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Effects of Management Practices on Grassland Birds: Ferruginous Hawk

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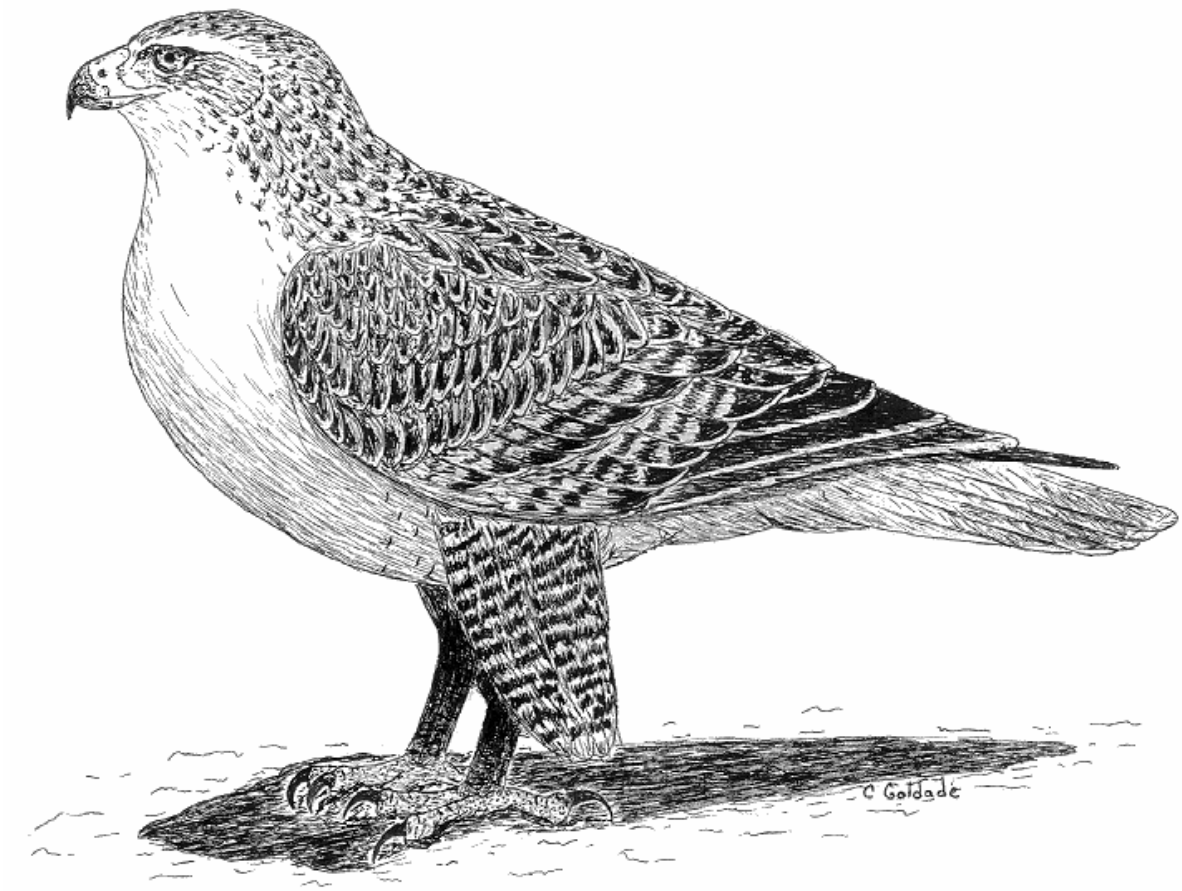
EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

FERRUGINOUS HAWK



Grasslands Ecosystem Initiative
Northern Prairie Wildlife Research Center
U.S. Geological Survey
Jamestown, North Dakota 58401

This report is one in a series of literature syntheses on North American grassland birds. The need for these reports was identified by the Prairie Pothole Joint Venture (PPJV), a part of the North American Waterfowl Management Plan. The PPJV recently adopted a new goal, to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region. To further that objective, it is essential to understand the habitat needs of birds other than waterfowl, and how management practices affect their habitats. The focus of these reports is on management of breeding habitat, particularly in the northern Great Plains.

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Species for which syntheses are available or are in preparation:

American Bittern
Mountain Plover
Marbled Godwit
Long-billed Curlew
Willet
Wilson's Phalarope
Upland Sandpiper
Greater Prairie-Chicken
Lesser Prairie-Chicken
Northern Harrier
Swainson's Hawk
Ferruginous Hawk
Short-eared Owl
Burrowing Owl
Horned Lark
Sedge Wren
Loggerhead Shrike
Sprague's Pipit
Grasshopper Sparrow
Baird's Sparrow
Henslow's Sparrow
Le Conte's Sparrow
Nelson's Sharp-tailed Sparrow
Vesper Sparrow
Savannah Sparrow
Lark Sparrow
Field Sparrow
Clay-colored Sparrow
Chestnut-collared Longspur
McCown's Longspur
Dickcissel
Lark Bunting
Bobolink
Eastern Meadowlark
Western Meadowlark
Brown-headed Cowbird

EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

FERRUGINOUS HAWK

Jill A. Dechant, Marriah L. Sondreal, Douglas H. Johnson, Lawrence D. Igl,
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January 1999
(revised January 2002)

ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

Information on the habitat requirements and effects of habitat management on grassland birds were summarized from information in more than 4,000 published and unpublished papers. A ***range map*** is provided to indicate the relative densities of the species in North America, based on Breeding Bird Survey (BBS) data. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief ***capsule statement***, which provides the fundamental components or keys to management for the species. A section on ***breeding range*** outlines the current breeding distribution of the species in North America, including areas that could not be mapped using BBS data. The ***suitable habitat*** section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A ***table*** near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. A special section on ***prey habitat*** is included for those predatory species that have more specific prey requirements. The ***area requirements*** section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The Brown-headed Cowbird (*Molothrus ater*) is an obligate brood parasite of many grassland birds. The section on ***cowbird brood parasitism*** summarizes rates of cowbird parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on ***breeding-season phenology and site fidelity*** includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. ***Species' response to management*** summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on ***management recommendations*** complements the previous section and summarizes specific recommendations for habitat management provided in the literature. If management recommendations differ in different portions of the species' breeding range, recommendations are given separately by region. The ***literature cited*** contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of grassland birds and their responses to habitat management is posted at the Web site mentioned below.

