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The Effects of Management Practices on Grassland Birds—Short-Eared Owl (*Asio flammeus*)

Chapter Q of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–Q

U.S. Department of the Interior
U.S. Geological Survey

Cover. Short-eared Owl. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.
Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

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By Jill A. Shaffer,[1] Lawrence D. Igl,[1] Douglas H. Johnson,[1] Marriah L. Sondreal,[1] Christopher M. Goldade,[1,2] Melvin P. Nenneman,[1,3] and Betty R. Euliss[1]

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The Effects of Management Practices on Grassland Birds

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
hectare (ha)	0.003861	square mile (mi^2)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Abbreviations

BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
sp.	species (an unspecified species within the genus)
spp.	species (applies to two or more species within the genus)

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Capsule Statement

The key to Short-eared Owl (*Asio flammeus*) management is providing large grasslands and wetlands, particularly those that can support high densities of voles (*Microtus* species [spp.]). Short-eared Owls have been reported to use habitats with 30–90 centimeters (cm) average vegetation height, 7–47 cm visual obstruction reading, 31–85 percent grass cover, 8–26 percent forb cover, less than (<) 18 percent shrub cover, 43 percent litter cover, and 1–2 cm litter depth. The descriptions of key vegetation characteristics are provided in table Q1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).

Breeding Range

Short-eared Owls inhabit every continent except Australia and Antarctica. In North America, Short-eared Owls breed from Alaska, continental Canada, and the southern Baffin Islands; south to central California; and east through Kansas, eastern Oklahoma, eastern Ohio, Pennsylvania, Maryland, and Prince Edward Island (National Geographic Society, 2011). The species may be expanding its range northward (Therrien, 2010; Reid and others, 2011; Smith and others, 2013). The relative densities of Short-eared Owls in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure Q1 (not all geographic places mentioned in report are shown on figure).

Suitable Habitat

Throughout the geographical area covered within this chapter—the Midwest and Great Plains of the United States and Canada—Short-eared Owls require large, open grasslands including native prairie, hayland, and Conservation Reserve Program (CRP) fields (Townsend, 1961; Clark, 1975; Stewart, 1975; Harris, 1980; Murphy, 1991; Johnson and Schwartz, 1993; Herkert and others, 1999; Igl, 2009; Wiggins and others, 2020). The species also will nest in moist areas, such as mesic prairie, wet meadows, and marshes (Stewart, 1975; Murphy, 1991; Igl and others, 2017; Artuso, 2018). The species occupies cropland areas like small-grain stubble, as well as reclaimed coal-mine grasslands (Stewart, 1975; Ingold, 2002). In western rangelands, Short-eared Owls occupy sagebrush steppe, riparian areas, wet portions of oldfields (idle or neglected arable lands that have naturally reverted back to perennial cover), and pastures (Linner, 1980; Lehman and others, 1998; Wiggins, 2004). Local occurrence of Short-eared Owls is unpredictable; Short-eared Owl populations fluctuate yearly because of variation in small-mammal populations (Beske and Champion, 1971; Clark,

Short-eared Owl. Illustration by Christopher M. Goldade, U.S. Geological Survey.

[1]U.S. Geological Survey.

[2]South Dakota Game, Fish and Parks (current).

