

The Effects of Management Practices on Grassland Birds— Prairie Falcon (*Falco mexicanus*)

Chapter S of

The Effects of Management Practices on Grassland Birds



Professional Paper 1842–S

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By John P. DeLong^{1,2} and Karen Steenhof^{1,3}

Chapter S of

The Effects of Management Practices on Grassland Birds

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Figure

- S1. Map showing the breeding, nonbreeding, and year-round distributions of the Prairie Falcon (*Falco mexicanus*) in North America.....2

Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square meter (m ²)	0.0002471	acre
square kilometer (km ²)	2.471	acre
square meter (m ²)	10.76	square foot (ft ²)
square kilometer (km ²)	0.3861	square mile (mi ²)

Abbreviations

- DDE dichlorodiphenyldichloroethylene
n sample size number
 sp. species (an unspecified species within the genus)
 spp. species (applies to two or more species within the genus)
 SRBPA Snake River Birds of Prey Area

Acknowledgments

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The Effects of Management Practices on Grassland Birds—Prairie Falcon (*Falco mexicanus*)

By John P. DeLong^{1,2} and Karen Steenhof^{1,3}

Capsule Statement

Keys to Prairie Falcon (*Falco mexicanus*) management include maintaining cliffs with suitable recesses for use as nest sites (that is, the substrate that supports the nest or the specific location of the nest on the landscape; Millsap and others, 2015; Steenhof and others, 2017), protecting nest sites from human disturbance by designating buffer zones, and maintaining open landscapes and habitats that support populations of ground squirrels (*Urocitellus* species [spp.]) and small birds. Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (<https://www.itis.gov>).

Breeding Range

Prairie Falcons breed from south-central British Columbia, southern Alberta, and southwestern Saskatchewan; through Washington, Oregon, Idaho, Montana, Wyoming, California, Nevada, Utah, New Mexico, and Arizona into Mexico; and east to southwestern North Dakota, north-central South Dakota, northwestern Nebraska, Colorado, the northwestern portion of the Texas Panhandle, and western Texas (National Geographic Society, 2011). The breeding, nonbreeding, and year-round (that is, where breeding and nonbreeding areas overlap) distribution of Prairie Falcons in the United States, southern Canada, and Mexico are shown in figure S1 (not all geographic places mentioned in report are shown on figure).

The importance of the Great Plains to Prairie Falcons may be primarily in providing postbreeding habitat and migratory corridors to Prairie Falcons that nest elsewhere on the continent and secondarily in providing suitable breeding habitat to a small nesting population (Dinsmore and others, 1984; Janssen, 1987; Steenhof, 2020). Falcons that nest in Canada, Idaho, Wyoming, Colorado, and California spend at least part of the year in the Great Plains (Enderson, 1964; Steenhof and others, 1984, 2005; Schmutz and others, 1991). For example,



Prairie Falcon. Illustration by Patsy D. Renz, used with permission.

over a 4-year period, most adult female Prairie Falcons that survived the breeding season and retained functioning satellite radio-transmitters in the Snake River Canyon of southwestern Idaho moved to summer-use areas in the northern Great Plains (that is, Alberta, Saskatchewan, North Dakota, South Dakota, and Montana) between July and mid-September (Steenhof and others, 2005). Young that fledge from nests in Colorado and Wyoming tend to move to the Great Plains during their first year (Enderson, 1964). The Great Plains also provide an important migratory corridor for falcons that nest elsewhere (Schmutz and others, 1991; Steenhof and others, 2005). The southern Great Plains are more important to Prairie Falcons during the winter (Steenhof and others, 2005). This species account will depart from other accounts in this series (Johnson and others, 2019) by not only describing suitable breeding habitat, but also providing information on the role of the Great Plains in providing habitat during the nonbreeding season (that is, the postbreeding and wintering periods).

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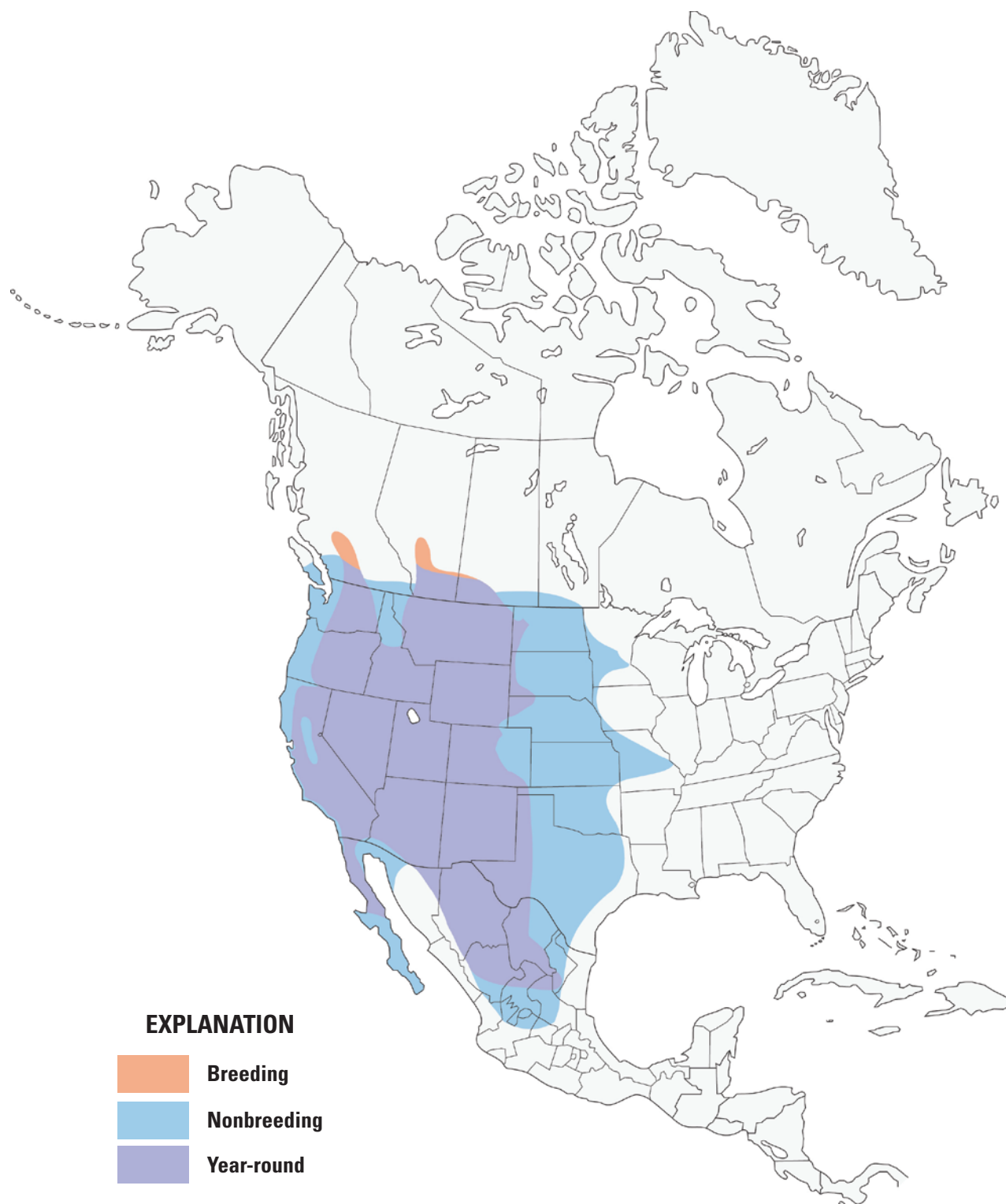


Figure S1. The breeding, nonbreeding, and year-round distributions of the Prairie Falcon (*Falco mexicanus*) in North America. Map modified from Steenhof (2013, used with permission by Cornell Lab of Ornithology).