This report has been downloaded from the Northern Prairie Wildlife Research Center World-Wide Web site, www.npwrc.usgs.gov/resource/literatr/grasbird/grasbird.htm. Please direct comments and suggestions to Douglas H. Johnson, Northern Prairie Wildlife Research Center, U.S. Geological Survey, 8711 37th Street SE, Jamestown, North Dakota 58401; telephone: 701-253-5539; fax: 701-253-5553; e-mail: Douglas_H_Johnson@usgs.gov.

FERRUGINOUS HAWK
(*Buteo regalis*)

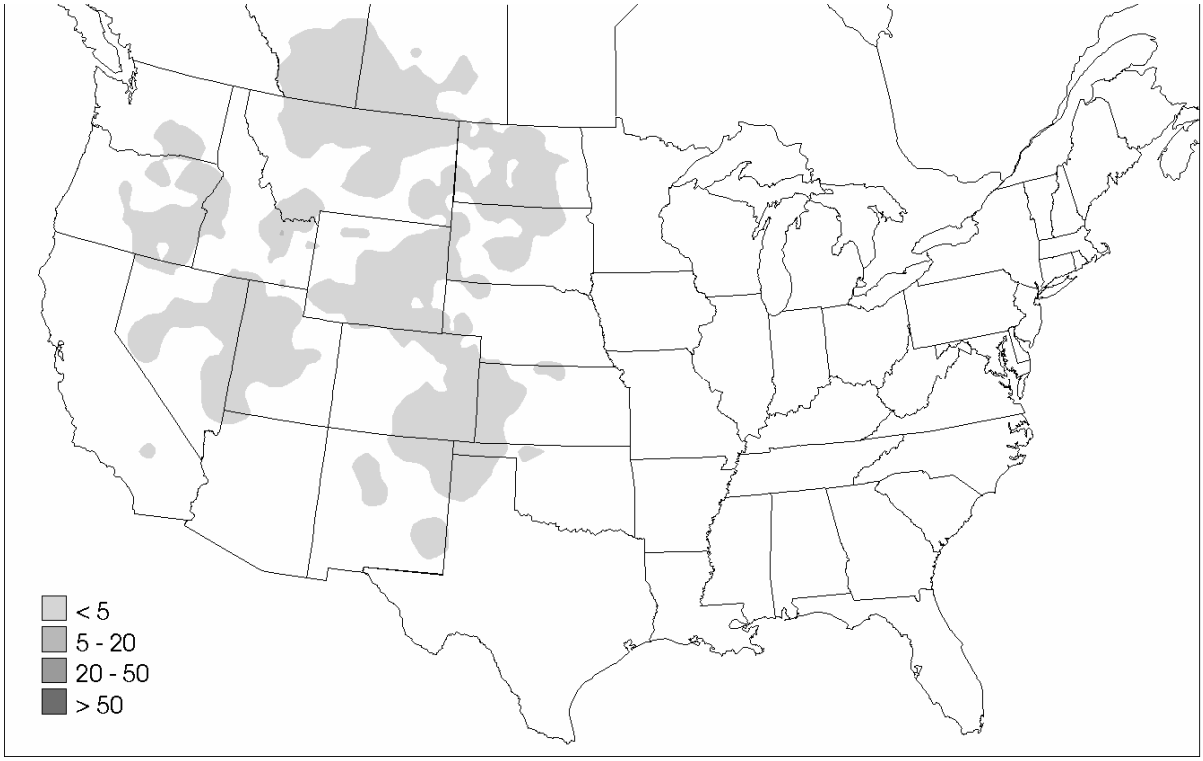

Figure. Breeding distribution of the Ferruginous Hawk in the United States and southern Canada, based on Breeding Bird Survey data, 1985-1991. Scale represents average number of individuals detected per route per year. Map from Price, J., S. Droege, and A. Price. 1995. The summer atlas of North American birds. Academic Press, London, England. 364 pages.

Keys to management are providing suitable nest sites, protecting active nest areas from disturbance, and improving habitat for prey.

Breeding range:

Ferruginous Hawks breed from northeastern Washington, southern Alberta and southern Saskatchewan, south to eastern Oregon, western Nevada, southern California, and northern Arizona, and east through northern Texas, western Oklahoma, and eastern North Dakota (National Geographic Society 1987). (See figure for the relative densities of Ferruginous Hawks in the United States and southern Canada, based on Breeding Bird Survey data.) Two subpopulations of Ferruginous Hawk are recognized (Bechard and Schmutz 1995). In this summary, "central" refers to the subpopulation east of the Rocky Mountains and "western" refers to the subpopulation west of the Rocky Mountains.

Suitable habitat:

Ferruginous Hawks prefer open grasslands and shrubsteppe communities. They use native and tame grasslands, pastures, hayland, cropland, and shrubsteppe (Stewart 1975, Woffinden 1975, Powers and Craig 1976, Fitzner et al. 1977, Blair 1978, Wakeley 1978, Lardy 1980, Schmidt 1981, Gilmer and Stewart 1983, Green and Morrison 1983, Konrad and Gilmer

1986, MacLaren et al. 1988, Palmer 1988, Roth and Marzluff 1989, Bechard et al. 1990, Black 1992, Leslie 1992, Niemuth 1992, Bechard and Schmutz 1995, Faanes and Lingle 1995, Houston 1995, Zelenak and Rotella 1997, Leary et al. 1998). Ferruginous Hawks usually occupy rolling or rugged terrain (Blair 1978, Palmer 1988, Black 1992). High elevations, forest interiors, narrow canyons, and cliff areas are avoided (Janes 1985, Palmer 1988, Black 1992), as is parkland habitat in Canada (Schmutz 1991*a*).

