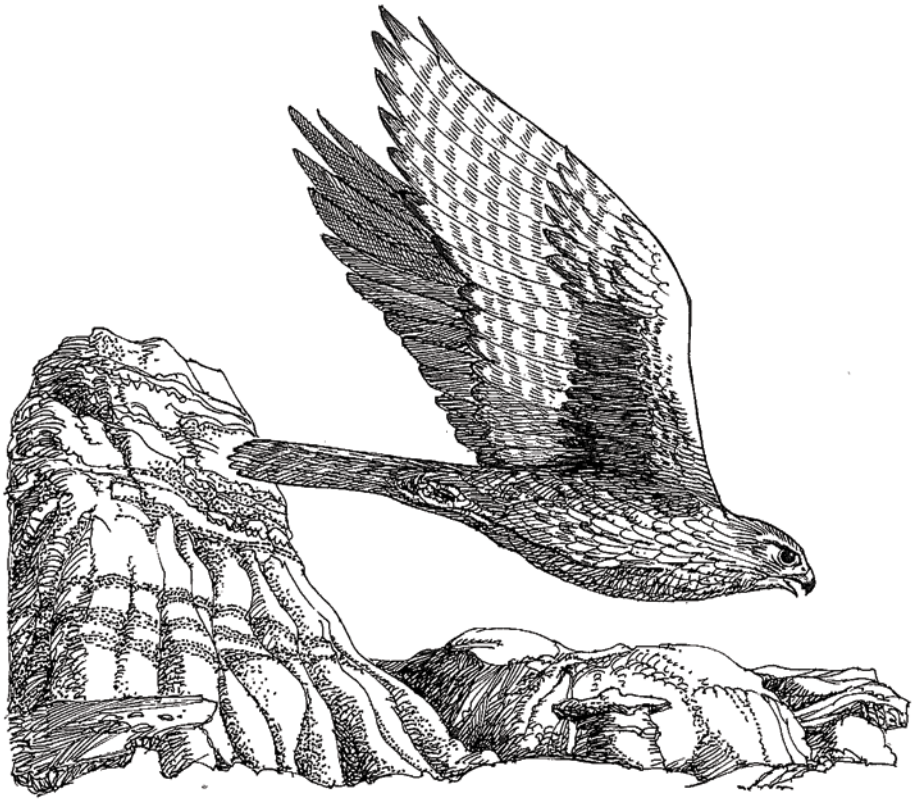
Status of the Prairie Falcon (*Falco mexicanus*) in Alberta



Alberta Wildlife Status Report No 42 (Update 2018)

alberta's species at risk program

Alberta Conservation Association

Alberta

Status of the Prairie Falcon (*Falco mexicanus*) in Alberta: Update 2018

Prepared for:

Alberta Environment and Parks (AEP)
Alberta Conservation Association (ACA)

Update prepared by:

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Preface

Every five years, Alberta Environment and Parks reviews the general status of wildlife species in Alberta. General status assessments have been conducted in 1991 (*The Status of Alberta Wildlife*), 1996 (*The Status of Alberta Wildlife*), 2000, 2005, 2010, and 2015 (available in a searchable database at http://aep.alberta.ca/fish-wildlife/species-at-risk/ since 2000). The general status process assigns individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. The 2015 general status assessments for vertebrates used the same methodology as assessments from 2000 to 2010, and adopted methodology from NatureServe (http://www.natureserve.org/) for invertebrates and plants. A key objective of general status assessment is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general status exercise, and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are considered at some level to be at risk or potentially at risk (e.g., general status of *At Risk or May Be At Risk*, NatureServe rank of S1, Committee on the Status of Endangered Wildlife in Canada [COSEWIC] rank of *Endangered/Threatened* at a national level), and species that are of uncertain status (e.g., general status of *Undetermined*).

Reports in this series are published and distributed by Alberta Conservation Association and Alberta Environment and Parks. They are intended to provide up-to-date information that will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide detailed information that will assist Alberta's Endangered Species Conservation Committee in identifying species that may be formally designated as *Endangered or Threatened* under *Alberta's Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

Executive Summary

The prairie falcon (*Falco mexicanus*) is a large, cliff-nesting falcon that inhabits western North America. It is associated with open, dry habitat and is found in grasslands, shrub-steppe deserts, alpine tundra or similar biomes. Its breeding range extends from southern British Columbia and Alberta to central Mexico. Less migratory than other North American raptors, the prairie falcon's winter range overlaps widely with its breeding range but extends a bit farther south and to the east. In the summer months, prairie falcons feed mostly on small to medium-sized mammals, such as ground squirrels. The winter diet of prairie falcons is different and comprises mostly grassland birds.

In Alberta, the prairie falcon is found mainly within the Grassland Natural Region, the southern parts of the Central Parkland and Foothills Parkland subregions of the Parkland Natural Region, and in late summer, within the Rocky Mountain Natural Region. The northernmost known breeding site is located along the Peace River, but the core of the species' breeding habitat is located south of Red Deer, along the Bow, Red Deer, Milk, South Saskatchewan, and Oldman rivers and their tributaries.

Currently, the prairie falcon is listed as a *Bird of Prey* under Alberta's *Wildlife Act*; its general status within the province has been considered Sensitive since 2000. Moreover, the species was identified as a *Species of Special Concern* in Alberta when it was last evaluated by the Endangered Species Conservation Committee and its Scientific Subcommittee in 2003, mostly because of its small population size. Despite the concern indicated by these status designations, an ongoing long-term survey of nest sites in southern Alberta suggests that prairie falcon nest site occupancy and productivity have remained stable.

The most significant threat to the prairie falcon in Alberta is the conversion of native grassland habitat to cropland, infrastructure and energy development, which removes the prime habitat for the prairie falcon's main prey species. Other important threats include exposure to several contaminants such as pesticides (rodenticides, e.g., strychnine) and lead, and the loss of nest sites (e.g., from slumping).

Acknowledgements

For the original 2002 report prepared by Dale Paton*:
Prairie falcon management in southern Alberta has involved numerous individuals over many years, some of whom I know of only by the names on reports and others I have had the privilege to share ideas and experiences with. Thanks to Richard Fyfe (retired; Canadian Wildlife Service), Harry Armbruster (Canadian Wildlife Service), Ursula Banasch (Canadian Wildlife Service), Geoff Holroyd (Canadian Wildlife Service), and Wayne Nelson (Alberta Sustainable Resource Development), who collected data about and protected the interests of prairie falcons when raptors were not considered very important. The Olendorff Memorial Library of the USGS Bureau of Land Management in Boise, Idaho provided many hard to obtain documents and I appreciate their excellent and prompt service. Thank you to John Campbell Jr. (raptor bander), Gordon Court (Alberta Sustainable Resource Development), Rob Corrigan (Alberta Conservation Association), Wayne Harris (Saskatchewan Environment and Resource Management), Mike Gollop (Saskatchewan Environment and Resource Management), Earl Wiltse (Saskatchewan Environment and Resource Management), and Ivan Shukster (raptor enthusiast) for their contributions to this manuscript. Drafts of this tome were improved with input from Sherry Feser, Dawn Birn (Alberta Conservation Association), Robin Gutsell, Gordon Court, Wayne Nelson, Gary Erickson (Alberta Sustainable Resource Development), Ursula Banasch, Harry Armbruster (Canadian Wildlife Service), and Ralph Cartar (University of Lethbridge).

*Note that some affiliations may have changed since 2002.

For the 2018 report updated by Alexandre Anctil, Hilde M. Johansen and Erik Hedlin:
We would like to thank Nicole Michel (National Audubon Society) and David Bradley (Bird Studies Canada) who helped obtain data used in this report. Thank you to Jeff Keith (Saskatchewan Fish, Wildlife and Lands branch, Ministry of Environment), and Allison Begley (Montana Fish, Wildlife and Parks) for providing comments on the status of the prairie falcon in Saskatchewan and Montana. We are grateful to John Campbell (licensed bird bander) who contributed important data. Karl Grantmyre (Alberta Society for Injured Birds of Prey) provided prairie falcon nest locations on the North Saskatchewan and Athabasca rivers. We also want to thank Gordon Court and Robin Gutsell (Alberta Fish and Wildlife Policy Division, Environment and Parks) for providing data and insightful comments, as well as Sue Peters (Alberta Conservation Association) for her help through the redaction of this document and Amanda Rezansoff (Alberta Conservation Association) for help with preparing the range map of Alberta. Thank-you to Geoff Holroyd (retired Canadian Wildlife Service biologist) and John Acorn (Scientific Subcommittee of Alberta's Endangered Species Conservation Committee; Instructor, Department of Renewable Resources, University of Alberta) for reviewing a draft of this report. We would like to thank the Alberta Bird of Prey Foundation and Caroline Martin (graduate student, University of Alberta) for providing information on the causes of injury in prairie falcons, Brandy L. Downey (Operations Division, Environment and Parks) and Lisa Takats Priestley (Strix Ecological Consulting) for providing information on effects of wind energy development on prairie falcons in Alberta, and Adam Smith (Environment and Climate Change Canada) for unpublished trend analyses of Breeding Bird Survey data. We greatly appreciate assistance from John Economidy (Princeton University Press) and Brian K. Wheeler (bird photographer, author and illustrator) in producing the North America range map. Lastly, we would like to thank Alastair Franke (University of Alberta) for his data analysis, support and comments.

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Introduction

The prairie falcon (*Falco mexicanus*) is a large, pale brown raptor that occupies the arid hills and grasslands of western North America (Taverner 1934, Wheeler and Clark 1995). It is one of six North American species in the genus *Falco*, and differs from other falcons as the species most adapted to survive in areas where drought is a part of the climate (Steenhof 2013). The breeding range of the prairie falcon stretches from southern Alberta, British Columbia and Saskatchewan, into the western United States, south to Baja California, Texas, and as far south as central Mexico (Steenhof 2013, Cornell Lab of Ornithology 2017).

Global population estimates for the prairie falcon are quite variable, ranging from a minimum of 8500 breeding individuals (4273 breeding pairs; Steenhof 2013) to 81,000 breeding individuals (Rosenberg et al. 2016). This difference suggests that population surveys of the species are needed throughout its range. Population trends are difficult to calculate, as very few reliable long-term data sets exist for this species (Steenhof 2013).

The prairie falcon was identified as a *Species of Special Concern** in Alberta in 2003, mostly because of its small population size. Concerns about prey and nest site availability, as well as a perceived reduction in its population and productivity (AEP 2017; G. Court pers. comm.) prompted this update of the status of the prairie falcon in Alberta. This report provides a summary of historical and recent information on the prairie falcon with the aim to update its status in Alberta.

* See Appendix 1 for defnitions of selected status designations

Distribution

1. Alberta

In Alberta, prairie falcons have not been the focus of an extensive survey since the Canadian Wildlife Service carried out surveys in the early 1970s. However, partial data on distribution and population trends are collected through peregrine falcon inventories (e.g., Corrigan 2000, cited by Alberta Environment and Sustainable Resource Development [ASRD] 2012), diverse impact assessment studies and bird banding efforts compiled in the Fish and Wildlife Management Information System (FWMIS), species at risk conservation projects (e.g., MULTISAR; Quinlan et al. 2003, Downey et al. 2005), The Atlas of Breeding Birds of Alberta (Federation of Alberta Naturalists 2007), and surveys by banders and birdwatchers who submit their prairie falcon observations to eBird (a global database managed by the Cornell Lab of Ornithology). In addition, data from various informal and semi-formal raptor monitoring efforts, some dating back to 1912, which have been compiled in the FWMIS database, provided important information on prairie falcon distribution in Alberta. See Appendix 2 for a summary of the sources of data used in this status update.

Prairie falcons breed in suitable cliff habitats along rivers or water bodies mainly in the Grassland Natural Region of Alberta, but also in the southern parts of the Central Parkland and Foothills Parkland subregions of the Parkland Natural Region, and occasionally the Rocky Mountain Natural Region (Semenchuk 1992, Figure 1). Nesting areas are located primarily in the badlands, on cliffs along the Bow, Red Deer, Milk, South Saskatchewan, and Oldman rivers and their tributaries, and along coulees. Recent observations also confirmed nest sites of prairie falcon along the North Saskatchewan and Pembina rivers (G. Court pers. comm.), the Athabasca River (K. Grantmyre pers. comm.), as well as a site along the Peace River (Stepnisky and Moyles 2005), which represents the northernmost known breeding site for the species in Alberta (Figure 1). About 10 prairie falcon nest sites have been documented in the montane and mountain regions of the southwestern portions of the province (Nelson and Bauer 1980, Nelson 1987, J. Campbell pers. obs., R. Fyfe pers. obs.). There are also non-breeding records of prairie falcon at Beaverhill Lake (Dekker 1982), in Banff and Jasper national parks (Dekker 1984, Holroyd and Van Tighem 1983), Kenilworth Lake west of Lloydminster (H. Armbruster pers. comm.), near the cities of Grande Prairie and Athabasca as well as one in St. Paul County east of Edmonton (Cornell Lab of Ornithology 2017) (Figure 1).