Suitable Habitat

Prairie Falcons inhabit grasslands, shrubsteppe, and agricultural habitats in mostly arid and semiarid landscapes (Skinner, 1961; Steenhof, 2020). Specifically, Prairie Falcons inhabit shortgrass prairies in Alberta (Hunt, 1993); mixed-grass and shortgrass prairies, xeric scrub grasslands, and agricultural areas in North Dakota (Allen, 1987a, 1987b); grasslands in South Dakota (Maher, 1982); open grasslands and sagebrush (*Artemisia* spp.) scrub in Nebraska (Johnsgard, 1980); grasslands and shrubsteppe in Montana and Wyoming (MacLaren and others, 1988; Phillips and Beske, 1990; Phillips and others, 1990; Squires and others, 1993; Van Horn, 1993); grasslands and sagebrush in Idaho (Marzluff and others, 1997; Steenhof and others, 1999); grasslands, open woodland, and shrubsteppe in California and Oregon (Garrett and Mitchell, 1973; Denton, 1975; Haak, 1982); shrubsteppe and other desert shrublands in southern California (Harmata and others, 1978); and vernal pools in the Central Valley and northeastern California (Silveira, 1998). The species also inhabits grasslands and shrubsteppe in alpine areas (Skinner, 1961; Marti and Braun, 1975; Williams, 1981).

Prairie Falcons nest at a wide range of elevations up to 3,690 meters (m) above sea level (Enderson, 1964; Leedy, 1972; Garrett and Mitchell, 1973; Marti and Braun, 1975; Williams, 1981; MacLaren and others, 1988; Lanning and Hitchcock, 1991; Steenhof, 2020). Prairie Falcons nest primarily on cliffs (Skinner, 1961; Johnsgard, 1980; South Dakota Ornithologists' Union, 1991; Steenhof, 2020), including buttes (Stewart, 1975; Squires and others, 1993; Conway and others, 1995), canyon walls (Ogden and Hornocker, 1977; Conway and others, 1995), rock outcrops (Marsh, 1936), ridges (Denton, 1975), bluffs (Leslie, 1992), and mine highwalls (Phillips and Beske, 1990). In Idaho, falcons also nested in a lava hole about 92 m wide and 61 m deep (Pitcher, 1977). Cliff features that Prairie Falcons will use as nest sites include potholes (depressions in the side of cliffs), horizontal ledges, and ledges within vertical cracks (Dekker and Bowles, 1930; Enderson, 1964; Leedy, 1972; Denton, 1975; Oliphant and others, 1976; Ogden and Hornocker, 1977; Call, 1978; Williams, 1981; Maher, 1982; Runde and Anderson, 1986; Allen, 1987b; Runde, 1987). Nest cliffs are made of a variety of rock types (Oliphant and others, 1976; Allen, 1987b). In locations where soft nesting substrates exist, such as in areas of silt or unconsolidated rock, nest sites may degrade and become unusable through time. Nest cliff lengths and heights range from 5 to 2,400 m and from 3 to 140 m, respectively (Skinner, 1961; Leedy, 1972; Denton, 1975; Williams, 1981; Allen, 1987b; Runde, 1987). In the Snake River Birds of Prey Area (SRBPA) in southwestern Idaho, the amount of cliff area per 10-kilometer (km) stretch of survey route explained 91 percent of the variation in nesting density (Steenhof and others, 1999), indicating that Prairie Falcons may be limited by the availability of nesting substrates. Similarly, in Wyoming, the area with the most cliffs harbored the greatest concentration of nest sites (Phillips and Beske, 1990).

Prairie Falcons do not build their own nests; nest-site selection may depend on the types of substrates available (Williams, 1981). Prairie Falcons may lay their eggs in small depressions scraped out of the substrate or in nests of other species (Steenhof, 2020). Prairie Falcons use natural nest sites (Runde and Anderson, 1986) on cliffs, including those built previously by Golden Eagles (*Aquila chrysaetos*), Red-tailed Hawks (*Buteo jamaicensis*), Common Ravens (*Corvus corax*), and woodrats (*Neotoma* spp.) (Dekker and Bowles, 1930; Leedy, 1972; Ogden and Hornocker, 1977; Harmata and others, 1978; Allen, 1987b; Runde, 1987). Infrequently, Prairie Falcons also may nest in trees or on transmission-line towers in the abandoned nests of other large bird species, including Common Raven and Black-billed Magpie (*Pica hudsonia*) (Skinner, 1961; MacLaren and others, 1984, 1988; Roppe and others, 1989; Bunnell and others, 1997). In Montana, Prairie Falcons used former Peregrine Falcon (*Falco peregrinus*) nest sites (Leedy, 1972). Prairie Falcons also will nest in cliff cavities created by humans (Oliphant and others, 1976; Mayer and Licht, 1995).

Vertical cracks, horizontal shelves, and sandstone or clay potholes on cliffs and bluffs provide the most typical opportunities for nesting; most cliff nest sites also have an overhang that protects the nest site from sun and weather (Steenhof, 2020). Average length, roof (or overhang) height, and depth of cliff nest sites range from 78.9 to 135.4 centimeters (cm), 45 to 83.2 cm, and 60 to 370 cm, respectively (Denton, 1975; Williams, 1981; Runde and Anderson, 1986; Allen, 1987b; Runde, 1987). Many nest-site floors are not flat (Runde, 1987; MacLaren and others, 1988). In Wyoming, there were no significant differences in nest-site dimensions (for example, roof height, width, length, floor area, floor slope, and roof slope) between successful and unsuccessful or occupied and unoccupied nests (Runde, 1987).

Prairie Falcons place nests from 1 to 76 m above cliff bases, typically in the top two-thirds of the cliff (Dekker and Bowles, 1930; Potter, 1937; Enderson, 1964; Leedy, 1972; Denton, 1975; Pitcher, 1977; Williams, 1981; Maher, 1982; Allen, 1987b; Runde, 1987; MacLaren and others, 1988; Roppe and others, 1989). In Colorado, nest-site height correlated strongly with cliff height (Williams, 1981). A tree nest in Wyoming was 4.5 m above the ground in a 6 m tall pine (*Pinus* spp.) tree; the nest was in a dilapidated magpie nest (MacLaren and others, 1984).

Some authors indicated that all nest-site aspects on cliffs were equally available (for example, Allen, 1987b), but others did not (for example, Leedy, 1972; Denton, 1975; Williams, 1981; Maher, 1982; Runde, 1987); therefore, it is not clear from those studies that falcons actually selected particular aspects. In a Wyoming study, nest-site aspects did not differ from random aspects (MacLaren and others, 1988). In contrast, nest sites tended to face south in North Dakota, Colorado, and Wyoming (Enderson, 1964; Williams, 1981; Allen, 1987b), 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 providing a thermoregulatory advantage. Many nest sites were protected from sun and weather by overhanging rock (Enderson, 1964; Leedy, 1972; Denton, 1975; Ogden and Hornocker, 1977; Williams, 1981; Allen, 1987b), and such protection may reduce nest failures (Ogden and Hornocker, 1977).

