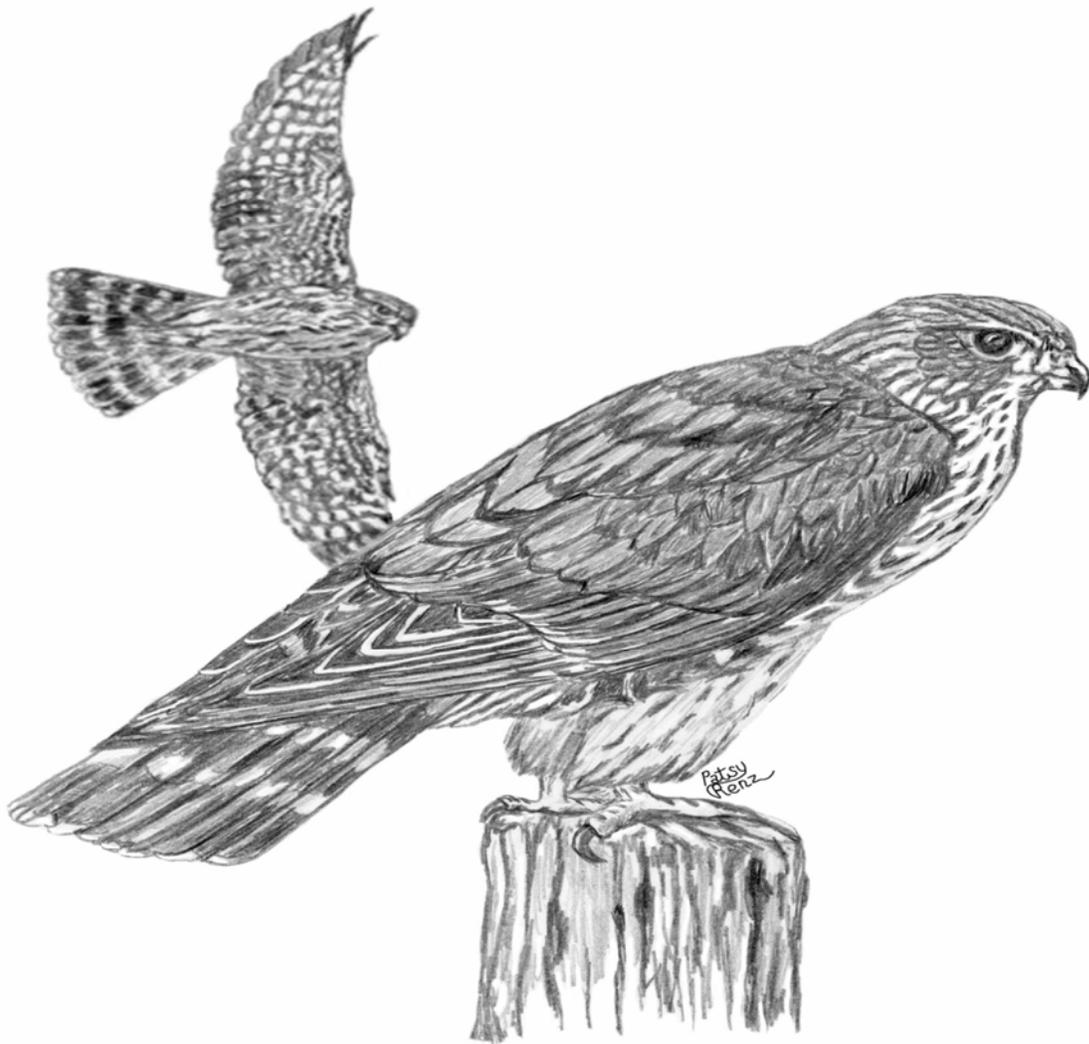


EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

MERLIN



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

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Species for which syntheses are available:

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

EFFECTS OF MANAGEMENT PRACTICES ON GRASSLAND BIRDS:

MERLIN

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ORGANIZATION AND FEATURES OF THIS SPECIES ACCOUNT

Information on the habitat requirements and effects of habitat management on grassland birds were summarized from information in more than 5,500 published and unpublished papers. A *range map* is provided to indicate the breeding, year-round, and nonbreeding ranges in the United States and southern Canada. Although birds frequently are observed outside the breeding range indicated, the maps are intended to show areas where managers might concentrate their attention. It may be ineffectual to manage habitat at a site for a species that rarely occurs in an area. The species account begins with a brief *capsule statement*, which provides the fundamental components or keys to management for the species. A section on *breeding range* outlines the current breeding distribution of the species in North America. The *suitable habitat* section describes the breeding habitat and occasionally microhabitat characteristics of the species, especially those habitats that occur in the Great Plains. Details on habitat and microhabitat requirements often provide clues to how a species will respond to a particular management practice. A *table* near the end of the account complements the section on suitable habitat, and lists the specific habitat characteristics for the species by individual studies. A special section on *prey habitat* is included for those predatory species that have more specific prey requirements. The *area requirements* section provides details on territory and home range sizes, minimum area requirements, and the effects of patch size, edges, and other landscape and habitat features on abundance and productivity. It may be futile to manage a small block of suitable habitat for a species that has minimum area requirements that are larger than the area being managed. The Brown-headed Cowbird (*Molothrus ater*) is an obligate brood parasite of many grassland birds. The section on *cowbird brood parasitism* summarizes rates of cowbird parasitism, host responses to parasitism, and factors that influence parasitism, such as nest concealment and host density. The impact of management depends, in part, upon a species' nesting phenology and biology. The section on *breeding-season phenology and site fidelity* includes details on spring arrival and fall departure for migratory populations in the Great Plains, peak breeding periods, the tendency to renest after nest failure or success, and the propensity to return to a previous breeding site. The duration and timing of breeding varies among regions and years. *Species' response to management* summarizes the current knowledge and major findings in the literature on the effects of different management practices on the species. The section on *management recommendations* complements the previous section and summarizes specific recommendations for habitat management provided in the literature. If management recommendations differ in different portions of the species' breeding range, recommendations are given separately by region. The *literature cited* contains references to published and unpublished literature on the management effects and habitat requirements of the species. This section is not meant to be a complete bibliography; a searchable, annotated bibliography of published and unpublished papers dealing with habitat needs of grassland birds and their responses to habitat management is posted at the Web site mentioned below.