Ferruginous Hawks are opportunistic nesters (Olendorff 1973, Woffinden 1975, Gilmer and Stewart 1983, MacLaren et al. 1988, Zelenak and Rotella 1997). Historically, the majority of nests were on or near the ground (dirt/rock/chalk outcrops, riverbed mounds, mud buttes, and rock piles); more recently, many nests are built in trees and large shrubs, on utility structures, artificial platforms, roofs of abandoned buildings, and river cutbanks (Davy 1930; Weston 1968; Olendorff 1973; Stewart 1975; Woffinden 1975; Lokemoen and Duebbert 1976; Fitzner et al. 1977; Blair 1978; Smith and Murphy 1978; Johnsgard 1979; Lardy 1980; Blair and Schitoskey 1982; Houston 1982, 1985; Gilmer and Stewart 1983; Woffinden and Murphy 1983; Ratcliffe and Murray 1984; Schmutz 1984, 1987, 1991*a*; Gaines 1985; MacLaren et al. 1988; Palmer 1988; Roth and Marzluff 1989; Bechard et al. 1990; De Smet and Conrad 1991; Atkinson 1992; Black 1992; Leslie 1992; Niemuth 1992; Bechard and Schmutz 1995; Faanes and Lingle 1995).

Landscapes with moderate coverages (<50%) of cropland and hayland are used for nesting and foraging (Blair 1978; Wakeley 1978; Gilmer and Stewart 1983; Konrad and Gilmer 1986; Schmutz 1989, 1991*a*; Bechard et al. 1990; Faanes and Lingle 1995; Leary et al. 1998). In North Dakota, hayfields and native pastures were the habitats most often used by both fledglings and adults, whereas cultivated fields rarely were used (Konrad and Gilmer 1986). Fledglings in South Dakota hunted in an area where native hay recently had been cut (Blair 1978). When prey densities were low in big sagebrush (*Artemisia tridentata)* /grassland habitat, agricultural fields served as important foraging areas (Leary et al. 1998). Ferruginous Hawks foraged extensively in alfalfa (*Medicago sativa*) and irrigated potato fields in Washington and in alfalfa fields in Idaho during the breeding season presumably because of high prey densities (Wakeley 1978, Leary et al. 1998).

Nest site selection depends upon available substrates and surrounding land use. Ground nests typically are located far from human activities and on elevated landforms in large grassland areas (Lokemoen and Duebbert 1976, Blair 1978, Blair and Schitoskey 1982, Gilmer and Stewart 1983, Atkinson 1992, Black 1992). Lone or peripheral trees are preferred over densely wooded areas when trees are selected as the nesting substrate (Weston 1968, Rising 1974, Lokemoen and Duebbert 1976, Gilmer and Stewart 1983, Woffinden and Murphy 1983, Palmer 1988, Bechard et al. 1990, Leslie 1992, Hansen 1994). Tree-nesting hawks seem to be less sensitive to surrounding land use, but they still avoid areas of intensive agriculture or high human disturbance (Gilmer and 1983; Schmutz 1984, 1987, 1991*a*; Bechard et al. 1990, Hansen 1994). In Alberta, however, cultivated areas (11-30% of 4,100-ha plots) had higher nesting densities than grassland areas with 0-11% cultivation (Schmutz 1989). In cultivated areas (20%) in northcentral Montana, nests closer to cultivated fields and roads were more successful, presumably because of higher prey densities associated with edge habitats (Zelenak and Rotella 1997). The numbers of fledglings produced in unfragmented rangeland versus a mixture of rangeland and cropland were not significantly different in Nebraska (Podany 1996). In eastern Colorado, Ferruginous Hawks nested more frequently in grassland areas than in cultivated areas (Olendorff 1973, Leslie 1992). In North Dakota, Ferruginous Hawks preferred to nest in areas

dominated by pasture and hayland (Gilmer and Stewart 1983, Gaines 1985). In southwestern Montana, sagebrush (*Artemisia*) and grasslands predominated within 100 m of nests (Atkinson 1992). Ground nests in northern Montana were located in grass-dominated, rolling (>10% slope) rangeland; in general, cropland and areas with dense (>30% cover), tall (>15.24 cm) sagebrush were avoided (Black 1992). In western Kansas, most nests were surrounded by ≥50% rangeland and 25-50% cropland, although one pair incorporated >75% cropland in its territory (Roth and Marzluff 1989). The majority of nests (86 of 99) were not in direct view of black-tailed prairie dog (*Cynomys ludovicianus*) towns, although most nest sites were within 8 km of towns (Roth and Marzluff 1989). In Utah, Idaho, Oregon, and California, Ferruginous Hawks preferred native grassland and shrubland habitats over cropland, and preferred areas with no perches (Janes 1985). In Washington, some nests occurred in agricultural fields, but most nests were in areas with higher percentages of grassland, shrubland, and western juniper (*Juniperus occidentalis*) (Bechard et al. 1990). Nest productivity in Idaho was greater in territories with higher amounts of crested wheatgrass (*Agropyron cristatum*) fields interspersed with desert shrub than in territories with monotypic stands of crested wheatgrass or shrubland, or with greater amounts of Utah juniper (*Juniperus osteosperma*), alfalfa, and cropland (Howard 1975).

