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NORTHERN GOSHAWK FOOD HABITS AND GOSHAWK PREY SPECIES HABITATS

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Abstract. Food habits of Northern Goshawk (*Accipiter gentilis*) were reviewed and evaluated to characterize diet across the species ranges and within the southwestern US. The eleven prey most frequently observed in southwest diet studies are the Abert squirrel (*Sciurus aberti*), red squirrel (*Tamiasciurus hudsonicus*), rock squirrel (*Spermophilus variegatus*), golden-mantled ground squirrel (*Spermophilus lateralis*), cliff chipmunk (*Eutamias dorsalis*), gray-collared chipmunk (*Eutamias cinereicollis*), mountain cottontail (*Sylvilagus nuttallii*), desert cottontail (*Sylvilagus audubonii)*, and eastern cottontail (*Sylvilagus floridanus),* Steller's Jay (*Cyanocitta stelleri*), and Northern Flicker (*Colaptes auratus*). Habitat characteristics and natural history information regarding these species were reviewed and compared to descriptions of goshawk habitat. Goshawks consume a wide variety of prey species across their range including medium-sized birds and small mammals. Percentage of mammals in goshawk diet is generally greater than avian prey. In certain areas, and during certain periods of the year, goshawks may consume only one or two prey species. While goshawks appear to be opportunistic in their feeding behavior, low diet breadth in some areas, particularly during winter months, is likely caused by the migration or hibernation of certain prey species. Both goshawks and their prey prefer habitats with relatively high canopy closure and large diameter trees, suggesting a habitat management strategy to benefit goshawks.

Key Words: *Accipiter gentilis*, diet, food habits, habitat requirements, Northern Goshawk.

HÁBITOS ALIMENTICIOS DEL GAVILÁN AZOR Y HÁBITATS DE LAS ESPECIES DE LAS PRESAS DEL GAVILÁN

Resumen. Los hábitos alimenticios del Gavilán Azor (*Accipiter gentilis*) fueron revisados y evaluados para caracterizar la dieta a lo largo de la especie, dentro del suroeste de Estados Unidos. Las once presas observadas más frecuentemente en estudios de dieta del suroeste son la ardilla (*Sciurus aberti*), ardilla roja (*Tamiasciurus hudsonicus*), ardilla (*Spermophilus variegatus*), ardilla terrestre de manto dorado (*Spermophilus lateralis*), ardilla listada (*Eutamias dorsalis*), ardilla (*Eutamias cinereicollis*), conejo de montaña, desierto y de pascua (*Sylvilagus* spp.), charra copetona (*Cyanocitta stelleri*) y carpintero de pechera (*Colaptes auratus*). Las características del hábitat y la información histórica natural relacionadas a esta especie fueron revisadas y comparadas para describir el hábitat del gavilán. Los gavilanes consumen una amplia variedad de especies de presas que están a su alcance, incluyendo aves de tamaño mediano y mamíferos pequeños. El porcentaje de mamíferos en la dieta del gavilán es generalmente mayor que las presas aves. En ciertas áreas, y durante ciertos períodos del año, los gavilanes quizás consumen solamente una o dos especies de presas. Mientras los gavilanes parecen ser oportunísticos en sus hábitos alimenticios, una baja amplitud de dieta en algunas áreas, particularmente durante los meses de invierno, es probablemente causada por migración o hibernación de ciertas especies de presa. Tanto gavilanes, como sus presas, prefieren hábitats con copas relativamente cerradas y árboles con mayor diámetro, sugiriendo una estrategia del manejo del hábitat para beneficiar a los gavilanes.

The Northern Goshawk (*Accipiter gentilis*, hereafter called goshawk) has been a key species in decisions regarding forest management across its range, especially in the southwestern US (Reynolds et al. 1992), the Rocky Mountain Region (Kennedy 2003), and Alaska (Iverson et al. 1996). Despite protection of nest stands (≥8 ha), Crocker-Bedford (1990) found that goshawk reproduction on the Kaibab Plateau declined following timber harvest in adjacent areas. Crocker-Bedford's (1990) study and several lawsuits that followed led to the formation of the Goshawk Scientific Committee (GSC) with a charter to develop a credible management strategy for the goshawk in the southwestern US (Reynolds et al. 1992). The resulting *Management Recommendations for the Northern Goshawk in the Southwestern United States* (MRNG) recommended managing goshawk habitats not only for the nest stand but also for goshawk prey species abundance (Reynolds et al. 1992). However, the Arizona Game and Fish Department (1993) and the USDI Fish and Wildlife Service (Spear 1993) argued that prey availability (as determined by forest structure) is more important than prey abundance because accipiter hawks are morphologically adapted to hunt in forests. Prey availability is a function of

prey abundance and forest structure (tree spacing, canopy closure, and ground cover) whereas prey abundance refers only to the quantity of prey. Despite these disagreements, most agree that nest-stand management alone is insufficient to maintain goshawk populations. Researchers and managers need to consider protecting and enhancing not only the nesting habitat of goshawks but also their foraging habitat and prey populations.

The purpose of my review is to characterize the diet of the goshawk across its range and in the southwestern US, to describe the habitat requirements of the primary prey species in the Southwest; and to identify the overlap between the goshawk's habitat and that of its primary prey.

GOSHAWK DIET STUDIES

Goshawk food habits have been described throughout its Holarctic boreal-forest range, including northern Europe (Widén 1987), the Mediterranean region (Mañosa 1994) and North America (Reynolds and Meslow 1984, Bosakowski and Smith 1992). These studies report a wide variety of prey items consumed by goshawks over their entire range (Table 1) and show goshawks to be opportunistic foragers with diets that reflect the diversity of available prey species (Opdam 1975, Widén 1987, Kenward and Widén 1989, Kennedy 1991). In western North America, the dietary diversity of goshawks ranked fourth highest out of 30 raptor species; continent-wide, goshawk dietary diversity ranked second highest out of 34 species (Marti et al. 1993).

Although goshawk diets are diverse, studies suggest that sometimes only one or two prey species represent the bulk of goshawk diet, at least seasonally (Palmer 1988, Stephens 2001, Drennan and Beier 2003). In New York and Pennsylvania, Meng (1959) reported American Crows (*Corvus brachyrhynchos*) and red squirrels (*Tamiasciurus hudsonicus*) accounted for 45% and 31% of the total diet, respectively. In Minnesota, Eng and Gullion (1962) reported goshawk predation was the single most important cause of mortality to Ruffed Grouse (*Bonasa umbellus*), accounting for 30% of known losses to banded birds. On the North Kaibab Plateau, Boal and Mannan (1994) found that goshawks consumed golden-mantled ground squirrels (*Spermophilus lateralis*) more than twice as often as any other species.

Such a dependence on a single prey species could lead to a decline in predator populations if that prey species declined (Craighead and Craighead 1956, Newton 1979a). However, this is unlikely in the Southwest, where goshawks preyed on 34 different prey species in New Mexico (Kennedy 1991) and between 19 (Boal and Mannan 1994) and 22 (Reynolds et al. 1994) in Arizona. A high number of prey species may buffer the effects of fluctuations in individual prey species populations (Boal and Mannan 1994). Goshawks in Nevada shifted their diet during the breeding season when nestling birds became more abundant and ground squirrels began to estivate (Younk and Bechard 1994a). The wide variety of prey consumed by goshawks in the western US is listed in Appendix 1.

Methods to Study Raptor Food Habits

Goshawk diets are studied using several different methods, including pellet analysis, stomach contents, uneaten prey remains, direct observation, photographic recording, the confined nestlings technique, and combinations of these methods. Some early studies described the diet of nesting goshawks anecdotally without quantification (Sutton 1925, Gromme 1935, Dixon and Dixon 1938). Comparisons between studies are often subjective and, in some cases, not possible due to differences in methods used and the objectives of the study. Some studies can be compared at various levels with minor modifications and an understanding of the techniques. Marti (1987) described all of the techniques used in the studies analyzed here and suggested improvements for future raptor food-habit study methodology.

Relative percentages of birds and mammals comprising the goshawk diet vary according to the technique used to collect diet information. Of the techniques used to evaluate diet, direct observation at the nest is considered the least biased and most accurate to determine diurnal raptor diets (Errington 1930, 1932; Marti 1987). However, direct observation is seldom used because it is time consuming (Errington 1932, Marti 1987), the probability of identifying different prey item types is not always equal, and no information on items consumed away from the nest can be obtained.

Diet analyses from prey remains and pellets tend to underestimate small mammals (Marti 1987). Bloom et al. (1986) suggested that collecting castings at nests might fail to detect nestling birds because they lack developed bones and feathers. Collopy (1983) found that his collection of prey remains accurately reflected the species composition of Golden Eagle (*Aquila chrysaetos*) diets but

TABLE 1. FREQUENCY OF PREY ITEMS OF SELECTED GOSHAWK DIETS ACROSS THEIR RANGE.

