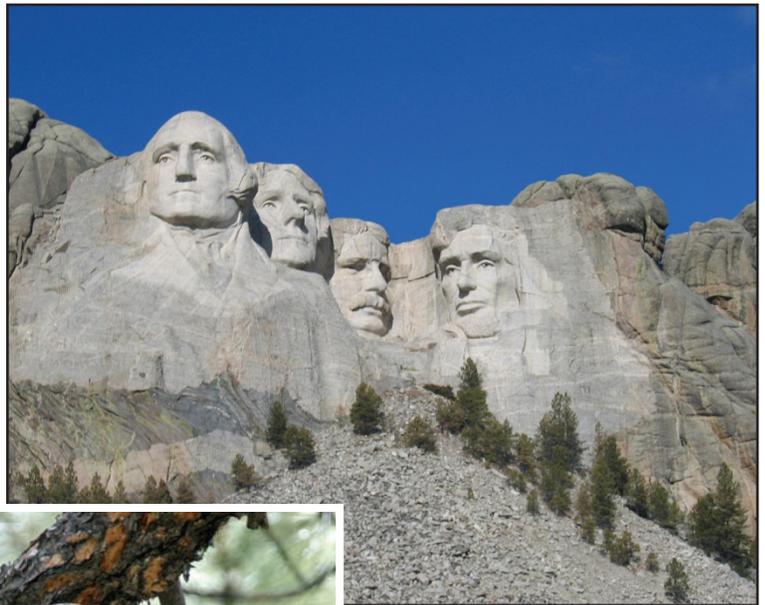
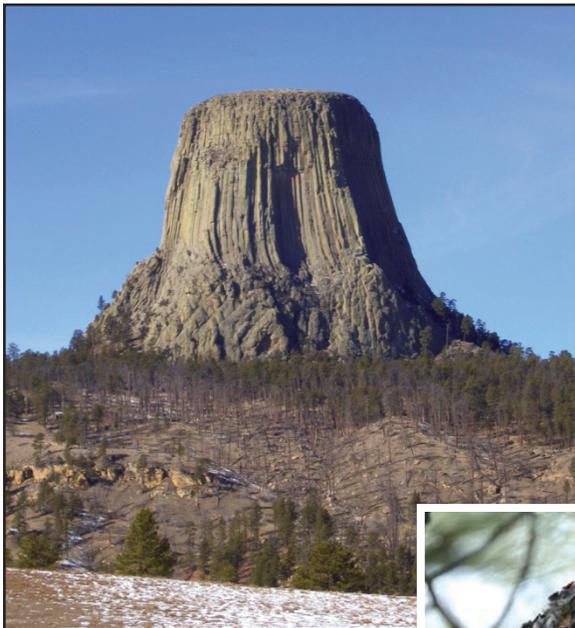


Northern Goshawk and Its Prey in the Black Hills: Habitat Assessment

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Abstract

The northern goshawk is classified as a Sensitive Species in all USDA Forest Service regions, including on the Black Hills National Forest in western South Dakota and northeastern Wyoming. An assessment was conducted of the quality of northern goshawk nesting and foraging habitat, along with the habitat quality of 22 of the goshawk's prey species. A Delphi (expert panel) evaluation of goshawk and prey habitat in 3,414 watersheds averaging 449 acres (182 ha) in size was completed by wildlife biologists from the Black Hills National Forest. The quality of goshawk nesting and foraging habitat and of prey group habitats was reported individually, then combined for each watershed. The optimum goshawk and prey habitat, totaling 67 watersheds or 34,427 acres (13,932 ha), was distributed throughout the nearly 1.5 million-acre (about 607,000-ha) Black Hills National Forest. Panel members found that the Bear Lodge Mountains, located in northeastern Wyoming, proportionally had the most optimum, high-, and medium-rated habitat. Wildfire, bark beetles, urban encroachment, and timber harvest can negatively affect northern goshawks and their prey's habitat. However, increasing the amount and presence of quaking aspen forests within the Black Hills will most likely improve the habitat of the goshawk by improving the habitat for many of its prey. Using previously articulated conditions as a template in the Forest Vegetation Simulator, we designed an example 100-year silvicultural system to create and maintain forest conditions for the northern goshawk and its prey on the Black Hills Experimental Forest.

Keywords: northern goshawk, *Accipiter gentilis atricapillus*, silviculture, forest structure, bark beetles, ponderosa pine, forest management.

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Introduction

The years following World War II saw a dramatic increase in the need for lumber, and timber production became the dominant use on many national forest lands. In response to concerns of unequal emphasis on timber production, Congress passed the Multiple-Use Sustained-Yield Act of 1960 (MUSYA; P.L. 86-517), which authorized and directed that national forests be managed under principles of multiple use and to produce a sustained yield of products and services. However, commercial timber harvest continued to dominate Forest Service management; and in the Pacific Northwest, clearcutting was the harvest method of choice, often in old-growth forests, to the dismay of many environmental organizations (Wellock 2010). Additionally, the National Environmental Policy Act of 1969 required interdisciplinary teams to develop environmental impact statements (EISs) for federal forest planning, and the Endangered Species Act of 1973 (ESA; P.L. 91-135, 83 Stat. 275) brought the U.S. Fish and Wildlife Service (USFWS, a regulatory agency) into the discussion on how to manage public lands to conserve habitat for rare species and ecological diversity (Peck 2000). Nevertheless, not until passage of the National Forest Management Act (NFMA; P.L. 94-588) of 1976 was wildlife to be integrated into the management of national forest lands. Prior to the Act, big game, such as deer and elk (*Cervidae* spp.), and game birds, such as grouse and turkeys (*Galliformes* spp.) were often the only wildlife species considered in forest management, and good timber management was thought to represent good wildlife management (Wellock 2010).

The northern spotted owl (*Strix occidentalis caurina*) was listed as threatened by the USFWS in 1990, and the loss of old-growth habitat was given as the primary reason. An Interagency Scientific Committee was formed to address the conservation of the owl and presented its recommendations in 1990 (Thomas and others 1990). The committee recommended that large tracts of old-growth forest be set aside for the owl in the Pacific Northwest. When implemented, the recommendations severely reduced the amount of timber being harvested and set a standard, if not a process, that could be used to address similar wildlife issues on National Forest System lands. In northern Arizona, Crocker-Bedford (1990) suggested that timber harvesting (cutting large trees) was causing declines in northern goshawk (*Accipiter gentilis atricapillus*; hereafter referred to as goshawk) populations similar to the effect timber harvesting was having on the northern spotted owl in the Northwest (fig. 1). Using this information,



Figure 1—The secretive northern goshawk lives in northern-latitude forests around the world.

environmental organizations sought more extensive protection of goshawk habitat in Arizona and New Mexico, as the viability of the species could be threatened, which would violate NFMA (Kennedy 2003).

In response to this perceived violation, the regional forester of the Forest Service Southwestern Region (Region 3, primarily Arizona and New Mexico) was asked in February 1990 to suspend all timber harvesting in goshawk territories until long-term survival of the species was assured (Peck 2000). That summer, the regional forester organized a scientific committee, similar to the one formed in the Northwest for the northern spotted owl, to review goshawk management needs in Region 3. In fact, at the first meeting with the regional forester, a copy of the northern spotted owl conservation strategy was offered to the committee as a model and potential process (Graham, personal communication). In 1992, Reynolds and others published their management recommendations for the goshawk in the Southwest, which did not include forest reserves (unlike the spotted owl strategy), and which suggested that goshawks are forest generalists whose populations are regulated by prey availability. Environmental groups and opposing state agencies continued to affirm that the species was an old-growth obligate that deserved protection under ESA. A 1991 petition to the USFWS to list goshawks as threatened or endangered within the western United States was denied on taxonomic grounds (Peck 2000). Since then, there has been periodic court litigation associated with goshawk listing or forest management actions that may affect the species. However, no changes in listing status for goshawks have resulted from subsequent petitions or the numerous court actions (Kennedy 2003).

The U.S. Forest Service (USFS), in cooperation with each state as directed by NFMA, identifies sensitive species that may be significantly affected by national forest land and resource management. The purpose of classifying a species as “sensitive” is to provide special management attention and emphasis to help ensure the species’ viability on national forests and grasslands, as well as to preclude contributing to trends toward endangerment and, ultimately, the need for listing under the ESA. The goshawk is also regarded as a sensitive species in all Forest Service regions and a species of concern in all USFWS regions in the United States (Kennedy 2003). States also use such a designation, and both South Dakota and Wyoming list the goshawk as sensitive based on Natural Heritage Program rankings. This program indicated that breeding populations were rare in South Dakota, although abundant in some local locations. A non-breeding population was also defined as rare throughout its South Dakota range, meaning the goshawk was vulnerable to extinction (Kennedy 2003). As a result of these concerns and the concern that goshawk populations or habitat abundance could be decreasing within the Forest Service Rocky Mountain Region (Wyoming, South Dakota, Nebraska, Kansas, and Colorado), the goshawk was added to the region’s Sensitive Species list (Kennedy 2003). Management of forests containing listed species adds oversight by the USFWS involving biological assessments, consultation, and biological opinions (Goblea and others 1999).

Straddling the Wyoming and South Dakota border in the USFS Rocky Mountain Region (Region 2) are the ponderosa pine (*Pinus ponderosa*)-dominated Black Hills (fig. 2), formed by a regional uplift of the Earth’s surface millions of years ago. About two-thirds of this elliptically shaped domal structure lies in South Dakota and the other third, the Bear Lodge Mountains, is located in northeastern Wyoming (fig. 3).



Figure 2—Ponderosa pine forests dominate the Black Hills of western South Dakota and northeastern Wyoming.

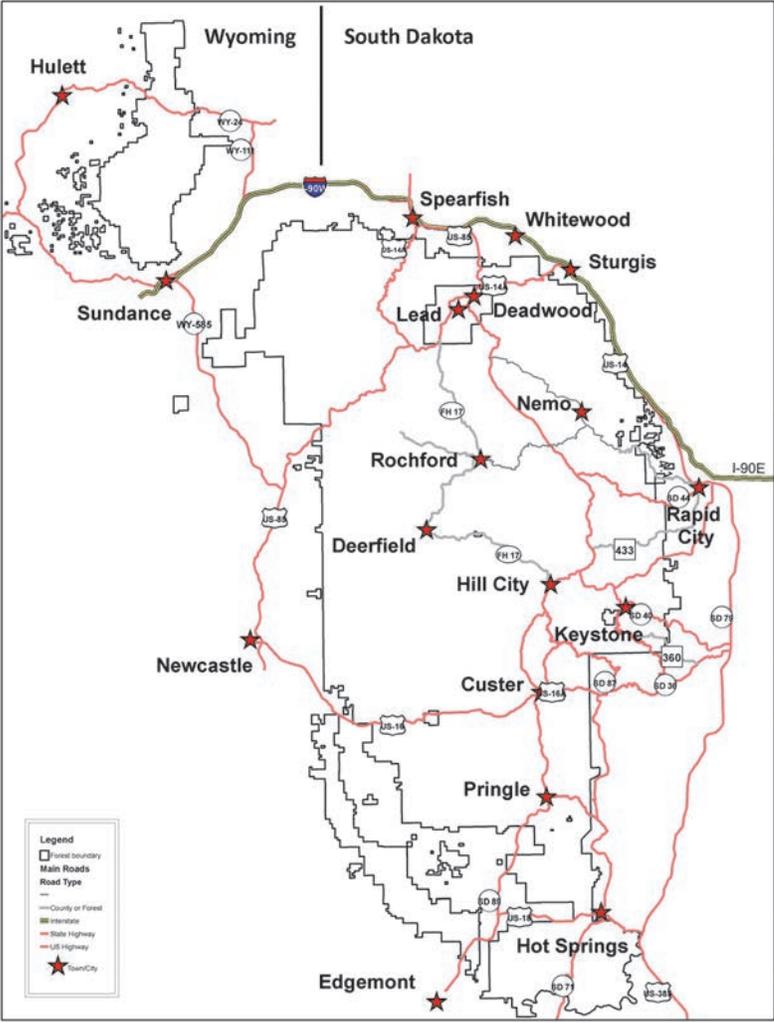


Figure 3—Although most of the Black Hills National Forest occurs in the Black Hills of South Dakota, a portion also occurs in the Bear Lodge Mountains of Wyoming.

The Black Hills have a total land base of about 6,000 mi² (15,540 km²)—125 mi from north to south and about 60 mi from east to west (200 by 96 km)—and goshawks have been known to occur throughout the area. White spruce (*Picea glauca*), quaking aspen (*Populus tremuloides*), and even limber pine (*Pinus flexilis*) and lodgepole pine (*Pinus contorta*) occur in the Black Hills. Nevertheless, nearly 1.5 million acres (about 607,000 ha) of ponderosa pine dominate the forests of the Black Hills (Boldt and Van Deusen 1974; Shepperd and Battaglia 2002) (fig. 4).

This amount of forest is remarkable in that the Black Hills have experienced more than a century of consumptive use (Boldt and Van Deusen 1974). During this period, virtually all of the area’s unreserved and operable forest acres have been cut over at least once, and many acres have received multiple partial cuts (fig. 5). Large tracts that were logged free of regulatory restraints prior to establishment of the Forest

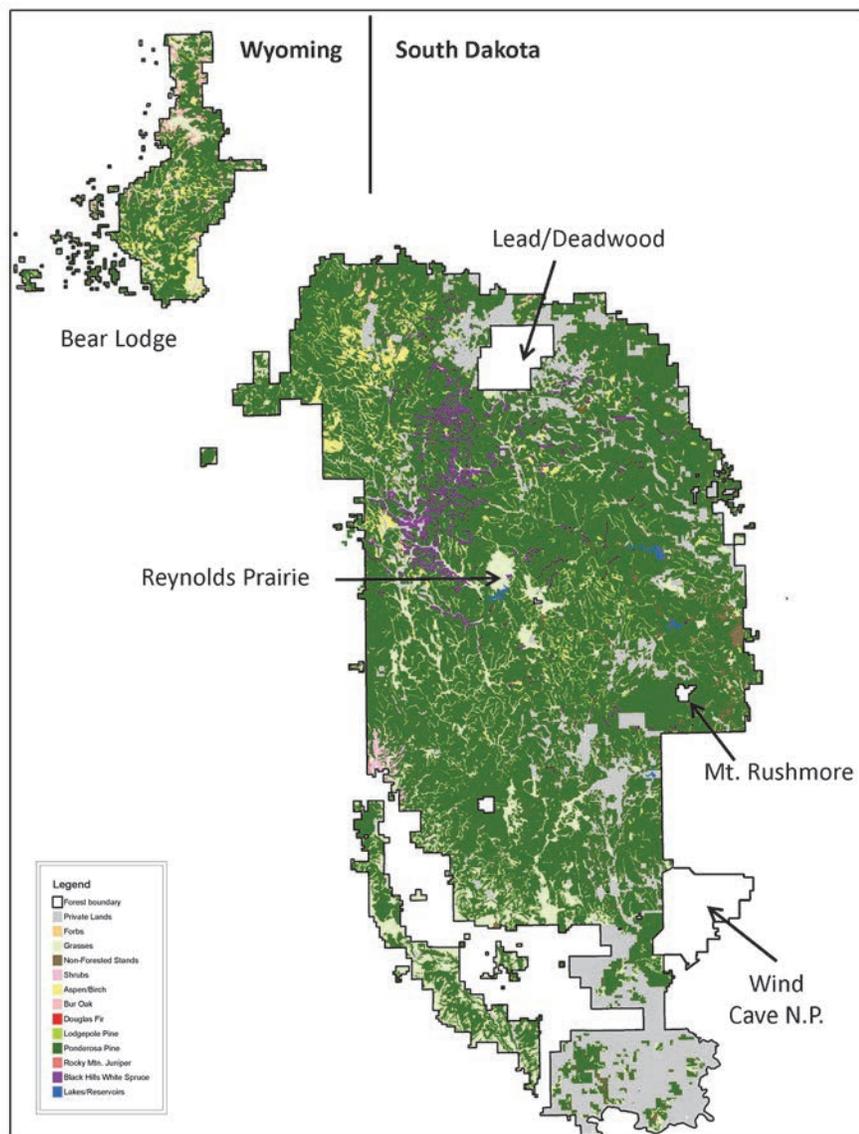


Figure 4—Ponderosa pine forests dominate the Black Hills vegetation, with a considerable amount of white spruce occurring in the north-central Black Hills and a variety of other conifers, hardwoods, meadows, and prairies comprising the remainder.

Reserve in 1897 were commercially clearcut and practically stripped of all trees large enough to yield a mine timber or a railroad tie. Persistent harvesting, coupled with the destructive impacts of wildfire, insects, diseases, and wind, have nearly eliminated the original old-growth stands on most of the commercial forest acres in the Black Hills and left only a few scattered old-growth remnants on the remaining acreage (Boldt and Van Deusen 1974; Walters and others 2013).

The unregulated harvest was controlled by the early 1900s, and for 50 years or so, a range of partial cutting systems was used to manage the forests, resulting in highly heterogeneous forests containing a wide variety of tree sizes arranged in a wide variety of mosaics (Harmon 1955) (fig. 6). However, wildfires burned and bark beetles and diseases killed trees during this period, adding complexity to the forests. In the 1960s, forest management changed to more intensive practices that tended to develop two and three age classes or canopies in many forests (Boldt and Van Deusen 1974) (fig. 7).



Figure 5—Timber harvesting commenced in the Black Hills in 1898 with Case One, the first commercial timber sale on federal property in the United States. The top photo shows Case 78 cutting in 1910, and the bottom photo shows tractor yarding near Moskee, Wyoming, in 1938.



Figure 6—A variety of forest structures remained after the Boodleman area was harvested in 1911.



Figure 7—By the mid- to late 1960s, most harvesting in the Black Hills was done using two-step shelterwoods.

Despite these massive changes over the last 100 years, most of the area is forested and, in many areas, densely covered with trees, which can lead to large wildfires. The last few years have also seen an epidemic (wide spread) of bark beetles that are killing large expanses of the ponderosa pine forests (fig. 8). A key feature of these forests is the intermediate shade tolerance of ponderosa pine, which allows regeneration under partial shade as well as full sunlight. Ponderosa pine seed is produced almost every year, with abundant crops every 2 to 5 years (Boldt and Van Deusen 1974). Frequent rain showers throughout the growing season, which lasts from early March to August, is the major climatic factor contributing to the prolific growth and establishment of ponderosa pine (fig. 9). In response to the natural disturbances and because of the ease of regeneration and prolific growth that occurs in the Black Hills since Case One in 1898, the area has had one of the most consistent commercial timber harvest programs in the United States (Clow 1998; Freeman 2015).



Figure 8—Since 2010, mountain pine beetles have been killing large expanses of ponderosa pine, especially in the central Black Hills.



Figure 9—Because of the spring and summer rains in the Black Hills and abundant seed crops, ponderosa pine readily regenerates and carpets the forest floor in most locales.

Regardless of the forest's condition, interest in goshawk occupancy in the area has increased and concerns that timber management activities might disturb nesting and cause nest abandonment have grown (Kennedy 2003). However, goshawks have continued to nest, reproduce, and forage in these forests. More than 200 nests were discovered over the last 20 years that are in territories distributed somewhat uniformly throughout the Black Hills (fig. 10). However, as a sensitive species and given the years of disturbance and harvesting occurring in the Black Hills, some uncertainty remains as to the status of the goshawk and its prey's habitat in the area (Klaver and

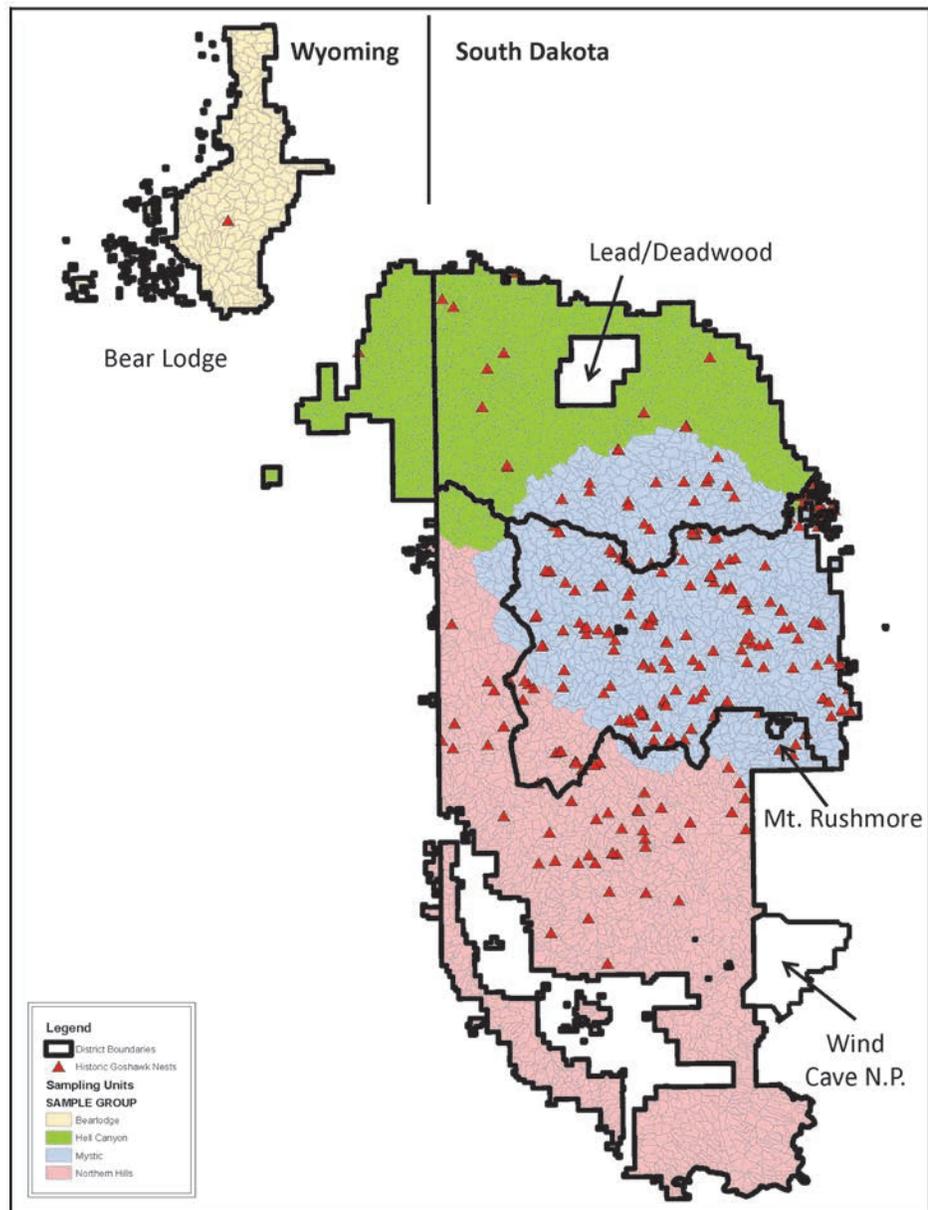


Figure 10—Locations of goshawk nests discovered between about 1980 and 2010 in the Black Hills.

others 2012). Although precise information on the goshawk and its prey is difficult to obtain owing to the species' elusiveness and the expense of conducting nest searches, the habitats of the goshawk and its prey in the Black Hills can be assessed using expert knowledge via a Delphi process. Such processes are not as rigorous as scientifically sampling goshawks, their prey, and the habitats they each use but can be informative and provide relevant information for managers to make informed decisions regarding a sensitive species. Examples of major resource assessments using such panels include Quigley and others (1996), Graham and others (1999, 2000), and Shaw (1999). As such, there is a considerable legacy and background on conducting such assessments that provide a template for assessing the habitat of the goshawk and its prey in the Black Hills.

Goshawks

General Taxonomy and Distribution

The goshawk is a wide-ranging species that occupies most northern latitude forests circling the globe. This Holarctic distribution includes most boreal and temperate forests of Eurasia and North America (Squires and Reynolds 1997). The Eurasian goshawk (*A. g. gentilis*) consists of up to six subspecies while three subspecies have been variously accepted within the North American group (*A. g. atricapillus*). The northern goshawk (continental type, *A. g. atricapillus*) is the most widespread of the three North American subspecies, breeding from north-central Alaska to Nova Scotia, Canada, and south into eastern mixed deciduous and western montane forests of the United States and northern Mexico (Brown and Amadon 1968; Squires and Reynolds 1997). Although it was previously described (Tavener 1940), the USFWS only recently recognized the Queen Charlotte goshawk (*A. g. laingi*) which occupies the coastal regions of southeast Alaska and British Columbia, Canada (American Ornithologists' Union 1983; USFWS 2007, 2009). Goshawks inhabiting the Sky Islands (i.e., isolated forested plateau landforms surrounded by deserts) of southeast Arizona and northern Mexico were described as a third subspecies named Apache goshawk (*A. g. apache*) (DeBano and others 1995; Friedmann 1950; van Rossem 1930). Although the Apache goshawk is not formally recognized by the American Ornithologist's Union or the USFWS, others consider them well differentiated and worthy of recognition (Snyder and Snyder 1991; Whaley and White 1994).

Goshawks winter locally throughout their breeding range and as far south as southern California, northern Mexico, Texas, and the northern portions of the Gulf States and Florida (Johnsgard 1990). They typically winter close to their breeding territories in order to continue defending them. At times, however, they make short-distance movements to lower elevations in the winter to hunt rabbits, hares (both are lagomorphs), ground squirrels (*Spermophilus*), and birds. Goshawks inhabiting the northern latitudes make southward irruptions (movements) on 10-year cycles when prey (specifically, grouse and snowshoe hare [*Lepus americanus*]) populations crash.

Goshawk Habitats

Across their range, goshawks use a wide variety of forested habitats, including mixed hardwood and eastern hemlock (*Tsuga canadensis*) forests in the eastern United States, ponderosa and lodgepole pine-dominated and mixed-conifer forests of the Rocky Mountains and Pacific Northwest, ponderosa pine forests in the southwestern United States and Black Hills of northeastern Wyoming and western South Dakota, and fragmented stands of quaking aspen within open sagebrush (*Artemisia* spp.) steppe habitats of the Great Basin (Bartelt 1977; Bechard and others 2006; DeStefano and others 2006; Erickson 1987; Graham and others 1999; Hayward and Escano 1989; Patla 1997; Reynolds and others 1992; Speiser and Bosakowski 1987; Younk and Bechard 1994). As a forest-dwelling predator of small mammals and birds, goshawks build nests in well-defined forest structures that are surrounded by forests, providing protection and foraging opportunities for young goshawks (post-fledging family areas) (Reynolds and others 1982, 1984). Home range and foraging areas are located in a forest setting that will provide sufficient prey to support the typical goshawk family of one to four nestlings during the spring and summer months (Kennedy 2003; Reynolds and others 1992).

Nest areas

Nest areas include the nest tree and its immediate surroundings. They are often used for more than 1 year, and many nest areas are used intermittently for decades (Crocker-Bedford 1990; Reynolds 1983; Steenhof 1987). Nest areas are occupied by breeding goshawks from early March until late September and are the focus of all movements and activities associated with nesting (Reynolds 1983). Nest areas can include one or more forest stands and several alternative nest structures and can occur over a wide range of landforms (Palmer 1988; Reynolds and others 1992). Most nest areas are either on slopes with northerly exposures (northwest to northeast) or in drainages or canyon bottoms protected by such slopes. Goshawks nest in both deciduous and coniferous trees, including in Fremont cottonwood (*Populus fremontii*), quaking aspen, ponderosa pine, lodgepole pine, white spruce, Douglas-fir (*Pseudotsuga menziesii*), and subalpine fir (*Abies lasiocarpa*). Goshawks are thought to favor nest sites closely associated with forest openings such as meadows, forest clearings, logging trails, and dirt roads, but this is not always the case (Erickson 1987; Gromme 1935; Hall 1984; Hayward and Escano 1989; Reynolds and others 1982). Similarly, water proximity is a feature associated with many goshawk nests—nests in Colorado quaking aspen were often near running water and many South Dakota nests were within 0.5 mi (0.8 km) of water. Like openings, however, nearby water is not always necessary (Bartelt 1977; Bond 1942; Hargis and others 1994; Reynolds and others 1982; Squires and Reynolds 1997).

Nest areas ranging in size from 20 to 25 acres (8 to 10 ha) vary in shape and are determined by nesting goshawk behavior. Nest areas usually contain relatively high tree canopy cover and a high density of large trees (Bartelt 1977; Crocker-Bedford and Chaney 1988; Daw and others 1998; Hall 1984; Hayward and Escano 1989; Kennedy 1988, 2003; McGowan 1975; Moore and Henny 1983; Reynolds 1982; Reynolds and others 1982; Saunders 1982; Speiser and Bosakowski 1987). Although goshawks are considered habitat generalists at large spatial scales and use a wide variety of forest

types, they tend to nest in a relatively narrow range of forest structural conditions (Erickson 1987; Hargis and others 1994; Palmer 1988; Reynolds and others 1982; Saunders 1982; Squires and Reynolds 1997; Squires and Ruggiero 1996). Goshawks appear to choose nest trees based on size and structure rather than species. In Wyoming and California, goshawks chose the larger trees in a forest to nest, however, in some eastern forests, nests were not always built in the largest tree occurring in the nest area (Saunders 1982; Speiser and Bosakowski 1989; Squires and Ruggiero 1996).

Although nest area canopy closure is often cited as an important habitat feature, the nest tree itself may be dead and offer little canopy cover (Dick and Plumpton 1998; Squires and Reynolds 1997). Goshawks have been known to nest in dead eastern white pines (*Pinus strobus*), quaking aspens, and lodgepole pines (Kennedy 2003; Martell and Dick 1996; Porter and Wilcox 1941). Nesting in dead trees may often reflect the hawk's fidelity to a nest that persists after the tree dies. The dense vegetation and sheltered slopes provide relatively mild and stable microenvironments, as well as protection from goshawk predators such as other goshawks, great-horned owls (*Bubo virginianus*), red-tailed hawks (*Buteo jamaicensis*), coyotes (*Canis latrans*), bobcats (*Lynx rufus*), raccoons (*Procyon lotor*), and humans (Moore and Henny 1983; Reynolds and others 1982).

Goshawks typically construct their nests in the lower one-third of the crown within the nest tree (fig. 11). Nest height is a reflection of tree height but nests are typically located 30 to 40 ft (9 to 12 m) above ground level. Goshawks build nests on one or two branches near the tree bole (occasionally on a limb 3.2 to 6.6 ft [1 to 2 m] from the bole) or in forks of the main stem (Bull and Hohmann 1994; Moore



Figure 11—Goshawk nests are bulky structures of branches, lined with leaves, and placed in the lower portion of the tree canopy.

and Henny 1983; Reynolds and others 1982; Speiser and Bosakowski 1987). They are normally bulky structures of twigs and branches reaching up to 3 ft (90 cm) in height with outside diameters ranging from 1.5 to 4.0 ft (45 to 122 cm) and inside diameters of 0.75 to 1.75 ft (23 to 53 cm). Goshawk nests often contain shallow cups (e.g., ≤ 9 inches [23 cm] deep) and are usually lined with such items as fresh tree boughs, dry or fresh leaves, grasses, mosses, feathers, clay, and bark chips (Allen 1978; Bull and Hohmann 1994; McGowan 1975; Peck and James 1983).

Goshawk breeding territories typically include one or more alternate nests, any one of which may be used over several years. Nests are usually located within 0.25 miles (0.4 km) of each other; however they can be as close as 150 ft (46 m) or distributed over larger areas (Reynolds and Joy 1998; Reynolds and others 1994, 2005; Reynolds and Wight 1978; Speiser and Bosakowski 1987; Woodbridge and Detrich 1994). As a group, alternate nests in a territory are thought to be surrounded by a post-fledgling family area, an area preferentially used by the adult female for foraging during the late nesting period and by fledged young during the 1 to 2 months they are dependent on the adults for food (Reynolds and others 1992; Wiens and others 2006).

Post-fledgling family area

In radiotelemetry studies of the post-fledgling behavior of goshawks, Kennedy (1989) and Kennedy and others (1994) described an area used by the adult female and young from the time the young leave the nest until they no longer depend on the adults for food. All the activities of young fledglings occurred in this area, centered near the nests, as the fledglings were dependent on the adults. However, as their flight skills improved, the fledglings moved over ever-larger distances from the nest (Kennedy and others 1994; Kennedy and Ward 2003). Reynolds and others (1992) defined this as the post-fledgling family area (PFA) and suggested that, for conserving this important part of a breeding home range through management, the desired forest structure is intermediate between the higher tree density of the nest area and the more open structure of prey habitats in foraging areas (Daw and DeStefano 2001; Reynolds and others 1992, 2006). PFAs vary in size from 200 to 600 acres (81 to 243 ha) and may correspond to the territory (a defended area) of a pair of goshawks. Similar to the other spatial components of a goshawk breeding territory, the size and shape of PFAs often depend on local conditions. PFAs provide the young goshawks with protection from predators and sufficient prey for the adult female and for the fledglings to develop their hunting skills in the weeks before they disperse (Finn and others 2002; Kennedy 1989, 2003; Reynolds and others 1992).

Reynolds and others (1992), following Kennedy (1989), developed the PFA concept, and several other researchers provided further evidence of an area around goshawk nests that reflects PFA conditions: McGrath and others (2003) in eastern Oregon and Washington; Johansson and others (1994) in Utah; Daw and DeStefano (2001) in Oregon; Penteriani and others (2001) in France; and Kennedy and others (1994) in New Mexico. (Note: some authors describe forest conditions in the “post-fledgling family area” while others describe conditions in a much smaller “post-fledgling area” that is used by the fledglings alone.) The size of PFAs likely varied depending on local environments, availability of prey, predation risk and whether the adult female’s core area was included (Kennedy 2003).

Foraging area

Adult male goshawks consume about 3.7 ounces (103.5 g) of birds or 4.3 ounces (121.1 g) of mammals each day (Fischer and Murphy 1986). Using these estimates, a family of two adults and two fledglings would likely consume between 125 and 150 pounds (57 to 68 kg) of birds and mammals during a typical 6-month breeding season. As with most raptors, males provide most of the food while females stay close to the nests—first to incubate eggs, then to brood and protect the young, and lastly to help provide her young with food (fig. 12). Therefore, home range size and habitat used by foraging goshawks is largely determined by the movements and activities of hunting males as they capture most of the required amount of prey to support the family. Goshawks hunt a wide variety of prey species, mostly medium- to large-sized birds (e.g., woodpeckers [*Picidae* spp.], grouse, jays [*Corvidae* spp.]) and mammals (e.g., squirrels, rabbits) or the larger prey available to forest-dwelling hawks (Kennedy 2003; Reynolds and Meslow 1984; Reynolds and others 1992; Storer 1966) (fig. 13). Although the particular species represented in goshawk diets vary regionally, when prey are grouped into guilds (groups of animals with similar habitats, foods, and foraging behavior) there is surprisingly little variation across the North American goshawk range. For example, Steller’s jay (*Cyanocitta stellari*), blue grouse (*Dendragapus obscurus*), and golden-mantled ground squirrel (*Citellus lateralis*) are common in the diets of Rocky Mountain and southwestern U.S. goshawks, but in the eastern United States, these species are replaced by the blue jay (*Cyanocitta cristata*), ruffed grouse (*Bonasa umbellus*), and eastern gray squirrel (*Sciurus carolinensis*). In northern latitudes, goshawks eat snowshoe hares, which are replaced in more southern latitudes by black-tailed jackrabbits (*Lepus californicus*) and cottontail rabbits (*Sylvilagus* spp.).



Figure 12—Nestling goshawks are protected by the female, while the male does most of the hunting, unless prey populations are low, requiring both parents to hunt.

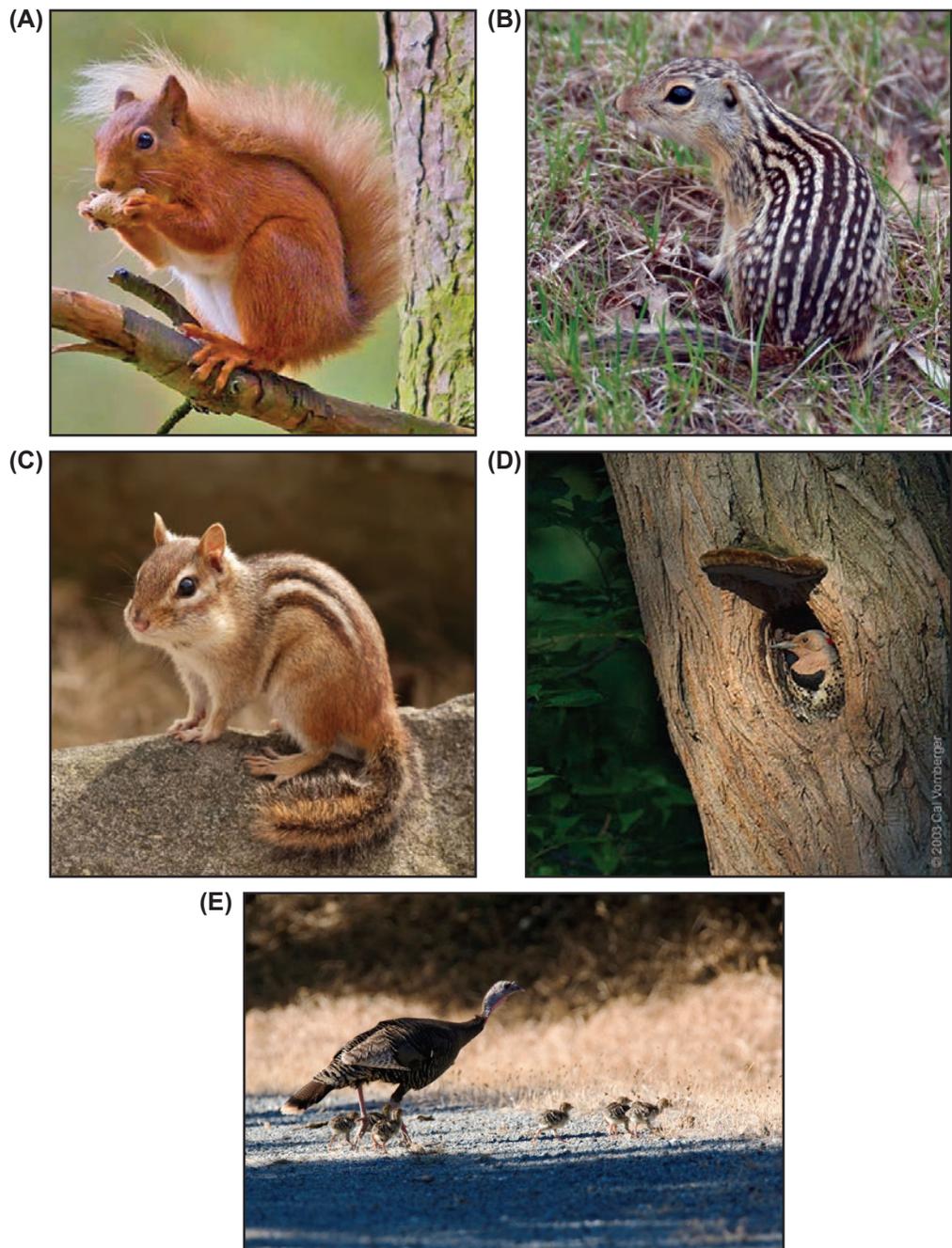


Figure 13—Goshawks prey on a variety of small mammals (e.g., (A) red squirrels; (B) ground squirrels; (C) chipmunks; and birds such as (D) woodpeckers, and (E) young turkeys.

The size of nesting goshawk home ranges has been estimated by several techniques, including plotting the foraging radius as the distances between goshawk nests in which grouse leg bands were found and the locations where the grouse were originally banded; plotting distances from nests based on sight records; and plotting with radiotelemetry (Austin 1993; Bright-Smith and Mannan 1994; Craighead and Craighead 1969; Eng and Gullion 1962; Hargis and others 1994; Iverson and others 1997; Reynolds 1983). Large prey such as rabbits and hares tend to have less dense

populations than smaller species, requiring goshawks to hunt over large areas in order to secure enough food for their family (Schoener 1983). Depending on habitat and estimation method, goshawk nesting home ranges in North America range from approximately 1,200 to 10,000 acres (approximately 500 to 4000 ha) (Austin 1993; Hargis and others 1994; Iverson and others 1996; Kennedy and others 1994). However, 5,000- to 7,000-acre (about 2000 to 2800-ha) home ranges are typical for most western forests (Eng and Gullion 1962; Kennedy and others 1994; Reynolds 1983; Reynolds and others 1992). This body size/home range size relationship is also noted with the sharp-shinned hawk (*Accipiter striatus*) as it feeds on small birds and has nesting home ranges of about 1,200 acres (485 ha), and with the Cooper's hawk (*Accipiter cooperii*), which feeds on birds and mammals of intermediate size and has home ranges of about 4,000 acres (1620 ha) (Craighead and Craighead 1969; Meyer 1987; Platt 1973; Reynolds 1983).

Telemetry studies attempt to determine what habitats goshawks use for foraging, but the species' elusive behavior and rapid movements through its large home ranges makes it difficult to identify actual habitat use (if they are really hunting) (Reynolds and others 2006a). Goshawks hunt in forest types containing a broad range of forest structures (Austin 1993; Beier and Drennan 1997; Bright-Smith and Mannan 1994; Hargis and others 1994; Kenward 1982; Widén 1989). Their hunting success depends not only on prey density but also on habitat features that allow them to hunt (Widén 1997). Goshawks are short-perch-short-flight predators (Widén 1997). That is, they search the immediate surroundings for prey in the lower vegetation column from tree perches (Reynolds and others 1984, 1992) for short periods (seconds) and then make short flights to new perches (Kenward 1982; Widén 1985). These foraging tactics may be a major factor influencing their preference for hunting in mature forests that contain mature-to-old large trees, high canopy base heights, and relatively open understories. These conditions provide abundant prey and perches, yet they are open enough to allow the goshawk to detect their prey, and to maneuver during attacks (Widén 1997). Most studies suggest that goshawks primarily hunt in mature and old forests, but they also use a variety of other forest age classes, structures, and compositions (Reynolds and others 2006a). Goshawks have been known to hunt in forest openings, along forest edges, and as they cross openings between woodlands (Kenward 1982). For example, the edge of quaking aspen groves intermingled with sagebrush is a condition favored by hunting goshawks in Nevada (Younk and Bechard 1994). It is also important to note that while some habitats may be avoided by foraging goshawks, those habitats may be important for prey reproduction (Boal and others 2003; Reynolds and others 1991, 2006).

Non-breeding season habitat

Goshawk winter habitat use is not as well documented as breeding habitat but is likely to vary depending on prey availability. Prey availability is likely a key factor influencing whether goshawks overwinter within their nesting ranges or elsewhere (Squires and Reynolds 1997). For example, goshawk populations in Canadian boreal forests, where the primary prey is snowshoe hare and ruffed grouse, fluctuate as the populations of these prey vary on an approximately 10-year cycle (Doyal and Smith 1997; Mueller and others 1977). Following spring declines in hare and grouse

populations, fall and winter goshawk populations also decrease. As these boreal forest goshawk populations decrease, goshawk numbers increase in southern Canada and the northern United States, suggesting that goshawks leave their northern territories to find better winter foraging to the south where hare and grouse populations do not cycle as strongly (Keith and Rusch 1988). During years when boreal grouse and hare numbers are high, fall-winter goshawk populations remain similar to summer populations, indicating goshawks winter within their breeding range.

Within the western United States, most radiotelemetry studies show that goshawks venture from their breeding ranges, but the regularity of such movements is unknown. In Wyoming, winter movements of four adult goshawks (two female and two male) were monitored with radiotelemetry. In all four cases, the goshawks moved south from their breeding territories 40 to 87 mi (65 to 140 km), and two were confirmed to spend their winters in southern locations and return to their breeding territories the following spring. One of the goshawks was confirmed killed, and another was not detected again until it returned to its breeding territory the following spring. Because these birds were followed for only 1 year, it is unknown as to whether their fall-winter movements south were normal migratory behavior or just seasonal wandering. As well, prey populations were not sampled, so causal effects are unknown.

Fifteen goshawks (5 males, 10 females) from the Uinta Mountains in Utah were radio-tracked during the winters of 1998-1999 and 1999-2000, but only three goshawks were followed both years. Two males and nine females moved from their nesting area an average of 34 mi (55 km) during the winter and the three goshawks monitored for two winters traveled an average of 35 mi (57 km) from their nesting ranges during the winter (Stephens 2001). In two other Utah studies, goshawks were tracked with satellite telemetry (Sonsthagen and others 2006a; Underwood and others 2006). Distance moved differed among individuals—where some remained resident on their breeding territories, some were semi-migratory (within 60 mi [100 km] from breeding site), and some were migratory (>60 mi [100 km] from breeding site). Goshawks that moved to lower elevation pinyon-juniper (*Pinus edulis-Juniperus* spp.) forests increased their home range size, presumably because prey abundance and availability was lower in these habitats (Sonsthagen and others 2006b). Pinyon-juniper habitat used by these hawks had high herbaceous cover and moderate shrub cover often intermixed with sagebrush- (*Artemisia* spp.) dominated openings. In addition, steep, forested ravines were frequently used by wintering goshawks in otherwise nonforested areas (Underwood and others 2006). In another study, Reynolds and others (1994) radio-tagged adult and juvenile goshawks in northern Arizona and tracked them during fall and early winter. All but one of the adults stayed on their summer ranges. However, one adult female was relocated in pinyon-juniper woodlands approximately 10 mi (16 km) from her nest. Most fledglings remained near their nest sites. Transmitters from two fledglings were recovered in pinyon-juniper woodlands, apparently shed after dispersing.

These studies showed that some goshawks move long distances to winter in areas away from their breeding sites, while most wintering goshawks apparently remain within or very close to their breeding territories. Why some goshawks depart their breeding ranges and others do not may have to do with territoriality combined

with prey availability. Goshawks that remain resident may aggressively push intruding goshawks out of their territory, especially when prey becomes limited. As winter prey availability declines below some threshold, one strategy would be to move to ever-lower elevations in search of food. Another theory suggests that goshawks that depart their breeding ranges are exhibiting winter site fidelity, returning to areas where they survived their first winter (Harmata and Stahlecker 1993).

Goshawks in the Black Hills

No mention of goshawks was made in George Bird Grinnell's report to William Ludlow in the "Reconnaissance of the Black Hills of Dakota, 1874" (Grinnell 1875). Their absence from the report, however, is not surprising considering that goshawks are an elusive species that are difficult to observe in their forested habitats. Over and Thomas (1921) noted the "goshawk was probably only a winter visitor in South Dakota," but also noted that "it probably nests sometimes in our state." On 4 August 1939, a fledgling female goshawk was collected in Wind Cave National Park (Pettingill and Whitney 1965). ORNIS (<http://www.ornisnet.org>) and an online database of bird specimens in museum collections showed an adult female collected in November 1906 by H. Behrens near Hermosa, South Dakota. Pettingill and Whitney (1965) also collected goshawks in the Black Hills during fall and winter, furthering evidence that goshawks winter in the Black Hills. Because recently observed (since 1973) wintering goshawks in the Black Hills were seen near known goshawk nest sites, it is possible that some of the historical wintering birds also nested in the area (Bakker 2005). (Note: We discovered an apparent error in Pettingill and Whitney [1965] as they reported a female collected on 27 November 1895 southeast of Hill City, South Dakota (Female No. 8840, University of Minnesota), whereas photos provided by the University of Minnesota's Bell Museum of two collection tags on this goshawk indicated the bird was collected on either 27 November or 27 February 1945.)

More recently, Wild (1973) reported that members of the Wilson Society found a nesting pair of goshawks in June 1965 near Sylvan Lake in the central Hills. In 1972, Wild (1973) observed three nesting pairs of goshawks in the central hills (Lawrence County), and during 1973 and 1974, USFS personnel reported several additional nests (Bartelt 1977). During 1975 and 1976, Bartelt (1977) visited some of these same nests and discovered an additional seven nests, and he described the habitat conditions at these nest sites. During 1980 and 1981, Erickson (1987) studied the habitat at some of the same nests as Bartelt (1977) as well as at new nests. Combined, these reports totaled 45 known nests in the Black Hills. Bartelt (1977) noted in his summary that "goshawk nests had become unusually abundant in the forest since 1972." Whether this "abundance" was observed because of recent goshawk population increases or because increased human activity (birding/timber sales/active nest searches, road access) facilitated increased detection is unknown. During a seven-year period (2003 to 2009), the South Dakota Game, Fish, and Parks commissioned a systematic survey for breeding goshawks, which resulted in the monitoring of 53 nests, of which 35, or 66 percent, fledged young (Knowles and Knowles 2009).

Characteristics of Occupied Habitats in the Black Hills

Goshawk nesting

Surveys conducted by the Black Hills National Forest show that goshawk nests occur at all elevations but are most common between 4,000 and 6,000 ft (1200 to 1800 m) (Burns, personal communication). Similarly, Erikson (1987) visited 45 nest sites that ranged in elevations between 5,085 and 6,299 ft (1550 to 1920 m). Both Erikson (1987) and surveys by the Black Hills National Forest show that nests were typically situated on gentle terrain, and Erikson (1987) measured slope angles ranging from 2.5 to 58.0 percent and averaging 12.6 percent (fig. 14). Similarly, Bartelt (1977) reported slope angles at nests ranging from flat to 10 percent. Nests are frequently on benches or bowl-shaped landforms in the upper one-third of mountain valleys. Nests occur on all slope aspects but are most common on northeastern and eastern facing slopes. Of the nests Erikson (1987) visited, 43 percent were on north- to northwest-facing slopes, 36 percent were on west-facing slopes, and 21 percent were on south- to southwest-facing slopes. Likewise, all of the nests Bartelt (1977) visited were on north-facing slopes and located near the top of a ridge. Such sites offer protection from winds and solar insolation, which appear to be an important factor in nest site selection (Reynolds and others 1982). Surveys by the Black Hills National Forest and Erikson



Figure 14—In the Black Hills, goshawk nests are frequently located on gentle slopes, as pictured.

