SPECIES ASSESSMENT FOR THE FERRUGINOUS HAWK (*BUTEO REGALIS*) IN WYOMING

prepared by

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prepared for

United States Department of the Interior
Bureau of Land Management
Wyoming State Office
Cheyenne, Wyoming

January 2005

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Introduction

The ferruginous hawk (*Buteo regalis*) occupies arid and open grassland, shrubsteppe, and desert in the western half of North America. It is the largest hawk in North America, with wingspans up to 1.5m and body mass >2kg. Breeding occurs from Alberta, Manitoba, and Saskatchewan south to New Mexico and Arizona, west to eastern California and Oregon, and east into the Dakotas, Nebraska, and Kansas. Primary wintering grounds are in the southwestern U.S. and northern Mexico. Ferruginous hawks breed across a large portion of Wyoming, and some individuals winter in the state as well.

The ferruginous hawk was petitioned, and denied, for listing under the federal Endangered Species Act in 1991 (USDI Fish and Wildlife Service 1992). Although not officially designated Threatened or Endangered, this species is generally accepted to be declining rangewide (Bechard 1981, Houston and Bechard 1984, Woffinden and Murphy 1989, Ure et al. 1991). Wyoming populations may be stable to increasing, and the state appears to support a relatively large amount of suitable habitat under current conditions. Viable populations of ferruginous hawks depend on large expanses of native grass and shrubs that support abundant prairie dogs (*Cynomys* spp.), other ground squirrels, and jackrabbits (*Lepus townsendii, L. californicus*), and with minimal human activities and disturbances during the breeding season.

Natural History

The natural history of ferruginous hawks, including identifying characteristics and reproductive rates, are summarized below. Most of this information has been compiled from Williams and Matteson (1948), Brown and Amadon (1968), Smithe (1975), Call (1978), Clark and

Wheeler (1987), Bechard and Schmutz (1995), and Sibley (2000).

Morphological Description

The ferruginous hawk is the largest hawk in North America. Adults are heavy, thickset birds with relatively large heads, broad breasts, and broad and powerful wings. Total body length ranges 56 - 64 cm; body mass ranges 0.9 - 2.1 kg; wingspan reaches up to 1.5m. By comparison, the more common red-tailed hawk (*B. jamaicensis*) averages ca. 48 cm total length, 1.1 kg body mass, and 1.2m wingspan (Sibley 2000). As with all raptors, female ferruginous hawks are generally larger than males.

Ferruginous hawks naturally range in color from light to very dark, with the lighter phases being more common in Wyoming. In all color phases the tail and flight feathers are light gray to white, appearing especially bright from below. The term "ferruginous" derives from the Latin “ferrugo” (rust), in reference to the rust-colored highlights in the plumage generally, and on the legs and upperparts in particular. Breast and belly are uniformly dark in dark phase birds, and white with rufous speckling on light phase birds. Legs are dark and form a distinctive “V” pattern on the underside of soaring light phase birds; this character is commonly used in field identification. Toes, cere, and mandible margins are yellow.

Juveniles are similar to adults but with more spotting and streaking on the breast and flanks; juvenile tails are also somewhat dusky and have indistinct banding. The eyes of juveniles are yellowish, turning brownish by the first year and eventually to a rich chocolate-brown in older birds.

Ferruginous and rough-legged hawks (*B. lagopus*) are the only hawks whose legs are fully-feathered down to the toes.

Ferruginous hawks commonly perch on trees, utility structures, farm buildings, fence posts, cliffs, outcrops, or high points on the ground. Due to their size they appear sluggish and cumbersome when taking flight, but they soar well and maintain faster flight than other North American buteos.

Taxonomy and Distribution

The ferruginous hawk was originally described in 1844 by G.R. Gray as *Archibuteo regalis* (American Ornithologists' Union 1998). Schmutz et al. (1993) found that the chromosomes in ferruginous hawks were similar in shape and number to those in the gray hawk (*B. nitidus*), red-tailed hawk, rough-legged hawk, white-tailed hawk (*B. albicaudatus*), roadside hawk (*B. magnirostris*), and Harris' hawk (*Parabuteo unicinctus*). The chromosomes differ in shape from those of Swainson's hawk (*B. swainsoni*), common buzzard (*B. buteo*), and broad-winged hawk (*B. platypterus*).

No subspecies are currently recognized, but the population segments to the east (Great Plains) and west (Intermountain) of the Continental Divide are recognized as somewhat distinct (Bechard and Schmutz 1995). No major genetic or morphometric differences have been found between these population segments, although adult females tend to have longer third toes, longer bills, and wider gapes in the eastern segment (Gossett 1993).

It is important to note that the Continental Divide splits Wyoming, so the state technically supports birds from each population segment. More importantly, the Continental Divide in south-central Wyoming is not a barrier to ferruginous hawks. Indeed, relatively high densities of breeding and even wintering birds occur across this sagebrush-dominated region. This may set somewhat complex biological and management contexts. Any biological distinctions between the population segments can be expected to intergrade here, as birds from each segment interbreed.

Moreover, any management strategies or stipulations pertaining to one or the other population segment may be applied somewhat arbitrarily in this region, because there is no clear segment boundary.

The ferruginous hawk breeds in arid and open landscapes from Saskatchewan south to New Mexico and Arizona, west to Alberta, Oregon, and eastern California, and east into Manitoba, the Dakotas, Nebraska, and Kansas. Primary wintering grounds are in the southwestern U.S., western Texas, and northern Mexico including Baja California (Weston 1969, Bechard and Schmutz 1995, Sibley 2000; see Figure 1).

Breeding occurs in most grassland, shrubsteppe, and desert environments in Wyoming. Wintering birds also occur at low densities in similar habitats in the state, typically in the southern counties.

Habitat Requirements

The ferruginous hawk occurs in open environments such as grassland, shrubsteppe, and cold deserts. These birds avoid areas of intensive agriculture, urban or suburban development, extremely high elevations, closed forests, and narrow canyons (Ensign 1983, Gilmer and Stewart 1983, Schmutz 1984, 1987, 1991, Bechard et al. 1990, Restani 1991).

Breeding Habitat

Ferruginous hawks nest in flat to rolling terrain dominated by grass or shrubs, ranging from level and featureless prairies to ridge-and-valley terrain with occasional buttes, cliff sets, and other rock outcrops. The latter description of more rugged terrain tends to apply to the western Intermountain population segment; the eastern, Great Plains birds are more grassland-oriented. In either case, trees typically occur only as small and scattered stands or thin stringers along riparian

zones (Smith and Murphy 1973, Woffinden 1975, Lokemoen and Duebbert 1976, Cottrell 1981, Roth and Marzluff 1989, Olendorff 1993, Bechard and Schmutz 1995, Dechant et al. 2001).

Kantrud and Kologiski (1982) found the highest densities of ferruginous hawks in heavily grazed areas of the northern Great Plains. In South Dakota 55% of nests were found in barren habitat types, with the remainder in ungrazed or lightly grazed prairie (Blair and Schitoskey 1982). Other researchers found South Dakota nests placed preferentially in lightly grazed or idled pasture (Lokemoen and Duebbert 1976, Blair 1978, Blair and Schitoskey 1982). In North Dakota nests were surrounded predominantly by pasture and haylands (94.8% of area surrounding tree nests; 76.5% of area surrounding ground nests; Gilmer and Stewart 1983).

In Idaho, desert shrub-steppe with an understory of crested wheatgrass (*Agropyron cristatum*) was the dominant vegetation type surrounding nests (Howard and Wolfe 1976).

Ferruginous hawks will build nests directly on the ground surface, but appear to prefer elevated features and landforms such as boulders, creek banks, knolls, low cliffs, ridge crests and rims, and buttes, when available (Blair 1978, Gilmer and Stewart 1983, Palmer 1988, Preston 1998). Large shrubs, isolated trees, haystacks, and utility structures are also used (Rolfe 1896, Davy 1930, Olendorff 1973, Schmutz 1984, Gaines 1985, Lokemoen and Duebbert 1976, Gilmer and Wiehe 1977, Gilmer and Stewart 1983, Steenhof et al. 1993, Bechard and Schmutz 1995).

It is generally understood that ground nesting was the historic norm (Bechard and Schmutz 1995), with selection for elevated positions possibly a strategy for avoiding trampling by bison (*Bos bison*) and other large mammals. Human development of ferruginous hawk range has provided novel nesting structures (e.g., utility poles, haystacks) and increased the abundance of other structures (e.g., trees). Some evidence strongly suggests that suitable nest structures limit ferruginous hawk densities at some sites (Schmutz et al. 1984).

Nest height ranges from ground level to greater than 20m above ground (Bechard and Schmutz 1995). Olendorff (1993) found that of 2,119 nests, 49% were in trees and shrubs, 21% on cliffs, 12% on utility structures, 10% on ground outcrops. In Colorado, 41% of nests were in human-made settings (Olendorff and Stoddard 1974, Gaines 1985). In North Dakota, almost half of 61 nests were on the ground in prairie vegetation (Johnsgard 1979). Other North Dakota researchers reported 21% of nests on the ground, 64% in trees (Gilmer and Stewart 1983).