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

Merlin
(*Falco columbarius*)

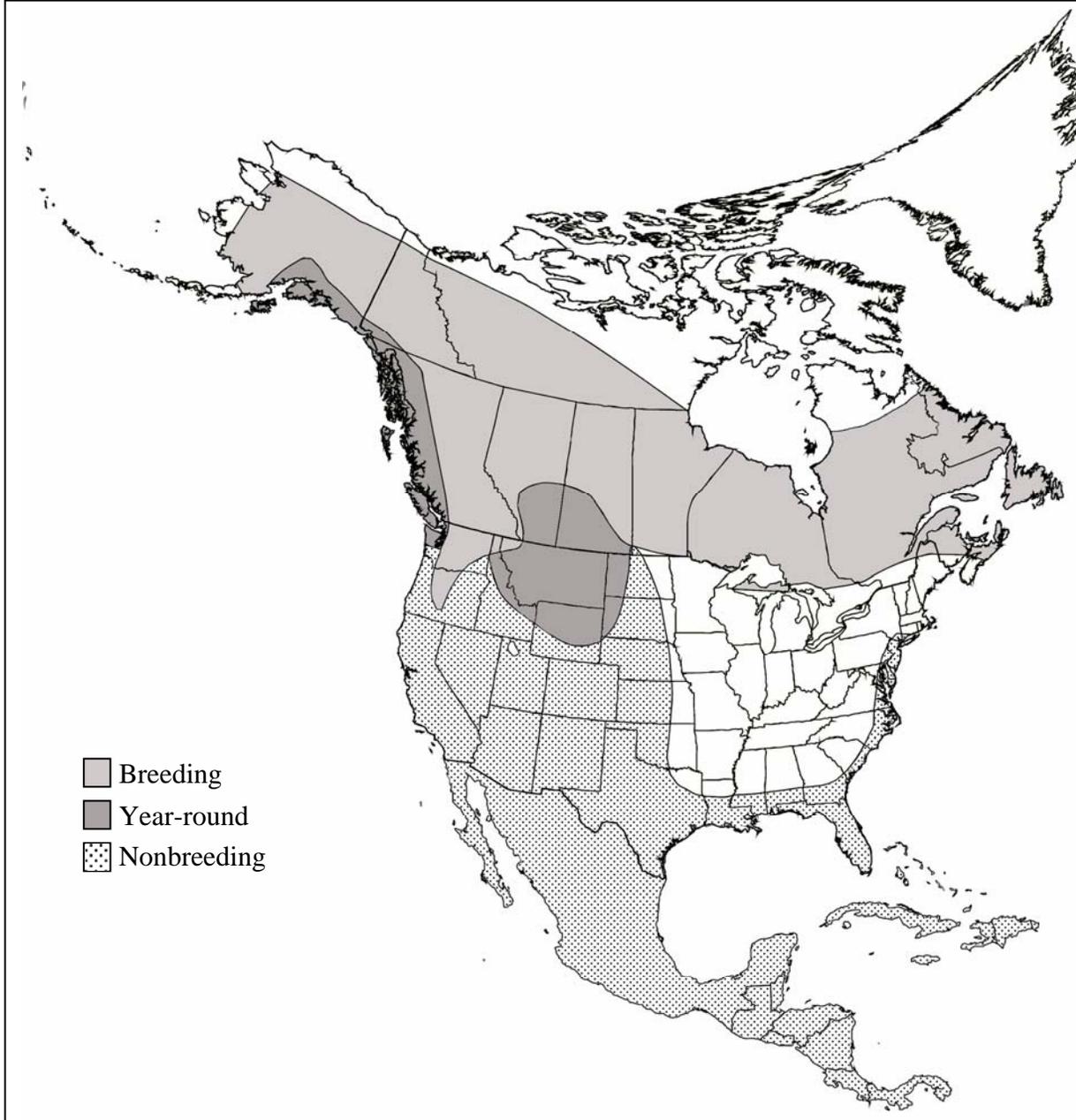


Figure. Distribution of Merlin in North America. Map adapted from Sodhi et al. (1993), used with permission of the authors.

Key to management is maintaining an interspersion of open grasslands for hunting with groves of deciduous or coniferous trees for nesting. Optimal habitat is in rural areas at least 400 m from human disturbance.

Breeding range:

Merlins breed from the northern limits of the tree line from northern Alaska to northern

Newfoundland and Labrador south throughout most of Canada (except the northeastern Northwest Territories and northern Quebec) as well as western Washington, Idaho, Montana, Wyoming, North Dakota, South Dakota, and northern Maine (National Geographic Society 1999). (See figure for breeding, year-round, and nonbreeding ranges of Merlin in the United States and southern Canada.)

Three Merlin subspecies are found in North America (Temple 1972). This account primarily deals with the Richardson's Merlin, *F. c. richardsonii*, which breeds in the northern Great Plains and prairie parkland. The Black subspecies, *F. c. suckleyi*, breeds in the dense forested areas of the Pacific Northwest, from western Oregon north to southern Alaska. The Taiga subspecies, *F. c. columbarius*, breeds in the taiga forests from Maine to northern Canada and Alaska, including the northern Rocky Mountain forest region of Idaho, western Montana, western Wyoming, and western Alberta.