(1987) indicated that goshawk nests in the Black Hills were often associated with a forest opening. Bartelt (1977) described such openings as being 0.12 to 0.50 acres (0.05 to 0.20 ha) in size and were within 30 to 50 ft (10 to 15 m) of a nest. Erikson (1987) reported that 21 percent of the nests he visited to be near meadows and 79 percent to be within 240 ft (73 m) of old logging roads. Of the 21 nests Bartelt (1977) studied, half were in the northern Black Hills where ponderosa pine is intermingled with quaking aspen and white spruce.

Goshawk nests in the Black Hills were most often in ponderosa pine trees. Knowles and Knowles (2009) located 21 nest trees, all but one was ponderosa pine and one was a white spruce with a broken top. One nest was discovered in a quaking aspen tree that was interspersed with ponderosa pine trees. Of the approximately 240 nests discovered on the Forest, nearly all occur in areas with trees exceeding 9.0 inches (22.8 cm) in diameter at breast height (DBH) and many were built in trees larger than 16.0 inches (40.6 cm) DBH (Bartelt 1977; Burns, personal communication; Knowles and Knowles 2009). Bartelt (1977) noted that most nests were placed in the lower portion of the tree canopy or in the bottom one-third of the canopy, with nest heights averaging 45 ft (13.8 m) above ground level.

Tree densities around nests ranged from 120 to 480 trees/acre (297 to 1186 trees/ha), and basal area often exceeded 125 ft²/acre (28.7 m²/ha). These tree densities result in canopy cover that is rarely less than 50 percent and usually greater than 60 percent (Bartelt 1977; Burns, personal communication; Knowles and Knowles 2009) (fig. 15). Not only does this canopy architecture occur around nests, but it



Figure 15—Canopy cover around goshawk nests in the Black Hills is rarely less than 50 percent.

typically extends upslope from the nest toward the ridge top (if a slope exists). Nest areas can have fairly open to moderately dense understories and often have small groups of young trees or saplings less than 9 inches (23 cm) DBH in close proximity. Bartelt (1977) described the densities in these small groups to be less than 400 trees/acre (162 trees/ha) of 40 ft (12 m) or shorter trees. Moreover, Erikson (1987) described nest sites as having uneven-aged, multilayered canopies with modest foliar height diversity. Snags, downed wood, and old stumps are key components of Black Hills nest areas (Bartelt 1977). For example, Knowles and Knowles (2009) found an average of 24 dead trees/acre (9.7 trees/ha) within 60 ft (18 m) of the 21 nest trees they visited. Erickson (1987) did not quantify the amount of decadence near the nests but said nest areas were characterized by abundant standing dead vegetation and much dead and down woody material. The effects of snags, logs, and woody debris on the “quality” of nest areas has not been reported but may simply reflect the decadence of the older forest sites preferred by goshawks for nesting.

Year-round habitat is of great importance. In winter, goshawks may remain within their breeding season home ranges, expand their home ranges to include additional habitats during the winter, or move to established, separate winter ranges. Whether goshawks in the Black Hills remain in or depart from their breeding territories is unknown, but they have been reported in winter months at lower elevations in the Black Hills. It is unknown whether these observations were of local goshawks or immigrants.

Goshawk prey

The species composition of prey in goshawk diets depends on the composition of the local bird and mammal populations and their relative abundances and availabilities to hunting goshawks (Reynolds and others 2006a). The mix of bird and mammal prey in the Black Hills is somewhat unique in that both eastern and western U.S. birds and mammals are represented (fig. 16). For example, Steller’s jays (*Cyanocitta stelleri*), golden-mantled ground squirrels (*Callospermophilus laterali*), and Williamson’s sapsuckers (*Sphyrapicus thyroideus*) are typical western U.S. prey items but are absent in the Black Hills fauna and absent in Black Hills goshawk diets. Instead, blue jays (*Cyanocitta cristata*) and red-headed woodpeckers (*Melanerpes erythrocephalus*), members of the local fauna, are common prey species in the Black Hills as well as elsewhere in the east where these species occur. Some prey species restricted to the western or eastern United States, but co-occur in the Black Hills, are the mountain cottontail (*Sylvilagus nuttallii*), eastern cottontail (*Sylvilagus floridanus*), Lewis’s woodpecker (*Melanerpes lewis*), and red-headed woodpecker (*Melanerpes erythrocephalus*). Prey occurring in both eastern and western U.S. forests and in the Black Hills includes the red squirrel (*Tamiasciurus hudsonicus*), ruffed grouse, northern flying squirrel (*Glaucomys sabrinus*), northern flicker (*Colaptes auratus*), hairy woodpecker (*Picoides villosus*), and American robin (*Turdus migratorius*). Black Hills goshawks prey on at least 33 different species of birds and mammals with 22 of those species considered potentially important. However, red squirrels, northern flickers (*Colaptes auratus*), ruffed grouse, gray jays (*Perisoreus canadensis*), young turkeys

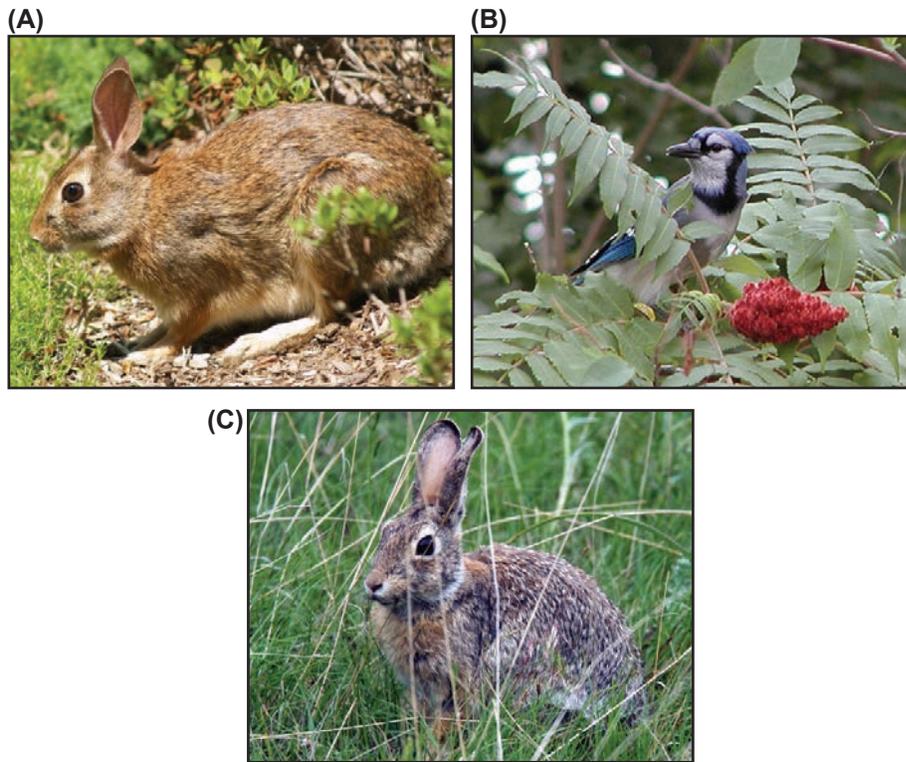


Figure 16—Prey species from both the eastern United States, including (A) eastern cottontail, and (B) blue jay, and the western United States, including (C) mountain cottontail, occur in the Black Hills.

(*Meleagris gallopavo*), and cottontail rabbits make up a substantial portion of the diets (table 1 and appendix).

In the four studies that documented prey remains found at Black Hills nest sites, only the red squirrel was observed at all four. Of other mammals, least chipmunks were observed in three studies; thirteen-lined ground-squirrels, mountain cottontails, and white-tailed jackrabbits were observed in two; and flying squirrels were observed in one. For birds, ruffed grouse, wild turkeys, and American robins were observed in two studies; and northern flickers, black-backed woodpeckers (*Picoides arcticus*), and three-toed woodpeckers (*Picoides dorsalis*) were observed in one (table 1). Although these studies have small sample sizes, they demonstrate the range of prey species captured by goshawks in the Black Hills and, by extension, the variety of habitats the prey occupy and the variety of habitats where goshawks hunt. Nine years of line transect surveys of bird faunas include goshawk detections in a variety of habitats, including non-forested, burned, riparian, shrubland, grassland, and meadow habitats as well as quaking aspen, white spruce, old ponderosa pine, mesic ponderosa pine, and dry ponderosa pine forests (Giroir and others 2007; Hutton and others 2006; Panjabi 2001; White and others 2010). The short-perch-short-flight hunting tactic utilized by goshawks is uniquely suited for hunting over large areas, which typically include a wide variety of habitats and is reflected in the diversity of prey species taken.

Table 1—Selected prey species for the Black Hills. Prey was grouped according to the habitats in which they occur, and a weight (1-3) was assigned to the group that was used to assess the value of the group in sustaining goshawks in the Black Hills. The habitats of high and medium important prey in a group are described in the Appendix.

Species	(Importance) Group	Source ¹	Comments
(2) Heavy-bodied ground-feeding birds (<i>Galliformes</i>)			
ruffed grouse	High	W, B	Young and adults
wild turkey	High	W, B	Young
sharp-tailed grouse	Low	WB	Associated with meadows
domestic chicken	Low	WB	Forest/urban interface
(2) Forest generalists			
mourning dove	Medium	WB	Forest/urban interface
rock dove	Low	K	
American robin	Medium	B, E,	
western tanager	Medium	WB	
black-headed grosbeak	Medium	WB	
Townsend's solitaire	Low	E	
junco	Low	B, E	
gray jay	Medium	B	
(2) Hares and rabbits (<i>Lagomorphs</i>)			
eastern cottontail	Medium	W	
mountain cottontail	High	B, K	
white-tailed jackrabbit	High	B, E	
(3) Tree squirrels			
eastern fox squirrel (Bear Lodge)	Low	W, B, E, K	Associated with bur oak
red squirrel	High	B	
northern flying squirrel	Medium	W, B	
(2) Ground squirrels			
least chipmunk areas	Medium	W, B, E, K	High elevations, burned
thirteen-lined ground squirrel	High	B, E	Soils suitable for burrowing
(2) Woodpeckers			
American three-toed woodpecker	Medium	E	
Lewis's woodpecker	Medium	WB	
northern flicker	High	E	
red-naped sapsucker	Medium	WB	
hairy woodpecker	Medium	WB	
red-headed woodpecker	Medium	WB	
black-backed woodpecker	Medium	E	
(1) Woodrat and other mammals			
bushy-tailed woodrat	Medium	B	Buildings, mining areas
black-tailed prairie dog	Low	WB	
masked shrew	Low	B	
voles	Low	B, K	
western harvest mouse	Low	B	
northern pocket gopher	Low	B	

¹ W = Wild (1973), B = Bartelt (1977), E = Erickson (1987), K = Knowles and Knowles (2009), and WB = wildlife biologists. The checklist of birds and mammals for the Black Hills and the expert knowledge of the wildlife biologists on the Black Hills National Forest were used in conjunction with the authors' knowledge to determine the presence and importance of the prey in the diets of Black Hills goshawks.

Assessment Methods

Prey Identification

To assess goshawk prey habitats in the Black Hills, we first identified a suite of potentially important prey species (table 1). A checklist of birds and mammals for the Black Hills combined with the expert knowledge of the wildlife biologists on the Black Hills National Forests and the authors' knowledge of goshawk diets and foraging ecology was used to estimate the potential occurrence and relative importance of the prey in Black Hills goshawk diets. We reviewed the relative importance of different bird and mammal prey species in goshawk diets throughout the Rocky Mountains and elsewhere, and compared and contrasted these diets with published Black Hills diets and Black Hills faunal lists. We reviewed literature on the likely relative abundances and availability of these species in the Black Hills and compared these to their occurrence in the diets of Black Hills goshawks (Bartelt 1977; Erickson 1987; Hansen and others 2011; Knowles and Knowles 2009; Mills and others 1995; Panjabi 2005; Pettingill and Whitney 1965; Rumble and others 1999; Turner 1974; White and others 2010; Wild 1973). To aid the assessment of current Black Hills prey habitats, we describe the distribution, habitat, diet, home range, and populations of prey species in the appendix.

Expert Panels

A Delphi process for rating the quality of goshawk habitat in the Black Hills was a compromise of data resolution, expert availability, and time required to complete the assessment. We evaluated various spatial entities and scales that we thought would be appropriate. The Black Hills National Forest keeps extensive vegetative data that could be assembled in various sizes and units of different vegetative configurations, which we thought would be ideal. However, upon examining the map of such information, we found that the sizes, shapes, and descriptions of the data were highly variable, making it difficult to assess key habitat features for goshawks and their prey. From this evaluation, we tried different-sized watersheds as a sampling unit. The units (or polygons) needed to be small enough to provide sufficient resolution to distinguish tree species, tree sizes, aspect, slope, canopy cover, vegetation arrangements, openings, and juxtaposition of these elements but also be large enough to produce a number of sample units that could be evaluated in a reasonable timeframe. We settled on using a 9th code watershed. Following is an example of this hierarchal watershed classification (USGS 2014):

1. Region—Missouri,
2. Subregion—Cheyenne,
3. Basin—Belle Fouche,
4. Subbasin—Redwater,
5. Watershed—Sand Creek,
- 6., 7. Subwatersheds—Cold Springs Creek and Idol Gulch, and
- 8., 9. Unnamed watersheds located along the Wyoming/South Dakota border south of Beulah, Wyoming, and east of Spearfish, South Dakota (fig. 17).

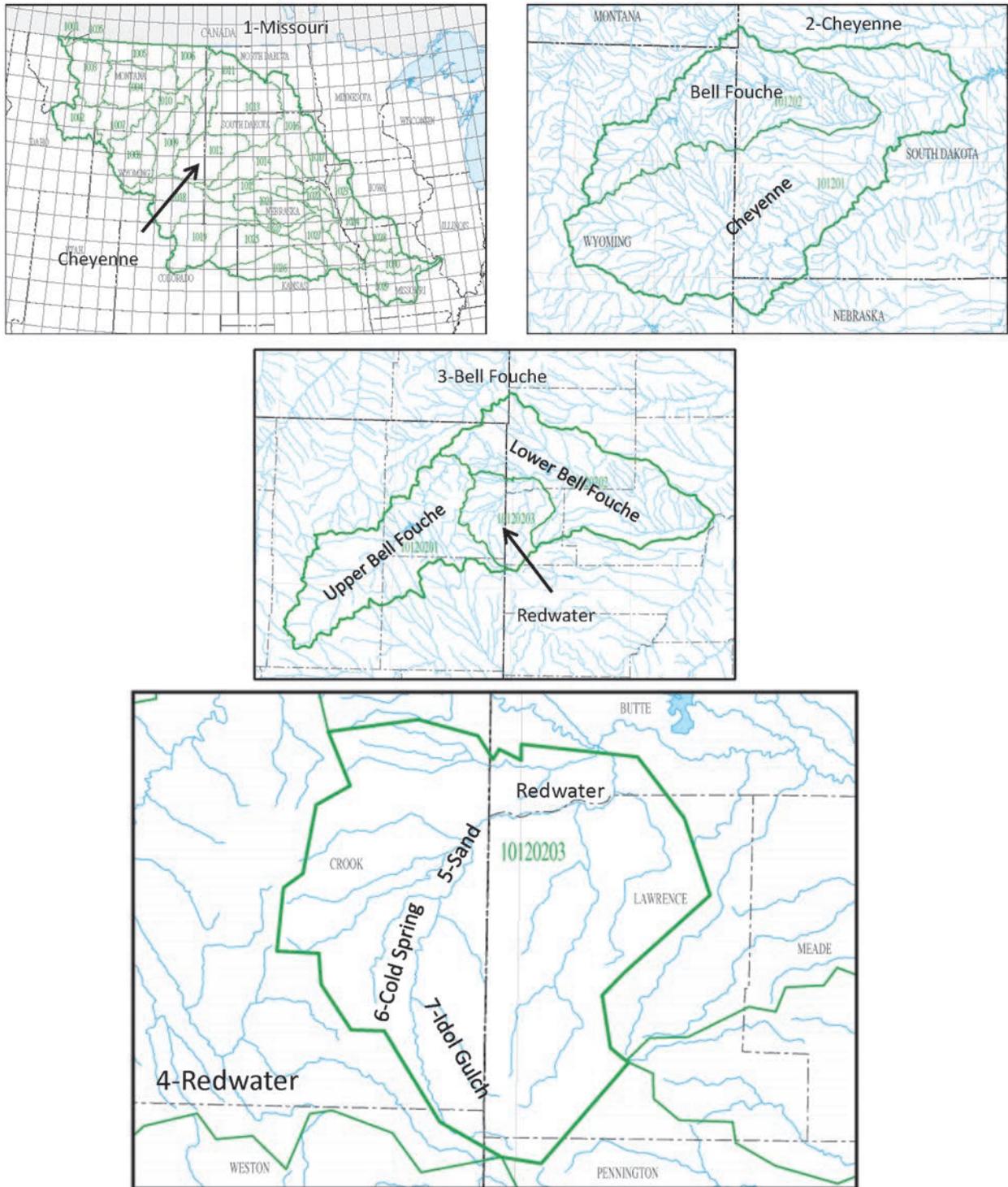


Figure 17—Example of the hierarchal watershed classification used to identify watersheds in the United States. For example, level 1: Missouri, 2: Cheyenne, 3: Belle Fouché, 4: Red Water, 5: Sand, 6: Cold Spring, 7: Idol Gulch, and two smaller level 8 and 9 watersheds not shown on the map. As a result, the hierarchy can define any watershed. For this assessment, the 9th level or 9th code watershed was chosen.

The 9th code watersheds we used in our assessment ranged in size from 53 to 1,270 acres (21 to 514 ha) and averaged 449 acres (182 ha). There is considerable variation in tree size, distribution, and associated vegetation from the southern to northern Black Hills. Therefore, we divided our assessment into four geographic areas that generally followed the boundaries of the four ranger districts located on the Black Hills National Forest: Bear Lodge Mountains (in Wyoming), Northern Hills, Mystic (central Black Hills), and Hell Canyon (southern Black Hills). This division resulted in 324 watersheds in the Bear Lodge Mountains area averaging 387 acres (157 ha) in size, 762 watersheds in the Northern Hills area averaging 487 acres (197 ha), 985 watersheds in the Mystic area averaging 488 acres (195 ha), and 1,342 watersheds in the Hell Canyon area averaging 432 acres (175 ha) (fig. 18).

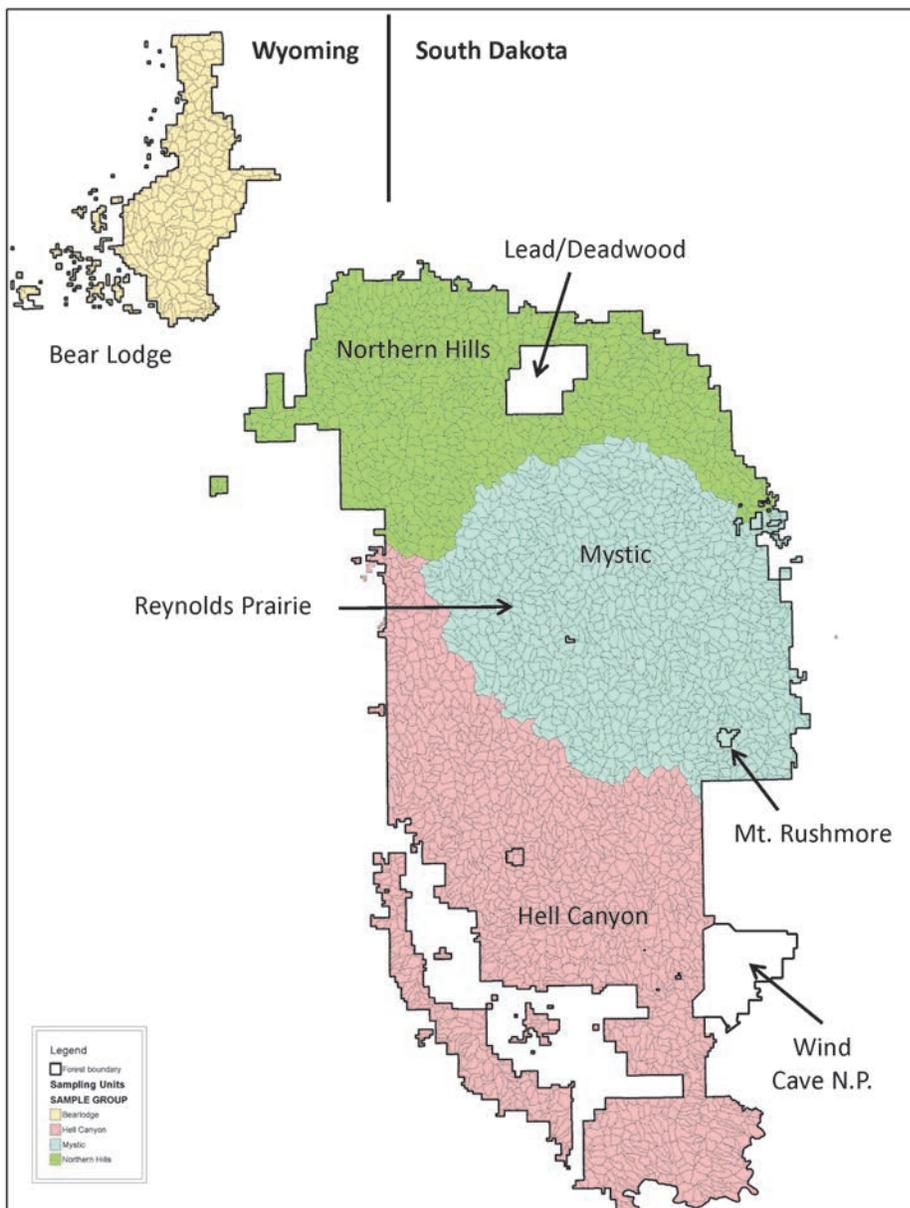


Figure 18—Distribution of the 3,414 9th code watersheds used in the assessment.

For the expert panel process, we arranged 10 days of workshops: two days for each of the four areas, one day of training, and one extra day. Eight Black Hills National Forest wildlife biologists familiar with goshawks and their prey were recruited to rate the physical and vegetative condition of each watershed relating to the goshawks and their prey individually and by prey group (guild) (fig. 19). The experts rated each watershed as high, medium, or low value for goshawk nesting habitat and foraging habitat and for providing high-, medium-, or low-rated habitat for seven prey groups: turkeys and grouse, forest generalists, hares and rabbits, tree squirrels, ground squirrels, woodpeckers, and woodrats (*Neotoma* spp.) (table 1). Workshops were held at central locations in each of the assessment areas to ensure we had local knowledge as well as wildlife biologists from throughout the Black Hills to do the rating. For each watershed, we provided a true-color aerial photo delineating watersheds and showing the current vegetation and detailed vegetative structure and composition, as well as the juxtaposition of roads, buildings, power lines, openings, and other germane habitat features. In addition to the photos, panelists (working in pairs) were provided with quantitative vegetative descriptions (e.g., tree size, trees/acre, basal area/acre, canopy cover, and tree species), slope angles, slope aspects, and elevations to help them judge the quality of the watershed related to goshawks and their prey.



Figure 19—During the workshop, experts considered detailed data from each watershed in order to rate the quality of both goshawk and its prey habitats (Delphi process).

Analysis

Using the categories high, medium, and low to rate the habitat elements eliminated the possibility of the experts subdividing their ratings into proportions (e.g., 1.2 or 2.5). After the ratings were completed, we translated the three categories into numbers in order to compute our composite ratings: high = 3, medium = 2, and low = 1. Based on the relative importance (considering each species' frequency in diets and their average biomass) of a prey species in Black Hills goshawk diets, we considered the woodrat to have the lowest value, tree squirrels to be three times more important than a woodrat, and the other species to be two times more important than a woodrat. Using these values, we weighted the scores the wildlife biologists provided for each prey group in the watershed and summed the weighted values to give an overall value of each watershed's biophysical characteristics related to providing prey habitat. Although prey habitat is important, we considered both goshawk nesting and foraging habitat to be more important and used the values of these two entities provided by the wildlife biologists as multipliers of the prey habitat in our final ratings. As a result, the overall goodness of a watershed for providing habitat for the goshawk and its prey was computed:

$$PH = (TS \times 3) + (RH \times 2) + (TG \times 2) + (WP \times 2) + (FG \times 2) + (GS \times 2) + (WR \times 1) \quad [\text{eq. 1}]$$

$$\text{Final score} = (PH \times GN) + (PH \times GF) \quad [\text{eq. 2}]$$

where:

PH = weighted prey habitat

TS = wildlife biologist watershed rating for tree squirrels

RH = wildlife biologist watershed rating for rabbits and hares

TG = wildlife biologist watershed rating for turkeys and grouse

WP = wildlife biologist watershed rating for woodpeckers

FG = wildlife biologist watershed rating for forest generalist

GS = wildlife biologist watershed rating for ground squirrels

WR = wildlife biologist watershed rating for wood rats

GN = wildlife biologist watershed rating for goshawk nesting

GF = wildlife biologist watershed rating for goshawk foraging

For example, watershed 596 located in the southwest section of the Hell Canyon area was rated by the wildlife biologists as having high tree squirrel habitat (3), medium rabbit and hare habitat (2), high turkey and grouse habitat (3), high woodpecker habitat (3), high forest generalist habitat (3), high ground squirrel habitat (3), and medium woodrat habitat (2). Goshawk nesting and foraging habitat were rated as high (3, respectively), therefore:

$$PH = TS \times 3 + RH \times 2 + TG \times 2 + WP \times 2 + FG \times 2 + GS \times 2 + WR \times 1 \quad [\text{eq. 1}]$$

$$39 = (3 \times 3) + (2 \times 2) + (3 \times 2) + (3 \times 2) + (3 \times 2) + (3 \times 2) + (2 \times 1)$$

$$\text{Final score} = PH \times GN + PH \times GF \quad 234 = (39 \times 3) + (39 \times 3) \quad [\text{eq. 2}]$$

This calculation was completed for all 3,414 9th code watersheds in the Black Hills. Final scores ranged from 28 (where the entire prey and goshawk habitat characteristics were rated as low) in many watersheds to 234 (watershed 596; equations 1 and 2). We arrayed the watersheds from the one with the highest score to those with the lowest and then computed the percentile distribution. From that, we defined both optimum goshawk and optimum prey habitat as watersheds with percentiles ≥ 98 percent, high-rated as watersheds with percentiles ≥ 95 percent and < 98 percent, medium-rated as watersheds with percentiles ≥ 50 percent and < 95 percent, and low-rated as watersheds with percentiles < 50 percent.

Results: Goshawk Habitat

Nest Areas

Goshawk nest areas have a relatively high tree canopy cover and a relatively high density of large trees (Bartelt 1974; Crocker-Bedford and Chaney 1988; Hall 1984; Hayward and Escano 1989; Kennedy 1988; McGowan 1975; Moore and Henny 1983; Reynolds and others 1982; Saunders 1982; Speiser and Bosakowski 1987). Most nest areas are either on slopes with northerly exposures (northwest to northeast) or in drainages or canyon bottoms protected by such slopes. Studies suggest that the relatively dense vegetation in nest areas provides goshawks a relatively mild and stable microenvironment, as well as protection from predators (e.g., other goshawks, great-horned owls, red-tailed hawks, coyotes, bobcats, raccoons, and humans) (Moore and Henny 1983; Reynolds and others 1982). Nest areas are relatively small compared to the sizes of watersheds defined in this assessment. Therefore, a particular watershed's medium or low rating for nest area habitat does not necessarily mean that it does not contain one or more 20 to 30-ac (8 to 12-ha) patches of high quality nest area habitat. Whether goshawks will nest in a particular watershed depends to a great extent on (1) the availability of a suitable nest area, (2) the location of its suitable nest area relative to the location of nests of neighboring goshawk pairs, and (3) the quality of surrounding goshawk foraging vegetation structures and prey habitats.

A small amount of area within the Black Hills was rated as high-quality nest area habitat for the goshawk (fig. 20). The northeastern edge of the northern Hills stands out for its concentration of the limited high-rated nest area habitat as does the Bear Lodge Mountains area for its proportionally large amount of high-rated nest area habitat. Also, the Bear Lodge Mountains area has a good amount of contiguous medium-rated nest area habitat (fig. 21). The Jasper Fire area in the south-central Black Hills and the southern prairie areas also stand out for their extensive amount of low-rated nest area habitat (figs. 20 and 22).

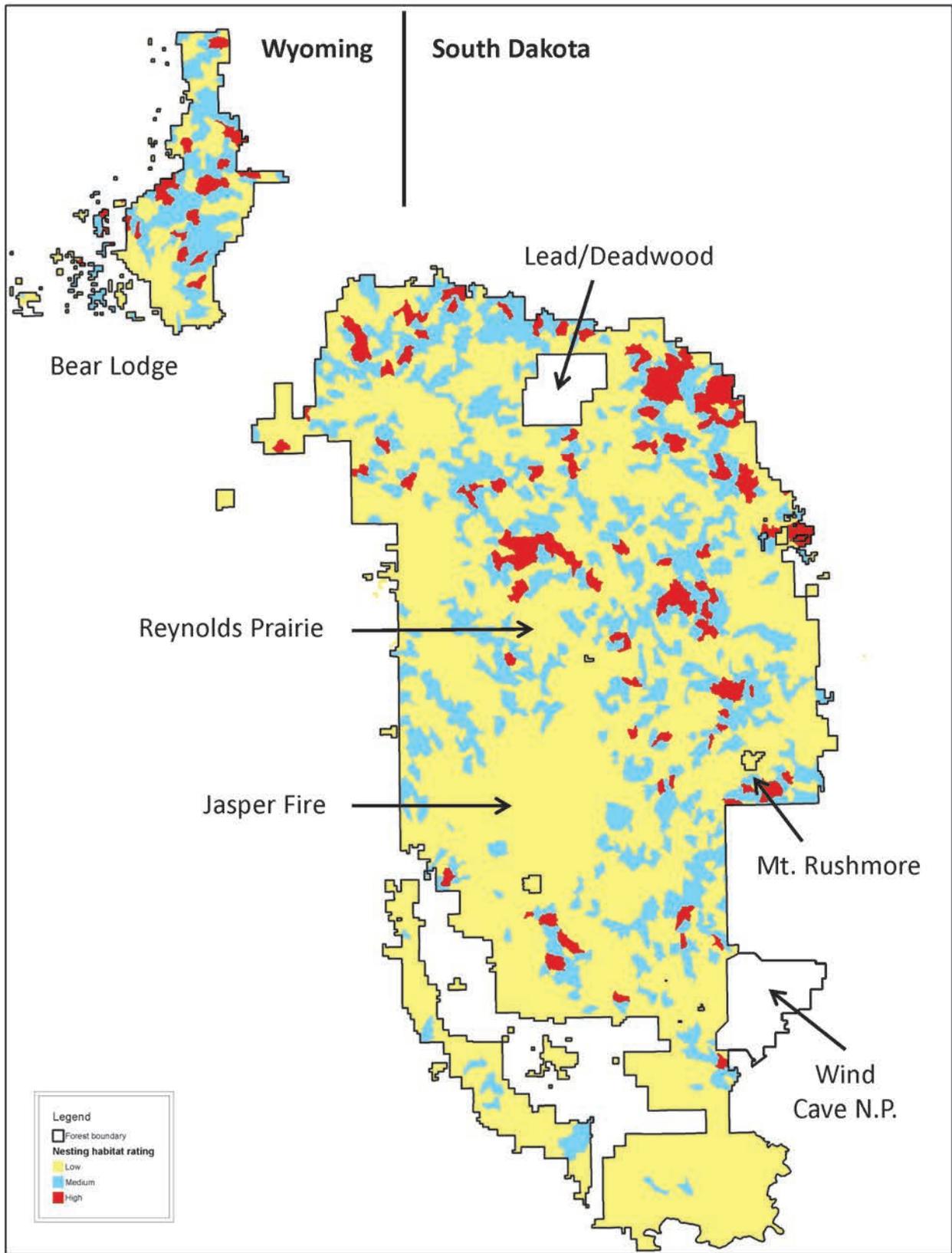


Figure 20—The northeastern perimeter of the Black Hills has a concentration of high rated (shown in red) goshawk *nesting* habitat.



Figure 21—The Bear Lodge Mountains contained a large portion of the habitat rated as moderate and high for nesting, as typified by large and closely spaced trees.



Figure 22—The area burned by the Jasper Fire in 2000 resulted in low-rated goshawk habitat but transitory woodpecker habitat.

Foraging Habitat

Limited radiotelemetry evidence suggests that goshawks prefer mature forests for foraging. For example, Fischer (1986) found that a radio-tagged male in Utah preferentially foraged in “mature” Douglas-fir/white fir (*Abies concolor*) stands. Widén (1989), studying radio-marked goshawks in winter in intensively managed conifer forests in Sweden, found that both sexes of goshawks preferentially foraged in forests greater than 60 years of age. However, age is not always a good indicator of forest structure or tree size (Reynolds and others 1992). Habitats used for foraging by goshawks in North America have been documented in a small number of telemetry studies (Austin 1993; Beier and Drennan 1997; Boal and others 2002; Bright-Smith and Mannan 1994; Hargis and others 1994). These studies suggest goshawks select foraging areas with specific structural attributes, including old or mature forest stands with open understories, relatively high densities of large trees, and relatively high canopy cover. It is possible, however, that actual foraging habitat selection occurs at spatial and temporal scales difficult to investigate using radiotelemetry (USFWS 1998). Small openings, tree fall gaps, edges, riparian zones, and rock outcrops are examples of small-scale landscape elements that may be important to foraging goshawks (Squires and Reynolds 1997). A measure of foraging habitat quality is the co-location of vegetation structural attributes that compliment goshawk hunting behavior with abundant prey. Prey abundance may be higher in areas with a diversity of habitats supporting a diversity of prey species.

Proportionally, the Bear Lodge Mountains have more high- and medium-rated goshawk vegetation structural attributes suitable for foraging than any other place in the Black Hills (fig. 23). Similarly, the area near Mount Rushmore is high-rated for foraging, and the majority of the northern Hills have a medium rating for foraging (figs. 23 and 24). The Jasper Fire area is an area of low-rated structural attributes for foraging. The southern Hills contains a small amount of high-rated foraging structures and a modest amount of medium-rated foraging structures, very likely because of islands of forest intermixed with the prairie (fig. 23).

Results: Prey Habitat

Grouse and Turkey

Turkeys and grouse (*Galliformes*) are an important food source for goshawks in the Black Hills. These ground-dwelling birds are in the larger size class of goshawk prey and return a lot of biomass for the energy the goshawks expend in capturing them (fig. 25). Given the opportunity, goshawks will prey on young wild turkeys. However, adult turkey hens can be an effective deterrent against predation through grouping of their young and aggressive behavior toward hunting goshawks (Lehman 2003; Reynolds, personal observation). Nevertheless, Rumble, who studied Merriam’s turkeys (*Meleagris gallopavo Merriami*) in the Black Hills, witnessed a goshawk preying on young turkeys (4 weeks old) as they flew from their roost. He noted that the goshawk failed in its first attempt to catch a turkey but was successful with its second attempt and flew off, with extreme difficulty, downhill with the young turkey in its talons (Rumble, personal communication).

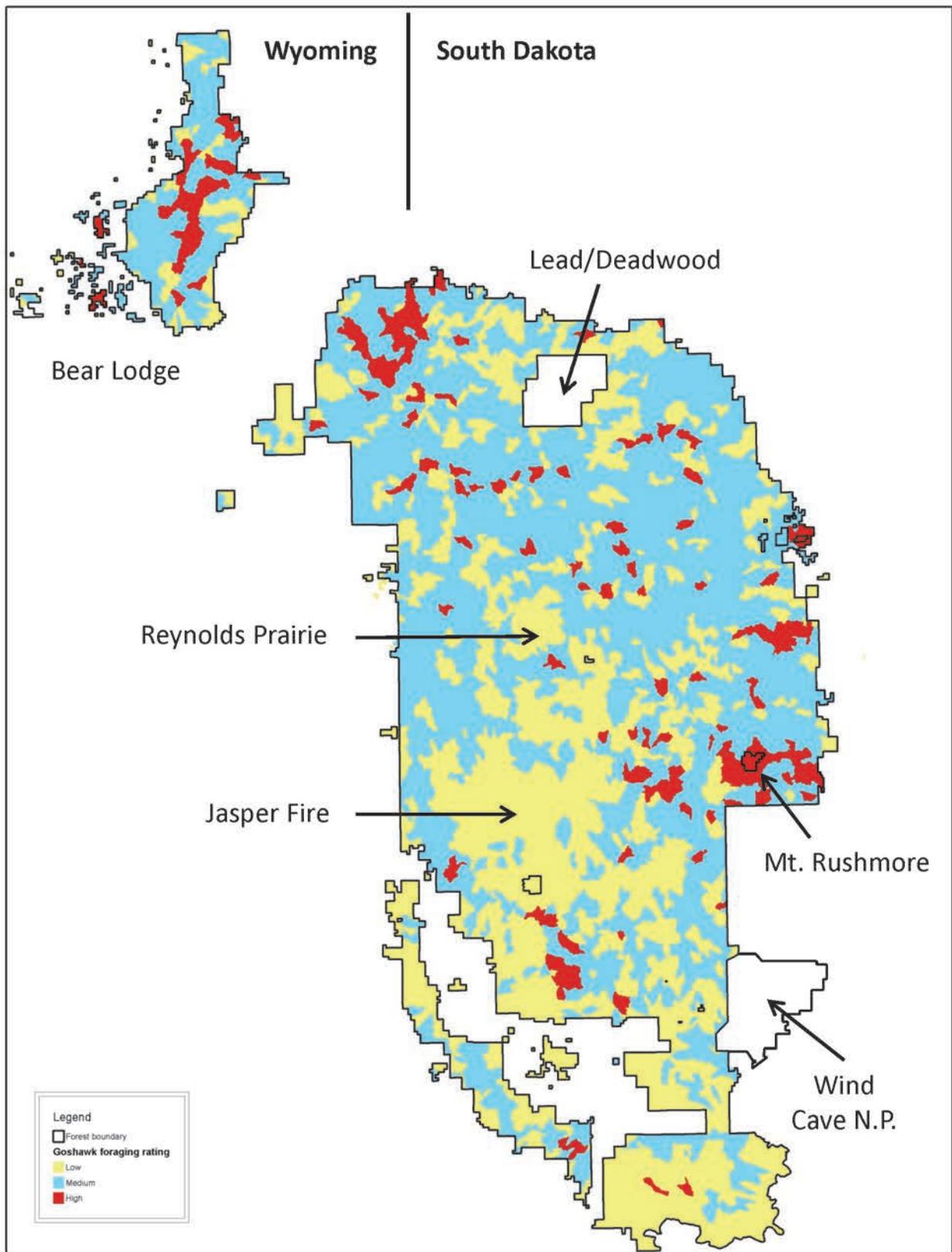


Figure 23—The Bear Lodge, northwestern Black Hills, and the area on the eastern edge of the central Black Hills contained the majority of the high-rated goshawk foraging habitat. The Northern Hills and Bear Lodge Mountains areas were also dominated by medium-rated foraging habitat.



Figure 24—The area around Mount Rushmore and especially to the west was high-rated for goshawk foraging habitat.

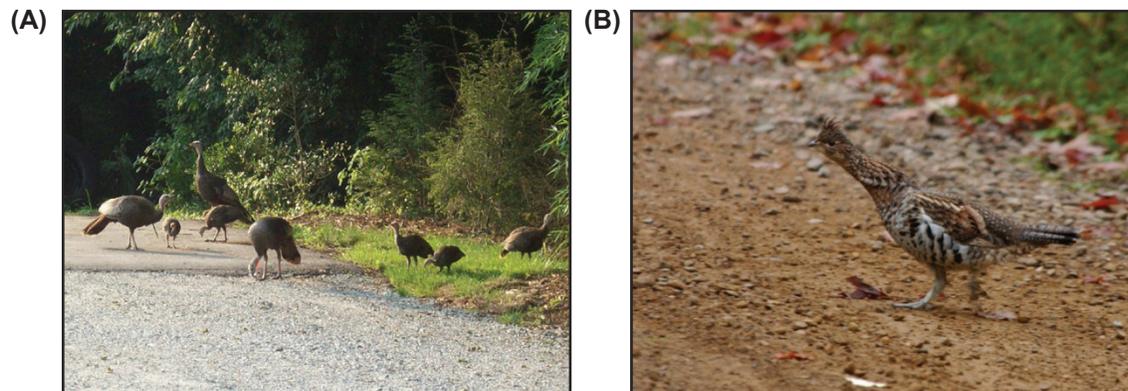


Figure 25—Young turkeys (A) and ruffed grouse (B) are some of the larger prey that goshawks kill in the Black Hills.

In the Black Hills, Rumble and Anderson (1993) studied radio-tagged turkeys over a 3-year period (1986 to 1989) and described their habitat. They found that ponderosa pine forests with moderate (41 to 70 percent) and high (71 to 100 percent) canopy cover were used year-round. During spring and summer, turkeys' use of moderate canopied pine habitats increased, after which they switched to more closed canopy habitats during fall and winter. Overall, use of ponderosa pine habitats with low (0 to 40 percent) canopy cover was minimal but increased in the summer when turkeys foraged on grass seeds, which were abundant in open habitats.

Across most of their range, ruffed grouse are strongly associated with quaking aspen forests and woodlands (Rusch and Keith 1971a; Rusch and others 2000; Wiggins 2006). Forests containing mosaics of openings and young (especially quaking aspen) to old forest structures provide both cover and foraging opportunities for ruffed grouse, especially if those areas are contiguous across the landscapes rather than isolated fragments (Bump and others 1947; Rusch and others 2000). Small openings (<1.0 acre [0.4 ha]) containing herbs, forbs, and fruit-bearing shrubs provide important brood foraging habitat, and patches of mature forest provide thermal cover during winter (Sharp 1963). Within the Black Hills, ruffed grouse are more prevalent in the Bear Lodge Mountains and northern Hills. These areas often have ponderosa pine forests interspersed with small groves of quaking aspen and bur oak (*Quercus macrocarpa*), valleys with mixtures of paper birch (*Betula papyrifera*) and hazelnut (*Corylus cornuta*), and riparian corridors (White and others 2010). Turkey and grouse habitat in ponderosa pine forests may be optimal for goshawk hunting where trees occur in small groups or patches with closed canopies (interlocking tree crowns) that are separated by small grass-forb-shrub openings (Reynolds and others 1992, 2006).

The very northern portion of the Black Hills offers the largest amount of habitat for these heavy-bodied, ground-feeding birds as it is typified by open prairie meadows intermixed with ponderosa pine. Also, the Bear Lodge Mountains proportionally have some of the larger amounts of turkey and grouse habitat in the Black Hills. This is likely related to the high amount of bur oak, which supplies the favored food of acorns, as well as a mixture of meadows and even grain fields present on the ridge tops. As a result, nearly all of the Bear Lodge Mountains are medium- and high-rated for grouse and turkey habitat. However, young turkeys are the most likely prey resource and would only be available during the nesting season, while grouse would be available year-round (fig. 26).

Forest Generalists

Forest generalists include American robins (*Turdus migratorius*), mourning doves (*Zenaidura macroura*), and other small birds. In general, such species are of medium importance in goshawk diets. The wide-ranging American robins inhabit woodlands, hardwood and coniferous forests, riparian areas, shelterbelts, wooded suburban areas, gardens, agricultural lands, and parks and lawns interspersed with shrubs. In the Black Hills, robins are typically found wherever there are trees. Robins use ponderosa pine, white spruce, quaking aspen, and bur oak forests in various combinations and amounts (Franzreb and Ohmart 1978; Panjabi 2001; Pettingill and Whitney 1965; Sallabanks and James 1999; Savard and Falls 1981; Siegel 1989; Stauffer and Best 1980; Yahner 1983) (fig. 27).

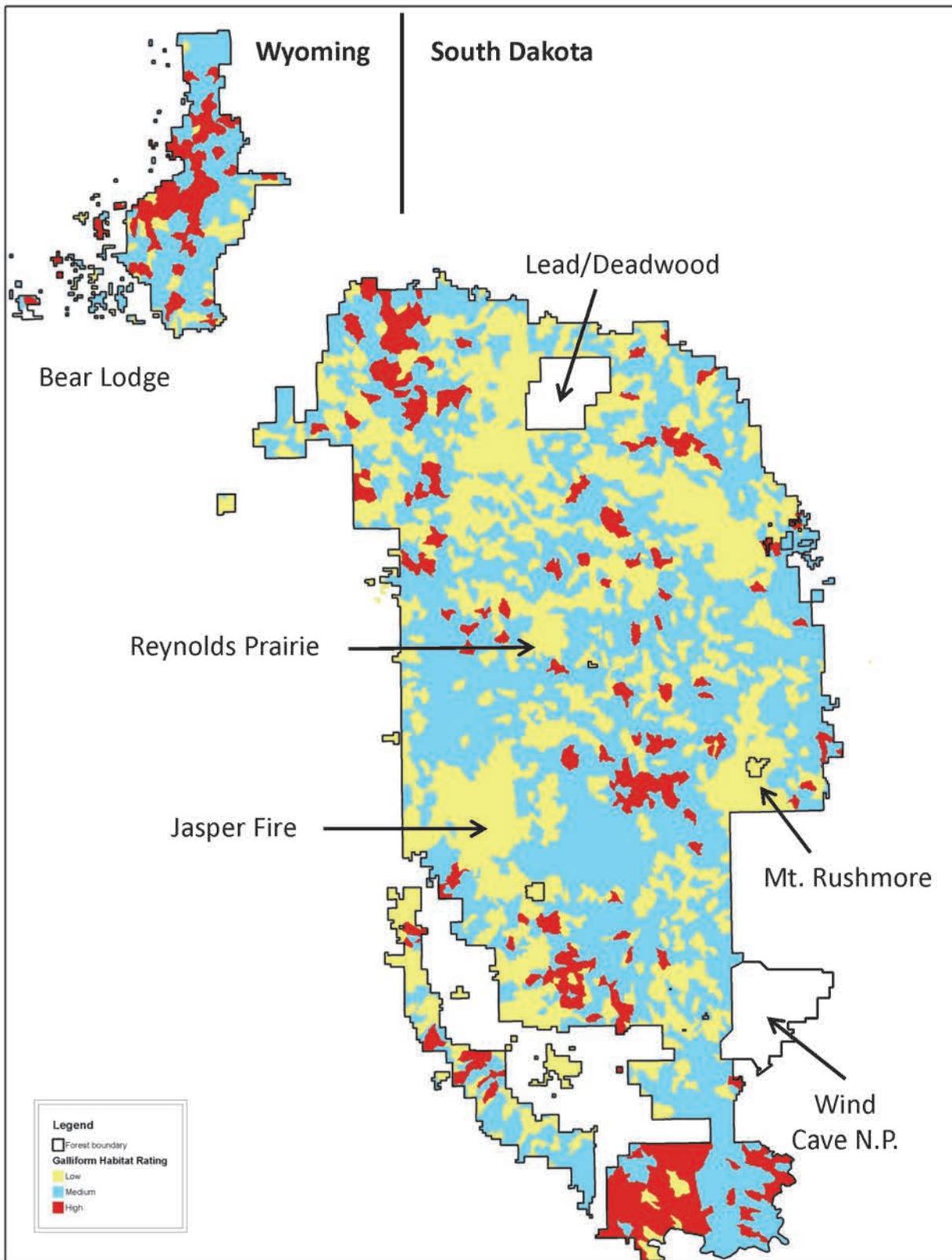


Figure 26—The Bear Lodge, northwestern Black Hills, and southern Black Hills stand out as areas having high-rated turkey and grouse (*Galliformes*) habitat.

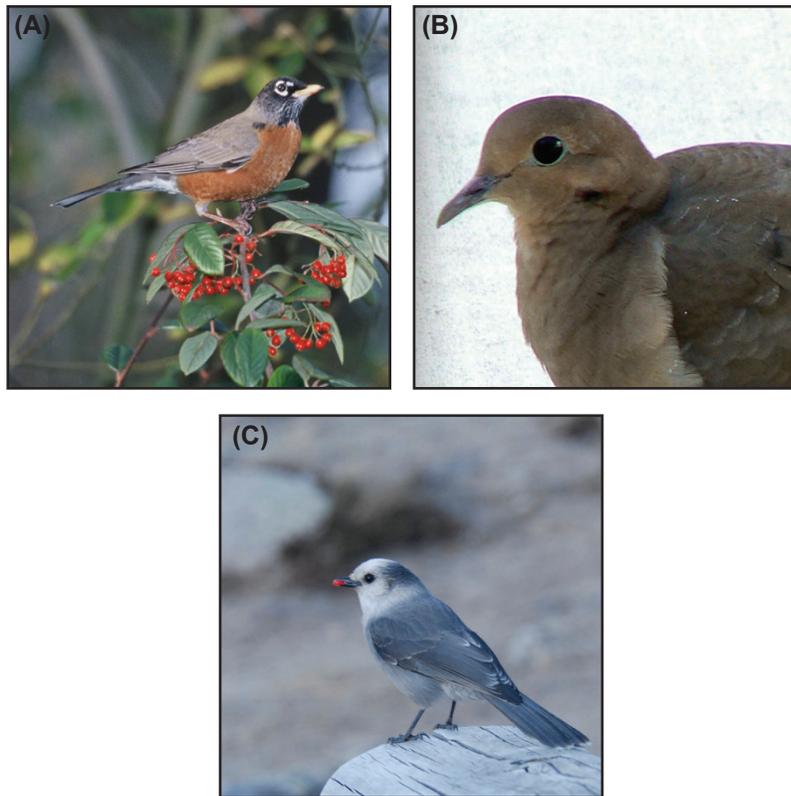


Figure 27—Forest generalists are song and other small birds that inhabit a variety of habitats. Examples are (A) American robin, (B) mourning dove, and (C) grey jay

Western tangers (*Piranga ludoviciana*) occur throughout the Black Hills, particularly at the lower elevations. They are most abundant in the southwestern Black Hills and are less common in the north, especially in the Bear Lodge Mountains (Panjabi 2001). Most often, they are found in ponderosa pine forests and riparian woodlands, but recent surveys found them in quaking aspen, white spruce, shrubland, and burned habitats (Panjabi 2001; Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991; White and others 2010). Mourning doves are usually found near forest edges in openings, along stream borders, or where two forest types meet. Gray jays (*Perisoreus canadensis*) are coniferous and mixed-coniferous forest dwellers whose habitat usually contains white spruce trees (Strickland and Ouellet 2011).