When in trees, nests are preferentially placed in lone or peripheral trees as opposed to those in stand interiors (Weston 1968, Lokemoen and Duebbert 1976, Gilmer and Stewart 1983, Woffinden and Murphy 1983, Palmer 1988, Bechard et al. 1990, Leslie 1992, Hansen 1994, Dechant et al. 2001). Ferruginous hawks nesting in trees appear to be less sensitive to disturbance than those nesting on the ground, but they still avoid areas of intensive agriculture or high levels of human disturbance (Gilmer and Stewart 1983, Schmutz 1984, 1987, 1991, Bechard et al. 1990).

The nest itself is typically an open platform constructed of sticks, shrub stems, and ground debris (Bechard and Schmutz 1995). Prior to 1900, nests in North Dakota were often partially constructed of bleached bison ribs (Houston and Bechard 1984).

Migration Habitat

Little is known about southern populations of ferruginous hawks, but they are believed to be sedentary or only locally-migratory (Bechard and Schmutz 1995). Northern populations (e.g., Canada, Washington, Montana, North Dakota) are completely migratory, with southward migration beginning August - early October depending on weather (Schmutz and Fyfe 1987). Most birds breeding in Wyoming are thought to migrate south. Birds wintering in the state are probably migrants from more northern breeding centers, but may include a few state breeders as well.

Habitats used during migration are not well known. Birds migrating through the Great Plains, including eastern Wyoming, tend to follow native grasslands where various ground squirrels and especially prairie dogs (primarily *Cynomys ludvicianus*; *C. leucurus* in central and southwest Wyoming) are available. Birds migrating through the Intermountain region generally use cold desert valleys and flats where lagomorphs are abundant (Schmutz and Fyfe 1987).

Wintering Habitat

Most birds breeding in the Great Plains winter on grasslands in Texas and northern Mexico, where they concentrate strongly on prairie dog colonies (Bechard and Schmutz 1995, Bak et al. 2001). In Texas, Schmutz (1987) found many wintering ferruginous hawks near prairie dog colonies surrounded by extensive cultivation, and concluded that agricultural practices and human activity did not have a negative effect on ferruginous hawks in winter as long as such colonies were present.

Studies of wintering birds have documented some crossover between the Great Plains and Intermountain population segments. Gossett (1993) found 4.1% of Great Plains breeders wintering in the Intermountain region, and 27.5% of Intermountain breeders wintering in the Great Plains region. As previously discussed, the Great Divide Basin in south-central Wyoming may be a major zone of contact between the Great Plains and Intermountain population segments, and may serve as a major crossover area for migrating birds.

Area Requirements

Breeding

Like other raptors ferruginous hawks are widely dispersed, especially during the nesting season (Fuller et al. 1995, Preston 1998). In the summer, ferruginous hawks aggressively defend nesting territories and prey concentrations against conspecifics (Smith and Murphy 1973).

Recorded nesting densities vary widely and are assumed to be controlled by availability of nesting structures/ locations and, especially, availability of prey (Thurow et al. 1980, Woffinden and Murphy 1989, Bechard and Schmutz 1995). Blair and Schitoskey (1982) reported one pair/ 292 km^2 and 1 pair/ 412 km^2 for two consecutive years in South Dakota. Other estimates are one pair/ 17.4 km^2 in South Dakota (Lokemoen and Duebbert 1976); one pair/ 39.9 km^2 in Utah (Weston 1968); one pair/ 99.9 km^2 in Colorado (Olendorff 1972); and one pair/ 33 km^2 in North Dakota (Gilmer and Stewart 1983).

In Alberta, establishment of artificial nest platforms increased densities from "already high" to approximately one pair for every 4-15 km^2 (Schmutz et al. 1984).

Estimates of home range sizes are 5.9 km^2 in Utah (Smith and Murphy 1973, Wakeley 1978), 7.6 km^2 in Idaho (McAnnis 1990), and 3.14 - 8.09 km^2 in the Columbia River Basin and Great Basin (Janes 1985). Wakeley (1978) estimated that one pair might require up to 21.7 km^2 for hunting.

Winter

Bechard and Schmutz (1995) suggested that ferruginous hawks defend winter territories. Smith and Murphy (1978) estimated a winter density of one hawk per 932 km^2 in central Utah. Other researchers found ferruginous hawks roosting communally in winter (Steenhof 1984, Bechard and Schmutz 1995). It is likely that winter area requirements and social interactions are determined almost entirely by food availability.

Movement and Activity Patterns

Ferruginous hawks roost in open areas, usually in lone trees or on utility poles. Hunting is typically timed to coincide with activity periods of major prey species. In very hot weather

hunting occurs mostly in early morning and late afternoon (Bechard and Schmutz 1995, Plumpton and Andersen 1997). In winter these hawks spend most of the day perched.

Migrating ferruginous hawks arrive on their breeding grounds beginning in late February - early April, depending on latitude (Olendorff 1973, Smith and Murphy 1973, Lokemoen and Duebbert 1976, Schmutz et al. 1980, Schmutz and Fyfe 1987, Bechard and Schmutz 1995). In South Dakota and North Dakota, first arrivals were reported in late March (Gilmer and Stewart 1983). Ferruginous hawks occur in Wyoming year-round, but are much more common during migration and breeding than in winter (Dorn and Dorn 1990).

Adults depart from their breeding grounds in late September - early October; young leave slightly earlier (Schmutz and Fyfe 1987, Blair and Schitoskey 1982). In Wyoming, adults usually depart in September (Dorn and Dorn 1990).

Reproduction

Nest site selection and nest building usually occurs in March in Utah and Colorado, and in April in North Dakota, Alberta and Saskatchewan (Schmutz et al. 1980, Bechard and Schmutz 1995). Prior to breeding, adults may engage in aerial displays involving diving, screaming, and spiraling toward the ground with interlocked talons (Powers 1981). Breeding pairs are aggressive towards conspecifics and vigorously defend breeding territories and prey concentrations (Smith and Murphy 1973).

Ferruginous hawks are apparently monogamous and some pair bonds may be maintained year-round. Males and females share in nest site selection, which typically involves visiting several nests from previous years (Bechard and Schmutz 1995). A pair may repair two or three nests before selecting one for egg laying (Olendorff 1973, Powers 1981). If disturbed during nest

building pairs may choose another site (Smith and Murphy 1973). Females do the majority of incubating while males hunt and guard the nest and territory (Powers 1981, Bechard and Schmutz 1995).

Brood dates generally range from mid-March to mid-May. The nesting period is ca. 26 May to 7 July in South Dakota; it begins in early to mid April in Colorado (Bechard and Schmutz 1995, Olendorff 1993). Call (1978) suggested nest building from 10 - 16 March; egg laying from 17 March - 1 April; incubation from 21 March - 21 May; hatching from 16 April - 21 May; and fledging from 4 June - 2 July.

Incubation lasts 32-33 days (Palmer 1988), and young hatch over a 2-4 day period (Bechard and Schmutz 1995). Young lie or sit for the first two weeks but can seek shade or shelter after 5-7 days (Bechard and Schmutz 1995). The young birds stand at 18-20 days, attempt self-feeding at about 11-12 days, begin casting pellets at 16-18 days, and seize food at 22-23 days. They are capable of flapping and jumping at 33-34 days.

The female attends the young for three weeks post-hatching and then begins to hunt full-time again (Bechard and Schmutz 1995). Young leave the nest at 38-50 days, but remain less than 200m from the nest for some time (Powers 1981, Konrad and Gilmer 1986). In Colorado, fledglings have been recorded from late June to late July (Preston 1998). Fledglings can kill prey at 52 days and, although they are proficient flyers 2 weeks post-fledging, they remain dependent on their parents for several weeks (Angell 1969, Blair and Schitoskey 1982, Bechard and Schmutz 1995).

Fidelity to nesting locations from year to year is high; several nests may be built in a given area and used in alternate years (Davy 1930, Weston 1968, Olendorff 1973, Blair 1978, Smith and Murphy 1978, Palmer 1988, Roth and Marzluff 1989, Schmutz 1991, Atkinson 1992, Houston

1995). Reoccupancy of nest sites may be related to nest success in prior years. De Smet (1992) found that 52% of 71 successful nests were reused, but only 14% of 63 unsuccessful nests were reused. Bechard and Schmutz (1995) reported one nest site that fledged young for 32 consecutive years.

As will be discussed in more detail below, ferruginous hawks are highly sensitive to disturbance during the nesting period. Productivity is lower for disturbed pairs than for undisturbed pairs, and nest abandonment is an apparently common response to disturbances.

Population Demographics

Fecundity and Survivorship

Ferruginous hawks begin breeding at 2 years old. Lifetime reproductive output is unknown, but one male in Alberta contributed to the fledging of at least 20 young over 7 years (Bechard and Schmutz 1995). Mean annual reproductive success ranges from 1.3 - 3.2 fledglings/ pair/ year rangewide (Lokemoen and Duebbert 1976, Fitzner et al. 1977, Smith and Murphy 1978, Thurow et al. 1980, Gilmer and Stewart 1983, Roth and Marzluff 1989, Houston 1991). Mean rates reported for the eastern portion of the breeding range are 2.1 - 2.2 (Lokemoen and Duebbert 1976, Gilmer and Stewart 1983, Roth and Marzluff 1989).