Suitable habitat:

In the Great Plains, Merlins prefer open grasslands for hunting and native or planted tree groves for nesting. They inhabit shortgrass and mixed-grass prairies, tame grasslands, pastures, hayland, shrubsteppe, woodland, wetland, cropland, and urban habitats, especially where these habitats have adjacent riparian woodland (Bent 1961; Fox 1964; Ellis 1976; Hodson 1976, 1978; Oliphant and Thompson 1976; Oliphant and McTaggart 1977; Smith 1978; Houston and Schmidt 1981; Young 1981; Becker 1984; Oliphant and Haug 1985; Becker and Sieg 1988; Dekker 1988; Warkentin and James 1988; Sieg and Becker 1990; Sodhi 1991; Sodhi et al. 1992; Houston and Hodson 1997; MOU 2002). Historically, Merlins inhabited rolling plains that contained small groves of *Populus* (cottonwoods, aspen) and other deciduous trees that were used for nesting (Bent 1961). During the 1970's, Richardson's Merlins began colonizing urban residential and industrial areas in some Canadian cities, most notably Saskatoon (Oliphant 1974, Sodhi et al. 1992) and Regina (Sodhi et al. 1993), Saskatchewan, and Edmonton, Alberta (Smith 1978), following the influx of nesting American Crows (*Corvus brachyrhynchos*) and Black-billed Magpies (*Pica hudsonia*) (Houston and Schmidt 1981), whose old nests are used by Merlins. More recent nesting records were reported in Grand Forks, Minot, Jamestown, and Dickinson, North Dakota (Martin 1999, 2000), and Minneapolis, Minnesota (MOU 2002).

Grasslands are the primary component of Merlin foraging habitat. Merlins require an interspersed of grassland and tree groves to meet the food requirements of pairs and their young (Hodson 1976). Foraging areas are commonly composed of at least 50% grassland. Merlins prefer native grasslands, probably because native vegetation supports the passerine species upon which Merlins prey (Hodson 1976). The conversion of native grassland to cropland has destroyed much of the traditional Merlin habitat in southwestern Saskatchewan (Hodson 1976). In Alberta, hunting ranges adjacent to 40 nest sites that were occupied during a 6-yr period contained an average of 78% grassland (Hodson 1976). In southwestern Montana, three radio-tagged male Merlins utilized five habitat types: shortgrass prairie, riparian, sagebrush (*Artemisia* spp.), cropland (grain and fallow fields), hayfields, and ponderosa pine (*Pinus ponderosa*) woodland (Becker 1984). The majority of radio locations were in sagebrush habitat (53.9%), followed by grasslands (15.6%), ponderosa pine (12%), riparian (9.9%), and cropland (8.5%). The three Merlins fed primarily on birds associated with grassland habitat, suggesting that the use of grasslands by Merlins was under-represented by radio-locations, probably because hunting perches were lacking in grasslands.

Wintering areas tend to include open habitats, including open plains and cropland where

small passerines winter in large flocks; coastal flats and saltwater marshes where sandpipers and other small shorebirds concentrate; or urban areas where House Sparrows (*Passer domesticus*), Bohemian Waxwings (*Bombycilla garrulus*), and other small birds are prevalent (Cade 1982). Little is known about winter habitat use in rural parts of the Great Plains because studies have largely focused on urban areas. Merlins spend more time than expected in industrial areas where prey is abundant (Warkentin and Oliphant 1990).

Throughout southern Saskatchewan, Merlin nest sites were located along major river systems (Oliphant and McTaggart 1977). Shelterbelts and groves of deciduous trees on tame grassland also were used by nesting Merlins (Fox 1964). In southeastern Montana, ponderosa pine woodland provided nesting habitat and some hunting habitat, as well as perches and night roosts (Becker 1984). Nest sites usually were located on a south-facing slope in an area with reduced tree density within a short distance of open grassland habitat where Merlins hunted (Becker 1984).

Merlins also nest in cities. Urban habitats in Saskatoon include residential yards, city parks, cemeteries, and university cropland and livestock areas (Oliphant and McTaggart 1977, Sodhi 1991). Male Merlins and some females generally avoided cropland, preferring residential areas, city parks, and grassland habitat both inside and outside of the city during the incubation, nestling, or post-fledging periods (Sodhi 1991). Merlins probably avoided cropland because this habitat had the lowest prey abundance among available habitats. In Edmonton, Merlins utilized river valley and upland nesting habitats (Smith 1978), and they eventually began nesting in white spruce (*Picea glauca*) planted in the river floodplain after they grew to a height of ≥ 15 m tall and supported old American Crow nests in their branches. However, only six locations upland from the river valley contained this nesting habitat, mainly in parks and cemeteries (Smith 1978). During one summer, three Merlin pairs nested in Minneapolis, Minnesota, and four active nests were found the following summer (MOU 2002).

As with other falcon (*Falco* spp.) species, Merlins do not build their own nests. Throughout their range in the northern Great Plains, nearly all nesting pairs use former or unused nests built by American Crows or Black-billed Magpies (Ellis 1976, Hodson 1976, Becker 1984, Warkentin and James 1988, Sieg and Becker 1990, Houston and Hodson 1997). Urban-nesting Merlins often use former crow nests built in spruce (Oliphant and Thompson 1976, Smith 1978, Warkentin and James 1988, Sodhi et al. 1992, MOU 2002). In Grand Forks, North Dakota, two pairs nested in old American Crow nests that were located in spruce (*Picea* spp.) trees (D. O. Lambeth, Grand Forks, North Dakota, pers. comm.). One nest was located in the yard of a fraternity house, at a busy intersection. In Minot, North Dakota, Merlins nested in a former American Crow nest located about 11 m high in a spruce tree in a residential area (R. Martin, Sawyer, North Dakota, pers. comm.).