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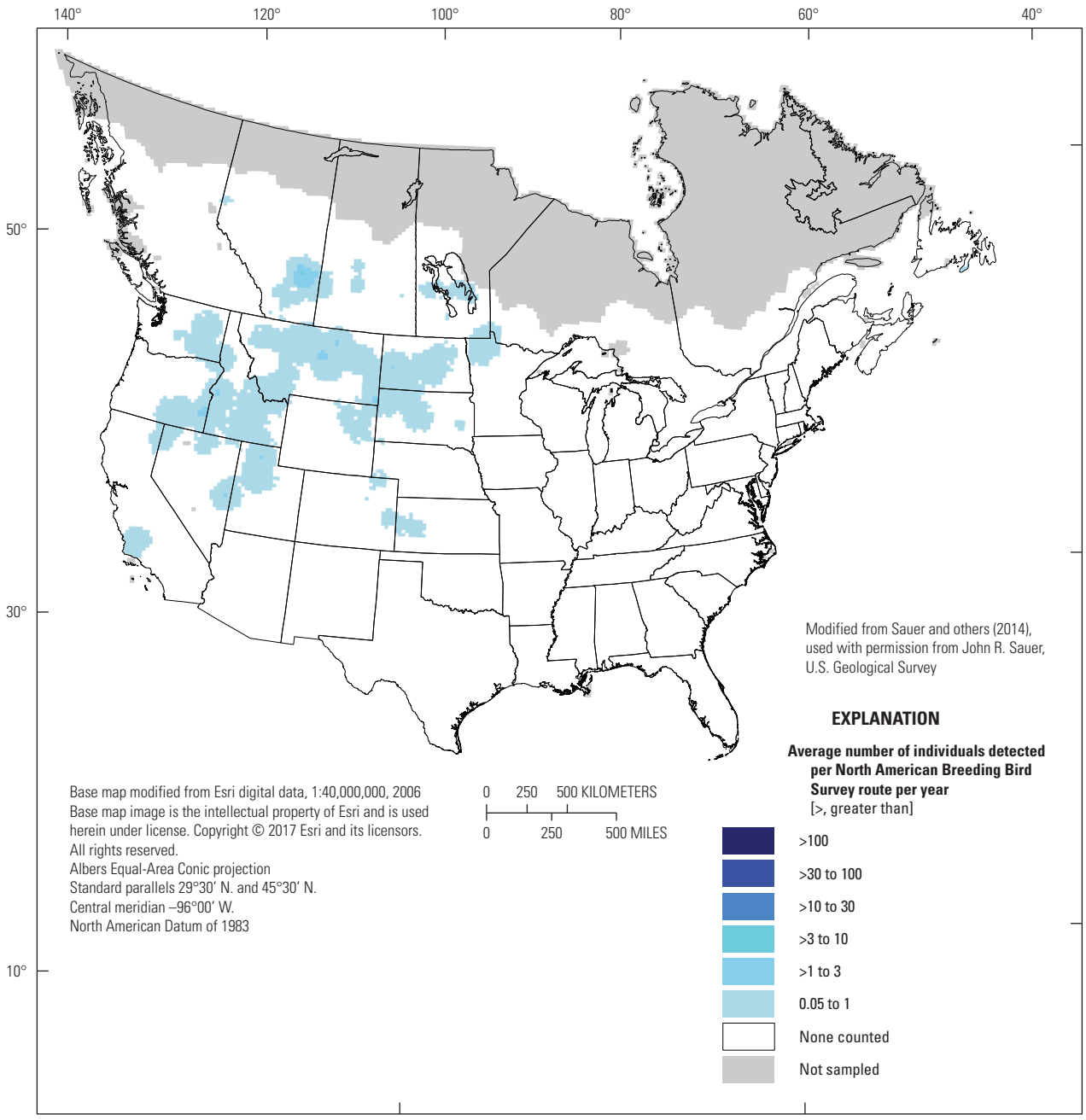

Figure Q1. The breeding distribution of the Short-eared Owl (*Asio flammeus*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

1975; Stewart, 1975; Harris, 1980; Evrard and others, 1991; Poulin and others, 2001; Johnson and others, 2013; Wiggins and others, 2020). Given adequate prey and sufficient habitat as described herein, Short-eared Owls are able to colonize new areas (Clark, 1975).

Short-eared Owls avoid habitats with short vegetation (Linner, 1980; Murphy, 1991) and require grasslands with a deep litter layer that provide nesting habitat for owls and their prey of small mammals (Swaney, 1993; Swengel and Swengel, 2014). Throughout the Midwest and northern Great Plains, Swengel and Swengel (2014) recorded the occurrence of Short-eared Owls primarily only in Wisconsin grasslands with above-average volume of dead plant litter on or near the ground, relative to grasslands where owls did not occur. Within the grasslands with high litter coverage, Short-eared Owls nested in the areas with the densest litter. In States such as Missouri, where native grasslands were managed with fire, haying, or both, and North Dakota, where native grasslands were managed with grazing and burning, litter was too sparse to provide suitable owl habitat (Swengel and Swengel, 2014).