Nest sites typically are within view of potential foraging areas in open grasslands and shrublands (Leedy, 1972; Salt and Salt, 1976; Williams, 1981; Maher, 1982; Allen, 1987b; Faanes and Lingle, 1995), but nest sites sometimes border forested and agricultural areas (Denton, 1975; Williams, 1981). Maher (1982) noted that cliff areas with trees blocking the entrance to potential nest sites were not used. Nest sites are often less than (<) 1.5 km from a water source (Denton, 1975; Williams, 1981; MacLaren and others, 1988). Many authors described Prairie Falcon nest sites as inaccessible to mammalian predators (Enderson, 1964; Leedy, 1972; Allen, 1987b).

Several studies have evaluated resource use relative to availability within breeding-season home ranges and core areas of Prairie Falcons. In southern Alberta, the proportion of native rangeland (that is, uncultivated land associated with colonies of Richardson's ground squirrels [*Urocitellus richardsonii*]) was significantly greater in home ranges than within a 15-km radius around each nest site; native rangeland was characterized by needle and thread (*Hesperostipa comata*), western wheatgrass (*Pascopyrum smithii*), threadleaf sedge (*Carex filifolia*), fringed sagewort (*Artemisia frigida*), and scarlet globemallow (*Sphaeralcea coccinea*) (Hunt, 1993). Based on availability, home ranges in the SRBPA had more than expected Nuttall's saltbush (*Atriplex nutallii*), winterfat (*Krascheninnikovia lanata*), Sandberg's bluegrass (*Poa secunda*), and squirreltail (*Elymus elymoides*) (Marzluff and others, 1997). Home ranges had less than expected fourwing saltbush (*Atriplex canescens*), shadscale saltbush (*Atriplex confertifolia*), cheatgrass (downy brome [*Bromus tectorum*]), green rabbitbrush (*Chrysothamnus viscidiflorus*), spiny hop-sage (*Grayia spinosa*), greasewood (*Sarcobatus vermiculatus*), littleleaf horsebrush (*Tetradymia glabrata*), and bluebunch wheatgrass (*Pseudoroegneria spicata*). Core areas (defined as encompassing 90 and 95 percent of radio-telemetry locations) had more than expected fourwing saltbush (Marzluff and others, 1997). Core areas had less than expected shadscale saltbush, Nuttall's saltbush, and greasewood. Falcons with more than expected bluegrass (*Poa* spp.) and winterfat in their home ranges were less selective than other falcons for these habitats in their core areas. Marzluff and others (1997) indicated that the prominent features of Prairie Falcon home ranges in the SRBPA may have resulted from the patchy distribution of landscape features associated with different densities and availabilities of Piute ground squirrels (*Urocitellus mollis*), which was once a subspecies of the Townsend's ground squirrel (*Urocitellus townsendii*).

In the Southern High Plains of Texas, wintering Prairie Falcons used moist-soil managed playa wetlands (Smith and others, 2004). Moist-soil management was designed to improve the production of seeds and invertebrates in playa

wetlands for migrating and wintering birds. Prairie Falcons prey on the birds and other fauna attracted to playa wetlands during winter (Smith, 2003).

Weather (for example, precipitation) may affect Prairie Falcon reproduction by interacting with prey availability or nest-parasite infestations. Steenhof and others (1999) reported that two extreme droughts over a 24-year period negatively affected Prairie Falcon productivity at the SRBPA; Prairie Falcon productivity declined as Piute ground squirrel populations declined after a winter drought (Smith and Johnson, 1985) and after a spring drought (Van Horne and others, 1997). Successful Prairie Falcons, however, produced larger broods in dry years and smaller broods in wet years; brood sizes at fledging were inversely related to the amount of precipitation prior to and during the onset of the breeding season (Steenhof and others, 1999). Steenhof and others (1999) indicated that precipitation before the breeding season may have increased the amount of grass and weed cover and interfered with the ability of Prairie Falcons to find prey. Long-term reproductive rates of Prairie Falcons were not related to spring precipitation during the brood-rearing period. However, precipitation during winter and early spring could enhance conditions for nest parasites and subsequently decrease the survival of Prairie Falcon nestlings (Steenhof and others, 1999); McFadzen and Marzluff (1996) reported more nestling mortality at SRBPA because of infestations of hematophagous ectoparasites in Prairie Falcon nests during a wet spring than during a dry spring.

Prey Habitat

Ideal habitat for foraging Prairie Falcons typically includes a mosaic of shrubs and grasses that harbor ground squirrels (Marzluff and others, 1997). Habitat for ground squirrels is primarily native grasslands and shrublands (Williams, 1981; Marzluff and others, 1997), but ground squirrels also may use nonnative pastures and fields (Koehler and Anderson, 1991; Kaufman and others, 2000). In southern Alberta, Richardson's ground squirrels were present in short-grass prairies (Hunt, 1993). In the SRBPA, Piute ground squirrels were more abundant in areas with Sandberg's bluegrass, but during a drought ground squirrel survival was higher in sagebrush habitats (Van Horne and others, 1997). The loss of shrubland refugia, through the conversion of shrubland to exotic grassland, was believed to reduce ground squirrel survival and densities during drought years (Van Horne and others, 1997). In the SRBPA, radio-telemetry locations of Prairie Falcons were associated with big sagebrush (*Artemisia tridentata*), winterfat, and Sandberg's bluegrass habitats, likely because these habitats support an abundance of ground squirrels (Marzluff and others, 1997). In Idaho, Piute ground squirrel populations fluctuated and declined as native grassland species were replaced by short-lived exotic grass species (for example, *Bromus tectorum*) because of increased fire intensities and overgrazing (Yensen and others, 1992).

In southern Alberta, foraging habitats depended on the type of prey pursued (Hunt, 1993). Core areas (relatively high-use areas as determined by radio-telemetry) used by Prairie Falcons to hunt for Richardson's ground squirrels had more needle and thread, western wheatgrass, thread-leaf sedge, fringed sagewort, and scarlet globemallow and less irrigated cropland than expected based on availability. Habitats in core areas used to hunt birds were proportional to available habitats, and falcons foraged along riparian and cliff areas more frequently when hunting bird prey than when hunting mammal prey (Hunt, 1993). In northeastern Wyoming, foraging locations of radio-marked Prairie Falcons had more grassland habitat than unused areas, suggesting a preference for grassland habitats (Squires and others, 1993). Most grasslands used by falcons were flat and lacked steep draws and areas of barren soil. Grassland habitats harbored prey species (thirteen-lined ground squirrels [*Ictidomys tridecemlineatus*], Western Meadowlarks [*Sturnella neglecta*], Horned Larks [*Eremophila alpestris*] and Lark Buntings [*Calamospiza melanocorys*]), and prey may have been more vulnerable in open grassland habitats than in shrub areas. Other habitats, including mixed sagebrush-wheatgrass (scientific name was not provided) grasslands, sagebrush, barren soil, agricultural lands, and forests, were used in proportion to their availability (Squires and others, 1993). In the SRBPA, locations of radio-marked Prairie Falcons were positively associated with Sandberg's bluegrass, big sagebrush, greasewood, fourwing saltbush, and prickly Russian thistle (*Salsola tragus*) (Marzluff and others, 1997). In addition, telemetry locations overlaid on Landsat imagery indicated that falcons were found more frequently in habitats dominated by winterfat, sagebrush, and grassland; falcon locations were lowest in areas with abundant rabbitbrush, cheatgrass, and squirreltail. Areas with at least one location of a radio-marked falcon averaged 5 percent cover of big sagebrush, 8 percent cover of Sandberg's bluegrass, and 2 percent cover of winterfat. Areas with 10 or more falcon locations of a radio-marked falcon averaged 12 percent cover of Sandberg's bluegrass, 5 percent cover of big sagebrush, 2.5 percent cover of winterfat, 5.5 percent cover of cheatgrass, and 6.7 percent cover of Russian thistle. Agricultural lands were generally interspersed among habitats used by falcons, and a slight positive association between falcon locations and agricultural lands was reported (Marzluff and others, 1997). In northern California, falcons selected open habitats (cropland, pasture, bunchgrass, and sagebrush-bunchgrass) for foraging (Haak, 1982). Most foraging attempts were in areas in which the vegetation height was <30 cm and bare ground cover was greater than (>) 50 percent of the area.