The height, exposure, and slope of Ferruginous Hawk nests were mostly similar across the species' range. In South Dakota, the mean height of buttes or hills on which ground nests were built was <10 m above the surrounding prairie; nests were oriented toward the south and west, providing access to prevailing winds from the south and west (Blair 1978). Lokemoen and Duebbert (1976) found ground nests in South Dakota were all oriented toward the west. Nests in southwestern Montana were significantly oriented toward the south (Atkinson 1992). Nests on rock outcrops in Montana were built on slopes averaging 62.8% and were found on the upper 35% of the slope (Atkinson 1992). In North Dakota, most ground nests were on slopes near hillcrests or ridgetops (Johnsgard 1979). Ground nests in northern Montana were located either on the top of a small rise or on slopes ranging from 10 to 50% (Black 1992). Average height of ground nests below the highest surrounding topographic feature was 10 m, whereas average height of ground nest sites above the valley floor was 10.4 m, indicating that nests were placed at mid-elevation sites within the immediate topography (Black 1992). Ferruginous Hawk nests in Wyoming were built on a mean slope of 14.26^{o}, and the mean height of nests was 4.55 m (MacLaren et al. 1988). In North Dakota, mean nest height was 8 m (Johnsgard 1979). In eastern Colorado, the mean height of nesting trees was 10.3 m (Leslie 1992). In western Kansas, nests were placed on ledges 2-3 m high (Rising 1974). In Manitoba, high nests were more successful than low nests; of 59 nests >8 m high, 69% were successful, compared to 58% of 57 nests 5-8 m high and 42% of 59 nests <5 m high (De Smet 1992). In southeastern Washington, 86% of nests on outcrops and in western junipers were located <10 m from the ground and had southern or western exposures (Bechard et al. 1990). In Oregon shrubsteppe, nests were in relatively short western juniper trees, were <10 m from the ground, and had large support branches (Green and Morrison 1983). In Washington, Idaho, and Utah, the majority of nests also were <10 m from the ground in western juniper and Utah juniper trees (Woffinden 1975, Fitzner et al. 1977, Woffinden and Murphy 1983, Hansen 1994). Howard (1975) and Howard and Wolfe (1976) also found Utah juniper trees were important nest substrates in southern Idaho and northern Utah. In Utah, nests were built 2-3 m from the ground, were most commonly located on the sides or summits of hills, and often had southern or eastern exposures (Weston 1968).

Woffinden (1975) found that the majority of nests in Utah were on slopes ranging from 15 to 80° with a mean of 42.5^{o}.

Ferruginous Hawks are easily disturbed during the breeding season (Olendorff 1973, Gilmer and Stewart 1983, Schmutz 1984, White and Thurow 1985, Bechard et al. 1990, Leslie 1992, Hansen 1994). Abandonment of nests occurs particularly in the early stages of nesting (Davy 1930, Weston 1968, Fitzner et al. 1977, Gilmer and Stewart 1983, White and Thurow 1985). Sensitivity to disturbance may be heightened in years of low prey abundance (White and Thurow 1985). In eastern Colorado, nests in remote locations had greater productivity compared to more accessible nests (Olendorff 1973). In South Dakota, the probability of fledging young was 11.4% greater in more remote nests than in nests within 2.47 km of occupied buildings (Blair 1978). In North Dakota, Ferruginous Hawks avoided cropland and nesting within 0.7 km of occupied buildings (Gaines 1985). In Alberta, Ferruginous Hawks rarely nested within 0.5 km of farmyards (Schmutz 1984). In other instances, Ferruginous Hawks are more tolerant of human disturbance. Nesting has occurred near active railroads and gravel roads (Rolfe 1896, Gilmer and Stewart 1983, MacLaren et al. 1988). In Manitoba, 75% of nests located using road surveys were within 0.8 km of roads or maintained trails (De Smet and Conrad 1991). A table near the end of the account lists the specific habitat characteristics for Ferruginous Hawks by study.

Prey habitat:

Ferruginous Hawk density and productivity are closely associated with cycles of prey abundance (Woffinden 1975; Powers and Craig 1976; Smith and Murphy 1978, Smith et al. 1981; Gilmer and Stewart 1983; Houston and Bechard 1984; White and Thurow 1985; Palmer 1988; Schmutz 1989, 1991*a*; Schmutz and Hungle 1989; Bechard and Schmutz 1995). Mammals are the primary prey during the breeding season, although birds, amphibians, reptiles, and insects also are taken (Weston 1968, Howard 1975, Fitzner et al. 1977, Blair 1978, Smith and Murphy 1978, Gilmer and Stewart 1983, Palmer 1988, De Smet and Conrad 1991, Atkinson 1992). Primary prey in central grasslands are ground squirrels (*Spermophilus* spp.), followed by eastern pocket gophers (*Thomomys* spp.) and white-tailed jackrabbits (*Lepus townsendii*) (Bechard and Schmutz 1995). Primary prey in western shrubsteppe are jackrabbits (*Lepus* spp.), followed by ground squirrels and pocket gophers (Smith and Murphy 1978, Bechard and Schmutz 1995). White-tailed (*Cynomys leucurus*) and black-tailed prairie dogs also serve as prey items (Powers and Craig 1976, MacLaren et al. 1988, Hansen 1994).

In Oregon, Janes (1985) found that the highest abundance of major prey species (white-tailed jackrabbits, Townsend's ground squirrels [*Spermophilus townsendii*], and northern pocket gophers [*Thomomys talpoides*]) occurred in native grasslands. In Utah and Idaho, black-tailed jackrabbits (*Lepus californicus*) were associated with sagebrush, preferring tall cover and open spaces (Westoby and Wagner 1973, Janes 1985). Black-tailed jackrabbits foraging in crested wheatgrass fields in Utah and Idaho concentrated their activity within 300 m of field edges (Westoby and Wagner 1973). Townsend's ground squirrels in Idaho were most abundant in grass-shrub vegetation in areas free from disturbance, especially from plowing, but also were observed in oldfields, pastures, and crested wheatgrass fields (Wakeley 1978). Northern pocket gophers in Idaho were most common in alfalfa fields (Wakeley 1978). In moderately cultivated areas of northcentral Montana, active burrow counts of Richardson's ground squirrels

(*Spermophilus richardsonii*) were higher along the edges of agricultural fields than in grasslands (Zelenak and Rotella 1997).