Clutch size ranges from 1-8 eggs (average 2-4) and apparently varies strongly with prey abundance (Smith and Murphy 1978, Smith et al. 1981, Palmer 1988, Bechard and Schmutz 1995). One clutch is produced per season, and re-nesting is rare (Woffinden 1975, Palmer 1988, Bechard and Schmutz 1995).

Nest success has been estimated at 70% (northeast Colorado), 75% (northwest Colorado and northeast Utah under high prey abundance), and 26% (northwest Colorado and northeast Utah

under low prey abundance) (Olendorff 1973, USDI Fish and Wildlife Service 1992).

Maximum longevity in the wild has been reported at 20 years (Lloyd 1937, Houston 1984). Schmutz and Fyfe (1987) estimated a first-year mortality rate of 65% based on banding data from the 1970s and 1980s. Bechard and Schmutz (1995) considered this an over-estimate because most mortality was human-related. Woffinden and Murphy (1989) estimated annual adult mortality at 25% based on reoccupancy of nest sites. This may also be an over-estimate given the species' potential for dispersal (Bechard and Schmutz 1995).

Limiting Factors

Typical causes of mortality include exposure, predation, shooting, vehicle collisions, and collisions with towers or high-tension wires (Gossett 1993, Bechard and Schmutz 1995). Eggs and young may be blown or pushed from the nest (Olendorff 1993). Gilmer and Stewart (1983) found that summer storms were a major cause of nest loss, with nests in trees being particularly vulnerable.

Predation is not known to be a widespread problem for ferruginous hawks (USDI Fish and Wildlife Service 1992). The primary predator of nestlings is the great horned owl (*Bubo virginianus*), but common ravens and crows (*Corvus* spp.) also prey on eggs and nestlings (Bechard and Schmutz 1995). Coyotes (*Canis latrans*), badgers (*Taxidea taxus*), and foxes (*Vulpes* spp.) probably threaten fledglings and pairs that nest on the ground (Bechard and Schmutz 1995).

Knowledge to-date suggests that the major limit to ferruginous hawks is not high mortality, but instead low reproductive output as caused by habitat loss to cultivation and cheatgrass (*Bromus tectorum*) invasion, reduced distribution and abundance of prey (especially prairie dogs), and locally-high (and probably increasing) levels of disturbance to nesting pairs. These factors are

discussed in more detail below.

Food Habits

Food Items

Ferruginous hawks in the Great Plains rely heavily on ground squirrels, especially prairie dogs; those in the Intermountain region feed primarily on lagomorphs (e.g., *Sylvilagus* spp., *Lepus* spp.) and probably secondarily on ground squirrels. Other small mammals, birds, reptiles, and large invertebrates such as locusts and crickets are occasionally taken in all regions (Weston 1968, Gilmer and Stewart 1983, Ehrlich et al. 1988, Finch 1991, Olendorff 1993, Gillihan and Hutchings 2000, Dechant et al. 2001). A summary of 20 food habits studies (Table 1) indicates that prairie dogs and other ground squirrels are taken most frequently, but that rabbits and hares represent most of the dietary biomass (Olendorff 1993).

Distribution, density, and productivity of ferruginous hawks are strongly and positively correlated with prey abundance (Woffinden 1975, Smith et al. 1981, White and Thurow 1985, Schmutz 1989, Schmutz and Hungle 1989, USDI Fish and Wildlife Service 1992, Bechard and Schmutz 1995). Several studies have demonstrated synchronous fluctuations in between populations of ferruginous hawks and major prey species, especially prairie dogs (e.g., Gilmer and Stewart 1983, Andrews and Righter 1992, Berry et al. 1998, Plumpton and Anderson 1998, Seery and Matiatos 2000).

Roth and Marzluff (1989) found 86% of nests in western Kansas within 8 km of active black-tailed prairie dog towns. Black-tailed prairie dogs appear to be especially important winter prey for Great Plains ferruginous hawks (Preston and Beane 1996, Plumpton and Anderson 1998), as this species of prairie dog does not hibernate and thus remains available all winter. Black-tailed

prairie dogs occupy the eastern third of Wyoming, and thus can be used by ferruginous hawks breeding and wintering there. White-tailed prairie dogs occupy the rest of the state; because they are obligate hibernators they are available only to breeding and migrating birds.

Ferruginous hawks will occasionally scavenge on mammal carcasses. This can lead to mortality from vehicle collisions when the hawks are scavenging road-kills (Howard 1975).

Foraging Strategy and Flexibility

Prey availability clearly influences distribution and habitat selection. In both breeding season and winter ferruginous hawks position themselves near prey concentrations and avoid dense vegetation that limits their ability to detect and attack prey (Howard and Wolfe 1976, Wakeley 1978). Grazing by large herbivores and prairie dogs can benefit ferruginous hawks by making prey more visible (Wakeley 1978, Gilmer and Stewart 1983).

Hunting can occur any time during the day (Smith and Murphy 1973, McAnnis 1990). Bloom et al. (1992) suggested that Intermountain populations are more crepuscular because their main prey - lagomorphs - are crepuscular, whereas Great Plains populations are more diurnal in order to match the activity periods of prairie dogs and other ground squirrels. In hot weather ferruginous hawks tend to hunt more in the cooler early and late hours of the day (Bechard and Schmutz 1995, Plumpton and Andersen 1997).

Bechard and Schmutz (1995) described four types of foraging pursuit patterns: still hunting from elevated perches with attack flights <100m; similar short-distance attacks originating from ground perches; aerial searching from altitudes <30m; and hovering searches during periods of strong wind. Attacks on ground squirrels tend to be short, as these prey flee to nearby burrows, while attacks on lagomorphs are typically longer.

In Utah, hunting success was greatest from the ground, followed by high flight, low flight, and still hunting from perches (Wakeley 1978). In southwest Idaho, ferruginous hawks had success rates >40% on ground squirrels and pocket gophers (McAnnis 1990).

Communal (groups of 6-12 immature and adult hawks) hunting and feeding has been observed in the winter, when ferruginous hawks concentrate on black-tailed prairie dog colonies. Anecdotal observations indicate that the birds hunt independently, but the activity associated with prey capture attracts other group members that attempt to pirate prey items. Several aggressive behaviors ensue. Communal hunts are not well-studied, and it is not known if a social hierarchy exists. Golden eagles (*Aquila chrysaetos*) and bald eagles (*Haliaeetus leucocephalus*) also occur at these sites and consistently displace ferruginous hawks from captured prey.

Conservation

Conservation Status

The Partners in Flight Watchlist identifies the ferruginous hawk as a "High Priority" species for Wyoming, North Dakota, South Dakota, and Nebraska. The Commission for Environmental Cooperation established under the North American Free Trade Agreement has also identified ferruginous hawk as a priority grassland species for conservation action.

Federal Endangered Species Act

Although the USDI Fish and Wildlife Service (USFWS) recognizes the ferruginous hawk as a species of concern (USDI Fish and Wildlife Service 1996), it does not give the species any special status under the Endangered Species Act. The ferruginous hawk was petitioned but rejected for listing 1991 (Ure et al. 1991, USDI Fish and Wildlife Service 1992).

In Canada the ferruginous hawk was downlisted from threatened to vulnerable in 1995. It is

considered a species of conservation concern in Mexico.

USDI Bureau of Land Management

The Wyoming State Office of the USDI Bureau of Land Management (BLM) lists the ferruginous hawk as a Sensitive Species. The BLM developed this designation to "ensure that any actions on public lands consider the overall welfare of these sensitive species and do not contribute to their decline." Sensitive species management will include: determining the distribution and current habitat needs of sensitive species; incorporating sensitive species in land use and activity plans; developing conservation strategies; ensuring that sensitive species are considered in National Environmental Policy Act analyses; and prioritizing necessary conservation work (USDI Bureau of Land Management 2001).

USDA Forest Service

The USDA Forest Service (USFS) lists the ferruginous hawk as a Sensitive Species in Region 2 (Colorado, Kansas, Nebraska, South Dakota, Wyoming).

State Wildlife Agencies

State agencies categorize the ferruginous hawk as endangered in Oregon, threatened in Utah, and of special concern in Colorado, California, Arizona and Oklahoma.

The Wyoming Game and Fish Department (WGFD) lists the ferruginous hawk as NSS3, indicating a restricted or declining population with extirpation possible but not necessarily imminent. This designation generally recognizes suitable habitat as vulnerable to ongoing disturbance and loss.

Heritage Ranks and Wyoming Contribution Rank

The ferruginous hawk has been assigned a rank of **G4/S4B/S3N** by the Wyoming Natural

Diversity Database (WYNDD, University of Wyoming; Keinath et al. 2003). The **G4** rank indicates that the full species is relatively secure rangewide; **S4B** indicates relative security during the breeding season, and **S3N** indicates somewhat less security during winter, in the state of Wyoming.