The prairie falcon's range extends over 129,179 km^2 of southern Alberta (Figure 1), which is about 2.7% of its global range (4,870,000 km^2; BirdLife International 2016). Satellite telemetry data show that some adults winter in or near their breeding areas and some winter in southcentral Saskatchewan (D. Paton and G.L. Holroyd pers. comm.). Hatch-year birds usually disperse from the breeding areas (Beebe 1974, Schmutz et al. 1991, Holroyd et al. 1995). From recovery data of banded falcons (n = 96), Schmutz et al. (1991) determined that prairie falcons used two migration routes and wintering areas. One route was oriented in a southeasterly direction, migrating to Saskatchewan, then south into the United States. The alternate route indicated that prairie falcons migrated southwesterly, passing over the Rocky Mountains to Washington, Idaho and Oregon. Some adult female falcons that bred in Idaho spent the second part of summer

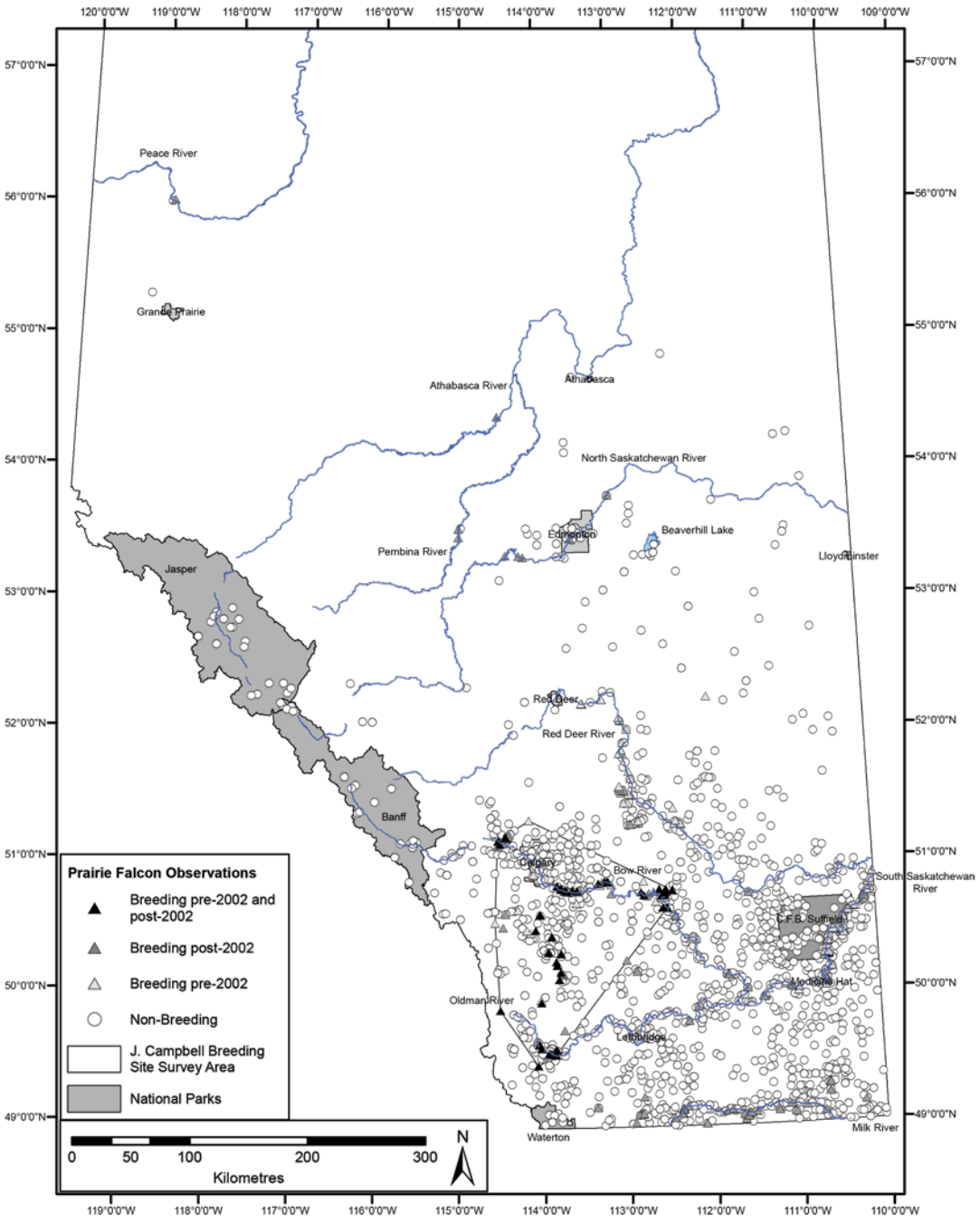

Figure 1. Distribution of the prairie falcon in Alberta, including data from the Fisheries and Wildlife Management Information System (1967–2017), eBird (2002–2017), J. Campbell (1985–2017), G. Court (1978–2015), Stepnisky and Moyles (2005), and K. Grantmyre (pers. comm.). See Appendix 2 for information on data sources. The polygon represents the area covered by J. Campbell's prairie falcon breeding sites surveys in Alberta, from 1985 to 2017. Non-breeding observations within 2 km of each other are represented by a single circle.

in southern Alberta and Saskatchewan before returning to Idaho or elsewhere for the winter (Steenhof et al. 2005). Overall, the prairie falcon is considered a facultative migrant in Alberta (G. Court pers. comm.).

Based on known prairie falcon breeding locations after 2002, the area of occupancy (the summed area of occupied 2-km x 2-km squares) is estimated at 440 km^2. The calculation of area of occupancy is closely linked to survey effort, and therefore, this represents a minimum area. Large-scale surveys dedicated to the inventory of breeding prairie falcons in Alberta would be necessary to refine this estimate. Because of inconsistent survey effort over the last decades, comparing the prairie falcon's area of occupancy in Alberta between different time periods holds little value as it would mostly reflect differences in survey effort. However, there is no indication of a range reduction when recent records are compared to the 1970s surveys by the Canadian Wildlife Service.

Although some degree of geographical isolation exists between the major breeding areas of prairie falcon in Alberta, it is unlikely that these represent actual subpopulations. Indeed, natal dispersal (see *Biology*), and probable immigration from contiguous populations of neighboring jurisdictions (see 3. *Rescue Potential in Population Size and Trends*), likely limit the degree of genetic isolation between different breeding areas of Alberta. Paton (2002) suggested that local declines occurred in Alberta, but there is no indication that breeding prairie falcons have disappeared entirely from certain areas. Overall, apart from slight interannual variation, the prairie falcon still occupies the entirety of its previously known range in Alberta. Moreover, recent discovery of northern breeding sites (e.g., Peace River) has increased the *known* range of prairie falcons in Alberta, but it is unknown whether this represents an increase in the *actual* range of the species.

2. Other Areas

In Canada, a few nest sites were found in the dry southcentral interior of British Columbia (mainly along the Thompson-Okanagan Plateau and Chilcotin-Cariboo Basin; Cannings et al. 1987, Hooper 1997), as well as at numerous sites in southwestern Saskatchewan (Godfrey 1966; Figure 2).

Prairie falcons have occasionally been reported in northern and eastern regions of western Canada, such as Nulki Lake and Fort St. John, British Columbia (Godfrey 1966, Campbell et al. 1990, Cornell Lab of Ornithology 2017), St. Louis, Saskatchewan (Godfrey 1966), and Winnipeg, Manitoba (Koes 1989). There are also noteworthy sightings of non-breeding falcons from eastern (Manitoba) and southern (Ontario) James Bay in July 2016 (Cornell Lab of Ornithology 2017). These records represent cases of vagrancy and are therefore not shown on Figure 2.

Prairie falcon breeding range outside of Canada comprises most of the western United-States, including Montana, portions of North Dakota, western Nebraska and eastern Colorado, south to Baja California, southern New Mexico, western and northern Texas, and as far south as northern and central Mexico (Johnsgard 1990, Lanning and Hitchcock 1991, Steenhof 2013). Wintering birds are found south of Washington, Idaho and Oregon, with some moving to the Midwestern United States, or occasionally to the eastern seaboard. On the Pacific coast of the United States, prairie falcons migrate as far south as Mexico and Baja California (Figure 2).

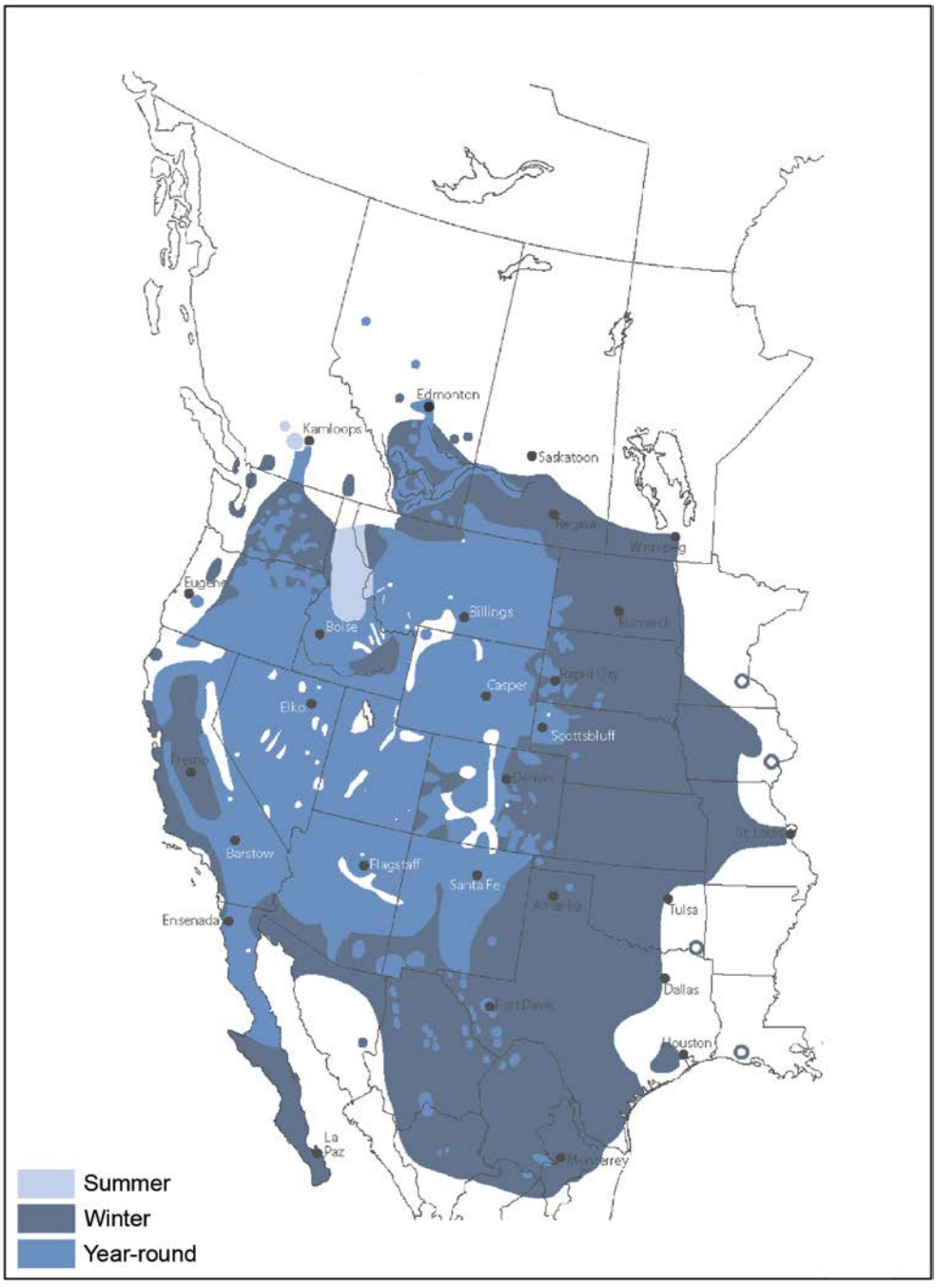

Figure 2. Distribution of the prairie falcon in North America. Adapted from the range map in Wheeler (2018) with permission from Princeton University Press; adjustments to the Alberta portion of the map from G. Court (pers. comm.).

Habitat

1. Breeding Habitat

Prairie falcons primarily inhabit dry environments of the southern Alberta prairies where suitable cliffs and outcrops occur, particularly along rivers and streams (Semenchuk 1992). Most common nest sites are in cavities, ledges, crevices, or potholes on volcanic buttes, sandstone canyons, bluffs, and isolated rock outcrops (Steenhof 2013). They use a variety of open habitats, such as grasslands, canyons, cropland, alpine tundra, foothills and dry mountain valleys for foraging and/or breeding (Bent 1961, Godfrey 1966, Beebe 1974, Marti and Braun 1975). An important component of all prairie habitat used by this species is the availability of perch sites such as snags, fence posts, rock faces, utility poles and hay bales. Landscapes with a few trees may be used, but extensive forests are usually avoided. The foraging habitat of prairie falcons consists of open prairies with low vegetation containing ground squirrels (e.g., *Spermophilus* sp., *Urocitellus* sp.) and small to medium-sized birds (Squires 1986, Steenhof and Kochert 1988, Hunt 1993, Steenhof 2013).

Prairie falcons breeding in Alberta and the United States prefer cliff nest sites and native prairie, which supports a ground squirrel prey base (Hunt 1993, Marzluff et al. 1997, Banasch and Barry 1998, Steenhof 2013, Steenhof et al. 1999). Nest sites are frequently adjacent to a flowing river, or a large water body, where the falcons can use nearby uplands to hunt (Semenchuk 1992, Hunt 1993). Streamside cliff habitat is often unused because of the lack of an adjacent food source or a suitable cliff-nesting site (Oliphant et al. 1976). Some breeding occurs at higher elevations in the montane and subalpine regions of the United States, but known core breeding areas are at lower elevations on the Canadian prairies (Marti and Braun 1975, Johnsgard 1990).

2. Migration and Wintering Habitat

Habitats used during post-breeding and migration are predominantly grasslands (Schmutz et al. 1991, Steenhof 2013). However, Dekker (1984), Holroyd and Van Tighem (1983) and Steenhof et al. (2005) observed prairie falcons in the post-breeding season through alpine, subalpine and montane areas of Alberta. If prey species are available, and the winter is mild, adult prairie falcons winter throughout their southern Alberta breeding range and may move to southern Saskatchewan (D. Paton and G.L. Holroyd pers. comm.), while juveniles typically migrate south to the United States and northern Mexico (Schmutz et al. 1991). Numerous individuals now regularly overwinter in cities as far north as Edmonton (Nelson 1974b, Dekker and Lange 2001, Cornell Lab of Ornithology 2017; J. Acorn pers. comm.).

During winter, prairie falcons exploit habitat with little or no snow, particularly those areas used by horned larks (*Eremophila alpestris*; Beauvais et al. 1992) and other prey species such as snow buntings (*Plectrophenax nivalis*; J. Acorn pers. comm.). Overwintering waterfowl, gray partridge (*Perdix perdix*), and rock doves (*Columba livia*), which have become available in Alberta only recently, are also part of the winter diet of the prairie falcon and have likely encouraged the species to winter near or within cities (G. Court pers. comm.).