Vulnerability of prey also is an important factor in habitat suitability, such that Ferruginous Hawks avoid dense vegetation that reduces their ability to see prey (Howard and Wolfe 1976, Wakeley 1978, Schmutz 1987). Prey vulnerability decreases where taller small-grain crops replace shorter grasses (Houston and Bechard 1984). Intensive agricultural practices, such as annual plowing and biennial fallowing, exclude many prey species (Wakeley 1978, Houston and Bechard 1984). In Alberta, prey abundance increases as the area of cultivation increases up to 30%, but abundance is reduced where agriculture is extensive, e.g., >30% (Schmutz 1989).

Area requirements:

Estimates of home range size vary from 3.14 to 8.09 km^2 in the Columbia River Basin and Great Basin regions of the western U.S. (Janes 1985). The average home range for Ferruginous Hawks was 90.3 km^2 in Washington, and the variability in home range was significantly related to distance from the nest to the nearest irrigated agricultural field (Leary et al. 1998). One male that nested closest to the surrounding agricultural fields had the smallest home range, whereas another male nesting farthest from the agricultural fields had the largest home range. An area of up to 21.7 km^2 may be required by one pair for hunting in Idaho (Wakeley 1978).

Brown-headed Cowbird brood parasitism:

The Ferruginous Hawk is an accidental but unsuitable host of the Brown-headed Cowbird (*Molothrus ater*), an obligate brood parasite (Friedmann 1929).

Breeding-season phenology and site fidelity:

Ferruginous Hawks occur on breeding areas from late February through early October (Weston 1968, Olendorff 1973, Maher 1974, Blair 1978, Smith and Murphy 1978, Gilmer and Stewart 1983, Schmutz and Fyfe 1987, Palmer 1988, Bechard and Schmutz 1995). Renesting within the same year is rare (Woffinden 1975, Palmer 1988). Territory and nest site reoccupancy is common for Ferruginous Hawks, and one of several nests within a territory may be used in alternate years (Davy 1930, Weston 1968, Olendorff 1973, Blair 1978, Smith and Murphy 1978, Palmer 1988, Roth and Marzluff 1989, Schmutz 1991*b*, Atkinson 1992, De Smet 1992, Houston 1995). Nest reoccupancy may be affected by nest success; in Manitoba, 52% of 71 successful nests were reused, compared to 14% of 63 unsuccessful nests (De Smet 1992). Mate fidelity also is common. (Schmutz 1991*b*).

Species' response to management:

In Idaho, Ferruginous Hawks readily nested in areas burned within the past 15 yr, as well as in unburned areas (Lehman et al. 1996). In southcentral Washington, nests occurred in recently burned sagebrush/downy brome (*Bromus tectorum*) habitat (Leary et al. 1998).

Grazing benefits Ferruginous Hawks by reducing vegetative cover and making prey more visible (Wakeley 1978, Konrad and Gilmer 1986). Kantrud and Kologiski (1982) found highest densities of Ferruginous Hawks in heavily grazed areas in the northern Great Plains. These areas provided a combination of grazing and soil type (typic borolls) that resulted in abundant prey

populations (Kantrud and Kologiski 1982). In South Dakota, Ferruginous Hawks preferentially placed ground nests in lightly grazed pasture or idle areas (Lokemoen and Duebbert 1976, Blair 1978, Blair and Schitoskey 1982). In Saskatchewan, preferred grassland habitat exists in large blocks of government pastures located along the Montana and Alberta borders (Houston and Bechard 1984). These blocks of habitat are the only remaining areas with stable Ferruginous Hawk populations in Saskatchewan (Houston and Bechard 1984). In Idaho and Utah, foraging Ferruginous Hawks require large pastures where Richardson's ground squirrels are abundant (Wakeley 1978, Houston and Bechard 1984). Livestock, however, can weaken nest trees by excessive rubbing or trampling (Houston 1982, Olendorff 1993). Bock et al. (1993) suggested that Ferruginous Hawks would respond negatively to grazing in shrubsteppe habitats, based on the ground cover requirements of their prey.

Conversion of grasslands to intensive cultivation has reduced the amount of preferred habitat that is available to Ferruginous Hawks and has been implicated in the population decline of the species in some areas (Schmutz 1984, Faanes and Lingle 1995). Agricultural development has restricted the species to areas of greater topographic relief or other areas unsuitable for agriculture (Stewart 1975). In Alberta, areas with >50% cultivation were not used by Ferruginous Hawks (Schmutz 1984, 1991*a*). Nesting densities of Ferruginous Hawk increased as the percentage of cultivation on plots increased to 30%, then declined (Schmutz 1989). Conversely, in Manitoba, productivity was not adversely affected by proximity of nests to agriculture; successful nests were surrounded by more cultivated land and less pasture than failed nests (De Smet and Conrad 1991). Seventy-eight percent of all nests had >30% cultivation within 2 km.

Petroleum development in breeding areas appears to have no negative impacts on the productivity of Ferruginous Hawks (Zelenak and Rotella 1997). The number of fledglings produced per nest in disturbed versus undisturbed areas of northcentral Montana did not differ, and no mortalities were directly attributed to oil-field activities (Van Horn 1993).

Management Recommendations:

Increase grassland area to increase Richardson's ground squirrel abundance in Canada (Houston and Bechard 1984). Improve prey habitat by providing native shrub vegetation and increasing edge (Howard and Wolfe 1976, Bechard and Schmutz 1995). If brush is chained, windrow it to provide cover for prey (Olendorff 1993). When converting land from sagebrush steppe to herbaceous grassland (e.g., to crested wheatgrass), create a mosaic of treated (chained or disced) and untreated areas (Howard and Wolfe 1976). To attract small rodents, maintain or restore sagebrush-grass rangeland, removing twoneedle pine (*Pinus edulis*)/Utah juniper stands (Howard and Wolfe 1976). If it is necessary to control lagomorph or rodent populations, try to lower the peaks of cyclic highs rather than completely exterminating them (Olendorff 1993).

