projection of the canopies of all trees)

$U_5$: Number of trees $\geq$ 50 cm (20 in) dbh per 0.4 ha (1.0 ac) (self explanatory)
**APPENDIX III**

List of all animals (scientific and common names) attributed to the diet of red-tailed hawks (*Buteo jamaicensis*).

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAMMALS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ORDER INSECTIVORA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Soricidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Blarina</em> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Blarina</em> brevicauda</td>
<td>northern short-tailed shrew</td>
<td>Errington 1933</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Blarina</em> carolinensis</td>
<td>southern short-tailed shrew</td>
<td>Fisher 1893</td>
</tr>
<tr>
<td><em>Cryptotis</em> spp.</td>
<td>least shrew</td>
<td>Fitch and Bare 1978</td>
</tr>
<tr>
<td><em>Cryptotis parva</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sorex</em> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sorex</em> cinereus</td>
<td>masked shrew</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td><em>Scalopus</em> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Scalopus</em> aquaticus</td>
<td>eastern mole</td>
<td>Spring 1993</td>
</tr>
<tr>
<td><em>Scapanus</em> latimanus</td>
<td>broad-footed mole</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td><strong>ORDER CHIROPTERA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Vespertilionidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lasiusurus</em> borealis</td>
<td>red bat</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td><strong>ORDER LAGOMORPHA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Ochotonidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ochotona</em> princeps</td>
<td>pika</td>
<td>Blumstein this study</td>
</tr>
<tr>
<td>F. Leporidae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lepus</em> spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lepus</em> americanus</td>
<td>snowshoe hare</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td><em>Lepus</em> californicus</td>
<td>black-tailed jack rabbit</td>
<td>Blumstein this study</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Lepus townsendii** | white-tailed jack rabbit  
**Sylvilagus spp.**  
**Sylvilagus audubonii** | desert cottontail  
**Sylvilagus bachmani** | brush rabbit  
**Sylvilagus floridanus** | eastern cottontail  
**Sylvilagus nuttalli** | Nuttall's cottontail  

**ORDER RODENTIA**  
**F. Sciuridae**  
*Ammospermophilus harrisi* | Harris' antelope squirrel  
*Ammospermophilus leucurus* | white-tailed antelope squirrel  
**Cynogetes spp.** | prairie dogs  
**Cynogetes ludovicianus** | black-tailed prairie dog  
**Glaucomys sabrinus** | northern flying squirrel  
**Marmota spp.**  
**Marmota flaviventris** | yellow-bellied marmot  
**Marmota monax** | woodchuck  

Fisher 1893  
Fitch et al. 1946  
Hardy 1939  
Hader 1978  
Smith and Murphy 1973  
Seidensticker 1970  

Blumstein this study  
Bohm 1978  
Cameron 1907  
Dixon 1906  
English 1934  
Errington 1933  
Fisher 1893  
Hardy 1939  
Lam 1926  
Latham 1950  
Lloyd 1887  
McDowell 1949  
Orians 1955  
Smith and Murphy 1973  

Belyea 1976  
Fitch and Bare 1978  
Gates 1972  
Howell et al. 1978  
Orians and Kuhlman 1956  
Petersen 1979  
Phealan and Robertson 1978  
Springer and Kirkley 1978  
Blumstein this study  
Fisher 1893  
Janes 1984  
Seidensticker 1970  

Knight 1902  
Lloyd 1887  
Blumstein this study  
Adamcik et al. 1979  
Luttich et al. 1970  
McIvaine and Keith 1974  
Latham 1950  
Latham 1987  

