The Effects of Livestock Grazing on the Habitat Suitability of Grassland-Dependant Vertebrate Species in British Columbia: A Literature Review

by

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DISCLAIMER

NOTE: The content of this report was completed in July of 2004 and reflects the state of our knowledge at that time. It has not been updated prior to publication 2011

Information on current status of native species in British Columbia can be found through B.C. Species and Ecosystems Explorer http://www.env.gov.bc.ca/atrisk/toolintro.html

SUMMARY

Grasslands make up only about 0.7% of the land area of British Columbia, and most of that area is grazed by livestock. Grazing affects the habitat suitability for most grassland-dependant vertebrate species, primarily due to changes in the structure of the grassland vegetation. Some species are most abundant in grazed grasslands, but many others are most abundant in ungrazed grasslands. Approximately 16% of vertebrate wildlife species and about 44% of red- and blue-listed species in British Columbia are most closely associated with grassland habitats.

Since most grasslands in British Columbia are grazed, populations of species that prefer ungrazed habitats may be lower than they were historically. This report summarizes literature on the habitat requirements of grassland-dependant vertebrate species and the effects of grazing on the habitat suitability for grassland wildlife communities. Four species that use different types of grassland vegetation communities were selected for detailed literature reviews of their habitat requirements. From these habitat requirements, standards can be developed to ensure that suitable habitat is maintained for these and other species that prefer structurally diverse grasslands.

Grassland small mammal communities are affected by grazing. Species richness and diversity in grasslands has been found to decrease with grazing in British Columbia and elsewhere in North America. The Meadow Vole requires live and dead vegetation for food and shelter and excessive grazing can reduce cover and forage to the point where population cycling does not occur. Grassland songbirds are also affected by grazing. Species richness and diversity often decrease with grazing pressure, although the total abundance or biomass of birds may not change. Nest success generally declines and nest predation and brood parasitism rates increase with decreasing vegetation complexity and increasing grazing. Vesper Sparrow nest density and nest success also decrease with increasing grazing. The microclimate of the nest site becomes less favourable to successful nesting if grassland vegetation is too short.

Many waterfowl species are closely associated with grasslands in British Columbia, and nest density, nest success, and nest predation rates are all affected by livestock grazing. Blue-winged Teal nest success decreases and nest predation rate increases with decreasing vegetation density around the nest. Nest density also affects nest predation rates, and nest density is affected by the quality of upland nest sites. Sharp-tailed Grouse nesting and overwinter habitat are affected by grazing. Nests require visual obstruction and are preferentially placed at the base of shrubs or other tall vegetation. An important winter habitat component is deciduous trees and shrubs. These often have limited distribution in grassland areas and shrub cover and tree recruitment may be reduced where they are heavily grazed by livestock. Insufficient winter habitat may reduce overwinter survival rates of Sharp-tailed Grouse and lead to population declines.

TABLE OF CONTENTS

1 INTRODUCTION

Many threatened and endangered vertebrate wildlife species in British Columbia are most closely associated with grasslands (Cannings et al. 1999; Fraser et al. 1999), but little direction is given to enable range managers to maintain grassland habitats for these species. Range monitoring in B.C. has focused on plant community composition and species abundance, rather than specifically on the structural attributes that are the most important for wildlife habitat. The emphasis on grassland vegetation community, rather than habitat attributes is, at least partially, due to the lack of information on specific habitat requirement thresholds for grassland-dependant species. This report summarizes the available literature on the habitat requirements of selected grassland-dependant wildlife species and identifies areas where additional research is required.

The extent and ownership status of grasslands in B.C. is also summarized, as is the economic activity generated by cattle ranching in B.C. The habitat requirements for four widespread grassland wildlife species are also examined in more detail. Widespread species were selected so that the habitat requirements of these species can be used to monitor range condition in grasslands across the province. Each selected species uses a different type of grassland habitat and different habitat attributes. Habitat types include dry, bunchgrass grasslands, wet meadows, shrubby riparian habitats, and herbaceous riparian habitats.

1.1 Grasslands in British Columbia

Grasslands are found in all 11 biogeoclimatic zones in the interior of B.C. High-elevation and northern grassland areas in the Alpine Tundra (AT), Montane Spruce (MS), Engelmann Spruce–Subalpine Fir (ESSF), Boreal White and Black Spruce (BWBS), and Spruce–Willow–Birch (SWB) biogeoclimatic zones are found primarily on frost-prone sites or on steep, warm-aspect exposures. Grasslands in the Sub-boreal-Spruce (SBS), Sub-boreal Pine–Spruce (SBPS), and Interior Cedar–Hemlock (ICH) zones are primarily confined to steep, dry, warm aspects. Grasslands in these zones make up only about 15% of the grassland area in the interior of B.C. (GCC 2003)[1].