Maintain ownership of public lands that have substantial numbers of Ferruginous Hawks (Olendorff 1993). Protect large tracts of native prairie from conversion to monotypic stands of grass or other types of agriculture (Howard and Wolfe 1976, Lardy 1980, Schmutz 1991*a*, Bechard and Schmutz 1995). Avoid seeding of exotic grasses and cultivating in Ferruginous Hawk habitat, where possible (Janes 1985). Leave scattered islands of shrubby vegetation in

crested wheatgrass fields so that the islands make up a minimum of 20% of the total area (Howard and Wolfe 1976).

Do not disturb nest sites from 15 March to 15 July (Howard and Wolfe 1976, Bechard and Schmutz 1995). Close public areas near nest sites to recreation during the breeding season (Lardy 1980) and close public land to firearms where dense populations of Ferruginous Hawks are particularly susceptible to shooting (Olendorff 1993). Establish buffer zones around nest sites (Leslie 1992) and delay energy development until 45 d after fledging (Konrad and Gilmer 1986). White and Thurow (1985) recommended creating a buffer zone of 0.25 km around nest sites. Atkinson (1992) suggested that a minimum distance of 0.45 km be maintained from the nest. Olendorff (1993) suggested buffer zones of 0.25 km for brief disturbances, 0.5 km for intermittent activities, 0.8 km for prolonged activities, and $\geq$1.0 km for construction or similar activities. Provide information to ranchers, seismic crews, prospectors, and others to avoid disturbance to the nest (Atkinson 1992). Conduct treatments, e.g., chaining, discing, plowing, or burning, during the non-nesting season to avoid direct impacts to Ferruginous Hawks and their prey species during the reproductive season (Olendorff 1993). Generally, avoid treatments between 1 March and 1 August each year, especially during the incubation period when Ferruginous Hawks are more prone to abandon nests if disturbed. Mitigate development impacts from mining, pipeline construction, and urbanization (Bechard and Schmutz 1995).

Enhance, protect, and create nest substrates through fencing of nest trees, supporting heavy tree nests that are at risk of toppling, and building artificial nesting structures where nest sites are otherwise lacking (Olendorff 1973, Smith and Murphy 1978, Houston 1985, Bechard and Schmutz 1995, Leary et al. 1998). Other successful nest structure management techniques are to remove some of the previous year's nesting material to reduce the chance of toppling, realign the nest over a vertical axis, widen the base of the nest, reinforce the base of the nest using wire netting or other materials, move the nest to a safer location, or provide protection from predators by nailing tin sheathing around the tree base (Craig and Anderson 1979). In converting tree communities to grassland, provide nest sites by leaving individual trees, a mosaic of stands of trees, or a thin scattering of trees (Olendorff 1993). Leave poles and cross-arms of unused electrical lines for hunting perches (Olendorff 1993).

Encourage rest-rotation or deferred-rotation grazing systems (Olendorff 1993). Delay grazing to allow for the completion of incubation (Atkinson 1992).

Table. Ferruginous Hawk habitat characteristics.

Author(s)	**Location(s)**	**Habitat(s) Studied***	**Species-specific Habitat Characteristics**
Atkinson 1992	Montana	Shortgrass pasture, shrubsteppe	Nested on rock outcrops with an average of 62.8% slope (nests were commonly found on the upper 35% of the slope); habitat within 100 m of nests was primarily big sagebrush (*Artemisia tridentata*) and grassland; nests were oriented toward the south
Bechard et al. 1990	Washington	Cropland, idle shrubsteppe, woodland	Nested in western juniper (*Juniperus occidentalis*) trees (isolated or near the edges of small woodlots) and on basalt rock outcrops; preferred nests were <10 m from the ground and southern and western exposures, some nests were in moderately cultivated areas, but avoided areas of intensive cultivation or high human disturbance; nests are often surrounded by higher percentages of grassland, shrubland, and juniper forest and low percentages of cropland
Black 1992	Montana	Shortgrass pasture, shrubsteppe	Nested primarily on the ground in grassland-dominated areas with rolling topography (>10% slope); ground nests were located either on the top of a small rise or on slopes ranging from 10 to 50%; the area immediately surrounding nest sites was characterized by <30% vegetative cover and vegetation <15.24 cm in height; the mean height of ground nests below the highest surrounding topographic feature was 10 m; the mean height of ground nest sites above the valley floor was 10.4 m, so that nests were placed at mid-elevation within the immediate topography; avoided cropland and areas with dense, tall sagebrush (*Artemisia*)
Blair 1978, Blair and Schitoskey	South Dakota	Cropland, idle mixed-grass, mixed-grass	Nested on mud buttes in unbroken, ungrazed, or lightly grazed prairie or badland areas surrounded by prairie;

1982		pasture, tame pasture	avoided areas used for small-grain farming. The probability of fledging young was 11.4% greater in more remote nests than in nests within 2.47 km of occupied buildings; fledglings used areas of recently cut native hay; mean height of nests (on buttes or hills) above the surrounding prairie was <10 m, and nests were oriented toward the south and west, providing access to prevailing winds from the south and west
Davy 1930	North Dakota	Idle mixed-grass	Nested in tall trees, low bushes, straw stacks, stone piles, and on the ground; nested in willow (*Salix* sp.), box elder (*Acer negundo*), and poplar (*Populus*)
De Smet 1992	Manitoba	Not given	Nested in cottonwood (*Populus deltoides*), box elder, quaking aspen (*Populus tremuloides*), or nest structures; nest structures consisted of wire baskets, modified nests from previous years, wooden platforms, stick bases, or modified raptor nests; average nesting success and number of young per initiated nest were higher in cottonwood and aspen trees than in other species of tree; higher nests had better success and productivity: of 59 nests >8 m high, 69% were successful compared to 58% of 57 nests 5-8 m high and 42% of 59 nests <5 m high; reoccupancy of nests was influenced by previous year's nest success: 37 of 71 (52%) successful nests were reused compared to 9 of 63 (14%) unsuccessful nests
De Smet and Conrad 1991	Manitoba	Cropland, mixed-grass pasture	Nested in quaking aspen, cottonwood, box elder, willow, American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*), mean nest height was 6.5 m; placed nests higher, shallower, and narrower than expected and on limbs rather than in major forks of trees. Most nests were found in isolated or scattered trees, but a few were found in dense