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 and others, 1978; Williams, 1981; Haak, 1982; Maher, 1982; MacLaren and others, 1988; Steenhof and

Kochert, 1988; Hunt, 1993; Steenhof, 2020). Prairie Falcons also may take prey as large as ducks, cottontail rabbits (*Sylvilagus* spp.), and Barn Owls (*Tyto alba*) (Bond, 1936; Skinner, 1961). In southern Alberta, 68 percent and 27 percent of 250 prey deliveries to Prairie Falcon nests were Richardson's ground squirrels and birds, respectively (Hunt, 1993). The most common bird species found in prey remains were Western Meadowlark, Horned Lark, and European Starling (*Sturnus vulgaris*). During a 6-year period in the SRBPA, Prairie Falcons consumed at least 64 prey species; the Piute ground squirrel was the only prey species that constituted >5 percent of the prey items found at nests in all years (Steenhof and Kochert, 1988). Falcon use of alternative prey correlated negatively with the density of ground squirrels. During a drought year in which ground squirrels constituted only 30 percent of the diet, passerines made up 26 percent of the prey (Steenhof and Kochert, 1988). In southwestern Wyoming, the most common prey species was Wyoming ground squirrel (*Urocitellus elegans*), with white-tailed prairie dogs (*Cynomys leucurus*), birds, and rabbits making up the remainder (MacLaren and others, 1988). In northwestern South Dakota, primary prey included Western Meadowlarks, thirteen-lined ground squirrels, and Rock Pigeons (*Columba livia*) (Maher, 1982). In northern California, falcons foraged primarily on Belding's ground squirrels (*Urocitellus beldingi*); however, during incubation and in some habitats, some Prairie Falcons preyed on voles (*Microtus* spp.) and passerines (Haak, 1982). In many areas, Horned Larks are an important prey species (Bond, 1936; Enderson, 1964; Haak, 1982; Steenhof and Kochert, 1988; Beauvais and others, 1992; Hunt, 1993; Steenhof, 2020). Hunt (1993) reported that diet assessment studies using pellets and prey remains at nest sites underestimated the importance of Richardson's ground squirrels as prey items because Prairie Falcons commonly prepare ground squirrels and discard their carcasses 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 generally are active only during the summer months, and Prairie Falcons typically forage on small grassland birds at other times of year (Edwards, 1973).

During winter, agricultural areas provide habitat for key avian prey species (Steenhof, 2020). In Washington, Colorado, and Wyoming, wintering Prairie Falcons were associated with irrigated farmland and winter wheat (*Triticum* spp.); these agricultural areas supported Horned Larks, which are a principal prey for Prairie Falcons in the winter (Enderson, 1964; Parker, 1972). Winter home ranges in east-central Colorado included significantly more milo (*Sorghum* species [sp.]) and fallow fields than predicted based on availability (Beauvais and others, 1992). These agricultural areas contained larger densities of Horned Larks, an important prey species, than other habitats. Wintering falcons were less abundant, and the two largest home ranges of adult males were in areas with no cultivated fields (Beauvais and others, 1992).

Area Requirements and Landscape Associations

Prairie Falcons range over large areas during the breeding season, but the size of their home ranges varies among geographic areas (Steenhof, 2020). Home-range sizes of 12 Prairie Falcons in southern Alberta averaged 72.5 square kilometers (km²) and varied from 31.3 to 192.0 km² (Hunt, 1993). Overlap of home ranges and foraging ranges between adjacent pairs varied from 38 to 100 percent and 22 to 100 percent, respectively. In northeastern Wyoming, the home-range sizes of six pairs of Prairie Falcons were determined using two methods (Squires and others, 1993). Using harmonic mean 95 percent contours and excluding nest sites and points <500 m from nest sites, home-range size averaged 69 km² and ranged from 11 to 139 km². Using minimum convex polygons, home-range sizes averaged 29.4 km² and ranged from 5 to 75 km². In a 4-year period, during which 28–36 Prairie Falcons were radio-tracked annually in the SRBPA, home-range sizes (determined using minimum convex polygons of radio-tracked birds and excluding nest sites) averaged 298 km² and varied from 204 to 400 km² (Marzluff and others, 1997). Years in which Prairie Falcons had large home ranges coincided with years of low Piute ground squirrel abundance, but annual differences in average home-range size, maximum home-range size, and size of core-use areas (defined as 90 and 95 percent of locations) were significant only for pairs that successfully raised young to 30 days. Size of area used did not vary by sex. Nonbreeding and unsuccessful birds used larger areas than successful birds, but this difference was only marginally significant for females (Marzluff and others, 1997). Haak (1982) defined home range in northern California as an area that included Prairie Falcon nest sites, foraging areas, and territories. Home-range sizes averaged 228 km² and varied from 34 to 389 km² (Haak, 1982). Mean home-range size was 143 and 69 km² in the incubation and nestling periods, respectively. Harmata and others (1978) described Prairie Falcon home range in the Mojave Desert of California as the connection of all the outermost points of telemetered locations, which they defined as the utilized range. Mean home-range sizes (determined from the outermost radio-telemetry points) for two males and two females were 71.9 km² and 46.6 km², respectively (Harmata and others, 1978). The home range for one breeding pair increased from 37.7 km² during the nestling period to 57.7 km² after young had fledged.

Prairie Falcons travel away from their nest sites to forage. In southern Alberta, falcons ranged as much as 20 km from their nest sites (Hunt, 1993). Based on direct observations of prey delivery, the distance traveled and the area covered for male Prairie Falcons when hunting for bird

prey were less than the distance travelled and area covered when hunting for Richardson's ground squirrels; forage trip distances for bird prey and ground squirrels were based on the prey species being delivered to the nest site (Hunt, 1993). In Wyoming, Prairie Falcons almost always foraged <15 km from their nest sites and typically <10 km from their nest sites (Squires and others, 1993). During a 4-year 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 and others, 1997). The maximum distance a falcon traveled from its nest site was 38.3 km. Both sexes had their shortest travel distances during the year of highest Piute ground squirrel abundance.