Most grasslands in the interior of B.C. are found in the southern low-elevation zones: the Bunchgrass (BG), Ponderosa Pine (PP) and Interior Douglas-fir (IDF) zones. These zones all have large areas of contiguous grasslands that occur on a wide range of sites. The driest of these zones, the BG, occurs at low elevations in large valleys, primarily the Thompson, Fraser, Chilcotin, and Okanagan valleys (Nicholson et al. 1991). Grasslands cover most of this zone; trees are limited to moist or cool sites. Shrub-steppe occurs in this zone on very dry, hot sites dominated by sagebrush or antelope brush. The PP zone occurs above the BG zone in most areas and also occurs in southern portions of the Columbia River Valley (Hope et al. 1991a). The PP is

[1] Grasslands Conservation Council of British Columbia. 2003. B.C. grasslands mapping project: a conservation risk assessment final report. Grasslands Conserv. Counc. B.C., Kamloops, BC. 108pp.

the warmest and driest zone that supports continuous tree cover, but grasslands occur throughout the PP, maintained by a combination of edaphic and topographic conditions as well as by fire. The IDF is cooler, moister and much more extensive than the other two grassland zones; much of this zone is dominated by forests (Hope et al. 1991b).

Of the almost 93 million hectares of land in B.C., only about 275,000 ha or 0.7% is grassland (GCC 2003). Almost as much of these grasslands are privately owned (43%) as are provincial Crown owned (46%). The remaining grassland area in B.C. is under federal government jurisdiction (10.1%) and most of that is in First Nations reservations.

Much of the privately owned grassland is in the form of ranches and is therefore grazed. Some privately owned grasslands are maintained in excellent condition, but other private grasslands are heavily grazed and have limited vegetation holdover from year-to-year. Regardless of the grazing management regimes on these lands, at this time there is no provincial protection of wildlife habitats on **privately** held grasslands. Often, private grasslands are not available to be inventoried by wildlife managers and researchers, and the use of private grasslands by sensitive wildlife species is not well known.

Of provincial Crown grasslands, 88% are under some form of grazing tenure (GCC 2003). Most grazing tenures on provincial Crown rangelands are in the form of grazing licences, which allow the licence-holder to graze a specified number of livestock for a specified period. These grazing licences are subject to range-use plans that are approved and administered by the B.C. Ministry of Forests, Range Section. Livestock grazing on First Nations lands under federal jurisdiction is also common.

Because only 12% (15,180 ha) of provincial Crown grassland is not grazed by livestock—and probably little private and federal grasslands is ungrazed—species that require or prefer undisturbed grassland conditions may be at risk of population declines.

Virtually all of the grassland-dependant species found in B.C. are found in the southern low-elevation grasslands and are uncommon in or absent from other grassland types. Nearly all red- and blue-listed grassland species, including Badger, Pallid Bat, Spotted Bat, Nuttall's Cottontail, Fringed Myotis, Western Small-footed Myotis, Upland Sandpiper, Sprague's Pipit, Sage Thrasher, Brewer's Sparrow, Grasshopper Sparrow, Columbian Sharp-tailed Grouse, Swainson's Hawk, Ferruginous Hawk, Burrowing Owl, Western Rattlesnake, Great Basin Spadefoot, Yellow-bellied Racer, Short-horned Lizard, and Gopher Snake are most closely associated with southern low-elevation grasslands (Cannings et al. 1999; Fraser et al. 1999).

The grasslands in B.C. are different in both structure and species composition from most other grassland types in North America (Weaver and Albertson 1956; Bazzaz and Parrish 1982; Wallis 1982). These differences result in different habitat suitability in undisturbed grasslands among the grassland types. The effects of grazing on habitat suitability and the responses of species to livestock grazing may differ among grasslands. Some of these differences will be described in detailed habitat suitability discussions for selected species below.