In rural Saskatchewan and Alberta, old magpie nests were used more often than crow or hawk nests (Fox 1964, Hodson 1976, Houston and Hodson 1997). In Montana, 48 of 49 Merlin pairs used old magpie nests in conifer trees; one pair used a former American Crow nest in a conifer (Ellis 1976, Becker 1984, Sieg and Becker 1990). All 42 former Black-billed Magpie nests used by Merlins had a stick canopy and 60% had a mud cup in the base (Sieg and Becker 1990). Merlins nesting in other states used old magpie nests built in groves of coniferous trees adjacent to grasslands, including western North Dakota (Stewart 1975, Postovit 1979, Sieg and Becker 1990), western South Dakota (Pulkrabek and O'Brian 1974, Sieg and Becker 1990, SDOU 1991), eastern Wyoming (Sieg and Becker 1990), and northwestern Nebraska (Sieg and Becker 1990, Sharp et al. 2001).

In Saskatchewan and Alberta, four pairs of Merlins used nests built by hawks. Three of these Merlin pairs used former Swainson's Hawk (*Buteo swainsonii*) nests (Houston and Schmidt 1981, Houston and Hodson 1997), and one Merlin pair nested in a former Ferruginous Hawk (*Buteo regalis*) nest (Hodson 1976). Near Calgary, Alberta, three Merlin pairs nested in cavities in the top of broken black poplars (*Populus trichocarpa*) trees (Bent 1961). In Saskatchewan, two Merlin pairs nested in natural tree cavities (Fox 1964). Although no specific information was provided, Richardson's Merlins were reported to nest occasionally in old magpie nests built in holes in cliffs, and a few Merlins were reported to nest on the ground (Call 1978).

Merlins nest in both coniferous and deciduous trees and shrubs. Coniferous trees supporting nests used by breeding Merlins include ponderosa pine (Bent 1961, Ellis 1976, Becker 1984, Sieg and Becker 1990), spruce (Bent 1961, Fox 1964, Oliphant and Thompson 1976, Smith 1978, Warkentin and James 1988, Sodhi et al. 1992, Houston and Hodson 1997, MOU 2002), jack pine (*Pinus banksiana*) (Fox 1964), Douglas fir (*Pseudotsuga menziesii*) (Ellis 1976), and limber pine (*Pinus flexilis*) (Ellis 1976). Conifers provide easy access and maximum concealment (Becker 1984). Deciduous trees and shrubs that have supported Merlin nests include maple (*Acer* sp.) (Hodson 1976, Houston and Hodson 1997), box elder (*Acer negundo*) (Fox 1964), aspen (Bent 1961, Fox 1964, Young 1981, Houston and Hodson 1997), poplar (Bent 1961; Hodson 1976; Oliphant and Thompson 1976, 1978; Smith 1978), black poplar (Bent 1961), cottonwood (Houston and Hodson 1997), birch (*Betula* sp.) (Fox 1964), green ash (*Fraxinus pennsylvanica*) (Houston and Hodson 1997), elm (*Ulmus* sp.) (Houston and Hodson 1997), willow (Bent 1961; Fox 1964; Hodson 1976; Oliphant and Thompson 1976, 1978; Young 1981), and chokecherry (*Prunus virginiana*) (Houston and Hodson 1997). Nest trees used by 20 pairs of Merlins in Edmonton were at least 35 yr old (Smith 1978). Nest heights among all studies varied from 2 m in willows (Oliphant and Thompson 1978) to 19 m in spruce (Warkentin and James 1988). In southeastern Montana, night roosts were located in pine woodlands near nest sites (Becker 1984).

Each member of a Merlin pair uses a favorite perch, often a branch in a tall dead tree that overlooks their territory (Fox 1964). A plucking perch often is used by males to prepare prey before transferring it to the female (Sodhi 1991). Perches also are important for hunting; of 286 hunting attempts, 95% were initiated from perches (Sodhi et al. 1991b). A table near the end of the account lists the specific habitat characteristics for Merlins by study.

Prey habitat:

Merlins prey primarily on small birds, usually in open grasslands or sites associated with human habitation (both urban and rural). Merlins may specialize on one or two locally abundant species of small (20- to 40-g) birds (Sodhi et al. 1993). In southwestern Saskatchewan and southeastern Alberta, Horned Larks (*Eremophila alpestris*), Chestnut-collared Longspurs (*Calcarius ornatus*), Brown-headed Cowbirds (*Molothrus ater*), Vesper Sparrows (*Pooecetes gramineus*), and Song Sparrows (*Melospiza melodia*) were the most abundant species and the most common prey (Fox 1964; Hodson 1978). In southern Alberta, Merlins hunted for prey primarily over grasslands (Hodson 1978). Grasslands were primarily grazed (>75% of the fields), but some grasslands were hayed and others remained idle. The two most common passerines found in grazed shortgrass prairie were Horned Larks and Chestnut-collared Longspurs, and these two species composed 87% of the total prey evidence found at Merlin nest sites. In southeastern Montana, 21 species of birds composed the majority of prey taken; seven

species of prey inhabited woodland and 14 species inhabited grasslands (Becker 1984). During spring and fall, Merlins hunting in pastures and cropland near Beaverhills Lake outside of Edmonton, Alberta, preyed on eight species of sandpipers (*Charadriiformes*) and five species of passerines (Dekker 1988). Rarely, small mammals, lizards, or large insects were utilized as prey, especially by Merlin fledglings.

In urban areas, an abundant prey base (e.g., non-migratory House Sparrows) provides an easily accessible source of food throughout the year (Warkentin and Oliphant 1990, Sodhi 1991). In residential or commercial urban areas, House Sparrows are the most common prey throughout the year, and waxwings (*Bombycilla* spp.) are important prey during winter (Oliphant and McTaggart 1977, Smith 1978, Servheen 1985, Warkentin and Oliphant 1990, Sodhi 1991). In Saskatchewan, maturation of ornamental mountain ash (*Sorbus* sp.) and crabapple (*Pyrus* spp.) trees and the resulting fruit crop attracted more consistent populations of some winter birds, particularly Bohemian Waxwings, making residential areas more attractive for Merlins during winter (Houston and Schmidt 1981).