3. Habitat Trends

In Canada, native grasslands spanned broad areas of Alberta, Saskatchewan and southern Manitoba, covering approximately 615,000 km^2 (Clayton et al. 1977, cited by Wang et al. 2014). At present, more than 82% of Canada's native grasslands has been lost, mostly to agriculture, urbanization and industrialization, and remaining grasslands are highly geographically fragmented (Bailey et al. 2010). The Grassland and Parkland natural regions of Alberta make up 24% of the province's land area (Alberta Biodiversity Monitoring Institute [ABMI] 2015), and it is estimated that as of 2016 about 57% (54,587 km^2 of the 95,566 km^2) of the Grassland Natural Region and 78% (47,426 km^2 of the 60,748 km^2) of the Parkland Natural Region has been converted to some form of human footprint* (Alberta Prairie Conservation Forum 2017, ABMI 2018). The Mixedgrass and Dry Mixedgrass subregions of the Grassland Natural Region, an integral portion of the prairie falcon breeding range in Alberta, have been largely altered; only approximately 31% of the original 18,600 km^2 of the Mixedgrass Subregion, and 43% of the original 47,750 km^2 of the Dry Mixedgrass Subregion remains today (Adams et al. 2013a, 2013b). Much of the conversion of native grasslands occurred during the early years of European settlement (Bailey et al. 2010), but the conversion continues, though at a slower rate. Indeed, between 1999 and 2016, the percentage of native habitat converted to human footprint increased by 2.5% and 2.4% for the Grassland and Parkland natural regions of Alberta, respectively (ABMI 2018).

Native grasslands are prime habitat for the Richardson's ground squirrel (*Urocitellus richardsonii*; Downey et al. 2006), which, in Alberta, is the main prey of the prairie falcon during the breeding season (Hunt 1993). By directly affecting prairie falcon foraging habitat, grassland conversion is likely the most important threat to the species in Alberta. Further discussion on the causes of fragmentation and decline in prairie falcon habitat will follow in the *Threats* section.

*Human footprint is defined as the visible conversion of native ecosystems to temporary or permanent residential, recreational, agricultural, or industrial landscapes (ABMI 2018). ABMI defines six categories of human footprint: agriculture; forest harvest; mines; wells and other energy features; transportation; urban, rural, and industrial; and human-created waterbodies.

Biology

This section focuses primarily on aspects of the species' biology that are relevant to its conservation, management and status.

1. Breeding Biology and Phenology

The prairie falcon, like many North American falcons, displays reversed sexual dimorphism; the adult female is larger (mean of 863 g) than the adult male (mean of 554 g; Enderson 1964, Beebe 1974). Age of sexual maturity is usually two years, although some prairie falcons have been reported to breed after one year (Platt 1981, Palmer 1988, Tesky 1994), and generation length has been estimated at 6.4 years (Birdlife International 2018).

Courtship and mate selection occur on the breeding grounds several weeks before laying (Fyfe et al. 1969, Tesky 1994). In Alberta, establishment of breeding territories usually begins in March, with egg laying occurring in mid- to late April. Fyfe (1990) noted prairie falcon pairs on territories along the Oldman River as early as the fourth of February. If mild weather conditions prevail, some territories may be occupied throughout the winter (Young et al. 1986, Fyfe 1990, H. Armbruster pers. comm.).

2. Nest Site Selection, Territoriality, and Dispersal

Prairie falcon nest sites are found on a variety of cliff substrates and are located at a wide range of heights (Bent 1961). Edwards (1973) found nest sites in his Alberta study area to be from 4.5 m to 9.0 m above the base of the cliff (n = 8). Runde and Anderson (1986) pooled nest site data (n = 418) from numerous studies and found that the average nest site height was in the upper two-thirds of the cliff (mean of 29.3 m, range 2.1 m–154.4 m, from the bottom of the cliff).

Prairie falcons often select a natural crevice, pothole, or ledge on a cliff with an overhang that shelters a nest site, which is a scraped-out depression of fine debris or sand (Bent 1961, Edwards 1968). Prairie falcons will also use abandoned common raven (*Corvus corax*), golden eagle (*Aquila chrysaetos*) and ferruginous hawk (*Buteo regalis*) nests, as well as man-made holes or ledges dug into cliffs lacking natural nesting sites (Bent 1961, Hickman 1971, J. Campbell pers. comm.). Some unusual nest location records include the ledge of a building (Nelson 1974a), a tree (MacLaren et al. 1984), a subterranean cave entrance (Haak 1995), and transmission towers (Roppe et al. 1989, Steenhof et al. 1993).

Prairie falcons tend to return to the same nesting territory year after year. At three study areas in Alberta, Colorado and Wyoming, 88% (n = 115) of prairie falcons returned to the same territory used in previous years (Runde 1987). Cliff territories may have more than one nest site, which can be used alternately over a number of years by the breeding pair. Runde (1987) found that fidelity varied by geographic location; 96% (n=49) of females in Alberta but only 60% (n=5) in Colorado returned to their previously used nesting territories. Of 40 radio-marked prairie falcons in the Snake River Birds of Prey National Conservation Area (BPNCA) in Idaho, at least 21

returned to nest within 2.5 km of where they nested in the previous year and most returned to the same territory or an adjacent one (Steenhof et al. 2005). Enderson (1964) suggested areas that have high territorial fidelity, such as Alberta, usually have low breeding densities.

Prairie falcons appear to exhibit a strong preference for certain nesting sites, which they tend to use every year (Runde 1987, Fyfe 1997); however, they are known to switch nesting sites on occasion. In Alberta and Saskatchewan, Runde (1987) calculated median breeding dispersal distance for five banded adult prairie falcons to be 3.2 km. Adult prairie falcons are also able to disperse to other nearby regions if suitable nesting and foraging habitats are available (Kirk and Banasch 1996, Steenhof et al. 2005). Juveniles (especially males) tend to return to the area where they were hatched in search of a nesting site; in Colorado, Wyoming and Alberta, median natal dispersal distance was farther for females (54.4 km, n = 55) than males (12.9 km, n = 33), and ranged from 0 km–225 km (Runde 1987).

3. Nesting Success and Survival

Prairie falcons raise only one brood per year (Semenchuk 1992). If the first clutch is removed or destroyed early in the incubation, a second clutch is usually laid at an alternate nest site within 20 to 25 days (Edwards 1973, Snow 1974, Allen et al. 1986). Most nestlings fledge by the third or fourth week of June (Fyfe 1992).

Prairie falcon clutch sizes range from two to six eggs, with four to five being the most common (Johnsgard 1990, Steenhof 2013). In Alberta, the mean number of eggs produced along the Oldman River was 4.5 eggs/clutch (n = 53; Fyfe 1992) and the mean number of eggs/clutch was 4.6 (n = 19) along the Bow River (Edwards 1973). Incubation begins when laying of the clutch nears completion and lasts 29 to 33 days (Webster 1944, Enderson 1971). Eggs hatch over a period of 36 to 48 hours and young typically fledge at 36 to 41 days (Enderson 1964). In the Snake River Birds of Prey National Conservation Area in Idaho, an average of 63% of prairie falcon pairs successfully fledged at least one young between 1974 and 1997 (Steenhof et al. 1999). Over the same period, mean brood size at fledging was 3.9 young per successful pair, 2.76 young per laying pair, and 2.46 young per territorial pair. Runde (1987), obtained very similar results when calculating the average percentage of successful pairs (70%) and the mean number of young produced per territory (2.46) across various locations between 1960 and 1985. In Alberta, Edwards (1973) reported that, on average, 88% of pairs were successful and that 2.50 young fledged per occupied territory between 1967 and 1971.

Female prairie falcons do most of the incubation, while males provide food for the female at the nest, and occasional relief from incubation when she feeds, preens, and bathes (Holthuijzen 1989, Hunt 1993, H. Armbruster pers. comm.). When the eggs hatch, the male provides the bulk of the food for the first three weeks, then both adults provide food for the young, but the male provides most of the food throughout the young-rearing period (Holthuijzen 1990, Hunt 1993). Polygamy is a rare occurrence; however, R. Fyfe observed two incidences of one male prairie falcon providing food to two nesting females. Of the four females, only one raised young successfully (R. Fyfe pers. comm.).

Juvenile prairie falcon mortality rate estimates are quite high, ranging from 65% (Denton 1975) to 85% (Runde 1987). In comparison, estimates of adult mortality rates are from 19% (Runde 1987) to 35% (Denton 1975). Life spans of prairie falcons could be as long as 20 years; the longest known banding recovery is 17 years and three months (Lutmerding and Love 2017). Runde (1987) calculated prairie falcon life expectancy to be 15.6 years.

4. Foraging Behaviour

During the breeding season, both sexes will vigorously defend the nest site, but prairie falcons tend to have undefended, although well-defined, home ranges (Haak 1982, Squires 1986, Hunt 1993). When prey are plentiful, the home ranges are relatively small (Marzluff et al. 1997), yet in Alberta falcons have been tracked by radio telemetry hunting as far as 20 km from the nest (Hunt 1993). Using minimum convex polygons, Hunt (1993) estimated that the average minimum home range size for individual radio-tagged nesting prairie falcons (n = 11) at the Bow River study site was 72 km^2 (min = 31 km^2, max = 192 km^2). For a few of the pairs (n = 5), the home ranges overlapped (38%–100%) with adjacent territorial pairs. Prairie falcons do not use their large home range in an even manner, and rather use a few core foraging areas more intensively than the rest of the home range (Hunt 1993, Marzluff et al. 1997). In Alberta, the core foraging areas of two adjacent pairs overlapped 19%–25% (Hunt 1993). In the Bow River study, uncultivated native grasslands, with ground squirrel habitat, was proportionately higher than expected within 15 km of the nest site (Wilcoxon paired sign-rank, $z = -1.82$, $p < 0.05$; Hunt 1993). Marzluff et al. (1997) studied the habitat use of 98 radio-tagged prairie falcons in the Snake River Birds of Prey National Conservation Area, Idaho, and found similar results. These data suggest that the availability of a ground squirrel prey base could be important to the distribution of prairie falcon home ranges (Hunt 1993, Steenhof 2013).

Very little is known about prey species and habitat use of post-breeding prairie falcons. Colorado researchers tracked 18 prairie falcons and noted that the minimum mean winter home ranges (30.2 km^2, range 3 km^2–38 km^2, n = 10) appeared to be smaller than during the nesting season (Beauvais et al. 1992). In Alberta, typical winter home range size remains unknown.

Population Size and Trends

1. Alberta

Over the last few decades, a range of estimates of prairie falcon population size has been suggested. In a 1978 status report prepared for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Woodsworth and Freemark (1978) estimated that more than 250 pairs nested in Alberta. In a 1996 COSEWIC report, Kirk and Banasch (1996) estimated the Canadian population to be 250 to 500 pairs, with the vast majority located in Alberta. In 2002, the Alberta population was estimated to a minimum of 181 breeding pairs (Paton 2002). More recently, the Partners in Flight Science Committee (2013) estimated the Alberta population at 1,900 breeding individuals; however, it should be noted that Breeding Bird Survey data, which are not well suited to document prairie falcon populations, were used to obtain this estimate. The lack of recent large-scale surveys makes it difficult to provide a more precise population estimate. However, because occupancy and productivity appear to have remained stable (as discussed below), the minimum number of breeding pairs of prairie falcon estimated by Paton (2002) is likely still valid. As this estimate did not include breeding sites from northern river basins, such as the North Saskatchewan, Pembina and Athabasca rivers, the minimum number of breeding pairs of prairie falcon across its entire range in Alberta is probably closer to 200.

Breeding Bird Surveys (BBS) in Alberta show a long-term (1970–2017) increasing annual trend of 0.6% per year, although not statistically significant and with very small sample size (A. Smith unpubl. update of Environment and Climate Change Canada [ECCC] 2017). The probability of the increase is estimated at 73%. On the other hand, the short-term data (2007–2017) show a slight decreasing trend of -0.5% per year (A. Smith unpubl. update of ECCC 2017). Again, this trend is not statistically significant and the probability of decrease in the population size is estimated at 58%. The overall reliability of the BBS results for prairie falcons in Alberta is considered low because of small sample sizes, and because the BBS is not a suitable method to survey this species (ECCC 2017). Currently, population trends in Alberta are difficult to estimate because of an overall lack of information.

The most important data source currently available for prairie falcons in Alberta is a long-term breeding survey conducted voluntarily by John Campbell. He is a licensed bird bander in Alberta who specializes in banding prairie falcons. John Campbell has banded falcons within the same general area of Alberta for more than three decades. Moreover, he constructs nesting habitat for the species by digging nest holes, particularly where the cliff substrate is prone to erosion. Through John Campbell's annual survey, 74 unique breeding territories were visited over a period of 32 years (1985–2017; a total of 1764 visits) in southwestern Alberta (see polygon in Figure 1, and Figure 3). Survey efforts have increased from 41 breeding sites in 1985 to 70 sites in 2017 (Table 1; Figure 4), with an average of 53 sites visited per year (not all sites were surveyed every year). The primary purpose for site visits was to band juveniles, and surveys were therefore conducted at an average brood age of 3.2 weeks to ensure the accurate identification of sex. With only one site visit occurring late in the season, it is very likely that many breeding failures

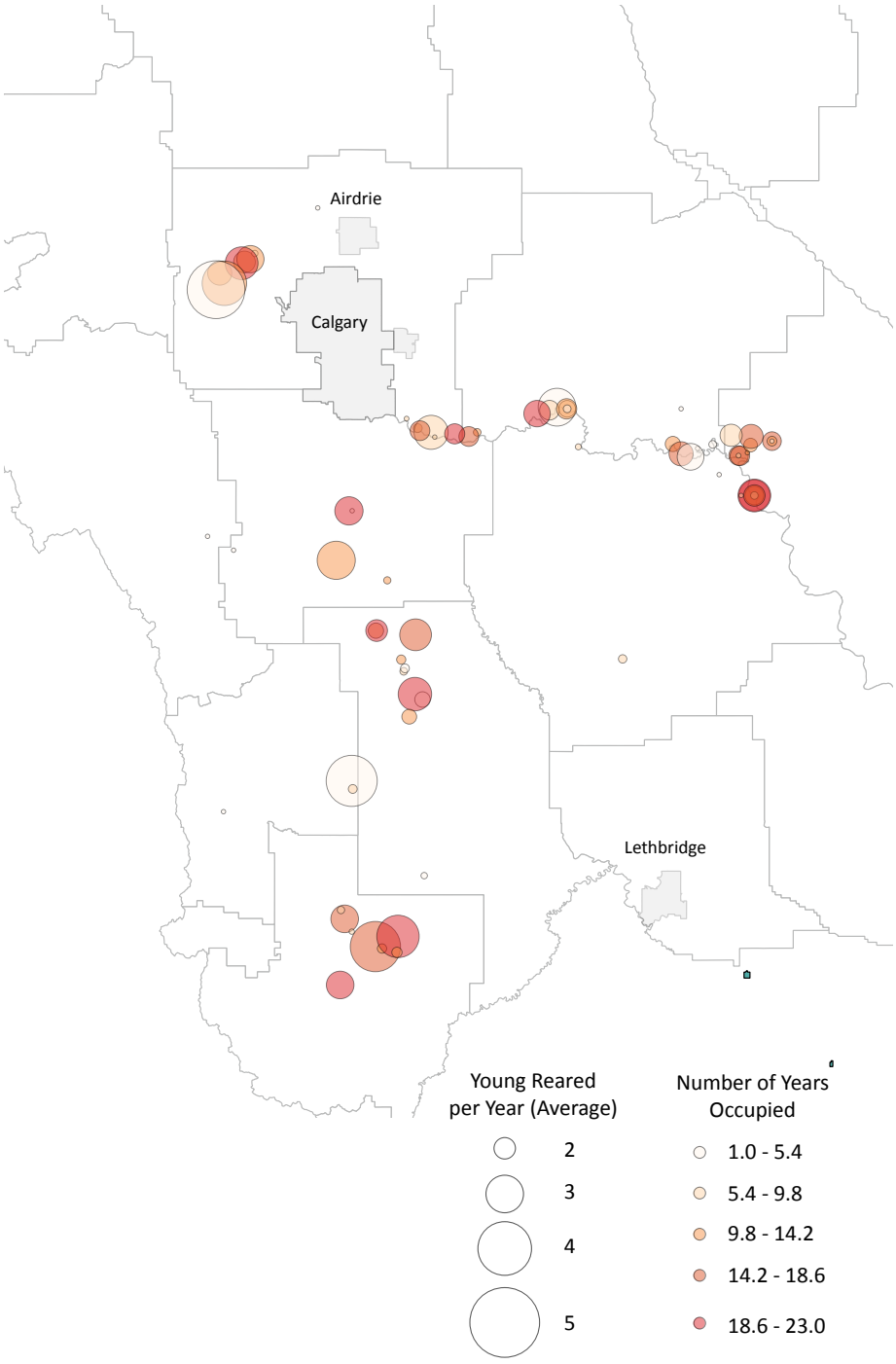

Figure 3. John Campbell's prairie falcon breeding site surveys in Alberta from 1985 to 2017. Sites are displayed according to occupancy and productivity, such that increased circle size indicates higher productivity (average number of young reared per year) and increased redness/darkness indicates longer occupancy (number of years occupied).