The Wyoming Contribution rank for ferruginous hawk is **Low**; this may be upgraded to **Medium** upon further analysis. This is based on a ranking system developed by WYNDD (Keinath and Beauvais 2003) that measures the contribution of Wyoming populations of a taxon to the rangewide persistence of that taxon, and considers several factors. For ferruginous hawk these factors include: (1) the species is a resident native in Wyoming, (2) the species has a somewhat widespread, but perhaps declining continental range, (3) the state encompasses a medium percentage of that continental range, and (4) Wyoming populations are relatively secure as compared to populations elsewhere.

Biological Conservation Issues

The most recent rangewide population estimate for ferruginous hawks is 5,842 to 11,330 (Olendorff 1993). However, Schmutz et al. (1992) estimated 14,000 for the Great Plains alone, and the estimated population in Canada in the early 1990s was 2,000 to 4,000 breeding pairs (Jensen 1995). Year to year movements of population centers makes it difficult to accurately estimate abundance.

Abundance in Wyoming

Breeding season observations reported by WYNDD are shown in Figure 2; it is recognized that this is not a complete or even nearly complete compilation of all know breeding season records. Olendorff (1993) suggested that the state supports >800 pairs, which places Wyoming

second to only southern Alberta in numbers of breeding ferruginous hawks. The species is generally accepted as widespread and somewhat common across the state in the breeding season; in winter it is uncommon and restricted mostly to the southern tier of counties.

Trends

The ferruginous hawk is considered to be declining in several areas, but there is little data available on magnitude of declines (Bechard 1981, Houston and Bechard 1984, Woffinden and Murphy 1989, Ure et al. 1991). The best documented declines are from the northern edge of the species' range in Canada (Bechard 1981, Houston and Bechard 1984, Schmutz 1984, Schmutz et al. 1992). The ferruginous hawk was nearly extirpated from the northeast quarter of North Dakota in the early 1900s (Stewart 1975). Based on nest vacancy, there were apparent declines in the 1980s within the core of the breeding range. Between 1979 and 1992 populations were stable in Arizona, Colorado, Idaho, Kansas, Montana, Nebraska, North Dakota, South Dakota, Texas, Washington, and

Saskatchwan. During this same period, population increases of 50% or more apparently occurred in Oregon, Wyoming, Alberta, and Manitoba. Declines in the past 10 years declines have been confirmed only in northern Utah and eastern Nevada (Olendorff 1993).

In Wyoming, local declines are assumed to have occurred in the vicinity of major disturbances such as urban centers, large and active surface mines, and intensively-developed petroleum fields. Also, it is assumed that current populations are lower than historic levels to the extent that both black-tailed and white-tailed prairie dogs have declined in distribution and abundance over the past 100 years. Although there is very little hard data on trends in Wyoming, the most likely scenario is a recent (ca. 20-30 yr) increase nested within a long-term (ca. 150 yr) decline in distribution and abundance.

Range Context in Wyoming

Wyoming forms the core of historic and current ferruginous hawk breeding range; the state sits on the northern periphery of winter range. Ferruginous hawks are found throughout the state at elevations ca. <2200m during the breeding season, and across the southern tier of counties at similar elevations in winter (Dorn and Dorn 1990). It is assumed that most birds wintering in the state are migrants from northern breeding centers, although some may be Wyoming breeders.

Importantly, ferruginous hawks in southwest Wyoming belong to the western or Intermountain population segment, whereas those in the rest of the state belong to the eastern or Great Plains segment. Moreover, the boundary between the 2 segments in the state is not clear. The Great Divide Basin in south-central Wyoming supports much suitable habitat for ferruginous hawks. It is likely that ferruginous hawks "crossover" in this region during breeding, migration, and possibly even winter. This may be an especially important crossover region during migration, allowing birds that breed in the Intermountain or Great Plains region to easily access wintering habitat in the other region (and vice versa as birds migrate back to breeding grounds). This could have important large-scale and long-term implications for conservation of ferruginous hawks: well-connected population segments that regularly exchange individuals and genes typically have higher probabilities of persistence than smaller, isolated population segments.

Intrinsic Vulnerability

A variety of factors can contribute to a species being intrinsically vulnerable, including low or variable population density, site fidelity, prey specialization, and sensitivity to disturbance and habitat alteration. Ferruginous hawks exhibit these listed factors, and as a result appear to have a moderately high level of intrinsic vulnerability.

Prey Specialization and Site Fidelity

A heavy reliance on prairie dogs in the Great Plains and eastern portions of the Intermountain region make ferruginous hawks especially vulnerable, as all prairie dog species have declined steeply in distribution and abundance and remain threatened by a combination of habitat conversion, sylvatic plague infection, shooting, and deliberate poisoning. The primary prey base in the Intermountain region, lagomorphs and small ground squirrels, are additionally threatened by the widespread and ongoing conversion of native vegetation to annual grasslands dominated by exotic cheatgrass (e.g., The Nature Conservancy 1999). Ferruginous hawks appear to have a high degree of site fidelity, suggesting that some pairs may return to and attempt to breed in regions of previously high prey density that are no longer suitable for successful reproduction.

Sensitivity to Disturbance

Ferruginous hawks are sensitive to disturbance when nesting (Olendorff 1973, Gilmer and Stewart 1983, Schmutz 1984, Bechard et al. 1990, Preston 1998, Gillihan and Hutchings 2000). Nest abandonment is a common response to disturbance, especially when it occurs during incubation (Davy 1930, Weston 1968, Fitzner et al. 1977, Gilmer and Stewart 1983). Pairs forced to abandon nests in one year are less likely to return to the same area in subsequent years, and adults subjected to disturbance appear less attentive to young and produce fewer fledglings. Sensitivity to disturbance is increased when prey availability is low (White and Thurow 1985). In eastern Colorado and South Dakota, remote nests were more productive than those in publicly-accessible locations (Olendorff 1973, Blair 1978).

Although generally sensitive, the specific response of nesting ferruginous hawks likely depends on the type and frequency of disturbance. Areas of intensive agriculture and human settlement are avoided, but nests are placed near active railroads and gravel roads (Rolfe 1896, Gilmer and Stewart 1983, MacLaren et al. 1988) suggesting some ability to acclimate to consistent

disturbance by vehicles. Similarly, Gilmer and Stewart (1983) found that pairs nesting <500m of highways and other well-traveled roads had nest success rates similar to other pairs. In contrast, White and Thurow (1985) found significantly more nests abandoned when subjected to periodic disturbances that mimicked human activities. The BLM has documented nest abandonment after a single visit by researchers, and considers nest abandonment from disturbance a potentially "severe population limiting factor" (Snow 1974).

It is reasonable to assume that the density of humans and roads, including many roads used only sporadically, will continue to increase across the Great Plains and Intermountain regions as motorized recreation and petroleum development increase. Under this assumption more ferruginous hawk nests will be disturbed and can be expected to fail (Preston 1998, Colorado Partners in Flight 2000, Gillihan and Hutchings 2000).

Extrinsic Threats and Reasons for Decline

Conversion of Native Grasslands and Shrubsteppe

Conversion of native vegetation to cultivated agriculture has probably had the largest negative impact on ferruginous hawks in the last 150 years, especially in the Great Plains but also in some portions of the Intermountain region (Lokemoen and Duebbert 1976, Gilmer and Stewart 1983, Finch 1991, Ostlie et al. 1997, Preston 1998, Gillihan and Hutchings 2000). The species clearly avoids plowed lands and heavy crop vegetation (USDI Fish and Wildlife Service 1992). Agricultural development includes a suite of changes that impact ferruginous hawks: landcover modification, prey reduction, increased human activity, and increased road density. The latter 2 changes also attend petroleum exploration and development, which are increasing throughout much ferruginous hawk range in the region generally, and Wyoming in particular.

Probably the largest threat to native vegetation in the Intermountain region, and by extension

to ferruginous hawks and several other vertebrates, is the complex interaction between invasion by the Asian annual cheatgrass and alteration of native fire regimes. Cheatgrass is steadily invading North America from west-to-east, having already saturated many portions of the Great Basin and replacing native landcover types with an exotic grassland. Cheatgrass can apparently colonize sites that are disturbed by almost any process, including wildfire, road building, off-road motorized use, heavy livestock grazing, chaining or discing, and surface mining.

Once stands of the highly-flammable cheatgrass become established, the probability of fire increases. Fires reduce shrub coverage and encourage cheatgrass spread, thus beginning a conversion cycle that is difficult to stop (Young et al. 1979, Knick and Rotenberry 1995, 2000). In southeastern Idaho from 1950 to 1979, the cheatgrass/ fire cycle reduced shrubsteppe from 51% to 30% of the total area, and also reduced intervals between wildfires from 80.5 to 27.5 years (U.S. Department of the Interior 1996). Large areas of Nevada and Utah have also been affected, with an almost complete replacement of native shrubs in some areas.