The habitat for these forest generalists is medium rated throughout most of the Black Hills. The Bear Lodge Mountains provide abundant high-rated habitat for this group of birds, most likely associated with the presence of bur oak that is often mixed with meadows and fields. Another two centers of high-rated habitat occur along the Wyoming border southwest of Spearfish and another occurs just west of Mount Rushmore. These areas again have an intermixture of forest and meadow habitats and urban settings that are frequently associated with this group of prey species (fig. 28).

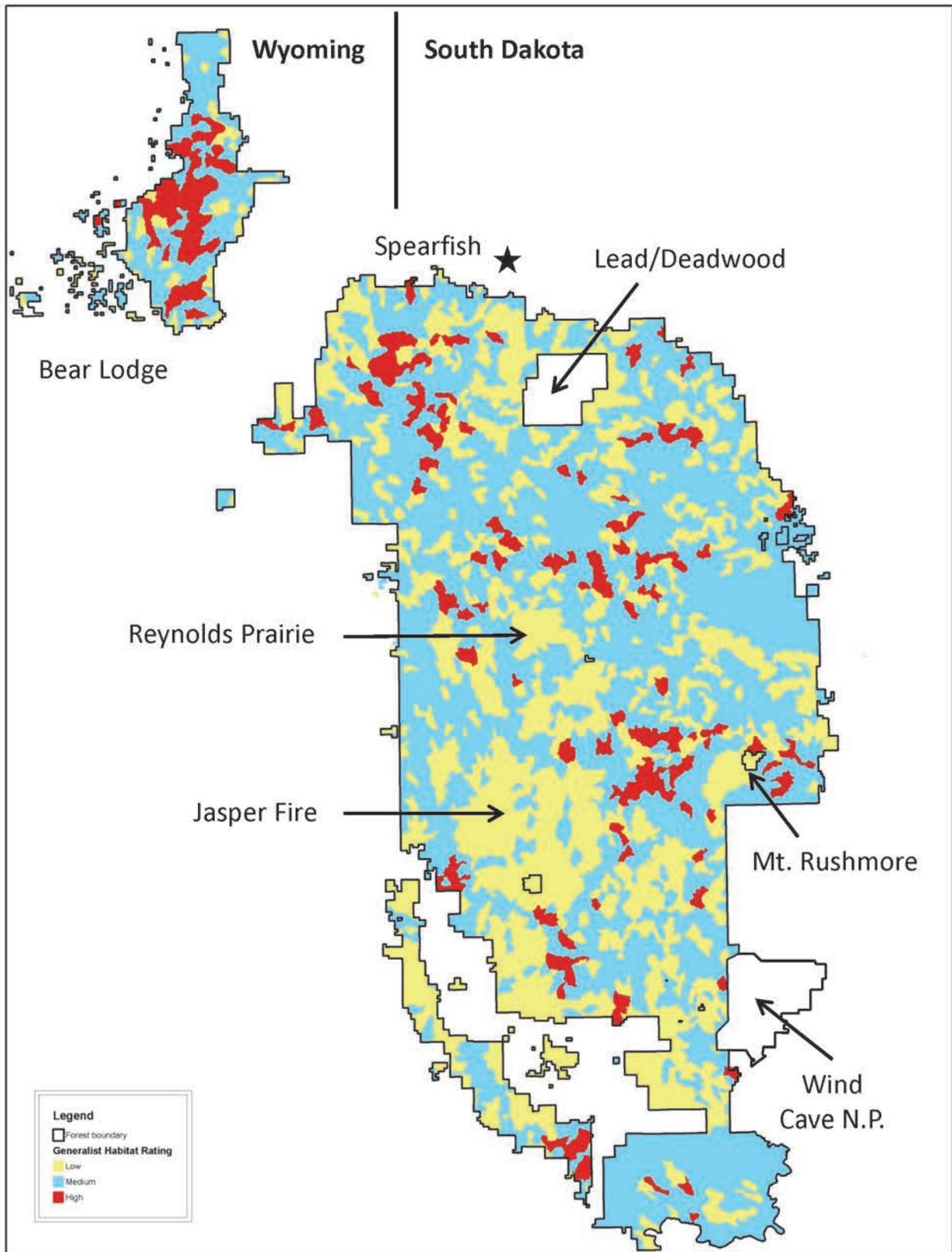


Figure 28—The Bear Lodge Mountains area and the area west of Mount Rushmore contain a large amount of high-rated forest generalist habitat.

Hares and Rabbits

Jackrabbits and cottontail rabbits (lagomorphs) are some of the larger prey that goshawks feed on in the Black Hills, making them high value (fig. 29). In the Black Hills, eastern (*Sylvilagus floridanus similis*) and mountain cottontails (*Sylvilagus nuttalli grangeri*) occupy brushy ravines, streamside thickets, and the forested edges of valley streams. Mountain cottontails inhabit pine-clad uplands and white spruce-filled canyons, usually near an abundance of rocks, fallen logs, shrubbery, or old buildings, all of which are usually in close proximity to small, open, grassy areas. Desert cottontails (*Sylvilagus audubonii*) occupy grasslands along the entire interface of the Black Hills and surrounding prairies, up to 5,000 ft (1524 m) in elevation. They are common in the upland prairie of Wind Cave National Park located in the southern Black Hills (Turner 1974).

White-tailed jackrabbits (*Lepus townsendii*) use many habitats, but appear to prefer grasslands and grassy forest openings (Higgins and others 2002) (fig. 30). They also use pastures, fields, and sagebrush habitats. In the Black Hills, white-tailed jackrabbits are not abundant and are probably more numerous on the prairies and plains surrounding the region; in the southern Black Hills, they occur with black-tailed jackrabbits (*Lepus californicus*) (Bailey 1926). White-tailed jackrabbits inhabit woodlands up to 6,000 ft (1829 m), using isolated grassy areas such as Reynolds Prairie (Deer Field Lake/Rochford area), Gillette Prairie (Hill City area), and the Bald Hills (Pactola Reservoir area). At the upper elevations, they frequent open woodlands of quaking aspen, ponderosa pine, and white spruce that border meadows and pastures. White-tailed jackrabbits are more abundant, however, on the surrounding flats where they inhabit the open prairie and upland grasslands of places such as Wind Cave National Park (Turner 1974). Like turkey and grouse, hare and rabbit habitats in ponderosa pine forests may be optimal where trees occur in small groups or patches with closed canopies (interlocking tree crowns) that are separated by small grass-forb-shrub openings (Reynolds and others 1992, 2006).

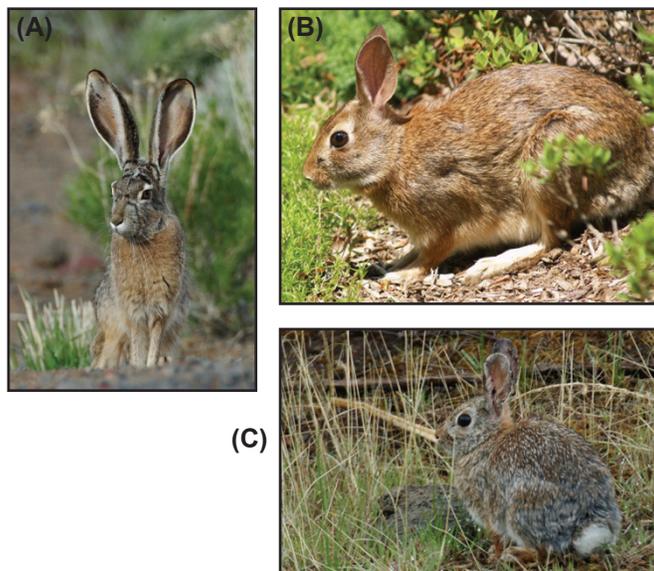


Figure 29—Jackrabbits and cottontails are some of the larger mammals that goshawks hunt in the Black Hills. Pictured here are (A) black-tailed jackrabbit, (B) eastern cottontail, and (C) mountain cottontail.

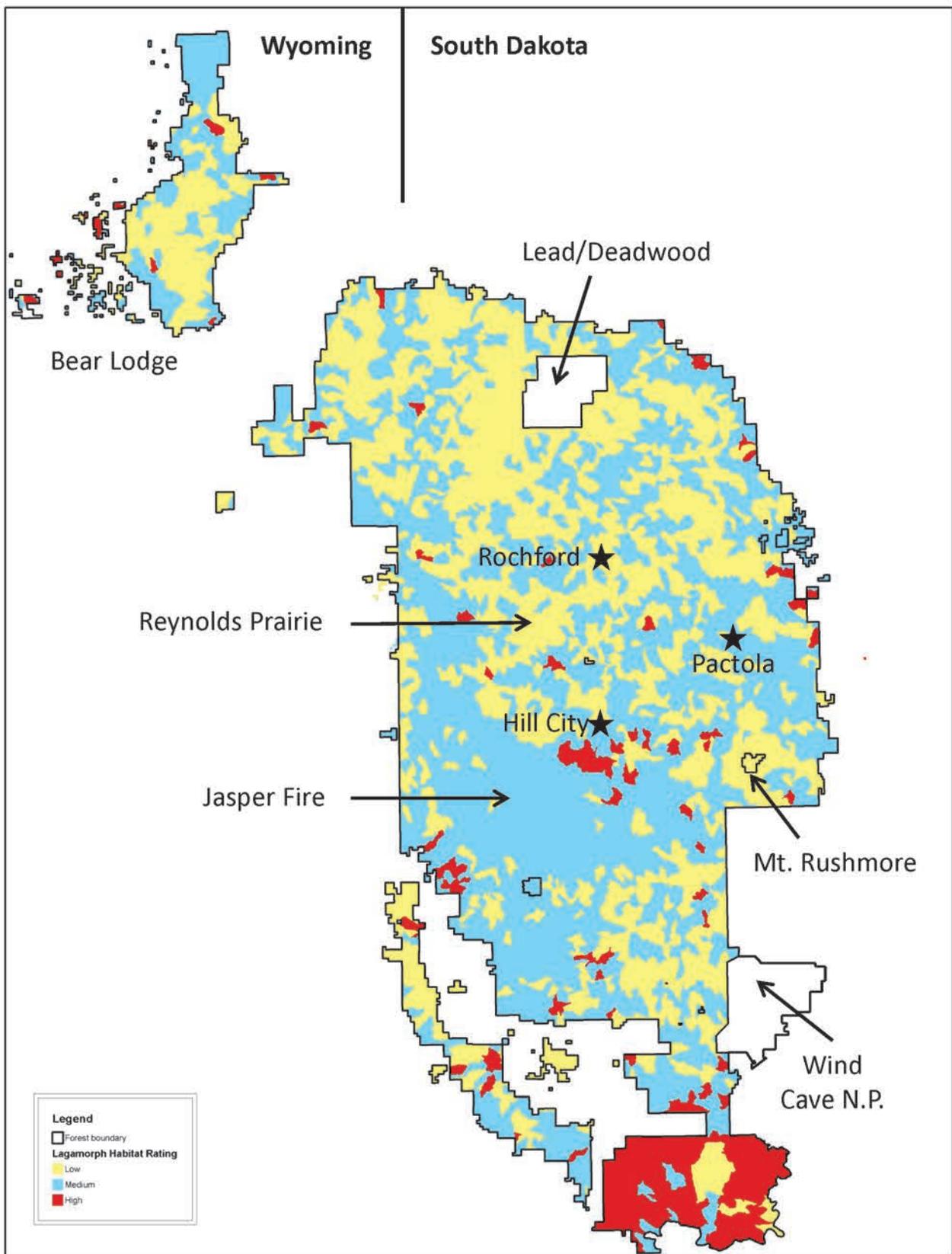


Figure 30—The Jasper Fire area and vicinity have a large area of medium-rated jack and cottontail rabbit habitat. Much of the southern Black Hills mixed prairie and forests are high-rated rabbit (lagomorphs) habitat.

Much like with the ground squirrels and turkeys, the greatest occurrence of high-rated habitat for the jackrabbits and cottontails occurs in the far southern Hills (fig. 30). Extensive amounts of meadows and the prairie habitats bordering islands of ponderosa pine typify these locations (fig. 31). However, medium-rated jackrabbit and cottontail habitat occurs throughout the Black Hills, most likely associated with the abundance of meadows intermixed with forest. The area west of Mount Rushmore stands out as an important prey location for hares and rabbits. The area burned by the Jasper Fire also contains significant amounts of medium-rated hare and rabbit habitat. In contrast to other prey, little high-rated and a modest amount of medium-rated rabbit and hare habitat occurs in the Bear Lodge Mountains (fig. 30).

Tree Squirrels

In the Black Hills, red squirrels (*Tamiasciurus hudsonicus dakotensis*) are most common above 5,200 ft (1585 m) but can be found throughout the Black Hills above 3,800 ft (1158 m) (fig. 32). Black Hills red squirrels prefer mature coniferous forests



Figure 31—The southern Black Hills contain a mix of prairie and forests that offer good cottontail and jackrabbit habitat as well as limited goshawk habitat.



Figure 32—Red squirrels and less abundant flying squirrels are the most important goshawk prey in the Black Hills.

and can be twice as abundant in white spruce forests as in ponderosa pine forests (Turner 1974; White and others 2010). However, they also live in pure mature stands of quaking aspen and in those mixed with ponderosa pine and bur oak (Higgins and others 2002; Turner 1974). A common characteristic of these forests is they usually have groups of trees with interlocking crowns. In addition, red squirrel inhabited forests usually contain trees of different ages and sizes along with cone-producing trees and large trees that can be used for nesting (Vahle and Patton 1983; Patton and Vahle 1986).

Across their range, northern flying squirrels (*Glaucomys sabrinus*) are associated with mature forests containing large diameter trees, large snags, downed logs, coarse woody debris, understory cover, and truffle abundance (Carey 1995; Carey and others 1999; Holloway and Malcolm 2007; Meyer and others 2005; Pyare and Longland 2002; Smith 2007; Smith and others 2004; Weigl 2007). Northern flying squirrels use den sites in natural and woodpecker-excavated cavities in trees, and stick nests built by birds and other squirrels (Hough and Dieter 2009c; Wells-Gosling and Heaney 1984) (fig. 32).

Tree squirrels are the most important prey item in the diets of Black Hills goshawks, and were therefore considered three times more valuable than a woodrat to the goshawk diet. A key feature used by the wildlife biologists for rating the quality of the habitat for the tree squirrels was the presence of large trees with interlocking crowns. With this feature, the area around Mount Rushmore and the Norbeck Wildlife Preserve and Black Elk Wilderness supplied a concentration of high-rated tree squirrel habitat, as did a portion of the Bear Lodge Mountains area (fig. 33). The area burned by the Jasper Fire and the prairie area in the far southern Black Hills had plentiful low-rated habitat for tree squirrels. Most of the northern Hills were rated as having medium habitat for tree squirrels.

Ground Squirrels

Chipmunks and thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), are important prey in the diets of Black Hills goshawks (Bartelt 1977; Erickson 1987; Promessi and others 2004; Rogers and others 2006; Squires 2000; Squires and Reynolds 1997; Turner 1974) (fig. 34). In the Black Hills, these squirrels occupy areas of short grass, including moderately grazed pastures, mowed borders of roadways, campgrounds, and upland meadows occurring up to 6,500 ft (1981 m) in elevation (Higgins and others 2002; Streubel and Fitzgerald 1978; Turner 1974).

The Bear Lodge Mountains with meadows, grassy fields, and farm fields have a large amount of high-rated ground squirrel habitat, and the remainder of the Black Hills is mostly rated as medium quality for ground squirrels (fig. 35). With the thirteen-lined squirrel favoring mowed grassy areas and even campgrounds, the area around Mount Rushmore and extending to the west also contained high-rated ground squirrel habitat. Similarly, the prairie edge in the southern Black Hills was also high-rated for ground squirrels.

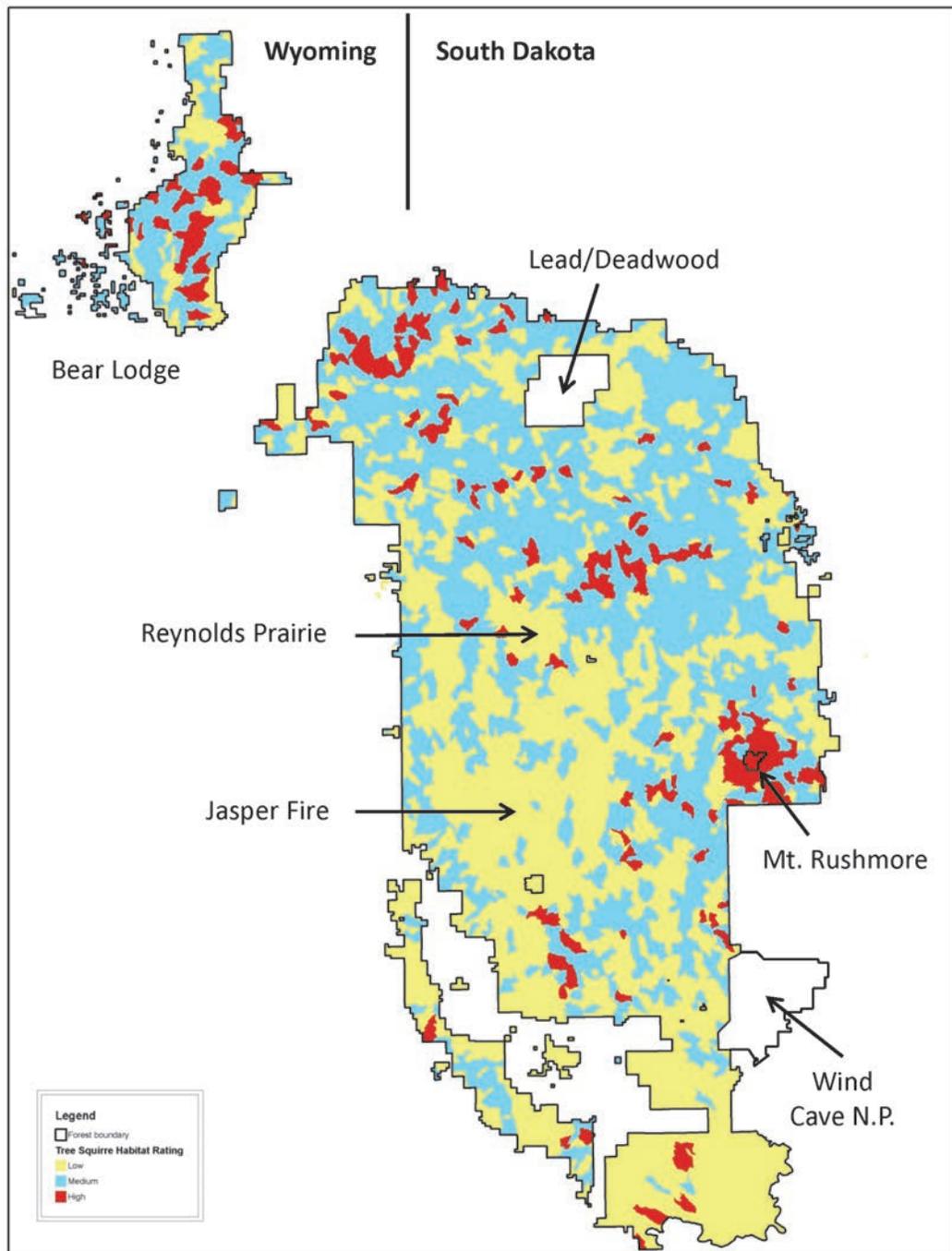


Figure 33—The Bear Lodge and the area around Mount Rushmore stand out as locations of high-rated tree squirrel habitat.

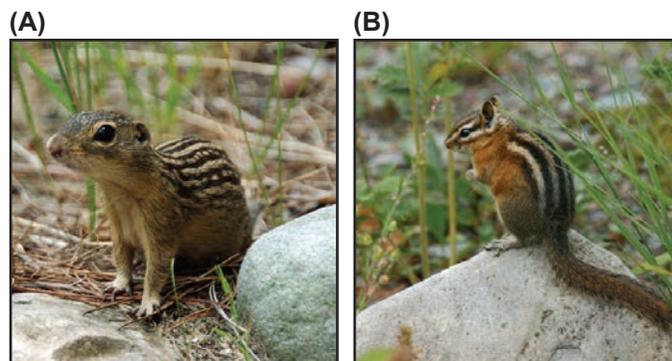


Figure 34—Thirteen-lined ground squirrels (A) and chipmunks (B) are the main ground squirrel prey of Black Hill's goshawks.

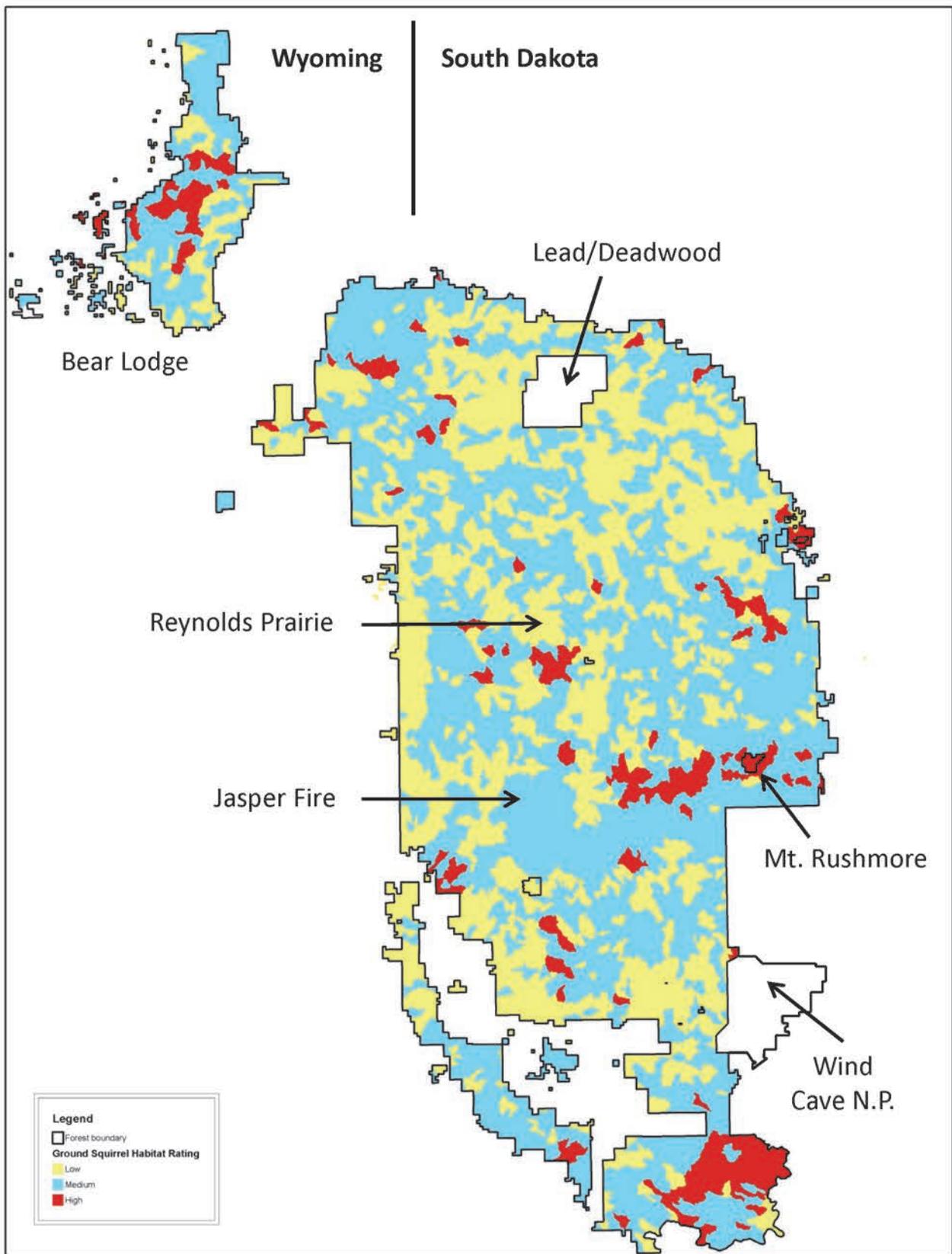


Figure 35—High-rated chipmunk and thirteen-lined ground squirrel habitat is prominent west of Mount Rushmore, in the Bear Lodge Mountains area, and in the southern Black Hills.

Woodpeckers

We identified seven species in the woodpecker prey group as being important to goshawks in the Black Hills (table 1 and fig. 36). The northern flicker (*Colaptes auratus*) was identified as a highly important prey item and the three-toed (*Picoides dorsalis*), Lewis's (*Melanerpes lewis*), hairy (*Picoides villosus*), red-headed (*Melanerpes erythrocephalus*), and black-backed (*Picoides arcticus*) woodpeckers and the red-naped sapsucker (*Sphyrapicus nuchalis*) were identified as moderately important prey items. The northern flicker's body size, conspicuous markings, and behavioral displays make it common prey of the goshawk. Northern flickers use open woodlands, fields, and meadows (Scott and others 1977). They are cavity nesters, as are the rest of the species in the woodpecker group. For example, hairy woodpeckers have a greater preference for habitats with abundant snags and available cavities over other vegetative conditions (Cary 1901; Rumble and others 1999). Similarly, Lewis's woodpeckers have been noted using the McVay burn area north of Hill City, South Dakota, where there was an abundance of snags (Pettingill and Whitney 1965). Most woodpeckers prefer grouped snags to single snags. Uniquely, red-naped sapsuckers like cavities that have been softened by wood rots (fungi) that can occur in trees with broken tops or other physical damage (Crockett and Hadow 1975).

As a group, the woodpeckers use a variety of forest conditions that includes coniferous and deciduous habitats, open pine forests, and landscapes that have experienced wildfires or beetle epidemics (Jackson and others 2002). For example, black-backed woodpeckers are strongly associated with recently burned and/or beetle-infested conifer forests, and in the southwestern part of the Black Hills, Lewis's woodpeckers have been seen using burnt timber on the sides of canyons (Cary 1901; Rumble and others 1999). Forest edges often are preferred by woodpeckers, as demonstrated by Lewis's woodpeckers (Pettingill and Whitney 1965). Similarly, three-toed woodpeckers are often observed using patchy environments and often seen foraging

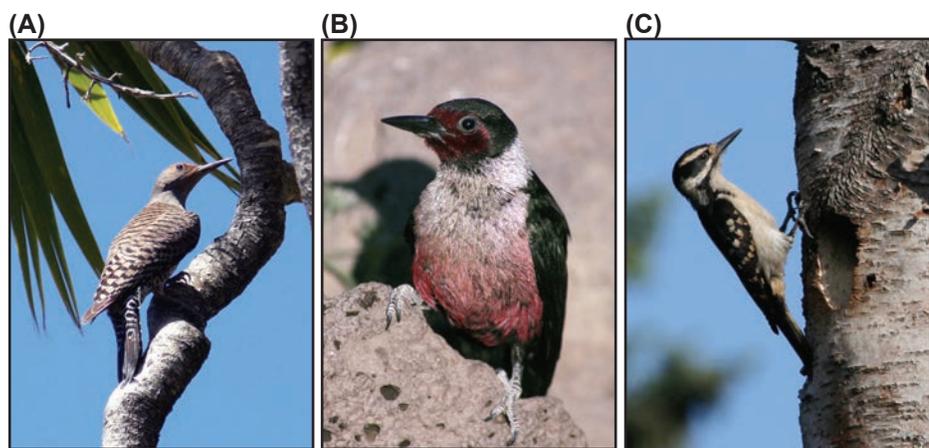


Figure 36—Woodpeckers are important prey species for Black Hills goshawks. Pictured are (A) the northern flicker, (B) Lewis's woodpecker, and (C) hairy woodpecker.

near the edge of ponderosa pine and white spruce stands (Mohren 2002). Woodland and riparian habitats are also well used by woodpeckers in the Black Hills, as demonstrated by Lewis's woodpeckers frequently using riparian woodlands dominated by cottonwoods (*Populus* spp.) or open areas with oaks (*Quercus* spp.) (South Dakota Ornithologists' Union 1991). In addition to these riparian habitats, Lewis's woodpeckers also use habitats with extensive shrub layers (Giroir and others 2007; Hutton and others 2006; Panjabi 2001, 2003; White and others 2010).

High-rated woodpecker habitat was dispersed mostly throughout the central and northern Black Hills with a few high-rated woodpecker habitats in the Bear Lodge Mountains (fig. 37). The area near Mount Rushmore once again provided some of the largest amount of high-rated prey habitat, this time for woodpeckers. Probably the main characteristic of woodpecker habitat was the presence of snags as in the Jasper Fire area. Prairie habitats in the southern Black Hills contained large, contiguous amounts of low-rated woodpecker habitat, while the majority of the remaining Black Hills was rated medium.

Woodrats

Bushy-tailed woodrats (packrats) use of forested habitats makes them potential prey for goshawks (fig. 38). The presence of rocky shelters such as those found in caves, crevices of cliffs, mineshafts, and piles of large boulders are indicative of woodrat habitat (Finley 1958; Smith 1997; Turner 1974). They also use abandoned buildings and wood piles (Grayson 2000). Shrub cover is an important habitat component, as it provides valuable cover while foraging. Den and foraging sites are therefore often in edge habitats and openings in the forest where shrub cover is present, especially where it is located near islands of rocky outcrops (Finley 1958).

The majority of the Black Hills is rated as low-quality woodrat habitat, with the exception of the area west of Mount Rushmore that has abundant rock cliffs often associated with buildings and some grassy meadows that received a high rating, as well as an area on the northeastern edge of the Black Hills that contains high-rated woodrat habitat (fig. 39).

Combined Prey Habitat

As previously mentioned, we considered woodrats to be the least important of the prey occurring in the diets of Black Hills goshawks, tree squirrels to be three times as important as woodrats, and the other species two times as important as woodrats. These were the weights we gave to the rankings the wildlife biologists assigned to each group of prey for each 9th code watershed. We summed these values to arrive at a composite rating for all the entire suite of prey groups for each watershed. For example, watershed 1095 in the Hell Canyon area had high-rated (3) habitat for all seven prey groups, and, using the appropriate weight for each prey group, the watershed had a composite prey score of 42 (fig. 18).

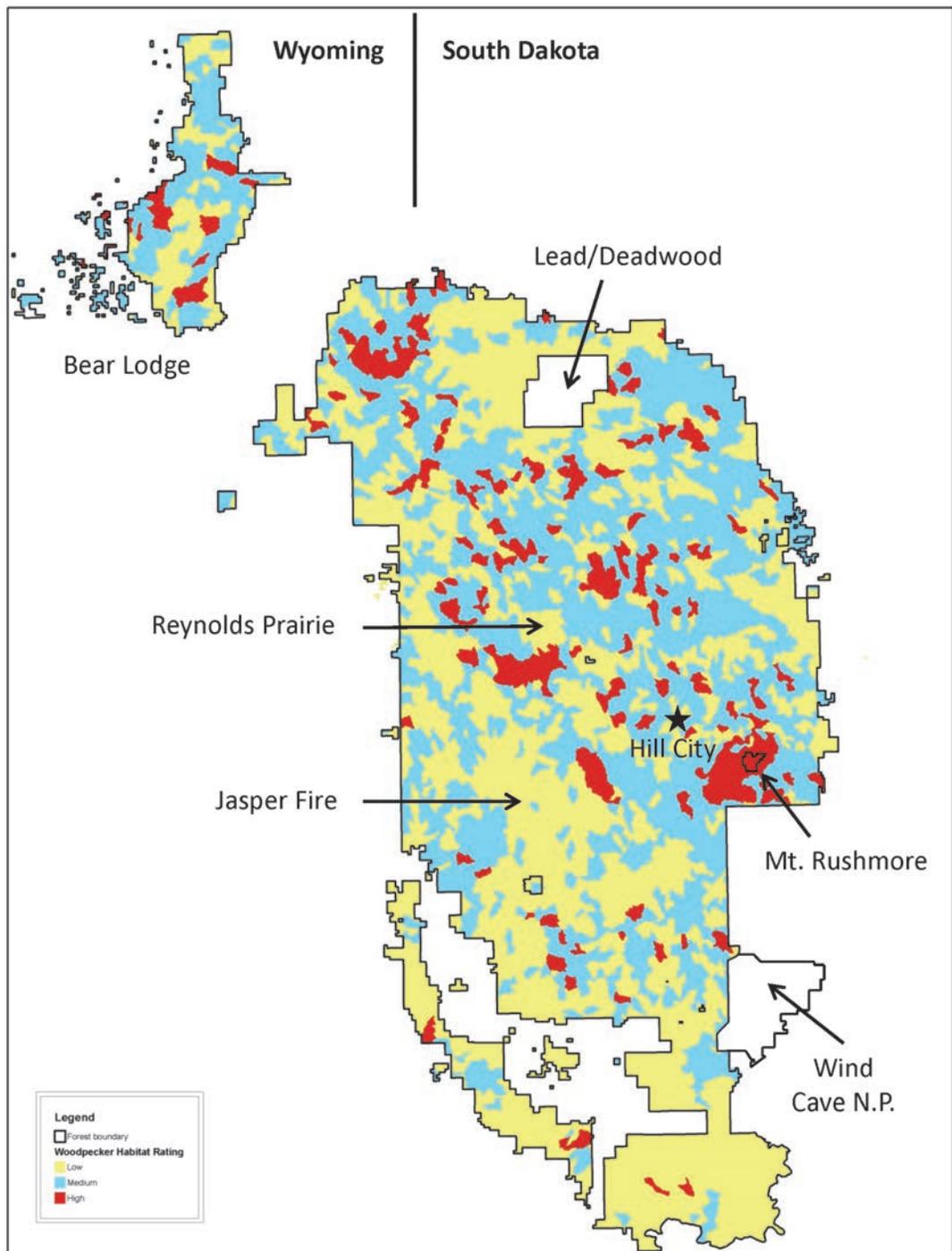


Figure 37—High- and medium-rated woodpecker habitat is distributed throughout the central Black Hills, Northern Hills, and Bear Lodge Mountain areas. The area near Mount Rushmore also contains a good quantity of high-rated woodpecker habitat.



Figure 38—The bushy-tailed woodrat (pack rat) is the lowest valued prey species found in the diets of Black Hills goshawks.

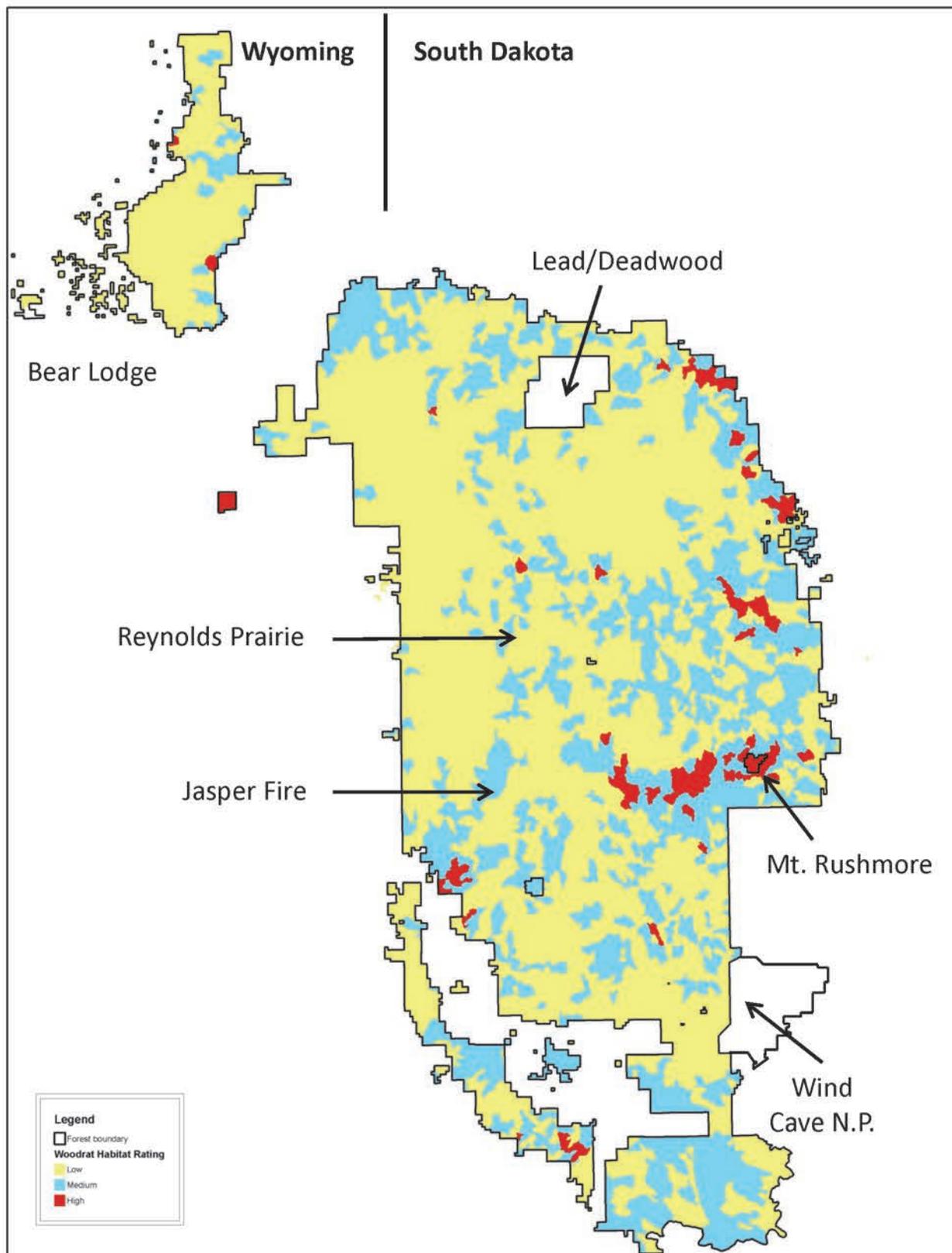


Figure 39—Very little high-rated woodrat habitat was found in the Black Hills. The exception is the area near Mount Rushmore that contains many rocky outcrops and buildings that provide habitat.

$$\begin{aligned} \text{Prey Habitat} = & \text{Tree Squirrel} \times 3 + \text{Rabbits Hares} \times 2 + \text{Turkeys Grouse} \times 2 \\ & + \text{Woodpeckers} \times 2 + \text{Forest Generalists} \times 2 + \text{Ground Squirrels} \times 2 + \\ & \text{Woodrats} \times 1 \end{aligned} \quad [\text{eq. 1}]$$

$$42 = 3 \times 3 + 3 \times 2 + 3 \times 1$$

This was the only watershed to receive this combined prey score, but several watersheds had a score of 14, indicating that the habitat in the watershed was rated low (1) for all of the prey groups. We arrayed the watersheds using the final scores and then computed the percentile distribution (see “Methods”). Using this distribution, we defined optimum, high, medium, and low prey habitats.

The Bear Lodge Mountains stand out as having a considerable amount of optimum and high-rated prey habitat, and nearly all of the remainder of the area had a medium rating for prey habitat (fig. 40). Similarly, the very southern part of the Black Hills where the prairie and the forest intermix also had a considerable amount of moderately rated habitat and a small amount of optimum and high-rated prey habitat. The area around Mount Rushmore and particularly to the west also is a conspicuous location of optimum, high-, and medium-rated habitat for goshawk prey. The Jasper Fire area and the area around Lead and Deadwood associated with fire and urban development had a large expanse of low-rated prey habitat.

Results: Goshawk and Prey Habitat

Composite scores of goshawk and prey habitat were computed by multiplying the goshawk nesting ratings by the combined and weighted prey habitat and then adding that value to the quantity of goshawk foraging multiplied by the combined and weighted prey habitat (equations 1, 2). Watershed 596, located in the southwest section of the Hell Canyon area, received the highest composite score of 234. Many watersheds received the lowest composite score of 28.

$$\begin{aligned} \text{Prey Habitat} = & \text{TS} \times 3 + \text{RH} \times 2 + \text{TG} \times 2 + \text{WP} \times 2 + \text{FG} \times 2 \\ & + \text{GS} \times 2 + \text{WR} \times 1 \end{aligned} \quad [\text{eq. 1}]$$

$$\text{Highest: } 39 = 3 \times 3 + 2 \times 2 + 3 \times 2 + 3 \times 2 + 3 \times 2 + 3 \times 2 + 2 \times 1$$

$$\text{Lowest: } 14 = 1 \times 3 + 1 \times 2 + 1 \times 1$$

$$\begin{aligned} \text{Final score} = & \text{Prey Habitat} \times \text{Goshawk Nesting} \\ & + \text{Prey Habitat} \times \text{Goshawk Foraging} \end{aligned} \quad [\text{eq. 2}]$$

$$\text{Highest: } 234 = 39 \times 3 + 39 \times 3$$

$$\text{Lowest: } 28 = 1 \times 14 + 1 \times 14$$

We arrayed the watersheds using the final scores and then computed the percentile distribution (see “Methods”). Using this distribution, we defined optimum, high, medium, and low rated goshawk and prey habitats.

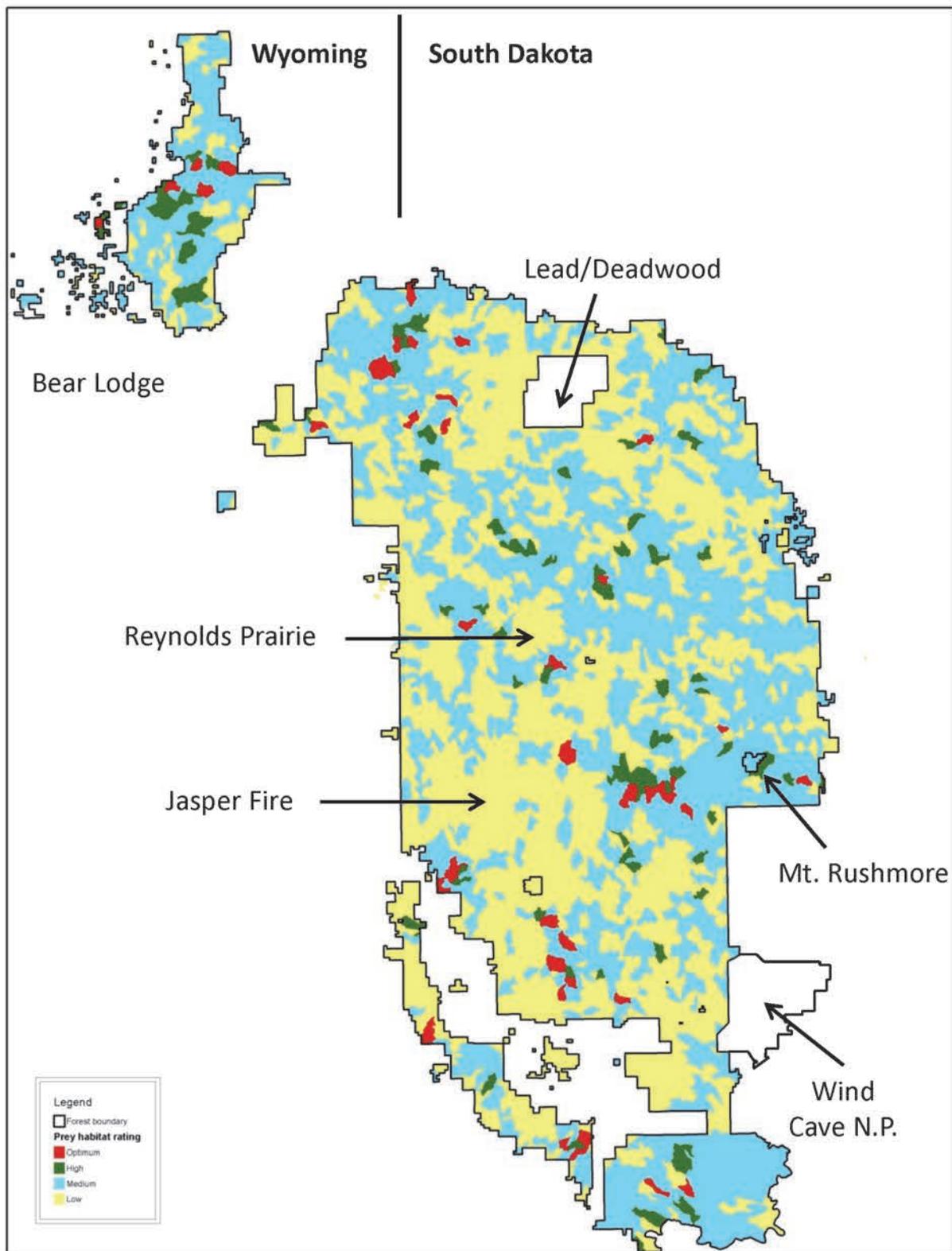


Figure 40—Tree squirrels were considered to be three times more important and the other prey were considered to be two times more important than woodrats in the diets of Black Hills goshawks. The Bear Lodge Mountains stand out as proportionally containing the most medium- and high-rated prey habitat in the Black Hills. Also, the prairie intermixed with the forests located in the southern Black Hills has abundant medium-rated prey habitat and some high-rated habitat.

Optimum and high-rated goshawk habitats are not plentiful in the Black Hills but are distributed over the extent of the Black Hills. Proportionally, the Bear Lodge Mountains have more optimum, high-, and medium-rated habitat than anywhere in the Black Hills (figs. 41 and 42). A very small amount of the Bear Lodge Mountains was rated low for goshawk and prey habitat combined. The northwestern corner of the northern Hills along the Wyoming border also contained a concentration of optimum and high-rated habitat intermixed with medium-rated habitat. Although the area near Mount Rushmore provided abundant prey habitat, its overall rating for goshawks was predominantly medium, exemplifying the importance we placed on nesting and foraging habitat in determining the goodness of a watershed related to the goshawk. Again, the Jasper Fire area contains much contiguous low-rated goshawk habitat. The forest intermixed with the prairie habitats in the southern Black Hills supplied a small and isolated amount of optimum habitat. The Jasper Fire and adjacent areas are the most conspicuous areas without high-rated or optimum habitat. Perhaps the most unique area of high and optimum habitat is the small patch located northwest of Rapid City and southeast of Nemo on the Black Hills National Forest boundary (fig. 42).

Goshawks and Their Prey in the Black Hills

More than 1.5 million acres (607,000 ha) of goshawk habitat in the Black Hills were assessed by the expert panels (table 2). The Black Hills were divided up into 3,414 watersheds that were distributed among four areas. The smallest was the Bear Lodge Mountains located in Wyoming that contained 325 watersheds covering 110,159 acres (44,580 ha) (figs. 3 and 18). Proportionally, the Bear Lodge Mountains has the largest amount of high-rated and optimum goshawk habitat (17 percent). Sixty-two percent of the Bear Lodge Mountains were rated as medium goshawk habitat and 21 percent was rated as low. Conversely, 63 percent or 360,320 acres (145,816 ha) of the southern Black Hills contained low-rated goshawk habitat (fig. 41). The Jasper Fire, which burned more than 83,000 acres (33,589 ha) in 2000, significantly diminished goshawk habitat in this area. In addition, the mountain pine beetle epidemic that is underway in the Black Hills is also converting many thousands of acres to low-rated habitat with abundant trees of all sizes being killed. However, there are 15,948 acres (6,454 ha) of optimum and highly rated habitat distributed throughout the area that could be added to the epidemic in the coming years (table 2).

Of the 3,414 watersheds in this assessment, 67 were rated optimum for goshawk habitat, 99 were rated high, 1,535 were rated medium, and 1,713 were rated low (table 2). The vast majority of the Black Hills is rated low (46 percent) and medium (48 percent) for providing goshawk habitat, with only 2 percent rated optimum and 4 percent rated high. The biggest factor in these proportions is the lack of big trees that goshawks prefer for nesting and hunting and the absence of quaking aspen that provide habitat for some important prey species (table 2).

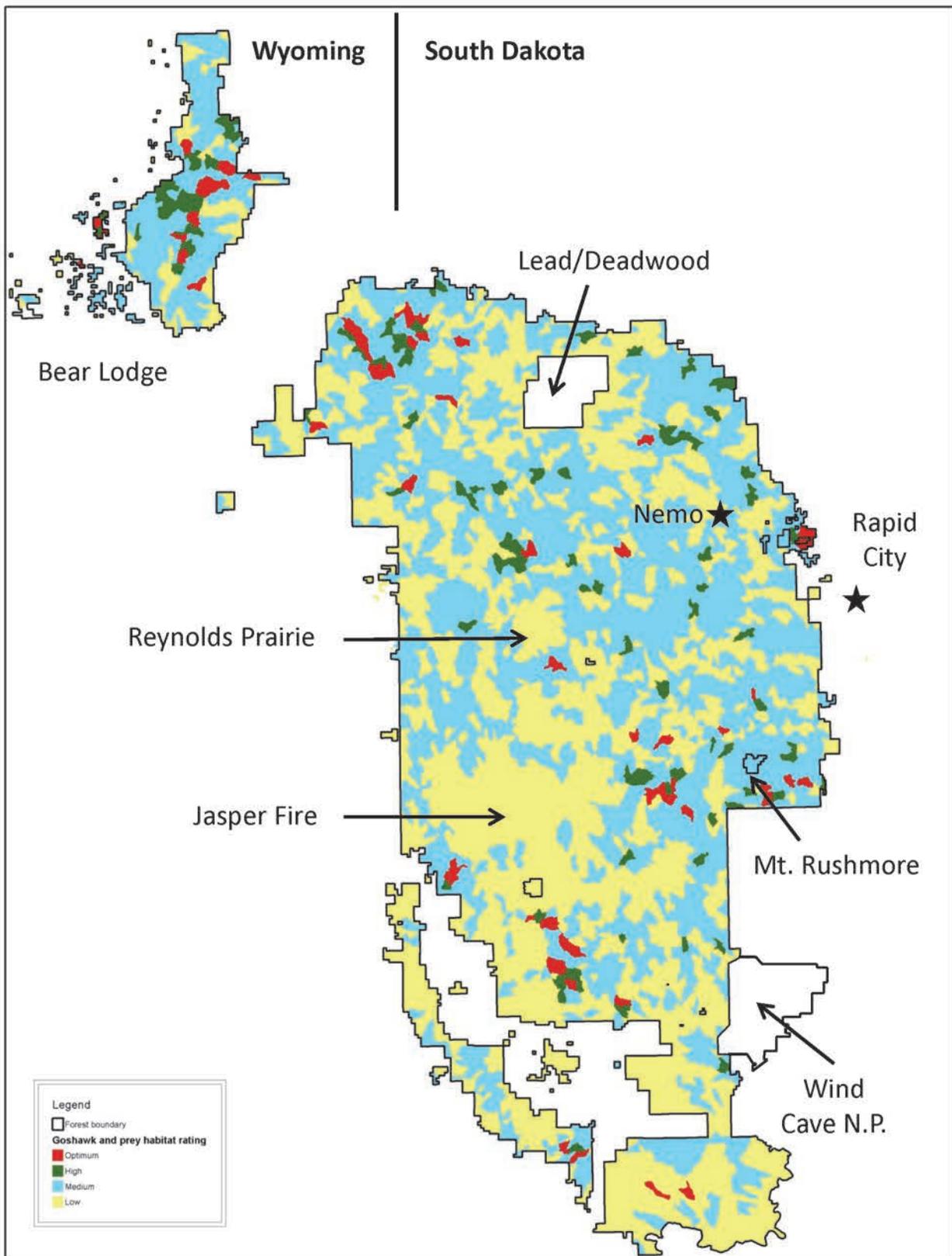


Figure 41—The area burned by the Jasper Fire located in the south-central Black Hills contained the largest area of low-rated goshawk and prey habitat combined. Proportionally, the Bear Lodge Mountains area contained the largest amount of high-rated and optimum goshawk habitat in the Black Hills. A large portion of the Northern Hills area was medium-rated for both goshawks and their prey.