Species	N.E. Spain Mañosa (1994)	Central Sweden Widén (1987)	Oregon Reynolds and Meslow (1984)	New York Bosakowski and Smith (1992)
Class Mammalia				
Blarina brevicauda				1
Marmota monax				1
Sylvilagus spp.			3	7
Lepus spp.		6	24	1
Oryctolagus vulgaris	333			
Sciurus spp.	86	124	4	60
Glaucomys sabrinus			15	
Tamiasciurus spp.			13	19
Tamias striatus				18
Spermophilus spp			23	
Microtus sp.				1
Peromyscus leucopus				7
Neotoma spp.			3	
Ondatra zibethicus				2
Class Aves				
Anas platyrhynchos	24		2	1
Anas acuta				1
Aythya fuligula	3			
Bucephala clangula	6			
Aix sponsa				3
Meleagris gallopavo				1
Dendrogapus obscurus			5	
Tetrao spp.	176			
Bonasa spp.	25		3	7
Collinus virginianus				6
Phasianus colchicus				4
Oreotyx pictus			10	
Zenaida macroura			7	21
Alectoris rufa	362			
Coturnix coturnix	21			
Columba spp.	248	141		17
Vanellus vanellus		4		
Scolopax rusticola		5		
Larus spp.		4		
Streptopelia turtur	28			
Bubo virginianus			1	
Asio spp.		1		
Otus spp.	27		1	
Athene noctua	18			
Aegolius acadicus			1	
Picus viridus	31			
Colaptes auratus			15	1
Melanerpes lewis			1	
Sphyrapicus spp.			2	
Picoides spp.	15	2	2	
Dendrocopus major		3		
Dryocopus pileatus			1	
Garrulus glandarius	184	99		
Corvus spp.		110		5
Perisoreus canadensis			5	
Cyanocitta spp.			30	21
Sturnus vulgaris	79			

TABLE 1. CONTINUED.

Species	N.E. Spain Mañosa (1994)	Central Sweden Widén (1987)	Oregon Reynolds and Meslow (1984)	New York Bosakowski and Smith (1992)
Pica spp.	54	37	1	
Turdus spp.	197	113	20	4
Ixoreus naevius			4	
Sialia sialis				1
Parus major		7		
Setophagia ruticella				1
Passer domesticus				3
Quiscalus quiscula				6
Piranga spp.				2
Melospiza melodia				4
Pheuticus melanocephalus		1		
Junco hyemalis		2		
Sturnella neglecta		2		
Carpodacus spp.		2		
Fringilla coelebs	23	12		

seriously underestimated the relative biomass of prey eaten compared to the direct observation method.

Diet studies typically report the frequency of occurrence for each prey species observed either through direct observation of prey deliveries at the nest or through analysis of pellets and prey remains. Some studies also include a conversion of the observed numbers of prey items to biomass estimated from published body weights. Where frequency and biomass are reported simultaneously, biomass figures show a larger percentage for mammals and a lower percentage for birds (Tables 2–5), because of the larger mean mass of mammals relative to birds.

Analyses of pellets and prey remains must determine the minimum number of prey items per sample (Reynolds and Meslow 1984); however, most studies are vague concerning techniques used. For example, if 10 pellets containing cottontail (*Sylvilagus* spp.) fur are examined does this mean that 10 cottontails were consumed or one just cottontail? A sample of goshawk pellets from Wyoming (N = 793) found that only 14% had remains exclusively from mammals while 79% contained both mammal and bird remains (Squires 2000). Some studies reported the percentage of prey items in a random sample of several pellets from multiple nests, treating each pellet as an independent sample, rather than each nest (Bloom et al. 1986, Kennedy 1991). Due to the variety of techniques used in goshawk diet studies for obtaining, analyzing, interpreting, and reporting data, cross-study comparison of results requires careful thought and understanding of the methods to provide meaning.

SOUTHWESTERN US DIET STUDIES

Goshawk diet studies in the Southwest are limited to the Kaibab and Coconino National Forests in Arizona (Boal and Mannan 1994, Reynolds et al. 1994, Drennan and Beier 2003) and the Jemez Mountains in New Mexico (Kennedy 1991). Three of these studies were conducted in the breeding season either using pellets and prey remains alone (Reynolds et al. 1994) or in combination with the direct observation of prey deliveries (Kennedy 1991, Boal and Mannan 1994) and one study was conducted during the winter (December–March) using direct observation of radio-tagged goshawks (Drennan and Beier 2003). Because of the variation in the techniques used in these studies and their limited geographic extent, the results may not be applicable to other areas in the Southwest.

The Boal and Mannan (1994) study, based on direct observation of prey deliveries (1,539 hr), is the most accurate quantification of goshawk prey selection in the Southwest. In the other two southwestern studies conducted during the breeding season, Reynolds et al. (1994) used pellets and prey remains and likely underestimated the percentage of small mammals in the diet, and Kennedy (1991) took a random sample (N = 63) of pellets from eight nests over five breeding seasons supplemented by 160 hr of direct observations. Boal and Mannan (1994) found a higher percentage of small mammals compared to other studies: 76% mammals versus 24% birds by frequency (Table 2). Kennedy's (1991) analysis, using both direct observation and analysis of prey remains and pellets demonstrated the bias

TABLE 2. PERCENT BIRDS AND MAMMALS IN GOSHAWK DIET BY FREQUENCY (BIOMASS) FOR DIRECT OBSERVATION STUDIES ONLY.

Study	State/region	Percent birds	Percent mammals
Boal and Mannan (1994)[a]	Arizona	24 (6)	76 (94)
Drennan and Beier (2003)[a,c]	Arizona	0	100
Kennedy (1991) [a,b]	New Mexico	33	67
Schnell (1958)	California	69 (54)	31 (46)
McCoy (1999)	California	21 (24)	79 (76)
Younk and Bechard (1994a)	Nevada	32	67
Bloxton (2002)	Washington	75	25
Lewis (2001)	Southeast Alaska	27 (26)	73 (74)
Schaeffer (1998)[d]	Alberta, Canada	24 (11)	76 (89)
Rutz (2003a)	Germany	91	9

[a] Southwestern US study.
[b] Kennedy (1991) reported results from three different techniques—direct observation, pellets and prey remains, and prey remains only.
[c] Winter study.
[d] Schaeffer (1998) provided results of two methods—direct observation and pellets and prey remains.

TABLE 3. PERCENT BIRDS AND MAMMALS IN GOSHAWK DIET BY FREQUENCY (BIOMASS) FOR STUDIES UTILIZING PELLETS AND PREY REMAINS.

Study	State/region	Percent birds	Percent mammals
Reynolds et al. (1994)[a]	Arizona	38	62
Kennedy (1991)[a,b]	New Mexico	51	49
Bloom et al. (1986)	California	48 (32)	52 (68)
Bull and Hohmann (1994)	Oregon	58	42
DeStephano et al. (1994)	Oregon	51 (37)	49 (63)
Reynolds and Meslow (1984)	Oregon	55	45
Thraikill et al. (2000)	Oregon	84	16
Watson et al. (1998)	Washington	50 (49)	50 (51)
Zachel (1985)	Alaska	21 (10)	78 (90)
Grzybowski and Eaton (1976)	New York	61	39
Meng 1959	New York, Pennsylvania	61	39
Bosakowski and Smith (1992)	New Jersey, New York, Connecticut	66	34
Penteriani (1997)	Italy	75 (71)	25 (29)
Lõhmus (1993)	Estonia	97	3
Schaeffer (1998)[c]	Alberta, Canada	47 (38)	53 (62)

[a] Southwestern US study.
[b] Kennedy (1991) reported results from three different techniques—direct observation, pellets and prey remains, and prey remains only.
[c] Schaeffer (1998) provided results of two methods—direct observation and pellets and prey.

TABLE 4. PERCENT BIRDS AND MAMMALS IN GOSHAWK DIET BY FREQUENCY FOR STOMACH ANALYSIS.

Study	State/region	Percent birds	Percent mammals
Storer (1966)[a]	North Dakota; Ontario, Canada	40	60
Sutton (1931)	Pennsylvania	67	33

[a] Winter study.

TABLE 5. PERCENT BIRDS AND MAMMALS IN GOSHAWK DIET BY FREQUENCY (BIOMASS) FOR PREY REMAINS TECHNIQUE.

Study	State/region	Percent birds	Percent mammals
Kennedy (1991)[a,b]	New Mexico	52	48
Stephens (2001)[c]	Utah	9	91
Doyle and Smith (1994)	Yukon, Canada	22 (14)	78 (86)

[a] Southwestern US study.
[b] Kennedy (1991) reported results from three different techniques—direct observation, pellets and prey remains, and prey remains only.
[c] Winter study.

of prey remains and pellet analysis towards birds. Using the direct observation technique she found a diet of 67% mammals to 33% birds (Table 2), whereas using pellet and prey remains analyses she found a diet of 51% birds and 49% mammals (Table 3). In contrast, Drennan and Beier (2003) observed winter diets of eight radio-tagged goshawks and found a diet of 100% mammals. In that study, not only were goshawks strictly consuming mammals but also they only took two species—cottontails and Abert squirrels (*Sciurus aberti*) and no individual goshawk consumed both.

Comparison of Goshawk Diets

This review summarizes the findings of 27 studies with quantitative information on goshawk diets as well as studies that provide only qualitative or anecdotal information. The four studies mentioned above were conducted within the Southwest and eleven of the studies were conducted in Washington, Oregon, California, Nevada, and Utah (Schnell 1958, Reynolds and Meslow 1984, Dixon and Dixon 1938, Bloom et al. 1986, Bull and Hohmann 1994, DeStephano et al. 1994, Younk and Bechard 1994b, Watson et al. 1998, McCoy 1999, Thraikill et al. 2000, Stephens 2001). The remaining studies are from the eastern US (Sutton 1925, 1931; Gromme 1935, Meng 1959, Storer 1966, Grzybowski and Eaton 1976, Bosakowski and Smith 1992), Alaska (Zachel 1985, Lewis 2001), Canada (Doyle and Smith 1994, Schaeffer 1998), and Europe (Opdam 1975, Lindén and Wikman 1983, Goszycynski and Pilatowski 1986, Widén 1987, Lõhmus 1993, Mañosa 1994, Penteriani 1997, Rutz 2003a). The percentages of small mammals and birds from quantitative goshawk diet studies conducted in North America are compared by study methods in Tables 2–5.