Blumstein this study  
Craighed and Craighed 1956  
Bohm 1978
<table>
<thead>
<tr>
<th>Genus</th>
<th>Species</th>
<th>Common Name</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sciurus spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sciurus aberti</td>
<td></td>
<td>Abert's squirrel</td>
<td>Blumstein this study, Fisher 1983, Hall 1981</td>
</tr>
<tr>
<td>Sciurus arizonensis</td>
<td>Arizona gray squirrel</td>
<td>Fisher 1893</td>
<td></td>
</tr>
<tr>
<td>Sciurus carolinensis</td>
<td>Gray squirrel</td>
<td>Fisher 1893</td>
<td></td>
</tr>
<tr>
<td>Sciurus douglasii</td>
<td>Douglas' squirrel</td>
<td>Miller 1920</td>
<td></td>
</tr>
<tr>
<td>Sciurus griseus</td>
<td>Western gray squirrel</td>
<td>Fitch et al. 1946</td>
<td></td>
</tr>
<tr>
<td>Sciurus niger</td>
<td>Fox squirrel</td>
<td>Belknap 1976</td>
<td></td>
</tr>
<tr>
<td>Spermophilus spp.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spermophilus armatus</td>
<td>Uinta ground squirrel</td>
<td>Craighead and Craighead 1956</td>
<td></td>
</tr>
<tr>
<td>Spermophilus beebeui</td>
<td>California ground squirrel</td>
<td>Bond 1947</td>
<td></td>
</tr>
<tr>
<td>Spermophilus beldingi</td>
<td>Belding's ground squirrel</td>
<td>Fitch et al. 1946</td>
<td></td>
</tr>
<tr>
<td>Spermophilus columbianus</td>
<td>Columbian ground squirrel</td>
<td>Janes 1984</td>
<td></td>
</tr>
<tr>
<td>Spermophilus franklini</td>
<td>Franklin's ground squirrel</td>
<td>Miller 1931</td>
<td></td>
</tr>
<tr>
<td>Spermophilus lateralis</td>
<td>Golden-mantled ground squirrel</td>
<td>Munro 1929</td>
<td></td>
</tr>
<tr>
<td>Spermophilus richardsonii</td>
<td>Richardson's ground squirrel</td>
<td>Adamick et al. 1979</td>
<td></td>
</tr>
</tbody>
</table>
Spermophilus tereticaudus  round-tailed ground squirrel
Spermophilus townsendii Townsend's ground squirrel
Spermophilus tridecemlineatus thirteen-lined ground squirrel
Spermophilus variegatus  rock squirrel
Tamias spp.
Tamias xerriami  Merriam's chipmunk
Tamias minimus  least chipmunk
Tamias striatus  eastern chipmunk
Tamias quadrivittatus  Colorado chipmunk
Tamias umbrinus  Uinta chipmunk
Tamiasciurus hudsonicus  red squirrel

Luttich et al. 1970
McInvail and Keith 1974
Schnutz et al. 1980
Seidensticker 1970
Mader 1978
Janes 1984
Smith and Murphy 1973
Belyea 1976
Blumstein this study
Bohm 1978
Cridle 1917
Errington 1933
Fisher 1899
Gates 1972
Hamerstrom and Hamerstrom 1951
Luttich et al. 1970
Oriam and Kuhlman 1956
Pellett 1912
Springer and Kirkley 1978
Fisher 1893
Bennett and Rudersdorf 1980
Blumstein this study
Bohm 1978
Errington 1933
Latham 1950
Luttringer 1935
McDowell 1949
Sutton 1928
Fitch et al. 1946
Blumstein this study
Craighead and Craighead 1955
Luttich et al. 1970
Smith and Murphy 1973
Fisher 1893
Hamerstrom and Hamerstrom 1951
Howell et al. 1978
Springer and Kirkley 1978
Fisher 1893
Blumstein this study
Bohm 1978
Craighead and Craighead 1956
English 1934
Fisher 1893
Luttich et al. 1970
Luttringer 1935
McDowell 1949
McInvail and Keith 1974
Mendall 1944
Seidensticker 1970
Springer and Kirkley 1978
Sutton 1928
Wade 1883
Warren 1890
F. Geomyidae

*Geomys* spp.  plains pocket gopher

*Geomys bursarius*  plains pocket gopher

*Thomomys bottae*  Botta's pocket gopher

*Thomomys talpoides*  northern pocket gopher

F. Heteromyidae

*Dipodomys hermanni*  Heermann's kangaroo rat

*Dipodomys ordii*  Ord's kangaroo rat

*Perognathus baileyi*  Bailey's pocket mouse

F. Castoridae

*Castor canadensis*  beaver

F. Cricetidae

*Clathrionomys* spp.  southern red-backed vole

*Clathrionomys gapperi*  southern red-backed vole

*Microtus* spp.