Table 1. Results from John Campbell's prairie falcon breeding site survey in Alberta, 1985-2017. See Figures 1 and 3 for locations.

Territory	Total Young	Young per Year (average)	Years Visited	Number of Years Occupied	Occupancy	Still Available	Unavailable Since, Cause for Loss
1st Low	62	2.07	30	17	0.57	Yes	-
1st Porcupine	74	2.74	27	17	0.63	Yes	-
2nd Low	42	1.4	30	10	0.33	Yes	-
Above Ferry	39	1.3	30	8	0.27	No	2017, Slumped[1]
Above Peregrine	2	0.07	30	1	0.03	Yes	-
Archie Hogg's	53	3.53	15	14	0.93	Yes	-
Arrowood	28	1.12	25	7	0.28	Yes	-
Barry's	14	3.5	4	4	1	No	1995, Slumped[1]
Bassano Dam 1	90	3	30	21	0.7	Yes	-
Bassano Dam 2	62	2.07	30	14	0.47	Yes	-
Bassano Dam 3	64	2.13	30	17	0.57	Yes	-
Bassano Dam 4 Backho	64	2.13	30	18	0.6	Yes	-
Bassano Dam Dam	94	3.13	30	21	0.7	Yes	-
Bassano Dam Fence	31	1.03	30	8	0.27	Yes	-
Bassano Dam Inlet	37	1.23	30	9	0.3	Yes	-
Bassano Dam Pumphouse	68	2.27	30	17	0.57	Yes	-
Bassano Doug	23	0.77	30	12	0.4	Yes	-
Before Bassano Dam	51	1.7	30	14	0.47	Yes	-
Big Hill - Hole	53	2.3	23	12	0.52	Yes	-

Table 1 continued

Territory	Total Young	Young per Year (average)	Years Visited	Number of Years Occupied	Occupancy	Still Available	Unavailable Since, Cause for Loss
Big Hill - Park	16	1.14	14	4	0.29	Yes	-
Bill Hill - Rich's	38	2.71	14	10	0.71	Yes	-
Black Dirt	1	0.08	12	1	0.08	No	2007, Slumped[1]
Boneyard - Beregevin	11	1.83	6	4	0.67	Yes	-
Boneyard Coulee	58	3.05	19	15	0.79	Yes	-
Bow - Tim (Ferry)	5	1.25	4	1	0.25	Yes	-
Bow Highwood	44	1.33	33	13	0.39	Yes	-
Buffalo Jump	80	4.44	18	18	1	Yes	-
Burnco Gravel Pit	34	1.03	33	8	0.24	Yes	-
Carsland Backwater	41	1.24	33	11	0.33	Yes	-
Cayley	40	1.21	33	11	0.33	Yes	-
Cochrane Bow	57	2.48	23	14	0.61	Yes	-
Conklin	89	3.18	28	22	0.79	Yes	-
Dam Power Line	37	1.37	27	10	0.37	Yes	-
Dey's	74	2.74	27	22	0.81	Yes	-
Dirt Bank	3	0.1	30	1	0.03	Yes	-
Eagle Eyrie	8	0.35	23	2	0.09	No	1997, Slumped[1]
Encana	29	3.22	9	7	0.78	Yes	-
Fairbrothers	77	3.85	20	20	1	Yes	-
Foster's	72	3.13	23	19	0.83	Yes	-

Table 1 continued

Territory	Total Young	Young per Year (average)	Years Visited	Number of Years Occupied	Occupancy	Still Available	Unavailable Since, Cause for Loss
Golf Course	49	1.81	27	13	0.48	Yes	-
Highwood River	71	2.15	33	17	0.52	Yes	-
Horse Shoe Canyon	9	4.5	2	2	1	No	1997, Flooded
Huterite Gardens	15	1.15	13	3	0.23	No	2013, GHOW[2]
Jumping Pound	44	4	11	10	0.91	Yes	-
Landslide	74	2.47	30	18	0.6	Yes	-
Langs	29	1.07	27	8	0.3	No	2009, Urban Dev.
Last Before Gap	25	0.83	30	7	0.23	Yes	-
Little Cliff S	25	1.92	13	7	0.54	Yes	-
Little Cliff	28	2.33	12	6	0.5	Yes	-
Long Rappel	57	2.48	23	15	0.65	Yes	-
MacKinnon Flats	21	0.68	31	6	0.19	Yes	-
Malloff	16	1.33	12	7	0.58	Yes	-
Mowatt's	33	1.22	27	9	0.33	Yes	-
Nanton 1	60	1.82	33	14	0.42	Yes	-
Nanton 2 (middle)	76	2.3	33	20	0.61	Yes	-
Nanton 3 (low)	22	0.37	33	5	0.15	Yes	-
Nanton East	11	0.33	33	3	0.09	Yes	-
Old Bridge	39	1.44	27	11	0.41	Yes	-
Old Car	30	2.14	14	7	0.5	Yes	-

Table 1 continued

Territory	Total Young	Young per Year (average)	Years Visited	Number of Years Occupied	Occupancy	Still Available	Unavailable Since, Cause for Loss
Peregrine (CPR)	46	2.19	21	11	0.52	Yes	-
Pine Coulee 1	45	1.36	33	12	0.36	Yes	-
Pine Coulee 2 (nose)	41	1.24	33	9	0.27	Yes	-
Pine Coulee S	8	1.33	6	5	0.83	Yes	-
Pot Holes	71	2.15	33	17	0.52	Yes	-
Power Line	8	2.67	3	3	1	Yes	-
Side Hole	72	2.18	33	19	0.58	Yes	-
Stevick's	16	0.59	27	4	0.15	Yes	-
Thiesen's	82	2.65	31	23	0.74	Yes	-
Tounge Creek 1	14	0.42	33	4	0.12	Yes	-
Tounge Creek 2	92	2.79	33	22	0.67	No	2014, GHOW[2]
Tounge Creek Lein	6	0.18	33	2	0.06	Yes	-
Willow Creek Jen's	41	1.78	23	10	0.43	Yes	-
Wineglass	15	5	3	3	1	Yes	-
Yellow Cliff	15	1.25	12	4	0.33	Yes	-

[1] "Slumped" means that for various reasons (e.g., high-water events, heavy rain) the nest hole collapses or erodes, thus eliminating the nest site.

[2] GHOW - great-horned owl

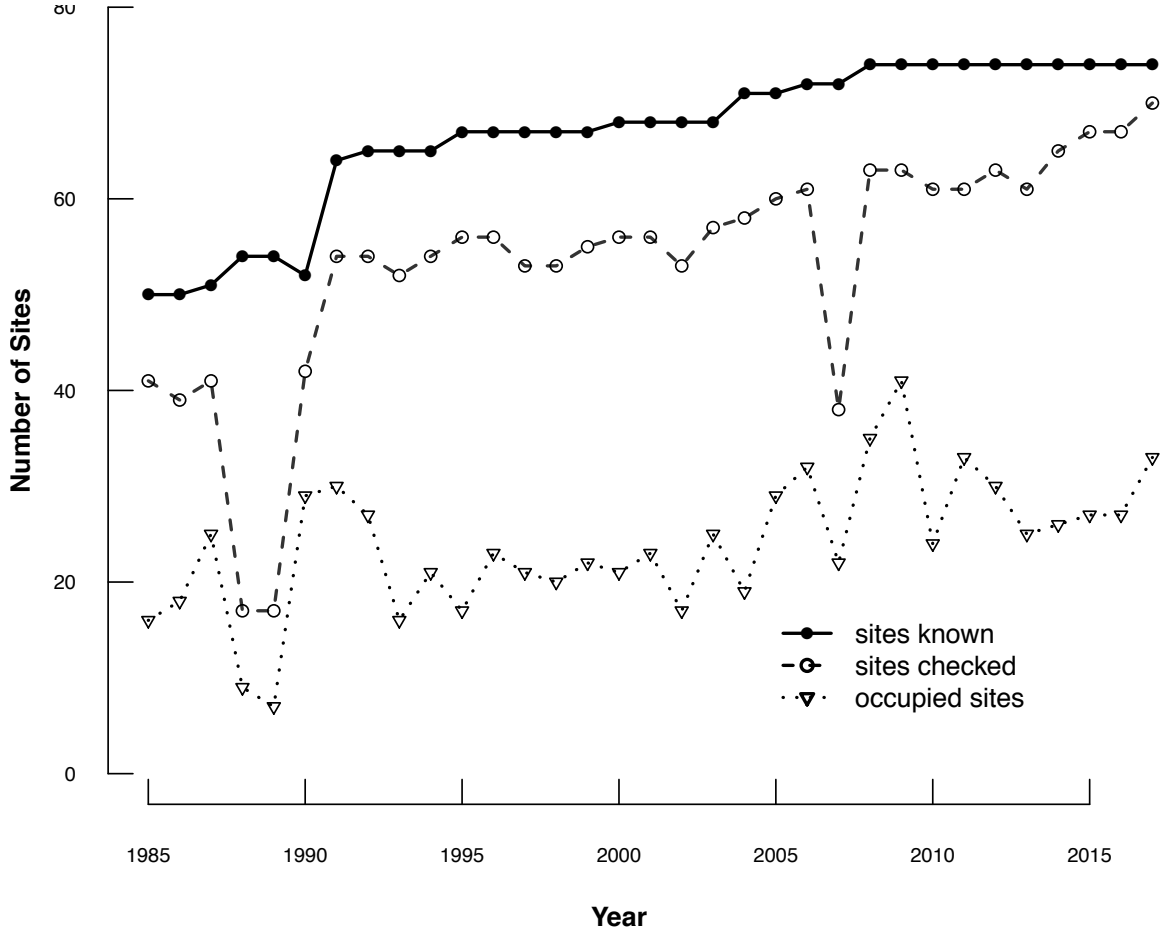

Figure 4. The total number of prairie falcon breeding sites known, checked, and known to be occupied between 1985 and 2017, as part of John Campbell's survey. A steady increase in the number of sites that are known, and the number of sites that are checked each year are the result of increases in survey effort over time.

were missed each year (i.e., many occupied sites could have been undetected). Therefore, results must be interpreted with caution as it is likely that this bias causes an underestimation of occupancy and an overestimation of productivity (as measured by the number of young per detected territorial pair; Steenhof and Newton 2007; Steenhof et al. 2017). Occupancy and productivity trends were calculated using the statistical method outlined by MacKenzie *et al*. (2003), where Lambda (λ) at time t = occupancy/productivity at time t+1 / occupancy/productivity at time t. An averaged λ value of >1 indicates expansion of occupancy or productivity, a value <1 indicates contraction, while a λ value equal to 1 indicates no change.

Of the total 1764 breeding territories monitored during this study period, 790 breeding pairs were detected, for an average occupancy of 50%. Occupancy was highest in 1990 at 69%, lowest in 1995 at 30%, and was relatively variable over the 32 years with a λ standard deviation of 0.25 (Figure 5). Despite the variation, there is no indication of occupancy contraction or expansion (λ = 1.03; Figures 4 and 5), nor is there an apparent trend when looking only at the last three generations (i.e., 19 years; λ = 1.01; Figure 5). Productivity has also remained stable (λ = 1.00 +/- 0.11), with an average of 3.9 (+/- 0.3) fledglings per detected territorial pair (Figure 6). Again, when looking only at the three last generations, no trend is detected (λ = 1.03 +/- 0.21; Figure 6).