As reported above, studies in the Southwest each report a higher percentage of small mammals compared to avian prey in the diet. For the 27 papers I reviewed that represent goshawk diet studies across their range, 14 reported >50% mammals by frequency and 10 out of 11 papers reported >50% mammals by biomass (not all papers reported prey biomass). Although mammals appear to be more important in goshawk diet overall, avian prey may be important in certain study areas and during certain times of the year. At Donner Lake, California, 56% of prey items delivered to a single goshawk nest were nestling and fledgling American Robin (*Turdus migratorius*) and Steller's Jay (*Cyanocitta stelleri*; Schnell 1958). In northern Nevada, goshawks consumed Belding's ground squirrel (*Spermophilus beldingi*) primarily but increased their consumption of American Robins and Northern Flickers (*Colaptes auratus*) after 1 July (Younk and Bechard 1994a), probably as a response to ground squirrels estivating in combination with an increase in the abundance of nestling and fledgling birds.

The percentage of birds and mammals in goshawk diet varies by region. Studies conducted in the northeastern US (Grzybowski and Eaton 1976, New York; Meng 1959, New York and New Jersey; Bosakowski and Smith 1992, New York, New Jersey, Connecticut; Sutton 1931, Pennsylvania) each reported a higher percentage of birds than mammals and each had similar values (i.e., 61–67% birds and 33–39% mammals) despite the relatively long period between studies. Seven of the nine studies conducted in California (Schnell 1958, Bloom et al. 1986, McCoy 1999), Oregon (Reynolds and Meslow 1984, Bull and Hohmann 1994, DeStephano et al. 1994, Thraikill et al. 2000) and Washington (Watson et al. 1998, Bloxton 2002) reported ≥50% birds by frequency. European studies in Italy (Penteriani 1997), Estonia (Lõhmus 1993), and Germany (Rutz 2003a) each reported very high percentages of birds (75–97%) compared to mammals (3–25%) by frequency. All of the studies conducted in Canada and Alaska that were reviewed, reported much higher percentages of mammals compared to birds.

One limitation of goshawk food-habit studies is that most have been conducted exclusively during the breeding season. One exception is Storer (1966) who collected data in the fall and winter from the north-central US and found a diet of 60% mammals and 40% birds from stomach analyses (Table 4). Other studies reporting on winter diet found nearly exclusive consumption of mammals during winter months in northern Arizona (Drennan and Beier 2003) and Utah (Stephens 2001). In southeast Alaska, the relative abundance of goshawk prey shifted during winter, with many common prey items absent or rare during that period (Iverson et al. 1996). The tendency for a higher percentage of mammals consumed in the winter would also be expected in the Southwest, due to the unavailability of many bird species in the ponderosa pine (*Pinus ponderosa*) forest type during the winter months (Table 6). Only three of seven mammal species present in this habitat type during summer remain active throughout winter. Other species are either intermittently present in winter or completely absent due to hibernation or migration.

TABLE 6. SEASONAL ABUNDANCE OF SELECTED GOSHAWK PREY SPECIES IN PONDEROSA PINE FOREST HABITAT IN THE SOUTHWESTERN US. X = PRESENT, - = INTERMITTENTLY PRESENT (I.E., DURING WARM, DRY PERIODS), BLANK = ABSENT DUE TO HIBERNATION OR MIGRATION. NUMBERS INDICATE TIMING OF PARTURITION AND THE NUMBER OF YOUNG.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Abert squirrel	x	x	x	x	x	2–5	x	x	x	x	x	x
Red squirrel	x	x	x	3.3	x	x	x	3.3	x	x	x	x
Golden-mantled ground squirrel			x	x	5.4	x	x	x	x			
Cliff chipmunk	-	-	x	x	x	4–5	x	4–5	x	x	x	-
Gray-collared chipmunk	-	-	x	x	x	4.9	x	x	x	x	x	-
Rock squirrel	-	-	x	x	5.6	x	x	5.6	x	x	-	-
Sylvilagus spp.	x	x	x	4–7	x	x	x	4.7	x	x	x	x
Red-naped Sapsucker	x	x	x	x	x	4–5	x	x	x	x	x	x
Williamson's Sapsucker	-	-	-	x	x	5–6	x	x	x	x	-	-
Northern Flicker	-	x	x	x	x	5–8	x	x	x	x	-	-
Hairy Woodpecker	x	x	x	x	x	4	x	x	x	x	x	x
Steller's Jay	x	x	x	x	x	4	x	x	x	x	x	x
American Robin	x	x	x	x	x	4	x	x	4	x	x	-
Mourning Dove	-	-	-	-	2	x	x	2	x	2	-	-
Blue Grouse	x	x	x	x	x	7–10	x	x	x	x	x	x
Band-tailed Pigeon	-	-	-	x	1	x	1	x	1	x	-	-
Total species present	8	9	12	15	16	16	16	16	16	16	10	7

Migratory patterns of goshawks vary across their range. In northern latitudes, goshawks respond to the cycles of prey species such as Ruffed Grouse and snowshoe hare (*Lepus americanus*), migrating south in large numbers in years when prey populations decline. In the lower 48 states, they are partial migrants in some areas (Squires and Ruggiero 1995, Stephens 2001) and permanent residents in other areas (Boal et al. 2003, Drennan and Beier 2003). Other researchers have noted that at least some goshawks in the Southwest winter in their breeding home range territory (P. Kennedy, unpubl. data; R. Reynolds, unpubl. data). If goshawks remain within their breeding territories during winter, the reduction in prey species diversity (Table 6) alone, or in combination with increased energetic requirements, may create a period of peak stress.

Few studies have investigated the relationship between winter caloric requirements, energy expenditures, prey availability and subsequent reproductive success for resident goshawks. Keane et al. (*this volume*) found that annual goshawk reproduction was greatest in years following winters with mild temperatures, high cone-crop production, and abundant populations of Douglas's squirrel (*Tamiasciurus douglasii*). Supplementary feeding at goshawk nests during the breeding season caused a demographic response in some years but not others (Ward and Kennedy 1994), suggesting that prey availability is not the only factor limiting goshawk productivity. J.M. Ward (unpubl. data) also speculated, based on preliminary data, that supplementary feeding at goshawk nests would not influence fitness in terms of the clutch size, timing of nesting, or the size of nestling goshawks, but that increased survival rates of nestling and fledgling goshawks was due to the greater time available, i.e., because they were not foraging, to nesting females for defending against predators.

Several studies have identified unusual prey items in goshawk diets. In Wyoming, Squires (2000) discovered mule deer (*Odocoileus hemionus*) and American marten (*Martes americana*) hair in five pellets regurgitated by goshawks but could not discern if these prey were killed or scavenged. Also in Wyoming, Squires (2000) documented carrion in the diet of goshawk, apparently a rare behavior for goshawks. In southeast Alaska, Lewis (2003) reported the first record of goshawks preying on Pigeon Guillemot (*Cepphus columba*), a seabird that has relatively little overlap with goshawk nesting territories. Cat (*Felis* sp.) was identified in the prey remains of a goshawk nesting in New Mexico (Kennedy 1991).

Key Prey Species

This comparison of goshawk food habits identifies three characteristics of goshawk diets in the Southwest: a preference for small mammals (Tables 2 and 3), a significant decrease in prey diversity during winter months (Table 6), and nine species of small mammals and two bird species which occurred most frequently in Southwest prey studies (Table 7). Based on these studies, the highest ranking mammal groups (N = 6) and bird species (N = 2) in the Southwest studies were selected for consideration in this report. The total number of mammal species was nine because two mammal groups had more than one species. The chipmunk group included two species because they were ranked in the top eight by two of the three studies (Kennedy 1991, Boal and Mannan 1994). I also included three cottontail species because these were rarely identified to species by any of the studies.

These 11 species were also selected by the GSC (Reynolds et al. 1992). However, the MRNG also included American Robin, Band-tailed Pigeon (*Columba fasciata*), Blue Grouse (*Dendrogapus obscurus*), Hairy Woodpecker (*Picoides villosus*), Mourning Dove (*Zenaida macroura*), Red-naped Sapsucker (*Sphyrapicus nuchalis*)), and Williamson's Sapsucker (*Sphyrapicus thyroideus*). While these species were present in goshawk diets in other regions (Schnell 1958, Meng 1959, Reynolds and Meslow 1984, Bloxton 2002), they represented <5% of the goshawk diet in the Southwest (Kennedy 1991, Boal and Mannan 1994, Reynolds et al. 1994).

HABITAT REQUIREMENTS AND NATURAL HISTORY OF SELECTED GOSHAWK PREY SPECIES

The 11 prey items most frequently observed in Southwest food habit studies were Abert squirrel, red squirrel, rock squirrel (*Spermophilus variegatus*), golden-mantled ground squirrel, cliff chipmunk, gray-collared chipmunk (*Eutamias cinereicollis*), mountain cottontail (*Sylvilagus nuttalli*), desert cottontail (*Sylvilagus auduboni)*, eastern cottontail (*Sylvilagus floridanus*), Steller's Jay, and Northern Flicker. Most of these species or their ecological equivalents are also important prey throughout the goshawks' geographic range.

Natural history and habitat requirements for the 11 prey species were researched in the literature and are presented in the following order: distribution, habitat, density, reproduction and development,

TABLE 7. IMPORTANT GOSHAWK PREY IN THE WESTERN US RANKED HIGHEST TO LOWEST BY FREQUENCY (BIOMASS). THE SYMBOL - INDICATES THE SPECIES WAS NOTED IN THE DIET BUT WAS NOT IN THE TOP EIGHT RANKS.