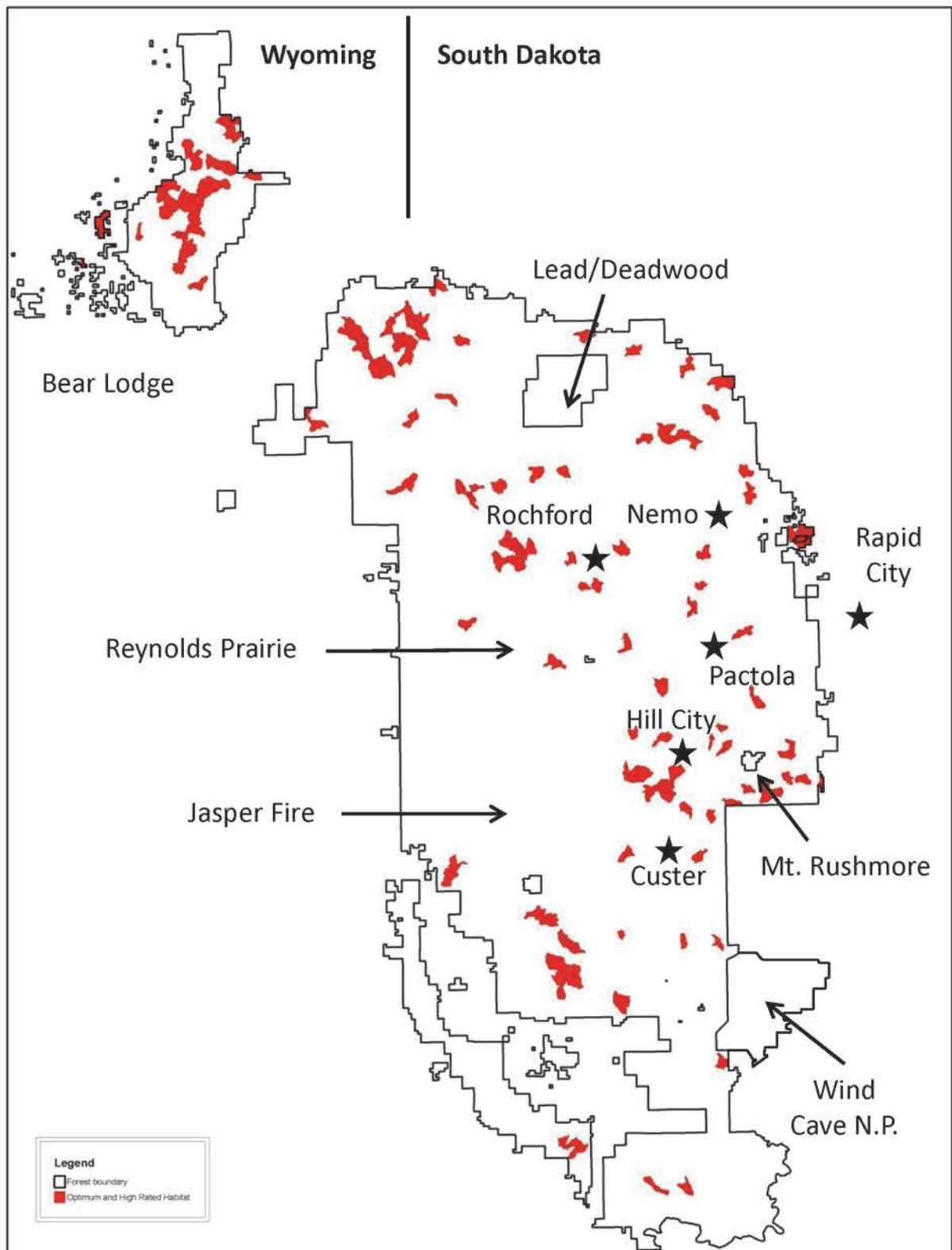


Figure 42—Except for the Jasper Fire burn area in the south-central Black Hills, optimum and high-rated *combined* goshawk and prey habitat are distributed throughout the Black Hills. Proportionally, the Bear Lodge Mountains contain the largest amount of optimum and high-rated habitat.

Table 2—The number of watersheds and number of acres of optimum, high-, medium-, and low-rated goshawk habitat occurring in the Black Hills National Forest that occurred in the different areas used in the assessment.

Area	Optimum		High		Medium		Low	
	Number	Acres	Number	Acres	Number	Acres	Number	Acres
Bear Lodge	14	7293	23	11,738	170	67,787	118	23,341
Northern Hills	15	9202	31	18,020	400	198,714	316	145,246
Mystic	20	9235	30	16,146	546	275,882	389	179,227
Hell Canyon	18	8697	15	7251	419	196,606	890	360,320
Total	67	34,427	99	53,155	1535	738,989	1713	708,134

Factors Affecting Black Hills Goshawks

Forest Management

No other national forest in the United States has had so long a history of active vegetative management as the Black Hills National Forest. Beginning with Case One in 1899 when the Homestake Mining Company purchased 15 million board feet of lumber and 5,100 cords of wood near Nemo, nearly all of the Black Hills National Forest has had some form of harvest activity (Boldt and Van Deusen 1974; Clow 1998) (fig. 43). In addition, millions of tourists come to the Black Hills each year to



Figure 43—The top photo, taken in 1938, shows a 1905 harvest. The bottom photo, taken in the early 1940s, shows a 1911 harvest with the subsequent regeneration thinned. Both photos show the wide variety of forest structure created by these early treatments.

visit destinations such as Mount Rushmore, Custer State Park, Deadwood, the Sturgis Motorcycle Rally, and Devils Tower, and to hunt and fish (Pretes 2003) (fig. 44). To provide for many of these values the Black Hills National Forest has more than 20 management areas designated for resource production, big game and resource production, with forest products, recreation, and big game production being emphasized over the largest area (fig. 45). Resource production emphasis dominates the management direction in the central and northern Black Hills with a large amount of the Bear Lodge dedicated to this activity. Depending on how and when the vegetation is manipulated (e.g., harvested, thinned, wild and prescribed fire), management may have a positive or negative impact on the habitat of the goshawk and its prey (Bull and Wales 2001; Reynolds and others 1992).



Figure 44—Millions of people come to the Black Hills each year to see Mount Rushmore, Devils Tower, and other sites, as well as to attend one of the largest motorcycle rallies in the United States.

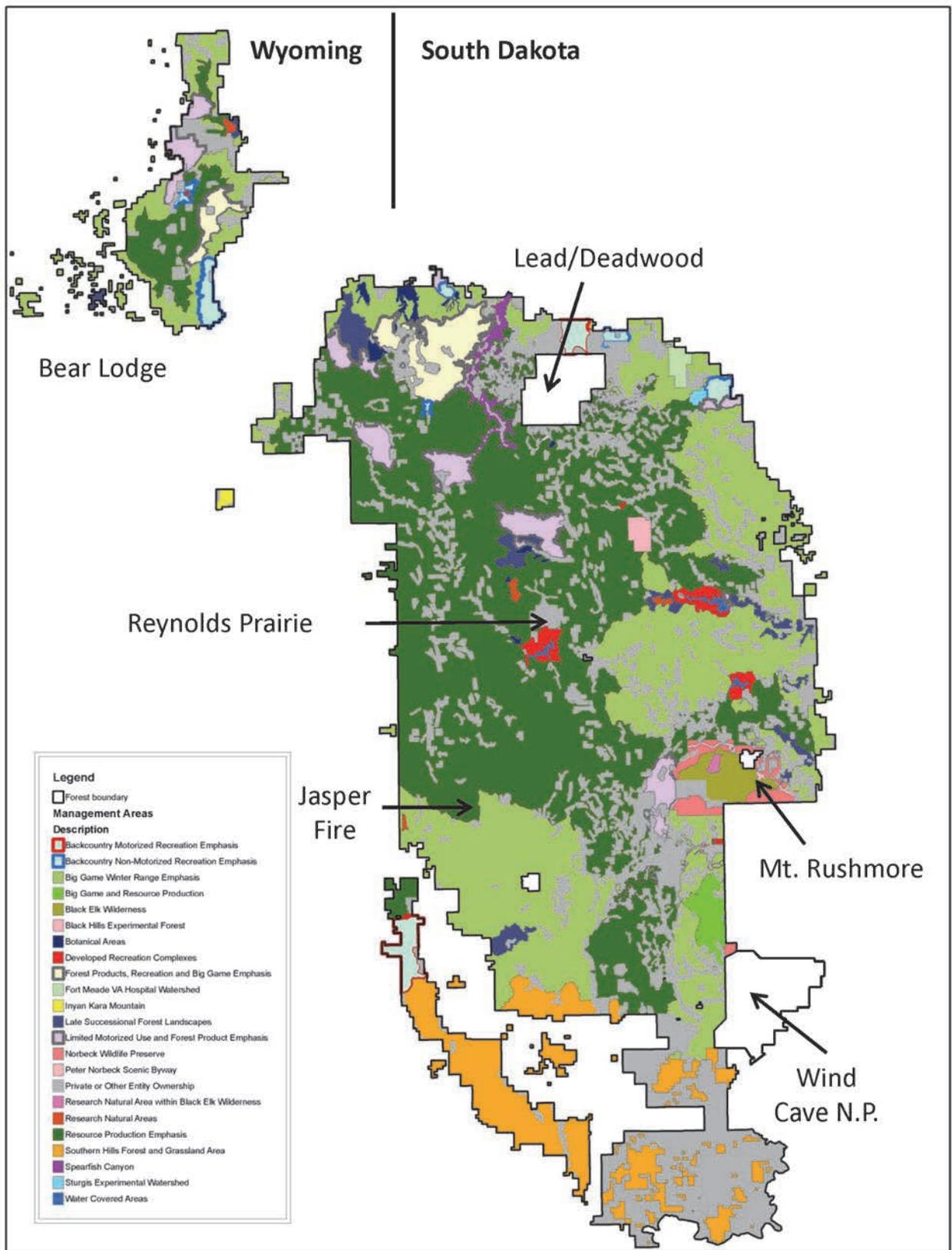


Figure 45—Map of the emphasis areas on the Black Hills National Forest. All of these management priorities potentially affect (directly or indirectly) the habitat of goshawks and their prey.

In general, the Black Hills has had a robust commercial timber harvest program for nearly a century, but as Baker (1934) stated in his silviculture text, there is an infinite number of ways in which a forest can be cut. Therefore, how these activities influenced the goshawk and its prey is uncertain, as around 200 known goshawk nests are distributed across the Black Hills. (Note: the extent to which these nests indicate numbers of breeding territories is unknown as some are clearly alternates within territories; see fig. 10). Before Case One, timber cutting practices in the black Hills entailed removing practically all trees that could produce a mine timber or a railroad tie. In response to this cutting, in 1913 Assistant Chief Forester W.B. Greeley and Assistant District (Regional) Forester C.W. Granger directed the Black Hills and Harney National Forests to adapt a conservative cutting policy using selection silvicultural systems (Newport 1954). However, such practices were not used in earnest until the early 1920s and then generally prevailed until the mid- to late-1960s (Boldt and Van Deusen 1974; Harmon 1955; Westveld 1935). These selection systems and high-risk marking were used to cover as much of the forest as possible to reduce risk and anticipated bark beetle mortality, and tended to leave a variety of forest structures (Alexander 1987; Harmon 1955; Keen and Salman 1942; Miller and Keen 1960) (fig. 46). After the 1960s a two-cut shelterwood became the standard harvesting practice that tended to homogenize stand structure, especially if associated with uniform thinnings (Alexander 1987) (fig. 47).



Figure 46—A variety of the shelterwood and selection cuttings that were used in 1911 created heterogeneous forest structures, as illustrated by these 1951 photographs.

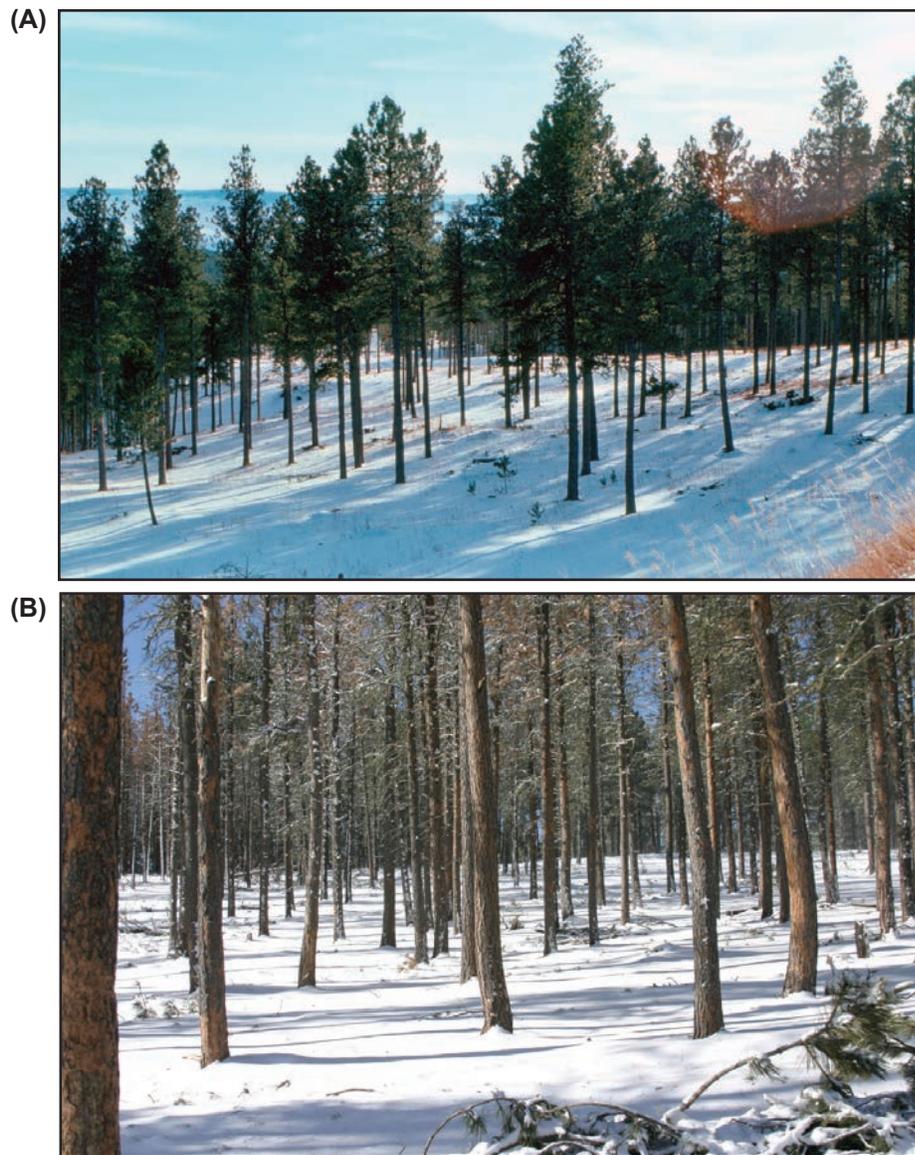


Figure 47—A shelterwood located in the Bear Lodge Mountains (A) photographed in 1975 and one on the Mystic Ranger District (B) photographed in 2006; both show uniform tree spacing.

Timber management activities, especially those that cause forest fragmentation, create uniform and monotypic forests, increase the extent of young forests, and reduce tree species diversity have been considered threats to goshawk habitat (Kennedy 2003; USFWS 1998). Forest conditions favored by goshawks, especially nest area characteristics, have been frequently described, but little information is available on how timber management directly impacts goshawk populations (Kennedy 2003; Reynolds and others 1992; Squires and Reynolds 1997). One of the limitations of studies investigating the effects of timber harvest on goshawk breeding habitat is that few studies have investigated goshawk habitat in forests not managed for timber harvest. However, some magnitude of forest change may cause goshawks to abandon nests, leave a

territory, fail to lay eggs, or fail to return to a territory (Reynolds and others 1992). By far, the best documented impact of tree harvests on goshawk breeding comes from the removal of nest trees, snags, downed wood, forest canopy, and entire nest areas (Beier and Drennan 1997; Bright-Smith and Mannan 1994; Crocker-Bedford 1990; Reynolds 1989; USFWS 1998; Woodbridge and Detrich 1994). However, Penteriani and Faivre (2001) found no difference in productivity of goshawk pairs reproducing in unlogged versus logged nesting stands during a long-term study (1984 to 1995 in Italy and 1993 to 1999 in France). When considering the same nest stand before and after timber harvest, the authors noted no short-term differences in productivity. Nonetheless, it was observed that 87.5 percent of goshawk pairs nesting in logged stands moved away only when the original stand canopy cover was altered by >30 percent. Even then, they moved only to the nearest neighboring mature stand suggesting goshawks will tolerate some levels of timber harvesting within the nest stand and may move to alternate nests areas if available.

Studies of goshawk habitat relations conducted on timberland may reflect the history of timber harvest in those areas. Finn and others (2002) using lands within Olympic National Park (Washington) as well as adjacent managed forest lands documented that loss of mature forest was detrimental to goshawk site occupancy and productivity in this area. Widén (1997) suggested that changes from selective cutting to clearcutting, replanting, and thinning in Finland and Scandinavia (Fennoscandia) from the 1950s to the 1980s are a result of changes in forest management practices that have altered goshawk foraging areas in this region. As a result of this intensive management, the boreal forest landscape of Fennoscandia is a highly fragmented patchwork of clearcuts and forest stands in different successional stages, and the proportion of old-growth forest has declined dramatically (<5 percent of Swedish forests are old-growth). Widén developed a cogent argument that suggests this landscape change has caused goshawk declines by reducing the availability of foraging habitat not nesting habitat. Goshawks can successfully nest in small patches of mature or old-growth forest (as small as 1 acre [0.4 ha]), but their foraging ranges cover 5,000 to 15,000 acres (about 2000 to 6000 ha), and in boreal forest in Europe they prefer large patches of mature forest for hunting. Widén suggested that changes in the boreal landscape have resulted in a deterioration of goshawk hunting ranges, making it more difficult for them to secure adequate food for breeding. This factor is probably more important than a shortage of nest sites. He also noted that declining prey densities (e.g., forest grouse and medium-sized mammals) may be associated with timber management, which would negatively affect goshawk numbers. As such, we know goshawk reproduction is influenced by prey availability (Byholm and others 2002; Lindén and Wikman 1980; Ranta and others 2003; Salafsky and others 2005, 2006; Tornberg 2001); the degree to which forest management in North America positively or negatively influences prey abundance and availability is not well documented.

Another factor in forest management is the potential for human activity to adversely impact goshawk nesting success (Squires and Reynolds 1997). Given the attraction to the Black Hills beauty and recreational opportunities, many people wish to live permanently or have seasonal residences in the area (fig. 48). As such, the majority of the South Dakota portion of the Black Hills is considered to be within the



Figure 48—Both summer and permanent homes are distributed throughout the Black Hills.

Wildland-Urban Interface (WUI) (fig. 49). The exception to the concentration of WUI lands in South Dakota is the Bear Lodge Mountains in Wyoming, which have few WUI lands.

Bark Beetles

Mountain pine beetles (*Dendroctonus ponderosae*) are capable of severely affecting the forests of the Black Hills (fig. 50). The beetle has been an endemic (local, small-scale) disturbance in the area as long as records have been kept; between 1895 and 1910 beetle epidemics (large scale) killed between one and two billion board feet of timber (Boldt and Van Deusen 1974; Newport 1954). In the 1930s and 1940s, bark beetle epidemics occurred in various locales throughout the Black Hills, and in the 1960s and 1970s, the northern Hills experienced a severe outbreak (McMillin and Allen 1999). Beginning in earnest in 2000, the central Black Hills has been experiencing a major epidemic of mountain pine beetles with major levels of tree mortality occurring from the vicinity of Mount Rushmore north nearly to Lead and Deadwood (fig. 51). Several areas rated as high or optimum goshawk habitat have been considerably impacted by beetle mortality (figs. 52 and 53). However, optimum and high-rated habitat in the Bear Lodge Mountains, northwestern, and southern Black Hills areas have not yet affected by beetles.

Stands with greater than 110 ft²/acre (25.3 m²/ha) of basal area and containing trees between 8 and 12 inches (20 and 30 cm) DBH, which typify many of those set aside for goshawk nesting, appear to be highly susceptible to bark beetles. This is especially true when beetle populations are at epidemic levels, as they were in 2013 in many places in the Black Hills. Also during high beetle populations, trees of all sizes become susceptible to beetle attack (Negrón and others 2008; Schmid and Mata 1992).

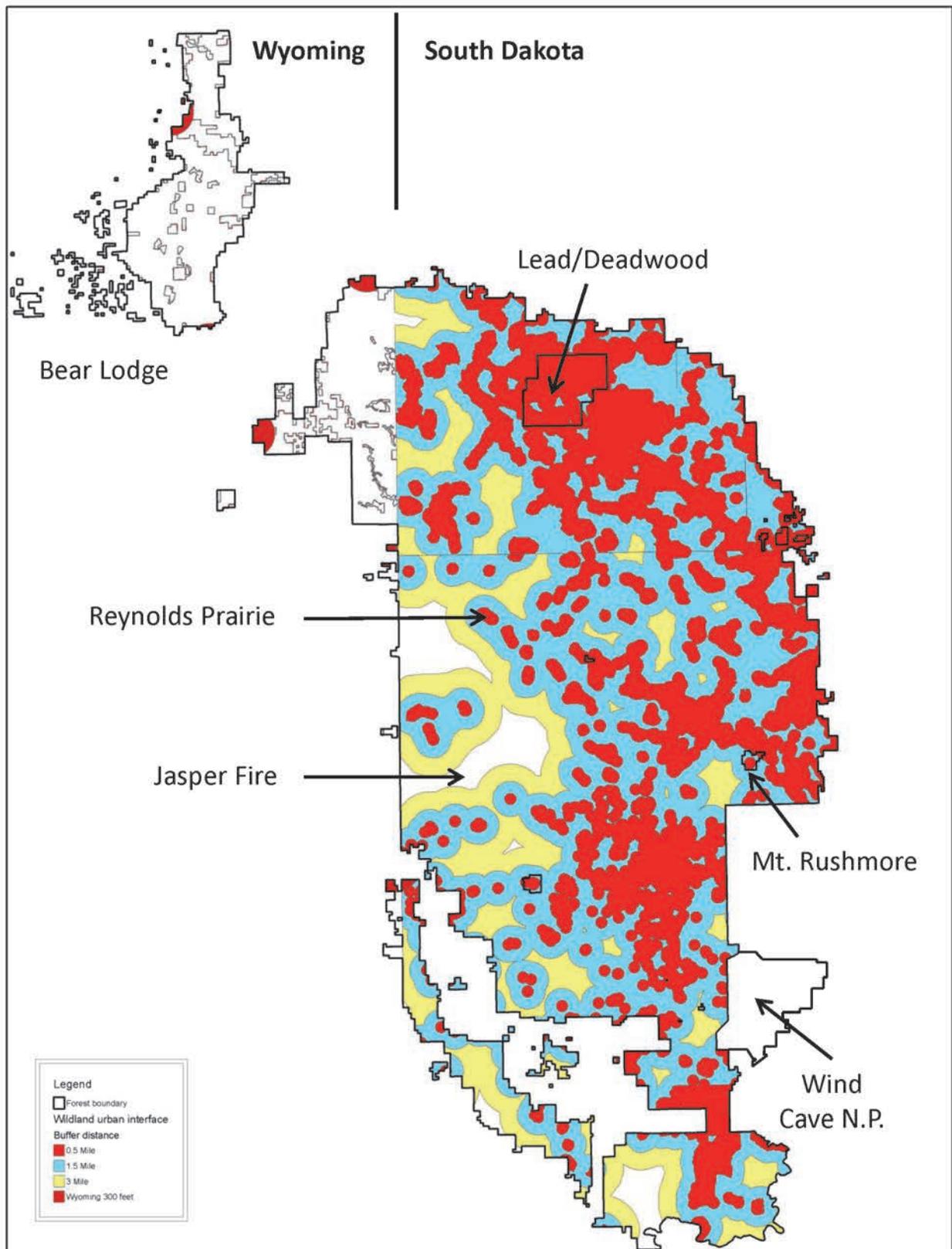


Figure 49—The eastern half of the Black Hills contains a number of homes, towns, camps, and tourist attractions, exemplifying the large amount of wildland-urban interface (WUI) lands that occur in the Black Hills. Within Wyoming, they were defined as being within 300 feet of a dwelling; and in South Dakota, the distances defining WUI were 3 miles (yellow), 1.5 miles (aqua), and 0.5 miles (red).

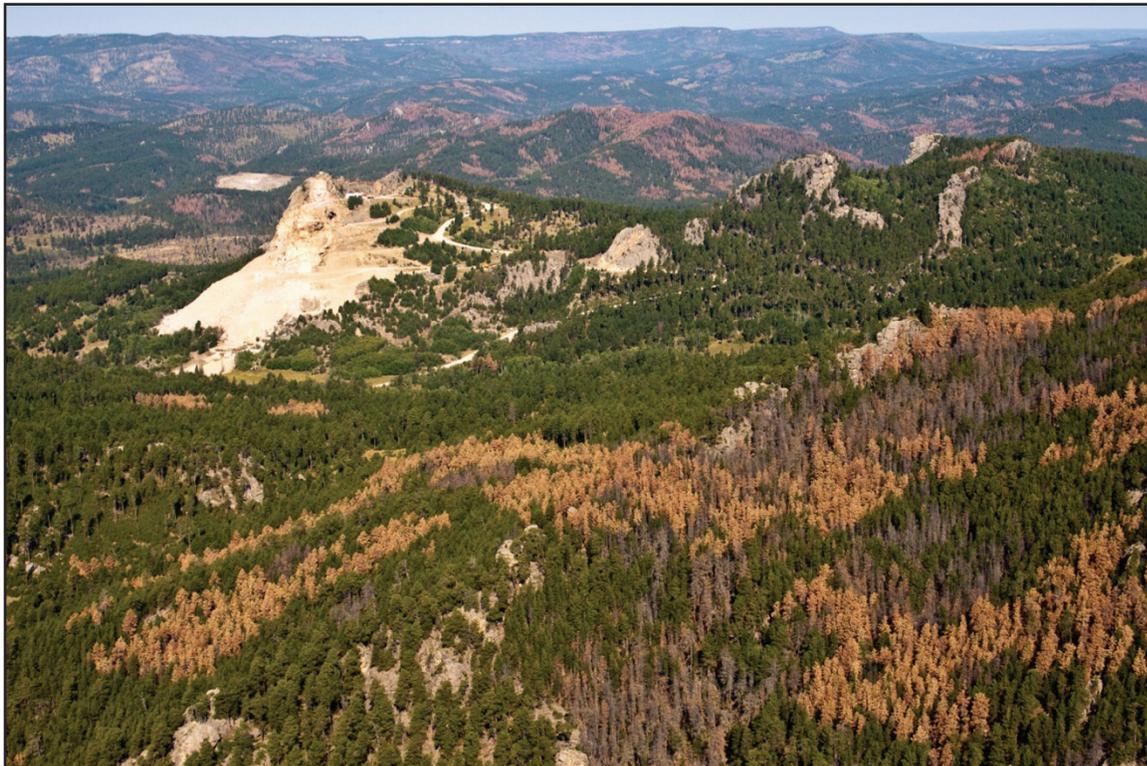
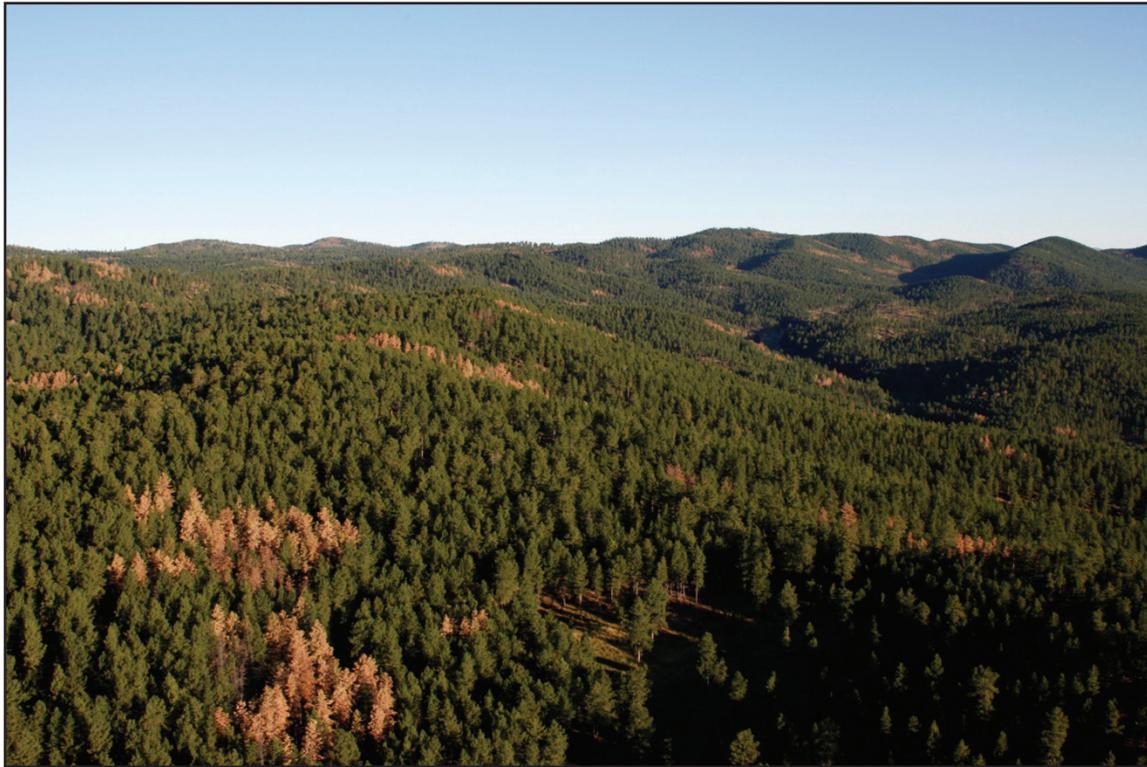


Figure 50—Mountain pine beetles have been an endemic (low level) and epidemic (wide spread) disturbance in the Black Hills since the reserve was first surveyed by Graves in 1898.

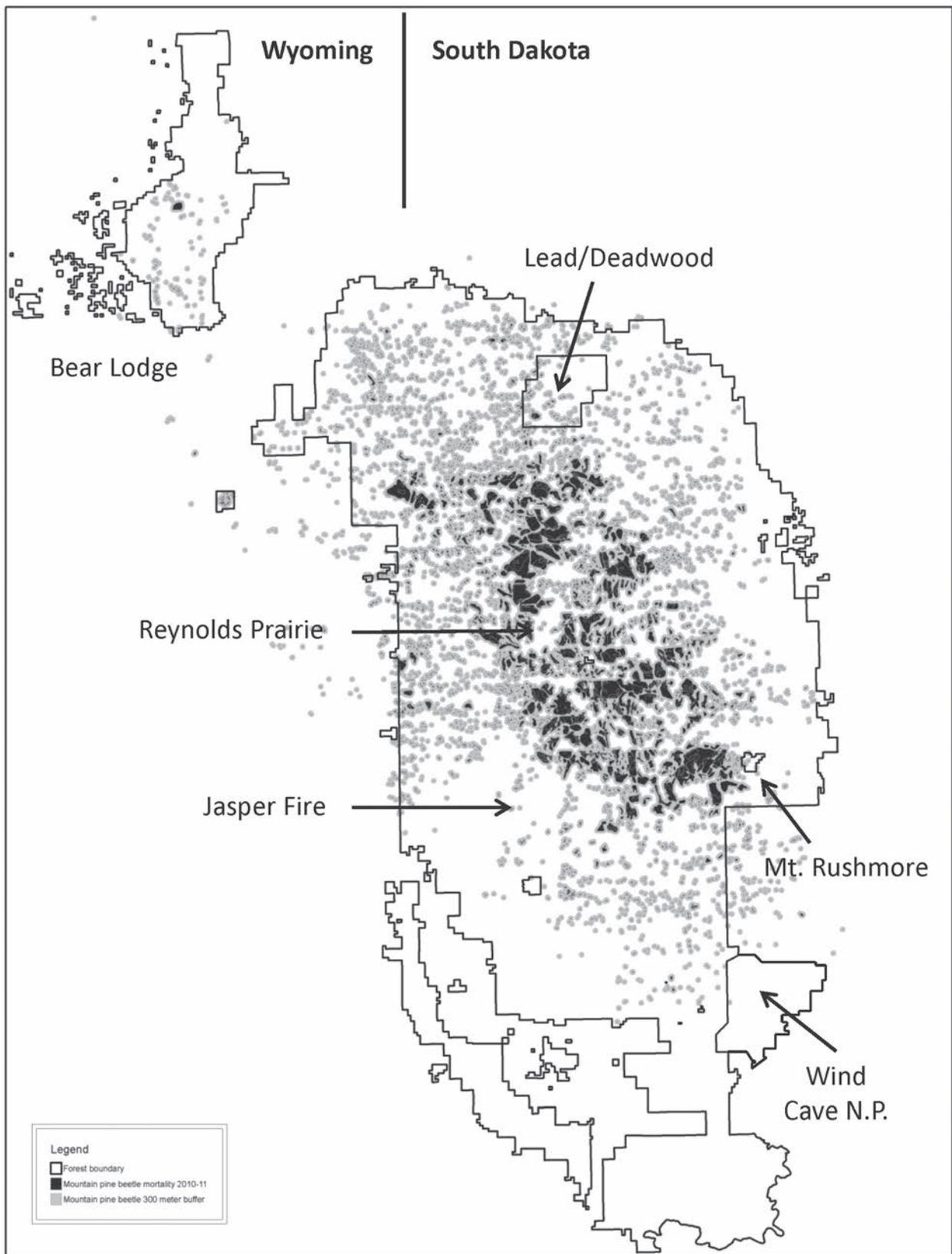


Figure 51—Existing mountain pine beetle mortality (1996–2011) is shown in black, surrounded by a grey 300-m buffer that is at high risk for infestation. The central Black Hills is at particularly high risk for mountain pine beetle activity.

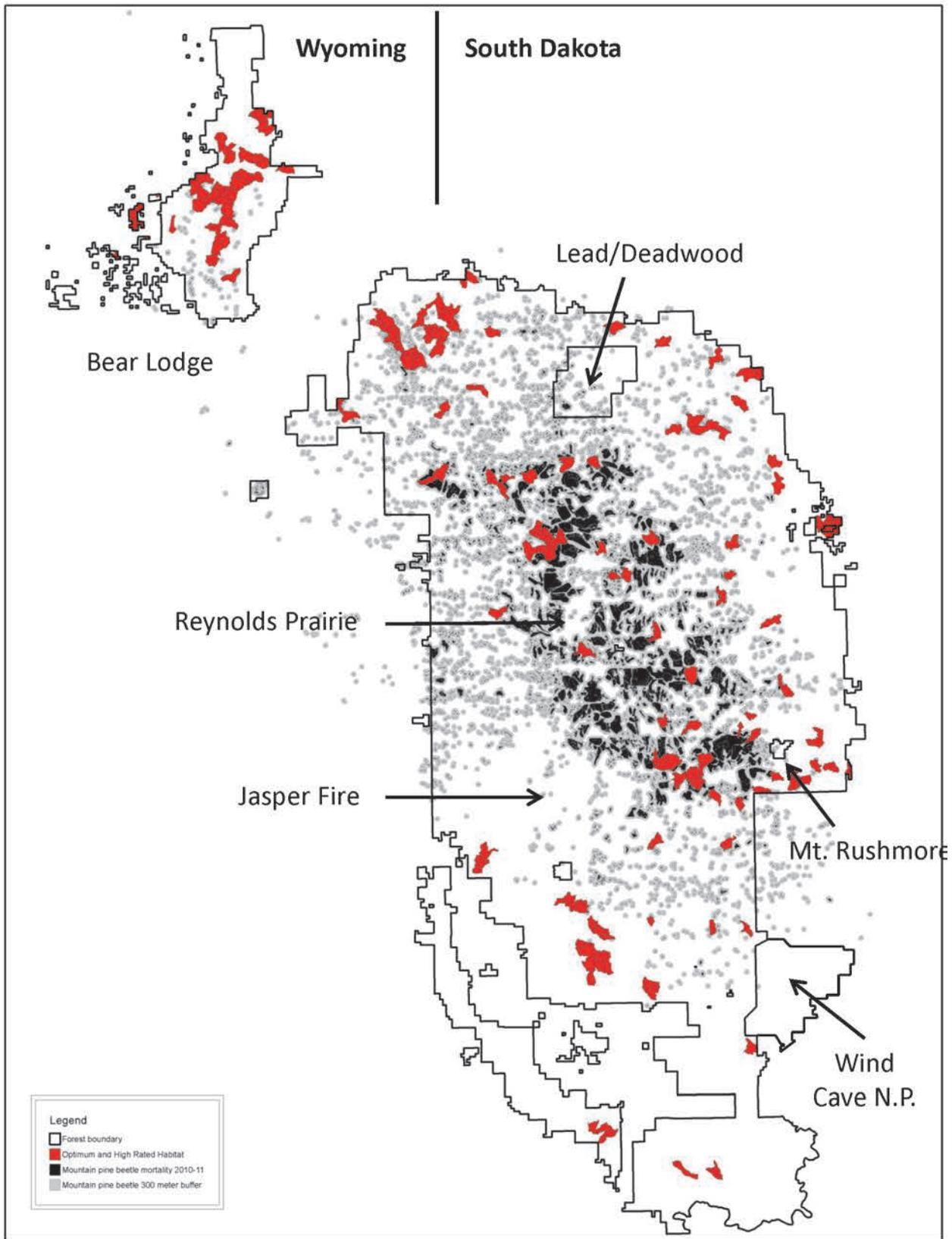


Figure 52—Several watersheds that were rated as optimum and high for goshawk habitat are either at risk or have been lost to mountain pine beetles.



Figure 53—Many goshawk nest areas, including the nest and surrounding trees, are being severely damaged by bark beetles in the Black Hills.

As stated previously, a variety of partial cutting strategies used for several decades throughout the Black Hills tended to leave heterogeneous forest structures, especially with trees larger than 10 inches (25.4 cm) DBH. But the homogenization of Black Hills forests in the last 50 years may have contributed to the aggressive nature of the 2000–2015 beetle epidemic (Bentz and others 2009; Shepperd and Battaglia 2002). For example, even stands that have some uneven-aged qualities still have small ranges in diameters (as reported by Negrón and others [2008]) where the mean diameter was 8.3 inches (21.1 cm) DBH with a standard error of 0.28 inches (0.7 cm).

Wildfire Hazard

A large portion of the Black Hills is considered very high risk for uncharacteristically severe wildfire (fig. 54). The two notable exceptions are where the Jasper Fire burned and the mixture of forest and prairie on the southern edge of the national forest. The very high hazard areas are intermixed with high and moderately high fire hazard areas. One could infer that a wildfire would tend to be mixed in its severity, but the Jasper Fire provides evidence that under high and extreme burning conditions, most of the Black Hills would be prone to severe crown fires (fig. 55). This, combined with the bark beetle and WUI threats to the forests, means there is considerable potential for loss of goshawk habitat in most of the Black Hills.

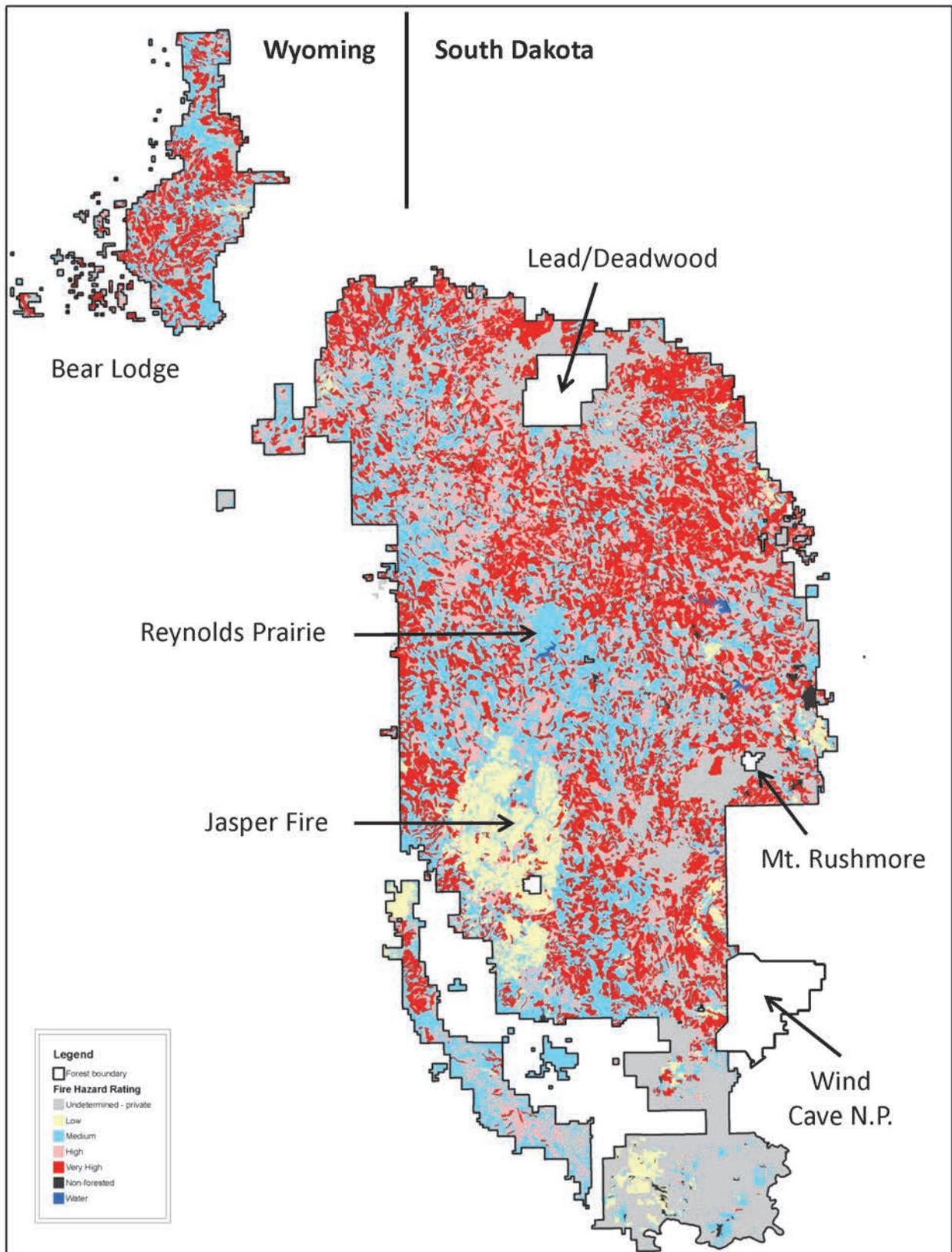


Figure 54—With the exception of the far southern Hills and the area where the Jasper Fire burned most of the Black Hills is at high risk for stand replacing wildfires (high shown in red).



Figure 55—Wildfires present a risk to the goshawk and its prey, as exhibited by the Red Point of 2003 (A) and Jasper Fire of 2000 (B).

Predation, Competition, and Disease

Predation

Although goshawks are top level predators, they become prey for other predators. Typical bird predators include great horned owls (*Bubo virginianus*), red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), and bald eagles (*Haliaeetus leucocephalus*). Tree climbing mammals such as pine martens (*Martes americana*) and bobcats (*Lynx rufus*) can prey on goshawks in the nest, and coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) can prey on fledglings when they are on the ground (Patla 1990).

Great-horned owls are probably the most important bird predator that goshawks encounter because of their killing capacity and abundance (Craighead and Craighead 1969; Reynolds and others 2006b) (fig. 56). Not only do they kill and consume nestlings and fledglings, but they also prey on adults (Boal and Mannan 1994; Crocker-Bedford 1990; Moore and Henny 1983; Rohner and Doyle 1992; Woodbridge and Detrich 1994). Territories of goshawks often overlap with those of great-horned owls, and because great-horned owls fledge their young while goshawks are still incubating, goshawks become particularly vulnerable to predation by the owls. Great-horned owls have also been known to prey on adult goshawks during the winter (Boal and others 2005). Similarly, a bald eagle in Wyoming killed a male goshawk as it was foraging in cottonwood trees along a river (Squires and Ruggiero 1995).

Goshawks in the Black Hills undoubtedly encounter great-horned owls, but the extent of the impact on goshawk populations there is unknown. During 7 years of goshawk surveys in the Black Hills, 22 percent (4 of 18) of nest failures were attributed to predation by great-horned owls or red-tailed hawks (Knowles and Knowles 2009). A similar loss of goshawks (18 percent) was attributed to bird predators in Minnesota (Boal and others 2005). Goshawk predation by great-horned owls in the Black Hills likely depends on owl abundance. A 2009 survey, designed to detect great-horned owls in the Black Hills, found that 47 percent of the routes surveyed contained owls, indicating they were widespread but less abundant than expected (Drilling 2010).

The number of goshawks taken by predators during the nesting seasons may be related to prey abundance (Crocker-Bedford 1990; Moore and Henny 1983; Rohner and Doyle 1992; Woodbridge and Detrich 1994; Zachel 1985). When prey abundance is low, females spend more time away from the nest hunting, thereby leaving the fledglings unprotected. When prey is abundant, as in supplemental feeding experiments, females tend to have higher nest attendance compared to unfed females (Rohner and Doyle 1992; Ward and Kennedy 1994; Zachel 1985).



Figure 56—Great horned owls are perhaps the most abundant predator that goshawks encounter. The two species also compete for nest habitat and prey.

Pine marten were reintroduced to the Black Hills (1980s) and are potential predators of nesting and wintering goshawks (Paragi and Wholecheese 1994). However, their potential impact on goshawks is low as there are few individuals and their distribution is limited to mature white spruce forests and riparian habitats in the northern Hills (Fecske and others 2002). There is evidence that under certain conditions, goshawk populations can be impacted by predation to an extent sufficient to limit populations. For example, during the early 1970s, goshawk populations in Wisconsin were increasing, but by the 1980s, nest failures from fisher (*Martes pennanti*) predation were affecting the population (Erdman and others 1998). If predation is limiting goshawk population abundance, it is likely to be site- and predator-specific and temporally and spatially variable.

Competition

Goshawks compete with other goshawks (intraspecific competition) for nesting and foraging habitat. Goshawks are very territorial, meaning they will defend a territory from use by other goshawks (Newton 1979; Reynolds and others 1992, 2006). As such, territoriality places a limit on the number of goshawks breeding within an area, which can affect populations (Reynolds and others 2006b). Defensive behavior allows an individual or nesting pair to secure the necessary prey, nest area, roost sites, and water for survival. However, to exploit good foraging opportunities, goshawks may use areas outside their defended territory and may even share these areas with other goshawks (Hargis and others 1994). In addition, territoriality can be a major determinant of nest locations, although the distribution of good and poor habitat, based on forest structure, usually determines nest locations within a territory (Reich and others 2004). When landscapes are saturated with breeding goshawks, competition for nest sites may result in a surplus of non-breeding “floater” hawks. These individuals are forced into non-breeding status and must wait for a territory vacancy resulting from a goshawk death or an individual leaving the area. Thus, non-territorial individuals act to stabilize local and regional populations through local recruitment and immigration from more distant populations.

Male goshawks are smaller than females and are the primary hunters during most of the breeding season (fig. 57). This reverse size dimorphism may have evolved to increase foraging efficiency of males and nest protection abilities of females, but also serves to reduce competition for prey between males and females (Reynolds 1972; Newton 1979). It is theorized that this trait allows the smaller males to capture the smaller prey that are more abundant, especially during the spring and summer. Larger females are better able to defend nests, produce large eggs, incubate a brood, and take larger prey during the non-breeding season. Therefore, by exploiting different prey resources the competition between pairs of goshawks is reduced.

Goshawks compete with other owls and hawks for nest sites. This interspecific competition frequently occurs with red-tailed, Cooper’s, and sharp-shinned hawks along with great-horned owls (figs. 56 and 58). These other raptors often use nests that were built by goshawks, forcing the goshawks to switch to, or build, an alternate nest within their territory. These other raptors also exhibit territorial behavior that could limit the use of an alternate goshawk nest by one of their own species. Different nesting preferences by the competitors also reduce the frequency of goshawk nests being usurped.



Figure 57—Male goshawks are smaller than females (reverse dimorphism) that favor the female staying and protecting the nest while the smaller male, using minimal energy, can feed the family.



Figure 58—Cooper's hawk, a close relative of the goshawk, can use goshawk nests and compete for the same prey.