Prairie Falcons may nest near one another wherever nesting substrates and habitat allow. Nest sites have been found within 1 km of one another in western Montana (Leedy, 1972), north-central Montana (Van Horn, 1993), eastern Oregon (Denton, 1975), and California (Garrett and Mitchell, 1973; Haak, 1982). In southeastern Montana and northern Wyoming, adjacent nest sites were no closer than 7.8 km (Phillips and others, 1990). Cliffs were small and only one pair of falcons used a given cliff. In northwestern South Dakota, nest sites were as close as 1.5 km (Maher, 1982). The distance between adjacent pairs in the SRBPA in Idaho averaged 646 m, but nest sites were as close as 50 m (Steenhof and others, 1999). In another Idaho study, the distance between adjacent pairs averaged 1.1 and 0.9 km in 1970 and 1972, respectively (Ogden and Hornocker, 1977).

Home-range sizes during winter tend to be smaller than home-range sizes during the breeding season. In east-central Colorado, one adult male had a winter range of 583 km² and 14 falcons had winter range sizes that varied from 12.3 to 68 km² and averaged 30.2 km² (Beauvais and others, 1992). Winter diurnal-use areas may even be smaller because winter roosts are sometimes far from areas used during daylight; a radio-tagged male wintering in central Colorado moved as much as 10 km between night roosts and diurnal use areas (Gatz and Hegdal, 1986). Although his total home range was 27.6 km², 91 percent of his locations were in a 9.3-km² area.

Brood Parasitism by Cowbirds and Other Species

The Prairie Falcon is an unsuitable host of the Brown-headed Cowbird (*Molothrus ater*), and no known records of cowbird brood parasitism exist for this species (Shaffer and others, 2019). Interspecific parasitism by other bird species has not been reported in Prairie Falcon nests; however, hybridization between a Prairie Falcon and a Peregrine Falcon has been documented in the wild (Oliphant, 1991).

Breeding-Season Phenology and Site Fidelity

Prairie Falcons occupy some breeding areas year-round (Denton, 1975; Salt and Salt, 1976; Hansen, 1994), but individuals from areas in the northern parts of the species' breeding range or from higher elevations migrate south and east for the winter (Skinner, 1961). In the far northern Great Plains (Alberta and Saskatchewan), Prairie Falcons occupy breeding areas beginning in late March, and the species may be present in this region through late October (Skinner, 1961; Maher, 1974; Salt and Salt, 1976). Prairie Falcons occupy breeding areas in the lower 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; South Dakota Ornithologists' Union, 1991). In Oregon and some of the Rocky Mountain States (Colorado, Montana, Wyoming), Prairie Falcons are on breeding areas beginning in mid-March (Enderson, 1964; Leedy, 1972; Olenhoff and Stoddart, 1974; Denton, 1975). Prairie Falcons occupy nesting areas in southwestern Idaho from February until June or July, at which time Prairie Falcons leave the nesting areas as Piute ground squirrels enter seasonal torpor and become inaccessible as prey (Steenhof and others, 1984, 2005). Individuals banded as nestlings in southwestern Idaho dispersed north and east of their natal areas soon after fledging but showed a tendency to return to breed in the general area where the individuals hatched (Steenhof and others, 1984). Most adult females banded on their nesting grounds in the SRBPA in southwestern Idaho dispersed to areas in Alberta, Saskatchewan, Montana, North Dakota, and South Dakota in late June through mid-July (Steenhof and others, 2005). Some individual Prairie Falcons return to southwestern Idaho in the fall and winter, whereas others winter in various parts of the Great Plains (Steenhof and others, 1984, 2005). At high elevations (3,450–4,270 m) in Colorado, Prairie Falcons occupied 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).

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). An analysis of the nesting phenology of Prairie Falcons from 20 sites across the species' range showed that clutch completion was later at higher latitudes and elevations (Williams, 1985). In southwestern Idaho, hatching dates ranged from April 6 to June 29 (Steenhof, 2020). Young typically fledge at 38–40 days (Steenhof, 2020). Fledging occurred from early June to mid-July in Oregon (Denton, 1975), from mid-June through mid-July in Montana (Van Horn, 1993), and from late June through late July in Colorado and Wyoming (Enderson, 1964; Squires, 1985). In Colorado

and Wyoming, nest phenology was as many as 28 days out of phase among nesting pairs (Enderson, 1964).

Of 517 nesting attempts observed during a 10-year period in Idaho, 1.5 percent were categorized as late (defined as nests in which young hatched after June 12) (Allen and others, 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 and others, 1986). Of 14 late nesting attempts from Idaho, New Mexico, Colorado, Wyoming, and North Dakota during the 1970s and 1980s, 62 percent were successful, and young were projected to fledge between July 20 and August 13 (Allen and others, 1986).

Prairie Falcons may renest following failure of initial nests. Of 17 nesting attempts in North Dakota, three were likely renesting attempts that happened after a late-April blizzard (Allen and others, 1986). Two pairs in Colorado renested after clutches were destroyed early in the incubation period (Enderson, 1964). Of eight nesting attempts after June 12 in Idaho, two were renesting attempts after the failure of initial nests (Allen and others, 1986). No records of double-brooding exist (Steenhof, 2020).

Prairie Falcons commonly use the same nest sites and territories in subsequent years (Anderson and Squires, 1997). At sites in Alberta, Saskatchewan, Colorado, and Wyoming, 88 percent of 115 banded individuals used the same territory in subsequent years (Runde, 1987). Site fidelity was greater in Alberta (94.3 percent) than in Wyoming (80 percent), but no significant difference between males and females was reported. In the entire study area, of 161 instances where pairs were captured on a particular territory in successive seasons, 22 percent had at least one new breeding adult. Turnover rates were 2–3 times higher in the Snake River Canyon of southwestern Idaho; 57 percent of 61 nesting areas had a different breeding adult than in the previous year. Higher turnover rates may be related to larger densities in Idaho (Lehman and others, 2000). In North Dakota, nest sites were reused frequently (Allen, 1987b; Mayer and Licht, 1995). In Colorado and Wyoming, falcons tended to use different nest sites on the same cliffs in subsequent years (Enderson, 1964). Radio-marked female Prairie Falcons from nesting areas in southwestern Idaho showed fidelity to both postbreeding summer-use areas and winter-use areas in the Great Plains. In the Snake River Canyon, 96 percent of 24 radio-marked falcons returned to nest within 2.5 km of where the falcons nested in the previous year (Steenhof and others, 2005).

Doyle and others (2018) used a genomics approach (that is, genome sequencing and assembly followed by single nucleotide polymorphism genotyping) to evaluate the extent to which gene flow exists in the Prairie Falcon in three populations in California and one population in Idaho. The results demonstrated that individuals sampled in California and Idaho represented a single panmictic population, indicating a tendency for the Prairie Falcon to disperse throughout its range.

Species' Response to Management

Because some areas (for example, the Great Plains) are used by individual Prairie Falcons during both the winter and breeding seasons, any changes to the landscape in those areas would likely affect breeding as well as nonbreeding individuals. In the SRBPA, Prairie Falcons selected primarily areas with native grassland and shrubs for foraging (Marzluff and others, 1997). Wildfires in the SRBPA resulted in a conversion of shrubland and perennial grass communities into exotic annual communities (Marzluff and others, 1997; Van Horne and others, 1997; Steenhof and others, 1999).