The relationship between cheatgrass invasion and ferruginous hawks has not been well-studied, but it is reasonable to assume that such a wholesale change in the fundamental producer level and disturbance regime of Intermountain ecosystems is reducing population viability.

Cheatgrass is present throughout Wyoming and is generally considered to be increasing in distribution and abundance in the state. It has not yet established to the point where it dominates large areas, and there is speculation that much of Wyoming may have too short of a growing season and receive too much summer moisture to allow cheatgrass to dominate as it has in portions of the Great Basin. However, cheatgrass is an annual that can evolve very quickly to novel environments, and disturbances to vegetation and soil are pervasive enough in Wyoming to assist cheatgrass spread. Wildfires and prescribed burns occur regularly, off-road motorized

recreation is increasing, and road development continues throughout much of the state, especially as a function of increased petroleum exploration and development.

Reductions in Prey Base

Distribution and abundance of prairie dogs have sharply declined as a result of the aforementioned habitat conversions as well as sylvatic plague infection, shooting, and deliberate poisoning. These processes have also affected other ground squirrels, and are assumed to affect ferruginous hawks mostly by reducing prey base with secondary poisoning also a possibility (Schmutz et al. 1989, Bechard and Schmutz 1995). Jackrabbit populations are also subjected to deliberate reductions during cyclic highpoints.

Other External Threats

As discussed above, nesting ferruginous hawks are sensitive to disturbance by human activities. From a historic perspective (ca. past 150 yrs) there has been a clear increase in such disturbance across ferruginous hawk range. Currently, it appears that this trend is continuing. Formerly wild and semi-wild landscapes are being subjected to urban and suburban sprawl across the area. Perhaps a more pervasive effect is the rapid increase in petroleum exploration and extraction in ferruginous hawk habitat. Activities directly associated with petroleum development can disturb this species, but perhaps more important is the increase in recreational activities that accompany the road networks originally built for petroleum work. These roads, coupled with an apparent increase in on- and off-road motorized recreation, could dramatically reduce ferruginous hawk reproductive output in many areas.

Predation may be important only locally and periodically; it is not considered a major threat. Young ferruginous hawks are most vulnerable. Other large raptors and generalist mammalian predators (e.g., coyotes, badgers) occasionally take ferruginous hawks (Bechard and Schmutz

1995).

Ferruginous hawks are sometimes killed in vehicle collisions, especially when scavenging road-killed mammals (Howard 1975). They are also infrequently killed in collisions with and electrocutions by utility lines (Olendorff 1993).

Protected Areas

There are relatively few protected areas within the breeding range of ferruginous hawks in Wyoming; those that exist are rather small and widely-scattered. It is likely that a few ferruginous hawks breed at least occasionally in some of these areas, such as BLM Areas of Critical Environmental Concern, USFWS National Wildlife Refuges (e.g., Seedskadee, Hutton Lake), and USDI National Park Service Units (e.g., Bighorn Canyon National Recreation Area, Devil's Tower National Monument). The vast majority of ferruginous hawks breeding in Wyoming do so on public (primarily BLM) land managed for multiple uses, and private land.

Conservation Action

Existing or Future Conservation Plans

There are no formal state or federal conservation plans for the ferruginous hawk in Wyoming. At least some management attention is focused on the species via Sensitive Species designations by the BLM and USFS, as well as its recognition as a Species of Concern by the USFWS and WGFD.

Conservation Elements

Based on the state-of-knowledge of ferruginous hawks in Wyoming and surrounding regions, conservation plans for this species should focus on (1) minimizing conversion, and maximizing re-

establishment, of native grassland and shrubsteppe, (2) maintaining dense and widespread populations of prey (especially prairie dogs, other ground squirrels, and lagomorphs), (3) minimizing disturbance to nesting pairs, and (4) enhancing nest substrates and structures in some local situations.

Land Conversion and Use

Ferruginous hawks clearly thrive in native prairie and shrubsteppe relative to areas modified to cultivated agriculture. In general, rangeland livestock production on native vegetation does not seem to limit ferruginous hawks, and appears easily consistent with their conservation (e.g., Wakeley 1978, Konrad and Gilmer 1986). Livestock producers should avoid overgrazing to the point of reducing prey populations (see Bock et al. 1993), cultivation, and seeding of exotic grasses. Leaving scattered islands of shrubby vegetation in crested wheatgrass fields (total shrub cover 20% of any given area) is recommended to maintain habitat quality for ferruginous hawks (Howard and Wolfe 1976, Janes 1985). Livestock have been known to weaken nest trees by excessive rubbing or trampling (Houston 1982, Olendorff 1993), suggesting that managers should attend to the health of small and isolated tree stands in some areas.

Ferruginous hawk populations require rather large tracts of native vegetation for long-term viability (Howard and Wolfe 1976, Lardy 1980, Schmutz 1991, Olendorff 1993, Bechard and Schmutz 1995). By virtue of its high, cold, and dry conditions, Wyoming has not experienced as much cultivation as surrounding states and thus still supports many large expanses of prairie and shrubsteppe, and many ferruginous hawks. In effect, Wyoming may have "inherited" a disproportionate amount of responsibility for ferruginous hawk conservation by virtue of the state's climate and geographic position. This applies to several other birds (e.g., *Chardrius montanus*, *Athene cunnicularia*) and mammals (e.g., *Vulpes velox*, *Cynomys ludovicanus*) whose

historic ranges centered on the Great Plains but whose current ranges center on Wyoming. The ability of the state to maintain these populations will hinge largely on how petroleum development, now increasing statewide, is balanced with the habitat needs of wildlife.

Prey Management

Habitat quality for ferruginous hawks is strongly tied to prey availability. Maintaining and enhancing native vegetation, as discussed above, will help maintain and enhance populations of major prey species (Houston and Bechard 1984, Bechard and Schmutz 1995), especially if managers avoid monotypic stands and create edge-rich mosaics of shrub and grass patches (Howard and Wolfe 1976, Olendorff 1993). However, prairie dogs (and to a lesser extent other ground squirrels, and lagomorphs) have been and continue to be subjected to severe population reductions by poisoning, shooting, and sylvatic plague infections. It is reasonable to assume that ferruginous hawk conservation, on a regional scale, will be successful only to the extent that these processes are regulated and monitored to allow for effective distributions and densities of prey. Managers should approach pest control more from the standpoint of reducing densities of prairie dogs, ground squirrels, and jackrabbits at the specific locations where they are causing damage, rather than complete eradication of the species across large areas (Olendorff 1993).

Disturbance Management

Disturbance during the nesting period clearly reduces the reproductive output of ferruginous hawks, and thus management that reduces disturbance will increase population persistence. Such management has both temporal and spatial considerations. The 15 March - 15 July period is probably the most critical time window (Howard and Wolfe 1976, Bechard and Schmutz 1995). Konrad and Gilmer (1986) suggest delaying energy development activities until 45 days post-fledging, which would extend this window at least into early August. From a spatial perspective,

most researchers recommend minimizing disturbance in buffer zones around nests. Suggested buffer radii range 0.25 - 0.45 km (White and Thurow 1985, Atkinson 1992). Olendorff (1993) suggested buffer radii of 0.25 km for brief disturbances, 0.5 km for intermittent activities, 0.8 km for prolonged activities, and >1.0 km for major construction or similar activities. Education of ranchers, seismic crews, prospectors, recreationists, and others about the importance of not disturbing ferruginous hawk nests may be an important complement to land use regulations (Atkinson 1992).

Given that human disturbance is a major impact on many other native wildlife (e.g., big game, large carnivores), and given that human activities in wild and semi-wild landscapes are probably most strongly related to road availability, natural resource managers can probably most efficiently manage disturbance by managing road densities. Again, this has both spatial (e.g., number and location of roads) as well as temporal (e.g., time periods when roads are open to motorized use) considerations.

Nest Structures

Direct management of nest substrate may be important in some local situations. Artificial nest platforms have increased densities of breeding pairs in areas where previously-used trees have died and fallen, where shrubs have been replaced by grassland, and where nest sites are otherwise rare (Schmutz et al. 1984, Olendorff 1993). Fencing nest trees, providing physical support to heavy tree nests, and even moving nests to safer locations have occasionally been used with success (Olendorff 1973, 1993; Smith and Murphy 1978, Houston 1985, Bechard and Schmutz 1995, Leary et al. 1998). Managers should recognize the potential for small and isolated stands of trees, and thin stringers of trees and shrubs along riparian zones and ridgelines, as important nesting sites for ferruginous hawks.

Information Needs

More information is needed regarding the differences, if any, between birds breeding in the Intermountain region and those breeding in the Great Plains. Furthermore, studies that detail the exchange of individuals between these population segments, especially focusing on regional crossover during migration and the extent to which such crossover occurs in the Great Divide Basin of southern Wyoming, will provide valuable information for long-term conservation and management of ferruginous hawks.

The winter ecology of ferruginous hawks, especially in Mexico, is poorly understood. It may be that impacts occurring to and on winter range could be just as important, or possibly more important, than impacts occurring on breeding grounds.

