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EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS: PRAIRIE FALCON

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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 adopted a 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:

American Bittern
Mountain Plover
Marbled Godwit
Long-billed Curlew
Willet
Wilson's Phalarope
Upland Sandpiper
Greater Prairie-Chicken
Lesser Prairie-Chicken
Greater Sage-Grouse
Northern Harrier
Swainson's Hawk
Ferruginous Hawk
Golden Eagle
Prairie Falcon
Merlin
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
Brewer's Sparrow
Clay-colored Sparrow
Chestnut-collared Longspur
McCown's Longspur
Dickcissel
Lark Bunting
Bobolink
Eastern Meadowlark
Western Meadowlark
Brown-headed Cowbird

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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and effects of habitat management on grassland birds were summarized from information in more than 4,000 published and unpublished papers.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 breeding, year-round, and nonbreeding ranges in the United States and southern Canada. 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. 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.

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Prairie Falcon
(*Falco mexicanus*)

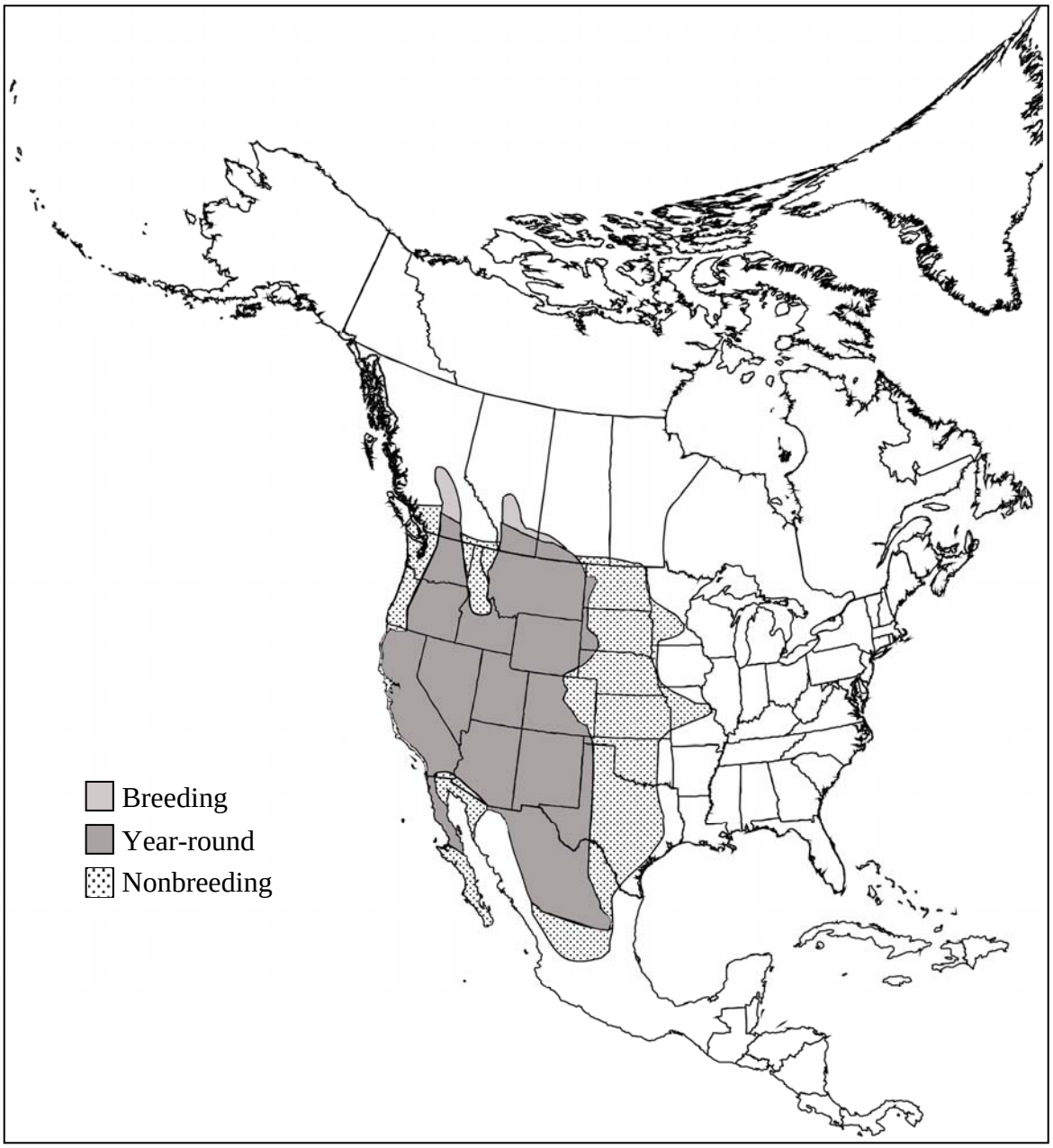

Figure. Distribution of Prairie Falcon in North America. Map adapted from Steenhof (1998), used with permission of the author.

The importance of the northern Great Plains to Prairie Falcons may be primarily in providing postbreeding habitat and migratory corridors and secondarily in providing suitable breeding habitat. Therefore, this species account will depart from other accounts in the grassland bird series by not only describing suitable breeding habitat, but also providing information on the role of the Great Plains in providing habitat during the non-nesting season.

In much of the Midwest, Prairie Falcons are primarily winter visitors or migrants (Dinsmore et al. 1984, Janssen 1987, Steenhof 1998). The grasslands of the Great Plains provide important nonbreeding season habitat for Prairie Falcons that nest in other parts of the continent. Falcons that nest in Canada, Colorado, Wyoming, and California, and Idaho spend at least part of the year in the Great Plains (Enderson 1964, Steenhof et al. 1984, Schmutz et al. 1991). The Great Plains is an important migratory corridor for falcons that nest in Canada (Schmutz et al. 1991). Young that fledge from nests in Colorado and Wyoming tend to move eastward to the plains provinces and states in their first year (Enderson 1964). Prairie Falcons that nest in the Snake River Canyon of southwest Idaho rely on Great Plains grasslands both during the summer post-breeding season and during winter. Of 33 adult female Prairie Falcons that survived the nesting season with working satellite-received radios from 1999 to 2002, 28 (85%) moved to summering areas within the northern Great Plains (Saskatchewan, southeastern Alberta, North Dakota, South Dakota, and Montana; K. Steenhof, unpublished data). The southern plains are more important to wintering falcons.