Species	Boal Mannan 1994[a]	Reynolds et al. 1994[a]	Kennedy 1991[b]	Bull and Hohmann 1994[b]	Reynolds and Meslow 1984[c]	McCoy 1999[d]	Bloom et al. 1986[d]	Schnell 1958[d]	Younk and Bechard 1994[e]
Golden-mantled-ground squirrel	1 (3)	7	4		4 (3)	2 (1)	3 (4)	3 (3)	4
Belding's ground squirrel								7 (5)	1
Rock squirrel	7 (4)	8	5						
Spermophilus sp.				3	-	-			3
Abert squirrel	6 (2)	3	1	-					
Gray squirrel					- (2)	- (6)			
Douglas squirrel					- (4)	1 (2)	1 (2)	4 (4)	
Northern flying squirrel					4 (5)				
Red squirrel	5 (5)	4	5	4	-				
Chipmunks	3 (7)	-	4	-	-	3 (5)		5 (-)	
Lagomorphs							- (1)		
Cottontail	2 (1)	1	3		-	8(5)			
Lepus spp.	-	4	-	2	2 (1)				
Steller's Jay	4 (6)	2	3	-	1 (6)	-	2 (-)	2 (1)	
Gray Jay						4 (6)			
Common Raven						- (3)			
Mountain Quail	-	-			- (7)				
Ring-billed Gull						6 (4)			
Clark's Nutcracker	-	-	-	-	-				
Woodpeckers	-	5	-	-	-	-			
American Robin	-	-	5	1	-	5 (7)		1 (2)	5
Grouse	-	-		-	-	- (7)	- (3)		
Northern Flicker	8 (8)	4	2	5	4 (8)		4 (-)		2

[a] Arizona.
[b] New Mexico.
[c] Oregon.
[d] California.
[e] Nevada.

home range, nest, and diet. While an effort was made to obtain research conducted in the Southwest, much pertinent information on these species was collected outside the area of interest. In some cases, information from closely related species was used to fill gaps in the knowledge base.

Abert Squirrel

Distribution and habitat

The Abert squirrel is a resident of ponderosa pine forests ranging from south-central Wyoming, through the southwestern US and into Durango, Mexico (McKee 1941). North of the Grand Canyon on the Kaibab Plateau, a subspecies is known as the Kaibab squirrel *(Sciurus aberti kaibabensis)*.

The Abert squirrel is apparently dependent on ponderosa pine forests (Keith 1965, States et al. 1988, Snyder 1993), although it has been known to occur occasionally in pinyon-juniper (*Pinus edulis-Juniperus* spp.) woodlands, Douglas-fir (*Pseudotsuga menziesii*), and spruce (*Picea* spp.)-fir forests (Rassmussen 1941, Keith 1965, Patton and Green 1970, Patton 1975b, Ratcliff et al. 1975, Hall 1981, Hoffmeister 1986). The best cover conditions are uneven-aged ponderosa pine stands with small even-aged groups within these stands (Patton 1975b). Average tree diameter for ideal stands is between 28 and 33 cm diameter at breast height (dbh); however, small groups of larger trees generally are present in the stand, resulting in a mosaic of diameter and height groups (Patton 1975b). Ratcliff et al. (1975) found that basal area and volume per hectare were significantly correlated with squirrel abundance but number of trees per hectare was not. Gambel oak (*Quercus gambeli*) were found in optimal stands at densities of 2.5–5 trees per ha in the 30–36 cm dbh class (Patton 1975b). Trees used for feeding averaged 48 cm dbh and nest trees averaged 43 cm dbh (Patton and Green 1970). Interlocking tree crowns are an essential component of both nesting and feeding stands (Patton 1975b, Hall 1981).

Densities

Population densities of Abert squirrel vary seasonally and annually (Pearson 1950, Keith 1965, Farentinos 1972, Hall 1981); however, statistics on squirrel harvests collected by the Arizona Game and Fish Commission suggest that populations are stable over long time periods. For example, for the 15-yr period from 1966–1981, hunters harvested between 1.2–2.4 squirrels per hunting trip, but for 10 of these years, the harvests varied only from 1.4–1.8 squirrels per hunting trip (Hoffmeister 1986; Appendix A.10).

Patton (1984) created a habitat capability model to evaluate Abert squirrel habitat quality and estimate population densities. The model used data on tree size, tree density, tree grouping, cone production, and squirrel densities to construct five habitat quality rankings and found from 0.05 squirrels per hectare in the lowest ranked habitat to 2.48 squirrels per hectare in the highest ranked habitat. On a 72-ha study area in Colorado, Farentinos (1972) found that population density varied from 0.3 squirrels per hectare in spring (N = 24) to 0.6 squirrels per hectare in the fall (N = 40). Trowbridge and Lawson (1941, as cited in Keith 1965) reported population density ranged from 0.3–1.3 squirrels per hectare in uncut stands. Population density on stands where timber harvesting had previously occurred was 0.03 squirrels per hectare for two consecutive years (Trowbridge and Lawson 1941, as cited in Keith 1965).

Reproduction and development

On the Mogollon Plateau, Keith (1965) reported mating in late April and May. Young were born between 10 June and 12 July. Litter size varied between two and five. The mean litter size was 3.4. Stephenson (1974) reported a mean litter size of 2.9 in northern Arizona.

Home range

Several authors have reported spatial overlap in Abert squirrel home ranges (Farentinos 1979, Patton 1975a, Pederson et al. 1976, Hall 1981). In Colorado, Farentinos (1979) reported the mean home range size for males as 20.7 ha in the breeding season and 7.5 ha in the non-breeding season. Home range size for females was 7.4 ha in the breeding season and 5.8 ha in the non-breeding season. Near Flagstaff, Arizona, Keith (1965) reported that adults have a home range of 2 ha in winter and 7.3 ha in summer. On the Beaver Creek watershed, 50 km south of Flagstaff, Patton (1975a) radio-tagged two males and one female Abert squirrels and calculated home ranges of 12.1, 34.4, and 4.0 ha, respectively. On the Kaibab Plateau, Hall (1981) found that three males had a mean home range size of 4.4 ha in the summer and a single female had a home range size of 14 ha. In Utah, Pederson et al. (1976) reported the mean home range size to be 2.5 ha (N = 7).

Nest

Abert squirrels appear to have two types of nests—summer (day) nests and nursery nests (Hall 1981). Generally, summer nests are poorly maintained and often lack a roof, whereas nursery nests are usually roofed and well maintained with fresh green clippings of ponderosa pine (Hall 1981). Nests are typically located in a fork of the main trunk or in the angle formed by the trunk and one or more limbs, and, on average, 15 m above ground in a 50 cm dbh ponderosa pine within an interlocking forest canopy (Hall 1981). Other researchers have reported average nest heights from 14 m above ground in southern Utah (Pederson et al. 1976), to 10.7 m in northern Colorado (Farentinos 1972). Pederson et al. (1976) found that squirrel nest boxes placed anywhere between 7.6 and 14 m in ponderosa pines were occupied by Abert squirrels in >50% of the cases. Hollow Gambel oak trees have been used as dens (Patton and Green 1970, Patton 1975b), but nesting attempts were not documented. Patton (1975a) followed three squirrels with radio transmitters, and found that each squirrel used multiple nests. Two males and one female used two, six, and five nests, respectively ($\overline{x} = 4.3$).

Diet

The Abert squirrel diet consists almost exclusively of ponderosa pine and associated fungi (Hall 1981); however, Reynolds (1966) reported Abert squirrels using pinyon pine in the same way they use ponderosa pine (i.e., eating the cambium of the subterminal branches) near Silver City, New Mexico. Cambium from subterminal twigs is taken throughout the year, but apical buds are a major item in winter diets of Abert squirrels in Arizona (Keith 1965, Hall 1981, Stephenson 1974). Staminate cones are eaten in late June when mature. Ovulate cones, the most nutritious part of ponderosa pine, are eaten to the degree available during late spring and summer. Hypogeous fungi is eaten in all seasons (Stephenson 1974), but is the major part of the diet in the summer (Hall 1981). Carrion, in small amounts, also has been noted in the diet (Coughlin 1938, Keith 1965). Acorns are taken when available and constitute as much as 40% of the fall diet during years of good cone crops (Stephenson 1974).

Abert squirrels are dependent on currently available food because they typically do not cache food (Keith 1965, Stephenson 1974). However, Hall (1981) observed three types of food storing behavior: burying cones in duff, storing mushrooms at a limb joint in a tree, and storing mushroom parts in terminal needle clusters. The first two types of storage may be for a period of days or weeks, while the terminal needle clusters are used for a few hours or 2 d at most.

Red Squirrel

Distribution and habitat

The red squirrel ranges from Alaska through most of Canada and the northern portions of the midwestern, northeastern, and Appalachian states. This squirrel inhabits coniferous forests throughout most of the Rocky Mountains and south into the higher elevation plateaus of Arizona and New Mexico (Hoffmeister 1986).

On the Mogollon Plateau, red squirrels are found only where firs and spruce are present (Burnett and Dickermann 1956). In the San Francisco Peaks, red squirrels are found mostly above 2,600 m elevation in Engelmann spruce (*Picea engelmannii*), corkbark fir (*Abies lasiocarpa*), bristlecone pine (*Pinus aristata),* and Douglas-fir (Hoffmeister 1986).

Spruce-fir, Douglas-fir, and lodgepole pine (*Pinus contorta*) forests types are preferred by red squirrels. In the Southwest, Engelmann spruce and a mixture of spruce and Douglas-fir are the most important habitats (Vahle 1978). The three most important overstory variables controlling red squirrel habitat in southwest mixed-conifer forests are size, density, and grouping of trees (Vahle and Patton 1983). Vahle and Patton (1983) reported that the best habitat consists of multi-storied stands of mixed conifer with trees from 30–36 cm dbh in dense groups of 0.4 ha or less. Generally, at least one 45 cm dbh tree is present in this cluster and is typically a Douglas-fir. A 50 cm dbh or greater live tree, snag, or downed log, was universally present at the center of the food cache.