*Microtus californicus*  California vole

*Microtus longicaudus*  long-tailed vole

*Microtus montanus*  montane vole

*Microtus ochrogaster*  prairie vole

*Microtus pennsylvanicus*  meadow vole
Bohm 1978
Craighead and Craighead 1956
Dixon 1906
Fisher 1993
Hamerstrom and Hamerstrom 1951
Luttich et al. 1970
McAtee 1935
McInwaille and Keith 1974
Mendall 1944
Munro 1929
Phelan and Robertson 1978
Sutton 1928
Fisher 1993
Hamerstrom and Hamerstrom 1951

**Microtus pinetorum** woodland vole

**Neotoma spp.** woodrats
**Neotoma albicula** white-throated woodrat
**Neotoma cinerea** bushy-tailed woodrat
**Neotoma floridana** eastern woodrat
**Neotoma fuscipes** dusky-footed woodrat
**Neotoma mexicana** Mexican woodrat
**Ondatra zibethicus** muskrat

**Onychomys torridus** southern grasshopper mouse

**Peromyscus spp.**
**Peromyscus boylii** brush mouse
**Peromyscus leucopus** white-footed mouse
**Peromyscus maniculatus** deer mouse

**Peromyscus truei** piñon mouse
**Reithrodontomys spp.**
**Reithrodontomys humilis** eastern harvest mouse
**Reithrodontomys megalotis** western harvest mouse
**Reithrodontomys montanus** plains harvest mouse

Blumstein this study
Craighead and Craighead 1956
Errington 1933
Springer and Kirkley 1978
Fitch et al. 1946
Fitch and Bare 1978
Adamcik et al. 1979
Blumstein this study
Fisher 1893
Fitch and Bare 1978
Janes 1984
Luttich et al. 1970
McInwaille and Keith 1974
Seidensticker 1970
Smith and Murphy 1973
Sumner 1929
Fitch et al. 1946
Errington and Breckenridge 1938
Fisher 1893
Fitch and Bare 1978
Fitch et al. 1946
<table>
<thead>
<tr>
<th>Taxonomy</th>
<th>Common Name</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sigmodon spp.</td>
<td>cotton rats</td>
<td>McAtee 1935</td>
</tr>
<tr>
<td>Sigmodon hispidus</td>
<td>hispid cotton rat</td>
<td>Fisher 1893</td>
</tr>
<tr>
<td>Synaptomus cooperi</td>
<td>southern bog lemming</td>
<td>Fisher 1893</td>
</tr>
<tr>
<td>Mus musculus</td>
<td>house mouse</td>
<td>Errington 1933</td>
</tr>
<tr>
<td>Rattus norvegicus</td>
<td>Norway rat</td>
<td>Errington and Breckenridge 1938</td>
</tr>
<tr>
<td>Rattus rattus</td>
<td>black rat</td>
<td>Fisher 1893</td>
</tr>
<tr>
<td>Zapus hudsonius</td>
<td>meadow jumping mouse</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td>Zapus princeps</td>
<td>western jumping mouse</td>
<td>Blumstein this study</td>
</tr>
<tr>
<td>Erethizon dorsatum</td>
<td>porcupine</td>
<td>Fisher 1883</td>
</tr>
<tr>
<td>F. Canidae</td>
<td>coyote</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td>Vulpes vulpes</td>
<td>red fox</td>
<td>McDowell 1949</td>
</tr>
<tr>
<td>Procyon lotor</td>
<td>raccoon</td>
<td>Blumstein this study</td>
</tr>
<tr>
<td>F. Mustelidae</td>
<td>striped skunk</td>
<td>Craighead and Craighead 1956</td>
</tr>
<tr>
<td>Mephitis mephitis</td>
<td>striped skunk</td>
<td>McDowell 1949</td>
</tr>
<tr>
<td>Mustela spp.</td>
<td>ermine</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td>Mustela erminea</td>
<td>ermine</td>
<td>Blumstein this study</td>
</tr>
<tr>
<td>Mustela frenata</td>
<td>long-tailed weasel</td>
<td>Hamerstrom and Hamerstrom 1951</td>
</tr>
<tr>
<td>F. Procyonidae</td>
<td>raccoon</td>
<td>Luttich et al. 1970</td>
</tr>
</tbody>
</table>