Wiggins (2004) cautioned that native grasslands throughout the Great Plains that are grazed by livestock to the extent that the litter layer is removed or sparse will not provide suitable habitat for Short-eared Owls. Duebbert and Lokemoen (1977) suggested that Short-eared Owls preferred grasslands in which litter had been allowed to accumulate for 2–8 years. Contiguous native grasslands with an adequate litter layer and low shrub cover, as well as marshy areas, provide suitable habitat throughout the Great Plains and upper Midwest (Wiggins and others, 2020). Swengel and Swengel (2014) found that Short-eared Owls in Wisconsin nested in tame grasslands with shrub cover that averaged 1.3–17.6 percent. Federal programs that revegetate former agricultural land, such as the CRP, and that preserve wetland habitats, such as the Wetland Reserve Program, provide idle grassland habitats with sufficient litter; however, the reproductive success of Short-eared Owls within these habitats is unknown (Wiggins, 2004). In some areas of the Great Plains, such as South Dakota and Kansas, CRP fields may be the primary nesting habitat for Short-eared Owls (Wiggins, 2004). In north-central Oklahoma, Short-eared Owls were more abundant in grasslands planted to a monoculture of nonnative yellow bluestem (*Bothriochloa ischaemum*) than in mixed-grass prairies (George, 2006).

Within western rangelands, Short-eared Owls occupy sagebrush steppe and marsh and riparian habitats (Dobkin and others, 1998; Wiggins, 2004; Miller and others, 2016). In Idaho, Oregon, and Washington sagebrush shrubsteppe, Rotenberry and Wiens (1978) described the species as common in bunchgrasses (mostly wheatgrass [formerly *Agropyron* spp.] and fescue [*Festuca* spp.]) with <5 percent shrub cover and as uncommon in sagebrush habitat with greater than (>) 5 percent shrub cover. In Idaho's Snake River Birds of Prey National Conservation Area, Short-eared Owls nested in sagebrush shrubsteppe rangelands, although specific vegetation characteristics at nest sites were not reported (Lehman and others, 1998). Throughout Idaho, Miller and others (2016) observed Short-eared Owls on 27 of 75 roadside transects surveyed within one breeding season. Within 400 meters (m) of surveyed points, Short-eared Owl occupancy was positively associated with fallow agriculture and plowed dirt agricultural land and negatively associated with grassland and cropland. Owing to the nature of the roadside survey protocol, contiguous undisturbed grasslands were not well-represented within the sampling framework, and agricultural lands predominated. Short-eared Owls in this fragmented landscape may have settled within fallow agricultural lands but stayed even after the fields had been plowed. Within 1 kilometer of surveyed points, owls were more often found in marsh or riparian habitats or areas with greater amounts of sagebrush habitat than in grassland habitat.

Short-eared Owls nest on the ground (Townsend, 1961; Stewart, 1975; Wiggins and others, 2020). Nests typically are built in dry uplands, but wetter lowlands, such as peat bogs, swales, and wet meadows, are used occasionally (Peabody, 1930; Clark, 1975; Linner, 1980; Wiggins and others, 2020). Nests may be fully concealed by dense cover, partially concealed by grasses and forbs, or poorly concealed in open fields and wetlands (Saunders, 1913; Townsend, 1961; Stewart, 1975; Duebbert and Lokemoen, 1977). In Montana, the species nested in grasses and forbs; 90 percent of vegetation around 28 nests was <0.5 m in height, 9 percent was 0.5–1 m in height, and 1 percent was >1 m in height, as measured from a 15-m line-intercept from nest center in four cardinal compass directions (Wiggins and others, 2020). In a northwestern Montana study, nest density was positively correlated with visual obstruction reading, which averaged 19 cm for 38 nests (Fondell and Ball, 2004). In the same general area of Montana, Hoekman and others (2002) examined orientation of nests and reported that nests had low vegetation density to the southeast and high vegetation density to the southwest, apparently as a mechanism to gain solar exposure in the morning and shade in the afternoon. In a variety of native and planted grasslands under a number of land uses in Manitoba, Montana, North Dakota, and South Dakota, 58 percent of 57 nests were found in forbs, especially alfalfa (*Medicago sativa*), 25 percent were in western snowberry (*Symphoricarpos occidentalis*), and 17 percent were in grass patches dominated by wheatgrass (Kantrud and Higgins, 1992). Residual vegetation accounted for 12–88 percent of total vegetation around nests. In North Dakota, Short-eared Owls nest in native prairies, swales, and wet-meadow zones of wetlands, hayfields, retired cropland, and fallow stubble fields (Peabody, 1930; Stewart, 1975). In a rangewide study in North America, 56 percent of 63 nests were in grassland, 24 percent in grain stubble, 14 percent in hayland, and 6 percent in low-statured perennial vegetation such as western snowberry (Clark, 1975). Examples of dominant plant species found at nest sites included cordgrass (*Spartina* spp.), alfalfa, common rivergrass (*Scolochloa festucacea*), wheatgrass, sweetclover (*Melilotus* species [sp.]) and bulrush (*Scirpus* sp.) (Clark, 1975). In North Dakota, nests were usually in areas with 30–60 cm tall vegetation and with 2- to 8-year-old residual vegetation (Duebbert and Lokemoen, 1977). In northwestern North Dakota, most Short-eared Owl nests were in sites dominated by western snowberry and with an herbaceous vegetation component (Murphy, 1993). In Wisconsin, two nests in CRP fields were surrounded by quackgrass (*Elymus repens*) (Evrard and others, 1991).