Little information on the direct effects of grazing on Prairie Falcons is available, but Prairie Falcons use areas grazed by livestock throughout their range (Steenhof, 2020). In the Mojave Desert in California, successful nest sites had less nearby grazing (grazing intensity not quantified) than unsuccessful nest sites (Boyce, 1988). In New Mexico, Platt (1974) considered overgrazing and concomitant erosion to be a principal threat to the stability of Prairie Falcon populations; livestock grazing reduces plant cover and may limit food for ground squirrels. Grazing also promotes dominance by exotic annual plant species and decreases native shrubs and perennial grasses that are preferred by ground squirrels and Prairie Falcons (U.S. Department of the Interior, 1996).

Large-scale agricultural development may adversely affect Prairie Falcons, especially in areas where Prairie Falcons forage on ground squirrels (Steenhof, 2020). In Alberta, breeding falcons selected native grasslands where Richardson's ground squirrels were most abundant; core-use areas had higher proportions of native rangeland and lower proportions of irrigated cropland than expected based on availability (Hunt, 1993). In Alberta, irrigation canals provided foraging habitat for Prairie Falcons (Hunt, 1993), and in southwestern Idaho, agricultural borders may provide important prey habitat during drought (Marzluff and others, 1997). In Montana, small areas of agriculture interspersed within native rangeland provided habitat for Prairie Falcon prey, but falcons and their prey were rare in extensive tracts of monoculture agriculture (Harmata, 1991). In southwestern Idaho, modern agricultural development (that is, farmed areas with sprinkler irrigation, large fields, and no fencerows) supported only 65 percent of the total prey biomass and energy (that is, kilocalories per hectare) available on native rangeland and only 6 percent of ground squirrel biomass (U.S. Department of the Interior, 1979). Poisoning, extensive use of farm machinery, and loss of cover precluded ground squirrels from maintaining populations in agricultural areas. Computer simulations predicted that as little as 15 percent agricultural conversion in the Snake River Plain would reduce Prairie Falcon productivity to a point at which the population could not replace itself (U.S. Department of the Interior, 1979). Land-use changes associated with agricultural development may have contributed to population declines of Prairie Falcons in parts of southern Alberta, Idaho, and California (Garrett and Mitchell, 1973; U.S. Department of the Interior, 1979; Steenhof, 2020).

Small-scale agriculture development, however, may benefit Prairie Falcons in areas where the development provides an ecotone for prey populations (Harmata, 1991; Steenhof, 2020).

Pesticides may cause mortality and reproductive impairment to Prairie Falcons. From 1985 to 1995, one of 734 poisoned raptors was a Prairie Falcon (Mineau and others, 1999). This fatality resulted from improper use of a pesticide. Chlorinated hydrocarbon pesticides may cause reproductive impairment in Prairie Falcons. In southern Alberta and neighboring Canadian Provinces, dichlorodiphenyldichloroethylene (DDE) concentrations in eggs were large enough to decrease productivity, and mean eggshell thickness from failed clutches was lower than that of eggs from clutches in which four young fledged (Fyfe and others, 1976). In western Montana, Prairie Falcons had relatively low organochlorine contamination from 1970 to 1971 (Leedy, 1972). Nonetheless, the average eggshell thickness ($n=19$ eggs) showed a 9 percent decrease from pre-1947 levels, and eggshell thickness correlated negatively with total chlorinated hydrocarbon residues in eggs. Average shell thickness was greater for eggs that hatched than for eggs that did not hatch. Richardson's ground squirrels in the area also were contaminated with DDE, although DDE levels seemed to be low. Of three study areas, falcon eggs from the study area that was treated with the highest amount of pesticides had the highest DDE and total chlorinated hydrocarbon residues and the thinnest eggshells; adult falcons also had the lowest nesting success and the fewest fledglings per occupied territory (Leedy, 1972). In a 3-year (1967, 1968, and 1972) study in Colorado, DDE residues in Prairie Falcon eggs correlated with eggshell thickness (Enderson and Wrege, 1973). Experimental feeding of DDE to Prairie Falcons in Colorado caused contamination of females, eggshell thinning, egg breakage, and reduced reproductive success relative to untreated birds (Enderson and Berger, 1970). In California, where DDE concentration levels were higher than the critical concentration levels set by Fyfe and others (1976), no young were produced (Jarman and others, 1996).

Human access to nesting sites may affect Prairie Falcon behavior and productivity (Boyce, 1988). Prairie Falcons may flush from nests when approached by humans (Van Horn, 1993), and human interference with nest sites may result in nest failures (Edwards, 1973). In a Colorado study, perched Prairie Falcons in winter were more likely than other raptor species to flush when approached by a pedestrian on foot or by a vehicle (Holmes and others, 1993). In Colorado and Wyoming, nest sites were <2.5 km from a road (Williams, 1981; MacLaren and others, 1988). In Oregon, 62 percent of 61 nest sites were <0.8 km from roads, and 15 percent of the 61 nest sites were <0.8 km from buildings (Denton, 1975). In the Mojave Desert in California, nests with easy human access had lower fledgling productivity (that is, the number of falcon young at least 36 days old that fledged or were expected to fledge from nests). Nests with easy access were close to roads, within easy human walking distance, at

low elevations, and on small cliffs or at nest sites near the ground (Boyce, 1988). Successful nest sites were harder to access and had fewer disturbances than unsuccessful nest sites. Military training exercises (for example, firing weapons and maneuvering tanks) may affect the foraging efficiency of nesting Prairie Falcons; Prairie Falcon pairs nesting near a military training area in southwestern Idaho flew over larger areas, spent less time in the immediate vicinity of their nests, and delivered fewer ground squirrels to their nests than did pairs in nearby areas (U.S. Department of the Interior, 1996). Changes in Prairie Falcon foraging behaviors were most apparent during intense military training exercises.

Capturing wild Prairie Falcons for falconry likely has not had a significant effect on wild populations of Prairie Falcons and other raptors in the United States because of the low participation rate in falconry and because most raptors used in falconry are produced through captive breeding rather than through harvesting birds from the wild (Millsap and Allen, 2006). Falconers in North America harvest a small number of juvenile, subadult, and adult Prairie Falcons each year (Millsap and Allen, 2006). Falconers in North America are required to obtain the necessary licenses and permits, and falconry is carefully regulated to ensure that Prairie Falcon and other raptor populations are not affected locally, regionally, or rangewide. Although the Prairie Falcon is the second most-harvested bird of prey for falconry in the United States, accounting for about 12–21 percent of the estimate of 1,000 raptors taken from the wild each year, only 0.2 percent of the Prairie Falcon population is taken annually for falconry (Brohn, 1986; Conway and others, 1995). In Wyoming, experimental removal of nestlings to mimic harvest for falconry (reducing the number of nestlings to no more than two) did not reduce nesting success in 6 of 8 years (Conway and others, 1995). Nesting success in harvested territories was lower than nesting success in nonharvested territories in the other 2 years (1983 and 1985). Adult territory fidelity was lower, and the recruitment rate for new inexperienced birds was higher, in an area where nestlings were removed than in an area where nestlings were not removed (Conway and others, 1995).