**ORDER CARNIVORA**

- F. Canidae
  - Canis latrans: coyote (Fitch et al. 1946)
  - Vulpes vulpes: red fox (McDowell 1949)
  - Procyon lotor: raccoon (Blumstein this study)
- F. Mustelidae
  - Mephitis mephitis: striped skunk (Adamcik et al. 1979)
- Mustela spp.
  - Mustela erminea: ermine (Adamcik et al. 1979)
  - Mustela frenata: long-tailed weasel (Hamerstrom and Hamerstrom 1951)
<table>
<thead>
<tr>
<th>Genus</th>
<th>Common Name</th>
<th>Authors</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Mustela</em></td>
<td>least weasel</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Mustela</em></td>
<td>black-footed ferret</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Felis</em></td>
<td>bobcat</td>
<td>Fitch et al.</td>
<td>1946</td>
</tr>
<tr>
<td><em>Equus</em></td>
<td>horse</td>
<td>Fitch et al.</td>
<td>1946</td>
</tr>
<tr>
<td><em>Sus</em></td>
<td>pigs</td>
<td>Errington et al.</td>
<td>1938</td>
</tr>
<tr>
<td><em>Bos</em></td>
<td>cow</td>
<td>Fisher</td>
<td>1918</td>
</tr>
<tr>
<td><em>Ovis</em></td>
<td>sheep</td>
<td>Fitch et al.</td>
<td>1946</td>
</tr>
<tr>
<td><em>Podiceps</em></td>
<td>red-necked grebe</td>
<td>Adamcik et al.</td>
<td>1979</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>ducks</td>
<td>Seidensticker</td>
<td>1970</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>northern pintail</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>American widgeon</td>
<td>Adamcik et al.</td>
<td>1979</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>green-winged teal</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>northern shoveler</td>
<td>Adamcik et al.</td>
<td>1979</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>blue-winged teal</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>mallard</td>
<td>Adamcik et al.</td>
<td>1979</td>
</tr>
<tr>
<td><em>Anas</em></td>
<td>gadwall</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Pythya</em></td>
<td>lesser scaup</td>
<td>Adamcik et al.</td>
<td>1979</td>
</tr>
<tr>
<td><em>Pythya</em></td>
<td>redhead</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Pythya</em></td>
<td>ring-necked duck</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
<tr>
<td><em>Bucephala</em></td>
<td>bufflehead</td>
<td>McInville et al.</td>
<td>1974</td>
</tr>
</tbody>
</table>

**ORDER PERISSODACTYLA**
*Equus caballus* (horse) - Effington and Breckenridge, 1938

**ORDER ARTIODACTYLA**
*Sus* spp. (pigs) - Warren, 1890

**ORDER ARTIODACTYLA**
*Bos* taurus (cow) - Fitch et al., 1946

**ORDER ARTIODACTYLA**
*Ovis* aries (sheep) - Fitch et al., 1946

**BIRDS**

**ORDER PODICIPEDIFORMES**
*Podiceps grisegena* (red-necked grebe) - Adamcik et al., 1979

**ORDER CICONIIFORMES**
*Butorides virescens* (green heron) - Belyea, 1976
*Nycticorax nycticorax* (black-crowned night heron) - Bailey, 1918
ORDER FALCONIFORMES

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accipiter cooperi</td>
<td>Cooper's hawk</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td>Buteo jamaicensis</td>
<td>red-tailed hawk</td>
<td>Luttich et al. 1970</td>
</tr>
<tr>
<td>Buteo lineatus</td>
<td>red-shouldered hawk</td>
<td>McInville and Keith 1974</td>
</tr>
<tr>
<td>Circus cyaneus</td>
<td>northern harrier</td>
<td>Peyton 1945</td>
</tr>
<tr>
<td>Falco peregrinus</td>
<td>peregrine falcon</td>
<td>Coffin 1906</td>
</tr>
<tr>
<td>Falco sparverius</td>
<td>American kestrel</td>
<td>Burtch 1927</td>
</tr>
</tbody>
</table>

ORDER GALLIFORMES

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alectoris graeca</td>
<td>rock partridge</td>
<td>Jones 1984</td>
</tr>
<tr>
<td>Bonasa umbellus</td>
<td>ruffed grouse</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td>Callipepla californicus</td>
<td>quail</td>
<td>Fisher 1893</td>
</tr>
<tr>
<td>Callipepla gambelii</td>
<td>Gambel's quail</td>
<td>Luttich et al. 1970</td>
</tr>
<tr>
<td>Callipepla squamata</td>
<td>scaled quail</td>
<td>McAtee 1935</td>
</tr>
<tr>
<td>Centrocercus urophasianus</td>
<td>sage grouse</td>
<td>McDowell 1949</td>
</tr>
<tr>
<td>Colinus spp.</td>
<td>bobwhite</td>
<td>Seidensticker 1970</td>
</tr>
<tr>
<td>Colinus virginianus</td>
<td>northern bobwhite</td>
<td>Effington and Breckenridge 1938</td>
</tr>
<tr>
<td>Gallus spp.</td>
<td>domestic chicken</td>
<td>Fisher 1893</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Springer and Kirkley 1978</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bailey 1918</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Effington 1933</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gates 1972</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lano 1927</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Latham 1950</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Luttich et al. 1970</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Luttringer 1935</td>
</tr>
<tr>
<td></td>
<td></td>
<td>McAtee 1935</td>
</tr>
<tr>
<td></td>
<td></td>
<td>McInville and Keith 1974</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mendall 1944</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orians and Kuhlm 1956</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pellett 1912</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Petersen 1979</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seidensticker 1970</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sutton 1928</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waile 1883</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warren 1890</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wood 1869</td>
</tr>
<tr>
<td>Perdix perdix</td>
<td>gray partridge</td>
<td>Adamcik et al. 1979</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beebe 1974</td>
</tr>
<tr>
<td></td>
<td></td>
<td>English 1934</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Effington and Breckenridge 1938</td>
</tr>
</tbody>
</table>
**ORDER GRUIFORMES**