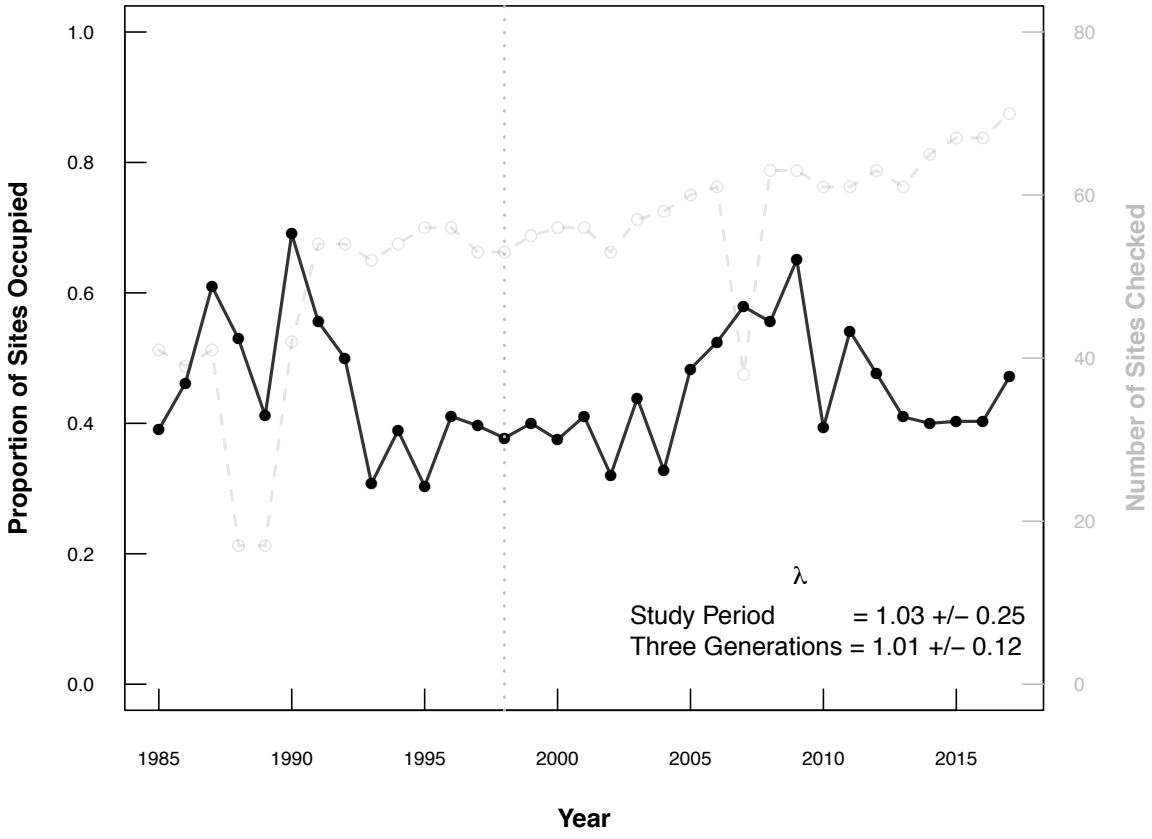

Figure 5. The proportion of sites known to be occupied compared to the number of sites checked, based on John Campbell's prairie falcon breeding site survey. Despite an increase in survey effort, occupancy remained constant during both the duration of the study period, and the three most recent generations (1985 to 2017, and 1998 to 2017, respectively). There has been considerable variation since 1985 (λ sd = 0.25), but the occupancy trend does not suggest contraction or expansion (λ = 1.03 since 1985, and 1.01 in the three most recent generations).

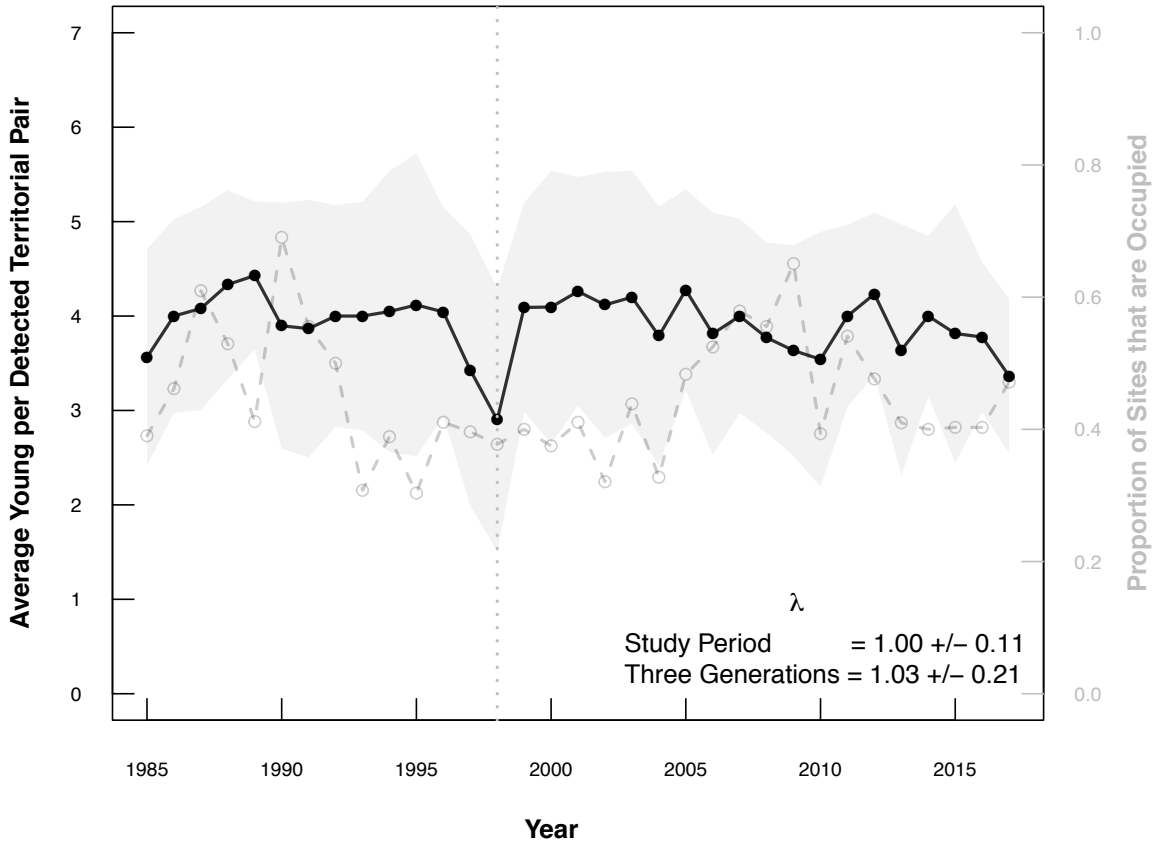

Figure 6. Average number of young per occupied site (standard deviation is represented by the shaded area) compared to the proportion of sites that are known to be occupied, based on John Campbell's prairie falcon breeding site survey. Similar to the occupancy trend (i.e., Figure 5), the average number of young successfully reared at occupied sites remains consistent over both the study period, and the three most recent generations (1985 to 2017, and 1998 to 2017, respectively).

Over the course of the study period, some natural nesting holes became unavailable to breeding pairs, for example due to flooding or slumping (J. Campbell pers. comm.). In many of these instances, replacement nesting holes (i.e., artificial sites) were excavated using a hammer drill, or the original nesting holes were repaired or enhanced. Twelve artificial nesting holes were also excavated on cliffs that had no known nesting holes. The number of artificial nest holes increased over time (4 in 1985, and 25 in 2017); however, the proportion of total occupied sites that were unnatural has remained consistent throughout this period (λ = 1.07 +/- 0.42, Figure 7).

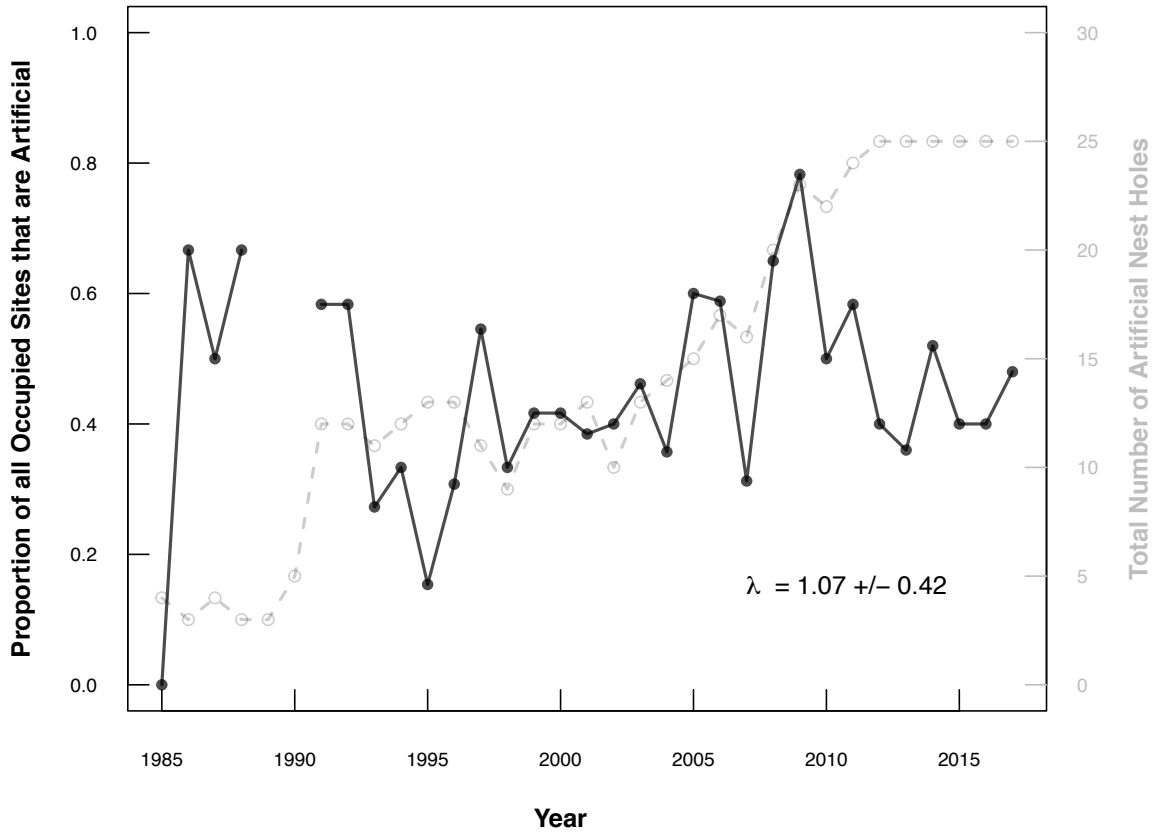

Figure 7. The proportion of sites occupied that are artificial compared to the total number of artificial nest holes available, based on John Campbell's prairie falcon breeding site surveys (1985–2017). There has been a substantial increase in the number of artificial nest holes across the study area; however, occupancy has remained balanced between natural and artificial holes.

Because only 50% of nest sites are occupied on average each year, it appears, at least within John Campbell's study area, that the number of nest sites might not be as limiting as suggested by previous reports (Paton 2002, ASRD 2012). Thorough investigation (including pre-breeding, early breeding and banding checks each season, at minimum) of nest site availability and occupancy would be necessary to better understand where, and if, the number of nest sites limits the prairie falcon population in Alberta.

Although there is a range of estimates available for the Alberta prairie falcon population, and population size may increase and decrease somewhat over time, there is no evidence for extreme fluctuation (i.e., greater than one order of magnitude). The level of variability in the number of occupied sites in Alberta between 1985 and 2017 does not reflect a population fluctuating more than one order of magnitude (see Figure 4).

2. Other Areas

There is considerable uncertainty regarding prairie falcon population size estimates for Canada and North America. Palmer (1988) estimated the total North American population of prairie falcons to be 5000 to 6000 pairs, and Steenhof (2013) suggests there is a minimum of 4273 breeding pairs in North America. However, based on BBS data, Rosenberg et al. (2016) estimate the North American population to 81,000 breeding individuals, including 2000 individuals in Canada (Partners in Flight Science Committee 2013). In a 1996 COSEWIC report, Kirk and Banasch (1996) estimated the Canadian population to be 250 to 500 pairs. The population in British Columbia is low and likely comprises 10 to 20 pairs (Cooper and Beauchesne, 2004). During the British Columbia Breeding Bird Atlas (2008–2012), the prairie falcon was observed in 18 of the 4508 different atlas squares inventoried (Bird Studies Canada 2017). The prairie falcon population in Saskatchewan was estimated at 25 to 50 breeding pairs in 2002, and recent information suggests that this estimate is likely still valid (J. Keith pers. comm.).

Overall, continental population trends are difficult to assess for this species and contradictions exist between data sources. BBS data indicate both long-term (1970–2017; 1.3% per year) and short-term (2007–2017; 0.8% per year) increasing trends (A. Smith unpubl. update of ECCC 2017). However, small sample sizes, low relative abundances on survey routes, missing data, as well as inappropriate survey design limit the reliability of the BBS results for this species (Sauer et al. 2017). Data from the Christmas Bird Count (CBC) also show an increasing trend from 1966 to 2013 (Soykan et al. 2016), but again, because of low numbers of individuals detected, CBC data are not well suited to evaluate trends for this species (Farmer et al. 2008, cited by Steenhof 2013). Between 1998 and 2005, significant decreasing trends in the fall migration count of prairie falcons were observed at the Goshutes, Nevada and Manzano, New Mexico watch sites, coinciding with a regional drought (Smith et al. 2008). However, counts of prairie falcons at the Manzano watch site were still above those of the 1980s (Smith et al. 2008). In Idaho, numbers of breeding pairs in the Snake River National Conservation Area declined significantly between 1976 and 1997 (Steenhof et al. 1999), but reached an all-time high count in 2002. This area was no longer monitored after 2003 (Steenhof 2013). In British Columbia, although the population is likely at, or near, an all-time low, it appears to be stable (Cooper and Beauchesne 2004). In Saskatchewan, no survey of the species has been undertaken in many years; therefore, information on trends in the Saskatchewan population is not available, but the population is thought to be stable (J. Keith pers. comm.). In Montana, prairie falcons are considered relatively common, and data obtained through the Montana Raptor Survey Routes (1977–2014), which consisted of 46 road-based surveys spread throughout the state, suggest that the Montana prairie falcon population is stable (A. Begley pers. comm.).

3. Rescue Potential

Immigration of prairie falcons from neighbouring jurisdiction is probable, and individuals would be adapted to survive and reproduce in Alberta. Steenhof et al. (2005) found evidence of long-range breeding dispersal in prairie falcons. This suggests that individuals can disperse across geographically separated breeding areas, which makes immigration from northern states, such as Montana or Idaho, very likely. Although adults show high fidelity to their nesting site or area, there is evidence of juvenile dispersal; in Canada (most of the data coming from Alberta), most birds banded as nestlings were found over 100 km away from their natal site in subsequent breeding seasons (Dunn et al. 2009). Montana is a likely source of prairie falcons into Alberta, particularly because the prairie falcon is considered a common and stable species there (NatureServe 2018; A. Begley pers. comm.); immigration may also occur from adjacent provinces within Canada, although the low population levels in British Columbia and Saskatchewan limit the immigration potential from these provinces.