Properly designed field studies have had no measurable effect on Prairie Falcon populations, but improper research methods may lead to nest desertion or damage to eggs or young (Steenhof, 2020). At the SRBPA in Idaho, Steenhof and others (2006) monitored the survival of 40 adult female Prairie Falcons fitted with one of three designs of a backpack harness that supported satellite-received platform transmitter terminals. Steenhof and others (2006) concluded that the platform transmitter terminals had no short-term effects on the falcons or their nesting success during the breeding season that the falcons were marked, but falcons that shed their transmitters increased their probability of survival; estimated annual survival was 49 percent for falcons that retained transmitters, compared to 87 percent for falcons that shed their transmitters. In southwestern Idaho, Kochert and others (1983) reported extensive feather wear and skin abrasions

from all-vinyl, wrap-around patagial wing markers, but the marked Prairie Falcons examined by the researchers seemed to be in good nutritional condition.

Electrocution from overhead power structures seems to be a minor mortality factor for the Prairie Falcon (Harness and Wilson, 2001). Dwyer and others (2015) indicated that flesh-to-flesh (that is, metacarpal-to-metacarpal) distances are a primary determinant of electrocution risk to raptors and other birds; metacarpal-to-metacarpal measurements quantify the total horizontal distance that can be bridged by the flesh of a bird. The average metacarpal-to-metacarpal measurement for two male Prairie Falcons was 62.7 cm. Of 1,428 electrocuted raptors found during an 11-year period in the western United States, one was a Prairie Falcon (Dwyer and others, 2015). Similarly, during a 3-year period in the interior western United States, <1 percent of 416 carcasses found below powerlines were Prairie Falcons (Benson, 1981).

Prairie Falcons may alter their behaviors in response to mining, oil and gas development, and related disturbances. In southwestern Idaho, the noise from explosives caused temporary changes in breeding behavior by Prairie Falcons such as sitting up or flushing from nest sites, but blasting had no severe adverse effects on behavior, productivity, and occupancy of nesting territories (Holthuijzen and others, 1990). The average readjustment time required for falcons to return to their preblast activity (that is, perching, preening, incubating, or brooding) was 1.4 minutes ($n=250$ observations). Incubating or brooding Prairie Falcons that flushed during a blast returned to their nest sites within 3.4 minutes ($n=25$ observations) after a blast. Falcons had different behavioral responses to experimental blasting and construction blasting. Prairie Falcons had a longer average readjustment time to experimental blasting (1.8 minutes; $n=183$ observations) than falcons exposed to construction blasting (0.5 minute; $n=67$ observations) for all nesting stages combined (Holthuijzen and others, 1990). The overall response and flushing rates in the experimental study location (68 and 58 percent, respectively) were higher than the response and flushing rates in the construction study location (16 and 7 percent, respectively). Incubating ($n=90$ observations) or brooding ($n=22$ observations) Prairie Falcons showed little response (7 and 0 percent, respectively) to blasting associated with dam construction (nest sites were at distances of 560–1,000 m from the dam); however, 57 percent of incubating falcons and 27 percent of brooding falcons reacted in response to experimental blasting, which was characterized by louder and more frequent blasts at an average distance of 127 m from nest sites. Prairie Falcons exposed to either experimental or construction blasts did not habituate behaviorally to the blasting but seemed to habituate to other construction activities (Holthuijzen and others, 1990).

In Montana, occupied and unoccupied nest sites did not differ significantly in distance to nearest active oil well, powerline, road, nest site of other raptor species, or nest site of other Prairie Falcons (Van Horn, 1993). In northeastern Wyoming, oil and gas extraction equipment was present in

primary foraging habitats but did not seem to have a significant effect on Prairie Falcon breeding; falcons foraged in areas with an oil-well density of about 1.4 oil wells per km² (Squires and others, 1993). In the Powder River Basin area of Wyoming, trends in nest use rates were similar between nests at sites undeveloped for coalbed methane (>805 m from the nearest active coalbed methane well) and sites developed (less than or equal to 805 m) for coalbed methane use (Carlisle and others, 2018).

Prairie Falcons and other raptors may pose a collision risk to aircraft. Trapping and translocating raptors at civil airports and military airfields is considered a useful tool for mitigating raptor hazards to aircraft (Schafer and Washburn, 2016). The U.S. Department of Agriculture captured, marked with auxiliary markers, and translocated 22 Prairie Falcons from airports and military bases in 16 States during an 8-year period. One Prairie Falcon returned to an airport and was translocated a second time (Schafer and Washburn, 2016).

Estimates of Prairie Falcon fatalities and risk of collisions from wind turbines are low (Smallwood and Thelander, 2008; Loss and others, 2013; Beston and others, 2016). In California, Prairie Falcons had a minor risk of collision with wind turbines at the Altamont Pass Wind Resource Area, which included a mix of older generation wind turbines and repowered wind turbines (Smallwood and Thelander, 2008; Smallwood and others, 2008; Smallwood and Karas, 2009). Smallwood and Thelander (2008) reported that three Prairie Falcons were killed by wind turbines at Altamont Pass Wind Resource Area during a 5-year period. After adjusting mortality estimates for searcher detection and scavenger removal rates, Smallwood and Thelander (2008) estimated that wind turbines at Altamont Pass killed 1.1 Prairie Falcons per year. Beston and others (2016) developed a prioritization system for 428 avian species to identify species most likely to experience population declines in the United States from wind facilities based on the species' current conservation status and the species' expected risk from wind turbines. The Prairie Falcon's average priority score was low (2.39 out of nine); Beston and others (2016) estimated that 2.54 percent of the Prairie Falcon breeding population in the United States are exposed to wind facilities. Loss and others (2013) reviewed published and unpublished reports on collision mortality at monopole wind turbines (that is, with a solid tower rather than a lattice tower) in the contiguous United States; one Prairie Falcon mortality was reported at one wind facility. Wulff and others (2016) examined diurnal flight heights of Prairie Falcons and determined that the species' average flight height was 4.9 m, which was not within the rotor-swept zone (32–124 m) of wind turbine blades. Smallwood and others (2009), however, reported that Prairie Falcons regularly foraged within the rotor-swept zone of operating turbines and perched on nonoperational turbines.

Prairie Falcons have been introduced in some areas to augment or restore wild populations (Steenhof, 2020). Captive-bred Prairie Falcon nestlings were successfully released from hack boxes on cliff faces in areas where

historical nesting territories had been abandoned (Depper, 1988). Captive-bred Prairie Falcon nestlings also were successfully fostered into occupied Prairie Falcon nests in areas where nesting populations had decreased (Granger, 1977). Interspecific cross-fostering (that is, transferring young from one species into the nest of another species) has been done successfully with wild Prairie Falcon nestlings placed into nests of Ferruginous Hawks (*Buteo regalis*), Red-tailed Hawks, and Swainson's Hawks (*Buteo swainsoni*) (Olendorff and Stoddart, 1974; Fyfe and others, 1978). Captive-bred Peregrine Falcon nestlings also have been successfully cross-fostered in Prairie Falcon nests (Drager and Linthicum, 1985).

Management Recommendations from the Literature

Steenhof (2020) suggested that management for Prairie Falcons may benefit from four primary strategies: (1) maintaining and enhancing the availability of nest sites, (2) managing foraging areas to provide habitat for prey species, (3) providing protection from human disturbances, and (4) restoring populations in areas where Prairie Falcon numbers have been reduced or the species has been extirpated. Based on a genomic analysis that showed genetic panmixia in the Prairie Falcon, Doyle and others (2018) concluded that management actions undertaken to benefit the Prairie Falcon at local or regional scales have the potential to affect the species as a whole. Where Prairie Falcons commonly use old nest sites of other large birds, reinforcement of old nests that have degraded may make them more suitable for nesting Prairie Falcons (Harmata and others, 1978).