Keys to management include maintaining open landscapes and habitats that support populations of ground squirrels (*Spermophilus* spp.) as well as Horned Larks (*Eremophila alpestris*) and Western Meadowlarks (*Sturnella neglecta*). For breeding individuals, maintain cliffs with suitable recesses for use as eyries, and protect nest sites from disturbance by designating buffer zones.

Breeding Range:

Prairie Falcons breed from southcentral British Columbia, southern Alberta, and southwestern Saskatchewan through Washington, Oregon, Idaho, Montana, Wyoming, California, Nevada, Utah, New Mexico, Arizona, and New Mexico into Mexico, and east to southwestern North Dakota, northcentral South Dakota, northwestern Nebraska, Colorado, the northwestern portion of the Texas Panhandle, and western Texas (National Geographic Society 1999). (See figure for the breeding, year-round, and nonbreeding ranges in the United States and southern Canada.)

Suitable habitat:

Prairie Falcons inhabit grasslands, shrubsteppe, and agricultural habitats in mostly arid landscapes (Skinner 1961, Steenhof 1998). They also inhabit alpine grasslands and alpine shrubsteppe (Skinner 1961, Marti and Braun 1975, Williams 1981). Prairie Falcons inhabit shortgrass prairie, xeric scrub grassland, and agricultural areas in North Dakota (Allen 1987*a*,*b*); grasslands in South Dakota (Maher 1982); open grasslands and sagebrush scrub in Nebraska (Johnsgard 1980); shortgrass prairie in Alberta (Hunt 1993); grasslands and shrubsteppe in Montana and Wyoming (MacLaren et al. 1988, Phillips and Beske 1990, Phillips et al. 1990, Squires et al. 1993, Van Horn 1993); shortgrass prairie and shrubsteppe in Idaho (Marzluff et al. 1997, Steenhof et al. 1999); grassland, open woodland, and shrubsteppe in California and Oregon (Garrett and Mitchell 1973, Denton 1975, Haak 1982); and shrubsteppe and other desert shrublands in southern California (Harmata et al. 1978). Nesting areas may be adjacent to woodland (Denton 1975, Williams 1981).

Prairie Falcons nest primarily on cliffs (Skinner 1961, Steenhof 1998), including buttes (Squires et al. 1993, Conway et al. 1995), canyon walls (Ogden and Hornocker 1977, Conway et

al. 1995), rock outcrops (Marsh 1936), ridges (Denton 1975), cave walls (Pitcher 1977), and mine highwalls (Phillips and Beske 1990). Nest cliffs are made of a variety of rock types, but where nesting substrates are soft, such as silt or unconsolidated rock, nest sites may weather and become unusable through time (Oliphant et al. 1976, Allen 1987*b*). Nest cliff lengths and heights range from 5 to 2400 m and from 3 to 140 m, respectively (Skinner 1961, Leedy 1972, Denton 1975, Williams 1981, Allen 1987*b*). Rarely, Prairie Falcons also may nest in trees or on transmission line towers in the abandoned nests of other large birds, including Common Raven (*Corvus corax*) and Black-billed Magpie (*Pica hudsonia*) (Skinner 1961; MacLaren et al. 1984, 1988; Roppe et al. 1989; Bunnell et al. 1997). In the Snake River Birds of Prey Area (SRBPA) in southwestern Idaho, the amount of cliff area present per 10-km stretch of survey route explained 91% of the variation in nesting density (Steenhof et al. 1999), indicating that Prairie Falcons may be limited by the availability of nesting substrates.

Eyrie selection may depend upon the types of substrates available (Williams 1981). Cliff features that Prairie Falcons will use as nest sites include potholes (depressions into the side cliffs), horizontal ledges, and ledges within vertical cracks (Dekker and Bowles 1930, Enderson 1964, Leedy 1972, Denton 1975, Ogden and Hornocker 1977, Williams 1981, Maher 1982, Allen 1987*b*). In addition, they will use cliff cavities created by humans (Oliphant et al. 1976). Prairie Falcons do not build their own nests, but rather lay their eggs in small depressions that they scrape out of the substrate. Prairie Falcons also use nest sites built on cliffs by Golden Eagles (*Aquila chrysaetos*), Red-tailed Hawks (*Buteo jamaicensis*), and Common Ravens (Dekker and Bowles 1930, Leedy 1972, Ogden and Hornocker 1977, Harmata et al. 1978, Allen 1987*b*). In Montana, Prairie Falcons also used former Peregrine Falcon (*Falco peregrinus*) nest sites (Leedy 1972). Prairie Falcons tend to nest in the top two-thirds the height of nest cliffs (Enderson 1964, Leedy 1972, Williams 1981, Maher 1982, Allen 1987*b*, Runde 1987), ranging from 1 to 61 m above cliff bases (Denton 1975, Allen 1987*b*). Maher (1982) noted that cliff areas with trees blocking the entrance to potential eyries were not used as nest sites.

In one Wyoming study, nest site aspects did not differ from random (MacLaren et al. 1988). In contrast, nest sites tended to face south in North Dakota and Colorado (Williams 1981, Allen 1987*b*), west in Oregon (Denton 1975), east in South Dakota (Maher 1982), south and east in Montana (Leedy 1972), and southwest in another Wyoming study (Runde 1987). Orientation of nest sites was typically interpreted as having a thermoregulatory advantage. Although some authors indicated that all nest site aspects were equally available (e.g., Allen 1987*b*), the others did not (e.g., Leedy 1972, Denton 1975, Williams 1981, Maher 1982, Runde 1987), and so it was not clear in those studies that falcons actually selected particular aspects from among available aspects. Many authors described Prairie Falcon nest sites as inaccessible to mammalian predators (Enderson 1964, Leedy 1972, Allen 1987*b*). In addition, nest sites often were protected from sun and weather by overhanging rock (Enderson 1964, Leedy 1972, Denton 1975, Williams 1981, Allen 1987*b*), and such protection may reduce nest failures (Ogden and Hornocker 1977).