			aspen bluffs; 75% of nests were within 0.8 km of roads or maintained trails. Successful nests had more cultivated land and less pasture nearby than failed nests; 78% percent of nests had >30% cultivation within 2 km
Faanes and Lingle 1995	Nebraska	Cropland, idle mixed-grass, idle shortgrass, idle tallgrass, pasture, sand-sage grassland, tame hayland, wetland, wet meadow, woodland	Preferred large blocks of native prairie; conversion of native prairie to cropland negatively impacted prey and nesting habitat; one nest was found in a cottonwood (*Populus sp.*) surrounded by alfalfa (*Medicago sativa*) and corn
Fitzner et al. 1977	Washington	Shrubsteppe	Nested in western juniper savannas and on rock outcrops; placed nests 3.5-7.5 m from the ground
Gaines 1985	North Dakota	Cropland, hayland, mixed-grass pasture	Preferred pasture or hayland ≤1.0 km to occupied nests; avoided nesting near cropland or within 0.7 km of human habitation
Gilmer and Stewart 1983	North Dakota	Cropland, hayland, mixed-grass pasture	Preferred to nest in pasture and hayland habitats; pasture and hayland made up 95% of the land around ground nests and 76.5% of the land around tree nests; pairs nesting in trees accepted a wider variety of surrounding land uses; nests ≤0.5 km to an interstate highway or other well-traveled road had similar nest success (at least one young was fledged) as other nesting pairs; ground nests occurred in rugged, high relief areas; used a variety of trees for nesting: cottonwood (*Populus deltoides*), peachleaf willow (*Salix amygdaloides*), box elder, green ash, and elm trees (*Ulmus*); nest trees were commonly isolated or in clusters or rows
Green and Morrison	Oregon	Shrubsteppe	Nests were built in short western juniper trees (mean=4.8

1983			m), were <10 m from the ground (mean=2.9 m), and had large support branches (mean radius=7.3 cm)
Houston and Bechard 1984	Saskatchewan	Cropland, mixed-grass pasture, shortgrass pasture	Large government pastures located along the Montana and Alberta borders were the only remaining areas with stable populations in Saskatchewan; required large pastures where Richardson's ground squirrels (*Spermophilus richardsonii*) were abundant; prey vulnerability decreased where taller small-grain crops replaced shorter grasses; intensive agricultural practices, such as annual plowing and biennial fallowing, excluded many prey species
Howard 1975	Idaho, Utah	Cropland, semidesert shrubsteppe, tame hayland, tame pasture	Majority of nests occurred in Utah juniper (*Juniperus osteosperma*) trees; productivity was higher in areas of crested wheatgrass (*Agropyron cristatum*) interspersed with desert shrub than monotypic stands of crested wheatgrass or shrubland, or with greater amounts of juniper, alfalfa, and cropland
Howard and Wolfe 1976	Idaho, Utah	Cropland, semidesert shrubsteppe, tame hayland, tame pasture	Avoided nesting in cultivated areas; Utah juniper trees were important nesting sites; avoided areas of dense vegetation which reduced a hawk's ability to see prey
Janes 1985	California, Idaho, Oregon, Utah	Cropland, semidesert shrubsteppe	Occupied both flat and elevated areas; avoided cropland and cliffs; preferred native grasslands and shrubland (mean percentages of grassland and shrubland in home ranges were 51% and 31.5%, respectively); preferred areas with zero perches (mean percentage of home range with zero perches was 77.3%)
Johnsgard 1979	Colorado, Kansas, Nebraska,	Idle shortgrass, mixed-grass pasture, wet meadow	Nested in grassland areas with scattered trees or clay buttes and bluffs for use as nesting sites; in North Dakota, about half of 61 nests were on the ground and the rest were on

	North Dakota, Oklahoma, New Mexico, South Dakota, Texas		boulders, piles of rocks, haystacks, strawstacks, and miscellaneous locations; most of the ground nests were on slopes near hillcrests or ridgetops; tree nests were located in isolated trees or in groves; nest heights above ground averaged 8 m and ranged from 3 to 14 m
Kantrud and Kologiski 1982	Colorado, Montana, Nebraska, North Dakota, South Dakota, Wyoming	Mixed-grass pasture, shortgrass pasture, shrubsteppe	Used heavily grazed areas of typic boroll soil type in the northern Great Plains where Richardson's ground squirrels were abundant
Konrad and Gilmer 1986	North Dakota	Cropland, hayland, mixed-grass pasture	Used hayfields and native pastures; avoided cultivated fields
Lardy 1980	Oregon	Cropland, shrubsteppe/tame grassland	Frequently built nests on cliff or ground that were characterized by a lack of shrub cover
Leary et al. 1998	Washington	Burned shrubsteppe/tame grassland, cropland, tame hayland	Foraged in alfalfa haylands and irrigated potato fields, and nested in recently burned sagebrush/downy brome (*Bromus tectorum*) habitat
Lehman et al. 1996	Idaho	Idle shortgrass, idle shrubsteppe	Nested in areas burned within the past 15 yr, as well as in unburned areas
Leslie 1992	Colorado	Cropland, idle, mixed-grass pasture, shortgrass pasture, woodland	Most frequently nested in lone or scattered trees in riparian areas; nested in cottonwood, box elder, and Russian olive (*Elaeagnus angustifolia*) trees; mean height of nesting tress was 10.3 m; used windbreaks and abandoned fields for nesting <5% of the time; one pair nested in cropland