Artificial nest sites can be created to provide additional nesting opportunities (Olendorff and Stoddart, 1974; Runde and Anderson, 1986; Runde, 1987; Phillips and others, 1990; Mayer and Licht, 1995). Runde and Anderson (1986) suggested that artificial nest sites should be built on cliffs that are a minimum of 14 m tall and about two-thirds up the cliff; the floor area should be about 0.7 square meter, gently slope to the front, and include overhead protection. Fyfe and Armbruster (1977) provided considerations when selecting cliffs for constructing cavities for nesting Prairie Falcons: (1) site location in relation to suitable habitat for prey; (2) freedom from excessive human activity; (3) a minimum cliff face height of 7 m; (4) a permanent solid substrate of clay, conglomerate, or sandstone; and (5) freedom from excessive erosion. Call (1979) recommended that cavities for nesting Prairie Falcons should be created on cliffs of solid, noneroding rock. Mayer and Licht (1995) recommended that artificial nest sites should be reinforced against erosion. Runde (1987) recommended that two or three alternative nest sites should be created on the same cliff. Olendorff and Stoddart (1974) suggested that alteration of existing cliffs to provide more nesting cavities may provide the greatest potential use by Prairie Falcons and other large falcons.

Land uses and habitat disturbances act both synergistically and cumulatively on Prairie Falcon populations and their prey (Steenhof and others, 1999). Large-scale agricultural development on the breeding grounds may adversely affect Prairie Falcons, especially in areas where the species forages on ground squirrels, but small-scale agricultural development may benefit Prairie Falcons by providing important prey habitat (Steenhof, 2020). Conversion of large tracts of native shrublands and grasslands to agriculture may negatively affect Prairie Falcons because prey populations are lower in agricultural lands than in native shrubland (Marzluff and others, 1997). Hunt (1993) emphasized the importance of protecting ground squirrel colonies and native rangeland near Prairie Falcon nest sites. Van Horn (1993) recommended that grasslands on privately owned tracts should be kept intact using incentive programs, such as conservation easements.

Conserving existing areas of natural vegetation, rehabilitating deteriorated areas, and restoring areas dominated by exotic vegetation are important considerations for management of Prairie Falcons and their foraging areas (U.S. Department of the Interior, 1996). In the SRBPA in southwestern Idaho, Prairie Falcons are associated with native shrubs and perennial grass vegetation (U.S. Department of the Interior, 1996). Although the cumulative long-term effects of wildfires, military training, livestock grazing, and drought on native vegetation may have adversely affected prey populations and Prairie Falcons in this region (U.S. Department of the Interior, 1996), there has been a significant increase in Prairie Falcon numbers detected on Christmas Bird Counts in North America between 1966 and 2012 (Butler and others, 2015). Prairie Falcons will benefit from suppression of wildfires, restoration of native shrubs and perennial grasses, and limitation of land disturbances within Prairie Falcon foraging areas (U.S. Department of the Interior, 1996; Marzluff and others, 1997; Steenhof and others, 1999). Marzluff and others (1997) suggested that controlling wildfires is perhaps the most beneficial management practice in shrubsteppe habitats, because wildfires convert native shrub and perennial grass communities to exotic annual grass communities, which in turn support less stable ground squirrel populations.

Minimizing disturbances near nest sites will benefit Prairie Falcons, but the effects of human disturbances near nesting Prairie Falcons will depend on the type of disturbance, its proximity to nesting birds, its duration, and its timing (Harmata and others, 1978). Prairie Falcons are more sensitive to disturbances during courtship and incubation than during brood rearing and after fledging (Harmata and others, 1978; Steenhof, 2020). The following distance recommendations for reducing disturbances near Prairie Falcon nest sites are suggestions that need further evaluation as to their effectiveness. Boyce (1988) recommended maintaining buffer zones around occupied nest sites and keeping roads and other access points at least a 15-minute (preferably a 30-minute) walk from nest sites. Call (1979) suggested that

mining operations should not be within 0.8–1.6 km of falcon nest sites. Holthuijzen and others (1990) recommended that blasting associated with limited human activities does not need to be restricted to >125 m from occupied Prairie Falcon nest sites, provided that the peak noise level does not exceed 140 decibels at the nest sites and that no more than three blasts occur on a given day or 90 blasts during the nesting season. Becker and Ball (1981) suggested excluding mine exploration and development within a 400-m buffer zone around individual Prairie Falcon nests. Suter and Jones (1981) recommended restriction of geothermal development within 1-km buffer zones around a Prairie Falcon nest site, based on questionnaires mailed to raptor researchers. In areas with petroleum extraction activity in Montana, Van Horn (1993) indicated that a buffer zone of 0.5 km around nest sites was sufficient to prevent nest-defense behavior during the postincubation stage in Prairie Falcons, but birds may still experience increased stress levels in the presence of humans within this range (Busch and others, 1978). Carlisle and others (2018) concluded that an 805-m radius buffer may be sufficient to limit avoidance of nearby coalbed methane development by nesting raptors; the authors indicated that future studies should clarify nesting habitat preferences and fitness outcomes in relation to energy development, while simultaneously accounting for local prey availability, densities of competitors, and weather.

Risk of electrocution to perching raptors can be reduced by retrofitting powerlines to increase separation between energized equipment (Avian Power Line Interaction Committee, 2006; Dwyer and others, 2015). The Avian Power Line Interaction Committee (2006) recommended 152 cm of horizontal separation and 102 cm of vertical separation between energized conductors and equipment as critical dimensions necessary to minimize risk of electrocution by Bald Eagles (*Haliaeetus leucocephalus*), Golden Eagles, and smaller raptors. These dimensions were recommended to accommodate safe perching by the largest raptors in North America.

To prevent collisions with wind turbines by Prairie Falcons and other raptors, Wulff and others (2016) recommended that wind turbines should not be placed in areas with high prey densities (for example, prairie dog towns) where raptors concentrate their foraging activities. Loss and others (2013) stressed the importance of considering species-specific and location-specific risks at wind facilities and the potential for cumulative impacts of multiple wind facilities and multiple mortality threats. Regional patterns of collision risk to birds may help inform broad-scale decisions about wind-facility siting. To reduce collisions and fatality rates, Smallwood and others (2009) recommended shutting down turbines during high-risk periods and during very strong winds, removing nonfunctional or nonoperational wind towers, repairing broken turbines, synchronizing turbine operations within a row of turbines, and leaving large areas free of wind turbines within a wind facility to enable safer movements by birds.

To reduce local harvest pressure associated with falconry, Conway and others (1995) recommended that falconers leave at least two young in each affected nest site and that harvesting should focus on the same territories each year, even though harvesting may cause some breeding birds to switch territories. Millsap and Allen (2006) recommended that falconry harvest rates for juvenile raptors in the United States should not exceed one-half of the estimated maximum sustainable yield up to a maximum of 5 percent, but they recommended lower harvest rates (1 percent) for some raptor species, such as the Prairie Falcon, until better estimates of vital rates confirm greater harvest potential.

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