1.2 Economics of British Columbia Grasslands

Cattle ranching is the largest land-use activity on grasslands in B.C., but extensive areas of grasslands have been lost to urbanization and other forms of agriculture. About 290,000 cattle or about 6.5% of the Canadian total are raised annually in B.C. (B.C. Cattlemen's Association, pers. comm.2004). From 1986 to 1996, cattle numbers increased by more than 30% across B.C., but the increase in the southern interior grasslands was only 11.5%. In 1986, 67.1% of beef cattle in B.C. were raised in the southern interior grasslands. By 1996 that total had dropped to 57.3%, and by 2001 it had dropped to 56.1%. There were 5011 cattle ranches operating in B.C. in 2001, 85% of which had less than 100 head of cattle. Large operations, those with more than 200 head, make up only 6% of ranches in B.C.

Beef cattle production made up about 16% of the economic activity in the agriculture sector in BC in 2001. Beef cattle cash receipts were $355 million in 2001 and contributed about $1.95 billion to the provincial economy. The beef cattle industry makes up about 1.5% of the provincial gross domestic product (B.C. Cattlemen's Association).

1.3 Effects of Grazing on Grassland Vegetation

Grazing is defined as the removal and consumption of leaf and stem material from plants by foraging livestock or wildlife (Holechek et al. 2001). Foliage removal has the effect of decreasing or, if excessive, eliminating the ability of the plant to photosynthesize (Campbell and Bawtree 1998). Range plants are most susceptible to defoliation in the spring when energy stores have been used to initiate plant growth. Defoliation during this period can have long-term effects on plant vigour (Holechek et al. 2001). The effects of foliage removal on plant vigour depends on the type of plant grazed, the moisture conditions at the time of defoliation, and the timing, frequency, and intensity of defoliation (Campbell and Bawtree 1998; Holechek et al. 2001)

Low levels of foliage removal can increase the tillering of grasses, leading to increased ground cover and better nutrient content for grazers (Campbell and Bawtree 1998). However, with high levels of defoliation, the plant must use stored carbohydrate reserves, in either root or shoot material, to regrow foliage (Holechek et al. 2001). Chronic heavy grazing can then lead to reduced root development, as root material is continuously reabsorbed to provide energy to grow foliage. If overgrazing persists, grazed plants can die (Holechek et al. 2001) and the plant community will shift to plant species that are more tolerant to grazing or are less used by grazers. For plant vigour to be unaffected by grazing, 50 to 70% of the annual leaf and stem production should be retained (Holechek et al. 2001).

Heavy grazing of pastures occurs when more than half of the fair- and poor-value forage plant biomass is consumed, leading to a clipped appearance (Holechek et al. 2001). Persistent heavy grazing can affect the vegetation species composition of grasslands (Holechek et al. 2001), which can affect grassland wildlife habitat suitability. This only results with long-term overuse of the range; however, as will be shown in following sections, the short-term consequences of this overgrazing probably has as great an effect on grassland wildlife communities as long-term vegetation community shifts. The following discussion will focus on the effects of grazing on vegetation structure and the resulting changes to wildlife habitat suitability.

1.4 Effects of Grazing on Grassland Wildlife

Some 16% (66 species) of the terrestrial vertebrate species found in B.C. are most closely associated with grasslands and another 60% (248 species) use grasslands for some part of their life history. Of the 83 red- or blue-listed interior vertebrate species, 37 (44%) are grassland-dependant species. Of the 66 grassland dependent vertebrate species in B.C., 56% are either red- or blue-listed. Part of the reason that such a high proportion of grassland wildlife species are red- or blue-listed is because grasslands are rare in B.C. However, the distribution and abundance of many of these listed grassland species has decreased over the past several decades, suggesting that these species are at risk of further declines or extirpation in B.C.

Many grassland wildlife species respond most strongly to the vegetation structural attributes of the habitat. Because livestock grazing and other agricultural practices likely exert the largest single influence on grasslands in North America, considerable effort has been made to study the effects of grazing on wildlife populations and wildlife habitat (Watkinson and Ormerod 2001). The ecological effects of grazing on wildlife habitat can include alteration of vegetation species and structure or changes in ecosystem function (Fleischner 1994). Milchunas et al. (1998) found that the trophic structure of wildlife communities often does not differ between grazed and ungrazed sites, but that species composition often differs greatly. Brown and McDonald (1995) argue that grazing may be an important component of grassland ecosystems, but that management objectives for grasslands emphasize economic returns rather than ecosystem health. They argue that it should be possible to balance ecosystem health with economics.