In Saskatoon, the mean number of birds (potential prey) increased with distance from Merlin nests (Sodhi et al. 1990). During 2 years in which House Sparrow nests were monitored, more sparrow fledglings were available during the Merlin nestling and fledgling periods, when more food (prey) was required by Merlin families (Sodhi et al. 1992). Potential prey species at five point counts in each of four Saskatoon habitats included averages of 4.5 species in urban habitat, 3.7 species in city parks and cemeteries, 2.7 species in grasslands, and 1.5 species in cropland (Sodhi 1991). A second index of abundance of potential prey species indicated that total numbers of individual birds used as prey increased from the Merlin's incubation to nestling period, but decreased markedly during the fledgling period.

Area requirements:

Breeding Merlins require a large area that provides a nest site and adequate populations of small birds. In Saskatchewan, Merlin home ranges were smaller where prey was more abundant, suggesting that prey abundance is an important variable affecting home range size (Sodhi 1991). The majority of male Merlins in Saskatoon adjusted the size of their range from one breeding period to another (e.g., incubation period to nestling period to fledgling period) in relation to changes in prey abundance. Hunting range size of female Merlins in urban Saskatoon was inversely correlated with their body mass and with House Sparrow abundance. Merlins did not defend hunting ranges for exclusive use, therefore neighbors exerted minimum pressure on hunting range sizes. Some overlap of hunting ranges was documented.

The hunting range sizes of 16 radio-tagged male Merlins and 11 radio-tagged females were studied in Saskatchewan (Sodhi 1991). Of the 16 males, 12 males were defined as residents that were hatched in Saskatoon; four males were defined as immigrants that were hatched at an unknown location outside Saskatoon. The mean hunting range sizes of the 12 resident males averaged 6.3 km², and the hunting range sizes of the four immigrant males averaged 33.7 km². The mean hunting ranges of three resident and eight immigrant females averaged 6.6 km² and 8.6 km², respectively. Eight of the 12 resident males and all four immigrant males spent some time hunting outside of the city. Seven of eight immigrant females hunted outside of the city compared to only one of three resident females.

In rural Saskatchewan, the minimum distance between breeding pairs along the North Saskatchewan River was 2.5 km (Oliphant and Thompson 1976). In the Kerrobert area of Saskatchewan, the proximity of three neighboring pairs of nesting Merlins was 1.6 km (Houston

and Schmidt 1981). In Saskatoon, the distance from a nest site to the nearest adjacent nest site averaged 1.2 km for 16 nests, ranging from 0.7 to 2.3 km (Oliphant and Haug 1985). In Edmonton, two pairs of Merlins nested within 1.5 km of one another in the Saskatchewan River Valley (Smith 1978).

In rural areas, nesting densities were 3.8 pairs/100 km² in southeastern Montana (Becker and Sieg 1985) and 17.5 pairs/100 km² in southern Alberta (Smith 1978). However, in Edmonton, eight pairs nested in a 40-km² area, suggesting that urban habitat was as attractive, or more attractive, than available rural habitat (Smith 1978). Breeding densities were greater in urban residential, city park, and cemetery habitats than in prairie and cropland habitat. During one breeding season in Saskatoon, 16 Merlin pairs nested within a 29-km² area (Oliphant and Haug 1985). Merlin nesting densities were 25.4 pairs/100 km² in Saskatoon, Saskatchewan (Sodhi et al. 1992), and 20 pairs of nesting Merlins/100 km² in Edmonton, Alberta (Smith 1978).

Brown-headed Cowbird brood parasitism:

The Merlin is an unsuitable host for the Brown-headed Cowbird, an obligate brood parasite.

Breeding-season phenology and site fidelity:

On the northern edge of the Great Plains, Merlins are present on breeding territories as early as February, and some may begin courtship activities immediately (Feldsine and Oliphant 1985). Males typically arrive on breeding areas about one month before females. In Alberta, males are common by early April (Bent 1961). In western Saskatchewan, male Merlins arrive in late February or early March (Fox 1964). In southeastern Montana, Merlins arrive about mid-March (Becker 1984, Becker and Sieg 1988). In western Saskatchewan, juvenile Merlins begin migrating southward during mid-August, and the fall flight of migrant Merlins across the Saskatchewan prairies is over by mid-October (Fox 1964). Merlins were one of the last migrants to leave southern Alberta; the latest fall sighting was early December (Bent 1961).

Renesting rarely has been reported for Merlins in the wild; however, apparent renesting has been reported in southern Alberta (Bent 1961, Hodson 1976). Although double-brooding has not been reported for Merlins, polygyny was documented once in Saskatoon (Sodhi 1989). One male occupied two different nest sites that were located about 450 m apart, and paired with different females at each site. At one nest, four nestlings were successfully raised; the second nest was deserted after about 5 wk after nesting began (from copulation to at least incubation).

In Saskatoon, mate fidelity between breeding seasons was low (20% of 60 nesting attempts involved the same male and female in two or more consecutive years) and was apparently related to site fidelity (Warkentin et al. 1991). Males were more likely to return to a particular site than females. No changes in productivity were associated with site or mate fidelity. Of 49 territories on which females were trapped, 20% contained the same birds from one year to the next (James et al. 1989). Of 29 territories on which males were trapped, 41% contained the same birds from one year to the next. Natal dispersal (movements between birthplace and breeding place) for 15 females was 3.0 km. For 25 males, it was 4.1 +/-2.92 km. These distances reflect movements within the study area, and not longer movements that may have been made outside the study area. A second method of determining natal dispersal was to compare the proportions of male and female adults trapped that had been banded locally as chicks. For females, 39% of 89 were banded locally as chicks, whereas 60% of 68 males were

banded as chicks. Females probably dispersed further than males. Breeding dispersal (movements between two or more breeding places) was 2.3 km for 29 females, and 1.1 km for 15 males.