For example, goshawks typically nest in relatively dense habitats on slopes or in drainage bottoms while red-tailed hawks prefer to nest in open habitats or on ridge tops (La Sorte and others 2004; Reynolds and others 1982). Additionally, great-horned owls are habitat generalists that typically nest in fragmented landscapes, but are often relatively common in more open ponderosa pine forests (Houston and others 1998).

Interspecific competition for prey occurs particularly with great-horned owls, other hawks, and small carnivores such as the weasel, pine martin, bobcat, coyote, and red fox (fig. 59). Red-tailed hawks prey on rabbits, squirrels, woodpeckers, and grouse and are the most abundant raptor in the Black Hills making them one, if not the greatest, competitor of the goshawk for prey (Panjabi 2003; White and others 2010). However, the wide diet niche of goshawks (Reynolds and Meslow 1984) affords them some buffer against competition. Where prey is limited to a few species (e.g., snowshoe hare and grouse), wintering goshawks may respond to prey reductions and presumed increased competition by moving to areas where prey are more diverse and perhaps more abundant. This interspecific competition can affect the survival of individuals or goshawk reproduction and can limit goshawk population sizes (Birch 1957).



Figure 59—Red-tailed hawks and coyotes are two of the many predators that hunt much of the same prey as goshawks.

Bacterial and Parasitic Diseases

Like all birds, goshawks are susceptible to disease caused by bacteria, fungi, viruses, and parasites. The distribution and abundance of disease agents vary by season, habitat, and region. In many cases, infections in individual raptors, or their local population, depend on the distribution and abundance of disease and how they are transmitted (e.g., mosquitos, flies, and infected prey).

Bacterial infections are probably the most important disease affecting raptors. Wild hawks acquire most bacterial infections through direct transmission from infected prey, which include gregarious wild birds (e.g., pigeons, doves, starlings, sparrows, and water birds), scavengers (crows), and domestic poultry. Bacterial infections can be transmitted between adult and nestling goshawks, and, in some cases, by insects. Infectious bacterial diseases found in raptors include avian cholera (*Pasteurella multocida*), erysipelas (*Erysipelothrix rhusiopathiae*), chlamydiosis, mycoplasmosis (*Mycoplasma* spp.), botulism, and avian tuberculosis (*Mycobacterium avium*). Contaminated bird feeders are important sources of *Salmonella* and mycoplasmosis infection from forest generalists, jays, and woodpeckers. Waterfowl can become sickened with avian cholera when lake water is contaminated. Most bacterial diseases are transmitted through direct contact with infected individuals, objects, dirt, or water.

Disease-causing fungal agents are normally present in a goshawk's environment, and disease usually results when a goshawk becomes immunosuppressed or otherwise stressed (Friend and Franson 1999). Aspergillosis (*Asperigillus* spp.), a fungal infection affecting the respiratory tract, was more common (53 percent) in migrating goshawks during an invasion year compared to a non-invasion year (7 percent), suggesting that stress increases a goshawk's susceptibility to infection (Redig and others 1980; Squires and Reynolds 1997). Inhalation is the primary route for *Asperigillus* infection.

As with bacterial diseases, viruses are transmitted to raptors when they feed on infected prey, through insect vectors, or through contact with contaminated surfaces. Viral diseases include avian leukosis sarcoma, Newcastle disease, West Nile virus, bronchitis, laryngotracheitis, avian pox, and herpesvirus. In Minnesota, West Nile virus caused death in wild and captive goshawks, but the threat to wild goshawk populations in the western United States may be lower because of the low abundance of mosquitos at elevations over 5,700 ft (1737 m) (Eisen and others 2008; Hull and others 2010; Wünschmann and others 2005). Raptors can, however, become infected with West Nile virus from eating infected prey making fledgling and adult goshawks that move to lower elevation habitats in late summer more susceptible to infection (Komar and others 2003).

Parasites are probably more common in goshawks than the aforementioned pathogens, and the physical costs associated with their infection can range from negligible to fatal (Newton 1998). For instance, a goshawk infested with parasitic worms may not feel the effects as long as prey is not limited. When prey becomes limited, goshawks with significant parasite loads will be more susceptible to starvation than those with milder infections. Intestinal parasites influence physical condition, affecting molt and overall energy levels. Goshawks become infected with intestinal roundworms (*Ascarida galli*, *Capillaria* spp., and *Serratospiculun* spp.), flat worms (Tremetodes),

and tape worms, all of which they get from prey. They can also be infected by blood parasites, including malaria (*Plasmodium* spp.), coccidia, leucocytozoon, haemoprotozoans, tripanosoma, microfilariae, and *Trichomonas gallinae*. Free ranging and falconry goshawks in Germany apparently act as final hosts for several *Sarcocystis* spp., which infect wild and domestic pigeons (Olias and others 2011). Heavy infestations of ectoparasites (e.g., fly larvae, *myiasis*, and *mallophaga* lice) usually occur in individuals already weakened by other factors (Reynolds and others 2006b; Squires and Reynolds 1997).

The importance of disease as a limiting factor to goshawk populations is unknown because diseases often predispose individuals to other mortality agents, making the determination of the ultimate cause of death equivocal (Esch 1975). However, in comparison to starvation and trauma, disease was not a significant cause of death in other raptor species (Keymer and others 1981; Redrobe 1997). Goshawks found dead in Europe indicated that starvation was the most important mortality factor followed by trauma and then combinations of starvation and disease (Kenward and others 1991; Tornberg and others 2006). The lack of strong evidence that disease limits North American and European goshawk populations combined with data from other birds, suggests that the effects of disease on goshawks are likely to be small or non-existent (Newton 1989; Reynolds and others 2006a; Rutz and others 2006). Nonetheless, disease may have its greatest impact on goshawk populations during periods of stress related to food shortages and weather when disease-weakened individuals are predisposed to a variety of mortality factors. Managing forests with considerations for intermixing habitats of both goshawks and their important prey species is a sensible plan for sustaining predator and prey populations and minimizing the frequency and degree of food shortages (Reynolds and others 1992, 2006a).

Silvicultural System Simulation for Creating and Maintaining Goshawk Habitat in the Black Hills

A silvicultural system is a planned series of treatments through the life of a forest directed at meeting forest management objectives (Baker 1934). A very important concept presented by Reynolds and others (1992; 2006a) was to create heterogeneous forests composed of up to six structural stages ranging from openings and seedlings to old vegetative complexes at both fine and landscape scales (Long and Smith 2000). Also, Reynolds and others (1992) recognized that high forest canopy cover was an essential component of goshawk habitat, especially in the older structures. As such, their canopy cover recommendations only applied to older vegetative structures, which, at a fine scale, could be less than 0.25 acres (0.1 ha) in size. This is an important concept when designing ponderosa pine forest conditions that are resilient to mountain pine beetle activity and yet capable of supporting goshawks and their prey. Depending on forest conditions—as previously stated, the majority of the Black Hills have been harvested and homogenized—it may take decades or even a century or more to create the desired conditions. Using Reynolds and others (1992) as a template, the following silvicultural system was designed to create and maintain forest conditions for the goshawk and its prey on the Black Hills Experimental Forest informed by those described by Harmon (1955) and Miller and Keen (1960). However, as Baker (1934) stated,

there is an infinite number of ways a forest can be treated, and this is only one of many that could be developed to produce goshawk habitat. The stand we selected for this example is located on the Black Hills Experimental Forest, which is about 2 mi (about 3 km) west of Highway 385 on the Rochford Road-616 and about 8 mi (about 13 km) east of Rochford, in the heart of the Black Hills (fig. 60).



Figure 60—The stand selected to simulate a silvicultural system aimed at producing and maintaining goshawk habitat was located in the northeastern portion of the Black Hills Experimental Forest.

For the most part, the Black Hills Experimental Forest received a major timber harvest in the 1980s that emulated the two-step shelterwood system that was used extensively throughout the Black Hills. In doing so, the majority of the stands have a few residual large trees overtopping an abundant amount of seedlings and saplings (fig. 61). Using actual tree data, from a harvested stand, the Forest Vegetation Simulator (FVS) projected the prescription and the Stand Visualization System (SVS) was used to display the results of the simulation (Dixon 2002) (figs. 61, 62, and 63). The “paint gun” tool available in SVS was used to identify individual trees for removal chosen by location and tree size (fig. 64). An individual irregular selection system was simulated using FVS and displayed using SVS for 100 years aimed at producing and maintaining goshawk habitat (table 3) (Graham and Jain 2005; Graham and others 2007; Reynolds and others 1992).



Figure 61—The stand used in the simulation was typical for the Black Hills (located on the Black Hills Experimental Forest) as it was harvested in the 1980s and contains abundant natural regeneration. Marked trees are to be left after a harvest.

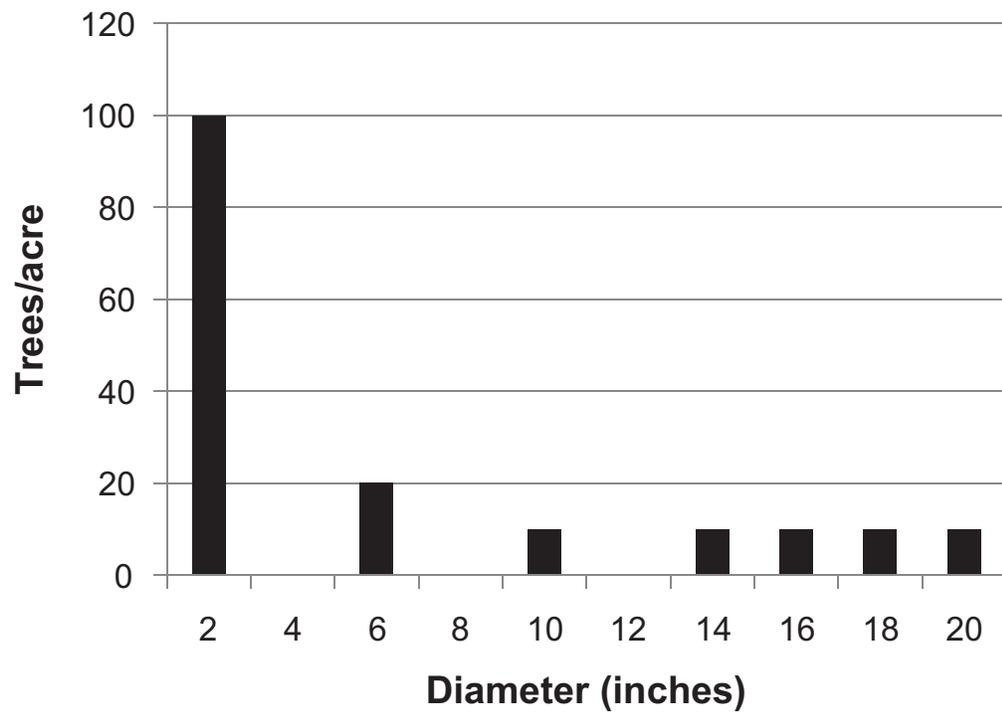


Figure 62—The diameter distribution of the stand used in the simulation located on the Black Hills Experimental Forest after the first entry (harvesting and masticating unwanted tree regeneration) of an irregular selection system aimed at creating and maintaining goshawk habitat.

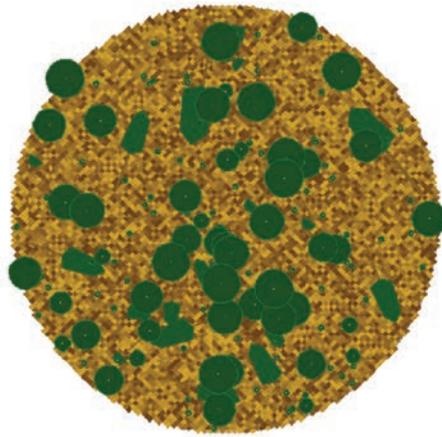


Figure 63—Actual ponderosa pine stand located on the Black Hills Experimental Forest with each tree positioned after the initial harvest (2013) using irregular selection to create and maintain northern goshawk habitat displayed using the stand visualization system (SVS).

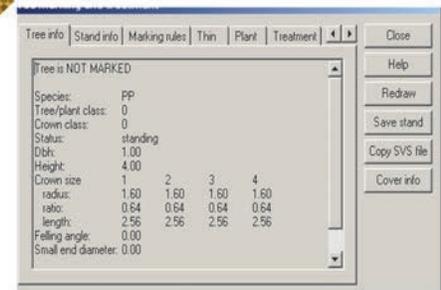
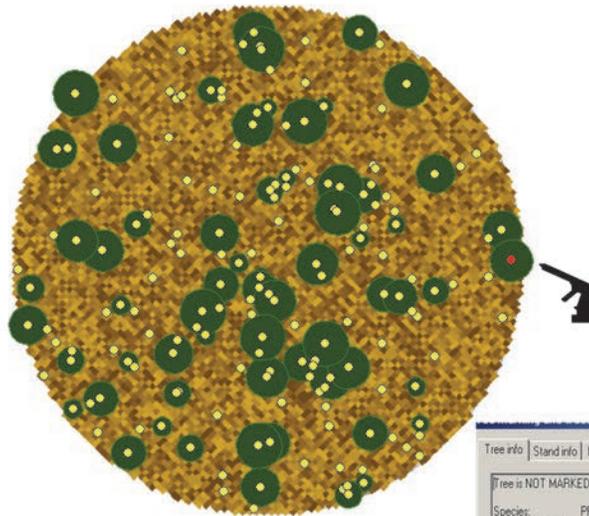


Figure 64—The Forest Vegetation Simulator (FVS) and the Stand Visualization System (SVS) were used to simulate forest treatments for 100 years to create and maintain goshawk habitat. The paint gun in SVS was used to locate actual trees (mapped in the field) to leave or remove in the simulation. As the paint gun points to a tree, its characteristics are displayed (see Figure 61).

Table 3—Stand characteristics of a 100-year simulation using the Forest Vegetation Simulator (FVS) for producing and maintaining goshawk habitat on the Black Hills Experimental Forest.

Year	Before treatment						Removals						After treatment					
	Trees	BA	SDI	Height	DBH	Total	Trees	Total	Merchantable	Per acre	Per acre	Merchantable	BA	SDI	Height	DBH		
	Per acre	ft ² /acre		Feet	Inches	ft ³ /ac	Per acre	ft ³ /acre	ft ³ /acre	BF/acre	BF/acre	ft ² /ac		Feet	Inches			
2013	170	74	142	64	8.9	1987	17	153	117	600	9300	66	127	64	8.9			
2023	150	71	134	65	9.3	1991	28	0	0	9366	9366	71	128	65	10.3			
2033	120	75	134	65	10.7	2133	6	196	175	10282	10282	68	122	62	10.4			
2043	112	72	128	63	10.9	2060	36	7	0	10019	10019	71	117	63	13.1			
2053	74	75	121	63	13.6	2166	0	0	0	10676	10676	75	121	63	13.6			
2063	73	78	125	64	14.0	2275	2	166	153	11343	11343	73	117	62	13.8			
2073	69	76	121	63	14.2	2216	3	332	309	11194	11194	66	108	58	13.6			
2083	84	70	118	59	12.4	1992	8	11	0	9960	9960	69	114	59	12.9			
2093	75	72	118	60	13.3	2081	7	186	164	10470	10470	66	108	58	13.3			
2103	67	69	111	59	13.7	1990	0	0	0	10067	10067	69	111	59	13.7			
2113	66	72	115	60	14.2	2084	0	0	0	10515	10515	72	115	60	14.2			

BA = Basal area.

SDI = Stand density index.

DBH = Diameter breast height (4.5 ft).

BF = Board foot.

Following is an outline of the 100-year simulation by decade, beginning in 2013:

- 2013:
 - Through mastication, all but 100 trees/acre (247/ha) of the regeneration were removed.
 - Seventeen saplings and pole-sized trees per acre (42/ha) were removed. These trees were removed from below larger trees to reduce ladder fuels that would minimize the chance of a surface fire burning the crowns of larger trees. These trees were selected on an SVS view using the paint gun to select the tree for removal (figs. 62 through 64).
- 2023:
 - Twenty-eight saplings per acre (69/ha) were removed leaving as irregular spacing as possible to create diverse structure as the forest develops.
 - Prescribed fire was used to control the abundant regeneration.
- 2033:
 - Six trees per acre (15/ha) were removed near or on the edge of tree groups. Trees were selected using the paint gun. Even though the basal area was 75 ft²/acre (17 m²/ha), there is evidence that groups of trees can be attacked by mountain pine beetles. However, at this density the overall stand hazard to bark beetle attack is low.
 - Prescribed fire was used to control the abundant regeneration.
- 2043:
 - Thirty-six non-merchantable trees per acre (89/ha) were removed, once again picking ladder fuel trees and those that might contribute to increasing density of tree groups.
 - Prescribed fire was used to control the abundant regeneration.
- 2053:
 - Prescribed fire was used to control the abundant regeneration.
- 2063:
 - Two trees per acre (5/ha) in and near groups of trees were removed to reduce the risk of a group being attacked by mountain pine beetles even though stand density is 78 ft²/acre (18 m²/ha).
 - Prescribed fire was used to control the abundant regeneration.
- 2073:
 - Three trees per acre (7/ha) in and near groups of trees were removed to reduce the risk of a group being attacked by mountain pine beetles even though stand basal area is 76 ft²/acre (17 m²/ha).
 - Through a combination of mechanical and prescribed fire treatments, 100 seedlings per acre (247/ha) were nurtured and arranged in an irregular pattern avoiding creating ladder fuels that would risk the loss of large trees in advent of a wildfire.

- 2083:
 - Eight small trees per acre (20/ha) were removed, producing 11 ft³/acre (0.8 m³/ha). They were chosen using the paint gun to protect tree groups from wildfire and potential mountain pine beetle impact.
 - Where needed, seedlings were thinned to create heterogeneous structures involving all tree cohorts. These structures by now contain trees ranging from 2 to more than 24 inches (5 to 61 cm) DBH.
- 2093:
 - Seven trees per acre (17/ha) in and near tree groups were removed to reduce the risk of a group being attacked by mountain pine beetles even though stand basal area density is 72 ft²/acre (16m²/ha). This treatment would produce 951 board feet/acre.
 - Prescribed fire was used to control the abundant regeneration.
- 2103:
 - Prescribed fire was used to control the abundant regeneration.
- 2113:
 - Prescribed fire was used to control the abundant regeneration.

After 100 years, as displayed by SVS, the stand on the Black Hills Experimental Forest would have 66 trees/acre (163/ha), 72 ft² of basal area/acre (17 m²/ha), and 10,515 board ft/acre (table 3). Trees would average 60.0 ft (18.3 m) in height and 14.2 inches (36.1 cm) DBH. Most importantly, they would be arranged in clumps and groups with minimal ladder fuels present and high canopy cover within the larger tree clumps or groups offering tree squirrel habitat while minimizing the risk of bark beetle attack (fig. 65). Note that this prescription describes a series of treatments that can be modified as the forest develops over decades of using robust adaptive management principles (fig. 66).

There are an infinite number of ways a forest can be treated to create desired conditions, and there are an infinite number of forest conditions growing on an infinite number of biophysical settings, which often have many competing values that need to be considered if not sustained. The importance of the silvicultural system in this application is that all treatments proposed are designed to create and maintain desirable conditions for the goshawk and its prey. This vision was a direct result of the conditions articulated by Reynolds and others (1992). We recognize that these conditions have not been tested scientifically but they do reflect historical conditions as described by Pearson (1950) in the southwestern United States and as viewed by George Custer when he came through the Black Hills in 1874 (Brown and Cook 2006; Grafe and Horstead 2002) (fig. 67).

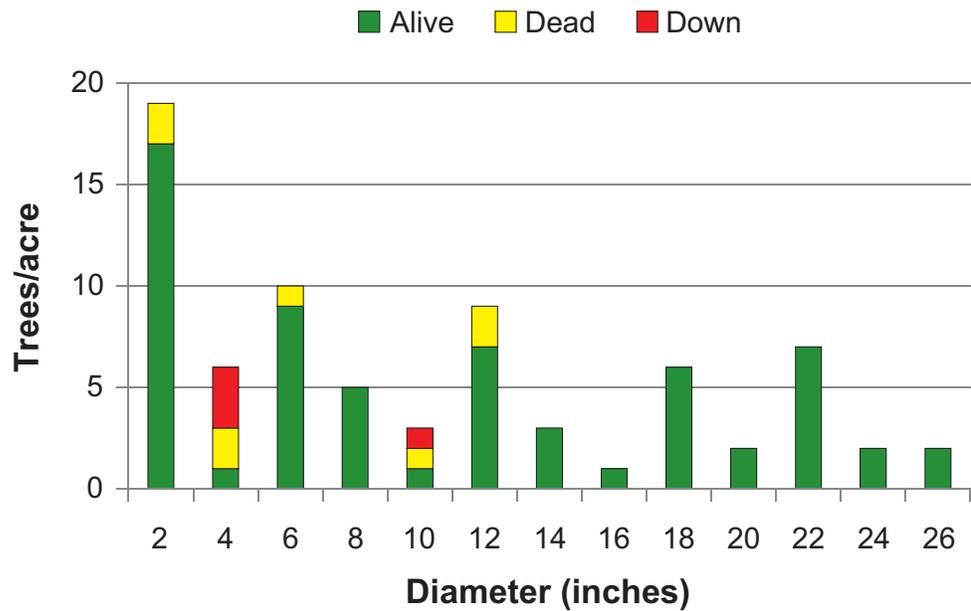
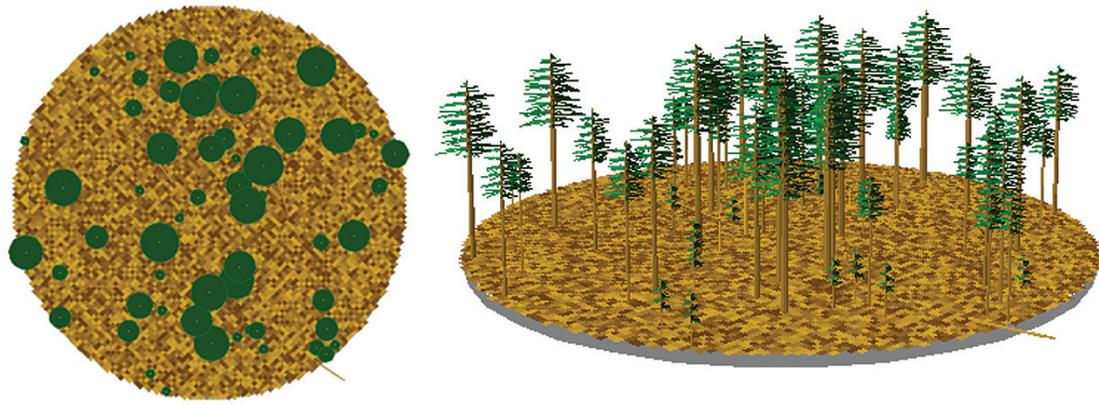


Figure 65—The resulting forest structure after a 100-year simulation of a stand located on the Black Hills Experimental aimed at creating and maintaining goshawk habitat. Note the tree diameters ranged from 2 to 26 inches and the trees, snags, and down logs are irregularly distributed.

Discussion

The habitats of goshawks and their prey in the Black Hills are highly diverse and at risk to change. Unfortunately, for the most part, both have been assessed as being low to medium quality for sustaining goshawks and their prey. With this challenge comes the opportunity to use the findings of this assessment in planning and management at multiple levels. No matter the question at hand, forest management requires some level of information such as this assessment for making informed decisions (Graham and others 2000; Kaufman and others 1994).

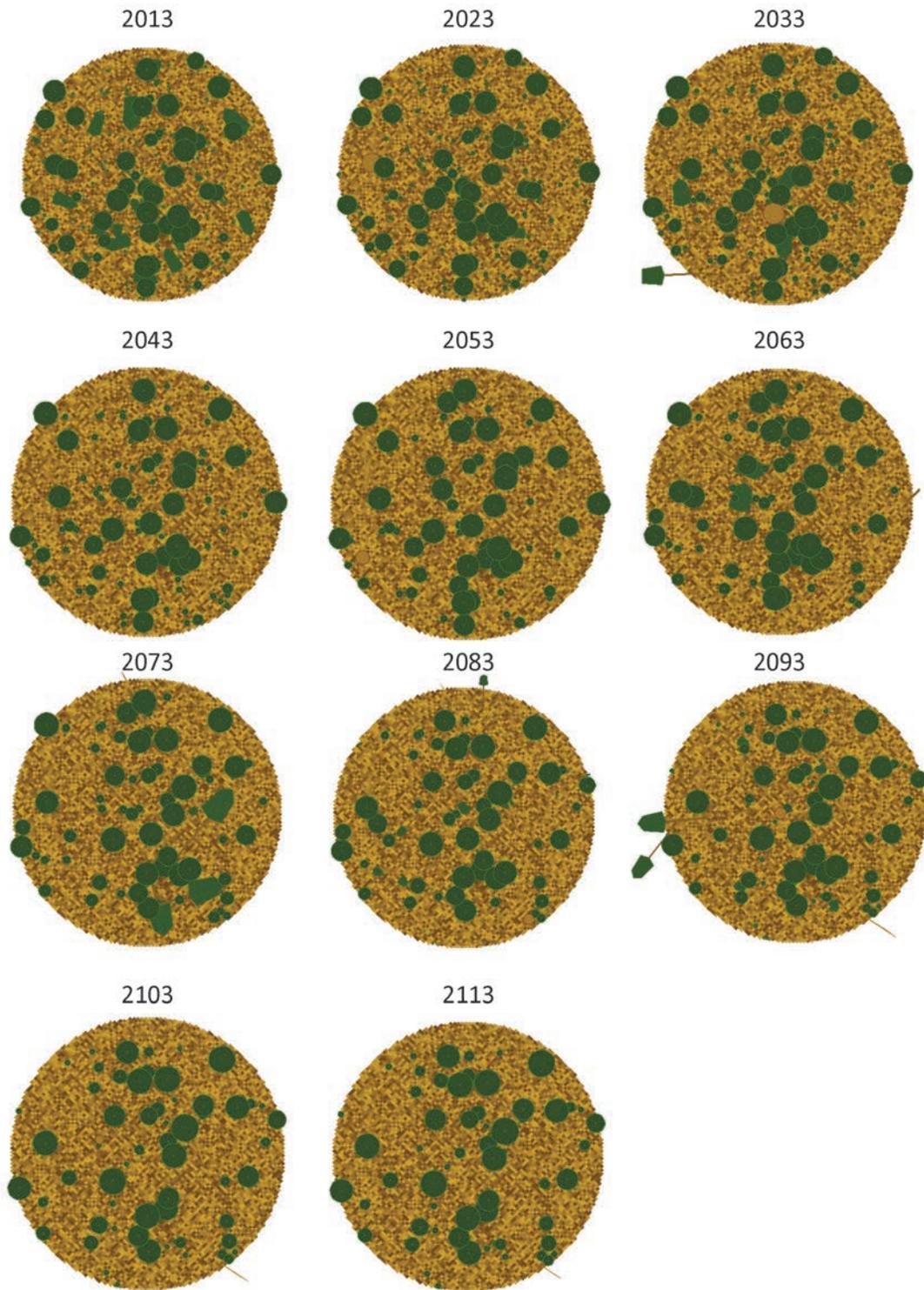


Figure 66—Overhead views for each year of the simulation after a treatment (e.g., precommercial thinning and commercial harvest).



Figure 67—In 1874 when General Custer visited the Black Hills, many areas contained abundant snags, down logs, clumped trees, and stands with rather open understories, as shown here both in the foreground and background.

Broad-scale assessments can provide context for actions and information applicable at lower or finer scales (Haynes and others 1996). For example, finding that a small quantity of optimum and high-rated goshawk and prey habitats are distributed somewhat evenly across the Black Hills and Bear Lodge Mountains provides context for management activities that may occur within one of these areas. Field evaluations can determine the particular state of the high-rated or optimum habitat and can inform actions that may enhance or protect the area. Also, broad-scale findings can be used to set priorities, especially when combined with other information such as the watershed assessment or bark beetle strategy.

The Bear Lodge Mountains stand out as proportionally having the largest amount of medium-rated to optimum goshawk habitat of any place in the Black Hills. In addition, the area is not currently at high risk to bark beetle attack and has minimal WUI lands. However, most of that area is at high risk to loss from wildfire. Therefore, the Bear Lodge Mountains offer the most opportunities for designing and implementing forest treatments that will enhance or maintain key goshawk habitat features yet reduce the risk of high severity wildfire and bark beetle attack.

The presence and abundance of quaking aspen is a key habitat feature for most birds that goshawks prey on in the Black Hills (see appendix). For example, 11 of the 13 birds reviewed used quaking aspen frequently and red-naped sapsuckers are considered a quaking aspen obligate. Quaking aspen is very important for maintaining black-headed grosbeak populations and ruffed grouse depend heavily on quaking aspen for foraging, nesting, and cover (Hansen and others 2011). Ruffed grouse were abundant residents in the Black Hills when Custer came to the Hills in 1874 and into the beginning of the 20th century suggesting that a considerable amount of quaking

aspen occurred in the Hills (Grinnell 1875; Knight 1902; Over and Thomas 1921). However, recent accounts indicate that ruffed grouse are rare in the Hills and only small populations live in the northern portion (Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991; White and others 2010). These ruffed grouse population trends are most likely related to the reduced amount (7 percent) of the current forest types of the Black Hills (all owners) that are considered quaking aspen (Hansen and others 2011; Walters and others 2013). As such, increasing the amount of quaking aspen in the Black Hills through harvesting, tending, prescribed fire, or other means will have a positive impact on populations of several prey species (e.g., birds) as well as goshawk populations as they are food limited (Reynolds and others 1992; Reynolds and others 2006a, b; Salafsky and others 2005).

Mountain pine beetles have been observed in the Black Hills since the forest reserve was described by Graves in 1899 (Graves 1899). In 1901, Hopkins completed a detailed survey of Black Hills bark beetles and was the first to provide recommendations to stave off beetle attack (Hopkins 1902, 1905). Tree density, tree size, tree vigor, tree juxtaposition, site productivity, weather, bark beetle populations, and several other known and unknown factors all interact to determine bark beetle dynamics (Fettig and others 2007; Larsson and others 1983; Olsen and others 1996; Schmid and Mata 2005; Stevens and others 1980). Nevertheless, a common thread in bark beetle conditions in the Black Hills is the presence of dense, uniform stands of trees in excess of 5 inches (12.7 cm) DBH and having densities in excess of 100 to 120 square ft of basal area per acre (27.5 m²/ha) making them at considerable risk to bark beetle attack (Schmid and others 1994). In addition, the biological principal that environmental complexity leads to stability (versus uniformity leads to instability), applies to Black Hills forests as their diversification will likely make them more resilient to the episodic bark beetle population outbreaks (Graham 1959). Similarly, Bentz and others (2009) attributed the homogenization of forests as a major contributor to insect epidemics, as did Sartwell and Stevens (1975) and Fettig and others (2007).

Wildfire, bark beetles, and lack of quaking aspen are impediments to producing and maintaining goshawk habitat. Conscious planning and management of Black Hills forests with considerations of the habitat structures used by goshawks and each of their prey species as described in this assessment have the capacity to produce and sustain the desired habitats and, ideally, support viable populations of goshawks. The forest structures suggested by Reynolds and others (1992) for sustaining goshawks and their prey in the Southwest have been challenged (Beir and Ingraldi 2012; Beir and others 2008; Reynolds and others 2012), but this model still appears to be appropriate for creating heterogeneous forests dominated by large trees, open understories, small openings, numerous snags, downed logs, and relatively high canopy-base heights (Kennedy 2003; Reynolds and others 2013). The 100-year silvicultural system simulated on the Black Hills Experimental Forest is an example of how a stand could be treated to produce the desired habitat conditions (fig. 66 and table 3). This model is only one of many ways in which a forest can be treated, but the desired conditions closely resemble historic ponderosa pine forests as described by Pearson (1950) in the Southwest, Miller and Keen (1960) in the Northwest, and viewed by Custer when he came through the Hills in 1874 (Grafe and Horstead 2002) (figs. 67 and 68).



Figure 68—Occasionally in the Black Hills, there are areas that contain large trees, down logs, open understories, and generally irregular in spacing. However, these areas are prone to rapid colonization by small trees that can compromise their fire and bark beetle resilience.

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Appendix: Natural History and Habitat for Selected Northern Goshawk Prey Species

We reviewed the life histories, ecologies, habitats, and distribution (i.e., northern Black Hills versus southern Hills) and abundance of goshawk prey species information in the Black Hills—information that was used in this assessment to rate the quality of existing habitat for goshawks and their prey across the Black Hills. We first identified prey species for this assessment from three goshawk diet studies in the Black Hills (Bartelt 1974; Erickson 1979, Knowles and Knowles 2009). Given these limited diet data, we reviewed bird and mammal (faunal) lists from the Black Hills for prey species that occurred in goshawk diets elsewhere in the western United States, firstly in ponderosa pine forests and secondarily in other forest types, which were potentially missed in the two Black Hills diet studies. Here, we report on those literature reviews of the natural history, ecology, habitat requirements, and population trends of 21 species. The structure of reviews for each species begins with general information that, more often than not, comes from studies conducted in geographic areas other than the Black Hills and ends with specific information from reports and publications based on studies conducted in the Black Hills.

American Robin

The American robin (*Turdus migratorius*) is a moderate-sized passerine (e.g., small perching bird) about 10 inches (25.4 cm) in length and weighing about 3.2 ounces (90.7 g) (Kilgore 1971; Ramsden and others 1979). Robins comprised 6.6 percent of the diet of northern goshawks in eastern Oregon and 5.6 percent of 36 prey deliveries to 7 goshawk nests in north-central New Mexico (Kennedy 1991; Reynolds and Meslow 1984). In the Oregon Coast Range 13 percent of the goshawk's diet was robins and 3.2 percent in southeast Alaska (Lewis and others 2006; Thraillkill and others 2000). Of 400 pellets collected at 40 nests in south-central Wyoming, 234 (30 percent) included robin remains (Squires 2000). Robins made up 3.6 percent of goshawk diets in ponderosa pine forests of northeastern California and 4.7 percent in Idaho (Patla 1997; Promessi and others 2004). Erickson (1987) and Bartelt (1977) found robin remains at 4 of 5 nests they visited in the Black Hills.

Distribution

The American robin is a common and widespread songbird throughout the United States (including Alaska), most of Canada, and Mexico. Most robins migrate south during winter however, many individuals winter as far north as southeast Alaska, southern Newfoundland, and South Dakota (Sallabanks and James 1999). In the Black Hills, robins are common summer residents at all elevations, transients during spring and fall, and rare winter visitors (Pettingill and Whitney 1965).

Habitat

Robins inhabit woodlands, hardwood and coniferous forests, riparian areas, shelterbelts, wooded suburban areas, gardens, agricultural lands, parks, and lawns (Franzreb and Ohmart 1978; Sallabanks and James 1999; Savard and Falls 1981; Siegel 1989; Stauffer and Best 1980; Yahner 1983). In the western United States,

robins are found throughout the ponderosa pine, mixed-conifer, and quaking aspen forests (Franzreb and Ohmart 1978; Siegel 1989; Winternitz 1976). Robins were not detected above 9,000 ft (2743 m) in the San Francisco Mountains of north-central Arizona (Coons 1984). In the Black Hills, robins are commonly found wherever there are trees. They inhabit ponderosa pine, white spruce, quaking aspen, and bur oak forests in all possible combinations. They are common in riparian areas and orchards, as well as in burns, meadows, and residential areas (Panjabi 2001; Pettingill and Whitney 1965).

American Robins show a preference for nesting in coniferous trees early in the breeding season (April through June) and then nest more often in deciduous trees later in the summer (June through July) (Savard and Falls 1981; Yahner 1983). Thirty-six percent of the nests discovered by Winternitz (1976) were in pure ponderosa pine forests and 27 percent in quaking aspen/willow (*Salix* spp.) stands. In non-urban areas, mean heights of American robin nests ranged from 2.3 to 4.7 ft (0.7 to 1.4 m) above ground level (Howell 1942; Preston 1946; Preston and Norris 1947; Savard and Falls 1981; Stauffer and Best 1980; Young 1955). In riparian habitats in Iowa, the mean height of nests was 32.2 ft (9.8 m) (Stauffer and Best 1986). Dellinger and others (2007) found a positive relationship between nest survival and decreasing nest height and reported more nests near forest edges such as roads and trails. Similarly, Davidson and Knight (2001) found that daily nest survival increased with proximity to forest edge and decreased with proximity to forest interiors. Savard and Falls (1981) noted that vertical distribution of foliage was more important in determining nest height than was foliage volume. More nests were located in the foliage layer just below the layer with the greatest volume regardless of tree type (conifer or deciduous). Howell (1942) noted 50 percent foliage cover around nests in the Pacific Northwest. In the Black Hills, American robins were most abundant in sapling to pole-sized quaking aspen and paper birch trees with greater than 70 percent canopy cover (Mills and others 2000). The time robins spent foraging on the ground decreased steadily as the distance from cover increased (Oyugi and Brown 2003).

Diet

Across their range, robins eat insects and worms primarily during the spring, while fruits dominate their diets in the fall and winter (Martin and others 1951; Russell and others 2009; Wheelwright 1986; Witmer 1996). In mixed-species and ponderosa pine forests in California, beetles (coleopterans) were the most common robin food (Otvos and Stark 1985). Similarly, Wheelwright (1986) found beetles comprised 40 percent of the robin's invertebrate diet while caterpillars, earthworms, flies, sowbugs, snails, spiders, termites, millipedes, and centipedes were also consumed (Martin and others 1951). Sugary, lipid-rich fruits, though low in protein, are also consumed by robins and in the eastern United States cherries (e.g., *Prunus* sp.) made up 23 percent of their diet (Witmer 1996).

Home range

Robin territories ranged in size from 0.3 to 2 acres (0.1 to 0.8 ha) and varied inversely with population density in New York, Wisconsin, and Tennessee (Sallabanks

and James 1999). Knupp and others (1977) reported robins defending immediate nest areas while still foraging in undefended areas up to 985 ft (300 m) away.

Populations

In an old ponderosa pine forest in northern Arizona robin nesting densities ranged from 2.3 to 20.0 breeding birds/100 acres (5.7 to 49.4/100 ha), in harvested forests densities ranged from 0.5 to 9.4 breeding birds/100 acres (1.2 to 23.3/100 ha), and in a harvested forest that retained over 90 ft²/acre (20.7 m²/ha) of trees greater than 20 inches (51 cm) DBH, robin densities averaged 3.3 breeding birds/100 acres (8.1/100 ha) (Haldeman 1968; Siegel 1989). In Arizona, robin breeding densities ranged from 2.0 to 7.5 birds/100 acres (4.9 to 18.5/100 ha) in undisturbed old ponderosa pine forests and in partially harvested mixed conifer forests, breeding densities ranged from 2.0 to 12.8 robins/100 acres (4.9 to 31.6/100 ha) (Franzreb 1977). Clearcut mixed conifer forests had robin breeding densities of 0.5 birds/100 acres (1.2/100 ha) (Haldeman 1968; Szaro and Balda 1979).

In the Black Hills from 2001 through 2009, average densities of American robins in white spruce forests were 150 birds/mile² (58 birds/km²) and the density in the southern Hills was 41 birds/mile² (16 birds/km²). Robin abundance averaged 49 birds/mile² (19 birds/km²) in burned ponderosa pine, 65 birds/mile² (24 birds/km²) in old ponderosa pine, and 93 birds/mile² (36 birds/km²) in the northern Black Hills (White and others 2010). Breeding density in the northern part of Rapid City, South Dakota, was 10 pairs/100 acres (24.7/100 ha) (Pettingill and Whitney 1965).

Shirley (2005) noted that robin abundance was negatively correlated with conifer density in British Columbia. Drolet and others (1999) found abundant robins living within poorly stocked boreal forests in Quebec. American robin densities were also found to be positively correlated with the proportion of quaking aspen occurring in the overstory. Stands with quaking aspen density expressed as basal area greater than 64 percent of the total basal area, contained high bird densities (Scott and Crouch 1988).

In the western United States American robins were associated with ponderosa pine forests (Saab and Powell 2005). Robin populations can significantly increase when ponderosa pine forests are severely burned, however spring fires can negatively affect robin populations (Kotliar and others 2007; Snyder 1992). Robins often respond positively to low and moderately severe prescribed fires in ponderosa pine forests that increase food availability (Dickson and others 2009; George and Zack 2008; Russell and others 2009; Smucker and others 2005). In beetle-killed lodgepole (*Pinus contorta*) and ponderosa pine forests that were harvested but retained structural complexity had high nest survival rates (Kroll and others 2010).

American Three-toed Woodpecker

The American three-toed woodpecker (*Picoides dorsalis*, formally *P. tridactylus*) is a medium-sized black and white woodpecker measuring 8 inches (20 cm) long and weighing 1.6 to 2.3 ounces (46 to 66 g) (Banks and others 2003; Leonard 2001). Although they are not abundant, their close association with spruce (*Picea* spp.) forests makes it an available prey species for goshawks where they co-occur (Squires and Reynolds 1997). In general, woodpeckers (including the hairy and black-backed

woodpeckers) regularly occur in goshawk diets (Lewis and others 2006; Promessi and others 2004; Rogers and others 2006; Smithers and others 2005; Squires 2000; Watson and others 1998). The three-toed woodpecker was found in goshawk prey remains in south-central Wyoming and in the Black Hills (Erickson 1987; Squires 2000).

Distribution

American three-toed woodpeckers occur throughout boreal and montane forests in North America, ranging from Alaska and Canada through northern, central, and southern Rocky Mountains in Idaho, Montana, Utah, Wyoming, Colorado, New Mexico, the Colorado Plateau in Utah, Arizona, New Mexico, the Cascade Mountains in Oregon and Washington, and in the northeastern United States. Three-toed woodpeckers are absent from Sierra Nevada mountains of California and Nevada. They live in the Black Hills where their distribution strongly coincides with white spruce forests (Leonard 2001; Steffen 1981; White and others 2010).

Habitat

American three-toed woodpeckers use mature and old coniferous forests with abundant insect-infested snags, dying trees, and woody debris (Goggans and others 1989; Koplín 1969; Leonard 2001). Some studies indicate they prefer moist to swampy areas and select nest sites relatively close to water (Hoffman 1997; Short 1974). Three-toed woodpeckers are strongly associated with burned and insect infested coniferous forests (Bull and others 1986; Hoffman 1997; Hoyt and Hannon 2002; Koplín 1969; McCambridge and Knight 1972; Murphy and Lehnhausen 1998).

In the western United States, three-toed woodpeckers use lodgepole pine, ponderosa pine, quaking aspen, and mixed-conifer forests (Goggans and others 1989; Mohren 2002). In the Black Hills, they use mixtures of ponderosa pine, white spruce, and quaking aspen despite the fact that white spruce and quaking aspen-dominated forests make up less than 6 percent of the Hill's forests (Mohren 2002). These woodpeckers use forests with minimal understory vegetation and those with high densities of small diameter and short snags. Three-toed woodpeckers are often found in forests disturbed by fire, flood, and wind or in old and decadent forests (Wiggins 2004). In beetle-infested forests of Oregon, 16 pairs of three-toed woodpeckers selected unharvested, pure lodgepole pine or mixed-conifer dominated by lodgepole pine forests for nesting (Goggans and others 1989). Likewise, in Oregon, Bull (1986) found three-toed woodpecker nests in pure lodgepole pine stands. In Idaho and Montana, 84 percent of the nests discovered were located in unharvested forests and in northwestern Montana, three-toed woodpeckers nested in only partially cut and burned forests, as opposed to those that were clearcut (Caton 1996; Hutto and Gallo 2006; Leonard 2001). Since three-toed woodpeckers have only been detected in mature white spruce, quaking aspen, and ponderosa pine forests in the Hills, it is likely they use these same areas for nesting.

Three-toed woodpeckers use live and dead trees for nesting, depending on how much decay a potential nest tree has. This woodpecker used more live (65 percent) than dead (35 percent) trees in Oregon and all had intact tops (Goggans and others 1989). In Montana, 97 percent of nest trees were dead and only 3 percent were alive, of which 80 percent had intact tops (Caton 1996). In Idaho and Montana, 59 of 61

nests were in snags (Leonard 2001). In British Columbia, nearly half of 23 nest trees were located in Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine snags with broken tops (Steeger and Dulisse 2002).

Three-toed woodpeckers excavate cavities in dead and live trees with decay, as the soft wood is easy to excavate. Both sexes build cavities which can take days to complete (Leonard 2001). In British Columbia, 5 of 13 nests were in lodgepole pine trees and the remaining 8 were in five other tree species (Steeger and Dulisse 1997). In Idaho and Montana, 31 percent of the nests were in Douglas-fir trees, 29 percent in lodgepole pine, 19 percent in ponderosa pine, and 14 percent in subalpine fir (*Abies lasiocarpa*) trees (Leonard 2001). In another Montana study, nests were located in quaking aspen (44 percent), western larch (*Larix occidentalis*) (30 percent), Engelmann spruce (*Picea engelmannii*) (18 percent), subalpine fir (4 percent), black cottonwood (*Populus trichocarpa*) (2 percent), and lodgepole pine (2 percent) trees (Caton 1996). Nests in Colorado were in Engelmann spruce (81 percent), lodgepole pine (12 percent), and subalpine fir (7 percent) trees (Koplin 1969). Bailey and Niedrach (1965) reported Colorado nests in quaking aspen and Engelmann spruce trees. In British Columbia, lodgepole pine (43 percent) and western larch (30 percent) trees were used most often, followed by quaking aspen (9 percent), Douglas-fir (9 percent), ponderosa pine (4 percent), and western red cedar (*Thuja plicata*) (4 percent) trees (Steeger and Dulisse 2002). Not much has been documented on three-toed woodpeckers' nests in the Black Hills, but Pettingill and Whitney (1965) reported a nest in the dead portion of a live white spruce.

Like black-backed woodpeckers, three-toed woodpeckers tend to use relatively small trees for nesting. In bark beetle-infested forests of Oregon, three-toed woodpeckers nest trees averaged 11 inches (28 cm) DBH (Goggans and others 1989). In Montana, nest cavities were found in quaking aspen, Engelmann spruce, and western larch trees having a mean DBH of 12 inches (31 cm) and mean height of 76 ft (23 m) (Caton 1966). Also in Montana, the mean DBH of nest trees was 9.8 inches (25 cm) (McClelland and others 1979). Nest trees in British Columbia averaged 10 inches (26 cm) DBH with a mean height of 69 ft (21 m) (Steeger and Dulisse 1997).

Foraging habitat consists of dying or recently killed trees that are beetle-infested. In Canada, three-toed woodpeckers used trees with 3 to 6 inch (8 to 15 cm) DBHs while black-backed woodpeckers used trees with 7.5 to 9.8 inch (19 to 25 cm) DBHs (Villard 1994). In Oregon, 3 three-toed woodpeckers foraged in mixed-conifer, lodgepole pine-dominated mixed-conifer, and lodgepole pine forests (Goggans and others 1989). They rarely foraged in seedling, sapling, multi-storied, or cut-over forests. In northeastern Colorado, three-toed woodpeckers foraged primarily on the trunks of burned Engelmann spruce trees but also used lodgepole pine and subalpine fir trees (Koplin 1969). Likewise, Bull and others (1986) found three-toed woodpeckers in Oregon used far more dead (78 percent) than live trees for foraging. Three-toed woodpeckers in Manitoba, Canada, foraged 95 percent the time on dead trees (Villard 1994). In the Black Hills, Mohren (2002) found that three-toed woodpeckers predominantly foraged on 9 inch (23 cm) DBH snags with broken tops. In Oregon, foraging trees averaged 9.5 inches (24 cm) DBH and 62 ft (19 m) tall (Bull and others 1986).

Three-toed woodpeckers prefer to forage on gently sloping to flat terrain (Bull and others 1986; Goggans and others 1989; Hoffman 1997; Short 1974). In the Black

Hills, three-toed woodpeckers foraged in patchy forests where they used the borders of ponderosa pine and white spruce stands (Mohren 2002). However, three-toed woodpeckers avoid foraging in areas with abrupt forest edges such as those on clearcuts (Gagne and others 2007).

Diet

Three-toed woodpeckers predominantly consume bark beetles of the family *Scolytidae* as well as other insects, arthropods, vegetable matter, and sap (Koplin 1969; Massey and Wygant 1954; Villard 1994). They forage by scaling, pecking, or flaking tree bark to expose the beetles and larvae that lie just below the surface (Bull and others 1986; Murphy and Lehnhausen 1998; Short 1974; Villard 1994). This is in contrast to the excavating that black-backed woodpeckers do to reach wood boring beetles (*Cerambycidae*). Three-toed and black-backed woodpeckers do not have similar foraging habits where three-toed woodpeckers tend to forage higher on tree boles and on smaller trees than black-backed woodpeckers (Short 1974; Villard 1994). Three-toed woodpeckers rarely forage on the ground or on downed logs (Villard 1994).

Home range

Home range sizes of three-toed woodpeckers are highly variable depending on time of year and available nest trees and food. Male home range sizes in Oregon, for example, varied in size from 131 to 751 acres (53 to 303 ha) (Goggans and others 1989).

Populations

Densities of three-toed woodpeckers tend to be lower in undisturbed forests than in burned and beetle-infested forests. In Colorado, Koplin (1969) found 0.10 three-toed woodpeckers/acre (0.25/ha) in an unburned Engelmann spruce-fir-lodgepole pine forest and 5.05 woodpeckers/acre (12.5/ha) in the same forest two years after it burned, about a 50-fold increase. In Grand Teton National Park, Wyoming, densities in unburned Engelmann spruce-fir forest were estimated at 0.04/100 acres (0.1/100 ha), and in 14 recently burned forests in Montana, the densities were 1.3 woodpeckers/100 acres (3.2/100 ha) (Hutto 1995; Taylor and Barmore 1980).

From 2001 to 2009 in the Black Hills, densities of three-toed woodpeckers in white spruce forests averaged 0.01/acre (0.02/ha) (White and others 2010). While observed in other forests, they were always associated with small stands of white spruce (Panjabi 2001, 2003). Interestingly, over a 9-year period, three-toed woodpeckers were never detected within major burns in the Black Hills (Giroir and others 2007). Likewise, in a survey in the Black Hills, Mohren (2002) only found this species in low densities within primarily white spruce and quaking aspen forests. He also detected them in other forests but, again, always associated with white spruce. Mohren (2002) did not find them in the large burns of the southwestern Hills. In unburned forests, Mohren (2002) estimated densities of 0.04/100 acres (0.09/ha) and population abundance of 320 individuals in 2001 and 440 in 2002.