In southern Alberta, breeding season home ranges had more needle-and-thread (*Stipa comata*), western wheatgrass (*Agropyron smithii*), threadleaved sedge (*Carex filifolia*), fringed sagewort (*Artemisia frigida*), and scarlet globemallow (*Malvastrum coccineum*) than expected from availability (Hunt 1993). Home ranges in the SRBPA had more Nuttall's saltbush (*Atriplex nuttallii*), winterfat (*Krascheninnikovia lanata*), Sandberg's bluegrass (*Poa sandbergii*), and squirreltail (*Sitanion histrix*) than expected from availability (Marzluff et al. 1997). Falcon home ranges had less four-wing saltbush (*Atriplex canescens*), shadscale (*Atriplex confertifolia*),

cheatgrass (*Bromus tectorum*), green rabbitbrush (*Chrysothamnus viscidiflorus*), spiny hopsage (*Grayia spinosa*), greasewood (*Sarcobatus vermiculatus*), horsebrush (*Tetradymia glabrata*), and bluebunch wheatgrass (*Pseudoroegneria spicata*) than expected from availability. Falcon core areas (defined as encompassing 90% and 95% of radio-telemetry locations) had more four-wing saltbush than expected from availability. Falcon core areas had less shadscale, Nuttall's saltbush, and greasewood than expected from availability. Falcons with more bluegrass and winterfat in their home ranges than expected from availability were less selective than other falcons for these habitats in their core areas.

In northeastern Wyoming, Prairie Falcon foraging locations (determined by radiotelemetry) had more grassland habitat than unused areas, suggesting preference for grassland habitats (Squires et al. 1993). Grassland habitats harbored prey species used by falcons, and prey may have been more vulnerable in open grassland habitats than in shrub areas. Other habitats, including mixed sagebrush/wheatgrass, sagebrush, barren soil, agricultural lands, and forests, were used in proportion to their availability. In southern Alberta, foraging habitats depended on the type of prey pursued (Hunt 1993). Core areas (relatively high-use areas as determined by radiotelemetry) used for hunting ground squirrels had more needle-and-thread, western wheatgrass, threadleaved sedge, fringed sagewort, and scarlet globemallow and less irrigated cropland than expected based on availability. Habitats in core areas used by hunting birds were proportional to available habitats. In the SRBPA, falcon locations (determined by radiotelemetry) were positively correlated with Sandberg's bluegrass, big sagebrush (*Artemisia tridentata*), greasewood, four-wing saltbush, and tumbleweed (*Salsola iberica*) (Marzluff et al. 1997). In addition, telemetry data overlaid on Landsat imagery indicated that falcons spent more time in areas with winterfat, sagebrush, and grassland than in other habitats. Falcon abundance was lowest in habitats with large amounts of rabbitbrush (*Chrysothamnus nauseosus*), cheatgrass, and squirreltail; cheatgrass dominated areas not used by falcons. Agricultural lands were generally interspersed among habitats used by falcons, and there was a slight association between falcon locations and agricultural lands. In northern California, falcons selected open habitats (cropland, pasture, bunchgrass, and sagebrush/bunchgrass) for foraging (Haak 1982). Most foraging attempts occurred where vegetation height <1 m from attack sites was <30 cm in height. Also, many foraging attempts occurred where bare ground covered >50% of the area.

Winter home ranges in eastcentral Colorado included significantly more cultivated or fallow land than predicted according to availability; these areas contained higher densities of Horned Larks than other habitats (Beauvais et al. 1992). A table near the end of the account lists the specific habitat characteristics for Prairie Falcons by study.

Prey habitat:

Prairie Falcons prey primarily on ground squirrels, secondarily on other small mammals and birds, and occasionally on lizards and insects (Roberts 1932, Skinner 1961, Enderson 1964, Leedy 1972, Denton 1975, Salt and Salt 1976, Harmata et al. 1978, Williams 1981, Haak 1982, Maher 1982, MacLaren et al. 1988, Steenhof and Kochert 1988, Hunt 1993, Steenhof 1998). They may take prey as large as ducks, cottontail rabbits (*Sylvilagus* spp.), and Barn Owls (*Tyto alba*) (Bond 1936, Skinner 1961). During an 11-yr period in the SRBPA, Piute ground squirrel (*Spermophilus mollis*) was the dominant prey species and the only species that made up more than 5% of the diet (Steenhof and Kochert 1988). Falcon use of alternative prey was negatively correlated with the density of ground squirrels. During a drought year in which ground squirrels comprised only 30% of the diet, passerines made up 26% of the prey. In southwestern

Wyoming, the most common prey species was Richardson's ground squirrel (*Spermophilus richardsonii*), with white-tailed prairie dogs (*Cynomys leucurus*), birds, and rabbits making up the remainder (MacLaren et al. 1988). In southern Alberta, 68% and 27% of 250 prey deliveries were ground squirrels and birds, respectively (Hunt 1993). Richardson's ground squirrel, Western Meadowlark, Horned Lark, and European Starling (*Sturnus vulgaris*) were the most common species found in prey remains. In northwestern South Dakota, primary prey included Western Meadowlarks, thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), and Rock Pigeons (*Columba livia*) (Maher 1982). In northern California, falcons foraged primarily on Belding's ground squirrels (*Spermophilus beldingi*) (Haak 1982). In many areas, Horned Larks are an important prey species (Bond 1936, Enderson 1964, Haak 1982, Steenhof and Kochert 1988, Beauvais et al. 1992, Hunt 1993, Steenhof 1998). Hunt (1993) found that diet assessment studies using pellets and prey remains at nest sites underestimated the importance of ground squirrels as prey items because Prairie Falcons consume some squirrels away from the nest. Because most studies of prey selection in Prairie Falcons used these techniques, ground squirrels are possibly more important as a prey item than indicated in the above studies. However, ground squirrels are active generally only during the summer months, and Prairie Falcons typically forage primarily on small grassland birds at other times of year (Edwards 1973).