More research into the effects of prey distribution, abundance, availability, and diversity on ferruginous hawk distribution, abundance, and fecundity is needed (Bechard and Schumtz 1995). It is not known, for example, if birds migrate in response to low prey availability - would more abundant and stable prey populations result in more non-migratory population segments? Also, the interaction between site-fidelity and prey availability should be examined more closely - do pairs return to previous nesting areas regardless of changes in prey availability, or do they move from year to year to locate prey concentrations? How far will they move from previous territories?

Detailed information on how disturbances affect nesting ferruginous hawks would allow managers to establish more effective and efficient land use rules. Clearly, such studies need to consider: (1) distance from disturbance to nest (i.e., for a particular disturbance type and at a particular period during the breeding cycle, at what distance do adults flush from the nest?), (2) the period during the breeding cycle at which disturbances occur (i.e., for a particular disturbance type

and distance-to-nest, are adults more likely to flush during the brooding or fledging period?), and (3) disturbance type (i.e., for a particular distance and time period, are adults more likely to flush in response to a motorized vehicle or a person on foot?).

Tables and Figures

Table 1. Ferruginous hawk prey, summarized from 20 field studies (Olendorff 1993).

Taxon	Sample Size	Percent Occurrence	Percent Biomass
Mammals	5,166	83.3	95.4
Lagomorphs	1,228	19.8	66.8
Squirrels and Prairie dogs	2,719	43.8	25.1
Pocket gophers	492	7.9	2.6
Kangaroo rats	412	6.6	0.7
Birds	822	13.2	3.8
Ducks	36	0.6	0.9
Galliformes	39	0.8	1.6
Passeriformes	644	11.8	1.3
Amphibians and Reptiles	147	2.4	0.8
Lizards	44	0.8	0.3
Snakes	100	1.6	0.5
Insects	68	1.1	0.0

Figure 1. Current range of ferruginous hawk (*Buteo regalis*) (Ridgely et al. 2003). Red and purple = breeding range. Blue and purple = winter range.

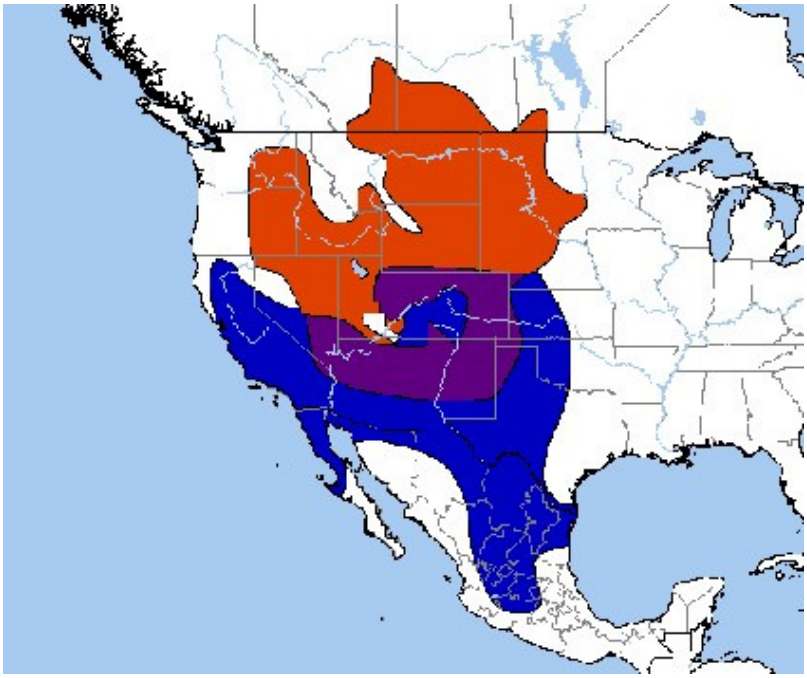
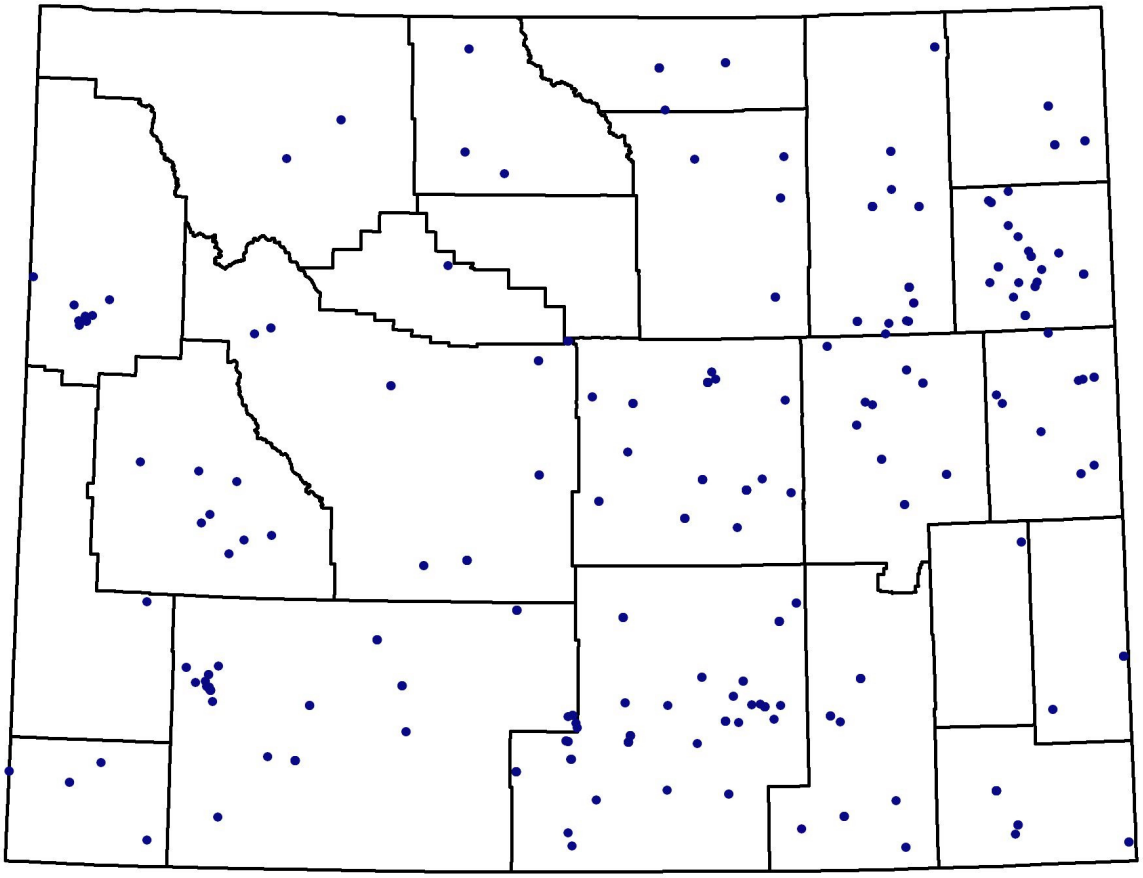


Figure 2. Documented occurrences of breeding ferruginous hawks in Wyoming (Wyoming Natural Diversity Database, University of Wyoming; download April 2004).



Literature Cited

American Ornithologists' Union. 1998. Check-list of North American Birds. 7th edition. American Ornithologists' Union. Washington D.C., USA.

Andrews, J.N. and R. Righter. 1992. Colorado birds: a reference to their distribution and habitat. Denver Museum of Natural History. Denver, Colorado, USA.

Angell, T. 1969. A study of the ferruginous hawk: adult and brood behavior. Living Bird 8:225-241.

Atkinson, E.C. 1992. Ferruginous hawk *(Buteo regalis*) inventories on the Dillon Resource Area of southwest Montana: 1992. Montana Natural Heritage Program. Helena, Montana.

Bak, J.M., K.G. Boykin, B.C. Thompson, and D.L. Daniel. 2001. Distribution of wintering ferruginous hawks (*Buteo regalis*) in relation to black-tailed prairie dog (*Cynomys ludovicianus*) colonies in southern New Mexico and northern Chihuahua. Journal of Raptor Research 35:124-129.

Bechard, M.J. 1981. Historical nest records for the ferruginous hawk in Manitoba. Canadian Field-Naturalist 95:467-469.

Bechard, M.J. and J.K. Schmutz. 1995. Ferruginous hawk (*Buteo regalis*). No. 172 *in* A. Poole and F. Gill (editors). The birds of North America. The Academy of Natural Sciences (Washington, DC, USA) and The American Ornithologists' Union (Philadelphia, Pennsylvania, USA).

Bechard, M.J., R.L. Knight, D.G. Smith, and R.E. Fitzner. 1990. Nest sites and habitats of sympatric hawks (*Buteo* spp.) in Washington. Journal of Field Ornithology 61:159-170.

Berry, M.E., C.E. Bock, and S.L. Haire. 1998. Abundance of diurnal raptors on open space grasslands in an urbanized landscape. Condor 100:601-608.