Densities

In central Alberta, Kemp and Keith (1970) reported densities of 0.06 adult squirrels per hectare on one study area and 0.1 squirrels per hectare on another study area; however, they acknowledged that their estimates were probably low. In the same area, Rusch and Reeder (1978) compared densities of red squirrels between stands of mixed spruce (*Picea* spp.), aspen (*Populus tremuloides*) and jack pine (*Pinus banksiana*). Mixed spruce stands supported the highest densities with 1.6–7.0 squirrels per hectare. Densities in jack pine were intermediate with 1–2.6 squirrels per hectare. Aspen stands

had the lowest densities with 0–1.0 squirrels per hectare. The numbers given by Rusch and Reeder (1978) are substantially larger than those Kemp and Keith (1970) reported due in part to the different methods and units of measurement. Rusch and Reeder (1978) used live-trapping, mark-recapture methods and estimated the entire population, while Kemp and Keith (1970) used an observation method and estimated only the adult portion of the total population.

In mixed conifer habitat in eastern Arizona, Vahle and Patton (1983) inventoried 141 squirrel caches to determine population densities. Despite finding one squirrel with eight caches, they confirmed the relationship of one squirrel per cache in fall and winter. Based on the number of caches they estimated population density in the range of 1–2.5 squirrels per hectare.

Sullivan and Moses (1986) compared red squirrel densities in thinned and unthinned lodgepole pine stands in British Columbia. Squirrels were more abundant in the unthinned stands with average densities during May and August of 1.2 squirrels per hectare compared to 0.2/ha in thinned stands. The authors suggested that young stands might provide a dispersal sink for juvenile and yearling squirrels.

Thompson et al. (1989) used track station transects to index red squirrel populations in Ontario. They compared their indices of abundance for uncut stands and stands of less than 5, 10, 20, and 30 yr old. The highest track counts were in the uncut stands ($\bar{x}$ = 30). The <5-, 10-, and 30-yr-old stands all had low scores (<4) but the 20-yr-old stand had a moderate population index (10).

Reproduction and development

Red squirrels may have one or two litters per year. Hoffmeister (1986) gives evidence for two litters in Arizona based on examination of dentition in juveniles on the Kaibab Plateau and in the Graham Mountains. The annual reproductive rate expressed as the number of young per female varied from 2.4–4.4 over a 4-yr study period in Rochester, Alberta (Rusch and Reeder 1978). Kemp and Keith (1970) also in Rochester, reported mean litter sizes of 3.4 and 4.3 for the years 1967 and 1968, respectively. Layne (1954) summarized litter sizes from several authors and reported a mean of 4.9 (range = 2–8). This figure is higher than the means of 3.9 for the study by Rusch and Reeder (1978), 4.0 by Wood (1967) and 3.3 by Smith (1968). In Colorado, Dolbeer (1973) found an average embryo count of 3.3 (range = 2–5).

Home range

Because red squirrels are notorious for their strong territorial behavior, most authors report the size of a defended territory and not the home range size. Rusch and Reeder (1978) estimated territory size of red squirrels at 0.2–0.7 ha. Kemp and Keith (1970) estimated territory size from observations in a variety of habitats and found territories ranging from 0.4–0.8 ha. Gurnell (1984) estimated territory size to be approximately 60–100% of the home-range size. Burt and Grossenheider (1980) report that home ranges are <3.4 ha in size.

Nest

Nest height is between 4.6 and 9.1 m above ground regardless of tree size (Vahle and Patton 1983). Nest tree measurements for 186 nest trees in eastern Arizona ranged as follows: tree dbh from 33.5–38.1 cm; tree height from 14.3–16 m; tree distance from center of cache from 4.0–4.7 m; number of trees with crowns interlocking nest tree crowns 2.3–2.7 (Vahle and Patton 1983). In Colorado, Hatt (1943) reported a horizontal diameter of 28–46 cm for nests and an inside diameter of 10–13 cm. The inside of the nest is generally composed of grasses. Nests are often placed in cavities within trees; if outside the bole, they are firmly supported and protected (Hoffmeister 1986).

Diet

The red squirrel feeds on a variety of seeds, nuts, eggs, and fungi (Burt and Grossenheider 1980). Layne (1954) divided food items into six categories based on stomach analyses of 145 stomachs collected in Ithaca, New York: mast, fleshy fruits, green plant matter, fungus, flesh, and insects. Mast was consumed every month of the year and represented almost 75% of the annual diet. Fleshy fruits and green plant matter each comprised nearly one-quarter of annual diets. Fungus was 7% of the annual diet despite only being consumed in July and August as 12% and 26% of the monthly diets, respectively.

In Alberta, Rusch and Reeder (1978) calculated that a single red squirrel consumed an average of 639 meristematic buds and the seeds from 35 pine cones each day. At the same study site, Rusch and Reeder (1978) noted that almost all species of fleshy mushrooms were consumed. In an outdoor enclosure at the University of Alaska, red squirrels were fed nothing but white spruce (*Picea glauca*) seeds for 3 wk and consumed about 144 cones per squirrel, per day (Brink and Dean 1966).

Rock Squirrel

Distribution and habitat

The rock squirrel is found in southern Nevada and most of Utah, Colorado, New Mexico, and Arizona (Burt and Grossenheider 1980). They are primarily found in or among rocks, on slopes, canyon walls, or rock piles (Hoffmeister 1986). In Arizona, they occur from as low as 490 m elevation in Yuma County to >3,350 m in Coconino County on the San Francisco Peaks.

Densities

Rock squirrels are less abundant in the winter, but whether they hibernate is unknown (Hoffmeister 1986).

Reproduction and development

Hoffmeister (1971) found a nest containing six young on 20 May in the Grand Canyon. Rock squirrels may have two litters in southern Arizona but only one in northern Arizona (Hoffmeister 1986).

Home range

Findley et al. (1975) referenced the work of W. Stalheim studying rock squirrels near Albuquerque, New Mexico, and reported squirrels having overlapping home ranges, which averaged about 14 ha per squirrel (N = 16).

Nest

Burrows and nests are placed in rock piles, making excavation and research difficult (Hoffmeister 1986).

Diet

In Arizona, rock squirrels have been observed eating the buds and seeds of mesquite (*Prosopis juliflora*), cactus (*Opuntia* spp.) fruit, juniper berries (*Juniperus* spp.), blooms of *Agave*, seeds of *Ephedra*, ripe fruits of western red currant *(Ribes cereum)*, ripe berries of gray thorn (*Acacia* spp.), bulbs of mariposa lilies (*Lilium* spp.), serviceberry (*Amelianchier* sp.), skunkbush (*Rhus* sp.), and lupine (*Lupinus* sp.) seeds, apricots and peaches, acorns (*Quercus* spp.), hackberry (*Celtis reticulata*), grapes (*Vitas* spp.), walnuts (*Juglans* spp.), cultivated corn (*Zea mays*) and wheat (*Triticum* spp.) (Hoffmeister 1986). Rock squirrels prefer leaves (Hart 1976).

Golden-mantled Ground Squirrel

Distribution and habitat

The golden-mantled ground squirrel is common throughout the mountains of the western US, southern British Columbia, and Alberta (McKeever 1964). It is usually found from the mid-transition zone up to the Hudsonian zone (Mullally 1953). In the Southwest, the golden-mantled ground squirrel occurs along the Mogollon Plateau from the San Francisco Peaks to the White Mountains, on the Kaibab Plateau, in the Chuska Mountains (Hoffmeister 1986), and in woodlands to above timberline in northern New Mexico (Findley et al. 1975).

A study conducted on the Beaver Creek watershed, 50 km south of Flagstaff, Arizona, found golden-mantled ground squirrels preferred dense, mature forest on a silviculturally treated watershed (Goodwin and Hungerford 1979). Only at higher elevations were the squirrels observed in more open stands (Goodwin and Hungerford 1979). Lowe (1975) found this species abundant in both dense and open forests above 2,256 m. In the Trinity Mountains of northern California, golden-mantled ground squirrels invaded cut areas within virgin forest after timber harvesting (Tevis 1956).

Densities

On the Beaver Creek watershed, Goodwin and Hungerford (1979) estimated densities of golden-mantled ground squirrels at 0.6 squirrels per hectare in denser forests and 0.1 squirrels per hectare in more open stands. In northeastern California, squirrels were more abundant in ponderosa pine forests than they were in either lodgepole pine, red fir (*Abies magnifica*), or white fir (*Abies concolor*) forest types (McKeever 1964).

In Arizona, golden-mantled ground squirrels hibernate from October or November until April or May, depending on elevation and seasonal variations (Hoffmeister 1986). McKeever (1964) found adults hibernating from mid-March to late May. Juveniles did not appear until mid-May to early June. Mullally (1953) reported hibernation dates from October or November until mid-March or April in southern California. Captive squirrels from the same study population hibernated from 25 December to early March, but were intermittently awake and active for short periods in all cases (Mullally 1953).

Reproduction and development

McKeever (1964) reported that almost all males emerged from hibernation in breeding condition, but females did not enter breeding condition until 2–3 wk after emerging from hibernation. The gestation period in captivity was about 27 d (McKeever 1964). Mean litter size in Lassen County, California was 5.0 (range = 3–8) for pregnant females (N = 36; McKeever 1964), and 5.1 embryos for Plumas County, California (Tevis 1955).

Home range

No information on home range size was found in the literature. However, based on body size, golden-mantled ground squirrels are expected to have a home range size intermediate between the smaller chipmunks (0.8 ha) and the larger Abert squirrel (2.0–21.0 ha).