Habitat for ground squirrels is primarily native grasslands and shrublands (Williams 1981), although they also may use non-native pastures and fields (Koehler and Anderson 1991, Kaufman et al. 2000). In southern Alberta, Richardson's ground squirrels were present primarily in shortgrass prairie (Hunt 1993). In the SRBPA, ground squirrels are most abundant in areas with Sandberg's bluegrass, but during droughts they survive better in sagebrush habitats (Marzluff et al. 1997, Steenhof et al. 1999). Conversion of shrubland to exotic grassland was thought to reduce the ability of ground squirrels to survive during drought years (Steenhof et al. 1999). In the SRBPA, falcon radio-telemetry locations were associated with big sagebrush, winterfat, and Sandberg's bluegrass habitats, likely because these habitats support an abundance of ground squirrels (Marzluff et al. 1997).

Area requirements:

In northeastern Wyoming, the home range size for six pairs of falcons was determined using two methods (Squires 1993). Using harmonic mean 95% contours and excluding nest sites and points <500 m from nest sites, home range size averaged 69 km^2 and ranged from 11 to 139 km^2. Using minimum convex polygons, home range sizes averaged 29.4 km^2 and ranged from 5 to 75 km^2. Home range sizes of 12 Prairie Falcons in southern Alberta averaged 72.5 km^2 and ranged from 31.3 to 192.0 km^2 (Hunt 1993). Overlap of home and foraging ranges varied from 38 to 100% and 22 to 100%, respectively, between adjacent pairs. In a 4-yr period, during which 28-36 Prairie Falcons were radio-tracked annually in the SRBPA, home range size (determined using minimum convex polygons of radio-tracked birds excluding nest sites) averaged 298 km^2 and ranged from 204 to 400 km^2 (Marzluff et al. 1997). Years in which Prairie Falcons had large home ranges coincided with years of low Piute ground squirrel abundance, but annual differences in average, maximum, and core use areas (defined as 90% and 95% of locations) were significant only for pairs that successfully raised young to 30 days. Area used did not vary by sex. Non-nesters and unsuccessful birds used larger areas than successful birds, but this difference was only marginally significant for females. In northern California, home range size averaged 228 km^2 and ranged from 34 to 389 km^2 (Haak 1982). In the Mojave Desert of

California, mean home range size (determined from outermost radio-telemetry points) for two males and two females was 71.9 km^2 and 46.6 km^2, respectively (Harmata et al. 1978).

During a 4-yr period in the SRBPA, falcons traveled an average of 7 km from their nest sites and an average maximum of 21.7 km from their nest sites (Marzluff et al. 1997). The maximum distance a falcon traveled from its nest site was 38.3 km. Both sexes had their lowest travel distances during the year of highest Piute ground squirrel abundance. In southern Alberta, falcons ranged up to 20 km from their nest sites (Hunt 1993). For male falcons, the distance traveled and the area covered when hunting birds were less than when hunting ground squirrels.

Prairie Falcons may nest in close proximity wherever nesting substrates and habitat allows. The distance between adjacent pairs in the SRBPA averaged 646 m, but nest sites were as close as 50 m apart (Steenhof et al. 1999). Adjacent falcon nest sites have been found within 1 km in California (Garrett and Mitchell 1973), western Montana (Leedy 1972), eastern Oregon (Denton 1975), and northcentral Montana (Van Horn 1993). In northwestern South Dakota, falcon nest sites were as close as 1.5 km (Maher 1982), and in southeastern Montana and northern Wyoming, falcon nest sites were no closer than 7.8 km (Phillips et al. 1990).

Winter home ranges tend to be smaller than in the breeding season. In east-central Colorado, winter range sizes varied from 12.3 to 68 km^2 and averaged 30.2 km^2 (Beauvais et al. 1992). Winter diurnal use areas may even be smaller because winter roosts are sometimes far from areas used during daylight; a male wintering in central Colorado moved up to 10 km between night roosts and diurnal use areas. Although his total home range was 27.6 km^2, he spent most of the day in a 9.3-km^2 area (Gatz and Hegdal 1986).

Brown-headed Cowbird brood parasitism:

No known records of brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) exist.

Breeding-season phenology and site fidelity:

Prairie Falcons may occur on some breeding areas year-round (Denton 1975, Salt and Salt 1976, Hansen 1994). However, individuals from breeding areas in the northern parts or higher elevations of the range migrate south and east for the winter (Skinner 1961), and individuals from arid nesting regions move north and east for the summer (Steenhof et al. 1984; K. Steenhof, unpublished data). In the far northern Great Plains (Alberta and Saskatchewan), Prairie Falcons occupy breeding areas from about late March, and they may be found in this region through late October (Skinner 1961, Maher 1974, Salt and Salt 1976). Prairie Falcons occupy nesting areas in southwest Idaho from February until June or July, at which time they leave the nesting areas as ground squirrels begin to hibernate and become inaccessible as prey. Some individual Prairie Falcons return to southwest Idaho in the fall and winter, and others winter in various parts of the Great Plains (Steenhof et al. 1984; K. Steenhof, unpublished data). Prairie Falcons occupy breeding areas in the northern Great Plains (North Dakota, South Dakota, and Wyoming) from early April through early July, but some birds may remain through early November (Skinner 1961, SDOU 1991). In Oregon and the Rocky Mountains (Colorado, Montana, Wyoming), Prairie Falcons occur on breeding areas beginning in mid-March (Enderson 1964, Leedy 1972, Denton 1975). At high elevations in Colorado (3450-4270 m), Prairie Falcons occupy breeding territories from May through September, but falcons were present in the area as early as mid-April and as late as mid-December (Marti and Braun 1975).