Blair, C.L. 1978. Breeding biology and prey selection of ferruginous hawks in northwestern South Dakota. MS Thesis, South Dakota State University. Brookings, South Dakota, USA.

Blair, C.L. and F. Schitoskey, Jr. 1982. Breeding biology and diet of the ferruginous hawk in South Dakota. Wilson Bulletin 94:46-54.

Bloom, P.H., J.L. Henckel, E.H. Henckel, J.K. Schmutz, B. Woodbridge, J.R. Bryan, R.L. Anders, P.J. Detrich, T.L. Maechtle, J.O. McKinley, M.D. McCrary, K. Titus and P.F. Schempf. 1992. The dho-gaza with great horned owl lure: an analysis of its effectiveness in capturing raptors. Journal of Raptor Research 26:167-178.

Bock, C.E., V.A. Saab, T.D. Rich and D.S. Dobkin. 1993. Effects of livestock grazing on Neotropical migratory landbirds in western North America. Pages 296-309 *in* D.M. Finch and P.W. Stangel (editors). Status and management of Neotropical migratory birds. USDA Forest Service General Technical Report RM-229.

Brown, L. and D. Amadon. 1968. Eagles, hawks, and falcons of the world. McGraw-Hill. New York, New York, USA.

Call, M.W. 1978. Nesting habitats and surveying techniques for common western raptors. USDI Bureau of Land Management Technical Note TN-316.

Clark, W.S. and B.K. Wheeler. 1987. A field guide to the hawks of North America. Houghton Mifflin Co. Boston, Massachusetts, USA.

Colorado Partners in Flight. 2000. Colorado land bird conservation plan, version 1.0. Colorado Partners in Flight. Estes Park, Colorado, USA.

Cottrell, M.J. 1981. Resource partitioning and reproductive success of three species of hawks (*Buteo* spp.) in an Oregon prairie. MS Thesis, Oregon State University. Corvallis, Oregon, USA.

Davy, G.L. 1930. Nesting of the ferruginous roughleg hawk in northern North Dakota. Oologist 47:14-18.

Dechant, J.A., M.L. Sondreal, D.H. Johnson, L.D. Igl, C.M. Goldade, P.A. Rabie and B.R. Euliss. 2001. Effects of management practices on grassland birds: ferruginous hawk. USGS Northern Prairie Wildlife Research Center. Jamestown, North Dakota, USA (http://www.npwrc.usgs.gov/resource/literatr/grasbird/ferhawk/ferhawk.htm)

DeSmet, K.D. 1992. Manitoba's threatened and endangered grassland birds: 1991 update and five-year summary.. Manitoba Department of Natural Resources Report No. 92-93.

Dorn, J.L. and R.D. Dorn. 1990. Wyoming birds. Mountain West Publishing. Cheyenne, Wyoming, USA.

Ehrlich, P.R., D.S. Dobkin and D. Wheye. 1988. The birder's handbook. Simon and Schuster. New York, New York, USA.

Ensign, J.T. 1983. Nest site selection, productivity, and food habits of ferruginous hawks in southeastern Montana. M.S Thesis, Montana State University. Bozeman, Montana, USA.

Finch, D.M. 1991. Threatened, endangered and vulnerable species of terrestrial vertebrates in the Rocky Mountain region. USDA Forest Service General Technical Report RM-215.

Fitzner, R.E., D. Berry, L.L. Boyd and C.A. Reick. 1977. Nesting of ferruginous hawks (*Buteo regalis*) in Washington, 1974-75. Condor 79:245-249.

Fuller, M.R., C.J. Henny and P.B. Wood. 1995. Raptors. Pages 65-69 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran and M.J. Mac (editors). Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. USDI National Biologial Survey. Washington, DC, USA.

Gaines, R.C. 1985. Nest site selection, habitat utilization, and breeding biology of the ferruginous hawk in central North Dakota. MS Thesis, North Dakota State University. Fargo, North Dakota, USA.

Gillihan, S.C. and S.W. Hutchings. 2000. Best management practices for shortgrass prairie birds: a landowner's guide. Rocky Mountain Bird Observatory. Brighton, Colorado, USA.

Gilmer, D.S. and R.E. Stewart. 1983. Ferruginous hawk populations and habitat use in North Dakota. Journal of Wildlife Management 47:146-157.

Gilmer, D.S. and J.M. Wiehe. 1977. Nesting by ferruginous hawks and other raptors on high voltage powerline towers. Prairie Naturalist 9:1-10.

Gossett, D.N. 1993. Studies of ferruginous hawk biology: I. Recoveries of banded ferruginous hawks from presumed eastern and western subpopulations. II. Morphological and genetic differences of presumed subpopulations of ferruginous hawks. III. Sex determination of nestling ferruginous hawks. MS Thesis, Boise State University. Boisie, Idaho, USA.

Hansen, R.W. 1994. Raptor use of the Idaho National Engineering Laboratory. MS Thesis, South Dakota State University. Brookings, South Dakota, USA.

Houston, C.S. 1982. Artificial nesting platforms for ferruginous hawks. Blue Jay 40:208-213.

Houston, C.S. 1984. Unusual story – record 20-year longevity of ferruginous hawk. Blue Jay 40:208-213.

Houston, C.S. 1985. Ferruginous hawk nest platforms--progress report. Blue Jay 43:243-246.

Houston, C.S. 1991. Ferruginous hawk nesting success: a 19-year study. Page 22 *in* G.L. Holroyd, G. Burns, and H.C. Smith (editors). Proceedings of the second endangered species and prairie conservation workshop. Provincial Museum of Alberta Natural History Occasional Paper No. 15.

Houston, C.S. 1995. Thirty-two consecutive years of reproductive success at a ferruginous hawk nest. Journal of Raptor Research 29:282-283.

Houston, C.S. and M.J. Bechard. 1984. Decline of the ferruginous hawk in Saskatchewan. American Birds 38:166-170.

Howard, R.P. 1975. Breeding ecology of the ferruginous hawk in northern Utah and southern Idaho. MS Thesis, Utah State University. Logan, Utah, USA.

Howard, R.P. and M.L. Wolfe. 1976. Range improvement practices and ferruginous hawks. Journal of Range Management 29:33-37.

Janes, S.W. 1985. Habitat selection in raptorial birds. Pages 159-188 *in* M.L. Cody (editor). Habitat selection in birds. Academic Press. New York, New York, USA.

Jensen, J. 1995. Recovery of the ferruginous hawk. Bird Trends (Canadian Wildlife Service) 4:23-24.

Johnsgard, P.A. 1979. Birds of the Great Plains: breeding species and their distribution. University of Nebraska Press. Lincoln, Nebraska, USA.

Kantrud, H.A. and R.L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the Northern Great Plains. USDI Fish and Wildlife Service Wildlife Research Report 15.

Keinath, D.A. and G.P. Beauvais. 2003. Wyoming animal element ranking guidelines. Wyoming Natural Diversity Database, University of Wyoming. Laramie, Wyoming, USA.

Keinath, D., B. Heidel, and G. Beauvais. 2003. Wyoming plant and animal species of concern. Wyoming Natural Diversity Database. University of Wyoming, Laramie, Wyoming, USA. Available online: http://uwdmnweb.uwyo.edu/wyndd/soc/2003

Knick, S.T. and J.T. Rotenberry. 1995. Landscape characteristics of fragmented shrubsteppe habitats and breeding passerine birds. Conservation Biology 9:1059-1071.

Knick, S.T. and J.T. Rotenberry. 2000. Ghosts of habitats past: contribution of landscape change to current habitats used by shrubland birds. Ecology 81:220-227.

Konrad, P.M. and D.S. Gilmer. 1986. Post fledging behavior of ferruginous hawks in North Dakota. Raptor Research 20:35-39.

Lardy, M.E. 1980. Raptor inventory and ferruginous hawk biology in southeastern Oregon. MS Thesis, University of Idaho. Moscow, Idaho, USA.

Leary, A.W., R. Mazaika and M. J. Bechard. 1998. Factors affecting the size of ferruginous hawk home ranges. Wilson Bulletin 110:198-205.

Leslie, D.G. 1992. Population status, habitat and nest-site characteristics of a raptor community in eastern Colorado. MS Thesis, Colorado State University. Fort Collins, Colorado, USA.

Lloyd, H. 1937. Twenty-year-old ferruginous rough-legged hawk. Canadian Field Naturalist 51:137.

Lokemoen, J.T. and H.F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. Condor 78:464-470.

MacLaren, P.A., S.H. Anderson and D.E. Runde. 1988. Food habits and nest characteristics of breeding raptors in southwestern Wyoming. Great Basin Naturalist 48:548-553.

McAnnis, D.M. 1990. Home range, activity budgets, and habitat use of ferruginous hawks (*Buteo regalis*) breeding in southwest Idaho. MS Thesis, Boise State University. Boise, Idaho, USA.

Olendorff, R.R. 1972. Large birds of prey of the Pawnee National Grassland: nesting habits and productivity 1969-1971. U.S. International Biological Program - Grassland Biome Technical Report 151.