Threats

This section will focus on threats that have an anthropogenic origin, as well as on other factors that occur naturally if they are amplified by human activities and result in increased pressure on the prairie falcon population. Threats are generally listed in order of importance (i.e., beginning with recent/current/imminent threats that are well documented and have caused/are causing/will cause population-scale harm).

“Locations” are geographically or ecologically distinct areas vulnerable to a single plausible threatening event, either natural (e.g., disease outbreak) or anthropogenic (e.g., habitat destruction) (as defined by IUCN 2012). As will be discussed in this section, the most important threat faced by the prairie falcon, native grassland conversion (through agriculture, roads, energy production and urban development), is still occurring, but is more localized than before. Therefore, at the moment, grassland conversion cannot affect a large portion of the population in a single event. All of these threats tend to be widespread but, with the exception of climate change, each threat acts at a relatively small scale when it occurs. Therefore, the number of locations (as defined by IUCN) is unknown, but certainly greater than 10.

1. Agriculture

As of 2013, an estimated 55.2% of Alberta’s Grassland and Parkland natural regions, which contain the prime habitat for prairie falcon in Alberta, had been converted to agriculture (ABMI 2015; also see *Habitat*). Agricultural footprint continues to increase; between 1999 and 2016, the total area of human footprint associated with agriculture increased by 1.42% and 0.38% in Alberta’s Grassland and Parkland natural regions, respectively (ABMI 2018). The ABMI (2018) defines agriculture footprint as areas of annual or perennial cultivation, including crops and tame pasture, as well as confined feeding operations and other high-density livestock areas.

The loss of native grassland habitat that supports abundant prey can have important consequences for the prairie falcon as it represents a loss of foraging habitat. Indeed, in Alberta, prairie falcons are highly dependent on Richardson’s ground squirrels as a main food source (Hunt 1993), which in turn, rely on native grasslands (Downey et al. 2006). Marzluff et al. (1997) and Steenhof et al. (1999) found that breeding success of prairie falcons was closely tied to the abundance of ground squirrels along the Snake River in Idaho. Computer simulations predicted that as little as 15% agricultural conversion on the Snake River Plain would reduce prairie falcon productivity to a point at which the population could not replace itself (U.S. Department of Interior 1979, cited by Steenhof 2013). Wildlife biologists (Canadian Wildlife Service unpubl. data) documented a prairie falcon population reduction from 18 pairs in 1972 to 13 pairs in 1988 along a stretch of the Bow River. Over the same time period, agricultural land-use increased 25% within 6 km of the same Bow River study (Hunt 1993, Holroyd 1995), and Hunt (1993) stated that only 5% of the area within 15 km of the Bow River nest sites was still native. It is possible, however, that other factors such as nest collapsing, or land-use changes other than agriculture, may have been missed (Kirk and Banasch 1996).

In Alberta, prairie falcons show a high degree of fidelity to their breeding sites (Runde 1987). Such fidelity is not seen in areas where nest sites are abundant (Enderson 1964, Ogden and Hornocker 1977, Squires 1986). Although nest sites in Alberta generally do not appear to be as limited as previously reported (see *Population Size and Trends*), they may still be locally and temporarily limited as a result of the random and ongoing balance between the formation (e.g., from erosion) and loss (e.g., from slumping) of nest sites (G. Court pers. comm.). Therefore, pairs in some areas might struggle to find a more suitable territory if the habitat adjacent to their nest site is destroyed or degraded (ASRD 2012), though further studies are needed to confirm this. Overall, nest sites might not be as abundant in Alberta as elsewhere within the prairie falcon's North American range.

The conversion of native grasslands to agricultural lands forces prairie falcons to travel greater distances to find prey, and could reduce their capacity to adequately provide food for nestlings (Marzluff et al. 1997). Indeed, large hunting territories have been associated with poor reproductive success in Idaho (Marzluff et al. 1997). On the other hand, cropland agriculture practiced on a small scale with interspersed areas of native grasslands containing colonies of ground squirrels and habitat for other prey species can minimize the impact of agriculture on prairie falcons (Hunt 1993, Marzluff et al. 1997). However, landowner attitudes towards ground squirrels and availability of strychnine make the co-occurrence of ground squirrel colonies and cultivation unlikely (Proulx et al. 2010a, 2010b, and Proulx 2011).

It is unclear how livestock grazing can affect prairie falcon habitat. In New Mexico, Platt (1974) suggested that overgrazing by cattle is one of the major threats to prairie falcon population stability as it reduces the plant cover and the food resources necessary for prey species' survival. However, in southern Saskatchewan, Bylo et al. (2014) found that in upland prairie habitats, the number of ground squirrel burrows increased with increasing grazing density by livestock. Moreover, it is possible that activities such as ranching may help protect the prairie against fragmentation, because ranchers prefer large blocks of pasture land to graze cattle. Most of the native habitat adjacent to the Bow River is used for livestock grazing and contained ground squirrels during the study by Hunt (1993; G.L. Holroyd pers. comm.).

2. Energy Production

Prairie falcons have shown tolerance toward oil and gas wells located in foraging habitat (Harmata 1991, Squires et al. 1993), and in a Montana study, such energy development did not affect breeding densities nor nest site selection (Harmata 1991). However, it has been suggested that energy production activities located too close to a nesting site could negatively affect prairie falcons by causing repeated disturbance (Squires et al. 1993, J. Campbell pers. comm.); nevertheless, more study is needed.

As of 2013, an estimated 2.5% of Alberta's Grassland and Parkland natural regions, which contain the prime habitat for prairie falcon in Alberta, had been converted to energy footprint (ABMI 2015; also see *Habitat*). Between 1999 and 2016, the total area of human footprint associated with energy production increased by 1.19% and 1.1% in the Grassland and the Parkland natural regions, respectively (ABMI 2018). The ABMI (2018) defines the energy footprint

as areas where soil or vegetation has been disturbed by the creation of mine sites, peat mines, pipelines, seismic lines, transmission lines, well sites, and wind-generation facilities. Habitat loss and fragmentation have been shown to have a negative impact on prairie falcon foraging and reproductive success (see 1. *Agriculture*).

The use of wind energy is expanding in Alberta. As of December 2017, 901 wind turbines had been installed in the province, mostly concentrated in the Grassland, Parkland, and Montane natural regions of southern and central Alberta (Bradley and Neville 2010, Canadian Wind Energy Association 2018). A study from 1995 suggested that prairie falcons are not particularly susceptible to collisions with wind turbines because of their behaviour and flight characteristics (U.S. Department of Energy 1995). A review of the literature shows that prairie falcon mortalities have been documented at wind turbine facilities in low numbers (Kingsley and Whittam 2005, Smallwood and Thelander 2005). Field studies in Alberta have recorded a small number of prairie falcon mortalities at wind turbines (B.L. Downey unpubl. AEP data), or none after fifteen years of monitoring at seven project areas in Alberta (Bird Studies Canada et al. 2016; L. Takats Priestley pers. comm.). Similarly, no prairie falcon mortalities were recorded after six years of monitoring at three project areas in B.C. (Bird Studies Canada et al. 2016; L. Takats Priestley pers. comm.). Other raptor species across North America such as red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*) and golden eagle (Erickson et al. 2001), as well as Swainson's hawk (*Buteo swainsoni*) in Alberta (Bird Studies Canada et al. 2016) tend to experience turbine-related mortality more often than the prairie falcon; for the hawks and kestrel, this may simply be because they are more common than are prairie falcons (L. Takats Priestley pers. comm.).

The Wildlife Directive for Alberta Wind Energy Projects (Government of Alberta 2017) provides a directive for minimizing the effects of wind energy development and operation on wildlife; specifically, the required setback is 1000 m from a prairie falcon nest site to the closest edge of the rotor swept area. Nevertheless, windfarms can result in a direct loss of foraging habitat for the prairie falcon (Zimmerling et al. 2013), and potentially additional indirect loss of habitat as a result of disturbance of nest sites leading to nest abandonment (B.L. Downey pers. obs., L. Takats Priestley pers. comm.); in one example from Alberta, wind turbines were constructed during the breeding season within 700 m of a prairie falcon nest. The nest, which had been previously active for over 20 years, has not produced young since it was disturbed (B.L. Downey pers. obs.).

3. Urban, Rural, and Industrial Development

As of 2013, an estimated 2.3% of Alberta's Grassland and Parkland natural regions, which contain the prime habitat for prairie falcon in Alberta, had been converted to urban, rural, and industrial footprint (ABMI 2015) (see *Habitat*; ABMI 2015), and is therefore associated with the loss and fragmentation of prairie falcon habitat (see 1. *Agriculture*). Between 1999 and 2016, the total area of human footprint associated with urban, rural, and industrial development increased by 0.22% and 1.05% in the Grassland and the Parkland natural regions, respectively (ABMI 2018). The ABMI (2018) defines urban footprint as residences, buildings and disturbed vegetation

and substrate associated with urban and rural settlements (housing, shopping centres, industrial areas, golf courses, and recreation areas), as well as bare ground cleared for industrial and commercial development.

Berry et al. (1998) studied the effects of suburban expansion on winter abundance of raptors near Boulder, Colorado. Their results show that some raptors (bald eagles [*Haliaeetus leucocephalus*], ferruginous hawks, rough-legged hawks [*Buteo lagopus*] and prairie falcons) avoided urbanized areas, even when urban development covered as little as 5% to 7% of the study areas. According to ABMI (2018), as of 2016, the urban/rural/industrial footprint represented 1.5% of the Grassland Natural Region and 3.8% of the Parkland Natural Region.

In seeming contradiction to Berry et al.'s (1998) findings, prairie falcons have shown some degree of tolerance to urban development and are known to breed very near suburban areas of Alberta (J. Acorn pers. comm.). Edwards (1968) found three nests in Alberta that were located within 250 metres of occupied houses. However, residential and industrial development, when located near a nest site, can be a source of repeated disturbance and cause prairie falcons to abandon a nest site, especially when disturbance is constant below or on the cliff (Cooper and Beauchesne 2004, G. Court pers. comm.). In British Columbia, urban development below former prairie falcon nesting cliffs in the Okanagan resulted in unsuitable nesting sites (Cooper and Beauchesne 2004). In Colorado, a buffer zone of 800 metres around a prairie falcon nesting site was recommended, over which no surface occupancy (including houses) could occur (Colorado Division of Wildlife 2008).

4. Transportation and Service Corridors

Although no Alberta-based data on the effects of roads on prairie falcons are available, roads have been shown to disturb them elsewhere. Constant disturbance from heavy traffic can reduce breeding success (Boyce 1982), cause the birds to abandon a nest (Harmata et al. 1978, cited by Steenhof 2013), or even avoid otherwise suitable nesting cliffs (Platt 1974). As of 2013, transportation infrastructure occupied 2.7% of the Grassland and Parkland natural regions (ABMI 2015), contributing to the loss and fragmentation of native grasslands habitat, which can negatively affect prairie falcons in Alberta (see 1. *Agriculture*). Between 1999 and 2016, the total area of human footprint associated with transportation increased by 0.25% and 0.15% in the Grassland and the Parkland natural regions, respectively (ABMI 2018). The ABMI (2018) defines transportation footprint as railways, roadways and trails with hard surfaces (concrete, asphalt, or gravel); roads or trails without gravel or pavement; and the vegetation alongside transportation features.

Prairie falcon mortalities from electrocution or collision with power lines are relatively uncommon, but possible (Cooper and Beauchesne 2004). No electrocutions of prairie falcons were found during studies conducted in southeastern Alberta in 2003–2004 (Platt 2005) and 2016–2017 (Martin 2018). Occasionally, prairie falcons have been found dead below power poles in Mexico (Cartron et al. 2000), suggesting that electrocution and collision with power lines might be more important on the Mexican wintering grounds, where power poles are built differently.

5. Pollution

Although the prairie falcon is sensitive to organochlorine pesticides (Fyfe et al. 1988), the decline from the effects of these pollutants was not as severe as it was for the population of peregrine falcon during the 1960s and 1970s. Fyfe et al. (1969) found that prairie falcon eggs contained a wide range of pesticide levels, suggesting that some prey were heavily contaminated, whereas others (for example, ground squirrels) were not. Since the prairie falcon summer diet consists mainly of ground squirrels, which consume food at a lower trophic level (and therefore have lower levels of pesticides in their tissues) compared to the bird prey that peregrine falcons typically consume, Fyfe et al. (1978) suggested that prairie falcons were not exposed to enough organochlorine pesticides to experience severe population declines.

In the late 1960s, high concentrations of mercury were found in the liver and eggs of prairie falcons in Alberta (Fimreite et al. 1970). Mercury was ingested when falcons preyed on birds that fed on mercury-treated seeds (Alberta Environment and Sustainable Resource Development 2012). However, mercury concentrations were never high enough to cause reproductive problems at the Canadian population level, and have now declined because of restrictions on the use of mercury compounds as seed dressings (Fyfe et al. 1976).

Mortality related to lead poisoning has been observed in captive individuals of prairie falcons (Redig et al. 1980). Lead can be ingested when feeding on prey shot with lead-based ammunition (Knopper et al. 2006). The importance of lead poisoning in wild prairie falcons remains, however, unknown. A study in Montana found that lead levels in the blood of prairie falcons were below that indicative of chronic or acute toxicity (Harmata 1991). However, as shooting of ground squirrels is considered an important source of lead in the food chain (Knopper et al. 2006, Pauli and Buskirk 2007), prairie falcon individuals are at risk of being exposed.

Liquid strychnine solution for the control of ground squirrels was banned by the federal government in 1993 and replaced by ready-to-use strychnine-treated oats (Proulx et al. 2010b). However, this new method proved to be inefficient for ground squirrel control (Proulx et al. 2010a), and the use of 2% liquid strychnine was authorised again in 2007. Proulx (2011) reported subsequent field evidence of non-target and secondary poisoning from strychnine, which included different species of raptors such as the northern harrier (Circus hudsonius) and Swainson's hawk. Richardson's ground squirrels live in colonies, making them an easy target for ground squirrel control. Considering that the prairie falcon feeds primarily on Richardson's ground squirrels, one of the target species of the strychnine control program, the prairie falcon is undoubtedly at risk from exposure to secondary poisoning.

It is important to note that no toxicological testing of prairie falcons nor their eggs has been conducted in prairie Canada in over 30 years (G.L. Holroyd pers. comm.).