Little is known of reproductive success for three-toed woodpeckers or factors that influence it. Tree harvesting likely has a negative influence on fledging success

and predators are also responsible for nest failures. In Oregon, Goggans and others (1988) found a few nests in harvested areas but 2 of 3 failed, whereas 5 out of 12 in unharvested stands failed. Within beetle-infested forests of British Columbia, where 40 percent of the lodgepole pine volume had been removed, hatching success for 8 nests was 100 percent but only 3 nests fledged young (Steeger and Dulisse 1997).

Black-Backed Woodpecker

The black-backed woodpecker (*Picoides arcticus*) is medium-sized, measuring 9 inches (23 cm) in length and weighing 2.2 to 3.1 ounces (61 to 88 g). Although they are not particularly abundant, their close association with conifer forests makes them potential prey for goshawks (Squires and Reynolds 1997). Several woodpeckers in the genus *Picoides* are eaten by goshawks, but the only known black-backed woodpecker killed by goshawks was in the Black Hills (Erickson 1987; Lewis and others 2006; Promessi and others 2004; Rogers and others 2006; Smithers and others 2005; Squires 2000; Watson and others 1998).

Distribution

Black-backed woodpeckers occur throughout the boreal and montane forests of Canada and Alaska, montane forests of the western United States, including the Sierra Nevada Mountains of California, Cascade Mountains of Oregon and Washington, and Rocky Mountains of Idaho and northwestern Wyoming. They are absent from the southern Rocky Mountains (e.g., Arizona, Colorado, and New Mexico) but occur in the Black Hills (Dixon and Saab 2000; Steffen 1981; White and others 2010).

Habitat

Black-backed woodpeckers are strongly associated with recently burned and/or beetle-infested conifer forests and they use a variety of conifer species throughout their range. In Alberta, Canada, they were often found in burned conifer forests (minor deciduous component) containing light to moderately burned, small diameter trees (Hoyt and Hannon 2002). In Alaska, moderate to heavily burned spruce trees were used most often as they contained abundant beetles (Murphy and Lehnhausen 1998). Within Oregon, black-backed woodpeckers used beetle infested ponderosa and lodgepole pine forests (Bull and others 1986). Likewise, in the Black Hills, they selected beetle infested ponderosa pine for foraging rather than for nesting (Bonnot and others 2008, 2009).

Black-backed woodpeckers also use unburned forests, but this use is poorly understood. In Alberta, Canada, black-backed woodpeckers used old (>110 years) and unburned black (*Picea mariana*) and white spruce stands located 47 to 93 mi (75 to 150 km) from recently (2 years) burned forests. However, no woodpeckers were observed in unburned forests within 31 miles (50 km) of the 2-year-old burn (Hoyt and Hannon (2002). Also Hoyt and Hannon (2002) suggested woodpeckers occupying unburned forests foraged in burned areas on the abundant insect populations. In unburned areas of the Black Hills, black-backed woodpeckers selected mature forests with high canopy cover (>70 percent), high tree and snag density, trees and snags with small diameters and short heights, and little or no ground cover (Mohren 2002). The author also suggested that forests with high canopy cover and high stem densities

might reduce black-backed woodpecker's vulnerability to goshawks. Such forests would also tend to have large amounts of dead and decaying trees and high insect populations (Hoyt and Hannon 2002; Mohren 2002).

In the Black Hills, abundance and availability of wood boring insects typically associated with high snag densities were the most important factors influencing black-backed woodpeckers' choice of nest sites (Bonnot and others 2008). For example, nest sites contained 108 snags/acre (267/ha) with DBHs exceeding 6 inches (15 cm) (Bonnot and others 2009). Likewise, in Idaho, nest density was higher in unharvested stands as opposed to harvested stands in which 50 percent of the snags had been removed. In the unharvested stands there were 33 trees/acre (81/ha) with an average DBH of 9 to 21 inches (23 to 53 cm). Also, in the unharvested areas, most of the trees were snags and of those 6.9 trees/acre (17/ha) had DBHs greater than 21 inches (53 cm) (Saab and Dudley 1998).

Black-backed woodpeckers frequently select nest sites well within a burn's interior. In the Black Hills, they selected nest sites located farther from an unburned forest edge than random sites. Vierling and others (2008) suggested that predators such as tree squirrels, chipmunks, and raccoons (*Procyon lotor* sp.) that typically occupy the forest interior and edge likely influence the woodpecker's nest site selection. Black-backed woodpeckers also select quaking aspen and old pine snags for nest sites some distance from beetle-infested tree patches where they feed (Bonnot and others 2009).

Black-backed woodpeckers excavate cavities in both live and dead deciduous trees such as quaking aspen, maple (*Acer* spp.), and birch, but they also nest in many dead and live conifers. Typically, both sexes participate in excavating a new cavity each year (Dixon and Saab 2000). While some black-backed woodpeckers in the Black Hills nest in live ponderosa pine and quaking aspen trees, the majority of nest cavities were excavated in snags (Bonnot and others 2009; Mohren 2002). Snags were large and often had broken tops and abundant decay making them easy to excavate (Bonnot and others 2009; Mohren 2002). Average cavity heights ranged from 16 ft (5 m) in Oregon to 36 ft (11 m) in Montana (Bull and others 1986; Caton 1996). In the Black Hills, cavity heights ranged from 2 ft (0.6 m) to 35 ft (10.5 m), and successful nests tended to be higher (Bonnot 2006) Average nest tree heights ranged from 62 ft (19 m) in Oregon to 105 ft (32 m) in Wyoming (Bull and others 1986; Hoffman 1997).

In Idaho, nests in ponderosa pine and Douglas-fir trees averaged 15.5 inches (39 cm) DBH, and in Oregon, ponderosa pine nest trees averaged 12.2 inches (31 cm) DBH (Bull and others 1986; Dixon and Saab 2000). In the Black Hills, the probability of a black-backed woodpecker selecting a nest tree was negatively associated with increasing tree diameter (Bonnot and others 2009). Black-backed woodpeckers may select small trees for nesting due to the greater proportions of sapwood to heartwood. These woodpeckers can readily excavate nests in sapwood as it usually contains more decay than heartwood. This strategy reduces the competition for nest cavities with larger woodpeckers that cannot expand the cavity for their own use (Bull and others 1986).

Post-burn harvesting can reduce the amount and quality of black-backed woodpecker habitat. In Idaho, nesting densities were more than double in unlogged post-burn forests compared to harvested areas in the same burn (Saab and Dudley 1998). This result was true when all or half of the merchantable trees were removed

post-fire. Despite differences in the number of nests among post-burn conditions, there was no difference in nesting success among the post-fire conditions created by no harvesting, removing all merchantable trees, and removing 50 percent of the merchantable trees. After wildfires in Montana, black-backed woodpeckers nested in unharvested areas, occurred sporadically in partially harvested areas, and were absent from areas that were clearcut (Caton 1996).

Diet

Black-backed woodpeckers consume wood-boring beetle larvae (e.g., longhorn), wood-boring jewel beetles, metallic wood-boring beetles (both *Buprestidae*), and bark beetles (Bent 1939; Dixon and Saab 2000). They also feed on ants, spiders, fruits, acorns, and tree cambium tissue (Beal 1911). As excavators, black-backed woodpeckers are well suited for extracting insect larvae from trees and down logs (Murphy and Lehnhausen 1998). For example, in boreal forests of Manitoba, Canada, this species foraged on fallen trees 41 percent of the time. Likewise, in spruce-larch (*Larix* spp.) bogs in New York, they were often seen foraging at the base of trees and on downed logs. Where they co-exist with three-toed woodpeckers, black-backed woodpeckers forage lower on tree trunks and on larger trees than do three-toed woodpeckers (Short 1974; Villard 1994).

Home range

The home range size of black-backed woodpeckers is likely to vary with time since bark beetle infestation occurred. In bark beetle infested lodgepole pine forests in Oregon, the home range of three black-backed woodpeckers ranged from 178 to 810 acres (72 to 328 ha) during the post-fledgling period (Goggans and others 1989). In southwestern Idaho, post-fledgling home range sizes of four adults in post-burn ponderosa pine and Douglas-fir forests ranged from 284 to 1893 acres (115 to 766 ha) and increased with time since fire (Dudley and Saab 2007). A single black-backed woodpecker living in southwestern Idaho had a breeding season home range of 178 acres (72 ha) and another used 151 acres (61 ha) in Vermont (Dixon and Saab 2000).

Populations

Populations of black-backed woodpeckers substantially increase following wildfires due to the abundant food supply. As the sapwood deteriorates after a fire, wood-boring beetle populations decrease and black-backed woodpeckers typically disperse and may abandon nests (Murphy and Lehnhausen 1998; Nappi and Drapeau 2009). Densities can be 6 to 20 times higher in burned compared to unburned forests, an observation that suggests burned forests are essential for maintaining black-backed woodpecker populations ((Mohren 2002; White and others 2010 Hutto 1995). In 2000, woodpecker densities in unburned Black Hills forests were 0.11 bird/100 acres (0.28/100 ha), and in 2001, they were 0.10 birds/100 acres. These densities were similar to those found in other unburned forests (Apfelbaum and Haney 1981; Bock and Lynch 1970; Mohren 2002; Murphy and Lehnhausen 1998).

Reproductive success of black-backed woodpeckers in burned forests decreases with time since the fire and predation was usually the cause of nest failure (Bonnot and others 2008; Nappi and Drapeau 2009; Vierling and others 2008). It is thought that

as a forest regenerates after fire, the newly established vegetation provides cover for mammals that can prey on the fledglings. Nesting success in Black Hills beetle-killed forests was 78 percent in 2004 and 44 percent in 2005 (Bonnot and others 2008). Similarly, from 2002 through 2004 in the Black Hills, nesting success was 60 percent in low severity burns, 50 percent in medium severity burns, and 80 percent in high severity burns (Vierling and others 2008). These rates were similar to those of 87 percent in burned forests in Idaho, 100 percent in burned forests of Wyoming, and 69 percent in beetle infested forests in Oregon (Dixon and Saab 2000; Goggans and others 1988). The effect of fire severity on nest success was likely related to the amount of cover left after a fire. As such, predators are likely to have a greater impact on nesting success in areas with the large amounts of cover after a burn or in areas where nests are located near unburned forests (Saab and Vierling 2001). Burned mature forests with high canopy cover also tend to have more nests and better nesting success than burned young forests with low canopy cover (Nappi and Drapeau 2009; Vierling and others 2008).

Black-Headed Grosbeak

The black-headed grosbeak (*Pheucticus melanocephalus*) is a medium-sized songbird measuring 7 to 7.5 inches (18 to 19 cm) in length and weighing 1.4 to 1.8 ounces (40 to 50 g) (Ortega and Hill 2010). Although rare, black-headed grosbeaks were found in goshawk prey remains in eastern Oregon, California, and Wyoming but have not been found in prey remains of the Black Hills (Bloom and others 1986; Reynolds and Meslow 1984; Squires 2000).

Distribution

Black-headed grosbeaks occur across western North America, from southwestern Canada (southern British Columbia and Alberta and southwestern Saskatchewan) south to Mexico (Baja California and central Mexico) and east to southwestern Texas and western North Dakota (Ortega and Hill 2010). Black-headed grosbeaks are summer residents in the lower elevations along the edges of the Black Hills as typified by populations found near Rapid City, Wind Cave National Park, and Hot Springs (Over and Thomas 1921; Panjabi 2003; Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991). Grosbeaks are migratory, breeding in North America and wintering in Mexico and Central America.

Habitat

Black-headed grosbeaks use large shade trees with well-developed shrub understories that include abundant vegetative edges and structural diversity (Dykstra and others 1999). They live in riparian and flood plains, openings in pine forests, quaking aspen groves, pinyon/juniper (*Pinus edulis/Juniperus* spp.) woodlands, oak (*Quercus* spp.) forests, savanna, orchards, deserts/dry grasslands, and urban yards (Ortega and Hill 2010; South Dakota Ornithologists' Union 1991). In the Black Hills, black-headed grosbeaks are frequently found in foothill and mountain riparian habitats containing cottonwood (*Populus* spp.), willow, box elder (*Acer negundo*), and chokeberry (*Prunus virginiana*) (Panjabi 2001, 2003). Quaking aspen is an important component of their habitat, and bur oak is frequently used in the Bear Lodge Mountains (Pettingill and Whitney 1965).

Black-headed grosbeaks nest in small deciduous trees and shrubs usually near streams. Nests are loosely built cups, without cementing materials, made of twigs, pine needles, rootlets, plant stems, and other green material. Plant species used for nesting include: willow, oak, alder, maple, blackberry (*Rubus* spp.), cottonwood, elderberry (*Sambucus* spp.), juniper, and pinyon pine (Ortega and Hill 2010; Ortega and Ortega 2003; Weston 1947). In the Black Hills, grosbeaks nest in low deciduous shrubs in riparian areas. Near Rapid City, nests were located 8 to 12 ft (2.4 to 3.7 m) off of the ground in willows (*Salix* spp.). In Spearfish Canyon, nests were located in chokecherry, and box elder 5 to 6 ft (1.5 to 1.8 m) off of the ground (Pettingill and Whitney 1965).

Diet

Black-headed grosbeaks consume grains, fruits, seeds, beetles, leaf buds, flowers, flower buds, moths, butterflies, and other insects (Ortega and Hill 2010; Weston 1947). This species switches among food items as they become available throughout the breeding season.

Home range

Little is known about the home ranges of black-headed grosbeaks. Both males and females aggressively defend their territories, which are established by singing males. One study found home ranges of 6.7 acres (2.7 ha) in Utah and 2 acres (0.8 ha) in New Mexico (Hill 1988b; Ritchison 1983).

Populations

Black-headed grosbeak abundance varies across its range with the highest densities reported in California and southwestern Oregon and the lowest in grassland and desert habitats (Ortega and Hill 2010). In 2002, grosbeak densities in the Black Hills were 10.3/100 acres (25.4/100 ha) in foothill riparian habitats, 5.2/100 acres (12.8/100 ha) in mountain riparian habitats, 2.6/100 acres (6.32/100 ha) in quaking aspen forests, and 0.7/100 acres (1.65/100 ha) in ponderosa pine forests of the northern Hills (Panjabi 2003). Similarly, White and others (2010) estimated densities of grosbeaks to be 1.1/100 acres (2.63/100 ha) in ponderosa pine forests of the northern Hills.

Adult grosbeaks are preyed upon by goshawks, Cooper's hawks, sharp-shinned hawks, and domestic and feral cats. In the Sandia Mountains of New Mexico, Hill (1988) found males having good nest success defending territories that were structurally heterogeneous. In contrast, homogenous, densely vegetated habitats tended to contain Steller's jays and other nest predators, making the male grosbeaks less effective at protecting their nests. In the Black Hills, blue jays are probably nest predators as they co-occur with black-headed grosbeaks in riparian habitats (Panjabi 2003). Because gray jays live at higher elevations, they are probably an infrequent nest predator of grosbeaks. Insecticides may reduce food supply, which can contribute to adult mortality, as can intense animal grazing that reduces shrub cover, thereby exposing grosbeaks to predators. As migrants, this species likely faces other threats during migration and where they overwinter (Gardali and Nur 2006; Ortega and Hill 2010).

Egg laying by other birds in grosbeak nests (nest parasitism) can be problematic, especially in intensely grazed habitats. The brown-headed cowbird (*Molothrus ater*),

though a rare summer resident in the Black Hills, has the potential to use grosbeak nests. There is evidence throughout the Black Hills that other birds were using grosbeak nests to some degree. It has been observed that the densities of the brown-headed cowbird were high in the same riparian habitats used by black-headed grosbeaks (Panjabi 2001, 2003; Pettingill and Whitney 1965).

Bushy-Tailed Woodrat (Pack Rat)

Bushy-tailed woodrats (*Neotoma cinerea*) are moderate-sized rodents. Males weigh around 13 ounces (337 g) and average 15 inches (379 mm) in total length and females weigh around 10 ounces (275 g) and average 14 inches (356 mm) in length. Body size also varies geographically with bushy-tailed woodrats living in colder climates (e.g., higher latitudes and elevations) being larger than those living in warmer climates. In the Black Hills, average length of 8 males was 14 inches (359 mm) and their average weight was 9.6 ounces (273 g) (Grayson 2000; Turner 1974). Their use of forests makes bushy-tailed woodrats potential goshawk prey (Promessi and others 2004; Reynolds and Meslow 1984; Watson and others 1998). Although their nighttime foraging behavior probably limits their availability, they can sometimes be active in the late afternoon. Bartelt (1977), for example, found woodrat remains at 3 of the 5 nests he visited in the Black Hills.

Distribution

Bushy-tailed woodrats occur in Canada from the Yukon and Northwest Territories, through British Columbia and western Alberta, south to northern California, northern Arizona, and New Mexico, and as far east as South and North Dakota. In the Black Hills, bushy-tailed woodrats live at the higher elevations and down to about 4,000 ft (1219 m) (Smith 1997).

Habitat

Bushy-tailed woodrats are often associated with Douglas-fir, spruce, quaking aspen, and ponderosa pine forests. Rocky shelters such as caves, crevices, cliffs, and piles of large boulders are key habitat features (Finley 1958; Smith 1997). They also use abandoned buildings, mine tunnels, and wood piles (Grayson 2000). They build dens (middens) within or near these structures, which can be associated with cavities in both live and dead trees and downed logs (Carey 1991; Finley 1958; Grayson 2000; Smith 1997; Ulev 2007). Dens are constructed from sticks, bones, conifer cones, feathers, owl pellets, bits of rope, leather, and paper that are stuffed into crevices or cavities (Higgins and others 2002; Turner 1974). Within dens, cup-shaped nests are constructed from shredded plant material such as leaves, bark, or dry grass (Smith 1997). One to four nests may occur in a single den, but a den is usually occupied by one woodrat at a time. Ten by ten foot (3 by 3 m) dens are normal for woodrats and a single den has been known to be occupied by woodrats for more than 40,000 years (Bentancourt and others 1990).

Shrub cover along forest edges provides excellent woodrat foraging, especially if it is located near rock outcrops where they prefer to den (Finley 1958). Riparian areas not only provide cover but also supply stream noise, which further protects the woodrats from predators. Such habitats in the Black Hills were occupied by woodrats

in the steep canyons of Beaver Creek, Ditch Creek, and Big and Little Spearfish Canyons (Turner 1974). Heavy grazing can degrade riparian habitats, interrupt woodrat dispersal, and isolate family groups (Carey 1991).

Diet

Bushy-tailed woodrats feed mostly on shrub and tree leaves, but they also consume seeds, bark, and fruits (Smith 1997). In Colorado, 89 different plant species were consumed by woodrats, with tree needles being the most common along with leaves from cherry (*Prunus* spp.), current (*Ribes* spp.), rose (*Rosa* spp.), and aster (*Aster* spp.) shrubs (Finley 1958). Woodrats begin in late summer collecting and storing food they will consume during the winter. This year-round activity potentially makes them important prey for wintering goshawks.

Home range

Bushy-tailed woodrats are territorial and strongly defend their food stores and dens against non-family members (Carey 1991). They have large home ranges with some in Canada being 20 times larger than those of other woodrats. Male home ranges averaged 15.1 acres (6.12 ha), and female home ranges averaged 8.8 acres (3.56 ha) (Topping and Millar 1996). In Oregon, home range for a single family group might be 2 to 5 acres (0.8 to 2 ha), but individuals typically venture up to 450 ft (137 m) from their den to forage, suggesting that home ranges can be as large as 15 acres (6 ha). Woodrat movements up to 1,250 ft (381 m) have been recorded (Carey 1991).

Populations

Because the rocky habitats used for dens vary spatially, bushy-tailed woodrat populations vary seasonally and annually (Smith 1997). In addition, such shelters provide stable living conditions all year, especially where snow depths are great and winters are cold. Therefore, these habitats may be the most important factor for determining bushy-tailed woodrat populations (Carey 1991). Areas with high populations may attract predators, which can exert significant pressure (e.g., predation and emigration) on a family group even resulting in local extinction. Facilitated by riparian corridors, dispersal of offspring is important for colonization of vacated habitats (Carey 1991). In Canada, one family group occupying 2 to 5 acres (0.8 to 2 ha) was typical and 5 woodrats/100 acres (12.4/100 ha) was an average population density (Banfield 1974). In Douglas-fir forests of Oregon, the density of bushy-tailed woodrats in closed-canopy areas along streams was 44/100 acres (108/100 ha), in rocky sites it was 20/100 acres (50/100 ha), and in mixed-conifer forests woodrat density was 8/100 acres (20/100 ha) (Carey and others 1992).

Cottontails

The eastern cottontail (*Sylvilagus floridanus similis*), mountain (or Nuttall's) cottontail (*S. nuttalli grangeri*), and desert (or Audubon's) cottontail (*S. audubonii baileyi*) are medium-sized rabbits (lagomorphs) with males averaging 13.8 inches (35.2 cm) long and their weight averages 25.3 ounces (719 g). Females average 14.5 inches (37.2 cm) in length and weigh an average of 27.9 ounces (790 g) (Chapman 1975; Orr 1940). Their widespread distribution, occurrence in numerous habitats and relatively large body size make them a common and important goshawk

prey throughout North America (Reynolds and Meslow 1984; Reynolds and others 2006). Of 670 prey deliveries in Arizona, 89 eastern cottontails (13.3 percent) represented 42.3 percent of the total biomass consumed (Rogers and others 2005). In Minnesota, eastern cottontails comprised 1.1 percent of goshawk diets and accounted for 4.8 percent of total biomass consumed (Smithers and others 2005). In Idaho, cottontails comprised 2 percent of the goshawk's diet, in New Mexico 29 percent of the prey taken by goshawks were cottontails, and 13 percent in Arizona (Kennedy 1991; Mannan and Boal 1993; Patla 1997; Salafsky and others 2005). In the Black Hills, cottontail remains were found beneath 3 of 5 nests Bartelt (1977) visited and cottontail remains were found below several nests visited by Knowles and Knowles (2009).

Distribution

Eastern cottontails have a wide distribution, occurring from extreme southern Canada south into South America and from the eastern United States across the Central Plains to the foothills of the Rockies (Chapman and others 1980). Eastern cottontails are uncommon in the Black Hills but do occur below 4,200 ft (1280 m) in the eastern portion of the Hills where desert cottontails also live (Turner 1974). Mountain cottontails range across the Intermountain West from just north of the Canadian border south to the American Southwest, and from the eastern slope of the Rockies to the eastern slope of the Cascade-Sierra Nevada range (Chapman 1975). Being the most abundant rabbit in the Black Hills, mountain cottontails occupy the central and western portions of the Black Hills, living in both ponderosa pine and white spruce forests, down to about 4,500 ft (1372 m) (Higgins and others 2002; Turner 1974). At lower elevations in the western Black Hills, mountain cottontails use forest edges and brushy draws where they may occur with desert cottontails. However, in the eastern Black Hills the two species are usually separated (Turner 1974). Desert cottontails range across the arid regions of the western United States and Mexico from near the Canadian border in Montana south to central Mexico and west to the Pacific coast (Chapman and Willner 1978). In the Black Hills, they are common in the upland prairie of Wind Cave National Park. The desert cottontail occupies lower elevation habitats around the entire Black Hills and surrounding prairies, up to 5,000 ft (1524 m) (Turner 1974).

Habitat

Cottontails are well adapted to a variety of vegetative types and therefore thrive in patchy landscapes such as desert scrub, grassland, woodland, and montane coniferous forest (Frey and Malaney 2006; Mankin and Warner 1999). Dense vegetation near the ground is a key determinant of habitat suitability (Althoff and others 1997). In the Black Hills, eastern and mountain cottontails occupy brushy ravines, streamside thickets, and forested edges of valley streams (Turner 1974). Mountain cottontails inhabit ponderosa pine uplands and white spruce filled canyons that often have an abundance of rocks, fallen logs, and shrubs (Turner 1974). Desert cottontails use open grasslands and pastures of lower elevations in the Hills. In the south-central Black Hills, Stebler (1939) found mountain cottontails in mountain prairies dominated by short grasses and sagebrush (*Artemisia*) but they were not found in ponderosa pine and bur oak forests or in riparian areas of the Hills.

Cottontails prefer areas with well-developed shrub and herbaceous understories for food and escape cover (Allen and others 1982; Althoff and others 1997; Bond and others 2001; Boyd and Henry 1991; Cayot 1978; Pils and others 1981). Farmsteads that contain buildings, trees, and shrubs are also frequently used by cottontails (Mankin and Warner 1999). In subalpine forests in New Mexico, mountain cottontails commonly used forest edges containing bristlecone pine (*Pinus aristata*), quaking aspen, and abundant ground cover (Malaney and Frey 2006).

In New Mexico, eastern and mountain cottontails chiefly inhabit ponderosa pine, mixed-species, and spruce-fir forests (Findley 1987). Frey and Malaney (2006) found that mountain cottontails occupied a wide range of elevations and vegetative zones where they preferred warm, open habitats or burned areas. In Arizona, eastern cottontails are generally restricted to oak woodlands associated with riparian habitats (Cockrum 1982). In Colorado, mountain cottontails decreased in abundance as elevation increased from 6,800 to 8,900 ft (2072 to 2713 m) (Cayot 1978). At higher elevations, mountain cottontail abundance tended to be greater on southeastern aspects where ponderosa pine was more common and bitterbrush (*Purshia tridentata*) ground cover increased to 50 percent. Prevalence of bare ground, common juniper, and downed timber were negatively associated with mountain cottontail abundance (Cayot 1978). In southern British Columbia, mountain cottontails used ponderosa pine forests, sagebrush dominated prairies, riparian areas, open Douglas-fir forests, and lodgepole pine forests (Sullivan and others 1989).

Most eastern cottontail nests are located in grass, dense shrubs, or among downed logs (Allen and others 1982; Althoff and others 1997). Althoff and others (1997) noted increased use of burrows when above ground temperatures dropped below freezing. Bond and others (2002a) speculated where winters are long and severe, shrub dominated habitats become important as they tend to moderate air temperatures.

Diet

Diets vary greatly among species and geographic region, but a wide variety of vegetation is acceptable provided that the cottontail's basic nutritional requirements are met (Chapman and others 1982). In a given geographic area, cottontails may eat more than 100 plant species but preferences vary locally (DeCalesta 1971). Bond and others (2002b) reported that eastern cottontails were food generalists at the microhabitat scale but showed a preference for certain land cover types. Herbaceous vegetation is the primary food during the growing season, while bark, buds, and twigs are consumed during the remainder of the year (Althoff and others 1997; Chapman and others 1982). Feeding on woody vegetation during the fall and winter is assumed to relate to reduced availability of herbaceous vegetation rather than a preference (Chapman and others 1982). In southern portions of the southwestern United States where winter climates are mild, herbaceous vegetation may provide an adequate year-round food source (Allen 1984). Eastern cottontails may eat snails, moth pupa, or cottontail carcasses when other foods are unavailable (Higgins and others 2002).

Mountain cottontail and most likely eastern cottontail nests are cup-like cavities scraped in the ground and lined with fur, grass, and small sticks (Chapman 1975; Higgins and others 2002). Chapman (1975) reported that mountain cottontails living in dense sagebrush or riparian vegetation probably spend most of their time above

ground, but in areas with sparse vegetation, they take protection in burrows or rock crevices. They preferred crevices in outcrops as daytime retreats in a sagebrush/juniper habitat in Oregon. Also, the abundance of such daytime retreats was related to population numbers (McKay and Verts 1978). Conversely, in Colorado, Cayot (1978) found no relationship between the presence of rocks and mountain cottontail populations. This disparity might be a result of variability in vegetative cover quantity and quality.

Home range

Home ranges of 25 radio-tagged eastern cottontails in a 14 acre (5.7 ha) woodlot in southwestern Wisconsin varied by individual, sex, and season (Trent and Rongstad 1974). Adult male home ranges increased from an average of 6.8 acres (2.8 ha) in the spring to an average of 9.9 acres (4 ha) in early summer and decreased to an average of 3.8 acres (1.5 ha) by late summer. Adult female home ranges in the spring averaged 4.3 acres (1.7 ha) and in the summer, fall, and mid-winter they averaged 2.1 acres (1.5 ha). Fall home range sizes of juveniles did not differ and there were no gender differences (Trent and Rongstad 1974). In Wisconsin, Mississippi, and Illinois, male home ranges were larger during the breeding than the non-breeding season and were larger than female home ranges during any season (Bond and others 2001; Mankin and Warner 1999). On agricultural land in Mississippi, breeding season home ranges for males averaged 14.8 acres (6.0 ha) and female's averaged 7.5 acres (3.0 ha). Smaller home ranges for females were attributed to their parental care and their "central place" foraging behavior close to their nest (Bond and others 2001). In summary, eastern cottontail home range size ranged from 0.20 to 20 acres (0.08 to 8.1 ha), with most studies reporting home ranges smaller than 9.9 acres (4 ha) (Mankin and Warner 1999).

Populations

Cottontail populations are characterized by substantial seasonal and annual fluctuations. Scribner and Warren (1990) estimated winter densities of eastern cottontails in Texas to range from 3.2 to 4.9 individuals/acre (1.3 to 2.0/ha). After reproduction and juvenile dispersal, the densities in these areas peaked at 10.9 to 11.3 individuals/acre (4.4 to 4.6/ha). Fall density of eastern cottontails in southwestern Wisconsin woodlots was estimated to be 3.6/acre (1.5/ha) (Trent and Rongstad 1974). In this population, the annual survival rate was estimated to range between 0.15 and 0.2 depending on the estimation method. Fall and winter eastern cottontail densities over a 5-year period in southern Wisconsin ranged from 7.4 to 23.7 individuals/acre (3.0 to 9.6/ha). On an experimentally managed 50-acre (20.2-ha) woodlot in Wisconsin cottontail densities ranged from 3.7 to 12.9 individuals/acre (1.5 to 5.2 ha) (Pils and others 1981). In Illinois, habitats predominantly soybean and corn row crops supported 0.08 to 4.00 eastern cottontails/100 acres (2 to 10/100 ha) (Mankin and Warner 1999). Food availability and quality were considered the primary factors regulating rabbit populations (Lochmiller and others 1995). Population densities of mountain cottontails in ponderosa pine forests in southern British Columbia varied annually from 0.09 to 0.17 individuals/acre (0.04 to 0.07/ha). McKay and Verts (1978) found that mountain cottontail population densities varied annually from 0.03 to 1.03 individuals/acre (0.1 to 0.42/ha) in shrub-juniper woodlands in central Oregon.

Plant species richness and cover likely increases forage efficiency and reduces predation risks to cottontails by reducing their exposure (Bond and others 2001). Malaney and Frey (2006) found early successional vegetative stages located adjacent to dense canopied sites were preferred by cottontails. Although prescribed fires may create short-term negative consequences for cottontails, fire improves forage quality for at least two seasons after burning, especially when arranged with patchy mosaics of food and cover (Bond and others 2002a). All cottontails make extensive use of trails, paths, and roads (Higgins and others 2002). Malaney and Frey (2006) hypothesized that mountain cottontails used high elevation spruce-fir forests in New Mexico because logging, fire, and roads created fine-scale openings and early successional vegetation, which they preferred.

Gray Jay

The gray jay (*Perisoreus canadensis*) is a small corvid (i.e., related to crows and ravens) typically weighing 2.2 to 2.9 ounces (62 to 82 g) and measuring 10.6 to 12.2 inches (27 to 31 cm) tall (Strickland and Ouellet 2011). Although not abundant, they occupy forests year-round so are an important winter prey for goshawks. In the Black Hills, Bartelt (1977) found the remains of a gray jay at one of the nests he visited (Bloom and others 1986; Cleghorn 1913; Patla 1997; Promessi and others 2004; Reynolds and Meslow 1984; Smithers and others 2005; Squires 2000; Watson and others 1998).

Distribution

The gray jay is widespread in boreal forests of Canada, northern New England (Vermont, New York, and New Hampshire), the Great Lakes states (Wisconsin and Michigan), and western mountain states (Washington, Oregon, California Idaho, Utah, Colorado, New Mexico, Arizona, and South Dakota) (Strickland and Ouellet 2011). In the Black Hills, gray jays are common permanent residents in forests above 4,000 ft (1219 m), but are found less frequently in the Bear Lodge Mountains of Wyoming and the extreme easterly and southern portions of the Black Hills (Pettingill and Whitney 1965; Panjabi 2003).

Habitat

Gray jays are strongly associated with pure spruce forests across their range but also use mixed spruce and other conifer forests (Strickland and Ouellet 2011). In Ontario, Canada, jays were most abundant in lowland black spruce (*Picea mariana*) bogs and less abundant in areas of mixed quaking aspen, white birch, (*Betula pendula*) balsam fir, (*Abies balsamea*), and white spruce. Gray jays are most common in lodgepole pine forests in the Yukon and in pure jack pine (*Pinus banksiana*) forests in Saskatchewan (Kirk and Hobson 2001; Sinclair and others 2011). In New Mexico, they used forests dominated by Engelmann spruce and subalpine fir (Bailey and others 1928). And in Colorado, they were found mainly in Engelmann spruce, subalpine fir, lodgepole pine, quaking aspen, and willow forests (Bailey and Niedrach 1965). Gray jays tend to use forest edges as they provide many insects and nesting songbirds both of which are consumed by the gray jay (Ibarzabal and Desrochers 2004). For example,

in managed forests of Quebec, gray jays were frequently found within 100 ft (about 30 m) of forest edges.

In the Black Hills, gray jays use dense ponderosa pine and white spruce forests and, on occasion, mixed species forests (Pettingill and Whitney 1965). Recent monitoring indicated that gray jays used white spruce dominated forests more than other types, but they were also found in burned areas and ponderosa pine dominated habitats (Panjabi 2001, 2003; White and others 2010). Although found in forests of all ages, they appear to prefer mature coniferous forests (Rutter 1969; Strickland and Ouellet 2011; Theberge 1976). Black Hills' gray jays were most abundant in mature ponderosa pine forests when canopy cover exceeded 40 percent compared to sapling and pole-sized ponderosa pine stands (Mills and others 2000; Rumble and others 1999). Use also varied seasonally with mature and old ponderosa pine forests preferred in the summer, while sapling and pole-sized stands were used in the winter.

Nest sites are chosen by the male who also initiates nest construction. Nests are cup-shaped and situated at low to moderate heights, mostly in spruce, but hemlock (*Tsuga* spp.), fir (*Abies* spp.), pine (*Pinus* spp.), tamaracks (*Larix* spp.), and willows are sometimes used (Strickland and Ouellet 2011). Nests are constructed of twigs, bark, lichens, and cocoon material from tent caterpillars. Nest trees located adjacent to a forest opening, which provides a southwestern exposure, allows the nest to be warmed by the sun (Strickland and Ouellet 2011). Nests are often placed near the tree trunk or on a horizontal branch.

Diet

Gray jays have a broad diet and they are “scatter hoarders” based on their well-known habit of caching food for winter consumption. Food items are first coated with sticky saliva, then worked into tree bark, pine needle bunches, tree-forks, and under lichen (Strickland and Ouellet 2011). Cached food is important for winter consumption and likely contributes to their propensity for late winter (February through March) nesting. Gray jays consume conifer seeds but do not extract seeds from cones. They eat mushrooms including the *Amanita* (which is known for its toxicity and hallucinogenic properties), slime molds, and engorged winter ticks removed from ungulates (Addison and others 1989; Strickland and Ouellet 2011). Gray jays are predatory, consuming eggs, nestlings, along with juvenile and adult birds (Barnard 1996; Boulet and others 2003; Darveau and others 1997; Pike 1978; Tozer and Allen 2004). They also eat small mammals (e.g., mice) and amphibians (Gill 1974; Tordoff 1980). Dead birds and mammals of all sizes are an important winter food. As demonstration of their broad diet, gray jays often find food in picnic areas and camp grounds (Strickland and Ouellet 2011).

Home range

Mated pairs occupy territories during the breeding season, but an additional 1 to 2 non-breeding individuals may also occupy a territory during the non-breeding season. These may include a juvenile born on the territory or one from another territory. Territory size in Ontario, Canada, was 319 acres (129 ha) but only 67 to 171 acres (27 to 69 ha) on Queen Charlotte Island, British Columbia (Strickland and Ouellet 2011). In Manitoba, Canada, home range size was approximately 161 acres (65 ha)

and in the Yukon Territory, home ranges were 57 acres (23 ha) for non-food supplemented gray jays and 37 acres (15 ha) for food supplemented individuals (Walley 1987).

Populations

While much of the gray jays' range in Canada and Alaska has not been covered by Breeding Bird surveys, the data collected so far indicate no significant continental trends in populations. Climate warming may be contributing to range reduction in the southern part of the species' range. Long-term research on a population in Ontario revealed a trend toward earlier breeding, declining reproductive success, and increasing rates of vacancies on territories. It appears that prolonged warmer autumns result in the decomposition of stored foods, which negatively impacts reproductive success the following breeding season. This declining population trend is likely related to the high number of young breeders that are less experienced and unable to compensate for the reduced food supply. In these conditions, young breeders tend to desert their nests, further impacting population numbers (Waite and Strickland 2006).

When habitats are saturated, territorial behavior limits gray jay populations which in turn ensures sufficient year-round food and cache sites for population stability. Density at habitat saturation in various locations in Canada was estimated at: 1.5 individuals/100 acres (3.7/100 ha) on Anticosti Island, Quebec, 0.6/100 acres (1.4/100 ha) in la Vérendrye, Quebec, 0.3/100 acres (0.7/ha) in Algonquin Provincial Park, Ontario, 0.6/100 acres (1.5/100 ha) in Manitoba, and 1.0/100 acres (2.4/100 ha) in the Yukon. Autumn densities of gray jays increased to 4.2/100 acres (10.3/100 ha) for Anticosti Island, 1.4/100 acres (3.5/100 ha) for la Vérendrye, and 0.7/100 acres (1.7/100 ha) in Algonquin Provincial Park. In Algonquin Provincial Park, the authors noted that much of the area they studied was never occupied by gray jays (Strickland and Ouellet 2011). Densities in the Black Hills from 2001 to 2009 were 7.9 jays/100 acres (19.4/100 ha) in white spruce forests, 7.7/100 acres (19.1/100 ha) in ponderosa pine forests, 1.7/100 acres (4.2/100 ha) in old ponderosa pine forests, and 1.2/100 acres (3/100 ha) in burned forests (White and others 2010).

Although gray jay mortality rates can be high, the bird can be long-lived. Nicholls (2009) reported that two gray jays living in Colorado were at least 17 years old and in Algonquin Provincial Park, Canada, one female and one male were both at least 16 years old (Strickland and Ouellet 2011). Mortality of young jays can be rather high. Strickland (1991) reported that 52 percent of the fledglings that stayed on their natal territories in Ontario and Quebec died by mid-October while 85 percent of those dispersing died. Of those surviving at the beginning of winter, 50 percent died by spring. Adult mortality was higher in the summer compared to winter, but annual mortality averaged about 20 percent (Strickland and Ouellet 2011).

Hairy Woodpecker

Hairy woodpeckers (*Picoides villosus*) are medium-sized birds that vary in size depending on the latitude where they live. Males weigh more than females and the average weights of male hairy woodpeckers were: 1.5 ounces (43 g) in Chiapas, Mexico, 2.6 ounces (75 g) in South Dakota, and 3.4 ounces (95 g) in Alaska. The average

weight of females living in South Dakota was 2.3 ounces (65 g) (Jackson and others 2002).

Hairy woodpeckers are a common prey of goshawks (Lewis and others 2006; Mannan and Boal 1993; Reynolds and Meslow 1984; Rogers and others 2006; Smithers and others 2005). In south-central Wyoming, 0.5 percent of regurgitated pellets found at 40 nests contained hairy woodpecker remains (Squires 2000). Over 10 years, hairy woodpeckers comprised 1.3 percent of prey remains collected at 82 nest sites in Washington (Watson and others 1998).

Distribution

Hairy woodpeckers are widely distributed and abundant throughout North America, having the widest distribution of all the *Picooides* woodpeckers. They range year-round from Central America north into Mexico, the United States, and most of Canada and Alaska (Jackson and others 2002). In the Black Hills, hairy woodpeckers are permanent residents at all elevations and are the most abundant cavity-nesting species found in the Hills during winter (Pettingill and Whitney 1965; Rumble and others 1999).

Habitat

This common woodpecker occupies coniferous and deciduous forests, burned forests, and beetle-infested forests. Hairy woodpeckers show a preference for open ponderosa pine and quaking aspen forests and tend to be more abundant when canopy cover is less than 70 percent (Jackson and others 2002; Mills and others 2000). In west-central Colorado when quaking aspen amounts exceeded 1 percent of the basal area in mixed species stands the density of woodpeckers was 3 to 5 birds/100 acres (7.4 to 12.3/100 ha) and in stands with less than 1 percent quaking aspen woodpecker density was 10 birds/100 acres (24.7/100 ha) (Scott and Crouch 1988). In the Black Hills, ponderosa pine harvesting that reduced stand density by 53 percent (expressed by basal area) and canopy cover by 58 percent had no significant effect on hairy woodpecker populations (Anderson and Crompton 2002). However, increasing canopy cover in the Black Hills positively influenced their abundance in mixed quaking aspen and paper birch forests (Mills and others 2000; Rumble and others 1999).

Hairy woodpeckers prefer to nest in live trees located in open woodlands with a deciduous understory. In hidden locations, such as on the underside of a tree limb, they excavate nest entrances ranging in diameter from 1.6 to 1.8 inches (4 to 4.6 cm) that are often used for several years. Because other cavity nesters such as starlings (*Sturnus vulgaris*) can use nest openings of this size, competition for nest sites may occur (Scott and others 1977). The heights of hairy woodpecker nests varied from 15 to 45 ft (4.6 to 13.7 m) but were typically located 35 ft (10.7 m) above the forest floor (Scott and others 1977). Scott and others (1980) located 2 hairy woodpecker nests in quaking aspen snags and 6 in live quaking aspen trees. Nest heights averaged 33 ft (10.1 m), tree heights averaged 59 ft (18 m), and tree DBH averaged 15 inches (38 cm). In Arizona, hairy woodpeckers showed a preference for nesting in ponderosa pine snags with DBHs exceeding 20 inches (51 cm) (Horton and Mannan 1988). Nest densities in a burned ponderosa pine forest in Idaho were 0.98 nests/100 acres (2.4/100 ha) and in a burned and harvested site where 40 percent of snags greater than 9 inches (23 cm)

DBH were removed, there were 0.39 nests/100 acres (0.96/100 ha) (Saab and others 2007, 2009). Winter roost trees in a burned ponderosa pine forest in Arizona had an average DBH of 22 inches (56 cm), which was 2.5 times larger than the average DBH of trees in the surrounding forest (Covert-Bratland and others 2007).

The forests hairy woodpeckers used during the summer and winter in the central Black Hills were similar. The size and number of snags and number of suitable and available cavities are better habitat descriptors than vegetative structure (Rumble and others 1999). Also in the Black Hills, timber harvesting that reduced snag density but maintained similar tree sizes to non-harvested areas did not impact woodpecker abundance (Dykstra and others 1997). As such, it appears that hairy woodpeckers do not prefer forests with large live trees or snags in the Black Hills, nor was their occurrence related to snag condition or density (Dykstra and others 1999; Mills and others 2000). Similar findings occurred in a burned ponderosa pine forest in Oregon where hairy woodpecker abundance decreased in response to post wildfire tree harvesting but populations did not differ between two harvest intensities. In the same study, no differences in woodpecker populations were detected between areas with 12 snags/acre (30/ha) and areas with 2 snags/acre (5/ha) (Cahall and Hayes 2009). The mere presence of snags may be as important as their numbers or densities, as noted in east Texas where hairy woodpeckers were found in clearcut forests containing 0.8 hardwood snags/100 acres (2/100 ha) but were absent from forests with no snags (Dickson and others 2009). Winter and breeding densities of hairy woodpeckers were 3.6 to 7.6 birds/100 acres (8.8 to 18.7/100 ha) in harvested hardwood forests in Kentucky that contained 6 to 13.3 snags/acre (14.8 to 32.9/ha) and 1.6 to 6 birds/100 acres (4.0 to 14.8/100 ha) were found in unharvested forests that contained 7.3 snags/acre (18/ha) (McPeck and others 1987). However, there is concern in some areas that timber harvest, fuel wood removal, or intense surface fires that decrease snag numbers may adversely affect hairy woodpecker populations (Balda 1975; Thomas and others 1979).

Diet

Hairy woodpeckers prefer to feed on insects living on dead or diseased trees, with approximately 80 percent of their diet being larval and adult beetles, ants, and caterpillars. Males tend to forage farther from the nest and consume larger insects (e.g., wood borers) than females who forage close to the nest on the surface of trees, shrubs, or on the ground for small insects and plant material (Morrison and With 1987; Scott and others 1977). Beetles, primarily wood boring and bark beetles, comprised 64 percent of the diets of hairy woodpeckers in California followed by carpenter ants (Scott and others 1977). In Arizona, ponderosa pine trees in both unburned and burned forests infested by bark beetles were 9 to 12 times more frequently foraged on by hairy woodpeckers than uninfested trees (Pope and others 2009). In the Black Hills, the abundance of mountain pine beetles makes them an ample food source (Anderson 2003). This insectivorous diet is often supplemented with fruit, grains, nuts, and ponderosa pine seeds (Otvos and Stark 1985).

With the presence of insects, hairy woodpeckers appear to be opportunists when it comes to choosing trees for foraging. Throughout the year in the Sierra Nevada, they frequently used both white fir (*Abies concolor*) and ponderosa pine for feeding (Morrison and others 1987; Morrison and With 1987). They foraged on live trees and

snags with similar frequency, but about 70 percent of their foraging time was spent on dead portions (e.g., bole and limbs) of live trees averaging 17.4 inches (44 cm) DBH. No difference in tree size preference for feeding was exhibited by either males or females, nor did feeding tree size differ between winter and breeding season (Morrison and With 1987). In the western Sierra Nevada during the breeding season, both sexes preferred foraging on tree trunks at heights from 33 to 39 ft (10 to 12 m), but these heights increased in the winter (Morrison and others 1987; Morrison and With 1987). In mixed-conifer forests of the Sierra Nevada, hairy woodpeckers foraged throughout tree canopies as well as on trees 4 to 12 inches (10 to 30 cm) DBH (Morrison and others 1986). However, in many areas, hairy woodpeckers frequently forage on large trees and snags (Covert-Bratland and others 2006; Pope and others 2009; Spiering and Knight 2005). In an unburned ponderosa pine forest in northern Arizona, hairy woodpeckers preferred to forage on 12 to 17 inch (30 to 42 cm) DBH trees located in patches 1.4 times less dense than surroundings areas but with a higher density of large trees (Covert-Bratland and others 2006).

Home range

Food abundance and presence most likely determine home range sizes for hairy woodpeckers. In a 1-year-old burned ponderosa pine forest, a winter home range size was estimated at 3.6 acres (1.46 ha), but 5 years later it was 19.0 acres (7.85 ha). This increase was most likely related to the decrease in both insect populations and standing snags since the fire (Covert-Bratland and others 2006). In Arizona's ponderosa pine forests, two-thirds of hairy woodpecker roost trees were located outside or on the edge of the home range. Eight of nine woodpeckers traveled more than 0.62 mi (1 km) from the roost to the farthest point in their home range (Covert-Bratland and others 2007).

Populations

In sapling, pole-sized, and mature ponderosa pine forests in the Black Hills, hairy woodpeckers were evenly distributed throughout the landscape at 3.2 birds/100 acres (8 birds/100 ha) regardless of snag densities and tree diameters (Spiering and Knight 2005). Sampling across multiple habitats from 2001 through 2009 indicated that hairy woodpecker densities in all unburned ponderosa pine and mixed ponderosa pine/white spruce forests in both the northern and southern Black Hills ranged from 1.6 to 2.4 birds/100 acres (4 to 6 birds/100 ha). However, in a burned forest 4.9 birds/100 acres (12 birds/100 ha) were found (White and others 2010).

Hairy woodpecker populations tend to increase after low, medium, and high severity wildfires and prescribed fires in ponderosa pine forests, though their densities decreased with time since fire (Covert-Bratland and others 2006; Dickson and others 2009; Pope and others 2009). In Arizona, Pope and others (2009) found winter hairy woodpecker densities to be 4.4 birds/100 acres (10.8/100 ha) or 5 times greater than densities found in unburned forests. Covert-Bratland and others (2006), also in Arizona, reported greater abundance of hairy woodpeckers in burned forests during the winter for 2 years, but abundances in burned and unburned forests were similar 7 years after the burn. Hairy woodpecker abundance also increased in response to a

severe mountain pine beetle outbreak in British Columbia though reproduction did not (Edworthy and others 2011).

Szaro and Balda (1982) studied the effects of timber harvest on breeding birds in ponderosa pine forests of Arizona. During all study years, with the exception of clearcuts, hairy woodpeckers were found in all types of harvested stands, including uncut areas where trees had not been removed for 60 years, light harvests in which large trees and dense thickets were selectively harvested, unharvested areas, and in areas that were thinned. Hairy woodpecker densities averaged about 3 pairs/100 acres (7.4/100 ha) across all forest conditions (Szaro and Balda 1982, 1986).

Least Chipmunk

Least chipmunks (*Tamias minimus*) weigh from 1.5 to 1.9 ounces (42 to 53 g) and range in length from 7.3 to 8.7 inches (18.5 to 22.2 cm), with male chipmunks in the Black Hills weighing 1.6 ounces (46 g) and measuring 7.7 inches (19.5 cm) long (Schlimme 2000; Turner 1974). Ten percent of the regurgitated pellets collected at 40 goshawk nests in south-central Wyoming contained the remains of least and Uinta chipmunks (*Neotamias umbrinus*) (Squires 2000). In 23 nest sites located in mixed ponderosa pine and spruce forests in northeastern California, 7.2 percent of the prey was chipmunks and 6.1 percent of prey consumed at 82 goshawk nests in Washington was chipmunks (Promessi and others 2004; Watson and others 1998). In the Black Hills, least chipmunk remains were found at all 5 nests studied by Bartelt (1977) and Erickson (1987).