- *Fulica americana*  
  American coot
  - Adamcik et al. 1979
  - Bohn 1978
  - Hubbard 1947
  - Luttich et al. 1970
  - McInville and Keith 1974
  - Page and Whitacre 1975

- *Gallinula chloropus*  
  Common moorhen
  - Errington 1933
  - Adamcik et al. 1979
  - Hamerstrom and Hamerstrom 1951

- *Porzana carolina*  
  Sora
  - Luttich et al. 1970
  - McInville and Keith 1974

- *Rallus elegans*  
  King rail
  - Fisher 1893
  - Bohn 1978

- *Rallus limicola*  
  Virginia rail
  - Page and Whitacre 1975
  - Adamcik et al. 1979
  - McInville and Keith 1974

**ORDER CHARADRIIFORMES**

- *Charadrius vociferus*  
  Killdeer
  - Adamcik et al. 1979
  - McInville and Keith 1974

- *Larus pipixcan*  
  Franklin’s gull
  - Luttich et al. 1970
  - Seidensticker 1970

- *Phalaropus tricolor*  
  Wilson’s phalarope
  - Seidensticker 1970

**ORDER COLUMBIFORMES**

- *Columba fasciata*  
  Band-tailed pigeon
  - Beebe 1974
  - Adamcik et al. 1979
  - McInville and Keith 1974
  - Orians and Kuhlman 1956
  - Springer and Kirkley 1978
  - Errington and Breckenridge 1938
  - Fisher 1893
  - Gates 1972
  - Springer and Kirkley 1978

- *Columba livia*  
  Rock dove
  - McInville and Keith 1974
  - Orians and Kuhlman 1956
  - Springer and Kirkley 1978
  - Errington and Breckenridge 1938
  - Fisher 1893
  - Gates 1972

- *Zenaida macroura*  
  Mourning dove
  - Springer and Kirkley 1978

**ORDER CUCULIFORMES**

- *Geococcyx californianus*  
  Greater roadrunner
  - Fitch et al. 1946

**ORDER STRIGIFORMES**

- *Asio flammeus*  
  Short-eared owl
  - Craighead and Craighead 1956

- *Otus spp.*  
  Screech owl
  - Finley 1905
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Authors</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otus asio</td>
<td>eastern screech owl</td>
<td>McFetee 1935</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fisher 1893</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fitch et al. 1946</td>
<td></td>
</tr>
<tr>
<td>ORDER CAPRINULGIFORMES</td>
<td>Chordeiles minor</td>
<td>common nighthawk</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Luttich et al. 1970</td>
<td></td>
</tr>
<tr>
<td>ORDER CORACIFORMES</td>
<td>Cerule alcubon</td>
<td>belted kingfisher</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Snyder 1926</td>
<td></td>
</tr>
<tr>
<td>ORDER PICIFORMES</td>
<td>Asyndesmus lewis</td>
<td>Lewis' woodpecker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fitch et al. 1946</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>English 1934</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hamerstrom and Hamerstrom 1951</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colaptes cafer</td>
<td>red-shafted flicker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Craighead and Craighead 1956</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fitch et al. 1946</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seidensticker 1970</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Melanerpes erythrocephalus</td>
<td>red-headed woodpecker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fisher 1893</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Melanerpes formicivorus</td>
<td>acorn woodpecker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fitch et al. 1946</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Picoides villosus</td>
<td>hairy woodpecker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Belyea 1976</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sphyrapicus varius</td>
<td>yellow-bellied sapsucker</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Adamic et al. 1979</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>McNivuelle and Keith 1974</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Luttich et al. 1970</td>
<td></td>
</tr>
<tr>
<td>ORDER PASSERIFORMES</td>
<td>Agelaius phoeniceus</td>
<td>red-winged blackbird</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Belyea 1976</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Boha 1978</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gates 1972</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hamerstrom and Hamerstrom 1951</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Luttich et al. 1970</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>McNivuelle and Keith 1974</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Springer and Kirkley 1978</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fisher 1893</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amechroessa savannah</td>
<td>grasshopper sparrow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apeliscter navelaececn</td>
<td>scrub jay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cardinals cardinalis</td>
<td>northern cardinal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Carduers tristis</td>
<td>American goldfinch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corcodraco mexicanus</td>
<td>house finch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Catharsas guttatus</td>
<td>heimis thrush</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chondrakese grammaticus</td>
<td>lark sparrow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corvus spp.</td>
<td>crows</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corvus brachyhynchus</td>
<td>American crow</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Belyea 1976</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Craighead and Craighead</td>
<td></td>
</tr>
</tbody>
</table>
Cyanocitta cristata  blue jay