Because so little grassland area in B.C. is ungrazed, grassland-dependant wildlife that reach their highest densities in grasslands with characteristics of ungrazed conditions are the most likely to be at risk of population declines in B.C. Furthermore, Brown and McDonald (1995) argue that sustainable management of grasslands should incorporate the environmental and biotic influences under which grasslands evolved. B.C. grasslands evolved under the influence of frequent fire and light grazing by ungulates, including wild sheep, but did not have the high-intensity grazing associated with Bison. Following this principle, management of grasslands in B.C. would include periodic spring and summer burning, but would not include high-intensity grazing (Gayton 2003).

Thus, the following discussion will focus on species that require, prefer, or reach their highest densities in ungrazed grasslands. Species that prefer grazed grassland conditions are unlikely to become limited by habitat availability in B.C., given that most grasslands are grazed. Some species do prefer grasslands with vegetation structures created by grazing including a few species rare to B.C., such as the Long-billed Curlew and Lark Sparrow.

1.4.1 Grassland small mammals with emphasis on the Meadow Vole

Several small mammal species are closely associated with grasslands in B.C. Red- and blue-listed small mammal species most closely associated with grasslands include White-tailed Jackrabbit, Nuttall's Cottontail, Great Basin Pocket Mouse, and Western Harvest Mouse (Cannings et al. 1999). These species are found only in the southern-most grasslands in the Okanagan Valley. Some more common small mammal species are also closely associated with grasslands. These include Western Jumping Mouse, Meadow Vole, Montane Vole, Columbian Ground Squirrel, and Northern Pocket Gopher (Banfield 1974).

The richness and diversity of small mammal species are affected by grazing. Bock et al. (1984) found that small mammals are more abundant in Arizona grasslands that had not been grazed for 15 years than in grasslands that had been continuously grazed over that period. The ungrazed study site had a significantly higher cover of herbs and grasses than the grazed site, whereas the grazed site had significantly more bare ground. Likewise, Reynolds and Trost (1980) found that the diversity and abundance of small mammals are reduced with grazing in sagebrush grasslands in Idaho. In their study, the structure of the vegetation community was little affected by grazing, but species richness of the vegetation was much lower in grazed areas. Rosenstock (1996) found that small mammal communities in large grassland patches that had been ungrazed for 30 years have 50% more species and 80% higher abundance than grazed areas in Utah. These large habitat patches had more litter and more abundant, taller grass than grazed habitats. He found no difference in small mammal communities between small, ungrazed patches (less than 1 ha exclosures) and grazed patches. In Colorado, Schulz and Leininger (1991) found no difference in small mammal community richness between grazed and ungrazed sites, but the small mammal species making up the community differed between treatments. In B.C., Roberts (1994) found higher small mammal abundances in ungrazed grasslands than in continuously grazed areas.

Small mammal communities in grassland riparian areas are also affected by grazing. In Wisconsin, ungrazed riparian areas have higher richness and abundance of small mammals than continuously or rotationally grazed riparian areas (Chapman and Ribic 2002). In B.C., Martin (1993) found that abundance and richness of small mammal communities is higher in ungrazed grassland riparian areas than in grazed riparian areas. Total cover of vegetation does not differ among treatments, but the cover of litter is significantly lower in grazed sites.

Small mammal species respond differently to grazing. Schulz and Leininger (1991) found that Deer Mice are most abundant in grazed areas, but Western Harvest Mice are most abundant in ungrazed areas. Likewise, in Kansas, Matlack et al. (2001) found that Deer Mice are most abundant in grazed sites, but Least Shrews and Western Harvest Mice are found only in ungrazed pastures. In B.C., Martin (1993) found Western Jumping Mice only in ungrazed grassland riparian areas. Roberts (1994) found higher densities of Deer Mice in grazed sites than in ungrazed sites, and higher densities of Montane Voles in sites that have been ungrazed for more than a decade than on sites that have been grazed over that period.

The population response of small mammals to grazing also varies among types of grassland. For example, Grant et al. (1982) and Steenhof and Kochert (1988) found small mammal communities in tallgrass prairies are more strongly influenced by grazing-related changes in vegetation structure than those in shortgrass or bunchgrass grasslands.

Grazing-related changes in small mammal communities are probably due to changes in microhabitat conditions resulting from vegetation alterations. Microhabitat conditions may affect population demographics of small mammals more than other factors (Birney et al. 1976; Adler 1987; Adler and Wilson 1989), and insufficient resources may limit population densities (Bergeron and Jodoin 1994) or delay emergence from hibernation (Cranford 1983).