Spatial and temporal variation in precipitation and temperature may affect the occurrence, abundance, and distribution of Short-eared Owls. Culp and others (2017) assessed the vulnerability of Short-eared Owls to changes in climatic factors (that is, changes in temperature and moisture) across the species' full annual cycle in the Upper Midwest and Great Lakes regions. The assessment considered factors such as background risk (that is, factors unrelated to climate change that could affect resiliency to climate change), climate change exposure (that is, exposure to temperature and moisture changes throughout the annual life cycle), and climate sensitivity and adaptability (that is, the ability of a species to physiologically and evolutionarily tolerate change). Short-eared Owls ranked moderate in the relative total vulnerability score (Culp and others, 2017). Wilsey and others (2019)

compiled avian occurrence data from 40 datasets to project climate vulnerability scores under scenarios in which global mean temperature increases 1.5, 2, or 3 degrees Celsius (ºC). Short-eared Owls ranked moderate in vulnerability during the breeding season under all three scenarios. Under projected greenhouse gas emission scenarios described by the Intergovernmental Panel on Climate Change (2000), Langham and others (2015) categorized the Short-eared Owl as a climate-endangered species, indicating that the species would lose more than 50 percent of its current distribution by 2050 across all scenarios, with no net gain from potential range expansion. However, northward range expansion into the Canadian Arctic Archipelago may be occurring. In 2000, Smith and others (2013) found two Short-eared Owl nests on Banks Island, Northwest Territories. Reid and others (2011) documented three nests on Herschel Island, Yukon, in 2007 and 2008. On Bylot Island in the northern Baffin Islands, Therrien (2010) documented a pair of territorial Short-eared Owls in 2008, although no nests or young were seen. These three published reports are north of the purported northern limit of the species' breeding range (Smith and others, 2013); Bylot Island is 1,000 kilometers north of the species' currently known breeding range (Therrien, 2010). Therrien (2010) ascribed the potential breeding range expansion to a warming climate, and Smith and others (2013) noted a 2–3 °C increase in the mean annual temperature over a current 50-year period in the Canadian Arctic. In Wisconsin, Swengel and Swengel (2013) reported warmer winters over a recent 21-year period (averaging 16 °C warmer compared to 1895–1989), and predicted that the above-average temperatures and normal overall snowfall amounts would make Wisconsin more tolerable for Short-eared Owls during winter.

Prey Habitat

Voles and other small rodents are the primary prey of Short-eared Owls; other mammals and, to a lesser extent, birds also are taken (Wiggins and others, 2020). In the Arctic, Short-eared Owls prey on tundra voles (*Microtus oeconomus*), northern collared lemmings (*Dicrostonyx groenlandicus*), and Nearctic brown lemmings (*Lemmus trimucronatus*) (Pitelka and others, 1955; Reid and others, 2011). Local population levels of Short-eared Owls typically exhibit considerable annual variation in concert with changes in population densities of voles and other small mammals; the species' reproductive output is likewise linked to fluctuations in small-mammal populations (Wiggins and others, 2020). In Saskatchewan, a dramatic 1-year increase in the meadow vole (*Microtus pennsylvanicus*) population was accompanied by a synchronous increase in the Short-eared Owl population (Poulin and others, 2001). In the Arctic Islands, years with high population levels of Nearctic brown lemmings and northern collared lemmings may account for the potential range expansion or extralimital breeding of Short-eared Owls (Smith and others, 2013).