Cyanocitta stelleri  Steller's jay
Dendroica spp.  warbler
Dendroica petechia  yellow warbler
Dumetella carolinensis  gray catbird
Eremophila alpestris  horned lark
Euphagus cyanocephalus  Brewer's black-bird
Icterus spurius  orchard oriole
Junco hyemalis  dark-eyed junco
Melospiza melodia  song sparrow
Holarctornus nnauleni  cowbirds
Holarctornus ater  brown-headed cowbird
Passer domesticus  house sparrow
Perisoreus canadensis  gray jay
Pheucticus ludovicianus  rose-breasted grosbeak
Pica pica  black-billed magpie
Pipilo erythrophthalmus  rufous-sided towhee
Pipilo fuscus  brown towhee
Piranga ludovicianae  western tanager
Poecile gramineus  vesper sparrow
Quiscalus quiscula  common grackle
Seiurus aurocapillus  ovenbird
Sialia currucoides  mountain bluebird
Sialia mexicana  western bluebird
Sialia sialis  eastern bluebird
Spizella arborea  American tree sparrow

1956
Fisher 1993
Gates 1972
Hogan 1983
Luttich et al. 1970
Orians and Kuhlman 1956
Seidensticker 1970
Stinson 1980
Gates 1972
Hamerstrom and Hamerstrom 1951
Luttich et al. 1970
Blumstein this study
Luttich et al. 1970
Adamcik et al. 1979
Mclnvaille and Keith 1974
Gates 1972
Janes 1984
Smith and Murphy 1973
Craighead and Craighead 1956
Luttich et al. 1970
Seidensticker 1970
Fisher 1893
Fisher 1893
Errington and Breckenridge 1938
Fisher 1893
Springer and Kirkley 1978
Sutton 1928
Luttich et al. 1970
Orians and Kuhlman 1956
Gates 1972
Adamcik et al. 1979
Luttich et al. 1970
Mclnvaille and Keith 1974
Luttich et al. 1970
Mclnvaille and Keith 1974
Seidensticker 1970
Adamcik et al. 1979
Blumstein this study
Janes 1984
Luttich et al. 1970
Mclnvaille and Keith 1974
Seidensticker 1970
Bond 1947
Fitch et al. 1946
Fitch et al. 1946
Blumstein this study
Seidensticker 1970
Criddle 1917
Fisher 1893
Fisher 1893
Gates 1972
Springer and Kirkley 1978
Luttich et al. 1970
Janes 1984
Smith and Murphy 1973
Fitch et al. 1946
Fisher 1893
Fisher 1893
| **Sturnella spp.** | Cameron 1907  
McAtee 1935  
Orians and Kuhlman 1956  
Warren 1890  
Fisher 1893  
Fitch et al. 1946  
Janes 1984  
Seidensticker 1970  
Adamczyk et al. 1979  
Belyea 1976  
Blumstein this study  
Luttich et al. 1970  
Orians and Kuhlman 1956  
Seidensticker 1970  
Smith and Murphy 1973  
Speer and Kirkley 1978  
Sutton 1928  
Smith and Murphy 1973  
Fitch et al. 1946  
McAtee 1935  
Adamczyk et al. 1979  
Blumstein this study  
Craighead and Craighead 1956  
Fisher 1893  
Luttich et al. 1970  
Orians and Kuhlman 1956  
Seidensticker 1970  
Fitch et al. 1946 |

| **Sturnella magna** | eastern meadowlark |
| **Sturnella neglecta** | western meadowlark |