Nest

Burrows are either dug into the ground near a large surface object, dug into a partially decomposed log or stump, or result from taking over a gopher hole (Mullally 1953). Fourteen burrows excavated by Mullally (1953) had an average depth of 46 cm and an average length of 112 cm. Seldom is more than one entrance present (Mullally 1953).

Diet

McKeever (1964) reported eight categories of food items from analyses of 561 stomachs collected throughout the year. Fungi were the most important item for the entire year, representing 57% of the stomach contents. Leaves were the second most important item, at 30% of the annual diet. Seeds, flowers, arthropods, mammals, fruit, and bulbs each represented <5% of the annual average diet. Seeds were especially important in fall, representing 30% of the diet for the month of October. Bulbs were taken only in fall and represented 30% of the diet for November. Carrion represented 10% of the diet for November; however, this figure is probably exaggerated in this study because of an abundance of dead animals caught in traps on the study area.

The diet of golden-mantled ground squirrels changes throughout the year. After emerging from hibernation in spring, the diet was 56% (by volume) leaf material (Tevis 1953). In summer and fall, intake of leafy material declined and fungi dominated the diet at 65% and 90%, respectively (Tevis 1953).

Tevis (1952, 1953) studied eating habits of golden-mantled ground squirrels during a food shortage caused by a failure in the conifer seed crop in the fall of 1950 and during a late frost in spring 1951 which killed many flowers of spring-blooming shrubs. The diet of golden-mantled ground squirrels for the year following the food shortage was marked by an increased consumption of fungi. Of the several populations studied, Tevis (1952) concluded that where hypogeous fungi flourished, it offset the deleterious effects of the failure of the seeds crops. In Colorado, the common dandelion (*Taraxacum officinale*) provided >80% of the diet between June and August (Carlton 1966). The stems were preferred and the seeds and flowers were rarely eaten (Carlton 1966).

GREY-COLLARED CHIPMUNK

Distribution and habitat

The grey-collared chipmunk ranges from Bill Williams Mountain and the San Francisco Peaks to the White Mountains in Arizona (Hoffmeister 1986). In New Mexico, the grey-collared chipmunk occurs on several mountains in the southern portion of the state including the Mogollon, Organ, Mimbres, Magdalena, San Mateo, and Elk mountains (Findley et al. 1975).

In Arizona, grey-collared chipmunks prefer mature forests above 2,225 m (Goodwin and Hungerford 1979). Lowe (1975) reported that grey-collared chipmunks were abundant in mature ponderosa pine forests west of Flagstaff at elevations between 2,250 and 2,440 m.

Densities

Clothier (1969) reported population densities as 5.0/ha in May and 12.5/ha in August in southeast Coconino County.

Reproduction and development

Young are born in the first 2 wk of June and the gestation period is at least 30 d (Clothier 1969). One litter per summer is produced. Mean litter size is 4.9 (range = 4–6). Young emerge from underground burrows in July (Clothier 1969).

Home range

No information on home range was found in the literature for grey-collared chipmunks. However,

eastern chipmunks (*Tamias striatus*) home range size is usually <0.8 ha (Burt and Grossenheider 1980).

Nest

Nests are located under logs, stumps, and roots or in tree cavities (Hoffmeister 1986).

Diet

No information on diet was found in the literature. However, based on information from similar species they likely consume an array of food items including seeds, berries, and fungi.

Cliff Chipmunk

Distribution and habitat

The cliff chipmunk is distributed from central Nevada through Utah, Arizona, and parts of western New Mexico (Burt and Grossenheider 1980). In Arizona, the cliff chipmunk is found from the Arizona Strip southeastward through the Mogollon Plateau to the White Mountains and on various isolated mountain ranges (Hoffmeister 1986).

Cliff chipmunks are found in a wide variety of habitats, especially where there are large rocks or cliffs (Hoffmeister 1986). In Arizona, they range from as low as 975 m in the Grand Canyon to as high as 2,865 m in the Graham Mountains (Hoffmeister 1986). In Nevada, Brown (1971) found that cliff chipmunks were restricted to stands of small diameter trees that were well spaced. In Arizona, cliff chipmunks are found along rock cliffs and in thinned pine stands (Goodwin and Hungerford 1979).

Densities

Goodwin and Hungerford (1979) found wide variations in population densities from 0.1 squirrel per hectare in dense pine stands to about 1.3 squirrels per hectare in thinned pine stands and along rock ledges. Density increased as thinning increased, but cliff chipmunks were not found in clearcuts (Goodwin and Hungerford 1979). Cliff chipmunks apparently do not hibernate, but they may become inactive during periods of extreme winter cold (Hoffmeister 1986).

Reproduction and development

Cliff chipmunks may have two litters a year in Arizona (Hoffmeister 1986). The closely related least chipmunk (*Eutamias minimus*), which also has eight mammae, has 2–6 young per litter and possibly two litters per year (Burt and Grossenheider 1980).

Home range

No information on home range was found in the literature for cliff chipmunks. However, home range size for eastern chipmunks is usually <0.8 ha (Burt and Grossenheider 1980).

Nest

No information on nesting habits of the cliff chipmunk was found in the literature. The least chipmunk excavates its own burrows beneath stumps and rocks (Burt and Grossenheider 1980).

Diet

Cliff chipmunks feed on the fruits and seeds of most of the trees and shrubs, as well as the seeds of grasses and forbs (Hoffmeister 1986). Stems and blossoms of plants are preferred over other parts (Hart 1976).

Cottontails

Distribution and habitat

Three species of cottontails occur in the Southwest—eastern cottontail, mountain cottontail, and desert cottontail. The eastern cottontail is most often found in mountains and adjacent slopes but it has never been found at elevations as high as those inhabited by the mountain cottontail (Hoffmeister 1986). Mountain and eastern cottontails are not known to overlap in their distribution anywhere in Arizona, but come within 10 km of each other in the White Mountains (Hoffmeister 1986). Mountain cottontails preferred habitats dominated by sagebrush (*Artemisia tridentata*) in southern British Columbia (Sullivan et al. 1989). In Colorado, Cayot (1978) found that mountain cottontails decreased in abundance as elevation increased from 2,070–2,710 m. At higher elevations, Cayot (1978) found a negative association between mountain cottontail abundance and bare ground, downed trees, and common juniper (*Juniperus communis*). Mountain cottontail abundance was greater on southeast aspects where ponderosa pine was more common and bitterbrush (*Purshia tridentata*) reached 50% cover. Mountain cottontails are typically high-mountain residents in Arizona, inhabiting grassy and rocky areas near

or among spruce-fir or on the sagebrush flats and gullies near ponderosa pine or spruce-fir forests (Hoffmeister 1986). The desert cottontail is found throughout the Southwest (Burt and Grossenheider 1980) but mostly inhabits deserts and semiarid grasslands at elevations below coniferous forest (Hoffmeister 1986).

Densities

Densities of eastern cottontail vary from one/2 ha to several times higher in winter concentrations (Burt and Grossenheider 1980). Trent and Rongstad (1974) estimated fall densities of eastern cottontails in a 6-ha woodlot in Wisconsin as 9/ha. McKay and Verts (1978) reported densities at monthly intervals over a 20-mo period in Oregon. Population densities ranged from 0.07–2.54/ha (McKay and Verts 1978). Population density peaked in August and was lowest in April over the 20-mo study period (McKay and Verts 1978). Scribner and Warren (1990) reported densities of eastern cottontails ranging from 8–28/ha in playa basins in Texas.

Reproduction and development

Reproduction occurs later at higher latitudes and higher elevations (Conaway et al. 1963). Mountain cottontails in Oregon averaged four litters in 1972 and only three litters in 1973 (McKay and Verts 1978). In Missouri, eastern cottontails had seven–eight litters per year each with four–six viable embryos resulting in approximately 35 young produced annually (Conaway et al. 1963). Powers and Verts (1971) reported 4.3 viable embryos per adult female mountain cottontail, which is lower than for the eastern cottontail but considerably greater than previously expected for mountain cottontails. The gestation period for six timed pregnancies of eastern cottontails was between 26 and 28 d (Marsden and Conaway 1963).

Home range

Home range size varies between species. Eastern cottontail home range size ranges from 1.2–8.0 ha and desert cottontail home range size from 0.4–6.0 ha (Burt and Grossenheider 1980). In southwestern Wisconsin, adult male home range size varied from 2.8 ha in spring to 4.0 ha in summer to 1.5 ha in late summer (Trent and Rongstad 1974). Adult female home range size varied from 1.7 ha in the spring to 0.8 ha throughout the summer and fall and did not overlap in the summer (Trent and Rongstad 1974). In Oregon, male eastern cottontails dispersed greater distances than females and juvenile males dispersed more than adult males (Chapman and Trethewey 1972).

Nest

The desert cottontail nest is a grass-lined depression in the ground (Burt and Grossenheider 1980). Eastern cottontail nests were located most often within dense brush, grass cover, and downed logs (Allen 1984). No information was found on the mountain cottontail nest.

Diet

The eastern cottontail feeds on green vegetation in the summer and bark and twigs in the winter (Burt and Grossenheider 1980). In California, mountain cottontails consumed mainly sagebrush and juniper in the fall and grasses in the spring and summer (Orr, 1940 as cited in Hoffmeister 1986).

Steller's Jay

Distribution and habitat

The Steller's Jay is a permanent resident of coniferous forest from southern Alaska, west through British Columbia and Alberta, and south through the western states into Mexico (Terres 1991). Coons (1984) found Steller's Jays present on the San Francisco Peaks during all months of the year. The mean elevation where birds were detected during the spring, summer, and fall was between 2,680 m and 2,900 m, but dropped to between 2,560 and 2,590 m during the period from November–February (Coons 1984).