Area Requirements and Landscape Associations

Short-eared Owls are associated with large, open expanses of grasslands (Byre, 1997; Wiggins and others, 2020). The species is generally considered a facultative colonial breeder, but breeding densities likely depend on total area of suitable habitat, quality of nesting cover, and especially prey availability (Wiggins and others, 2020). Of more than 150 sites surveyed in Illinois, Iowa, Minnesota, Missouri, North Dakota, South Dakota, and Wisconsin, Swengel and Swengel (2014) reported that Short-eared Owls occurred only in grassland patches exceeding 48 hectares (ha) and with adjacent grasslands of at least 590 ha. In Illinois, nests were found in managed grassland tracts as small as 28 ha (Herkert and others, 1999). However, the authors suggested that Short-eared Owls may be responding more to the total amount of grassland available in the surrounding landscape than to the sizes of individual grassland fragments; use of small fragments was likely related to proximity of larger, contiguous tracts of grassland (Herkert and others, 1999).

The territory size of the Short-eared Owl varies. In southcentral Manitoba, mean size of five territories in 1 year was 73.9 ha, but a single territory of 121.4 ha was documented in the previous year (Clark, 1975). However, in Montana, 32 nests were found within 164 ha (Wiggins and others, 2020). In the northeastern United States, breeding territory size generally decreased with an increase in vole densities (Clark, 1975). In herbaceous grasslands and sand dune vegetation in Massachusetts, mean territory size for 10 nests was 64.7 ha and varied from 48 to 126 ha (Holt, 1992).

Brood Parasitism by Cowbirds and Other Species

The Short-eared Owl is an unsuitable host of the Brown-headed Cowbird (*Molothrus ater*), and no known records of cowbird brood parasitism exist for this species (Shaffer and others, 2019a). Interspecific egg dumping by a Mallard (*Anas platyrhynchos*) in a Short-eared Owl nest was reported by B. Swaney (pers. commun. [n.d.] in Wiggins and others, 2020).

Breeding-Season Phenology and Site Fidelity

Short-eared Owls generally breed from early April to late August (Maher, 1974; Stewart, 1975; Linner, 1980; Berkey and others, 1993; Swaney, 1993), but breeding may occur earlier in southern portions of the species' range (Walk and others, 1999). Early dates of spring arrival on breeding territories

range from late March to early May (Townsend, 1961). In areas where the wintering and breeding ranges overlap, Short-eared Owls may begin nesting by late March (Wiggins and others, 2020). Initiation dates for 35 Short-eared Owl nests in the north-central United States and south-central Canada ranged from March 31 to June 26, with 90 percent of initiations between April 22 and June 14; hatch dates for 16 nests ranged from May 4 to July 16 (Kantrud and Higgins, 1992). Swaney (1993) calculated an average nest-initiation date for Short-eared Owls in northwestern Montana as April 13, with some owls estimated to have initiated nesting in early to mid-March. In Illinois, Short-eared Owl eggs were laid as early as March 15 and as late as May 10 (Walk and others, 1999). In northwestern North Dakota, estimated hatch dates for Short-eared Owl nests ranged from May 2 to July 23, with a mean hatch date of June 13 (Murphy and Ensign, 1996). If the first clutch is destroyed, Short-eared Owls may renest (Townsend, 1961; Wiggins and others, 2020). There is little evidence of Short-eared Owls producing two successful broods in one breeding season (Wiggins and others, 2020). Late dates of departure from breeding areas range from early September (Saskatchewan) to late November (Alaska) (Townsend, 1961). As the species is strongly nomadic, it generally has low or no site fidelity (Booms and others, 2014; Johnson and others, 2017). In Idaho sagebrush steppe, Lehman and others (1998) reported that <25 percent of Short-eared Owl nesting areas used in 1 year were occupied the next year, and occupancy after 3 years was 15 percent. Keyes (2011) used deuterium stable isotope analysis to investigate the spatial origins, extent of nomadism, and site fidelity of Short-eared Owls in Canada and the United States. Short-eared Owls exhibited different movement strategies across their range in North America; some Short-eared Owls had isotopic results that suggested site fidelity to breeding areas, whereas other owls had isotopic results that suggested nomadism (Keyes, 2011).