| **Sturnus vulgaris** | European starling |

| **Troglodytes troglodytes** | winter wren |
| **Tyrannus tyrannus** | eastern kingbird |
| **Tyrannus verticalis** | western kingbird |

| **Turdus spp.** | robins |
| **Turdus migratorius** | American robin |

| **Zonotrichia spp.** | |

**ORDER CAUDATA**

| **Ambystoma spp.** | mole salamanders |

**ORDER SALIENTIA**

| **Bufo spp.** | toads |
| **Bufo americanus** | American toad |
| **Bufo cognatus** | great plains toad |
| **Rana spp.** | |

| **Rana clamitans** | green frog |

**AMPHIBIANS AND REPTILES**

| **Bufo ** | **Rana ** | **Bufo americanus** | **Bufo cognatus** | **Rana clamitans** | **Amphibians and reptiles** |
| **spp.** | **clamitans** | **American toad** | **great plains toad** | **green frog** | **Salamanders and lizards** |

| **ORDER CAUDATA** | **Ambystoma spp.** | **mole salamanders** |

| **Bufo spp.** | **toads** |
| **Bufo americanus** | **American toad** |
| **Bufo cognatus** | **great plains toad** |
| **Rana clamitans** | **green frog** |

| **Rana spp.** | **green frog** |

**ORDER SALIENTIA**

| **Bufo spp.** | **Bufo americanus** | **American toad** |
| **Bufo cognatus** | **great plains toad** |
| **Rana spp.** | **green frog** |

| **Bufo americanus** | **American toad** |
| **Bufo cognatus** | **great plains toad** |
| **Rana clamitans** | **green frog** |

**Salamanders and lizards**

| **Bufo spp.** | **Bufo americanus** | **American toad** |
| **Bufo cognatus** | **great plains toad** |
| **Rana clamitans** | **green frog** |

| **Rana spp.** | **green frog** |

**ORDER SALIENTIA**

| **Bufo spp.** | **Bufo americanus** | **American toad** |
| **Bufo cognatus** | **great plains toad** |
| **Rana clamitans** | **green frog** |

| **Rana spp.** | **green frog** |
ORDER TESTUDINES  

ORDER SAURIA  

Cnemidophorus sexlineatus  six-lined racerunner  Fitch and Bare 1978  
Cnemidophorus tesselatus  Colorado checkered whiptail  Fitch et al. 1946  
Crotaphytus collaris  collared lizard  Smith and Murphy 1973  
Eumeces gilberti  Gilbert's skink  Fitch et al. 1946  
Gerrhonotus coeruleus  northern alligator lizard  Bond 1947  
Gerrhonotus multicarinatus  southern alligator lizard  Fitch et al. 1946  
Ophisaurus attenuatus  slender glass lizard  Fitch and Bare 1978  
Phrynosoma spp.  horned lizards  Mader 1978  
Sceloporus magister  desert spiny lizard  Mader 1978  
Sceloporus occidentalis  western fence lizard  Fitch et al. 1946  
Uta stansburiana  side-blotched lizard  Fitch et al. 1946  

ORDER SERPENTES  

Agkistrodon contortrix  copperhead  
Coluber constrictor  racer  
Crotalus spp.  rattlesnakes  
Crotalus horridus  timber rattlesnake  Fitch and Bare 1978  
Crotalus molossus  blacktail rattlesnake  Johnson 1964  
Crotalus viridis  western rattlesnake  Fitch et al. 1946  
Diadophis punctatus  ringneck snake  Fitch and Bare 1978  
Elaphe obsoleta  rat snake  
Heterodon spp.  hognose snake  
Lampropeltis spp.  
Lampropeltis getulus  common kingsnake  Fitch et al. 1946  
Lampropeltis triangulum  milk snake  English 1934  
Masticophis lateralis  striped racer  Dixon 1906  
Masticophis taeniatus  striated whipsnake  Smith and Murphy 1973  
Nerodia sipedon  northern water snake  Dixon 1906  
Pituophis spp.  