Lokemoen and Duebbert 1976	South Dakota	Idle mixed-grass, mixed-grass hayland, mixed-grass pasture	Ground nests were located far from human activities, on elevated landforms in large grassland areas, or $\leq$1.6 km to idle or lightly grazed prairie; ground nests had a western exposure; preferred lone trees or small, open groves over woodland for tree nests
MacLaren et al. 1988	Wyoming	Idle shortgrass	Nested on sandstone pillars, in trees, and on cliffs; mean values for nest variables were as follows: 34.30 cm diameter at breast height of nest trees, 4.55 m nest height, 5.51 m nest substrate height, 14.26^{o} slope, 0.34 km from water, and 0.44 km from a road
Niemuth 1992	Wyoming	Shortgrass pasture, shrubsteppe	Nested on the cross-arms of an abandoned center-pivot irrigation system and on the roof of an abandoned shed
Olendorff 1973	Colorado	Cropland, idle shortgrass, shortgrass pasture	Majority of nests were in grassland, only one nest was found in cropland; more remote nests had higher fledging success than more easily accessible nests
Podany 1996	Nebraska	Cropland, mixed-grass pasture, shortgrass pasture	No significant difference existed for the number of young fledged in unfragmented rangeland versus a mixture of rangeland and cropland
Powers and Craig 1976	Idaho	Semidesert shrubsteppe	Nested in Utah juniper or on slopes of alluvial bluffs; population fluctuations followed population cycles of prey
Ratcliffe and Murray 1984	Manitoba	Mixed-grass pasture	Nested in trembling aspen
Rising 1974	Kansas	Cropland, shortgrass pasture, woodland	Nested in cottonwood, mulberry (*Morus*), and osage orange trees (*Maclura pomifera*), or on ledges 2-3 m high
Roth and Marzluff 1989	Kansas	Cropland, shortgrass pasture	Nested mostly on chalk outcroppings and the slopes of loess canyons; nesting on chalk buttes, trees, and the ground was

			rare; nests were surrounded by 50-75% rangeland and 25-50% cropland; 90% of nests were surrounded by ≥50% rangeland; majority of nests (86 of 99) were not in direct view of black-tailed prairie dog (*Cynomys ludovicianus*) towns, although most nest sites were ≤8 km to prairie dog towns
Schmidt 1981	North Dakota	Idle mixed-grass, mixed-grass pasture	Two nests were found in black cottonwood (*Populus trichocarpa*) trees
Schmutz 1984	Alberta	Cropland, mixed-grass pasture	Preferred trees for nesting; avoided nesting within 0.5 km of a farmyard and in areas of >50% cultivation
Schmutz 1987	Alberta	Cropland, mixed-grass pasture	Preferred arid grasslands, which provided nest sites with greater visibility and opportunities to hunt prey; avoided areas of intensive agriculture or high human disturbance
Schmutz 1989	Alberta	Cropland, mixed-grass pasture, tame hayland, tame pasture	Nesting densities in Alberta increased as the percentage of cultivation on plots increased to 30%, then nesting densities declined; moderately cultivated areas (11-30% of 4,100-ha plots), had higher nesting densities than grassland areas with 0-11% cultivation
Schmutz 1991*a*	Alberta	Cropland, mixed-grass prairie	Nested in areas with few cultivated fields, presumably because of prey availability; avoided parkland habitat
Smith and Murphy 1978	Utah	Semidesert shrubsteppe	Preferred nesting in trees over the ground or ledges; Utah juniper was the tree species most used for nesting
Smith et al. 1981	Utah	Semidesert shrubsteppe	Density and productivity were closely correlated with cycles of prey abundance
Stewart 1975	North Dakota	Mixed-grass prairie	Preferred extensive areas of mixed-grass prairie; placed nests on the ground, in trees, and on rock piles and hay bales

Wakeley 1978	Idaho	Cropland, idle tame, semidesert shrubsteppe, tame hayland, tame pasture	Foraged in areas of bare ground and pasture significantly more than expected by chance; may forage in alfalfa fields where prey densities were presumably higher; avoided areas of dense vegetation that reduce the ability to see prey; grazing may benefit hunting activities by reducing vegetative cover and increasing the visibility of prey
Weston 1968	Utah	Semidesert shrubsteppe	Nested on sides or summits of hills, on the ground, or in trees; most nests with southern or eastern exposure were on the ground; nests in Utah juniper were 1.82-3.04 m high
Woffinden 1975	Utah	Semidesert shrubsteppe	Nested in Utah juniper trees and on rock outcrops; majority of nests are on slopes; nest trees are short (1.2-4.9 m in height) and placed near cover that is suitable for black-tailed jackrabbits (*Lepus californicus*); nest on slopes ranging from 15 to 80° (mean of 42.5^{o})
Woffinden and Murphy 1983	Idaho	Semidesert shrubsteppe	Preferred to nest in lone or peripheral trees; also nested on rock outcrops and the ground; mean nest tree height was <10 m
Zelenak and Rotella 1997	Montana	Cropland, shortgrass pasture	Nested mainly on cliffs, but also on the ground, rock outcroppings, and grain bins; nests closer to cultivated fields may be more successful because of higher densities of prey associated with edge habitats

*In an effort to standardize terminology among studies, various descriptors were used to denote the management or type of habitat. "Idle" used as a modifier (e.g., idle tallgrass) denotes undisturbed or unmanaged (e.g., not burned, mowed, or grazed) areas. "Idle" by itself denotes unmanaged areas in which the plant species were not mentioned. Examples of "idle" habitats include weedy or fallow areas (e.g., oldfields), fencerows, grassed waterways, terraces, ditches, and road rights-of-way. "Tame" denotes introduced plant species (e.g., smooth brome [*Bromus inermis*]) that are not native to North American prairies. "Hayland" refers to any habitat that was mowed, regardless of whether the resulting cut vegetation was removed. "Burned" includes habitats that were burned intentionally or accidentally or those burned by natural forces (e.g., lightning). In situations where there are two or more descriptors (e.g., idle tame hayland), the first descriptor modifies the following descriptors. For example, idle tame hayland is habitat that is usually mowed annually but happened to be undisturbed during the year of the study.

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