Olendorff, R.R. 1973. The ecology of the nesting birds of prey of northeastern Colorado. U.S. International Biological Program - Grassland Biome Technical Report 211.

Olendorff, R.R. 1993. Status, biology, and management of ferruginous hawks: a review. USDI Bureau of Land Management Special Report (Boise, Idaho, USA).

Olendorff, R.R. and J.W. Stoddard, Jr. 1974. Potential for management of raptor populations in western grasslands. Pages 47-88 *in* F.N. Hamerstrom, Jr., B.E. Harrell, and R.R. Olendorff (editors). Management of raptors. Raptor Research Report No.2. Raptor Research Foundation, Vermillion, South Dakota, USA.

Ostlie, W.R., R.E. Schneider, J.M. Aldrich, T.M. Faust, R.L.B. McKim and S.J. Chaplin. 1997. The status of biodiversity in the Great Plains. The Nature Conservancy. Arlington, Virginia, USA.

Palmer, R.S. 1988. Handbook of North American birds, volume 5. Yale University Press. New Haven, Connecticut, USA.

Plumpton, D.L. and D.E. Andersen. 1998. Anthropogenic effects on winter behavior of ferruginous hawks. Journal of Wildlife Management 62:340-346.

Powers, L.R. 1981. Nesting behavior of the ferruginous hawk (*Buteo regalis*). Ph.D. Dissertation, Idaho State University. Pocatello, Idaho, USA.

Preston, C.R. 1998. Ferruginous hawk. Pages 122-123 *in* H.E. Kingery (editor). Colorado Breeding Bird Atlas. Colorado Bird Atlas Partnership and Colorado Division of Wildlife. Denver, Colorado, USA.

Preston, C.R. and R.D. Beane. 1996. Occurrence and distribution of diurnal raptors in relation to human activity and other factors at Rocky Mountain Arsenal, Colorado. Pages 365-374 *in* D.M. Bird, D.E. Varland, and J.J. Negro (editors). Raptors in human landscapes. Academic Press. London, UK.

Restani, M. 1991. Resource partitioning among three Buteo species in the Centennial Valley, Montana. Condor 93:1007-1010.

Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young and J.R. Zook. 2003. Digital distribution maps of the birds of the western hemisphere, version 1.0. NatureServe. Arlington, Virginia, USA.

Rolfe, E.S. 1896. Notes from the Devil's Lake region. Osprey 10:125-128.

Roth, S.D., Jr., and J.M. Marzluff. 1989. Nest placement and productivity of ferruginous hawks in western Kansas. Transactions of the Kansas Academy of Science 92:132-148.

Schmutz, J.K. 1984. Ferruginous and Swainson's hawk abundance and distribution in relation to land use in southeastern Alberta. Journal of Wildlife Management 48:1180-1187.

Schmutz, J.K. 1987. The effect of agriculture on ferruginous and Swainson's hawks. Journal of Range Management 40:438-440.

Schmutz, J.K. 1989. Hawk occupancy of disturbed grasslands in relation to models of habitat selection. Condor 91:362-371.

Schmutz, J.K. 1991. Population dynamics of ferruginous hawks in Alberta. Pages 212-214 *in* G.L. Holroyd, G. Burns, and H.C. Smith (editors). Proceedings of the second endangered species and prairie conservation workshop. Provincial Museum of Alberta Natural History Occasional Paper No. 15.

Schmutz, J.K. 1995. Updated status report on the ferruginous hawk (*Buteo regalis*) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario, Canada.

Schmutz, J.K., and R.W. Fyfe. 1987. Migration and mortality of Alberta ferruginous hawks. Condor 89:169-174.

Schmutz, J.K. and D.J. Hungle. 1989. Population of ferruginous and Swainson's hawks increase in synchrony with ground squirrels. Canadian Journal of Zoology 67:2596-2601.

Schmutz, J.K., S.H. Brechtel, K.D. DeSmet, D.G. Hjertaas, G.L. Holroyd, C.S. Houston, and R.W. Nero. 1992. Recovery plan for the ferruginous hawk in Canada. Recovery of National Endangered Wildlife (RENEW). Ottawa, Ontario, Canada.

Schmutz, S.M., J.S. Moker and T.D. Thue. 1993. Chromosomes of five North American buteonine hawks. Journal of Raptor Research 27:196-202.

Schmutz, J.K., D.A. Moore and A.R. Smith. 1984. Artificial nests for ferruginous and Swainson's hawks. Journal of Wildlife Management 48:1009-1013.

Schmutz, J.K., A. Rose and R.G. Johnson. 1989. Hazards to raptors from strychnine poisoned ground squirrels. Journal of Raptor Research 23:147-151.

Schmutz, J.K., S.M. Schmutz and D.A. Boag. 1980. Coexistence of three species of hawks *(Buteo* spp.) in the prairie-parkland ecotone. Canadian Journal of Zoology 58:1075-1089.

Seery, D.B. and D.J. Matiatos. 2000. Response of wintering buteos to plague epizootics in prairie dogs. Western North American Naturalist 60:420-425.

Sibley, D.A. 2000. The Sibley guide to birds. Alfred A. Knopf. New York, New York, USA.

Smith, D.G. and J.R. Murphy. 1973. Breeding ecology of raptors in the eastern Great Basin of Utah. Brigham Young University Science Bulletin - Biological Series 13:1-76.

Smith, D.G., and J.R. Murphy. 1978. Biology of the ferruginous hawk in central Utah. Sociobiology 3:79-98.

Smith, D.G., J.R. Murphy and N.D. Woffinden. 1981. Relationships between jackrabbit abundance and ferruginous hawk reproduction. Condor 83:52-56.

Smithe, F.B. 1975. Naturalist's color guide. American Museum of Natural History. New York, New York, USA.

Snow, C. 1974. Habitat management series for unique or endangered species, report no. 13, ferruginous hawk, *Buteo regalis*. USDI Bureau of Land Management Technical Note T/N-255.

Steenhof, K. 1984. Use of an interspecific communal roost by wintering ferruginous fawks. Wilson Bulletin 96:137-138.

Steenhof, K., M.N. Kochert and J.A. Roppe. 1993. Nesting by raptors and ravens on electrical transmission line towers. Journal of Wildlife Management 57:271-281.

Stewart, R.E. 1975. Breeding birds of North Dakota. Tri-College Center for Environmental Studies. Fargo, North Dakota, USA.

The Nature Conservancy. 1999. Species management abstract: ferruginous hawk (*Buteo regalis*). The Nature Conservancy. Arlington, Virginia, USA.

Thurow, T.L., C.M. White, R.P. Howard and J.F. Sullivan. 1980. Raptor ecology of Raft River Valley, Idaho. EG&G, Inc. Idaho Falls, Idaho, USA.

U.S. Department of the Interior. 1996. Effects of military training and fire on habitats, prey and raptors in the Snake River Birds of Prey National Conservation Area. USDI Geological Survey / Bureau of Land Management / IDARNG Final Report, Boise, Idaho, USA.

USDI Bureau of Land Management. 2001. Instruction memorandum no. WY-2001-040, sensitive species policy and list. USDI Bureau of Land Management, Cheyenne, Wyoming.

USDI Fish and Wildlife Service. 1992. Endangered and threatened wildlife and plants - notice of finding on petition to list the ferruginous hawk. Federal Register 57:37507-37513.

USDI Fish and Wildlife Service. 1996. Threatened wildlife and plants: review of plant and animal taxa that are candidates for listing as endangered or threatened species - notice of review. Federal Register 61.

Ure, J., P. Briggs and S.W. Hoffman. 1991. A petition to list as endangered the ferruginous hawk (*Buteo regalis*), as provided by the Endangered Species Act of 1973, as amended in 1982. Letter to Director. USDI Fish and Wildlife Service. Washington, DC, USA.

Wakeley, J.S. 1978. Factors affecting the use of hunting sites by ferruginous hawks. Condor: 80:316-326.

Weston, J.B. 1968. Nesting ecology of the ferruginous hawk, *Buteo regalis*. Brigham Young University Science Bulletin 10:25-36.

White, C.M. and T.L. Thurow. 1985. Reproduction of ferruginous hawks exposed to controlled disturbance. Condor 87:14-22.

Williams, R.B. and C.P. Matteson, Jr. 1948. Wyoming hawks. Wyoming Game and Fish Department Publication Bulletin No. 5.

Woffinden, N.D. 1975. Ecology of the ferruginous hawk (*Buteo regalis*) in central Utah: population dynamics and nest site selection. MS Thesis, Brigham Young University. Provo, Utah, USA.

Woffinden, N.D. and J.R. Murphy. 1983. Ferruginous hawk nest site selection. Journal of Wildlife Management 47:216-219.

Woffinden, N.D. and J. R. Murphy. 1989. Decline of a ferruginous hawk population: a 20-year summary. Journal of Wildlife Management 53:1127-1132.

Young, J.A., R.E. Eckert Jr. and R.A. Evans. 1979. Historical perspectives regarding the sagebrush ecosystem. Pages 1-13 *in* The sagebrush ecosystem: a symposium. Utah State University, Logan, Utah, USA.