Species' Response to Management

The Short-eared Owl's nomadic nature presents challenges for conservation, research, and monitoring (Booms and others, 2014). Nomadism and low site fidelity make it difficult to monitor the species' population trends and to understand its most crucial habitat needs, the general effects of management practices on habitats, or the species' response to management. A long-term monitoring program using satellite technology that can track seasonal and annual movements could provide information on fidelity and use of breeding areas (Holroyd and Trefry, 2008; Booms and others, 2014; Wiggins and others, 2020). Short-eared Owls are sympatric with Northern Harriers (*Circus hudsonius*) in North America (Holt and others, 1987). Swengel and Swengel (2014) documented a relationship between the abundance of Northern Harriers and Short-eared Owls in several States; regionwide, sites with owls had above-average Northern Harrier abundance. Therefore, management practices that benefit Northern Harriers (Shaffer and others, 2019b) also may benefit Short-eared Owls. However, Swaney (1993) indicated that Northern Harriers in Montana grasslands nested in denser cover than Short-eared Owls.

Although disturbance of vegetation during nesting generally has a negative effect on Short-eared Owls, periodic disturbance of grasslands may be necessary to maintain suitable nesting habitat. In Wisconsin, grazing treatments for shrub reduction that covered <5 percent of the land area per year and that were applied in 2 consecutive years were compatible with Short-eared Owls selecting suitable breeding habitat in unmanaged areas (Swengel and Swengel, 2014). In Illinois, Short-eared Owls preferred to initiate nesting in grasslands that had been rotary-mowed within the previous 12 months to a height of 30–40 cm tall over idle grasslands with taller vegetation (Herkert and others, 1999). The species also preferred grasslands managed through haying, seed-harvesting, grazing, or burning during the 12 months before the breeding season to grasslands left undisturbed for at least 12 months before the beginning of the breeding season. However, in reclaimed coal-mine grasslands in Ohio, Short-eared Owls nested only in fields that had been idle (that is, unmowed) before the onset of the nesting season (Ingold, 2002).

In moderately grazed and idle grasslands in Missouri, Short-eared Owls preferred grasslands of medium-to-tall stature with about 50 percent grass/forb coverage at 1 cm above ground and about 30 percent grass/forb coverage at 25 cm above ground (Skinner and others, 1984). In western Montana, Short-eared Owl nesting densities and nest success were higher on ungrazed plots than on grazed plots (Fondell, 1997; Fondell and Ball, 2004). Reduced nest success on grazed plots was attributed mainly to higher nest depredation rates. In North Dakota, Short-eared Owl nests were found in upland sites with tall, dense vegetation and 2- to 8-year accumulations of residual vegetation but not in upland sites that were annually grazed, hayed, or burned (Duebbert and Lokemoen, 1977). In idle native and seeded grasslands in North Dakota, Kantrud and Higgins (1992) found nesting Short-eared Owls, but no nests were found in fields grazed during the breeding season.

Within sagebrush steppe in Oregon, Dobkin and others (1998) examined the effect of livestock exclusion of riparian meadows on avian abundance. Livestock had been excluded for >30 years, and the excluded areas had been rototilled, disked, fertilized, and planted with five varieties of dryland alfalfa and five varieties of grass species, probably tame species. Dobkin and others (1998) reported that a Short-eared Owl was located within an exclosed area in 1 of the 4 years of study.

Pesticides may cause Short-eared Owl mortality (Mineau and others, 1999). In Colorado, Benson and Baker (1971) reported mortalities of Short-eared Owls after the application of monocrotophos in wheat (*Triticum* spp.) fields to control cutworm (*Noctuidae*) larvae; the owls presumably died from secondary poisoning by scavenging on dead or dying songbirds in treated areas. In Utah, 14 bird species, including

Short-eared Owl, were killed by granular carbofuran in fields of corn (*Zea mays*) (Mineau, 1993). Wiggins and others (2020) suggested that residue levels of pesticides, such as dichlorodiphenyltrichloroethane (DDT) and dichlorodiphenyldichloroethylene (DDE), are too low in Short-eared Owls to pose a problem for eggshell thickness, embryonic mortality, or tissue damage, but that new research is merited. In Oregon, Henny and others (1984) found low concentrations of DDE in four of five sampled Short-eared Owl eggs.