Densities

Haldeman (1968) reported the number of breeding pairs in three study areas. Ponderosa pine, burned ponderosa pine, and a mixed-stand composed of fir, pine, and aspen, supported 8, 7, and 10 pairs of birds per 40 ha, respectively (Haldeman 1968). Breeding densities during a 3-yr study in five different forest treatments ranged from zero pairs per 40 ha in the cleared plot to nine pairs per 40 ha on the control plot. The number of birds seen per hour in the winter was 0.1 both in a mixed-stand of fir, pine, and aspen, and in a pure ponderosa pine stand (Haldeman 1968). In west-central Colorado, the density of Steller's Jays in an aspen-conifer forest ranged from four/40 ha in the

78% aspen overstory forest to one/40 ha in both 98% and 1% aspen overstory forests (Scott and Crouch 1988).

Reproduction and development

Females incubate for 16 d and the young are altricial. Both sexes help raising young (Erlich et al. 1988).

Home range

Brown (1963) reported that Steller's Jays maintained non-overlapping areas of dominance around their nests ranging in size from 0.02–0.4 ha in size. However, larger home ranges adjacent to each other did overlap and were from 0.9–1.4 ha in size. In Arizona, Vander Wall and Balda (1981, 1983) reported Steller's Jays flying as far as 3.2 km daily to forage on pine seeds, acorns, berries, and other seasonally abundant food.

Nest

Steller's Jays build cup nests with a bulky foundation of large sticks cemented together with mud (Bent 1946). The inside of the cup is lined with rootlets or pine needles (Bent 1946). Nests are built on horizontal limbs or in the crotch of trees (Erlich et al. 1988).

Diet

Based on two stomachs collected in northern California, Coleoptera accounted for 92% and Lepidoptera 4% of the diet (Otvos and Stark 1985). During December and January the diet was between 90 and 99% acorns or pine seeds (Erlich et al. 1988).

Northern Flicker

Distribution and habitat

The Northern Flicker ranges from treeline in Alaska and across northern Canada, south through most of the lower 48 states (Terres 1991). In Arizona, Northern Flickers have a widely scattered elevational distribution. On the San Francisco Peaks from June–September, mean elevation ranged between 2,590 m and 2,835 m (Coons 1984). Northern Flickers were not recorded during November, December, or January anywhere on the San Francisco Peaks study area including a site as low as 2,440 m (Coons 1984).

Densities

Haldeman (1968) recorded densities in three different forest stands—ponderosa pine, burned ponderosa pine, and a mixed-stand of fir, pine, and aspen. The number of breeding pairs per 40 ha was 9, 17, and 7, respectively. Breeding densities during a three year study in five different forest treatments ranged from zero pairs per 40 ha in cleared plots, to four pairs per 40 ha on strip cut plots (Szaro and Balda 1979). Densities of Northern Flickers in the Santa Catalina Mountains north of Tucson, averaged two/40 ha (Horton and Mannan 1988). At the same study area, Horton and Mannan (1988) recorded a decrease in density on plots that were control burned. Prior to burning in 1984, the density was 2.6/40 ha and in 1985, after the burn, the numbers dropped to 2.1/40 ha (Horton and Mannan 1988).

In winter the number of birds seen per hour was 0.2 in a mixed stand of fir, pine, and aspen and 0.9 in a pure ponderosa pine stand (Haldeman 1968). Flicker densities were positively correlated with aspen overstory density (Scott and Crouch 1988).

Reproduction and development

Northern Flickers are monogamous and the average clutch is five–eight eggs (range 3–12) (Erlich et al. 1988). They have one brood per year over most of their range but two broods is common in the south (Erlich et al. 1988). Both sexes share incubation of the eggs for 11–14 d when young are born altricial. The young fledge from 25–28 d after hatching (Erlich et al. 1988).

Home range

Home range and territory are likely the same size but no specific figures are available (Moore 1995). A territory of 16 ha was estimated for a breeding pair in a conifer forest in Ontario (Lawrence 1967)

Nest

The Northern Flicker is a primary cavity nester and excavates nest holes preferentially in snags but sometimes in live trees, typically cottonwood (*Populus* spp.), willow (*Salix* spp.), sycamore (*Platanus* spp.), or juniper (Bent 1939). Scott and Patton (1975) recorded 10 nests in the White Mountains of Arizona, five in dead ponderosa pine, two in dead aspen, and three in live aspen. The average height of these 10 nests was 13 m above ground level (Scott and Patton 1975). Preston and Norris

(1947) reported two nests at 6 m above ground level. On the Mogollon rim in central Arizona, Li and Martin (1991) found average nest height to be 16 m above ground level. In the Sierra Nevada Mountains, mean height of nest trees was 13 m and mean nest height was 8 m (N = 68; Rafael and White 1984).

Mean nest tree dbh was 45 cm in Arizona (Li and Martin 1991). In the Sierra Nevada, mean dbh of nest trees was 60 cm. The majority of nests (97%) were in aspen trees and the remainder was in conifers (N = 37; Li and Martin 1991). Northern Flickers selected snags 57% of the time; 14% of Northern Flicker nests were found in dead portions of live trees and 30% in live trees (Li and Martin 1991). In the Sierra Nevada, Northern Flickers used snags, dead portions of live trees and live trees 78%, 20%, and 3% of the time, respectively (N = 20; Rafael and White 1984).

Diet

The Northern Flicker feeds chiefly on the ground but occasionally may capture flying insects and glean bark (Erlich et al. 1988). The preferred food is ants, more than any other North American bird (Erlich et al. 1988). In addition to ants, some beetles, caterpillars, crickets, spiders, and codling moths are eaten (Bent 1939). Acorns are the main plant item in the diet (Bent 1939). Otvos and Stark (1985) reported the stomach contents of nine Northern Flickers collected between 1962 and 1968 in northern California. Formicids (Hymenoptera) composed nearly 90% of the diet with *Liometopum* spp., *Prenolepis imparis*, *Formica* spp., and *Lasius* spp. each contributing about 20% to the total diet. Plant material comprised 3% of the diet (Otvos and Stark 1985). Scott et al. (1977) reported that animal matter comprised 60% of the Northern Flickers diet and of this, 75% was ants. Plant material in Northern Flicker diets includes seeds of annuals, cultivated grains, and the fruits of shrubs and trees (Scott et al. 1977).

PREY SPECIES HABITAT

The habitats used by the primary prey of the goshawk in the Southwest vary from small (<1 ha) stands of large, mature Douglas-fir with high canopy closure for red squirrels, to areas with relatively low canopy cover and high grass-forb cover for golden-mantled ground squirrels. All of the prey species occur in ponderosa pine forest except red squirrels, which are restricted to spruce-fir forest. The desert cottontail, cliff chipmunk, rock squirrel, and Northern Flicker are found in more than three different habitat types on the Coconino National Forest (Anonymous 1991a, 1991b). The Abert squirrel is the only species restricted to ponderosa pine forest.

Home range size of goshawk prey species is variable but always much smaller than the home range size of any individual goshawk. Home ranges of prey species varies from less than 1 ha for chipmunks to >20 ha for Abert squirrel. By contrast, goshawk home ranges in North America are estimated to range from 570–3,500 ha depending on sex and habitat characteristics (Squires and Reynolds 1997).

Goshawks and their prey may respond differently to silvicultural treatments. For example, golden-mantled ground squirrels preferred dense, mature forest over open stands on silviculturally treated forest in Arizona (Goodwin and Hungerford 1979), but they increased in numbers in northern California following clear-cut timber harvest (Tevis 1956). On the Kaibab National Forest in northern Arizona, Crocker-Bedford (1990) estimated that the number of Northern Goshawk pairs declined by >50% following timber harvest. This contrast in the type of response to a forest treatment illustrates the complexity of forest management and suggests that decisions cannot be based on the needs of a single prey species alone.

This review summarizes several goshawk dietary studies to identify the primary prey of the goshawk in the Southwest and the habitats of these prey species. However, knowledge of the habitats used by goshawk prey must be associated to the habitats used by goshawks, because many of the prey species occupy habitats where goshawks are unlikely to encounter them (e.g., Northern Flicker in Mojave desert scrub). Life-history traits of goshawk prey are variable. Most of these species produce young during the goshawk nesting season (May–July) but many hibernate or migrate to lower elevations during the winter months (Table 6). Population dynamics of these species is variable with some species cyclic and others relatively stable year to year.

GOSHAWK HABITAT

Several studies have characterized goshawk nesting habitat across its range. Despite highly variable tree species composition both within a region and across the subspecies' range, these studies generally agree that goshawk nest sites have large trees, dense canopies, and, in the southern portion of the hawk's range, are typically on slopes with northerly aspects (Bartlelt 1977, Moore and Henny 1983, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Hayward and Escano 1989). Whereas nest stands have been studied extensively,

little is known about the structure and composition of goshawk foraging habitat.

Only eight studies have described goshawk foraging habitats. In North America, four studies found that goshawks preferred stands with average tree diameter ≥52 cm dbh (Austin 1993), greater canopy cover, basal area, and tree densities than at random sites (Hargis et al. 1994), areas with high canopy closure as determined from LANDSAT imagery (Bright-Smith and Mannan 1994), and greater density of large trees (>40 cm dbh), higher canopy closure, and higher tree density than paired comparison sites (Beier and Drennan 1997). In Europe, Widén (1989) found that goshawks preferred mature conifers over younger stands in a Swedish boreal forest. In three Swedish and one British study area, Kenward (1982) reported that goshawks spent 50% of their time in woodlands which comprised only 12% of their habitat. In the same study, goshawks avoided open country and had a preference for woodland edge or forested areas within 200 m of an opening. Despite the preference for mature forest conditions reported in these studies which were conducted in the breeding season, goshawks used all available habitats for foraging including dense stands of small diameter trees, meadows, seedling and sapling stands, and clearcuts. During winter, goshawks in Arizona used habitats with more medium-sized trees and denser canopy closure than paired reference sites, but indices of prey abundance did not differ between used and reference sites, suggesting that goshawks are habitat specialists even during winter (Drennan and Beier 2003). In Utah, wintering goshawks used habitats with greater canopy closure and greater tree density than random locations (Stephens 2001).