Pituophis catenifer  pacific gopher snake  Bond 1947  
Phrynops spp.  horned lizards  Mader 1978  
Sceloporus mauster  desert spiny lizard  Hader 1978  
Sceloporus occidentalis  western fence lizard  Fitch et al. 1946  
Q&stamburiana  side-blotched lizard  Fitch et al. 1946  

Rhinocheilus lecontei  hognose snake
Thamnophis spp.  common garter snake
Thamnophis sirtalis  common garter snake

ORDER SALMONIFORMES
Oncorhynchus keta  chum salmon
ORDER CYPRINIFORMES
Catostomus spp.  suckers
Cyprinus carpio  common carp
ORDER SILUROIDES

INVERTEBRATES
CLASS ARACHNIDA
  O. Araneae  spiders
    F. Arachnidae
  O. Scorpiones  scorpions
CLASS CHILOPODA
  O. Chilopoda  centipedes
CLASS CRUSTACEA
  F. Astacidae  crayfish
CLASS INSECTA

FISH
ORDER STALMMASTER 1980
SALMONIFORMES
Stalmaster 1980

ORDER CYPRINIFORMES
Catostomus spp.  suckers
Cyprinus carpio  common carp

INVERTEBRATES
CLASS ARACHNIDA
  O. Araneae  spiders
    F. Arachnidae
  O. Scorpiones  scorpions
CLASS CHILOPODA
  O. Chilopoda  centipedes
CLASS CRUSTACEA
  F. Astacidae  crayfish
CLASS INSECTA

FITCH AND BARE 1978
Janes 1984
Hader 1978
Stinson 1980
Smith and Murphy 1973
Fitch et al. 1946
Craighed and Craighead 1956
Errington 1933
Errington and Breckenridge 1938
Fitch et al. 1946
Latham 1950
McAtee 1935
Mendall 1944
Seidensticker 1970
Springer and Kirke 1978
Belyea 1976
Fitch and Bare 1978
Sutton 1928

FICH AND BARE 1978
Gates 1972
McAtee 1935
McDowell 1949
Pearson 1933
<table>
<thead>
<tr>
<th>Insect Order</th>
<th>Family</th>
<th>Common Name</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diptera</strong></td>
<td>F. Caliifornidae</td>
<td>Lucilia spp.</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td></td>
<td>F. Cuterebridae</td>
<td>Cuterebra spp.</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td><strong>Hemiptera</strong></td>
<td>F. Belostomatidae</td>
<td>Belostomatid spp.</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td></td>
<td>F. Corixidae</td>
<td>Corixid spp.</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td><strong>Homoptera</strong></td>
<td>F. Diaspididae</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hymenoptera</strong></td>
<td>F. Formicidae</td>
<td>ants</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td></td>
<td>F. Vespidae</td>
<td>hornets</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td></td>
<td>Vespuca spp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lepidoptera</strong></td>
<td></td>
<td>moths and butterflies</td>
<td>Fitch et al. 1946</td>
</tr>
<tr>
<td><strong>Orthoptera</strong></td>
<td>F. Acrididae</td>
<td>crickets and grasshoppers</td>
<td>Fitch et al. 1946</td>
</tr>
</tbody>
</table>

F. Buprestidae
- Acmaeodera spp.
- Buprestis spp.
- Polycesta spp.
- Byrrhidae
- Amphipala spp.
- Carabidae
- Amara spp.
- Calosoma spp.
- Carabid spp.
- Chrysomelidae
- Leptinotarsa decemlineata (Colorado potato beetle)
- Odonata spp.
- Elateridae
- Elaterid spp.
- Hydrophilidae
- Hydrous spp.
- Scarabaeidae
- Phobetus comatus
- Scarabaeid spp.
- Serica spp.
- Silpha spp.
- Tenebrionidae
- Conionitis spp.
- Eleodes spp.
- Nyctoporis spp.
- Tenebrionid spp.

F. Chrysomelidae
- Oiptera flies
- Lucilia spp.
- Cuterebridae
- Cuterebra spp.

F. Hecniptera
- Belostomatidae
- Belostomatid spp.
- Corixidae
- Corixid spp.

F. Hymenoptera
- Formicidae
- Vespidae
- Vespuca spp.

F. Orthoptera
- Acrididae

References:
- Fitch and Bare 1978
- Gates 1972
- Luttringer 1935
- Fitch et al. 1946
- Errington and Breckenridge 1938
- McAlpine 1935
- Fitch et al. 1946
- Fitch et al. 1946
- Sutton 1928
- Blight 1924
Melanoplus spp. grasshoppers
F. Decticidae crickets
Anabrus longipes
F. Gryllidae field crickets
Gryllus spp.
F. Stenopelmatidae
Stenopelmatus fuscus Jerusalem cricket
CLASS NEMATODA

Luttringer 1935
McAtee 1935
Mendall 1944
Sutton 1928
Errington and Breckenridge 1938
Munro 1929
Errington and Breckenridge 1938
Fitch et al. 1946
Luttringer 1935