Anthropogenic structures (such as fences, powerlines, and wind turbines) and aircraft may cause mortality to Short-eared Owls. Some Short-eared Owls are injured or killed by collisions with barbed-wire fences, powerlines, or vehicles (Fitzner, 1975; Knight and others, 1980). Short-eared Owls are active during the day as well as during the night (Wiggins and others, 2020); nocturnal activity—when their visibility to humans would be poor—may account for Jacobson's (2005) observation that Short-eared Owls are common victims of vehicle collisions because they often hunt near roads at the same height as vehicle windshields. Beston and others (2016) developed a prioritization system to identify avian species most likely to experience population declines in the United States from wind facilities based on the species' current conservation status and the species' expected risk from wind turbines. The Short-eared Owl scored a 3.62 out of nine; 2.87 percent of the Short-eared Owl breeding population in the United States was estimated to be exposed to wind facilities. Loss and others (2013) reviewed published and unpublished reports on collision mortality at monopole wind turbines (that is, with a solid tower rather than a lattice tower) in the contiguous United States; 10 Short-eared Owl mortalities were reported at six wind facilities. DeVault and others (2011) ranked the relative hazards of wildlife to aircraft within 152 m of ground level, based on data from the U.S. Federal Aviation Administration National Wildlife Strike Database from 1990 to 2009. The database included 58 Short-eared Owl strikes, and the relative hazard score for Short-eared Owl was 12 out of a possible 100 (higher scores indicating higher risk). Dolbeer and Wright (2008) reported 117 Short-eared Owl strikes with civil aircraft in the United States between 1990 and 2007, including four strikes that resulted in damage to the aircraft and four strikes that had a negative effect on the aircraft flight. Linnell and Washburn (2018) summarized owl collision data from the Federal Aviation Administration's National Wildlife Strike Database and the U.S. Air Force's Birdstrike Database between January 1, 1990, and June 30, 2014; 19 percent of 2,456 owl strikes with civil or U.S. Air Force aircraft in the United States were Short-eared Owls. During this period, Short-eared Owl strikes with civil aircraft and U.S. Air Force aircraft increased by 700 percent and 300 percent, respectively. The proportion of Short-eared Owl strikes that caused damage was 9.7 percent, with an average reported cost of $155,010 per reported damaging owl strike (Linnell and Washburn, 2018).

Management Recommendations from the Literature

Degradation of grassland habitats and conversion of contiguous grassland tracts to other land uses, typically agriculture, are the greatest threat to Short-eared Owl populations (Booms and others, 2014). Preservation of large, open grasslands and restoration of degraded or converted grasslands are high priorities for Short-eared Owls and their prey (Wiggins and others, 2020). Because Short-eared Owls are highly nomadic and the species tracks irruptions in abundance of small mammals across the landscape, the species may be present in an area in some years but not present in other years (Wiggins and others, 2020). As such, suitable habitat should be maintained even when the species is not present (Clark, 1975; Wiggins and others, 2020).

Johnson (1996) emphasized the importance of protecting native grasslands through conservation easements, land purchases, and development of farm programs with wildlife habitat conservation priorities. Privately owned lands (especially pastureland generally referred to as working lands) can provide habitat and protect native ecosystems, as >70 percent of the United States is held in private ownership (Ciuzio and others, 2013). Conservation partnerships between Federal, State, and Tribal agencies; nongovernmental organizations; and private landowners result in programs like grassbanks. Gripne (2005) described a grassbank as a conservation tool that exchanges the value of a given amount of livestock forage that is not produced for conservation benefits. Several authors have recommended the continuation of the CRP as a means to provide nesting habitat for Short-eared Owl and other species of grassland birds (Sinclair, 1990; Murphy, 1991; Bock and others, 1993). Other conservation collaborations with agricultural producers may further encourage maintenance of native habitats (Hilty and others, 2021).

Providing mosaics of grasslands and wetlands, in which tracts of land are managed under staggered schedules of disturbance (for example, prescribed fire, livestock grazing, or mowing) separated by years of nondisturbance, will ensure that some areas are available for nesting Short-eared Owls (Ryan, 1990; Murphy, 1993; Walk and Warner, 2000). Periodic disturbance is necessary in Great Plains grasslands mainly to prevent or reverse invasion by woody or introduced plant species and to maintain levels of vegetation height and density plus residual vegetation accumulations appropriate for a desired community of grassland birds. However, the frequency of disturbance that is appropriate varies among grassland types within the region (Murphy, 1993). In North Dakota, periodic burning, mowing, or grazing may help to maintain the 2- to 8-year-old accumulations of residual vegetation preferred by Short-eared Owls (Duebbert and Lokemoen, 1977; Berkey and others, 1993; Murphy, 1993). In tallgrass prairies, burning, mowing, or grazing every 2–5 years will maintain grassland