Meadow Voles are one of the most abundant and widespread rodents in Canada in a variety of open habitats (Banfield 1974). Meadow Voles occur in more productive grassland areas in B.C. In drier upland sites with sparse vegetation, the Meadow Vole is replaced by the Montane Vole. Meadow Vole densities decrease with increasing density of woody vegetation (Adler 1987) and increase with increasing grass and forb density (Klatt and Getz 1987). Meadow Vole diets in summer and winter are dominated by grass and sedge foliage, with forbs and seeds in lesser amounts (Bergeron and Jodoin 1994). Diet quality for Meadow Voles decreases with increasing phenolic compounds in forage plants; these compounds generally increase with age of the plant (Bucyanayandi and Bergeron 1990).

Female Meadow Voles are territorial, defending a small area around the nest site. Home ranges are 0.03 to 0.9 ha, depending on habitat quality and season. Throughout the year, Meadow Voles construct and use runways in thick grassy areas. Grass stems are cut and surrounding vegetation overgrows the runway, providing overhead cover and security. Meadow Voles are active mainly during the early morning and pre-dusk times of the day (Banfield 1974).

Fecundity of Meadow Voles is extremely high in good habitats; breeding commences in April and continues until October or even into February when food is abundant (Banfield 1974). Gestation is 20 or 21 days with an average of 6.3 young per litter. Litter sizes increase with increasing food availability. Females can produce as many as 17 litters per year, but in the wild, the average number is 3.5 litters per year. Female voles begin mating at about 21 days of age, whereas males do not become reproductively active until about 45 days of age.

Meadow Vole populations undergo cyclic population fluctuations with population peaks about every 3 to 4 years. Populations can exceed 1000 per hectare at the peak population density. If resources are insufficient, populations may be unable to grow fast enough to initiate population cycling (Birney et al. 1976). When resources are limiting, a breeding population can be maintained, but that population will not undergo population cycling. The failure to undergo population cycling is likely due to poor recruitment and overwinter survival.

Grazing can affect Meadow Vole population density. Grazing reduces Meadow Vole densities in riparian areas in Wisconsin (Chapman and Ribic 2002). This is probably due to decreased forage availability (Jones 1990) or cover (Birney et al. 1976; Klatt and Getz 1987; Adler and Wilson 1989; Hall et al. 1991; Peles and Barrett 1996; Yu-Teh and Batzli 2001).

Experimental reduction of grass cover reduces the body mass, population density, and recruitment rates of Meadow Voles in Ohio (Peles and Barrett 1996). Increasing cover of grasses also results in higher survival rate of Meadow Voles (Adler and Wilson 1989). A similar experiment by Yu-Teh and Batzli (2001) in Massachusetts found that population density decreases with decreasing cover, but that recruitment and survival rates do not change. In their study, adding supplemental food to the habitat did not increase population densities, suggesting that food was not the limiting factor on population density. Supplemental food can lead to population increases in some habitats. Sullivan and Sullivan (1984) found that supplemental feeding increases the density of Meadow Voles in harvested forests in B.C. and Jones (1990) found that increasing the quantity of food in poor habitat leads to decreased female territory sizes and increased Meadow Vole densities.

Cover alone does not predict vole densities. In Ohio, treatment of fields with fertilizers or sewage sludge increases the biomass of vegetation, but decreases the vegetation species richness and the biomass of preferred forage species (Hall et al. 1991). With the change in vegetation, the abundance of Meadow Voles decreases and their survival and recruitment rates are reduced.

Above a threshold value of cover and food, Meadow Vole populations appear to be limited by factors other than resources. Vole density does not increase when grass cover exceeds 20% in Massachusetts (Adler and Wilson 1989). Similarly in Ohio, an experimental addition of cover does not lead to increased densities, whereas reductions in cover lead to density declines (Peles and Barrett 1996). Birney et al. (1976) hypothesize that Meadow Vole populations cannot undergo population cycling when vegetation cover is below a certain threshold value. It is unclear what threshold values for cover and food apply in B.C. grasslands. Martin (1993) found that Meadow Voles are as abundant in plots with a vegetation cover of 55% as they are in plots with more cover.

Summary of Meadow Vole Habitat Requirements

Vegetation density is the main habitat attribute affecting Meadow Vole density. Sufficient vegetation cover to allow population cycling will ensure that Meadow Vole productivity is high. Since litter provides cover, but live vegetation is required for food, a combination of live and dead vegetation is needed. A combined cover of litter and grass of more than 55% should provide adequate habitat for Meadow Voles, but this threshold needs to be confirmed with quantitative research.