Distribution

Least chipmunks are the smallest and most widely distributed of the North American chipmunks making them important goshawk prey. However, it is difficult to determine the chipmunk species at nest sites. They range as far north as the central Yukon in Canada, east to the northern Great Lakes states, and south to parts of Arizona and New Mexico, and in the Rocky Mountains they have been observed at elevations exceeding 11,483 ft (3500 m). However, on the Colorado Front Range, fewer least chipmunks were observed at higher elevations compared to lower elevations. At higher elevations, populations can suffer serious declines and possible local extinction as a result of harsh and prolonged winters with deep snow (Bergstrom and Hoffmann 1991; Hadley and Wilson 2004a). The western third of South Dakota, including the arid badlands, contains least chipmunks and it is the only chipmunk that lives in the Black Hills (Higgins and others 2002; Turner 1974; Verts and Carraway 2001).

Habitat

Least chipmunks use a wide variety of habitats occurring at many elevations, including greasewood flats, sagebrush deserts, pinyon-juniper woodlands, oak woodlands, deciduous and coniferous forests, and alpine tundra (Higgins and others 2002). Least chipmunks are typically associated with forest openings and areas close to escape cover, which also influences their foraging behavior (Root and others 2001; Smith 1995; Verts and Carraway 2001). As such, forest management activities and disturbances that create forest openings, such as thinning or wildfires, can favor chipmunk occupancy. In New Mexico and Arizona, thinning and wildfires that resulted

in more snags, stumps, and even slash piles left after thinning were beneficial to least chipmunk populations (Converse and others 2006). Similarly, forest diversity created by ski runs in spruce-fir forests in Colorado with and without scattered trees in them provided habitat favored by these chipmunks (Hadley and Wilson 2004b).

In Arizona and New Mexico, least chipmunks frequently use spruce-fir forests containing rocky or mesic habitats (Hoffmeister 1986). These chipmunks are generally absent from homogenous conifer forests but were found in ponderosa pine, Douglas-fir, and mixed subalpine fir and spruce forests along the Colorado Front Range (Hadley and Wilson 2004a). However, they were not found in closed lodgepole pine forests in the same area (Bergstrom and Hoffmann 1991). In Montana lodgepole pine forests, least chipmunks were only found in areas disturbed by harvesting (Martinsen 1968). They were also found in prey remains at goshawk nests in Wyoming but the forest conditions are unknown (Squires 2000). Also in Colorado, least chipmunks were found in meadows above tree line, shrubby habitats, and woodlands containing dense ground-level vegetation (Bergstrom and Hoffmann 1991; Hadley and Wilson 2004b; Vaughan 1974). Least chipmunks also often climb or perch in shrubs and trees to feed and nest (Verts and Carraway 2001). In all forests, these chipmunks use logs, stumps, and rocks as observation points and burrow locations (Higgins and others 2002; Vaughan 1974; Winterrowd and Devenport 2004).

Least chipmunks dig burrows beneath rocks, logs, or tree roots. In the subalpine forests of Colorado, they showed a preference for locating burrows under large rocks and, on occasion, used woodpecker cavities for nests (Verts and Carraway 2001). Burrows provide protection from predators, protection from heat and cold, sites for bearing and raising young, and locations for food caches (Bihl and Smith 1998; Heller and Poulson 1972; Higgins and others 2002). Burrows are small and grass-lined chambers located about 1 foot (30 cm) below the soil surface. They are reached by one or two tunnels with 1.5 inch (3.7 cm) diameter entrances, usually 2 to 3 ft (61 to 91 cm) long (Bihl and Smith 1998; Higgins and others 2002).

Diet

Least chipmunks consume both plant and animal material, and their diet varies depending on local food availability (Devenport and others 1998; Verts and Carraway 2001). Diets vary across regions and elevations but typically include a variety of nuts, grains, conifer seeds, fruits, flowers, leaves, mushrooms, and insects, with seeds usually making up of more than 50 percent of a chipmunk's diet (Higgins and others 2002; Vaughan 1974). They forage during the day when temperatures are usually moderate and return to a den at night (Vaughan 1974). In subalpine meadows in Colorado, least chipmunks ate flowers and forbs in the early summer and occasionally raided "sap wells" established by red-breasted sapsuckers. By mid-summer, insects and larvae made up most of their diet and seeds and berries were consumed in autumn (Devenport and others 1998; Vaughan 1974). In autumn, they cache seeds, nuts, and grains beneath stumps or logs and in small pits (i.e., scatter hoarding) and later move this cached food to their burrows. Least chipmunks will consume this stored food between bouts of torpor (i.e., semi hibernation state lasting hours to weeks). When torpor begins and ends depends on the latitude and amount of snow cover. Least chipmunks

generally emerge from their burrows in March and April and are active above ground through October or November (Verts and Carraway 2001).

Home range

Least chipmunks are not sociable and do not tolerate least chipmunks within the immediate area of their burrows or in vegetation patches where they forage. However, home ranges generally overlap and individuals occasionally forage next to one another (Higgins and others 2002; Winterrowd and Devenport 2004). Home range size depends on habitat quality and can vary from less than 1 acre (0.4 ha) up to several acres (Higgins and others 2002). In a harvested lodgepole pine forest in Montana, least chipmunk home ranges changed between seasons and years in response to food availability (Martinsen 1968). The average male home range size over 2 years was 3.2 acres (1.29 ha), and the average female home range size was 2.4 acres (0.97 ha). Male home ranges in Alberta, Canada, averaged 3 acres (1.22 ha) in size and female home ranges averaged 1.6 acres (0.66 ha) in size (Sheppard 1972). In ponderosa pine forests of Colorado, male home ranges varied from 3.9 to 13.4 acres (1.6 to 5.4 ha) in size and a single female's home range covered 3.4 acres (1.4 ha) (Bergstrom 1988).

Populations

In a burned ponderosa pine forest in New Mexico, least chipmunk densities ranged from 0 to 0.8 chipmunks/acre (0 to 1.9/ha) (Converse and others 2006). In subalpine meadows of Colorado, mean chipmunk density over three summers ranged from 4.6 to 9.0 chipmunks/acre (11.4 to 22.2/ha) (Vaughan 1974). Also in Colorado, least chipmunk densities on open ski runs and along ski run edges averaged 1.1/acre (2.6/ha), whereas no chipmunks were trapped or observed in adjacent spruce-fir forests (Hadley and Wilson 2004a).

Lewis's Woodpecker

The Lewis's woodpecker (*Melanerpes lewis*) is a medium to large woodpecker measuring 10.0 to 10.5 inches (25.4 to 26.7 cm) long and weighing 3 to 4 ounces (85 to 113 g) (Abele and others 2004). Woodpeckers, in general, are a favored prey of goshawks, but the Lewis's woodpecker has only been reported in the diets of Oregon goshawks (Lewis and others 2006; Promessi and others 2004; Reynolds and Meslow 1984; Rogers and others 2006; Smithers and others 2005; Squires 2000; Watson and others 1998). Although they are rare in the Black Hills, Lewis's woodpeckers have a close association with open ponderosa pine forests, which dominate the Black Hills, making them potential goshawk prey (South Dakota Ornithologists' Union 1991; Squires and Reynolds 1997).

Distribution

Lewis's woodpeckers occur from southwestern British Columbia south into the Cascade Mountains (Washington and Oregon), Sierra Nevada (California and Nevada), Colorado Plateau (eastern Utah and northern Arizona), and Rocky Mountains (New Mexico, Colorado, Idaho, Montana, Wyoming, and South Dakota). In the Black Hills, Lewis's woodpeckers are uncommon summer residents and rare winter residents and have been reported to leave higher elevation habitats (e.g., McVey burn)

for lower ones in August and September (Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991).

Habitat

Breeding habitats for Lewis's woodpeckers include open ponderosa pine forest, open riparian woodland dominated by cottonwoods, quaking aspen stands, oak woodlands, and burned or harvested pine forests and they avoid dense forests (Bock 1970; Tobalske 1997; Vande Voort 2011; Vierling 1997). Lewis's woodpeckers frequently use open and burned forests as they usually have an abundance of snags, a shrub dominated forest floor, and abundant insect populations. Open tree canopies also provide space for these woodpeckers to fly-catch and avoid being captured by hawks (Saab and Vierling 2001).

In the Black Hills, Lewis's woodpeckers used riparian woodlands dominated by cottonwoods or open areas with oaks (South Dakota Ornithologists' Union 1991). In the southwestern Hills, they were seen using burned forests along canyons (Cary 1901). Also in the Hills, they use vegetative edges in ponderosa pine forests and burned areas with an abundance of snags (Pettingill and Whitney 1965). From 2001 to 2009, although rarely detected, Lewis's woodpeckers were observed in burned areas of the southwestern Black Hills, ponderosa pine forests in the southern Black Hills, montane riparian areas, and within shrublands (Giroir and others 2007; Hutton and others 2006; Panjabi 2001, 2003; White and others 2010).

Forests with large diameter trees, open tree canopies, and a shrub-dominated forest floor are preferred by Lewis's woodpeckers for nesting (Bock and Lynch 1970). In Wyoming, they nested in burned areas with an open canopy and nest trees were typically dead, burned, or decaying (Linder 1994; Tobalske 1997). Common nest trees include large conifers and deciduous trees such as cottonwood, willow, and paper birch. Nest trees tend to be tall and of large diameter. For example, in riparian areas on the plains of Colorado, all nest trees were in decaying or dead cottonwoods that averaged 67 ft (20.4 m) tall and 3.7 ft (113 cm) DBH compared to random trees that averaged 41 ft (12.5 m) tall and had an average DBH of 25.1 inches (64 cm) (Vierling 1997). In Wyoming, 35 nest trees averaged 34.7 ft (10.59 m) tall and 19.2 inches (49 cm) DBH (Linder 1994). In Idaho, average DBH for 354 nest trees (snags) in a burned and mostly harvested forest was 18 inches (46 cm). In a Black Hills burned forest, Lewis's woodpeckers nested in highly decayed snags that averaged 15.1 inches (38 cm) DBH (Gentry and Vierling 2008).

Lewis's woodpeckers are weak excavators and tend to use cavities excavated by other Lewis's woodpeckers, northern flickers, and hairy woodpeckers (Tobalske 1997). When they do excavate their own nests, they do so in highly decayed and/or soft-wooded trees and snags. In the Black Hills, 40 of 55 nests were in old cavities and 15 were in old cavities modified by Lewis's woodpeckers (Gentry and Vierling 2007). Mean cavity height in the Black Hills was 27.9 ft (8.5 m) and the ratio of cavity height to snag height was 0.85, indicating that Lewis's woodpeckers tended to nest near the top of snags (Gentry and Vierling 2007).

Nest sites appear to be an important factor influencing reproductive success. Populations in burned forests have higher reproductive success compared to those living in hardwood riparian areas. For example, in Idaho, nest success in burned

ponderosa pine stands was 78 percent compared to 46 percent in Colorado riparian areas (Saab and Vierling 2001). In burned forests of Wyoming, nest success was 85 percent, 56 percent in Colorado plains riparian areas, and 25 percent in Colorado cottonwood dominated woodlands (Linder 1994; Tashiro-Vierling 1994). Higher nest success in burned ponderosa pine forests suggests they contain source populations of Lewis's woodpeckers. Saab and Vierling (2001) found that fecundity (number of young produced by reproductive females) was 0.69 in ponderosa pine forests compared to 0.38 in riparian areas.

In the Black Hills, nest survival was 90 percent for 55 nests from 2002 through 2005. The nests occurred in burned ponderosa pine forests with only four failures: two predations, one nest snag falling, and one adult abandonment (Gentry and Vierling 2007). Fortunately for Lewis's woodpeckers in the Black Hills, typical nest predators such as the black bear, (*Ursus americanus*), grizzly bear (*Ursus arctos horribilis*), and Stellar's jay do not co-occur with them, and the pine marten (*Martes americana*) is restricted to white spruce forests. Similar to other populations of Lewis's woodpeckers, burned forests in the Hills are source habitats, as adult females were replaced at a rate of 1.54 young female per adult female from 2001 to 2005 (Gentry and Vierling 2007).

Diet

The Lewis's woodpecker forages on non-wood boring insects, including ants, bees, wasps, beetles, and grasshoppers. They also consume acorns, nuts, grains, and fruit and store these items in bark crevices in the fall and winter (Tobalske 1997). Lewis's woodpeckers forage by fly-catching from perches and gleaning insects from the trunks and limbs of trees and shrubs but do not dig in the soil (Bock 1970; Tobalske 1997). They forage on large snags, telephone poles, fence posts, and any location with an open view. In cottonwood trees on the plains in Colorado, foraging during October through April consisted of gleaning (30 percent), storing acorns (26 percent), fly-catching (24 percent), and working acorn stores (20 percent) (Hadow 1973).

Lewis's woodpecker's migratory patterns are highly variable both within and among years. In general, individuals in Washington, Idaho, and Montana are non-resident while those in the central portions of the range are partially resident (Tobalske 1997). For example, during the winter of 1969 through 1970, some Lewis's woodpeckers on the Colorado plains wintered on their breeding grounds while others moved to winter along the foothills west of Pueblo, Colorado (Hadow 1973). In the two subsequent years, no Lewis's woodpeckers were observed in the same foothills during the winter. In the Black Hills, during the winter Lewis's woodpeckers moved to cottonwood dominated riparian areas located at lower elevations and it was uncertain whether some individuals used these areas year-round (Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991). During winter migration, Lewis's woodpeckers form loose flocks of adults and fledglings (Tobalske 1997). Once at their winter sites, they become territorial and mated pairs sometimes share stored food (Bock 1970; Vierling 1997).

Winter habitat includes oak woodlands, commercial orchards, corn fields, and cottonwood dominated riparian areas. Important winter habitat features include large trees, snags, and utility poles that have cracks that can be used for storing acorns and

grains. For example, on the Colorado plains wintering Lewis's woodpeckers used dead and decaying cottonwoods that averaged 57.4 ft (17.5 m) tall with an average DBH of 41.3 inches (104.8 cm) (Tobalske 1997).

Home range

Home range characteristics of Lewis's woodpeckers are not well known but are expected to vary with food availability and distribution. During the breeding season, Lewis's woodpeckers defend their nest snags but several pairs may nest in very close proximity or even in the same snag (Bock 1970; Currier 1928; Hadow 1973; Tashiro-Vierling 1994).

Populations

Determining population trends for Lewis's woodpecker has been difficult because populations fluctuate as their habitat changes. In addition they have a sporadic distribution and most often their presence is uncommon or rare (Tobalske 1997). Between 1960 and 1991, Breeding Bird Survey (BBS) and Christmas Bird Counts (CBC) data indicate that populations may have declined by as much as 60 percent (Tobalske 1997). This trend estimate, however, was based on a small number (20) of CBC routes and unspecified sizes of BBS samples (Tashiro-Vierling 1994; Tobalske 1997). From 1966 through 1994, 61 BBS census routes indicated relative abundance of Lewis's woodpeckers to be 0.18 birds/25 miles (1.2/50 km). The Black Hills is the most northeasterly part of the Lewis's woodpecker range, and, although Cary (1901) noted they were common there, others noted their rarity in the region (Grinnell 1875; Pettingill and Whitney 1965). In 9 years of monitoring in the Black Hills, fewer than 10 individuals were seen per year, except in the last year when 34 individuals were detected in burned habitats (White and others 2010).

Mourning Dove

The mourning dove (*Zenaida macroura*) is a moderately sized bird averaging 12 inches (30.5 cm) in length and averaging 8 ounces (227 g) in weight. In Oregon, Reynolds and Meslow (1984) found mourning doves the ninth most common prey item and they made up 3 percent of the goshawk's diet. Despite its common occurrence in goshawk diets elsewhere, the mourning dove was absent from the prey captured by goshawks in the Black Hills.

Distribution

The mourning dove is the most abundant and widely distributed dove in North America, ranging from southern Canada throughout the contiguous United States, Mexico, and into Central America and they may also breed in southeastern Alaska (American Ornithologists' Union 1983; Martin and others 1951; Otis and others 2008). Mourning doves are a locally abundant summer resident in the Black Hills but migrate out of the area for the winter (Pettingill and Whitney 1965). While they occur across the Black Hills, they are most abundant in the southwestern portions (Panjabi 2001).

Habitat

The mourning dove inhabits farmlands, ranchlands, deserts, grasslands, woodlands, and forests (Soutiere and Bolen 1972). In the Southwest, mourning doves

frequent grasslands, pinyon-juniper woodlands, oak woodlands, and ponderosa pine forests. They do occur in mixed species forests above 7,000 ft (2134 m), although their densities are lower than in other habitats (Davis and Sintz 1973; Franzreb 1977; Sedgwick 1987). At elevations below 7,000 ft (2134 m), also in the Southwest, mourning doves prefer pinyon-juniper woodlands and riparian areas for nesting. In the Black Hills, mourning doves occupy ponderosa pine forests, burned forests, deciduous forests, riparian areas, agricultural lands, and residential areas (Pettingill and Whitney 1965; Panjabi 2001, 2003). Within forests, mourning doves prefer vegetative edges. In contiguous forests, stream borders or the junctions between forest types are preferred. Broad or abrupt borders between fields and forest are not as favorable as narrow, finger-like or peninsular-shaped forest edges (Hopkins and Odum 1953). In forest and woodland habitats, mourning doves often nest near 1- to 5-acre (0.4- to 2.0-ha) vegetative openings.

In New Mexico of the 40 nests Davis and Sintz (1973) visited, 78 percent were located where tree cover was patchy to moderately dense and 22 percent were found in dense or open forests. Mourning doves typically select large trees for building their nests. For example, in southwestern New Mexico, the average DBH of 40 nest trees was 18.6 inches (47.2 cm), while the average DBH of all woody plants in the area was 13.8 inches (35.1) (Davis and Sintz 1973). In Arizona Haldeman (1968) observed mourning doves nesting in large yellow-barked ponderosa pines and other large conifers. In Iowa, Jumber and others (1956) reported nest trees averaged 17.4 inches (44.2 cm) DBH and McClure (1946) reported 20.3 inch (51.6 cm) DBH nest trees. The DBH of mourning dove nest trees in California averaged 13.0 inches (33.0), in Nebraska they averaged 10.2 inches (25.9 cm), and in pinyon-juniper woodlands of northwestern Colorado they ranged from 33 to 40 inches (83.8 to 101.6 cm) DBH (McClure 1946; Sedgwick 1987).

In New Mexico mourning dove nest trees averaged 26 ft (7.9 m) tall with most nests placed 8 to 12 ft (2.4 to 3.7 m) above the forest floor (Davis and Sintz 1973). Soutiere and Bolen (1972) found doves living within the rolling plains of Texas preferred to nest in mesquite (*Hilaria* spp.) trees with large branches. Such trees with sturdy horizontal limbs allow nests to be built away from tree trunks to provide unobstructed flight paths (Harris and others 1963; Knight and others 1984; Putera and others 1985; Yahner 1983). Also securely constructed nests, influenced by their placement, determined the probability of nest success (Coon and others 1981).

For up to 30 days after hatching mourning dove fledglings use reference areas (RAs) for resting and feeding interactions primarily with the male parent. Located under dense canopies interspersed with openings, an average of three 3.3 ft² (0.31 m²) RAs were used by mourning dove fledglings. The RAs were usually located on the forest floor or on a tree limb within 150 ft (45.7 m) of the nest tree (Hitchcock and Mirarchi 1986). Fledglings more than 13 days old used non-vegetated, forest floor RAs, more frequently (59 percent) than those located on tree limbs. The length of RA tree crowns averaged 26.3 ft (8.0 m) and their crown ratios averaged 76 percent. Such trees were used for both RAs and roosting with RA trees averaging 13.3 inches (33.8 cm) DBH and roost trees averaged 13.7 inches (34.8 cm) DBH (Grand and Mirarchi 1988).

Diet

Mourning doves are versatile and opportunistic feeders. Feeding on the ground, they consume seeds, grains, small amounts of other vegetative material, and traces of insect and animal parts (Best and Smartt 1986; Griffing and Davis 1974; Martin and others 1951; Tyler and Jenkins 1979).

Home Range

In Missouri, adult mourning doves moved up to 4.8 miles (7.7 km) from nest sites to feeding areas (Sayre and others 1980). In an Idaho desert, Howe and Flake (1988) reported maximum daily movements of 5 adult doves to be 0.7 to 2.4 miles/day (1.1 to 3.9 km). The average distance traveled from a nest to a feeding area was 2.3 miles (37 km) and the average distance traveled to water was 1.1 miles (1.8 km).

Populations

Mourning dove nesting densities in Illinois apple orchards ranged from 0.6 to 12.9 nests/acre (1.53 to 31.75 nests/ha) (Putera and others 1985). In a wooded floodplain in New Mexico, nest densities were 3.3 nests/acre (8.1 nests/ha) and 18.2 nests/acre (45.0 nests/ha) in a small, isolated shelterbelt in North Dakota (Davis and Sintz 1973; Randall 1955). In Washington fruit orchards, Knight and others (1984) reported that the number of mourning doves nests ranged from 0 to 6.6/100. The average density of breeding mourning doves in a dense ponderosa pine forest was 1.2/100 acres (3.0/100 ha), in an old ponderosa pine forest their average density was 1.1 breeding pairs/100 acres (2.7/100 ha), and in an open old ponderosa pine forest their average density was 1.4 breeding pairs/100 acres (3.5/100 ha) (Siegel 1989). An old ponderosa pine forest near Flagstaff, Arizona contained 7 pairs/100 acres (17.2/100 ha) and a mixed-species forest on the San Francisco Mountains, also near Flagstaff contained 3 pairs/100 acres (7.4/100 ha) (Haldeman 1968). In old mixed-species forests of Oregon, no breeding mourning doves were detected in the first 2 years of monitoring, but 0.1 birds/100 acres (0.2/100 ha) were detected during the third year. In thinned mixed-species forests in Oregon, densities averaged 0.5 breeding birds/100 acres (1.2/100 ha) (Mannan and Meslow 1984). Although some birds were noted, no breeding birds were counted in mixed-species stands in Arizona (Franzreb 1977).

Northern Flicker

The northern flicker (*Colaptes auratus*) is a relatively large woodpecker whose size varies geographically and with subspecies. In general, males are larger than females and flickers in northern latitudes are larger than those living farther south (Wiebe and Moore 2008). Typical length is 11.8 to 13.8 inches (30 to 35 cm) (Wiebe and Moore 2008). The weight of males in Colorado averaged 5.5 ounces (156 g) and the weight of females averaged 4.9 ounces (139 g) (Short 1965).

Because the northern flicker is distributed throughout the United States and with its conspicuous markings it is a common goshawk prey. In Oregon, 6 percent of 228 prey remains found at 59 goshawk nests were flickers and in New Mexico, 14.3 percent of 106 prey remains found at goshawk nests were flickers (Kennedy 1991; Reynolds and Meslow 1984). On the Kaibab Plateau in Arizona, Mannan and Boal (1993) found flickers in 5.2 percent of 289 prey remains discovered at 22 nests

and Reynolds and others (1994) found flickers in 24 percent of prey collected at 37 nests. In the Warner Mountains of California, flickers comprised 6.8 percent of 221 prey remains found at 23 nests (Promessi and others 2004). In Wyoming, 270 of 793 regurgitated pellets (34 percent) found at 40 nests contained flicker remains (Squires 2000). In Idaho, northern flickers comprised 9.4 percent of the goshawk's diet (Patla 1997). Flickers were also present in goshawk diets in the Black Hills National Forest (Erickson 1987).

Distribution

The northern flicker is a common resident in many forests of the United States. Two subspecies are the yellow-shafted flicker (*C. a. auratus*), which occurs in the eastern United States and across most of Canada, and the red-shafted flicker (*C. a. cafer*) which ranges across the western United States and Mexico. They readily hybridize across the Great Plains and through southwestern Canada. The Black Hills lie in the center of this zone where most flickers are thought to be hybrids (Pettingill and Whitney 1965; Short 1965). However, Short (1965) also referred to the Black Hills flickers as an "outlying *cafer* (red-shafted) population." Flickers are year-round residents at all elevations in the Black Hills (Pettingill and Whitney 1965; Wiebe and Moore 2008).

Habitat

Northern flickers nest in open woodlands, fields, and meadows. Scott and others (1977) reported flickers usually place nests along vegetative edges and in continuous forests only in and around openings (Scott and others 1977). For example in the quaking aspen forests of Utah nests were most often associated with meadow edges (Lawler and Edwards 2002). In mixed quaking aspen forests with a 98 percent quaking aspen component, northern flicker density averaged 7 birds/100 acres (17.2/100 ha) and in areas with less quaking aspen the flicker density was 1 to 4 birds/100 acres (2.5 to 9.9/100 ha) (Scott and Crouch 1988). Dobkin and others (1995) reported a 70 percent average canopy cover above flicker nests in quaking aspen forests of the Black Hills. Also in the Hills, northern flickers were most abundant in mixed ponderosa pine, quaking aspen, and paper birch forests with more than 70 percent canopy cover (Mills and others 2000).

Flickers excavate 2.75-inch (6.99-cm) diameter nest entrances in dead limbs of cottonwood, pine, oak, and juniper trees up to 100 ft (30.5 m) but typically they are located between 10 and 30 ft (3 and 9 m) above the forest floor (Fisher and Wiebe 2006; Martin and others 2004; Scott and others 1977). Fisher and Wiebe (2006) reported that nests located higher in trees compared to those at lower locations suffered less predation from squirrels and their nests were less frequently taken by European starlings.

In Arizona, northern flicker nests were frequently found in unharvested areas with ponderosa pine snags greater than 20 inches (50.8 cm) DBH (Horton and Mannan 1988). Flickers also preferred ponderosa pine trees for nesting in New Mexico (Arsenault 2004). In burned ponderosa pine forests in the Black Hills, nest tree DBHs averaged 11.6 inches (29.4 cm) and nest density was associated with high pre-fire canopy cover (Vierling and others 2008). Scott and others (1980) characterized

29 nests located in ponderosa pine, subalpine fir-spruce, and quaking aspen forests. Eight were in ponderosa pine snags, 6 were in quaking aspen snags, 14 were in live quaking aspen trees, and one was in an unidentified conifer snag. Nest heights averaged 36 ft (11 m), nest tree heights averaged 64 ft (20 m), and nest tree DBHs averaged 16 inches (41 cm). Average DBH for quaking aspen nest trees in Oregon was 11.5 inches (29.1 cm) and 13.7 inches (34.7 cm) in British Columbia (Dobkin and others 1995; Martin and others 2004). In a mixed-species forest in Arizona, 36 nests were located and 21 were in quaking aspen snags, 5 in dead portions of live quaking aspen trees, and 10 in live quaking aspen trees. Average nest height was 53.5 ft (16.3 m), and average nest tree DBH was 17.7 inches (45 cm). Areas around nests contained an average of 18 aspen snags per acre (44/ha) and 9 conifer snags per acre (22/ha) (Li and Martin 1991).

Flickers in British Columbia foraged primarily in areas with short grass and abundant bare ground that also contained a high density of small anthills. The proximity of these foraging areas to vegetative edges determined the distances flickers traveled to find forage which often exceeded 0.9 miles (1.5 km) (Elchuk 2002; Elchuk and Wiebe 2003b).

Diet

In most habitats animal matter comprises the majority (60 percent) of the northern flicker's diet and 75 percent of that was ants and the remainder included beetles, wasps, caterpillars, crickets, and larval forms of many species (Scott and others 1977). Plant material commonly found in flicker diets includes seeds, cultivated grains, and fruits (Scott and others 1977). In a California ponderosa pine forest, 87 percent of the total food volume consumed by northern flickers was sawflies, wasps, bees, ants, and an additional 9 percent were aphids, leaf hoppers, and other *Homoptera* (i.e., largest insect order) species (Otvos and Stark 1985; Scott and others 1977). In British Columbia, flickers avoided large anthills of aggressive wood ants (*Formica* spp.) (although they would eat stray individuals), preferring to feed on smaller ants (e.g., *Lasius* spp. *Tapinoma sessile*) (Elchuk and Wiebe 2002). During inclement weather when ants stay mostly beneath ground, flickers pried open pieces of cow dung to obtain other insects for food (Elchuk and Wiebe 2002).

Home range

In British Columbia, northern flicker home ranges consisted of grasslands interspersed with patches of quaking aspen, Douglas-fir, and lodgepole pine and their size averaged 61.8 acres (25 ha) and ranged from 12 to 269 acres (5 to 109 ha). Individual birds used multiple core areas averaging 17.3 acres (7 ha) in size which were located near nest trees and foraging areas. Home range size averaged 44.5 acres (18 ha) for re-nesting birds while those in a first laying attempt used smaller areas. Home range size increased with increasing distance to the nearest neighbor (Elchuk and Wiebe 2003b). Flickers fiercely defend nest areas with agonistic (e.g., related to fighting or threatening) calls and displays, but do not defend feeding areas (Elchuk and Wiebe 2003a). Elchuk and Wiebe (2003a) observed up to 21 breeding pairs/mile² (8/km²) and noted 50 percent home range overlap.

Populations

Northern flicker populations exhibited little change in response to a variety of conditions in mixed-species and ponderosa pine forests in the western United States. Only in areas that were clearcut did the flicker show a population decline (Franzreb and Ohmart 1978; Kilgore 1971; Mannan and Meslow 1984; Medin 1985; Szaro and Balda 1979). On the Kaibab Plateau in northern Arizona, flicker breeding densities in dense old forests was 6.7 pairs/acre (16.6/ha), 6.4 pairs/acre (15.8/ha) in light harvested old forests, and 3.4 pairs/acre (8.4/ha) in open old ponderosa pine forests (Siegel 1989).

In the Black Hills, northern flicker density was 41.2 birds/mile² (15.9 /km²) in burned forests, 6.5 birds/mile², (2.5 /km²) in ponderosa pine forests, 8.8 birds/mile² (3.4 /km²) in old ponderosa pine forests, and 9.8 birds/mile², (3.8/km²) in white spruce forests (White and others 2010). Flicker densities in burned areas increased steadily with time since fire, rising from 4.1 birds/mile² (1.6 /km²) in 2001 to 41.2 birds/mile² (15.9 /km²) in 2009. A similar trend was observed by Saab and others (2007) over 10 years in a burned ponderosa pine forest in Idaho. Edworthy and others (2011) found that abundance of individuals and nests increased following a mountain pine beetle outbreak in British Columbia's Douglas-fir zone.

In Arizona Szaro and Balda (1982) found that with the exception of clearcuts, northern flickers were located in all types of tree harvesting including areas where trees had not been cut for 60 years. They found birds in light harvests where large trees and dense thickets were selectively removed, in strips of moderate tree harvests, unharvested areas, and in areas intensely harvested. Northern flicker densities averaged about 3 pairs/100 acres (7.4/100 ha) and did not differ among harvest areas (Szaro and Balda 1982, 1986). In Idaho, flickers used large patches of severely burned ponderosa pine that had high canopy cover before burning and contained both large snags and high snag densities (Russell and others 2007; Saab and others 2009). Flicker nest densities were higher in unharvested burned areas compared to harvested burned areas (Saab and others 2007). Management activities that emulate mixed severity fire effects and retain high numbers of large snags in clumps are likely to benefit flicker populations (Saab and others 2009; Vierling and others 2008).

Northern Flying Squirrel

The northern flying squirrel (*Glaucomys sabrinus*) is a medium-sized gliding squirrel ranging from 10.8 to 13.5 inches (27.4 to 34.2 cm) in length and weighing about 2.6 to 4.9 ounces (75 to 140 g) (Malamuth and Mulheisen 1999). The length of flying squirrels in the Black Hills averaged 11.8 inches (30 cm) compared to the 13.0 inch (32.9 cm) average length of those living in western Wyoming (Turner 1974).

In California, 6 percent of 234 prey items were flying squirrels and in Idaho, they comprised 1 percent of goshawks' diet (Bloom and others 1986; Patla 1997). In mixed-conifer forests in Oregon, flying squirrels made up 7 percent of goshawk diets and in Washington, 4.2 percent of prey items at 82 nests over a 10-year period were flying squirrels (Reynolds and Meslow 1984; Watson and others 1998). Goshawks also consumed flying squirrels in temperate rainforests of southeast Alaska and ponderosa pine forests of northeastern California (Lewis and others 2006; Promessi and

others 2004). Although found in the Black Hills, flying squirrel remains were found at only one of the five goshawk nests visited by Bartelt (1977).

Distribution

Northern flying squirrels live in forests throughout northern North America, from southeastern Alaska across the southern tier of Canadian provinces and south into the Great Lakes states, New England, and the Appalachians. In the western United States, the species' range extends south into California and into Idaho, Montana, Utah, northern Wyoming, and western South Dakota. In California, they inhabit the Coast, Klamath, Southern Cascade, Sierra Nevada, and Transverse mountain ranges (Williams and others 1992). The distribution of northern flying squirrels in South Dakota is limited primarily to the isolated population in the Black Hills in white spruce forests located above 4,500 ft (1372 m) elevation. This population is located approximately 245 mi (394 km) east of its nearest neighboring population in Park County, Wyoming (Turner 1974; Wells-Gosling and Heaney 1984).

Habitat

Flying squirrels are forest dwelling and are found only in areas with trees of sufficient size and density that provide for denning and gliding (Jameson and Peeters 1988). Northern flying squirrels inhabit a variety of coniferous forests in California, including mixed-conifer, Douglas-fir, red fir (*Abies magnifica*), white fir, ponderosa pine, lodgepole pine, and oak woodlands from sea level up to 7,500 ft (2286 m) elevations (Ingles 1965; McKeever 1961; Williams and others 1992). In general, they tend to nest in mesic ponderosa pine, quaking aspen, spruce, and paper birch forests (Hough and Dieter 2009a; Kruger 2004; Turner 1974).

Northern flying squirrels typically live in dense and mature forests however they are opportunist and capable of adjusting to a wide range of forest conditions (Carey and others 1992; Cotton and Parker 2000; Hough and Dieter 2009b; Lehmkuhl and others 2006; Smith and others 2005; Thomas and others 1990; Waters and Zabel 1995; Weigl 2007). Raphael and others (1986) and Rosenberg and Anthony (1992) found similar squirrel abundance in both mid-aged and old forests. Mid-aged forests may appear to support healthy squirrel densities but, in reality, they are population drops from neighboring old forests and usually do not maintain viable populations (Fisher and Wilkinson 2005; Smith and Person 2007). Cotton and Parker (2000) noted that flying squirrels in mid-aged spruce-fir forests selected the larger, taller, and older trees for nesting. Not surprisingly, flying squirrels were not found within clearcuts less than 20 years old and forest openings (Gashwiler 1970; Williams and others 1992). Also snags, downed logs, coarse woody debris, thick litter layer, and understory cover are important for habitation (Carey 1995; Carey and others 1999; Holloway and Malcolm 2007; Meyer and others 2005, 2007; Pyare and Longland 2002; Smith 2007; Smith and others 2004; Weigl 2007).

Flying squirrels glide from tree to tree relying on elevated launch and landing sites. Large openings or wide tree spacing probably limits their movement and increases their vulnerability to predation (Wells-Gosling and Heaney 1984; Williams and others 1992). In Douglas-fir forests of northern California, Rosenberg and Raphael (1986) found squirrels in 60 to 80 percent of stands larger than 50 acres (20.2 ha)

compared with 15 percent occupancy of stands of 25 to 50 acres (10.1 to 20.2 ha) and less than 10 percent occupancy of stands less than 15 acres (6.1 ha) in size. Lehmkuhl and Ruggiero (1991) suggested northern flying squirrels could be at risk of local extinction because of mature forest fragmentation.

Northern flying squirrels den in natural and woodpecker-excavated cavities in trees, drey nests comprised of sticks, dry leaves, and grass built by birds and squirrels, and tree branches deformed by dwarf mistletoe (*Arceuthobium* spp.) (Hough and Dieter 2009c; Wells-Gosling and Heaney 1984). One female may use up to seven dens in both hardwoods and conifers for nesting, daytime resting, and protection from weather (Carey 1991; Carey and others 1997). Flying squirrels tend to select nest trees that are older, taller, and larger than random trees (Bakker and Hastings 2002; Carey and others 1997; Cotton and Parker 2000; Meyer and others 2005). In the Black Hills, cavity nests were located in dead and live quaking aspen, paper birch, and ponderosa pine trees. However, drey squirrel nests were only found in live ponderosa pine and white spruce trees (Hough 2008). Snags were used almost five times more often than expected based on their availability, and DBH of all nest trees was larger than available snags, averaging 11.4 inches (29 cm) DBH (Hough and Dieter 2009c). Carey (1991) found nest cavities in live conifers averaging 49 inches (124 cm) DBH and in snags averaging 35 inches (89 cm) DBH.

Diet

Although they are tree dwelling, flying squirrels often forage on the ground for seeds and mushrooms. In the Sierra Nevada Mountains tree lichens, an important flying squirrel food, were more abundant in old red and white fir forests than in young forests (Waters and Zabel 1995). Mushrooms are strongly associated with deep soil surface organic layers, decayed logs, and high canopy cover, which are typically found in mature and old forests located on cool and moist aspects (Gabel and others 2010; Lehmkuhl and others 2004; Luoma and others 1991; Maser and others 1978, 1985; McKeever 1960; Tevis 1956; Williams and others 1992). In Oregon, over 80 percent of the summer diet consisted of mushrooms and 71 percent of these mushrooms were gilled (*Basidiomycetes*) and 26 percent was case (*Ascomycetes*). Also in Oregon, 50 percent of the year-round flying squirrel diet was lichens (Maser and others 1978; Maser and others 1985). In the Sierra Nevada, Hall (1991) reported that mushrooms and lichens were the primary year-round food for flying squirrels and they likely cached mushrooms to eat during the winter. In the northern Black Hills, over 90 percent of flying squirrel feces collected contained fungal spores, predominantly from genus *Rhizopogon* (e.g., fungi growing on tree roots) (Gabel and others 2010). Other flying squirrel foods include seeds, nuts, bird eggs, nestlings, insects, tree sap, buds, berries, and tree cones (Weigl 2007; Wells-Gosling and Heaney 1984).

Home range

Northern flying squirrel home range size is limited by food abundance and, to a lesser extent, den site availability (Hough 2008). In Wind Cave National Park the average size of female flying squirrel home ranges was 11.4 acres (4.6 ha) (Duckwitz 2001). Also in the Black Hills, Hough and Dieter (2009a) reported home range sizes for males of 27.7 acres (11.2 ha) and 17.1 acres (6.9 ha) for females. They indicated

that home ranges in the mesic and more structurally complex forest of the northern Black Hills were more than twice as large as those located in the drier southern hills. Male home ranges are generally two to three times as large as females and often overlap with those of several females, presumably to increase breeding potential (Carey and others 1997; Holloway and Malcolm 2007; Hough and Dieter 2009a; Martin and Anthony 1999). In ponderosa pine forests with 40 percent canopy cover in Washington, home range size was 11.4 acres (4.6 ha) and 85 percent larger than those located in nearby mixed-conifer forests (Lehmkuhl and others 2006). Core areas were generally centered on food patches, while nest sites were often located near home range perimeters (Holloway and Malcolm 2007; Smith 2007).

Populations

Estimated flying squirrel densities in coniferous forests of the Pacific Northwest ranged from 0.4 to 1.2 animals/acre (1 to 3/ha) and did not show trends relative to habitat, geographic location, or elevation (Thomas and others 1990). However, Gomez and others (2005) reported that squirrel density increased with increased mushroom biomass, large logs, and conifers with DBHs greater than 19.7 inches (50 cm). In southwestern Oregon mean density of flying squirrels was 0.8 squirrels/acre (2/ha) in old Douglas-fir forests and 0.4 squirrels/acre (1/ha) in mid-aged forests (Carey and others 1992). Witt (1992) reported 2.47 flying squirrels/acre (0.85/ha) in an old hemlock-fir forest, which was six times the number found in a 65-year-old forest. However, the occurrence of flying squirrels was far less in mature forests if their range was less than 50 acres (20 ha) in size (Rosenberg and Raphael 1986).

Doyle (1990) reported similar densities of flying squirrels in riparian and upland habitats but found a larger proportion of juveniles in upland habitats, suggesting that riparian habitats may serve as population sources, whereas upland habitats may be population sinks for dispersing juveniles. Waters and Zabel (1995) observed highest squirrel densities in old forest, intermediate densities in young forest, and lowest densities in forests with scattered overstory trees. Structure (e.g., young, mid-aged, and old) appears to be more influential on flying squirrel populations than seral stage (e.g., pioneer, mid-seral, and climax) (Rosenberg and Anthony 1992; Carey and others 1999). Therefore, squirrel abundance usually increases in a forest from the time it is disturbed (e.g., harvested and burned) as it progresses to old forest (Fisher and Wilkinson 2005). Lehmkuhl and others (2006) found 0.5 squirrels/acre (1.2/ha) in open ponderosa pine forests and 0.9 squirrels/acre (2.2/ha) in mixed-conifer forest and they postulated that a threshold of 55 percent canopy cover separated low- from high-density flying squirrel populations.

Tree harvesting that removes snags, defective trees, mature forests, and mistletoe-infected trees will likely reduce the quality of flying squirrel habitat (Carey and others 2002; Lehmkuhl and others 2006; Smith 2007). Clearcut and partial cut harvesting resulting in tree spacings greater than 120 ft may limit flying squirrel gliding and increase their predation risk. Carey (1995) found that forest treatments that produce heterogeneous canopy cover negatively affected population abundance. However, he reported that population levels rebounded to pre-thinning levels after 5 years. In contrast, other studies showed that thinning of mid-aged forests showed no negative short-term effects on squirrel survival rates, densities, or mushroom

production (Carey and others 2002; Gomez and others 2005; Ransome and Sullivan 2002). However, Carey (2001) indicated that where squirrel densities were low, effects of thinning may be hard to detect. Squirrel populations in young forests containing a legacy of old trees, snags, down logs, and developed understory can equal the populations found in old forests (Carey 1995).

Isolated northern flying squirrel populations, such as those at the southern extension of the species' range, are highly susceptible to decline as a result of timber harvest (Koprowski 2005; Weigl 2007). Flying squirrels in the Black Hills are at risk simply because they are rare and their range being restricted to the mesic northern portion of the Hills. Because of this, the Black Hills National Forest considers the northern flying squirrel a species of special concern (USDA Forest Service 2005).

Red-Headed Woodpecker

The red-headed woodpecker (*Melanerpes erythrocephalus*) is a medium-sized bird being 7.9 to 9.4 inches (20 to 24 cm) long and weighing 2.0 to 3.2 ounces (56 to 91 g) (Smith and others 2000). This woodpecker is one of five *Melanerpes* species living in the United States, and although members of this genus regularly occur in the diet of goshawks the red-headed woodpecker has yet to be recorded (Reynolds and Meslow 1984).

Distribution

Red-headed woodpeckers range from southern New England west to eastern Saskatchewan and the eastern slope of the Rocky Mountains, south to central New Mexico, and east to the Gulf Coast (Smith and others 2000). They are common summer residents within most of South Dakota, except in the Black Hills where they occur primarily at lower elevations (Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991). Recent monitoring in the Black Hills found this species mostly in the Jasper Fire area but also in ponderosa pine and riparian habitats, especially where they were associated with burned areas (Panjabi 2003; White and others 2010).

Habitat

Red-headed woodpeckers use open forests with uncluttered understories containing mature hardwoods, snags, stumps, and trees with dead limbs (Bent 1939; Smith and others 2000). They use vegetative edges, upland forests, woodlots, and shelterbelts along agricultural fields (Luensmann 2006). Riparian areas, upland meadows, forest bottomlands, beaver ponds, and open wooded swamps are favored by this woodpecker. Red-headed woodpeckers also use forests disturbed by harvesting, wind, ice, flooding, insects, fire, and especially those that remove tree leaves. Also orchards, residential areas, isolated trees, roadside fence posts, utility poles, and golf courses are frequented by red-headed woodpeckers (Anderson 2003; Pettingill and Whitney 1965; Smith and others 2000; South Dakota Ornithologists' Union 1991).

Red-headed woodpeckers nest in snags, stumps, dead limbs, and dead portions of pine, birch, oak, elm, maple, cottonwood, willow, box elder, and white ash (*Fraxinus americana*) (Johnsgard 1986; Twomey 1945; Smith and others 2000). They prefer nest trees to be grouped (Sedgwick and Knopf 1990). In addition, they tend to

avoid pure live forests, as exemplified in the Black Hills, as no red-headed woodpeckers were detected in 272 samples of live forests (Spiering and Knight 2005). They also use telephone poles, nest boxes, split-rail fence rails, and buildings for nesting and they often reuse the same cavity for several years. They prefer well-worn and smooth-surfaced nest sites compared to those with bark and as weak excavators, they often use existing cavities (Bent 1939; Smith and others 2000). In riparian areas of South Dakota red-headed woodpeckers nested in cottonwood trees and they also nested in burned ponderosa pine trees (Gentry and Vierling 2008; Sharp and Uresk 1990). Within the Jasper Fire that burned in the Black Hills in 2000, 53 percent of red-headed woodpecker nests were in the few quaking aspen snags that remained and the other 47 percent were in dead ponderosa pine trees (Vierling and Lentile 2006).

In the Jasper Fire area, nest trees averaged 10.8 inches (27.4 cm) DBH while random trees averaged 8 inches (20.4 cm) DBH and in areas in the Hills near the fire, nest snags averaged 28.5 ft (8.7 m) tall and 15 inches (38.2 cm) DBH (Gentry and Vierling 2008; Vierling and Lentile 2006). Also within the Jasper Fire area red-headed woodpecker nest snags averaged 14.9 inches (37.8 cm) DBH and nest height averaged 35.1 ft (10.7 m) (Vierling and others 2009). Across the Wyoming border in the Bear Lodge, the average height of two nests located in ponderosa pine snags was 30 ft (9.1 m) (Pettingill and Whitney 1965). Elsewhere in South Dakota, the average height of a nest located in a dead branch of an ornamental poplar and one in a utility pole was 60 ft (18.3 m) (Pettingill and Whitney 1965).

Diet

Red-headed woodpeckers forage by fly-catching insects on the ground, on dead trees, utility poles, and dead branches (Beal 1911; Smith and others 2000). Based on the analysis of 443 stomachs collected throughout the year, approximately 34 percent of their diet was animal matter consisting of grasshoppers, bees, wasps, crickets, beetles, and caterpillars with the remainder being plant material (Beal 1911). These woodpeckers also consume birds, bird eggs, nestlings, mice, and lizards. Red-headed woodpeckers also eat seeds, acorns, sap, nuts, berries, fruit, and corn (Smith and others 2000). Acorns are an important food, especially during the winter, making these woodpeckers somewhat nomadic as they search for oak forests (Smith and others 2000; South Dakota Ornithologists' Union 1991; Vierling and others 2009). They store many of these foods such as grasshoppers, corn, and acorns in tree crevices and under tree bark for later consumption (Beal 1911).

Home range

Red-headed woodpecker territories vary in size with habitat and winter territories generally smaller. Home ranges in the Black Hills were estimated to be 3 to 6 acres (1.2 to 2.4 ha) in size (Haldeman 1980).

Populations

Due to population declines, red-headed woodpeckers are considered a species of conservation concern among the Badlands, Prairies, and several other Bird Conservation Regions, (USFWS 2008). Historically, red-headed woodpecker populations increased when forests were cleared for agriculture, years with abundant acorn

production, and outbreaks of Rocky Mountain grasshoppers. Population declines have occurred when forests recovered after disturbance and seed producing beech, elm, and oak forests declined. Tree harvesting that removes snags, dead tree limbs, broken tree stumps, and acorn producing oaks, along with the loss of cottonwoods in riparian areas can negatively impact populations (Sedgwick and Knopf 1990). Also populations can be threatened by the expansion of European starlings (competitor for cavity nests) and fire suppression (Smith and others 2000).

Grinnell (1875), who accompanied General Custer to the Black Hills 1874, described red-headed woodpeckers as “especially abundant and seen where ever there was timber” and Cary (1901) described them as “the most abundant woodpecker in the Hills.” However, today (2014) they are uncommon in the Black Hills and bird monitoring conducted from 2001 through 2009 detected only a handful of individuals in a variety of riparian, grassland, shrubland, and ponderosa pine habitats (Panjabi 2001, 2003; White and Giroir 2008). However, the majority of red-headed woodpeckers were seen in burned forests where densities averaged 5.14 woodpeckers/mile² (1.99/km²) (White and others 2010).

Red-Naped Sapsucker

The red-naped sapsucker (*Sphyrapicus nuchalis*) is a medium-sized woodpecker that averages 7.5 to 8.3 inches (19 to 21 cm) long and weighs approximately 1.1 to 2.3 ounces (32 to 66 g) (Walters and others 2002). The red-naped sapsucker is one of four *Sphyrapicus* species that occupy forests of North America and they are regularly consumed by goshawks (Bloom and others 1986; Lewis and others 2006; Patla 1997; Reynolds and Meslow 1984; Squires 2000).

Distribution

Red-naped sapsuckers reside in forests of southeast Alaska, British Columbia, Alberta, Rocky Mountains (i.e., Idaho, Nevada, Montana, Utah, Colorado, Arizona and New Mexico), California, and the Black Hills. They winter in Arizona, New Mexico, Baja California, and northwestern Mexico (Walters and others 2002). In the Black Hills, red-naped sapsuckers are considered uncommon summer residents at all elevations (Pettingill and Whitney 1965; South Dakota Ornithologists’ Union 1991). Recent surveys found them in low to moderate abundance across the Hills, but they were most abundant in the northern Black Hills (Panjabi 2001, 2003; White and others 2010).