habitat by preventing succession to woody vegetation while allowing populations of voles and other small mammal prey to recover between disturbances (Leman and Clausen, 1984; Kaufman and others, 1990). Conversely, annual mowing or burning may cause vole populations to decline (Leman and Clausen, 1984; Kaufman and others, 1990). Swengel and Swengel (2014) suggested that Short-eared Owls will benefit from management programs that disproportionately favor maintaining large grassland areas with high litter accumulations. To maintain Short-eared Owl breeding habitat on conservation grasslands, Swengel and Swengel (2014) recommended that less than one-fifth of hayland should be hayed per year in late summer, with significant areas always managed without haying. Huang and others (2010) suggested alternating mowed and unmowed grass strips (annually or less often), such that unmowed areas maintain thatch for voles and mowed areas provide easier owl access to voles; no specifics as to strip width was provided, nor was the practice evaluated for success in providing suitable Short-eared Owl habitat. In North Dakota, Berkey and others (1993) suggested that periodic haying of dense nesting cover in uplands stimulates plant growth and also invasion of nonnative plant species. In Illinois, Herkert and others (1999) recommended that vegetation should be maintained at 30–40 cm tall by burning, mowing, or other techniques.

Although Short-eared Owls nest in pastures and rangeland (Keyes and Gahbauer, 2016), Short-eared Owls likely respond negatively to overgrazing (typically defined as stocking livestock at maximal rates for a given rangeland site type) and season-long grazing. Bock and others (1993) and Dobkin and others (1998) suggested creating a series of large, landscape-scale livestock exclosures across the western United States so that the effects of livestock grazing on birds can be measured. Increasing the amount of western rangeland from which livestock are excluded may benefit Short-eared Owls and other species that require relatively dense vegetation (Bock and others, 1993).

Removal of unnecessary fences may reduce mortalities or injuries associated with collisions with fences (Fitzner, 1975). For fences that cannot be removed, hanging ribbons, foil, or other markers may increase visibility of the fences and reduce collisions. Single-strand, electrified smooth-wire fences may pose less risk of collision than multistrand barbed-wire fences and, in comparison, cause no risk of entanglement. To reduce collisions with vehicles along highways, Jacobson (2005) suggested that the strategic placement of poles or short fencing along roadsides or medians may create an apparent barrier that results in Short-eared Owls flying higher. To reduce owl strikes with U.S. civil and U.S. Air Force aircraft, Linnell and Washburn (2018) suggested an integrated wildlife damage management program that includes nonlethal hazing, live capture and translocation, habitat modification, and other methods; however, the authors recommended further research that focuses on the development and evaluation of effective species-specific methods to reduce owl strikes on airfields.

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Table Q1. Measured values of vegetation structure and composition in Short-eared Owl (*Asio flammeus*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.

[cm, centimeter; %, percent; --, no data; <, less than; CRP, Conservation Reserve Program]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Dobkin and others, 1998	Oregon	Sagebrush steppe, riparian meadow	Idle	--	--	--	--	<1	--	--	--
Duebbert and Lokemoen, 1977 (nests)	North Dakota	Mixed-grass prairie, tame grassland	--	30–60	--	--	--	--	--	--	--
Evrard and others, 1991 (nests)	Wisconsin	Tame grassland (CRP)	--	70–90	36–47[a]	--	--	--	--	--	--
Fondell, 1997 (nests)	Montana	Tame grassland	Idle	--	22.2[a]	--	--	--	--	--	2.27
Fondell, 1997 (nests)	Montana	Tame grassland	Grazed	--	18.9[a]	--	--	--	--	--	2.13
Fondell and Ball, 2004	Montana	Tame grassland	Grazed	--	6.5[a]	31	25.6	0.5	--	43.3	1.3
Kantrud and Higgins, 1992 (nests)	Manitoba, Montana, North Dakota, South Dakota	Mixed-grass prairie, tame grassland	Idle, grazed	--	21[a], 43[b]	--	--	--	--	42[c]	--
Murphy, 1993 (nests)	North Dakota	Mixed-grass prairie	--	--	12[a]	--	--	--	--	--	--
Swaney, 1993 (nests)	Montana	Tame grassland	Idle, grazed	--	20.3[a]	--	--	--	--	--	--
Swengel and Swengel, 2014	Wisconsin	Tame grassland	--	--	--	--	--	1.3–17.6	--	--	--
Wiggins and others, 2020 (nests)	Montana	Unknown	--	<50	--	85	8	--	--	--	--

[a]Visual obstruction reading (Robel and others, 1970).

[b]Effective vegetation height.

[c]Standing dead vegetation.

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