In Alberta, nine of 12 adult male recaptures occurred at the same nest site, two were <4 km from their previous nest sites, and one was 12.8 km from the original site (Hodson 1976). Of 10 adult female recaptures, two were captured at the same site, three were captured 16-32 km away, and two were captured >120 km away from the original site. Banding-recapture information indicates that pairs re-mate only by chance in ensuing years. It also is likely that most males return to the same site in successive years, whereas most females do not. One ground nest in Newfoundland was used by nesting Merlins (*F. c. columbarius*) for 23 consecutive years, although it is unknown whether the same pair occupied this site during this period (Trimble 1975).

Species' response to management:

Murphy (1991) considered Merlins to be one of the prairie raptors that benefits from frequent disturbance of uplands by burning, mowing, or grazing techniques that yield low, light-to-moderately dense grass and forb cover, which forms a habitat mosaic for prey. In Alberta, Merlins hunted over mowed and idle shortgrass prairie (Hodson 1978).

Grazing practices affect the prey species on which Merlins depend and provide open hunting areas for Merlins. In southern Alberta, Merlins hunt for prey primarily over grazed grasslands (Hodson 1978). In southeastern Montana, a combination of low-to-moderate grazing of grassland and sagebrush habitats probably created a diverse mosaic of favorable habitats for the three primary bird species, Horned Larks, Lark Buntings (*Calamospiza melanocorys*), and Vesper Sparrows, which composed more than half of Merlin prey (Becker 1984). Intensive grazing or the overstocking of livestock may reduce vegetative diversity of grassland and sagebrush habitats, and subsequently reduce prey diversity. In southwestern Saskatchewan, Merlins nested in shelterbelts or in groves of deciduous trees in which the trees had been rubbed bare of the lower branches by cattle and the undergrowth was trampled and destroyed (Fox 1971). These cattle-induced features of trees and shelterbelts appear to be the first stage in the destruction of the trees by cattle.

Conversion of native grasslands into cultivated farmland in rural areas has reduced suitable breeding habitat for Merlins (Trimble 1975), but Merlins have adapted to urban habitats. The breeding range of Richardson's Merlins contracted rapidly during a 20-yr period beginning in 1955. This contraction has been attributed to the conversion of native grasslands to cultivated farmland. Richardson's Merlins that nested in rural Saskatchewan and Alberta shifted their distribution in response to cultivation of prairie. Merlins began to inhabit cities where nest sites and prey were common. Smith (1978) reported that Merlin nesting habitat was created after conifers were planted in the river floodplain in Edmonton, where conifers historically had been scarce. The youngest tree in which an active Merlin nest was found was 35 yr old.

Merlin populations are adversely affected by pesticide contamination that results in eggshell thinning and reduced nesting success. Chemicals causing contamination include DDE (dichlorodiphenylethylene), dieldrin, heptachlor epoxide, PCB (polychlorinated biphenyl), and mercury (Ellis 1976, Fyfe et al. 1976, Hodson 1976, Fox and Donald 1980, Becker 1984, Noble and Ellis 1990). The most severe cases of pesticide contamination may go undetected because heavily contaminated Merlins may not attempt to nest or may die without detection (Fyfe et al.

1976, Fox and Donald 1980, Noble and Ellis 1990). Because Richardson's Merlins winter in the Great Plains of southern Canada, the United States, and northern Mexico, the subspecies does not face continued problems of exposure to persistent pesticides, unlike Taiga Merlins, which winter in Central America and from northern South America to Peru, where persistent pesticides are still used. Due to legislation that prohibited use of persistent pesticides in the United States and Canada, most Merlin populations appear to have recovered from pesticide contamination and are reproducing successfully. However, Merlin eggs collected as recently as 1988 from the prairie provinces in Canada contained pesticide levels high enough to affect reproductive success (Noble and Ellis 1990).

Merlins may be a good indicator species for assessing the impact of environmental disturbances, such as coal mining (Becker and Ball 1983). Merlin populations appear to show less year-to-year fluctuations than raptors that depend on cyclical populations of rodents for food. Merlins obviously can tolerate some human disturbance, because they successfully nest in urban residential areas. Where breeding Merlins already are established and persistent disturbance is subsequently imposed, populations may decline from increased stress and reduced productivity (Becker and Ball 1983). If suitable nesting habitat can be maintained in coal-mining recovery areas, Merlins could serve as an indicator of the success of maintenance or recovery efforts of prairie ecosystems. Because Merlin nests often are relatively easy to find, breeding and productivity can be monitored to provide information that is more biologically sensitive than a present-or-absent measurement. Individual Merlins differ in their tolerance to human disturbance. Like other raptors, Merlins are most susceptible to nest abandonment if disturbed during incubation. Nestling survival also may be affected due to prolonged disturbance during brood rearing.

Other human activities also may impact breeding Merlins. Illegal shooting does not appear to be a major mortality factor for Merlins (Fyfe 1977), although shooting probably had a detrimental impact during earlier decades (Evans 1982). However, in Saskatoon, recent shootings caused mortality of 7% of a Merlin population (James et al. 1989). In southeastern Montana, permanent recreation facilities, such as camping or picnic areas, were likely to displace local nesting pairs of Merlins (Becker 1984). Injury to a Merlin after being caught on a fishhook attached to a discarded fishing line was reported (Parrish and Maurer 1991). Researchers and others that climb nest trees should be careful not to disturb Merlins during early incubation so that the birds desert their nests (Oliphant 1974), because Merlins are most susceptible to nest abandonment if disturbed during incubation than during other periods of their nesting cycle (Becker and Ball 1983). In southeastern Montana, Merlins tolerated repeated nest visits during the brood-rearing period (Becker and Ball 1983).

Radio transmitters that weighed about 2% of the body mass of an adult Merlin appeared to have no significant effect on reproductive success or survival (Sodhi et al. 1991a). Falconers collect some nestlings or migrating Merlins each year. Falconers must be licensed, but the impacts of falconry on Merlin populations should be monitored continuously. Merlins have bred successfully in captivity, and the release in 1979 of six Merlins in Regina, Saskatchewan, may have been the basis for the establishment of a breeding population that numbered about 20 breeding pairs by around 1992 (Sodhi et al. 1993).