1.4.2 Grassland songbirds with emphasis on the Vesper Sparrow

Many songbird species are closely associated with grasslands in B.C. Red- or blue-listed songbird species most closely associated with grasslands include the Yellow-breasted Chat, Sage Thrasher, Canyon Wren, Brewer's Sparrow, Lark Sparrow, Grasshopper Sparrow, and Bobolink (Fraser et al. 1999). Some more common and widespread songbird species are also closely associated with grasslands in B.C. In North America, grassland-nesting bird species are declining faster than bird species that nest in other habitat types (Petterjohn and Sauer 1999).

Vesper Sparrow Ecology

The Vesper Sparrow was chosen for detailed habitat description because it is often the most abundant bird species in grasslands of the province (Campbell et al. 2001). Additionally the habitat requirements for this species have been relatively well studied across its range. Many Vesper Sparrow populations have experienced declines (Petterjohn and Sauer 1999), although they have increased in some areas (Jones and Bock 2002[2]) and do not appear to be declining in B.C. (Campbell et al. 2001).

The Vesper Sparrow is one of the most common and widespread grassland songbird species in B.C., occurring from the Cariboo region south to the International border (Campbell et al. 2001). It winters in southern United States and northern Mexico and nests in a range of open habitats across the United States and southern Canada. In B.C., the Vesper Sparrow is most common in low-elevation grasslands, reaching its highest abundance in the Okanagan, Similkameen, and Thompson valleys. It is often the most abundant bird in the grasslands of the Cariboo (Campbell et al. 2001).

The Vesper Sparrow breeds in bunchgrass grasslands, sagebrush shrub-steppe, and open areas in Douglas-fir, ponderosa pine, or lodgepole pine forests (Campbell et al. 2001). It will also nest along fence lines with taller vegetation and within agricultural fields once vegetation reaches about 10 cm in height (Rodenhouse and Best 1983). Most nests in B.C. have been recorded in big sagebrush rangelands, grassland with scattered ponderosa pine or Douglas-fir trees, or meadow habitats (Campbell et al. 2001).

The diet of adult Vesper Sparrows consists almost entirely of insects, and nestlings are fed exclusively animal material, especially insects (Rodenhouse and Best 1994). Foraging is concentrated on the ground in areas with sparse vegetation, but insects may be gleaned from foliage up to 25 cm above the ground (Rodenhouse and Best 1994). Most foraging occurs within the territory of a Vesper Sparrow pair during the nesting season, and Vesper Sparrows usually walk a short distance between foraging bouts (Rodenhouse and Best 1994).

Response of Birds to Livestock Grazing

Studies examining the response of grassland bird species and communities to livestock grazing are numerous. Not all grassland songbird species respond equally to grazing. In Arizona, Grasshopper Sparrows and Cassin's Sparrows are absent from grazed plots, whereas Horned Larks and Lark Sparrow are most abundant in these plots (Bock and Webb 1984). Another study in Arizona also found that Grasshopper Sparrows, Cassin's Sparrows (and Chipping Sparrow only in winter) are significantly more abundant in both summer and winter on ungrazed sites, whereas Quail, Doves, Flickers, Horned Larks, Northern Mockingbirds, and Lark Sparrows are more abundant in the grazed sites (Bock et al. 1984). Baker and Guthery (1990) found that

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[2] Jones, Z.F. and C.E. Bock. 2002. Conservation of grassland birds in an urbanizing landscape: a historical perspective. Condor 104(3): 643-651.

Eastern Meadowlark abundance is lower in heavily grazed plots than in lightly grazed plots, but mourning doves are more abundant in the heavily grazed plots.

Several studies have found relationships between songbird community abundance, diversity, or richness and livestock grazing. Bird species richness decreases with grazing in North Dakota shortgrass grasslands, but total abundance of birds is higher in grazed sites (Kantrud 1981). Although total bird abundance is higher at the grazed site in this study, the bird community in grazed sites is dominated by a few abundant species. Similarly, in comparing a number of sites in Texas and Oklahoma, Grzybowski (1982), found a higher biomass of wintering birds in heavily grazed grasslands, but the community is dominated by a few abundant species. In Saskatchewan tallgrass prairie, grazed sites have a higher abundance of feeding birds, but most of these species nest in other habitat types (Dale 1984). Given that foraging habitat is often different from nesting habitat, these results are not unexpected.