Habitat

Red-naped sapsuckers use deciduous and mixed woodlands containing mature and dead trees. They are found in ponderosa pine, quaking aspen, mixed-conifer, lodgepole pine, and mixed Douglas-fir/western larch/ponderosa pine forests. They were also found in riparian areas containing quaking aspen, birch, and willow (Scott and others 1977; Walters and others 2002). In the Rocky Mountains, sapsuckers used pure quaking aspen forests or quaking aspen mixed with open conifer forests. In Montana, red-naped sapsuckers used mature mixed-conifer forests of western larch, Douglas-fir, and paper birch (McClelland and McClelland 2000). In Utah and Idaho, sapsuckers were strongly associated with quaking aspen and mature Douglas-fir

forests (Smith 1982). They also used harvested forests where groves of quaking aspen were retained (Walters and others 2002). In the Black Hills, red-naped sapsuckers mainly used ponderosa pine and quaking aspen forests but were also found in riparian areas and white spruce forests (Pettingill and Whitney 1965; Panjabi 2001, 2003; White and others 2010). Although nests have been found in a variety of deciduous and coniferous forests, red-naped sapsuckers nest almost exclusively in mature and diseased quaking aspen forests that incorporate foraging areas. In addition to nesting in mature quaking aspen trees in Colorado, sapsuckers used mixed cottonwood-willow forests in riparian areas especially when they were associated with foraging areas (Vasquez 2005).

Red-naped sapsuckers are cavity nesters and they occasionally reuse a nest, but typically they excavate a new cavity each year. For example, in Montana, 22 of 42 nest trees were used for 2 consecutive years and only 6 were reused for more than 2 years (McClelland and McClelland 2000). Similarly, in Colorado, only 3 of 33 cavities were reused, but 22 of the 33 nests were located in the same trees as the previous year's cavities (Daily 1993). Quaking aspen trees are preferred by sapsuckers for nesting and they select trees infected with stem rots (fungi) to ease nest excavation. In Colorado and Wyoming, 51 nests were located in quaking aspen trees and most were infected with the shelf fungus (*Phellinus igniarius*) (Crockett and Hadow 1975). Similarly, 13 nests were located in Wyoming and all were in quaking aspen also infected with a stem rot (Loose and Anderson 1995). The DBH of quaking aspen trees used for nesting tend to be larger than the average quaking aspen tree available and the number of nests located in a stand was strongly associated with the number of quaking aspen trees greater than 7.1 inches (18 cm) DBH (Crockett and Hadow 1975). Nest stands had 36 overstory trees per acre (90/ha) and when compared to other stands had greater ground cover (73 percent versus 35 percent) and greater grass cover (39 percent versus 10 percent) (Loose and Anderson 1995). Scott and others (1980) characterized 6 nests located in ponderosa pine, spruce-fir, and quaking aspen forests within in the Rocky Mountains. Five nests were located in live quaking aspen trees and the other was in a conifer snag.

Sapsuckers excavate cavities relatively low on a tree, especially if the tree has no nests. New nests are located above older ones as stem rots usually begin near a tree's base and progresses upward with time (Daily 1993). In Colorado, the average nest tree was 62 ft (19 m) tall and nest height averaged 39 ft (12 m) with the DBH of nest trees averaging 16 inches (40.6 cm) (Scott and others 1980). Of 20 nests discovered in Arizona, all were located in quaking aspen trees (20 percent snags, 25 percent dead portions of live trees, and 55 percent live trees), average nest tree height was 43.6 ft (13.3 m), and average nest tree DBH was 14.6 inches (37.1 cm) (Li and Martin 1991). An average of 1.7 (4.2/ha) quaking aspen and 0.6 (1.5/ha) conifer snags per acre were located around the nests. Conifers containing sapsucker nests tend to have larger DBHs than quaking aspen nest trees allowing nests to be located high in the tree where the tree bark is thinner and the cavity is better protected from predators (Crockett and Hadow 1975).

In Colorado red-naped sapsuckers foraged in quaking aspen, willow, conifer, and cottonwood trees close to their nests (Crockett and Hadow 1975). In Wyoming, they foraged in young and mature lodgepole pine, multi-story lodgepole pine, spruce-fir,

and quaking aspen forests. Trees and snags used for foraging averaged 11 inches (28 cm) DBH and random trees averaged 4.5 inches (11.4 cm) DBH. Logs used for foraging were no larger than others available (Loose and Anderson 1995).

Diet

Red-naped sapsuckers feed on tree sap throughout the year, but the amount taken, tree species used, and location of the sap wells on a tree vary seasonally (Bock and Larson 1986; Scott and others 1977; Walters and others 2002). Rocky Mountain juniper (*Juniperus scopulorum*), Douglas-fir, lodgepole pine, white spruce, willow, quaking aspen, and cottonwood trees are frequently drilled by sapsuckers (Loose and Anderson 1995). During the breeding season, red-naped sapsuckers in Colorado and Wyoming used a variety of conifers and deciduous trees and shrubs for sap-sucking (Crockett and Hadow 1975). In early spring, sap wells are drilled into tree boles using a series of parallel holes. Exploratory wells are made initially but they are enlarged into a single well when sap starts to flow. Occasionally, sapsucker drilling can girdle and kill tree branches and a family foraging on willow trees was known to do sufficient damage that it may take years for the trees to recover (Ehrlich and Daily 1988). Although sap constitutes the majority of plant material eaten by sapsuckers, tree fruit often makes up a small proportion of their diet (Bock and Larson 1986; Scott and others 1977). Most (80 percent) of the animal material consumed by sapsuckers are ants, but they also consume beetles, wasps, and other insects that get trapped in sap wells, gleaned from trees, or by fly-catching (Scott and others 1977; Walters 1996).

Home range

Territories of red-naped sapsuckers include both nest and sap-well trees. In British Columbia, average territory size was 13.2 acres (2.47 ha). Most movements were less than 1,640 ft (500 m) from the nest, although some sapsuckers traveled nearly a mile (1.6 km) to maintain sap wells in willow trees. In Colorado, territory size averaged 4.1 acres (1.67 ha) (Walters 1996).

Populations

Breeding Bird Survey data indicate red-naped sapsucker populations are increasing in the United States, and there is an increasing population trend in South Dakota (Sauer and others 2011a). In the Black Hills, they are considered quaking aspen-paper birch obligates, and their highest abundance was associated with forest compositions that included at least 4 quaking aspen-paper birch snags/acre (1/ha) that had DBHs greater than 5.9 inches (15 cm) (Mills and others 2000). From 2001 to 2009, the total number of red-naped sapsuckers observed in the Hills ranged from 306 in 2001 to 118 in 2006 (White and others 2010). Densities for the same period in mid-aged ponderosa pine forests were 42.5 birds/mile² (16.4 /km²), in old ponderosa pine forests densities were 32.9 birds/mile² (12.7/km²), and in white spruce forests densities were 32.4 birds/mile² (12.5/km²) (White and others 2010). All three forest types included quaking aspen. Populations of sapsuckers in quaking aspen forests were nearly twice as high, ranging from 73.8 birds/mile² (28.5/km²) in 2001 to 125.3/mile² (48.4/km²) in 2004 (White and Giroir 2008).

Red Squirrel

The red squirrel (*Tamiasciurus hudsonicus*) is a small tree squirrel ranging in length from 10.8 to 15.0 inches (27.0 to 38.5 cm) and weighs from 6.9 to 9.9 ounces (197 to 282 g) (Steele 1998). Black Hills red squirrels (*T. h. dakotensis*) are larger than those living to the west and southwest of the Hills and average 13.7 inches (34.8 cm) long and they weigh an average of 10.3 ounces (292 g) (Turner 1974).

The red squirrel is a common year-round prey of goshawks in the Black Hills, which makes the species especially important. During three breeding seasons in Alberta, Canada an estimated 306 red squirrels were captured by a pair of goshawks and during the winter, when less prey is available, they likely captured many more (Rusch and Reeder 1978). In New York red squirrels comprised 12 percent of the goshawk's diet, in Minnesota, 31 percent, and in California they comprised 21 percent (Bloom and others 1986; Grzybowski and Eaton 1976; Meng 1959; Smithers and others 2005). In Arizona, 29 percent of the prey captured by goshawks was red squirrels in 1991 and 12 percent from 1999 to 2003 (Reynolds and others 1994; Salafsky and others 2005). In Idaho, red squirrels comprised 17.8 percent of the goshawk's diet and in Wyoming, 50 percent of 793 fecal pellets collected contained red squirrel remains (Patla 1997; Squires 2000). In the Black Hills, red squirrel remains were found at all of nests located by Bartelt (1977), Erickson (1987), and Knowles and Knowles (2009).

Distribution

Red squirrels live in the forests of Alaska, the boreal of Canada, and the hardwood and coniferous forests of the upper midwestern, northeastern, and Appalachian states. They range throughout coniferous forests of the Rocky Mountains and south into the mountains and higher elevation plateaus of Arizona and New Mexico (Hoffmeister 1986; Steele 1998). In the Black Hills, red squirrels are most common above 5,200 ft (1585 m), especially in the white spruce forests, but they occur throughout the Hills above 3,800 ft (1158 m) (Turner 1974).

Habitat

In the western United States, red squirrels are found most often in mature spruce-fir, Douglas-fir, and lodgepole pine forests. Mature forests appear to offer excellent breeding conditions and have higher squirrel survival rates than do younger stands. However, young forests offer yearling and young squirrels areas to move to (Sullivan and Moses 1986). Red squirrels are less common in mixed ponderosa pine and Douglas-fir forests and are rare in pure ponderosa pine (Gurnell 1984; Hoffmeister 1986; Rasmussen 1941; Sullivan and Moses 1986). Uphoff (1990) found high densities of red squirrels in low elevation mixed-coniferous and deciduous forests in Arizona. In the Black Hills, red squirrels live in white spruce, often mixed with ponderosa pine, pure and mixed quaking aspen forests, and oak woodlands (Higgins and others 2002; Turner 1974).

Large and centrally located food caches (middens) are critically important for red squirrels. Over the winter, this stored food is consumed and during the summer it is consumed by juveniles as they learn to forage (Gurnell 1984; Kemp and Keith 1970; Patton and Vahle 1986; Rusch and Reeder 1978; Smith 1968b; Uphoff 1990). Seed crops can fluctuate widely from year to year, often making cached cones an

important food source for several winters (Smith 1968b). Caches located in moist and well shaded areas provide optimal conditions for cone storage (Rothwell 1979). Shade from groups of mature trees and from mid and lower vegetation maintain temperature and humidity at levels sufficient to prevent cones from opening and minimize the drying of mushrooms, conifer buds, grasses, berries, and insects that are also cached. In Arizona, Vahle and Patton (1983) found that 90 percent of 141 caches had canopy cover greater than 60 percent and also in Arizona canopy cover over and within 33 ft (10.1 m) of middens averaged 89 percent (Mannan and Smith 1991). Very often one or more snags, fallen logs, and/or live trees greater than 20 inches (50.8 cm) DBH provide support for primary caches (Vahle and Patton 1983). In old mixed conifer forests, density measured by basal area averaged 197 ft²/acre (45.2 m²/ha) at cache sites and at random sites averaged 142 ft²/acre (32.6/m²). Cache sites also had more than 3 trees/acre (7.4/ha) with 20 inch (50.8 cm) DBHs (Patton and Vahle 1986; Vahle and Patton 1983). Similarly, Mannan and Smith (1991) found an average of 4 trees/acre (9.9/ha) with DBHs greater than 16 inches (40.6 cm) at middens.

Old-trees tend to produce 20 to 30 times more cones than trees that are 50 to 100 years old (Hermann and Lavender 1990). For example Douglas-fir trees 200 to 300 years old are far better at producing cones than younger trees. White fir begins producing cones approximately at 40 years of age and continues well beyond 300 years. Dominant white fir trees 12 to 35 inches (30.5 to 88.9 cm) DBH tend to be the best and most reliable cone producers (Laacke 1990). Engelmann spruces begin producing abundant cones at DBHs greater than 15 inches (38.1 cm) and that are 150 to 200 years old and blue spruce's (*Picea pungens*) best seed-producing years are from age 50 to 150 years (Alexander and Shepperd 1990; Fechner 1990).

Red squirrels prefer to nest in trees located within groups of trees with interlocking crowns (Vahle and Patton 1983). In Wyoming, 48 percent of 65 nest trees had crowns with greater than 75 percent overlap with other trees and the remaining nest trees had 15 to 75 percent overlap (Rothwell 1979). In a mixed species forest in Arizona, nest trees averaged 14 inches (35.6 cm) DBH and the largest nest trees were found at cache sites. Nest trees on average were located within 15 ft (4.6 m) of the cache center (Vahle and Patton 1983). Layne (1954) found leaf nests in trees with 4- to 16-inch (10.2- to 40.6-cm) DBHs located in a mixed hardwood forest of New York and cavity nests were located in trees with 12- to 36-inch (30.5- to 91.4-cm) DBHs.

Diet

In coniferous forest, seeds are the year-round food of red squirrels. The number of cones required to sustain a single red squirrel for a year ranges from 42,000 to 100,000. It has been estimated that 9 to 25 large cone-producing trees per territory would be necessary to support a red squirrel or 3 to 4 trees trees/acre (7.4 to 9.9/ha) with DBHs greater than 18 inches (45.7 cm) DBH (Gurnell 1984; Patton and Vahle 1986; Rusch and Reeder 1978; Smith 1968a; Vahle 1978;). Common seeds eaten by red squirrels in the Southwest are from Douglas-fir, blue spruce, Engelmann spruce, and white fir (Gurnell 1984; Patton and Vahle 1986; Rusch and Reeder 1978; Smith 1968a; Sullivan and Moses 1986). On the Kaibab Plateau in northern Arizona, ponderosa pine seeds were occasionally consumed by red squirrels and in feeding trials

they were second most preferred and were the most nutritious out of seven species tested (Rasmussen 1941; Smith 1968a).

Tree buds, fruits, sap, acorns, insects, and bird eggs are also consumed by red squirrels, especially if conifer seed supplies are low (Brink and Dean 1966; Hatt 1929; Layne 1954; Rusch and Reeder 1978; Smith 1968a, 1968b; Uphoff 1990). Depending on location, conifer pollen is consumed for 2 or 3 weeks, while mushrooms are usually available throughout the summer. After being dried, they are cached along with cones (Hatt 1929; Rusch and Reeder 1978; Smith 1968a, 1968b). Mushrooms of 42 fungi species have been eaten by squirrels in the Cascade Mountains of southern British Columbia, with false truffles (*Rhizopogon*), pine spike (*Chroogomphus*), and butter (*Suillus*) mushrooms being preferred (Smith 1968a). In the northern Hills, Oregon mushrooms (*basidiomycetes*) were eaten most frequently by red squirrels and made up 77 percent of the diet (Maser and others 1978). In Arizona, the most common mushrooms gathered were the beef steak (*Fistulina hepatica*), brown (*Cortinarius rufolivuccus*), and angle wing (*Pleurotus porrigens*), which were dried and cached (Uphoff 1990). However pine truffles (*Geopora cooperi*) and puffballs (*Basidiomycota*) would be eaten immediately upon discovery and were the most common summer food eaten by females in Arizona (Uphoff 1990).

Home range

Adult red squirrels used 0.7 to 2.0 acres (0.3 to 0.8 ha) in a lodgepole pine forest and from 0.5 to 11 acres (1.3 to 4.5 ha) in a mixed hardwood-conifer forest (Gurnell 1984; Layne 1954). In British Columbia, adult territories were contiguous and non-overlapping and averaged 1.3 acres (0.5 ha) at high elevation sites and 2.2 acres (0.9 ha) at low elevation sites. Territories estimated for 23 marked red squirrels in mixed white spruce, black spruce, jack pine, quaking aspen, and poplar forests ranged from 0.6 to 2.0 acres (0.2 to 0.8 ha) (Kemp and Keith 1970; Rusch and Reeder 1978).

Populations

Red squirrels are generally more abundant in mature and unharvested forests than in treated and young forests (Thompson and others 1989). Densities of red squirrels spanning 50 years averaged 1.1/acre (2.7/ha) in spruce forests, 0.7 squirrels/acre (1.7/ha) in mixed conifer forests, and 0.4 squirrels/acre (1.0/ha) in pine forests (Rusch and Reeder 1978). Vahle and Patton (1983) found red squirrel population densities in old mixed species stands to be 0.4 to 1 squirrels/acre (1.0 to 2.5/ha), while Ward (2001) estimated densities of 0.03 to 0.32 squirrels/acre (0.1 to 0.8/ha) in mixed species forests. Also, Ward (2001) found an average of 1.7 squirrels/acre (4.2/ha) in 45-foot wide corridors along drainages (primarily occupied by females), but only 0.61 squirrels/acre (1.5/ha) were found in corridors on the upper slope drainages. In a natural 20-year-old lodgepole pine forest, red squirrel densities were 0.5/acre (1.2/ha), and in areas that had been thinned densities were 0.2 squirrels/acre (0.5/ha).

Ruffed Grouse

Ruffed grouse (*Bonasa umbellus*) are medium-sized birds living in deciduous and coniferous forests and woodlands. Adult males average 16.9 to 19.7 inches (43 to 50 cm) tall are slightly larger than the 15.7 to 18.5 (40 to 47 cm) inch tall females.

Weighing from 15.8 to 26.5 ounces (450 to 750 g), ruffed grouse are high value prey for goshawks (Rusch and others 2000). Of 39 prey remains found at two goshawk nests in the Oregon Coast Range, 45 percent were ruffed grouse (Thraillkill and others 2000). Less than 1 percent of the prey remains collected from nests in Oregon and Washington were ruffed grouse and in Idaho, they comprised 18.8 percent of the goshawk's diet (Patla 1997; Reynolds and Meslow 1984; Watson and others 1998;). In Minnesota, using video recordings of goshawks delivering prey to nests, Smithers and others (2005) estimated that ruffed grouse comprised 5 percent of the prey and 11 percent of the biomass. Over the course of 10 years, 18.2 percent of prey remains found at 10 nests in New York were ruffed grouse (Grzybowski and Eaton 1976). In the Black Hills, ruffed grouse remains were found underneath 4 of 5 of goshawk nests Bartelt (1977) visited.

Distribution

Ruffed grouse are widely distributed across Canadian and northern U.S. forests, occurring south into the higher elevations of the Pacific Coastal region, north-central Utah, and northwestern Colorado and into the southern Appalachian Mountains. Isolated populations also occur in the Black Hills and populations have been restored across the Midwestern states and in northeastern Nevada. Ruffed grouse were abundant residents in the Black Hills when Custer came to the Hills in 1874 and into the beginning of the 20th century (Grinnell 1875; Knight 1902; Over and Thomas 1921). More recent accounts suggest that ruffed grouse are rare in the Hills and only small populations live in the northern portion (Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991; White and others 2010).

Habitat

Across most of their range, ruffed grouse are strongly associated with quaking aspen forests (Rusch and Keith 1971a; Rusch and others 2000; Wiggins 2006). In Minnesota, ruffed grouse used pure quaking aspen, mixed quaking aspen hardwood, and mixed quaking aspen conifer forests but avoided forests without a quaking aspen overstory (Svoboda and Gullion 1972). Also in Utah and Wyoming ruffed grouse were found primarily in quaking aspen forests (Dorn and Dorn 1990; Hayward and others 1976). Ruffed grouse live in boreal forests but dense mature forests are rarely used (Gullion 1970; Gullion and Marshall 1968; Rusch and Keith 1971b). In the Black Hills, ruffed grouse lived in deciduous woodlands, quaking aspen groves, and mixed-conifer woodlands (Pettingill and Whitney 1965). Also in the Hills, the species uses mesic ponderosa pine forests interspersed with small groves of quaking aspen, paper birch, and bur oak along with riparian areas (White and others 2010).

Because grouse are non-migratory, a structural stage mosaic of young to old forests that provides both cover (e.g., thermal, hiding) and foraging (e.g., herbs, forbs, and fruit bearing shrubs) were used year-round (Bump and others 1947; Gullion and Alm 1983; Sharp 1963; Rusch and others 2000). However, in Minnesota, ruffed grouse selected home ranges with high densities of small and uniform vegetative patches and home ranges were centered on areas with abrupt vegetative edges (Svoboda and Gullion 1972). Patches of young quaking aspen and mixed vegetative patches containing tens of thousands of stems per acre (ha) are frequently used by

ruffed grouse and can be sustained by light burning (Gullion and Alm 1983; Jones and DeByle 1985; Stauffer and Peterson 1985b). Also, such burning may reduce the invasion or succession of quaking aspen to conifers (Mueggler 1985).

Male ruffed grouse are particularly territorial and express their presence by “drumming” (i.e., opening and closing their wings in rapid succession) on elevated rocks, stumps, exposed roots, snow banks, mounds of dirt, and piles of logs (Rusch and others 2000). Drumming sites are the center of a male’s territory during late winter to early spring and their presence may determine site occupancy (Archibald 1975; Hansen and others 2011b; Zimmerman and Gutierrez 2008). Male grouse are particularly conspicuous at this time and vulnerable to predators (Tirpak and others 2010). They select drumming, and alternate drumming sites, in deciduous forests that afford aerial cover while providing horizontal visibility and avoid conifer forests and those with dense understories for drumming (Gullion 1970; Gullion and Marshall 1968; Hansen and others 2011b; Rusch and Keith 1971a; Rusch and others 2000; Zimmerman and Gutierrez 2008). In 8- to 25-year-old quaking aspen stands of Minnesota, 40 percent of the male grouse observed, used drumming logs at least 7.9 inches (20 cm) in diameter and greater than 6.6 ft (2 m) in length. Similar sites were chosen by ruffed grouse for drumming in the Black Hills (Gullion and Alm 1983; Hansen and others 2011b; Rusch and others 2000).

Quaking aspen and other hardwood forests with open understories are used by ruffed grouse for nesting. Nests located in moist riparian areas provide broods a cool setting during the heat of late summer (Wiggins 2006). Nests were placed in shallow depressions, usually at the base of trees but also at the base of stumps, under slash piles, or in shrubs (Bump and others 1947; Rusch and others 2000). Most often, nests were located in mature quaking aspen stands, allowing incubating females to feed on emerging quaking aspen leaves (Cade and Sousa 1985; Maxson 1978; Rusch and others 2000).

Suitable winter habitat is critical for long-term population stability of ruffed grouse (Gullion and Alm 1983). Ruffed grouse frequently roost within snow banks where temperatures rarely dip below 20 °F (-6.6 °C), which allow them to maintain body heat even though air temperatures are much colder (Gullion 1970). Quaking aspen and, in particular, young quaking aspen stands with minimal canopy cover (rather than conifer stands) can provide adequate snow for burrows and protection from predators (Gullion 1970; Rusch and Keith 1971a; Stauffer and Peterson 1985a; Thompson and Fritzell 1989). Also, in the winter, young quaking aspen stands provide buds upon which ruffed grouse can forage (Svoboda and Gullion 1972). In areas with mild winters and wet or icy snow conditions that preclude snow roosting, grouse selected areas with moderate to high canopy cover. For example, in Missouri, grouse used dense coniferous forests for winter roosting and avoided areas with deciduous cover (Rusch and others 2000; Thompson and Fritzell 1989).

Diet

Ruffed grouse consume a variety of plant and animal foods, which varies seasonally, regionally, and with grouse age. Missouri grouse relied heavily on high protein foods during the summer, high fat and carbohydrate foods during the winter, and high mineral foods during the spring (Johnsgard 1973; Korschgen 1966). In

winter, adults rely on buds, twigs, and especially quaking aspen catkins (Rusch and others 2000). Where quaking aspen co-occurs with bigtooth aspen (*Populus grandidentata*) and paper birch, ruffed grouse prefer quaking aspen catkins (Svoboda and Gullion 1972). In Virginia, principal December foods were soft fruits (69 percent; e.g., greenbrier, *Smilax* spp., grape *Vitis* spp., cranberry, *Viburnum* spp., dogwood, *Cornus* spp., and rose) followed by hard fruits (18 percent; e.g., oaks, *Quercus alba*, *Q. ilicifolia*, *Q. rubra*, and sumac *Rhus* spp.). In January through April, the species switched to mostly eating leaves (Norman and Kirkpatrick 1984). Wintering ruffed grouse in Idaho, fed primarily on buds and leaves of mountain ash (*Sorbus scopulina*), serviceberry (*Amelanchier alnifolia*), mountain maple (*Acer glabrum*), chokecherry, willow, black cottonwood, snowberry (*Symphoricarpos albus*), and buck brush (*Ceanothus velutinus*) (Marshall 1946). In Utah, grouse ate rose; quaking aspen buds, twigs, and leaves; chokecherries; and meadow-rue (*Thalictrum alpinum*) fruit (Phillips 1967). Ruffed grouse less than 5 weeks old primarily feed on insects and other invertebrates (50 to 75 percent) and switch to leaves throughout the summer (Bump and others 1947; Cade and Sousa 1985; Johnsgard 1973; Rusch and others 2000).

Home range

In general, home range sizes of adult ruffed grouse males are larger in winter than in summer when their movements are restricted to central drumming areas. However, their home ranges are smaller than juvenile male and brooding female home ranges (Archibald 1975; Fearer and Stauffer 2003). In Minnesota, 15 radio-tagged female ruffed grouse had home ranges that averaged 29.9 acres (12.1 ha) in size before they laid eggs when they likely visited several drumming males. During egg-laying home range sizes averaged 20.8 acres (8.4 ha) and during incubation they averaged 2.2 acres (0.9 ha) (Maxson 1978). During the first three weeks post-incubation, females with broods had home range sizes from 7.4 to 24.7 acres (3 to 10 ha) and those without broods had home ranges that averaged 3.7 acres (1.5 ha) in size. After 5 weeks, home range size decreased when broods switched to feeding primarily on vegetation (Bump and others 1947; Maxson 1978). Also in Minnesota, summer home range size for six broods averaged 31.9 acres (12.9 ha), but they decreased in size as the summer progressed (Godfrey 1975). In Virginia, home range size for both males and females averaged 82.3 acres (33.3 ha) and in Missouri, home range sizes for 32 radio-tagged males averaged 168 acres (68 ha) in the spring and summer and 257 acres (104 ha) in the fall and winter (Fearer and Stauffer 2003; Thompson and Fritzell 1989).

Populations

Ruffed grouse populations vary among habitats, years, and regions. Spring density estimates in good habitats average, about 3.2 drumming males or 40 adults per 100 acres (8 drummers or 22 adults/100 ha) and densities would be lower in lesser quality habitats (Rusch and others 2000). Predicted occupancy estimates for ruffed grouse in the Black Hills were low because of quaking aspen scarcity and this prediction was validated during the 2001 to 2009 breeding bird monitoring found too few individuals to provide population estimates (Hansen and others 2011a; White and others 2010). Interestingly, the survey detected a drop from 36 grouse in 2001 and

62 grouse in 2002 to fewer than 10 grouse observed from 2003 through 2010 (White and others 2010).

Thirteen-Lined Ground Squirrel

Thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) are important goshawk prey and their remains were found at most nests in the Black Hills (Bartelt 1977; Erickson 1987; Promessi and others 2004; Rogers and others 2006; Squires 2000; Squires and Reynolds 1997). They are a small squirrel weighing 3.9 to 4.9 ounces (110 to 140 g) and average 9.8 inches (25.0 cm) long (Petrella 1999). However individuals can gain substantial weight prior to hibernation with a male increasing 38 percent in body weight or 8.7 ounces (246 g) (Streubel and Fitzgerald 1978). There are 9 or 10 subspecies of the thirteen-lined ground squirrel and *S. t. pallidus* lives in the Black Hills (Streubel and Fitzgerald 1978; Wilson and Ruff 1999).

Distribution

Once restricted to the plains states, thirteen-lined ground squirrels have expanded their range north and east as forested areas were cleared. They now range from south-central Canada south to the Texas Gulf Coast, and from the western slopes of the Rocky Mountains east to the Great Lakes States and as far east as central Ohio (Streubel and Fitzgerald 1978). They are most common below 5,500 ft (1676 m) in the Black Hills, but range up to 6,500 ft (1981 m) (Turner 1974).

Habitat

Throughout its range thirteen-lined ground squirrels use grasslands, especially native short-grasslands, golf courses, and highway borders preferring to occupy high points within these settings (Streubel and Fitzgerald 1978). In the Black Hills thirteen-lined ground squirrels inhabit similar areas, in addition to campgrounds and upland meadows (Higgins and others 2002; Turner 1974). In Colorado on the Pawnee National Grasslands, thirteen-lined ground squirrels used dry lands and avoided fertilized and irrigated fields and in Wyoming, they were found in short-grass communities and were transient in sagegrass and yucca-grass communities (Grant 1972; Maxwell and Brown 1968). Often in clay, loam, or sandy-loam soils, thirteen-lined ground squirrels build burrow systems that they use year-round for protection from predators and weather. Individuals may have several burrows which are usually shallow, temporary, and have secondary escape exits hidden in tall grass (Higgins and others 2002). Thirteen-lined ground squirrels hibernate from mid-September until early April using burrows that have steep entrances and extend to 20 ft (6 m) below ground, (Higgins and others 2002; Streubel and Fitzgerald 1978; Turner 1974). At the end of these tunnel systems is a grass-lined chamber used for resting and nesting while other chambers hold caches of seed and dry vegetation for consumption when food is scarce (Higgins and others 2002).

Diet

Thirteen-lined ground squirrels consume seeds, grasses, leaves, and roots but also up to 50 percent of their diet can consist of birds, snakes, and small animals (Higgins and others 2002). For example, in Manitoba, Canada the diet of 80 squirrels

was 54 percent insects, 44 percent plant material, and 2 percent unidentified (Banfield 1974).

Home range

Female thirteen-lined ground squirrels tend to use the same home range every year while males do not (Rongstad 1965). In Manitoba, Canada, home range sizes for both males and females ranged between 1.62 (0.7 ha) and 11.7 acres (4.7 ha) while those of males usually were larger than those of females (Banfield 1974). In a tallgrass prairie of Kansas from 1983 to 1987, the average home range size for males was 1.38 acres (0.56 ha) and the average for females was 0.9 acres (0.36 ha) (Clark and others 1990). Ground squirrels can travel considerable distances, especially to and from grain fields, as exemplified by males in Wisconsin traveling 96 yards (88.2 m) and females 99 yards (90.1 m) (Banfield 1974; Rongstad 1965).

Populations

In Michigan, thirteen-lined ground squirrel density was estimated to be 2.2 squirrels/acre (5.4/ha) and in Wisconsin, the average density was 8.9 to 10.7 squirrels/acre (22.0 to 26.4/ha) (Banfield 1974; Rongstad 1965). In Wisconsin, squirrel density was estimated to be 1.2 to 8.0/acre (2.9 to 19.8/ha) and in dry lands of Colorado, the density was 20.8 squirrels/acre (51.4/ha) (Grant 1972; Jackson 1961). In the tallgrass prairie of Kansas, densities of squirrels from 1983 through 1987 ranged from 2.6 to 5.6 squirrels/acre (6.4 to 13.8) (Clark and others 1990).

Western Tanager

The western tanager (*Piranga ludoviciana*) is a medium-sized songbird measuring 6.5 to 7.7 inches (16.5 to 19.5 cm) long and weighing 0.8 to 1.3 ounces (24 to 36 g) (Hudon 1999). As summer residents in the Black Hills and because of their association with open ponderosa pine, they are potential prey for goshawks (Pettingill and Whitney 1965; South Dakota Ornithologists' Union 1991; Squires and Reynolds 1997). However, low frequencies of western tanager remains have been found at goshawk nests (Promessi and others 2004; Squires 2000).

Distribution

The breeding range of the western tanager extends from southeast Alaska, down the Pacific Coast, to northern Baja California, Mexico, east to western Texas, north through central New Mexico, central Colorado, eastern Nebraska, western South Dakota, and into the southern Northwest Territories, Canada and they migrate to Mexico and Central America (Hudon 1999; Isler and Isler 1999). Especially at the lower elevations and the south western portion, western tanagers inhabit most of the Hills. However, they are less common in the northern and Bear Lodge portions of the Hills (Panjabi 2001).

Habitat

Western tanagers live in open coniferous and mixed woodlands. Individuals and nests are common in Douglas-fir, ponderosa pine, lodgepole pine, quaking aspen, and mixed coniferous-deciduous forests as well as in riparian and oak woodlands. They also use edges along roads, meadows, and other forest openings for nesting (Hudon

1999). In the Colorado Front Range, 93 percent of 58 nests were in ponderosa pine and the remainder in Douglas-fir forests (Fischer and others 2002). In the Black Hills, western tanagers primarily used ponderosa pine forests and riparian woodlands but also used quaking aspen, white spruce, shrubland, and burned forests (Panjabi 2001; Pettingill and Whitney 1965; White and others 2010; South Dakota Ornithologists' Union 1991).

Tanagers tend to nest in forests with high canopy cover and relatively open understories (Evans and others 1998). For example, in Colorado, nest stand canopy cover averaged 71 percent and was never less than 31 percent; in New Mexico, canopy cover averaged 77 percent; and in Arizona and New Mexico, nest stand canopy cover averaged 66 percent (Fischer and others 2002; Hudon 1999; Shy 1984). In Idaho, forests with tanager nests had 81 percent canopy cover and random sites had 74 percent canopy cover. In the Black Hills, western tanagers were most abundant in multi-storied ponderosa pine forests with greater than 40 percent canopy cover, especially those with bur oak and quaking aspen understories (Evans and others 1998; Mills and others 2000).

Western tanagers prefer forests with relatively large trees to nest in, and they typically place their open-cup nests near the end of a main branch surrounded by smaller branches. However, in deciduous trees, they often build their nest next to the tree bole (Evans and others 1998; Hudon 1999). In Colorado, nests were well hidden at the center of branches and typically located mid-crown (e.g., 54 percent of tree height), making tree height a good predictor of nest height (Fischer and others 2002). Nests were usually built within 30 ft (\approx 9 m) of the forest floor, but some have been located as high as 75 ft (about 23 m) (Hudon 1999).

Diet

Western tanagers glean and fly-catch wasps, ants, termites, stink bugs, cicadas, beetles, nut weevils, grasshoppers, dragonflies, caterpillars, scale insects, and sawflies during the breeding season (Hudon 1999). They also eat the fruits of hawthorn (*Crataegus* spp.), cherry, elderberry, Russian olive (*Elaeagnus angustifolia*), blackberry, mulberry (*Morus* spp.) serviceberry, and buds of several shrubs (Hudon 1999).

Home range

Home range size for western tanagers is not well known. As measured by singing males, home ranges of 7 acres (2.83 ha) were estimated for western tanagers in Montana; however, this was likely an overestimate as 90 percent of the home ranges overlapped. Core areas, which did not overlap, averaged 2 acres (0.81 ha) in size and were used 59 percent of the time (Samuel and others 1985). In Idaho, telemetry data found the average size of territories to be 1.5 to 2.5 acres (0.6 to 1 ha) and average tanager home range size to be 9.6 acres (3.91 ha) (Evans and others 1998).

Populations

Western tanager populations fluctuate during both summer and winter migrations. Across their range from 1966 to 1996, relative abundance estimated from 554 Breeding Bird survey routes was 4.2 birds/route (Sauer and others 1997). In Idaho, densities averaged 22 pairs/100 acres (54/100 ha) (Medin 1985). In mixed conifer

forests in Wyoming, western tanager densities averaged 12 birds/100 acres (30/100 ha) and were highest in lodgepole pine mixed with spruce compared to pure lodgepole pine or spruce-fir stands (Salt 1957). In Arizona, from 2007 to 2009, tanager densities varied little among years with an average of 161 birds/mile² (62 birds/km²) found in mixed conifer forests, 62 birds/mile² (24 birds/km²) found in ponderosa pine forests, and 23 birds/mile² (9 birds/km²) found in pinyon-juniper forests (Birek and others 2010). From 2001 through 2003 in the Black Hills 21 to 23 birds/mile² (8 to 9 birds/km²) were found in ponderosa pine forests but in 2009 the density increased to 47 birds/mile² (18.1 birds/km²) (Panjabi 2001, 2003; White and others 2010). Most of this increase was in the central and southern portions of Hills. In addition, tanagers were most abundant in burned forests where densities from 2001 to 2009 were greater than 26 birds/mile² (10 birds/km²) for all years except 2007 when 21 birds/mile² (8 birds/km²) were detected, and the highest density detected was 60 birds/mile² (23 birds/km²) in 2003 (White and others 2010). However, over a 3-year period in the Sierra Nevada mountains, an average of 5.6 pairs/100 acres (13.8/100 ha) nested in unburned forests while 0.8 pairs/100 acres (1.9/100 ha) nested in green trees that remained after a forest burned (Bock and Lynch 1970).

White-Tailed Jackrabbit

The white-tailed jackrabbit (*Lepus townsendii*) is a large jackrabbit living in the North American plains and Intermountain West. White-tailed jackrabbits range from 22 to 26 inches (56 to 66 cm) long and weigh from 5.5 to 8.8 pounds (2.5 to 4 kg), with females being slightly larger than males (Gosline 2001; Lim 1987). The *L. t. townsendii* subspecies lives west of the Continental Divide and *L. t. campestris* lives to the east (Lim 1987). Because of their relative abundance and large size, adult and young jackrabbits are important prey for goshawks (Lewis and others 2006; Promessi and others 2004; Smithers and others 2005; Squires 2000; Watson and others 1998) and their remains were found at 2 of the 5 nests Bartelt (1977) visited in the Hills.

Distribution

White-tailed jackrabbits occur from the plains of west-central Canada (e.g., Saskatchewan and Alberta) south into the United States Great Plains, from Wisconsin west to the Rocky Mountains, as far south as New Mexico, and from the Great Basin region to the Oregon Cascades and Sierra Nevada mountains. They live from nearly sea level to locales over 14,000 ft (4250 m) and often co-occur with black-tailed jackrabbits (*L. californicus*). Some of their habitat was reduced when prairies were converted to agriculture lands but their range expanded where woodlands in Minnesota and Manitoba were converted to farmland (Gosline 2001; Lim 1987; Wilson and Ruff 1999).

Habitat

White-tailed jackrabbits use grasslands, forest openings, pastures, fields, and sage lands, and in Colorado, used grasslands more than meadows or sage lands (Higgins and others 2002; Bear and Hansen 1966). Also in Colorado, they used alfalfa and crested wheatgrass fields and avoided areas with four wing saltbush (*Atriplex canescens*) and sage where black-tailed jackrabbits lived (Flinders and Hansen 1973).

During severe weather, white-tailed jackrabbits seek shelter in forests but they remain along the edges, and when the snow is 3 ft (1 m) or deeper, they may dig snow caves for added protection (Bailey 1926). Also in the winter, they are drawn to grass-dominated ridge tops that have been cleared of snow by the wind (Bear and Hansen 1966). In the Black Hills, white-tailed jackrabbits inhabit woodlands up to 6,000 ft (1829 m) in elevation, especially the prairies such as Reynolds, Gillette, Bald Hills, and those in Wind Cave National Park. At the higher elevations in the Hills, they use quaking aspen, ponderosa pine, and white spruce forests that border meadows, prairies, and pastures (Turner 1974).

Diet

White-tailed jackrabbits eat grasses and forbs throughout the spring, summer, and fall and prefer to eat succulent new growth (Bear and Hansen 1966; Lim 1987). In Colorado they ate sedges (*Carex* spp.), goosefoot (*Chenopodium* spp), dandelion (*Taraxacum officinal*), clover (*Trifolium* spp.), and in the winter (when they switched to shrubs) ate pasture sage (*Artemisia frigid*) and rabbitbrush (*Chrysothamnus parryi*). When feeding on shrubs, white-tailed jackrabbits tend to avoid leaves and eat mostly stems and the young tend to feed more on grasses than shrubs (Bear and Hansen 1966).

Home range

Very little is known of home range size for white-tailed jackrabbits, but individuals likely restrict their activities to one large area (Jackson 1961). In the eastern portion of their range, circular home ranges from 246 to 566 acres (100 to 229 ha) in size were estimated but varied by sex, cover, water, and food availability (Lim 1987).

Populations

White-tailed jackrabbits are not abundant within the Black Hills but frequent the surrounding plains (Bailey 1926). In Minnesota, during the early part of the 20th century their densities ranged from 15.5 to 31.0 jackrabbits/mile² (6 to 12/km²) with a high of 111.4 jackrabbits/mile² (43/km²) (Mohr and Mohr 1936). In Wyoming, their density was 18.1 jackrabbits/mile² (7/km²), and on the Pawnee National Grasslands in Colorado, their density was 3.5 jackrabbits/mile² (1.35/km²) (Flinders and Hansen 1973; Rogowitz and Wolfe 1991).

Merriam's Wild Turkey

Wild turkeys (*Meleagris gallopavo*) are large birds whose size varies across their range and whose weight varies considerably with season and food availability. Adult males generally weigh from 15 to 24 pounds (6.8 to 11 kg) and females weigh about 8 to 12 pounds (3.6 to 5.4 kg) (McCullough 2001). Length of Merriam's (*M. g. Merriami*) turkeys, the subspecies occurring in the Black Hills, ranged from 35 to 50 inches (89 to 127 cm) for turkeys in Colorado (Bailey and Niedrach 1965).

Goshawks do prey on adult-sized wild turkeys, as a female goshawk killed and consumed an adult wild turkey in Connecticut (Golet and others 2003). Juvenile wild turkey remains were found at goshawk nests in the New Jersey-New York Highlands area, and a goshawk was preying on an adult female wild turkey in south-central New York (Bosakowski and others 1992; Roberts and others 1995). Bartelt (1977)

found adult hen feathers at two of five nests he visited in the Black Hills. However, goshawks are more likely to prey on young wild turkeys (poults), but protective hens are often an effective deterrent in preventing poults from being taken by goshawks (Lehman 2003).

Distribution

Wild turkeys range across much of the eastern United States, from New England into Florida, and west to the Central Plains states. They also occur in all western states and south into northwestern Mexico. The Merriam's subspecies lives in the western United States and in particular ponderosa pine forests (Eaton 1992). The historical range of Merriam's turkeys was limited to southwestern Oklahoma, Colorado, New Mexico, northwest Texas, and northern Arizona but they were introduced throughout the western United States. In three separate releases from 1948 through 1951, a total of 29 Merriam's turkeys trapped in Colorado and New Mexico were introduced to the Black Hills (Petersen and Richardson 1975). Since then, their population has grown and they are now a valued game bird and they are abundant throughout the Hills.

Habitat

Merriam's turkeys use mixed conifer, ponderosa pine, Gamble's oak, and pin-yon-juniper forests and this use varies according to the time of year, sex, and breeding status. Turkeys use a variety of habitats during and among winters depending on food, snow conditions, and roosting opportunities (Hoffman and others 1993). They rely heavily on seed for food during the winter and mature ponderosa pine trees tend to be better cone and seed producers than younger trees, making them preferred winter habitat (Rumble and Anderson 1996). Also, seed availability is predicated on snow depth making closed forests more desirable for turkeys in the winter than open ones. Forests located on southern aspects tend to have less snow than those located on other aspects and they are inclined to become snow free earlier in the spring also making them favored turkey winter habitat (Petersen and Richardson 1975). When snow depths exceed 6 inches (15 cm), turkeys' ability to scratch for seed is diminished and at snow depths greater than 14 inches (36 cm) they can become weakened and roost in trees until conditions improve (Austin and DeGraff 1975; Rumble and Anderson 1996).

Turkeys often move to lower elevations in the winter and return to their breeding and nesting grounds in the spring. They often use well-established migration corridors which usually have contiguous canopy cover. For example in Colorado turkeys moved 2.3 miles (3.7 km) from winter to breeding grounds and in Oregon, hens moved an average of 8 miles (12.8 km) (Crawford and Lutz 1984; Dickson 1992).

In the Black Hills, turkeys used ponderosa pine forests with moderate (41 to 70 percent) canopy cover during the spring and summer with abundant shrubs and those with high (71 to 100 percent) canopy cover during the fall and winter, which provided turkeys protection from the weather. They avoided open forests (0 to 40 percent canopy cover) but during the summer they may forage on grass seed in forest openings. Also in the Hills during spring and summer, turkeys foraged on insects and forbs in quaking aspen/paper birch forests located in riparian areas. Turkeys preferred such forests with 41 to 71 percent canopy cover and avoided those with 72 to 100 percent canopy cover (Rumble and Anderson 1993).

Roosts provide turkeys with security, resting, and sleeping sites along with protection from wind, rain, and snow. In the Hills, turkeys tended to roost on ridge tops that contained all slope aspects but were more common on slopes with easterly aspects (Rumble 1992). Roost sites are typically located in mature to old conifer forests and usually range in size from 0.25 to 1.25 acres (0.1 to 0.5 ha) and contain 10 or more roost trees (Dickson 1992; Hoffman and others 1993). In some areas, turkeys form large flocks during the winter necessitating large roosting areas. However, in the Black Hills, turkeys do not congregate in the winter and their winter roost sites are similar to those used in the summer (Dickson 1992; Rumble 1992). In the ponderosa pine forests of the Black Hills winter, summer, and hens-with-poults roost sites had canopy cover greater than 50 percent, tree densities measured by basal area between 83 and 109 ft²/acre (19 to 25m²/ha), and trees with an average of DBH greater than 8.7 inches (22 cm). All roost trees averaged 14.5 inches (37 cm) DBH, but the range of tree sizes used by hens with poults was 10 to 22 inches (25 to 56 cm) DBH. Also in the Black Hills, forests with 242 trees/acre (598/ha) were used for winter roosting, forests with 216 trees/acre (534/ha) were used for summer roosting, and forests with 394 trees/acre (973/ha) were used by hens with poults for roosting. One to nine roost trees were used by turkeys in the Black Hills, with winter areas having the most roost trees and hens with poults using the fewest roost trees, while summer roost sites were intermediate in the number of roost trees used. Turkeys used large trees for roosting that averaged 89 ft (27 m) tall with an average of 35 inches (89 cm) between branches, which allowed flight access for the turkeys. Roosting height averaged 41 ft (12.5 m) and roosting height for hens with poults during winter averaged 44 ft (13.4m) (Rumble 1992).

Diet

Merriam's turkeys eat grass, leaves, seeds, forbs, pine seeds, acorns, invertebrates, cultivated crops, juniper berries, clover, kinnikinnick (*Arctostaphylos uva-ursi*), hawthorn, snowberry, and rose hips depending on the season and the region. When available, acorns and ponderosa pine seeds can comprise 80 to 90 percent of a turkey's diet, while grasses are the most important and consistently available food. Poults rely heavily on insects and add plants and seeds to their diets as they age (Hoffman and others 1993). In the Black Hills from 1965 through 1969, turkeys consumed kinnikinnick seed, ponderosa pine seed, and bur oak acorns during the summer along with grasshoppers that were the most common animal food eaten. During the winter, Black Hills' turkeys foraged in grain fields and livestock feeding areas where they ate oats and wheat, and in forested areas, they ate ponderosa pine seed and acorns (Petersen and Richardson 1975).

Home range

Spring home ranges of males can be large and may overlap (Dickson 1992). In Colorado, spring home range size for males averaged 2 mile² (5.2 km²), winter home ranges for males in Oregon averaged 0.11 mile² (0.28 km²), and spring home range sizes in Oregon averaged 1 mile² (2.2 km²) (Crawford and Lutz 1984; Hoffman 1991). The size of spring home ranges for male turkeys in the Black Hills averaged 1.7 mile² (4.4 km²) in 2005 and 5 mile² (13.2 km²) in 2006. Also in the Black Hills, one

male turkey had a 21.5 mile² (55.8 km²) home range and two others had 11.6 mile² (30.1 km²) spring home ranges (Steinke 2006).

Populations

In 1992, the U.S. population of Merriam's turkeys was estimated at 100,000 (Eaton 1992). Breeding Bird Surveys indicated increasing populations but insufficient data make these estimates unreliable (Sauer and others 2011b). At the local scale, reproductive, survival, immigration, and emigration rates influence populations, however immigration and emigration minimally influence regional populations (Vangilder 1992). Turkey longevity depends on habitat quality and hunting pressure, with ≈50 percent mortality rates common their first year and much lower and relatively constant rates in subsequent years. The average life span of a turkey in the Black Hills is 4 years with one turkey living for over 8 years (Hoffman and others 1993; Rumble and others 2003). The 29 turkeys introduced to the Black Hills from 1948 through 1951 grew to 7000 by 1960, and in 2012, tens of thousands of turkeys likely live in the Black Hills (Rumble and others 2003; South Dakota Department of Game, Fish, and Parks 2012).

Nesting success strongly influences turkey populations, and adult nest success in the central and southern Black Hills from 1993 to 2005 ranged from 36 to 98 percent (Vangilder 1992; Rumble and Hodorff 1993; Lehman 2005). Nesting by juvenile hens is uncommon. However, in the central and southern Black Hills, nesting success of juveniles and yearlings ranged from 23 to 100 percent (Rumble and Hodorff 1993; Lehman 2005; Rumble and others 2003). Predators usually cause most nest failures but humans and livestock can make a nest fail (Ligon 1946). Also precipitation while a hen is incubating eggs increases their detection as wet feathers give off strong odors (Lehman 2005). As such, during the nesting season, hens experience their lowest survival rates of the year as they are frequently killed by coyotes, foxes, raptors, and other predators (Rumble and others 2003).

In general, the survival rate for turkeys is quite good. For example the survival rate for hens in the southern Black Hills was 67 percent, 68 percent in the central Black Hills, 45 percent in Montana, and 75 percent in Arizona (Lehman 2005; Rumble and others 2003). The survival rate for male turkeys in the Black Hills was 42 percent, in Oregon 38 percent, and 83 percent in Arizona (Crawford and Lutz 1984; Steinke 2006; Wakeling and Rogers 1998). Similar to survival rates of female turkeys in the Black Hills, the lowest survival rate of 47 percent for males occurred in the spring during hunting season (Huxoll 2010). Turkey hunting is very popular in the Black Hills with an unlimited number of hunting permits available. In 2000, 3374 spring hunting permits were sold and the number peaked at 6656 permits in 2006 but declined steadily to 4435 permits sold in 2012. Also, hunter success declined to 38 percent in 2012 with 1685 turkeys harvested (South Dakota Department of Game, Fish, and Parks 2012).

Poult survival also has a strong effect on turkey populations with poult survival in the eastern United States during their first 14 days ranging from 27 to 44 percent (Kurzejeski and Vangilder 1992; Dickson 1992). First 4 week poult survival in

Wyoming was 36 percent, 36 to 59 percent in Arizona, and 43 percent in the Black Hills (Hengel 1990; Wakeling 1991; Flake and Day 1996). Four week survival of poults raised by yearling females in the Black Hills was 11 percent (Lehman and others 2008). The survival of poults during the first 5 days after hatching can be greatly reduced when rain combined with air temperatures less than 52 °F (11 °C) occurs even with good care by hens (Lehman and others 2008).

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