Management Recommendations:

Preserve large expanses of grassland and sagebrush-dominated grassland habitats (Becker and Ball 1983). Preserve ponderosa pine stands adjacent to sagebrush and grassland habitats (Becker 1984). Limit human activities in habitats where Merlins are known to nest (Becker 1984). Compensate for destruction, loss, or lack of nest sites by relocating magpie nests into an area, or by constructing artificial nest sites (Becker and Ball 1983).

Encourage rest-rotation grazing plans or similar grazing alternatives that maintain or create a mosaic of livestock grazing areas with a variety of grazing intensities, which should provide a diversity of microhabitats for Merlin prey species (Becker 1984). Do not permit intensive grazing or overstocking of livestock that may reduce vegetative diversity of grassland and sagebrush habitats, and that would likewise reduce Merlin prey abundance.

Continue to restrict the use of pesticides in the United States and Canada (Evans 1982). Because Merlins winter as far south as Peru (Cade 1982), encourage this practice throughout Latin America (Evans 1982).

In areas proposed for mining, begin data collection during the pre-mining phase to gather baseline information about Merlin populations, including data on nesting pairs, productivity, prey utilization, and habitat utilization (Kennedy 1980). Because most studies have utilized data from previous investigations without regard for wide geographic variations in raptor population dynamics and related factors, investigators must conduct long-term, site-specific studies, which will require a much greater commitment of time and funding.

In advance of the exploration and development phases of mining, provide information to workers to help minimize impacts to nesting Merlins, such as access to Merlin habitat by exploration crews, the types of exploration activities proposed, critical periods in the nesting cycle, and guidelines to minimize disturbances (Becker 1984). Prohibit human activities within 400 m of active nests during the Merlin's breeding season (15 March to 30 July); any exceptions should be examined on a case-by-case basis (Becker and Ball 1983). Where concentrations of nesting pairs occur, initiate more stringent regulations during mining development. Review potential impacts on breeding Merlins and their habitats with regard to the location, timing, and human-use of the mining facility before roads or industrial facilities are developed. Require that all personnel adhere to guidelines on location, scheduling, and zones of disturbance (Becker 1984).

Emphasize the protection of natural nest sites, habitats, and populations during the development phase of mining or during mining activities, when Merlin nesting and hunting habitats are likely to be seriously disturbed or destroyed (Becker and Ball 1983). Protect mature trees whenever possible, because it may take several decades to re-establish nesting, perching, and roosting trees. Restrict firearms on mining sites to deter illegal shooting of Merlins.

During the reclamation phase of mining, re-establish diverse native vegetation as rapidly as possible after mining activities cease (Becker 1984). Replace nest trees with the largest possible trees by transplanting. If grazing is permitted, protect existing or transplanted trees from damage

by livestock by fencing. In areas where human activities impact Merlin nesting territories, establish a 400-m radius zone of no disturbance surrounding known or suspected nest sites from 15 March to 30 July.

Locate permanent recreation facilities away from known or potential Merlin nest sites (Becker 1984). Review potential impacts on breeding Merlins and their habitats before developing recreation areas and associated roads with regard to the location of facilities, timing of disturbances, and human uses of any facilities (Trimble 1975, Becker 1984). Carefully regulate falconry to ensure that Merlin populations are not impacted locally, regionally, or rangewide (Trimble 1975).

Table. Merlin habitat characteristics.

Author(s)	Location(s)	Habitat(s) Studied*	Species-specific Habitat Characteristics
Becker 1984, Becker and Sieg 1988	Montana	Cropland, mixed-grass pasture, riparian woodland, shrubsteppe, woodland	Nested in former Black-billed Magpie (<i>Pica hudsonia</i>) nests built in ponderosa pine (<i>Pinus ponderosa</i>); hunted and perched in shrubsteppe (<i>Artemisia</i> spp.), mixed-grass prairie, ponderosa pine woodland, riparian, and cropland; preyed primarily on birds associated with prairie habitat
Bent 1961	Alberta	Shortgrass prairie, woodland	Nested in cavities in the tops of broken black poplars (<i>Populus trichocarpa</i>), in dense spruce (<i>Picea</i> sp.) woods, in poplars (<i>Populus</i> spp.) in small groves, and in an old, canopied Black-billed Magpie nest in a willow (<i>Salix</i> sp.) stand; nests ranged in height from 4.5 to 18 m above the ground
Dekker 1988	Alberta	Cropland, shortgrass pasture	Hunted in cropland and shortgrass pasture
Ellis 1976	Montana	Cropland, shortgrass prairie, woodland	Of seven nests, six were in magpie nests in Douglas fir (<i>Pseudotsuga menziesii</i>), ponderosa pine (<i>Pinus ponderosa</i>), limber pine (<i>Pinus flexilis</i>), and one unidentified conifer; the remaining nest was in a former American Crow (<i>Corvus brachyrhynchos</i>) nest in a ponderosa pine; prairie habitat adjacent to nest sites included flat or rolling landscapes, although three nest sites were located on hills above prairie; nest sites were located in four conifer groves bordering open prairie, a conifer grove on a butte above open prairie and cropland, a small dense conifer grove in a mesic draw, and a conifer shelterbelt near a highway surrounded by prairie
Fox 1964	Saskatchewan	Mixed-grass pasture, riparian, tame pasture, woodland	Of 25 nests, 12 were in woodland, on bluffs, river edges or islands; seven were in shelterbelts among open grassland, and six were in coniferous woodland; 21 nests were in deciduous trees, and four were in coniferous trees; 13 nests were originally built by crows, 10 were built by magpies, and two were in natural tree cavities