Bird communities are more severely affected by drought in heavily grazed pastures than in ungrazed pastures (George et al. 1992). Declines in abundance are attributed to decreased cover of vegetation during the drought; population decreases and the reduction in vegetative cover are more severe in heavily grazed fields. Bock and Bock (1999) had similar results in Arizona with decreased abundance of ground-foraging birds in grazed fields one year after the end of a drought, when grasses in an ungrazed exclosure were taller and denser than grasses outside the exclosure. Two years after the end of the drought, both grass composition and bird communities were more similar inside and outside the exclosures.

The diversity and abundance of songbirds is also affected by grazing in grassland riparian areas (Kauffman and Krueger 1984). Schulz and Leininger (1991) found that bird species richness is higher in ungrazed riparian sites in Colorado grasslands, but that the abundance of only one species, Wilson's Warbler, is significantly higher in ungrazed sites. Taylor and Littlefield (1986) found a decreasing abundance of Willow Flycatchers and Yellow Warblers with increasing numbers of cattle grazing in riparian areas of pastures in Oregon. Taylor (1986) and Dobkin et al. (1998) both found that diversity and abundance of songbirds is lower in grazed riparian areas than ungrazed areas in Oregon. Both of these studies attributed changes in bird communities to changes in vegetation structure due to grazing. Likewise, Sanders and Edge (1998) found that bird species richness and abundance in shrub-steppe riparian areas in eastern Oregon is higher with more vertical diversity, cover of shrubs, and width of the riparian vegetation strip.

Grazing probably affects grassland bird communities most significantly by altering vegetation structure and heterogeneity rather than by affecting birds directly. Gougen and Mathews (1998) found no difference in bird community between grazed and ungrazed pinyon-juniper sites where the vegetation did not differ between treatments, suggesting that grazing-induced changes to vegetation structure, rather than the presence of cattle, is the factor affecting bird abundance.

Vegetation treatments to improve forage production for cattle can also influence bird populations. Elimination of sagebrush by herbicide treatment in Montana eliminated Brewer's Sparrows from the site but did not change the abundance of Vesper Sparrows (Best 1972). Mesquite removal by herbicides in Texas increased the abundance of grassland birds but decreased the abundance of shrubland birds (Gruver and Guthery 1986). Sagebrush removal by fire in several northwestern states resulted in reduced abundance and diversity of birds (Welch 2002).

The importance of vegetation structure is highlighted by studies examining the effects of hayfield mowing on grassland bird communities. Mowing altered bird communities in hayfields in Saskatchewan (Dale et al. 1997). In this study, Baird's Sparrows and Sprague's Pipits are most common in native grasslands, whereas Savannah Sparrows are most abundant in idle hayfields. No species are most abundant in the mowed hayfields. Mowing of the hayfield reduced Savannah Sparrow density by 80% for the remainder of the nesting season. Mowing alfalfa fields also decreases the abundance of songbirds in Iowa (Frawley and Best 1991).

Some species react to differences in vegetation species rather than changes in vegetation structure. Diversity of vegetation species is positively correlated with bird community diversity and richness in hayfields in New York (Bollinger 1995). Bollinger and Gavin (1989) found that Eastern Meadowlarks prefer older hayfields that have lower cover of alfalfa and higher cover of grasses. Bollinger (1995) also found that Bobolinks, Upland Sandpipers, Grasshopper Sparrows, and Henslow's Sparrows are more abundant in hayfields with a higher proportion of grasses than fields with a higher proportion of alfalfa. Bird communities in restored grasslands in Iowa are similar in species, abundance, and diversity to bird communities in native grasslands (Fletcher and Koford 2002).

Few studies examining the effect of weed infestation on bird communities are available. One study found that some species decline with leafy spurge cover in North Dakota, whereas others are unaffected (Scheiman et al. 2003).

Vesper Sparrow densities in continuously grazed pastures are lower than in either ungrazed or rotationally grazed grasslands in Wisconsin, presumably because they need larger areas to meet dietary requirements (Temple et al. 1999). Vesper Sparrow nests are found in rotationally grazed pastures where vegetation is relatively taller than in continuously grazed pastures, although specific habitat measurements were not given.