An analysis of the nesting phenology of Prairie Falcons from 20 sites across the species'

range showed that the mean date of clutch completion ranged from 10 March to 10 May (Williams 1985). Latitude accounted for 64% of the variation in mean clutch completion date, with completion occurring later at higher latitudes. Elevation accounted for 21% of the variation in mean clutch completion date, with completion occurring later at higher elevations. Egg-laying begins in mid-February in Texas and Mexico, early March in California, late March in Oregon and Washington, and mid-April in Colorado, Wyoming, Montana, Alberta, and Saskatchewan (Skinner 1961, Enderson 1964, Squires 1985, Van Horn 1993). Hatch dates in the Snake River Canyon ranged from 8 April to 1 July with a mean hatch date of 5 May (n = 29 years, 1436 nesting attempts; K. Steenhof, unpublished data). Fledging occurred from late June through late July in Colorado and Wyoming (Enderson 1964, Squires 1985), from early June to mid-July in Oregon (Denton 1975), and mid-June through mid-July in Montana (Van Horn 1993). In Colorado and Wyoming, nest phenology was up to 28 days out of phase among nesting pairs (Enderson 1964).

Of 517 nesting attempts observed during a 10-yr period in Idaho, 8 (1.5%) were categorized as late (defined as nests in which young hatched after 12 June) (Allen et al. 1986). The occurrence of late nesting was not associated with precipitation during the incubation period, and there were no nest site characteristics that differentiated late nesting attempts from others (Allen et al. 1986). Of 14 late nesting attempts from Idaho, New Mexico, Colorado, Wyoming, and North Dakota during the 1970's and 1980's, eight (62%) were successful, and young fledged from 20 July to 13 August (Allen et al. 1986). Of eight nesting attempts after 12 June in Idaho, two were renesting attempts after the failure of initial nests (Allen et al. 1986). Of 17 nesting attempts in North Dakota, three (18%) were likely renesting attempts that occurred after a late-April blizzard (Allen et al. 1986). Two pairs in Colorado renested after clutches were destroyed early during incubation (Enderson 1964). No records of double-brooding exist.

At sites in Alberta, Colorado, Saskatchewan, and Wyoming, site fidelity between years was 87.8%, with no significant difference between males and females (Runde 1987). Site fidelity was higher in Alberta (94.3%) than in Wyoming (80.0%). Of 161 instances where falcons were captured on a particular territory in successive seasons, 22% had at least one new breeding adult. Turnover rates were 2-3 times higher in the Snake River Canyon of southwestern Idaho: 57% of 61 nesting areas had a different breeding adult than in the previous year. Higher turnover rates may be related to higher densities in Idaho (Lehman et al. 2000).

Species' response to management:

Because the Great Plains also is important to Prairie Falcons as a wintering area, changes to the landscape would likely affect breeding as well as nonbreeding individuals.

In the SRBPA, Prairie Falcons selected primarily unburned areas with native grassland and shrubs for foraging (Marzluff et al. 1997). Wildfires in the SRBPA resulted in a conversion of shrubland to exotic annual grassland, thereby reducing habitat for primary prey species such as ground squirrels (Steenhof et al. 1999).

Although little direct information on the effects of grazing on Prairie Falcons is available, Prairie Falcons occur in grazed areas throughout their range. In the Mojave desert, successful nest sites had less nearby grazing (grazing intensity not quantified) than unsuccessful nest sites (Boyce 1988).

Prairie Falcons have been killed by pesticide poisoning, but this appears to be a relatively minor problem for this species. During an 11-yr period, only one of 734 poisoned raptors was a Prairie Falcon (Mineau et al. 1999). This mortality resulted from a pesticide abuse, in which the

pesticide was intentionally used in a manner not in accord with the legally approved uses.

Chlorinated hydrocarbon pesticides appear to have caused reproductive impairment in Prairie Falcons. In a 3-yr period in Colorado, dichlorodiphenyldichloroethylene (DDE) residues in Prairie Falcon eggs were correlated with eggshell thickness (Enderson and Wrege 1973). Experimental feeding of DDE to Prairie Falcons in Colorado caused contamination of females, eggshell thinning, egg breakages, and reduced reproductive success relative to control birds (Enderson and Berger 1970). In southern Alberta and neighboring Canadian provinces, DDE concentrations in eggs were high enough to decrease productivity, and the mean shell-thickness index of eggs from totally failed clutches was lower than eggs from clutches in which four young fledged (Fyfe et al. 1976). Populations in these areas may have stabilized since that time (Oliphant et al. 1976). During a 2-yr period in Montana, Prairie Falcons had relatively low organochlorine contamination (Leedy 1972). Nonetheless, the average thickness showed a 9% decrease from pre-1947 levels and eggshell thickness was negatively correlated with total chlorinated hydrocarbon residues in eggs. Average shell thickness was greater for eggs that hatched than eggs that did not hatch. Ground squirrels in the area also had DDE contamination, although DDE levels appeared to be fairly low. Of three study areas, the one that had the greatest amount of land treated with pesticides also had the highest DDE and total chlorinated hydrocarbon residues in falcon eggs, the thinnest eggshells, the lowest nesting success, and the fewest fledglings per occupied territory.

Oil and gas development did not appear to have a significant impact on Prairie Falcon breeding in northeastern Wyoming, although oil and gas extraction equipment was present in primary foraging habitats (Squires et al. 1993). In northcentral Montana, Prairie Falcons did not appear to avoid nesting in areas with roads or active oil wells (Van Horn 1993). In southwestern Idaho, the noise from explosives caused temporary changes in breeding behavior by falcons such as sitting up or flushing from nest sites; the average time required for falcons to return to their pre-blast activities was 1.4 minutes (Holthuijzen et al. 1990). During incubation and brooding, falcons did not alter their behaviors in response to blasting associated with dam reconstruction (nest sites were at distances of 560-1000 m from the dam). However, falcons ceased incubation and brooding in response to experimental blasting, which was characterized by louder and more frequent blasts at an average distance of 127 m from nest sites. Although falcons exposed to experimental blasts did not suffer lower productivity than falcons in a control area, they did not habituate behaviorally to the activity.