6. Climate Change and Severe Weather

At least one recent climatic model indicates, in the context of climate change, that rain storm frequency and intensity are likely to increase in Alberta (Kuo et al. 2015). Previous studies have shown that rain storms can reduce the breeding success of various raptor species (e.g., Dawson and Bortolotti 2000, Anctil et al. 2014). In Alberta, detrimental effects of storms on breeding success have been observed at least in peregrine falcons (G. Court pers. comm.) and burrowing owls (Fisher et al. 2015). Considering that these species inhabit the same areas as prairie falcons in Alberta, and that peregrine falcons also use very similar nest sites, an increase in the frequency and intensity of rain events is likely to have a negative impact on the breeding success of prairie falcons.

On the other hand, evaporation is expected to increase as a result of the increase in temperature, and most of the Canadian prairies should become dryer during the summer months (Schindler and Donahue 2006). In Idaho, Steenhof et al. (1999) found that extreme drought reduced ground squirrel abundance, which had negative impacts on prairie falcon breeding success.

Prairie falcon wintering habitat is expected to shift northwards, thus reducing migration distances for Alberta prairie falcons, which are at the northern limit of the species' distribution (Paprocki et al. 2014). This could be advantageous for Alberta prairie falcons, as Steenhof et al. (2005) found that individuals migrating shorter distances tended to have higher breeding success. However, climatic models also suggest that the grassland habitat will experience a northward shift in Alberta (Schneider et al. 2009), potentially reducing that advantage, but also potentially increasing habitat availability for prairie falcons. Overall, the long-term impact of climate change on prairie falcons in Alberta is complex and difficult to predict.

No modelling of the specific effects of climate change on the prairie falcon has been conducted; the ABMI has not calculated a Climate Change Vulnerability Index (CCVI) for the prairie falcon in Alberta.

7. Cliff Bank Erosion

In Alberta, many prairie falcon nest sites are holes in cliff banks (see *Habitat* section). Annual high water, extreme high-water events, or rain eventually erode the cliff face, and the cliff can slump into the river, eliminating the nest site (Banasch and Barry 1998; see Table 1). At least 9 of the 29 known sites on the South Saskatchewan River have been lost as a result of slumping (Banasch and Barry 1998). It is important to note that erosion also creates new nest sites, just as it destroys old ones, and that the rate of erosion has most likely been affected by the regulation of river flows.

8. Persecution and Harvest

Historically, persecution of prairie falcons was reported as a problem in Alberta (Van Tighem 1967, Dekker 1985). Currently, the situation has improved greatly, probably partly because of the increased public awareness of the importance of raptors in our ecosystems (Desmarchelier et al. 2010). For example, the Alberta Bird of Prey Foundation, a licensed raptor rescue and conservation organization, has not received any prairie falcons, dead or injured, that were shot over the past 30 years (Alberta Bird of Prey Foundation pers. comm.).

Although prairie falcons can be legally harvested as nestlings, immatures or adults for falconry in Alberta, very few are taken each year in the province. Between 1987 and 2017, 41 prairie falcons were harvested from the wild in Alberta, 14 of which were released back into the wild (G. Court unpubl. data). In contrast, the prairie falcon is the second most commonly harvested bird of prey in the United States (Steenhof 2013), and it is possible that some individuals are removed from the Alberta breeding population if they are harvested on their wintering grounds. Nevertheless, the impact of legal harvest on the Alberta prairie falcon population is thought to be minimal (G. Court pers. comm.).

9. Prey Poisoning

Richardson's ground squirrel, the prairie falcon's main prey during the breeding season, is considered an agricultural pest because of the damage it can cause to crops (Proulx 2010), and farmers have been trying to control their populations since cultivation of the prairies began. Following a recent outbreak in the Canadian Prairies (Proulx 2010), the use of 2% liquid strychnine was authorized again in 2007 (Proulx et al. 2010a). Such poison can remove over 70% of adults and juvenile ground squirrels in spring and summer (Proulx et al. 2010a). Because no population monitoring program for Richardson's ground squirrel exists, it is impossible to assess population trends for this species. However, the recent use of 2% liquid strychnine, combined with other control methods (e.g., shooting, fumigation) has likely reduced their abundance. The impact of fewer prey on the prairie falcon population in Alberta remains unknown.

10. Interspecific Competition

Because they share similar nesting habitats, prairie falcons and peregrine falcons may compete for nest sites (Dekker and Corrigan 2006). From the 1960s until the 1990s, this competition was nearly non-existent in Alberta, as peregrine falcons were extirpated from the south of the province as a result of the use of organochlorine pesticides (Holroyd and Banasch 1996). However, owing to recovery efforts, peregrine falcon populations in North America have gradually recovered and 28 pairs were found in southern Alberta in 2016 (G. Court pers. comm.). Observations in the Red Deer River valley suggest that when competing for nest sites, peregrine falcons are the dominant aggressors and could possibly evict prairie falcons from their nest sites (Dekker and Corrigan 2006). As the peregrine falcon population continues to grow in Alberta, competition for nest sites could increase in areas where both species occur.

Prairie falcons also compete with other species for food resources, and in winter, prey theft by other species such as bald eagle and gyrfalcon (*Falco rusticolus*) is frequently observed by birdwatchers (Dekker and Lange 2001, J. Acorn pers. comm.). During the breeding period, species such as Swainson's hawk and ferruginous hawk (*Buteo regalis*) feed widely on ground squirrels (Bechard et al. 2010, Ng et al. 2017) and are likely to compete indirectly with prairie falcon for food. The impact of interspecific competition on the prairie falcon population in Alberta is unknown.

Status Designations

1. Alberta

The prairie falcon is currently listed as a Bird of Prey under Alberta's *Wildlife Act* (Government of Alberta 2018).

The 2000, 2005, 2010 and 2015 *General Status of Alberta Wild Species* ranked the prairie falcon as *Sensitive* because of concerns about adequate ground squirrel prey base and availability of secure nest sites in its core range in southern Alberta, as well as a perceived reduction in its northern range (ASRD 2012, AEP 2017). Because of the concerns at the time, in 2003 the Scientific Subcommittee (SSC) of Alberta's Endangered Species Conservation Committee (ESCC) assessed the prairie falcon as a *Species of Special Concern* (AEP 2014). Although it qualified for *Threatened* status because of its small population size, it was downgraded to *Species of Special Concern* because the SSC considered that immigration of individuals from neighboring jurisdictions (mostly Montana and Saskatchewan) would reduce the risk of extinction for prairie falcons in Alberta (R. Gutsell pers. comm.).

The Canadian Endangered Species Conservation Council (CESCC 2016) ranks the Alberta population as S3B,S4N,S3M (*Vulnerable* during breeding and migration, *Apparently Secure* during non-breeding).

2. Other Areas

Historically, prairie falcons were identified as an endangered species in Canada because of their restricted range (Godfrey 1970). However, beginning in 1978, the COSEWIC listed the prairie falcon as "Not in any category" (Woodsworth and Freemark 1978), and in 1982 the status changed to *Not At Risk* because of increasing, or stable, populations (Woodsworth and Freemark 1981). The last COSEWIC assessment for the prairie falcon confirmed the species as *Not At Risk* in Canada because of a lack of evidence of overall decline or population change (Kirk and Banasch 1996; COSEWIC 2018). Because of the lack of recent data, and the fact that the species is at the northern limits of its range, Kirk and Banasch (1996) suggested the prairie falcon is a species of long-term concern and should be monitored.

In Canada, the species is ranked nationally *Vulnerable* during breeding and migration and *Apparently Secure* during non-breeding (N3B,N4N,N3M) (CESCC 2016). In British Columbia, the prairie falcon is ranked S2 (*Imperiled*) and is currently on the provincial Red List, principally because of low numbers of breeding pairs, and loss of foraging habitat (CESCC 2016, B.C. Conservation Data Centre 2017). In 2001, the prairie falcon was ranked as S4 in Saskatchewan, suggesting populations are apparently secure, but may be of long-term concern (Saskatchewan Conservation Data Centre 2001). Currently, the species is ranked as S3B,S3N,S3M (*Vulnerable*

during breeding, non-breeding and migration) in Saskatchewan, meaning at moderate risk of local extinction because of a restricted range, few populations, recent and widespread declines, threats, or other factors (CESCC 2016, Saskatchewan Conservation data Centre 2017).

NatureServe (2018) ranks this species as Secure during breeding and non-breeding nationally in the United States (N5B,N5N) (although it is worth noting that this rank was assigned in 1997), and as *Secure* globally (G5) because of its large range in western and central North America and its mostly stable population trends, although there have been some local declines. In Montana and Idaho, the breeding populations are ranked *Apparently Secure* (S4).

Recent Management and Research in Alberta

1. Habitat Conservation and Management

In the past, management actions in Alberta have included a prairie falcon re-introduction program at Fish Creek Provincial Park (Depper 1988), the fostering of chicks (Fyfe et al. 1978, Fyfe 1989), the rehabilitation of injured birds at certified centres, and the construction of artificial nest holes to replace nest sites lost from natural causes and from human disturbance (Paul and Steele 1976, Fyfe 1989, J. Campbell pers. comm.). During the 1970s, Canadian Wildlife Service personnel dug new nest holes and ledges in the cliffs adjacent to the Bassano Reservoir. This action resulted in 12–13 pairs of prairie falcons using the cliff sites to raise young. All of these sites slumped into the reservoir (Paton 2002); however, data from J. Campbell's survey show that a few pairs (3 to 8 depending on year) still use other sites by the reservoir for nesting (Table 1).

During the 1980s and 1990s, a monitoring program was established to evaluate the effects of dam construction on raptors, and the effectiveness of artificial nest sites to mitigate for the loss of nest sites at the Oldman River Dam (Young 1988, Fyfe 1989). For most of the 10 years of monitoring at the Oldman River Reservoir, approximately 50% of the nest sites occupied within the study area were located in artificial or improved sites (Paton 1999b). In 1993, six Wildlife Control Areas (public exclusion areas designated under Alberta's *Wildlife Act*) were established along the Oldman River Reservoir to specifically protect birds of prey (Fyfe 1994). According to J. Campbell's data, some of the sites located in the Wildlife Control Areas are still used by prairie falcons today, though not every year.

In the early 1990s, through the Permanent Cover Program of Agriculture Canada, many landowners committed to maintain parts of their land in permanent cover for a 10- or 21-year period. Overall, 2,208 km^2 were removed from annual cropping in Alberta (Vaisey et al. 2000), which helped maintain quality habitat for grassland bird species, such as the prairie falcon (McMaster and Davis 2001).

Currently, there are no management or conservation programs focusing exclusively on prairie falcons in Alberta. As discussed above, the conservation of this species in Alberta depends on the conservation of natural grassland habitat and thus its foraging habitat. Several programs are in place to protect the remaining native grasslands, such as the MULTISAR program. Through MULTISAR, Alberta Conservation Association has partnered with Alberta Environment and Parks, the Prairie Conservation Forum, landholders and other organizations to conserve multiple species at risk at the landscape level in southern Alberta. The prairie falcon is one of the species targeted by the MULTISAR program, which promotes conservation through voluntary participation of landowners and lease holders to implement beneficial management practices on native prairie habitat (MULTISAR 2017). Since it was established in 2002, MULTISAR has implemented 155 habitat enhancement projects on over 1,343 km^2 of land (MULTISAR 2017). Currently, they

use Habitat Conservation Strategies, education, outreach and awareness programs, as well as research, monitoring and evaluation of habitat management.

Other stewardship programs in Alberta could indirectly conserve prairie falcon habitat. The Prairie Habitat Joint Venture (PHJV) is a partnership between governments and organizations of Alberta, Saskatchewan and Manitoba, created under the North American Waterfowl Management Plan (NAWMP). The PHJV is working cooperatively with farmers and other landowners to conserve grassland habitats, as well as providing guidance for provincial partners in conservation planning, program implementation and policy initiatives, with the goal to restore and prevent further loss of native lands (Alberta NAWMP Partnership Management Committee 2008).

Operation Grassland Community of the Alberta Fish and Game Association, is a program where the members work together towards sustainable ranching and farming practices, as well as conservation of the prairie habitat and its wildlife. The latest Prairie Conservation Action Plan of the Prairie Conservation Forum (2016) aims at completing inventories and assessments of biodiversity, sharing knowledge, and promoting prairie conservation and stewardship of native prairie and parkland ecosystems. The Nature Conservancy of Canada (2017) and their Natural Areas Conservation Program has also contributed to the conservation of more than 460 km^2 (113,000 acres) of grassland habitat across Canada in the last decade.

2. Research

Past research included the sampling of eggs for pesticides and mercury (Fyfe et al. 1969, Fimreite et al. 1970; see *Threats*), an assessment of the foraging habitat of the prairie falcon using Landsat imagery (Usher 1993), and a Master of Science thesis studying the diet and habitat use of nesting prairie falcons in an agricultural landscape in southern Alberta (Hunt 1993). Hunt (1993) determined that ground squirrel colonies near nest sites are very important. The average distance over which falcons with radio transmitters delivered prey was 6 km for ground squirrels and 4 km for bird prey. Because prairie falcons are ground squirrel specialists in summer, it is impossible to effectively manage falcons without managing their prey and habitat.

Between 2008 and 2010 a cultivated field of 0.57 km^2 within the mixed grass prairie of southeastern Alberta was restored with native grasses and silver sagebrush plugs (Downey et al. 2013). Species diversity on the site increased from being dominated by horned larks to 13 species using the land within three years, including Sprague's pipit (*Anthus spragueii*) and chestnut-collared longspur (*Calcarius ornatus*), two native grassland specialists listed as Threatened under Canada's *Species at Risk Act*. These results suggest that it is possible to restore native grasslands, which is prime habitat for prairie falcons in Alberta.

Overall, besides the limited population surveys included in this report and non-targeted grassland habitat conservation measures discussed above, none of the more ambitious research and population monitoring actions that were recommended in the most recent prairie falcon conservation management plan (Alberta Environment and Sustainable Resource Development 2012) have been undertaken.

Synthesis

Currently, the most important prairie falcon breeding survey in the province spans 32 years and includes an average of 53 known nest sites checked every year. Based on the data from this survey, occupancy and productivity appear to have remained stable between 1985 and 2017. This long-term survey, however, covers only a relatively small area of the species range in Alberta and might not be representative of the provincial situation; occupancy and productivity are likely similar in other parts of the Grassland Natural Region, but may be different in other natural regions. Since the 1970s, there has been no targeted monitoring of prairie falcons across Alberta. Because of this, the provincial population size remains uncertain and trends are difficult to evaluate. The prairie falcon in Alberta would therefore strongly benefit from province-wide monitoring effort, which would allow biologists to accurately identify population size and trends. Such surveys should also allow detection of local declines, and therefore identify areas where management actions are most needed.