Hodson 1976	Alberta, Saskatchewan	Cropland, mixed-grass pasture, shortgrass pasture	Hunting ranges adjoining 40 nest sites averaged 78% grassland and 22% cropland and woodland; grasslands were primarily mixed-grass prairie dominated by needlegrass (<i>Stipa</i>) and wheatgrass (<i>Agropyron</i>) or shortgrass prairie dominated by grama (<i>Bouteloua</i>) and needlegrass (<i>Stipa</i>), but their composition was dependent on grazing pressure; in heavily grazed grassland, fringed sagewort (<i>Artemesia frigida</i>) and needleleaf sedge (<i>Carex duriuscula</i>) were common; trees in grasslands occurred in natural groves of quaking aspen (<i>Populus tremuloides</i>) and willows (<i>Salix</i> sp.) that surrounded wetlands, and in stands of aspen, willow, and box elder (<i>Acer negundo</i>), which were remnants of planted windbreaks; most pairs nested in former magpie and crow nests, but one pair nested in a former Ferruginous Hawk (<i>Buteo regalis</i>) nest; prime factors affecting the Merlin population were human-induced land-use changes, especially conversion of native grasslands to cropland
Hodson 1978	Alberta	Idle shortgrass, shortgrass hayland, shortgrass pasture, woodland	Nested in small native or planted groves of poplars (<i>Populus</i> sp.), willows, and/or box elder adjacent to shortgrass (<i>Stipa/Agropyron</i>) prairie; primarily hunted for prey over shortgrass prairie, which was mostly grazed, but included some mowed shortgrass hayland and idle shortgrass
Hodson and Hodson 1997	Saskatchewan	Not given	Of 125 Merlin nests, 102 originally were built by magpies, 21 by crows, and two by Swainson's Hawks; most Merlin nests were in deciduous trees; 66 nests were in maple (<i>Acer</i> sp.), 22 in aspen, 13 in green ash (<i>Fraxinus americana</i>), 11 in willow, 5 in elm (<i>Ulmus</i> sp.), 3 in unidentified trees, 2 in cottonwood, 2 in spruce, and 1 in chokecherry (<i>Prunus virginiana</i>)
Houston and Schmidt 1981	Saskatchewan	Riparian woodland, urban	Early records indicate nesting Merlins were restricted to wooded river valleys; most nests were former magpie and crow nests; however, one pair of Merlins used a former Swainson's Hawk (<i>Buteo swainsonii</i>) nest; maturation of

			ornamental mountain ash (<i>Sorbus</i> sp.) and crabapple (<i>Pyrus</i> sp.) trees attracted more consistent populations of winter birds, particularly Bohemian Waxwings (<i>Bombycilla garrulus</i>), making residential areas more attractive for Merlins during winter
D. O. Lambeth, Grand Forks, North Dakota pers. comm.	North Dakota	Urban	Two pairs nested in old crow nests in spruce trees in Grand Forks; one nest was located in the yard of a fraternity house at a busy intersection
MOU 2002	Minnesota	Urban	One pair nested successfully in a tall spruce tree in a suburb of Minneapolis
Oliphant and Haug 1985	Saskatchewan	Urban	Nested primarily in old crow nests built in mature spruce trees
Oliphant and McTaggart 1977	Saskatchewan	Cropland, pasture, urban	One nest site was on a university campus; the male hunted in adjacent residential areas and the university's cropland and livestock areas; a second nest site was in a tree in a city cemetery; that male hunted in the cemetery and in adjacent residential and semi-industrial areas
Oliphant and Thompson 1976	Saskatchewan	Riparian woodland, urban	Throughout southern Saskatchewan, nests were located along major river systems; along a 40-km stretch of the North Saskatchewan River near Saskatoon, most Merlins nested in unused crow or magpie nests in small willows 2- to 4-m high, or in old magpie nests in large deciduous trees, usually <i>Populus</i> species; in areas of Saskatoon, Merlins nested primarily in old crow nests built in mature spruce trees
Sieg and Becker 1990	Montana	Cropland, mixed-grass pasture, shortgrass pasture, woodland	Preferred nesting in unused magpie nests in ponderosa pines on south-facing slopes of sandstone buttes that ranged about 300 m above adjacent grazed prairies that were dominated by western wheatgrass (<i>Agropyron smithii</i>), blue grama (<i>Bouteloua gracilis</i>), prairie junegrass (<i>Koeleria cristata</i>), and needle-and-thread grass (<i>Stipa comata</i>)
Smith 1978	Alberta	Urban, woodland	Nested in unused corvid nests (11 crow and 3 magpie nests) located in 13 spruce trees and one aspen; all trees were at least

			35 yr old; in an urban area, 9 pairs nested in the river valley and 5 pairs nested in upland city parks or cemeteries; in rural areas, 17 of 18 nests were in spruce
Sodhi 1991; Sodhi et al. 1990, 1991a,b, 1992	Saskatchewan	Cropland, mixed-grass pasture, tame pasture, urban	Nested in crow nests built in mature spruce trees; a high reproductive rate indicated the urban environment provided prime habitat with ample corvid nest sites in spruce trees and abundant prey, primarily House Sparrows (<i>Passer domesticus</i>); hunted in urban habitat, and grasslands and croplands adjacent to the city
Warkentin and James 1988	Saskatchewan	Urban	Nested in crow nests in conifers primarily and showed a strong tendency to avoid nesting in magpie nests; used crow nests during 54 of 58 nesting attempts; average nest site characteristics at 58 active Merlin nests were 12.5 m nest tree height, 40.6 cm nest tree diameter, 8.9 m nest height, 1.9% shrub coverage, 57.2 m distance from nest tree to nearest building, 22.4 m distance to nearest road, and 35.6 m distance to nearest light pole.
Young 1981	Saskatchewan	Woodland	One pair nested in an old magpie nest built 3 m above ground in a stunted aspen on a bluff overlooking an 11-km-long glacial outwash valley devoid of trees except along spring-fed ravines and north-facing slopes; a second pair nested in an old magpie nest built 3.7 m above the ground in a 0.5-km ² aspen-and-willow thicket in an area composed of stunted trees, including aspens and willows, and sagebrush

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

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