Overall, human disturbance appears to be a potential factor resulting in nest failures (Boyce 1988). In the Mojave desert (California), the ease with which humans could access nest sites (measured by cliff characteristics and distance to roads or human habitations) was positively correlated with distance to roads and habitation, and the amount of human disturbance (shooting, off-road vehicle use, climbing, hiking) near nest sites was negatively correlated with falcon productivity. Successful nest sites were harder to access and had fewer disturbances than unsuccessful nest sites. Falcons may flush from nest sites when approached by humans (Van Horn 1993), and human interference with nest sites apparently has resulted in nest failures in many areas (Edwards 1973). During an 8-yr period in Wyoming, experimental removal of nestlings to mimic harvest for falconry (reducing the number of nestlings to ≤ 2) did not reduce nest success in 6 of 8 yr (Conway et al. 1995). Adult nest site fidelity was lower and the recruitment rate for young birds was higher in an area where nestlings were removed than in an area where they were not removed.

Prairie Falcons have been electrocuted, but this appears to be relatively minor problem

for this species (Harness and Wilson 2001). Of 1428 electrocuted raptors found during an 11-yr period in the western United States, only one was a Prairie Falcon. Similarly, during a 3-yr period in the interior western United States, less than 1% of 416 carcasses found below power lines were Prairie Falcons (Benson 1981).

Management Recommendations:

Maintain grasslands on privately owned tracts through incentive programs, such as the Conservation Reserve Program.

Restore and maintain remnant playa lakes because they may be a key feature to which Prairie Falcons are attracted.

In southwestern Idaho, suppress wildfires, restore native shrubs and perennial grasses, and limit land disturbances within Prairie Falcon foraging areas (Marzluff et al. 1997, Steenhof et al. 1999). Do not convert large tracts of native shrubland and grassland to agriculture as this likely will reduce prey numbers (Marzluff et al. 1997).

Preserve ground squirrel colonies and habitats near Prairie Falcon nest sites (Hunt 1993).

Maintain buffer zones around occupied eyries, keeping roads and other access points at least a 15-minute walk from eyries (Boyce 1988).

Mining operations should not be conducted within 0.8-1.6 km of falcon nest sites (Call 1979). Blasting should occur no closer than 125 m from nest sites, and no more than three blasts should be conducted per day (Holthuijzen et al. 1990).

When eyries must be destroyed because of energy, urban, or recreational development, artificial eyries may be created (Runde 1987, Phillips et al. 1990). These eyries should be built on southwest-facing cliffs at least 14 m tall, placed about two-thirds the height of the nest cliff, and should have a floor area of about 7000 cm^2, a gentle slope to the front, and overhead protection (Runde 1987). Cavities for falcons should be on cliffs of solid, non-eroding rock (Call 1979). Two or three alternate sites should be created on the same cliff (Runde 1987).

Where Prairie Falcons commonly use old nest sites of other large birds, reinforcement and filling the nest sites with sand or dirt might make them more usable by Prairie Falcons and thus help to ensure the continued use of certain nest cliffs (Harmata et al. 1978).

When harvesting nestlings for falconry, at least two young should be left in each harvested nest (Conway et al. 1995). Although harvesting may cause some breeders to switch territories, harvesting should be focused on the same territories each year.

Table. Prairie Falcon habitat characteristics.

Author(s)	**Location(s)**	**Habitat(s) Studied***	**Species-specific Habitat Characteristics**
Allen 1987*a,b*	North Dakota	Mixed-grass prairie, shortgrass, shrubsteppe, woodland	Nested in cliff cavities, on cliff ledges with good protection from weather, and on old Golden Eagle (*Aquila chrysaetos*) and Red-tailed Hawk (*Buteo jamaicensis*) cliff nests; 31 nest cliffs averaged 103 m in length; 63% of 31 eyrie cliffs were small and scattered throughout the area; 34 eyrie cliffs averaged 11 m in height; 33 eyries averaged 7 m above the base of the cliff; 41 eyries were an average of 69 m above the lowest point in the area; successful eyries were as low as 1 m above the base of the cliff, but 36 of the natural eyries were inaccessible to mammalian predators; at least 0.5 km of open terrain was visible from most of the eyries; all cliff aspects were equally available, but 61% of eyries were oriented southwest, south, and southeast, suggesting avoidance of northerly aspects; eyries were reused frequently; 29 eyries averaged 45 cm in height and 0.24 m^3 in volume; 31 eyries averaged 86 cm in width and 80 cm in depth
Bunnell et al. 1997	Utah	Not given	Nested on an old Common Raven (*Corvus corax*) nest built on the lattice of a transmission line tower
Dekker and Bowles 1930	Washington	Shrubsteppe	Nested on ledges, in potholes (depressions into the side of cliffs), in niches on cliffs; also used old nest sites of other raptors and Common Ravens; nest heights averaged about 15 m above the ground; often nested in close proximity to other raptors
Denton 1975	Oregon	Grassland, shrubsteppe,	Nested on bluffs, ridges, canyon walls, and monolithic rock formations; of 49 nest cliff heights, 14% were <8 m, 43%