Although the prairie falcon population in Alberta appears stable, protection of nest sites and adjacent native grasslands should be a priority for this naturally low-density species. The prairie falcon relies strongly on native grasslands where it can find its main summer prey, ground squirrels, and its main winter prey, horned larks, in sufficient numbers. Thus, the loss and fragmentation of native grassland habitats to anthropogenic disturbances (e.g., agriculture, road and urban development) is likely the most important threat to prairie falcons in Alberta. Almost two-thirds of Alberta's prairies (Grassland and Parkland natural regions) has been converted to human footprint, and the anthropogenic pressure on this important habitat is still occurring. It is undeniable that a resilient prairie falcon population in Alberta is strongly linked to the conservation of native grassland habitats.

Research efforts should focus on the prairie falcon's level of tolerance for disturbance on nesting cliffs, especially in urban and semi-urban areas. The species would also benefit from research on other factors, such as pollution and climate change, that could directly, or indirectly (i.e., through their prey base or nest site availability), affect prairie falcon survival and reproductive success. Understanding how these factors are influencing survival and reproductive success will facilitate the implementation of management policies that aim to conserve the prairie falcon and its habitat in Alberta.

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Appendices

Appendix 1
Definitions of status ranks and legal designations.

A. General Status of Alberta Wild Species Categories
(used in 2000, 2005, 2010, and 2015 General Status exercises)
(Government of Alberta 2011)

Rank	Definitions
At Risk	Any species known to be *At Risk* after formal detailed status assessment and legal designation as *Endangered* or *Threatened* in Alberta.
May Be At Risk	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Any species that is not *At Risk, May Be At Risk* or *Sensitive*.
Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	Any species that has not been examined during this exercise.
Exotic/Alien	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	Any species no longer thought to be present in Alberta (Extirpated) or no longer believed to be present anywhere in the world (Extinct).
Accidental/ Vagrant	Any species occurring infrequently and unpredictably in Alberta, i.e., outside its usual range.

B. Alberta Species at Risk Formal Status Designations

Species designated as Endangered under Alberta's *Wildlife Act* include those listed as *Endangered* or *Threatened* in the Wildlife Regulation (in bold).

Rank	Definitions
Endangered	**A species facing imminent extirpation or extinction.**
Threatened	**A species likely to become endangered if limiting factors are not reversed.**
Species of Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2017)

Rank	Definitions
Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation or extinction.
Special Concern	A species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Not at Risk	A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient	A category that applies when the available information is insufficient to (a) resolve a wildlife species' eligibility for assessment, or (b) permit an assessment of the wildlife species' risk of extinction.

D. United States *Endangered Species Act* (U.S. Fish & Wildlife Service 2005)

Rank	Definitions
Endangered	Any species that is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

E. Heritage Status Ranks: Subnational (S) ranks in Alberta (after Alberta Conservation Information Management System 2017)

Rank	Definitions
S1	Known from five or fewer occurrences or especially vulnerable to extirpation because of other factors.
S2	Known from 20 or fewer occurrences or vulnerable to extirpation because of other factors.
S3	Known from 100 or fewer occurrences, or somewhat vulnerable due to other factors, such as restricted range, relatively small population sizes, or other factors.
S4	Apparently secure. Taxon is uncommon but not rare. Potentially some cause for long-term concern because of declines or other factors.
S5	Secure. Taxon is common, widespread, and abundant.
SX	Taxon is believed to be extirpated from the province. Not located despite intensive searches of historical sites and other appropriate habitat. Virtually no likelihood that it will be rediscovered.
SH	Known from only historical records but still some hope of rediscovery. Evidence that the taxon may no longer be present but not enough to state this with certainty.
S?	Not yet ranked, or rank tentatively assigned.
S#S#	A numeric range rank is used to indicate any range of uncertainty about the status of the taxon. Example: S2S3 or S1S3. Ranges cannot skip more than two ranks.

Rank	Definitions
SU	Taxon is currently unrankable because of a lack of information or substantially conflicting information. Example: native versus non-native status not resolved.
SNR	Not ranked. Conservation status not yet assessed.
SNA	Not applicable. A conservation status rank is not applicable because the species or ecosystem is not a suitable target for conservation activities. Example: introduced species.
S#?	Inexact numeric rank. Applied when a specific rank is most likely appropriate but for which some conflicting information or unresolved questions remain.

Global (G), National (N) and other Subnational (S) ranks
(after NatureServe 2016)

Rank	Definitions
G1/N1/S1	Critically Imperiled. At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2/N2/S2	Imperiled. At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3/N3/S3	Vulnerable. At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4/N4/S4	Apparently Secure. At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5/N5/S5	Secure. At very low risk or extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GX/NX/SX	Presumed Extinct/Extirpated. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood of rediscovery.

Rank	Definitions
GH/NH/SH	Possibly Extinct/Extirpated. Known from only historical occurrences but some hope of rediscovery.
G?/N?/S?	Inexact Numeric Rank. Denotes inexact numeric rank.
G#G#/N#N#/ S#S#	A numeric range rank (e.g., G2G3, G1G3) is used to indicate the range of uncertainty about the exact status of a taxon or ecosystem type. Ranges cannot skip more than two ranks.
GU/NU/SU	Unrankable. Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.
GNR/NNR/SNR	Unranked. Conservation status not yet assessed.
GNA/NNA/SNA	Not Applicable. A conservation status rank is not applicable because the species is not a suitable target for conservation activities

Appendix 2
Data-sources summary table

FWMIS = Fisheries and Wildlife Management Information System

Data Source	Project Name	Type of Location Data	Type(s) of Additional Information	Number of Observations	Time Span
FWMIS	(data repository for multiple projects)	Lat - Long	Some projects include breeding evidence in their comments	15,966 (total for entire database	1967–2017
John Campbell	Surveys and banding	Lat - Long	Nest occupancy, breeding success	2400	1985–2017
Gordon Court	N/A	Lat - Long	Nesting sites	4	1978–2015
eBird	Global database	Lat - Long	Breeding evidence	74,643	1895–2017 (used only data from 2002 onwards)

Appendix 3
Technical Summary

A summary of information contained within this report and used by the Scientific Subcommittee of Alberta's Endangered Species Conservation Committee for the purpose of status assessment based on International Union for Conservation of Nature criteria. For definitions of terms used in this technical summary, go to: www.iucnredlist.org/technical-documents/categories-and-criteria and www.cosepac.gc.ca/eng/sct2/sct2_6_e.cfm

Genus species: *Falco mexicanus*
Common name: Prairie Falcon

Range of occurrence in Alberta: Nesting areas are primarily located in badlands, on cliffs along the Bow, Red Deer, Milk, South Saskatchewan, and Oldman rivers and their tributaries, and along coulees. Recent observations also confirmed nest sites of prairie falcon along the North Saskatchewan, Pembina, and Athabasca rivers, as well as a site along the Peace River, which represents the northernmost known breeding site for the species in Alberta, thus expanding the known range of the species. Most prairie falcon nest sites are within the Grassland and southern portion of the Parkland natural regions; about 10 nest sites have been observed in the Rocky Mountain Natural Region in southwestern Alberta.

Demographic Information	
Generation time (usually average age of parents in the population) *See Biology section.*	6.4 yrs
Is there an observed continuing decline in number of mature individuals? Partial dataset indicates nest site occupancy and productivity have remained constant over time. *See Population Size and Trends section, and Figures 5 & 6.*	No
Estimated percent of continuing decline in total number of mature individuals within 2 generations. Partial dataset indicates nest site occupancy and productivity have remained constant over time. *See Population Size and Trends section, and Figures 5 & 6.*	N/A

Demographic Information	
Observed percent reduction (or increase) in total number of mature individuals over the last 3 generations. Partial dataset indicates nest site occupancy and productivity have remained constant over time. *See Population Size and Trends section, and Figures 5 & 6.*	N/A
Projected or suspected] percent reduction (or increase) in total number of mature individuals over the next 3 generations. Partial dataset indicates nest site occupancy and productivity have remained constant over time; no change is projected for the future. *See Population Size and Trends section, and Figures 5 & 6.*	N/A
Observed percent reduction (or increase) in total number of mature individuals over any 3-generation period, over a time period including both the past and the future. Partial dataset indicates nest site occupancy and productivity have remained constant over time and no change is projected for the future. *See Population Size and Trends section, and Figures 5 & 6.*	N/A
Are the causes of the decline clearly reversible and understood and ceased? *See Habitat section and Threats section.*	Not declining
Are there extreme fluctuations (i.e., exceeding one order of magnitude) in number of mature individuals? There is a range of estimates available, and population size may increase and decrease somewhat over time; however, there is no evidence for extreme fluctuation. *See Population Size and Trends section.*	No

Extent and Occupancy Information	
Estimated extent of occurrence *See Distribution (1. Alberta) section.*	129,179 km²
Area of occupancy (AO) Based on known prairie falcon breeding locations after 2002. *See Distribution (1. Alberta) section.*	440 km²
Is the total population severely fragmented (i.e., most individuals found in small and isolated subpopulations)? Prairie falcons nest along rivers, so their breeding distribution is naturally discontinuous, but the Alberta population is not considered severely fragmented. *See Distribution and Habitat sections*	No
Number of locations The most important threat faced by the prairie falcon, native grassland conversion, is still occurring, but is more localized than before. Therefore, at the moment, grassland conversion cannot affect a large portion of the population in a single event. This suggests that the number of locations is not small. *See Threats section.*	Unknown, but certainly more than 10
Is there an observed, inferred, or projected continuing decline in extent of occurrence? Overall distribution of prairie falcons in Alberta appears to have remained stable, although slight annual variations likely exist. Moreover, recent discovery of northern breeding sites (e.g., Peace River) has increased the known range in Alberta**.** *See Distribution (1. Alberta) section.*	Unlikely

Extent and Occupancy Information	
Is there an observed, inferred, or projected continuing decline in index of area of occupancy? Changes in area of occupancy likely reflect changes in survey effort; however, there is no indication that prairie falcons have disappeared entirely from certain areas. *See Distribution (1. Alberta) section*	Unlikely
Is there an observed, inferred, or projected continuing decline in number of subpopulations? Some degree of geographical isolation exists between the major breeding areas in Alberta, but it is unlikely that these represent actual subpopulations. *See Distribution (1. Alberta) section.*	N/A
Is there an observed, inferred, or projected continuing decline in number of locations? *See Distribution (1. Alberta) and Threats sections.*	No
Is there an observed, inferred, or projected continuing decline in area, and quality of habitat? Continuing decline of native grassland habitat area and quality. Between 1999 and 2016, the percent of native grassland converted to human footprint increased by 2.5% and 2.4% for the Grassland and Parkland natural regions of Alberta, respectively. *See Habitat and Threats sections*	Yes
Are there extreme fluctuations in number of subpopulations? Population not likely structured into separate subpopulations. *See Distribution (1. Alberta) section.*	N/A
Are there extreme fluctuations in number of locations? *See Distribution (1. Alberta) and Threats sections.*	No

Extent and Occupancy Information	
Are there extreme fluctuations in extent of occurrence? *See Distribution (1. Alberta) section.*	No
Are there extreme fluctuations in index of area of occupancy? Any apparent changes in area of occupancy likely reflect changes in survey effort. *See Distribution (1. Alberta) section.*	No

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total It is impossible to provide an accurate number of mature individuals as surveys necessary to estimate provincial population size have not been realized. Since occupancy and productivity appear to have remained stable, the minimum number of breeding pairs of prairie falcon estimated by Paton (2002) is likely still valid. As this estimate did not include breeding sites from northern river basins, such as the North Saskatchewan, Pembina and Athabasca rivers, the minimum number of breeding pairs of prairie falcon across its entire range in Alberta is probably closer to 200. *See Population Size and Trends (1. Alberta) section.*	A minimum of approximately 400 mature individuals, based on estimate of 200 pairs

Quantitative Analysis

Population	N Mature Individuals
Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not calculated

Threats

(Actual or imminent threats, to subpopulations or habitats. List from highest to least impact, as per IUCN Threats Calculator [http://www.iucnredlist.org/technical-documents/classification-schemes/threats-classification-scheme]. Rate immediacy, scope and severity.)

See Threats section.

Loss and fragmentation of native grasslands through agriculture, road, energy and urban development. Other threats include contamination by pesticides, rodenticides and heavy metals, the loss of nesting sites (e.g., slumping of cliff) at a rate that exceeds creation of new sites, human persecution or harvesting, climate change and interspecific competition.

Rescue Effect (immigration from outside Alberta)

Status of outside population(s)? Possibly increasing over global range (Breeding Bird Survey and Christmas Bird Count data); stable but low population levels in British Columbia and Saskatchewan. Considered common and stable in Montana. **S***ee Population Size and Trends (3. Rescue Potential) and Status Designation sections.*	
Is immigration known or possible? *See Population Size and Trends (3. Rescue Potential) section.*	Probable
Would immigrants be adapted to survive in Alberta? *See Population Size and Trends (3. Rescue Potential) section.*	Yes
Is there sufficient habitat for immigrants in Alberta? Because only 50% of nests sites are occupied on average each year, it appears that, at least within one study area, the number of nest sites might not be as limiting as has been suggested. However, nest sites may still be locally and temporarily limited as a result of the random and ongoing balance between the formation (e.g., from erosion) and loss (e.g., from slumping) of nest sites. *See Habitat and Threats sections*	Currently yes, but suitable foraging habitat (native grasslands) is likely limited

Is rescue from outside populations likely? Montana is the most likely source of migrants as the species is considered common and stable. Immigration from Saskatchewan is also possible, but the population size is lower. *See Population Size and Trends (3. Rescue Potential) section.*	Very likely, but probably limited in quantity.

Current Status

Provincial: *Species of Special Concern* since 2003 (AEP 2014); *Sensitive* (The General Status of Alberta Wild Species 2015); protected under *Wildlife Act* as a *Bird of Prey* (Government of Alberta 2018).

National: *Not At Risk* (COSEWIC); N3B,N4N,N3M in Canada (NatureServe 2018)

Elsewhere: B.C.: *Imperiled* (S2; B.C. Conservation Data Centre); Saskatchewan: *Vulnerable* (S3B,S3N,S3M; Saskatchewan Conservation Data Centre); Montana: *Apparently Secure* (S4; NatureServe); Idaho: breeding population *Apparently Secure* (S4B; NatureServe), wintering population *Vulnerable* (S3N; NatureServe).

See Status Designations section.

Authors of Technical Summary: Alexandre Anctil and Hilde Johansen

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