OVERLAP BETWEEN GOSHAWK HABITAT AND PREY SPECIES HABITAT

The habitats used by goshawks and their prey vary throughout the year. In summer, habitats used by goshawks and their primary prey appear to overlap entirely for some individuals, as expected. In winter, goshawks may remain on their breeding territories in ponderosa pine forest, descend to lower elevation pinyon-juniper woodland and grassland, or ascend to spruce-fir forests. Goshawks wintering in ponderosa pine forest overlap with Abert squirrels and some bird species, a relatively narrow prey base compared to goshawks wintering in pinyon-juniper where a greater diversity of prey species are available. In the spruce-fir zone, red squirrel is the only prey species available to goshawks. Although no studies in the Southwest have shown goshawk winter movements in response to low populations of prey species, this pattern has been documented for studies areas at more northern latitudes (Doyle and Smith 1994, Yukon, Canada, 60° N). If goshawk movements at lower latitudes are driven by prey abundance, the most sensitive habitat would be spruce-fir where only a single prey species is expected present during winter months.

Habitats used by goshawks and their primary prey share several similar attributes. At the coarsest scale, both goshawks and their prey require forested habitats for at least part of the year. At a finer scale, most prey species reach their highest densities in habitats with high canopy closure, high numbers of large trees per hectare, and presence of downed woody material, and snags, habitats that are also preferred by goshawks. Although habitats used by goshawks and their prey have many similarities, they also have many differences. The biggest difference across all prey species is related to the area of habitat used; goshawks use relatively large areas compared to most prey species. During the breeding season goshawks typically range over areas >500 ha whereas most prey species have small home ranges (<20 ha). Because goshawk habitat covers large areas, it is inherently more diverse than the habitats used by individual prey species. As a result, goshawks probably respond to the composition of habitat types across the landscape more so than prey species.

CONCLUSION

Goshawks consume a wide variety of prey across their range. In the Southwest, goshawks consume a greater percentage of mammalian prey compared to avian prey. This preference for mammals is also evident in diet studies conducted in Canada and Alaska. However, in the Pacific Northwest and the northeastern US, goshawk diet studies report greater percentages of avian prey in goshawk diet compared to mammals (Tables 2–5).

Although this review focused mainly on goshawk prey and prey habitats in the Southwest, diets of goshawk in the western US are highly similar (Table 7) with many of the same prey species or their ecological equivalents present in diets throughout this region. Cottontails, golden-mantled ground squirrel, chipmunks, Steller's Jay, Northern Flicker, and American Robin are common prey throughout the western US, and in other regions where they occur. In California and Oregon, the ponderosa pine-dependent Abert squirrel of the Southwest is replaced by the mixed-conifer dwelling Douglas squirrel and northern flying squirrel (*Glaucomys sabrinus*).

Although the forest types used by these species are different, the general requirements are similar (mature forest with relatively high canopy closure, groups of closely spaced trees, and hypogeous fungi) suggesting that successful habitat management approaches might be similar for these regions.

Goshawk diet has been reported from >30 studies across their range but is relatively limited in the Southwest. Southwest diet studies are limited to two studies on the Kaibab Plateau in Arizona (Boal and Mannan 1994, Reynolds et al. 1994) and one study in the Jemez Mountains of New Mexico (Kennedy 1991). Results of these studies may not be applicable to other areas within the Southwest. Further, all three studies were conducted in the breeding season when prey populations were at their peak. Winter diet of goshawks is poorly known; however, this may be the period of greatest stress on goshawks in terms of food availability and weather conditions. Two studies suggest an extremely narrow diet breadth during winter (Stephens 2001, Drennan and Beier 2003). Further research on the wintering diet of goshawks, both in ponderosa pine forest and pinyon-juniper woodlands, should be a priority. Ideally, this research should be directed at the relationship of winter prey availability and goshawk fitness.

Basic natural history information on many of the primary prey species of goshawks in the Southwest is lacking, especially for rock squirrels, chipmunks, and cottontails. This review identifies many of the gaps in knowledge on these prey species. In addition, comparisons between prey studies and goshawk studies are often difficult because different variables were measured or different scales of habitat were evaluated. For example, prey species habitat might be described only for a small area such as a nest site, whereas, goshawk habitat studies are generally focused on larger areas that include the nest area and in some cases, winter habitat and foraging habitat. Future studies on goshawk foraging and prey ecology should carefully select habitat variables for measurement and consider the appropriate scale to allow for better comparisons between preferences of predator and prey.

The wide range of habitats used by the goshawks' primary prey species in the Southwest reflects the diversity of habitats used by goshawks. Because goshawk prey species occur in a wide range of habitats, forest managers should consider maintaining habitat components essential for goshawk nesting and foraging while maintaining habitat elements of preferred prey in areas that may not meet the criteria of documented habitat characteristics for goshawks. This approach suggests managing for a mosaic of habitat types across the landscape that provide habitat that meets the requirements of goshawk prey species and goshawks. The practice of managing landscapes in a more holistic manner, considering areas beyond the traditionally recognized limits of a species, will benefit not only goshawks but their prey species as well.

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APPENDIX 1. List of species observed in goshawk diets in western North America. Based on Schnell 1958, Bloom et al. 1986, Kennedy 1991, Boal and Mannan 1994, Bull and Hohmann 1994, and Reynolds et al. 1994.

Mammals
- Black-tailed jackrabbit (*Lepus californicus*)
- White-tailed jackrabbit (*Lepus. townsendii*)
- Snowshoe hare (*Lepus americanus*)
- Cottontail (*Sylvilagus* spp.)
- Golden-mantled ground squirrel (*Spermophilus lateralis*)
- Belding's ground squirrel (*Spermophilu beldingi*)
- California ground squirrel (*Spermophilubeecheyi*)
- Rock squirrel (*Spermophilus variegatus*)
- Douglas' squirrel (*Tamiasciurus douglasii*)
- Red squirrel (*Tamiasciurus hudsonicus*)
- Northern flying squirrel (*Glaucomys sabrinus*)
- Western gray squirrel (*Sciurus griseus*)
- Abert squirrel (*Sciurus* aberti)
- Cliff chipmunk (*Eutamias dorsalis*)
- Uinta chipmunk (*Eutamias umbrinus*)
- Yellow pine chipmunk (*Eutamias amoenus*)
- Broad-footed mole (*Scapanus latimus*)
- Woodrat (*Neotoma* spp.)
- Weasel (*Mustela* spp.)
- Unidentified microtine
- Cat (*Felis* spp.)

Birds
- Mallard (*Anas platyrhynchos*)
- Gadwall (*Anas strepera*)
- Cooper's Hawk (*Accipiter cooperii*)
- Northern Goshawk (*Accipiter gentilis*)
- American Kestrel (*Falco sparverius*)
- Prairie Falcon (*Falco mexicanus*)
- Blue Grouse (*Dendrogapus obscurus*)
- Ruffed Grouse (*Bonasa umbellus*)
- Mountain Quail (*Oreortyx pictus*)
- Band-tailed Pigeon (*Columba fasciata*)
- Rock Pigeon (*Columba livia*)
- Mourning Dove (*Zenaida macroura*)

Birds (continued)
- Long-eared Owl (*Asio otus*)
- Spotted Owl (*Strix occidentalis*)
- Western Screech-owl (*Otus kennicottii*)
- Northern Pygmy Owl (*Glaucidium gnoma*)
- Belted Kingfisher (*Ceryle alcyon*)
- Northern Flicker (*Colaptes auratus*)
- White-headed Woodpecker (*Picoides albolarvatus*)
- Red-breasted Sapsucker (*Sphyrapicus ruber*)
- Williamson's Sapsucker (*Sphyrapicus thyroideus*)
- Red-naped Sapsucker (*Sphyrapicus nuchalis*)
- Hairy Woodpecker (*Picoides villosus*)
- Nuttall's Woodpecker (*Picoides nuttallii*)
- Pileated Woodpecker (*Dryocopus pileatus*)
- Western Scrub Jay (*Aphelocoma coerulescens*)
- Gray Jay (*Aphelocoma ultramarina*)
- Steller's Jay (*Cyanocitta stelleri*)
- Clark's Nutcracker (*Nucifraga columbiana*)
- Common Raven (*Corvus corax*)
- American Crow (*Corvus brachyrhnchos*)
- Pygmy Nuthatch (*Sitta pygmaea*)
- Western Bluebird (*Sialia mexicana*)
- Mountain Bluebird (*Sialia currucoides*)
- Hermit Thrush (*Catharus guttatus*)
- American Robin (*Turdus migratorius*)
- European Starling (*Sternus vulgaris*)
- Yellow-rumped Warbler (*Dendroica coronata*)
- Black-headed Grosbeak (*Pheucticus melanocephalus*)
- Eastern Towhee (*Pipilo erythrophthalmus*)
- Dark-eyed Junco (*Junco hyemalis*)
- Western Meadowlark (*Sturnella neglecta*)
- Western Tanager (*Piranga ludoviciana*)
- Unidentified finch (*Carpodacus* spp.)
- Evening Grosbeak (*Coccothraustes vespertinus*)