		woodland	were between 8 and 30 m, 25% were between 30 and 61 m, and 18% were >61 m; of 41 nest sites, 19% were <8 m, 64% were between 8 and 30 m, 12% were between 30 and 61 m, and 5% were >61 m above the bottom of the nest cliff (note that lower height nest sites were located and measured more often than higher nest sites); of 36 nest sites, 42% were in potholes, 39% were in vertical cracks, and 19% were on horizontal ledges; potholes ranged in size from 60 cm to 3.7 m deep; 75% of all nest sites were sheltered from sun and rain; many (unspecified) nest sites contained remnant material from other bird species or woodrats (*Neotoma* spp.); of 36 falcon nest sites, 61% had exposures from 181 to 360_; 62% of nest sites were <0.8 km from roads; 15% of nest sites were <0.8 km from buildings; 76% of nest sites were <0.4 km from a water source; 32% of nest sites bordered agricultural land; 24% of nest sites were in forested areas; adjacent nest sites were as close as 0.4 km apart
Enderson 1964	Colorado, Wyoming	Not given	Nest cliffs averaged 15.8 m in height and ranged from 7.7 to 38.7 m; nest sites averaged 11.1 m above the base of cliffs; of 36 nest sites, 44% were on open shelves, 44% were in potholes, and 11% were in larger caves; a rock overhang protected all but one nest site, and 78% of nest sites were inaccessible to mammalian predators because of smooth rock surrounding the nest site; 61% of nest sites faced south, 14% of nest sites faced north, and 25% of nest sites faced east or west; falcons tended to use different nest sites on the same cliffs in subsequent years
Faanes and Lingle 1995	Nebraska	Grassland	Usually nested on cliffs that overlooked large tracts of native prairie

Garrett and Mitchell 1973	California	Grassland, shrubland, woodland	Nested at elevations from zero to over 3000 m; neighboring pairs were as close as 100 m; nesting pair densities were as high as about 1 per km^2
Haak 1982	California	Grassland, shrubland, woodland	Home range size averaged 228 km^2 and ranged from 34 to 389 km^2; mean home range size was 143 and 69 km^2 in the incubation and nestling period, respectively; nested as close as 90 m to other Prairie Falcon nest sites
Harmata et al. 1978	California	Alkali sink, desert scrub, shrubsteppe	Nested on cliffs; three of four nest sites were placed on old Common Raven nests, and one nest site was in a cliff pothole; mean home range size was 71.9 km^2 for males and 46.6 km^2 for females; the home range increased for one pair from 37.7 km^2 during the nestling period to 57.7 km^2 after fledging
Hunt 1993	Alberta	Cropland, grassland	Nested along river canyon; home range sizes averaged 72.5 km^2 and ranged from 31.3 to 192.0 km^2 (home range size was positively correlated with the number of telemetry points acquired; hence these are minimum values); overlap of home ranges varied from 45 to 100% within pairs and from 38 to 100% between adjacent pairs; overlap of foraging ranges varied from 33 to 93% within pairs and from 22 to 100% between adjacent pairs; falcons traveled up to 20 km from their nest sites; male falcons traveled farther from nest sites and covered more area when hunting ground squirrels (*Spermophilus* spp.) than when hunting birds; falcons foraged along riparian and cliff areas more frequently when hunting birds; home ranges had more native rangeland [needle-and-thread (*Stipa comata*), western wheatgrass (*Agropyron smithii*), threadleaved sedge (*Carex filifolia*), fringed sagewort (*Artemisia frigida*), and scarlet globemallow (*Malvastrum coccineum*)] than expected from availability; core areas (areas used by

			falcons relatively more than other areas) used for hunting ground squirrels had more native range and less irrigated cropland than expected; core areas used for hunting birds had habitats in proportion to availability
Johnsgard 1990	Nebraska	Not given	Used open grasslands and sagebrush scrub; nested on cliffs, bluffs, and outcrops
Leedy 1972	Montana	Grassland, hayland, woodland	Of 57 nesting territories, 8% were below 1220 m elevation, 83% were at elevations between 1220 and 1830 m, and 9% were at elevations higher than 1830 m; 45 nest cliffs averaged 38 m and ranged from 9 to 91 m in height; 49 eyries averaged 24 m and ranged from 3 to 76 m above the cliff base; eyries appeared to be inaccessible to mammalian predators; 8% of eyries faced north, 39% faced east, 33% faced south, and 20% faced west; 39% of eyries were on ledges in vertical cracks, 20% were on horizontal shelves, and 41% were in caves or potholes; eyries on horizontal shelves were protected from weather by overhanging rock less often than eyries in vertical cracks or caves and potholes; eyries also were placed on old cliff-nests of Common Ravens, Golden Eagles, Red-tailed Hawks, and woodrat stick nests; some Prairie Falcons eyries were former Peregrine Falcon (*Falcon peregrinus*) eyries; of 57 nesting territories, 98% overlooked some grassland
Leslie 1992	Colorado	Cropland, idle mixed-grass pasture, shortgrass pasture, woodland	Nested on chalk bluffs
MacLaren et al. 1984, 1988	Wyoming	Grassland, shrubsteppe, woodland	Nested on cliffs and in a tree; nest sites were an average of 5.3 m above ground; average elevation of nest sites was 2099 m; average slope for nest sites was 23°; mean

			distances to nearest water source and road were 0.24 and 0.50 km, respectively; nest aspects were not different from random; the tree nest was a former Black-billed Magpie (*Pica hudsonia*) nest 4.5 m above the ground in a pine (*Pinus* spp.) tree 6 m tall with a diameter at breast height of 26 cm
Maher 1982	South Dakota	Cropland, grassland, shrubland, woodland	Nest cliffs averaged 16 m and ranged from 10.6 to 23 m in height; eyries averaged 10 m and ranged from 6 to 18 m above the cliff base; of 21 eyries, 71% were in potholes (defined here as a depression into the cliff with an opening <1 m^2 and which was enclosed on all sides except for the entrance), 19% were in larger caves, and 10% were in other raptor nest sites; used exposed ledges or vertical cracks as roost sites; of 18 nest sites, 78% were oriented between 0 and 180_, presumably to take advantage of early morning warming and late afternoon shade while being protected from prevailing west winds; talus slopes below nest sites were dominated by grassland habitats, but three areas had young elms (*Ulmus* sp.), ashes (*Fraxinus* sp.), and pines; cliff areas that had trees blocking the entrance to potential eyries were not used
Marti and Braun 1975	Colorado	Alpine tundra	Nested at 3690 m
Marzluff et al. 1997	Idaho	Shrubsteppe, tame grassland	Home range sizes averaged 298 km^2; the number of falcon radio locations per area was positively correlated with percent cover of Sandberg's bluegrass (*Poa sandbergii*), big sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), four-wing saltbush (*Atriplex canescens*), and tumbleweed (*Salsola iberica*); areas with ≥1 falcon location averaged 5% cover of big sagebrush, 8% cover of Sandberg's bluegrass, and 2% cover of winterfat

			(*Krascheninnikovia lanata*); areas with ≥10 falcon locations averaged 12% cover of Sandberg's bluegrass, 5% cover of big sagebrush, 2.5% cover of winterfat, 5.5% cover of cheatgrass (*Bromus tectorum*), and 6.7% cover of tumbleweed; cheatgrass dominated areas not used by falcons; there was a slight association between falcon radio locations and agricultural lands, likely because agricultural lands were interspersed among native habitats used by falcons; home ranges had more Nuttall's saltbush (*Atriplex nutallii*), winterfat, Sandberg's bluegrass, and squirreltail (*Elymus elymoides*) and less four-wing saltbush, shadscale (*Atriplex confertifolia*), cheatgrass, green rabbitbrush (*Chrysothamnus viscidiflorus*), spiny hopsage (*Grayia spinosa*), greasewood, horsebrush (*Tetradymia glabrata*), and bluebunch wheatgrass (*Pseudoroegneria spicata*) than expected from availability; core areas had more four-wing saltbush and less shadscale, Nuttall's saltbush, and greasewood than expected from availability; falcons with greater percent cover of bluegrass and winterfat in home ranges than expected from availability were less selective than other falcons for these plants in their core areas; percent cover of bluegrass and winterfat in core areas increased with selectivity for these plants
Ogden and Hornocker 1977	Idaho	Not given	Nested in cavities, on ledges, and on abandoned cliff nests of Common Ravens, Red-tailed Hawks, and Golden Eagles; nest aspect varied widely; distance between adjacent pairs averaged 1.4 and 0.9 km in 1970 and 1972, respectively
Oliphant et al. 1976	Saskatchewan	Not given	Nested on cliff ledges and in both human-dug and natural holes on cliffs
Phillips and Beske 1990	Wyoming	Cropland, grassland,	Nested on cliffs and a coal-mine highwall; cliffs were

		shrubsteppe, woodland	scarce in the study area, and most areas did not support falcons; the area with the most cliffs harbored the greatest concentration of nest sites
Phillips et al. 1990	Montana, Wyoming	Hayland, riparian grassland, shrubsteppe, woodland	Nested in sandstone cliffs; cliffs were small and only one pair of falcons used a given cliff; distances between occupied nest sites averaged 7.8 km
Pitcher 1977	Idaho	Shrubsteppe	Nested in a lava hole about 92 m wide and 61 m deep; eyrie was on the east-facing wall about 40 m from the bottom and about 5 m from the top
Potter 1937	Saskatchewan	Not given	Nested on a 9-m-high cliff
Roppe et al. 1989	Nevada	Not given	Nested in old Common Raven nests built on the lattice of transmission line towers; one nest was at a height of about 30 m
Runde 1987	Wyoming	Not given	Of 71 eyries, 41% were in potholes, 24% were in crevices, 25% were on ledges, and 10% were on old stick nests of other birds; height of 68 eyrie openings averaged 47.9 cm; width of 70 eyries averaged 91.2 cm; length of 71 eyries averaged 135.4 cm; floor area of 70 eyries averaged 9325 cm^2; entrance opening of 56 eyries averaged 5375 cm^2; floor slope of 67 eyries averaged 7.4_; roof slope of 56 eyries averaged 12.3_; nest cliff heights averaged 14.6 m and ranged from 4.3 to 34.6 m; eyrie heights averaged 9.8 m and ranged from 2.9 to 30.6 m above the base of the cliff; eyries were placed at an average of 67% of cliff height; eyrie aspects were in all directions, but 70.2% faced southwest; there were no significant differences in eyrie characteristics between successful and unsuccessful or occupied and unoccupied sites

Salt and Salt 1976	Alberta, Saskatchewan	Grassland	Nested on cliffs and creek banks near prairie habitats
SDOU 1991	South Dakota	Grassland	Nested on cliffs
Squires et al. 1993	Wyoming	Grassland, shrubsteppe	Nested on buttes; foraged close to nest sites (almost always <15 km and typically <10 km from nest sites); used areas had more grassland than unused areas; most grassland used by falcons was flat, with few draws and with areas of barren soil
Steenhof et al. 1999	Idaho	Srubsteppe, tame grassland	Nested on cliffs; density of nest sites along the Snake River Canyon was positively correlated with the amount of cliff area available
Stewart 1975	North Dakota	Not given	Nest sites were located on buttes and cliffs
Van Horn 1993	Montana	Cropland, grassland, shrubland, woodland	Nested on cliffs; occupied and unoccupied eyries did not differ significantly in distance to nearest power line, road, active oil well, nest site of other raptor species, or nest site of other Prairie Falcons; eyries occurred at a linear density of 0.6 nests per km along 22.3 km of cliffs
Williams 1981	Colorado	Grassland, shrubsteppe	Elevation of 15 nest sites averaged 2720 m and ranged from 2390 to 3050 m; eyries typically overlooked expanses of sagebrush; three territories were located above 2900 m and overlooked spruce (*Picea* spp.)-fir (*Abies* spp.) forest, but all were <2 km from sagebrush habitat in the valleys; all eyries were <1.5 km from a water source and <2.5 km from a road; nest cliff height averaged 55.8 m and ranged from 15 to 140 m; eyrie height was strongly correlated with cliff height, with eyries placed at about 61% of cliff height; nest cliff lengths averaged 660 m and ranged from 150 to 2400 m; eyries were place in potholes, on ledges, and on old stick

			nests, with the type of site apparently determined by the features associated with the geology of the nest cliff; eyries typically had more than 50% shading at midday; average length, width, and height of eyries were 78.9, 81.1, and 83.2 cm, respectively

*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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