Habitat Structure and Songbird Communities

Studies relating bird communities to vegetation structure are numerous. Changes in grassland bird communities with grazing are presumed to be due to grazing-related changes in vegetation structure (Kauffman et al. 1983; Brady et al. 1989), but functional response studies examining threshold levels of habitat attributes are lacking (Watkinson and Ormerod 2001). A study in the Cariboo-Chilcotin grasslands of B.C. found that bird abundance increased with increasing vegetation complexity, but that individual species responded to habitat structure differently (Hooper and Savard 1991). Mills et al. (1991) reported that species richness during the nesting season is strongly affected by vegetation volume. A study conducted across North American grasslands found that bird species presence is better predicted by vegetation structure than by other factors (Rottenberry and Wiens 1980). Delisle and Savidge (1997) found that species abundance differs between fields planted with tall, dense grasses, and fields with shorter, sparser legume-grass mixes.

The density of Vesper Sparrows, as with other grassland bird species, varies with vegetation structure more than other habitat attributes (Haire et al. 2000). The climate of B.C. grasslands is drier than that of other grassland types in North America, leading to a more cover of bare ground, shorter maximum vegetation heights, and lower vegetative cover than is found in other grassland types (Holechek et al. 2001). The vegetation structure that results from grazing varies considerably among grassland types, resulting in different habitat suitability. Annual production of tallgrass, mixed grass, and shortgrass prairie, all found to the east of the Rocky Mountains, is usually much higher than that of B.C. bunchgrass grasslands (Holechek et al. 2001). In addition, the growth form of the vegetation differs among grassland types, with eastern sod-grasses forming more or less continuous ground cover, whereas bunchgrass grasslands have patchy cover with considerable bare ground.

The literature on the effects of grazing on Vesper Sparrow habitat suitability is full of apparently contradictory results; some studies found an increase in Vesper Sparrow density with grazing and others found that grazing decreases Vesper Sparrows. These differences are fairly clearly divided along grassland types.

In eastern grasslands, where sod grasses dominate grassland communities and maximum vegetation heights are tall, Vesper Sparrows tend to respond positively to grazing. In Alberta, Vesper Sparrows are more abundant in cultivated fields or grazed grasslands than in undisturbed grasslands (Owens and Myres 1973). Bock et al. (1984) found that Vesper Sparrow are more abundant in winter on grazed sites where grass cover was 55.6%, and bare ground cover was 34.6% than on ungrazed sites where grass cover was 80.4% and bare ground cover was 17.6%. In Montana, Vesper Sparrow densities are highest in areas with more continuous vegetation cover and shorter grass heights (Reed 1986). In this study, Vesper Sparrow territories were established where grass heights were 20.2 to 29.0 cm, whereas areas with vegetation of 22.7 to 34.5 cm were avoided. In the shortgrass grasslands of Saskatchewan, there is no difference in Vesper Sparrow territory density between fields planted with crested wheatgrass and natural pastures, suggesting that the structure of vegetation influences habitat quality more than the species of vegetation (Davis and Duncan 1999). Vesper Sparrow density is negatively correlated with vegetation height in this study. Burned areas, which have reduced vegetation heights during the nesting season, also support higher densities of Vesper Sparrows than unburned areas in southern tallgrass prairies in Saskatchewan (Davis et al. 2000).

In shrub-steppe and bunchgrass grasslands of the Great Basin, Vesper Sparrows tend to respond negatively to grazing. Vesper Sparrows were seen only in ungrazed crested wheatgrass pastures in Idaho and were absent from grazed sites (Reynolds and Trost 1980). In bunchgrass grasslands in B.C., Hooper and Savard (1991) found that Vesper Sparrow abundance is highest in grasslands with the tallest, densest vegetation. Also in Cariboo grasslands, Hooper and Pitt (1994) found the highest abundance of Vesper Sparrows where May-June vegetation height is at least 8 cm, and grass cover is 33% or more.

Vesper Sparrows also respond to shrub cover differently across their distribution. A study in Montana (Best 1972) found that reducing or eliminating the cover of big sagebrush had no effect on the density of Vesper Sparrows. However, Wiens and Rottenberry (1985) found that Vesper

Sparrows first appeared in their study area in southern Oregon after a herbicide-induced reduction of big sagebrush and a corresponding increase in grass cover.

Nest Success

As discussed above, the effect of grazing on songbirds has often been assessed by comparing the abundance, diversity, or richness of bird species in grazed and ungrazed habitats. This type of information is valuable for assessing habitat suitability, but it may provide inaccurate impressions about the health of bird communities. Reproductive productivity is likely the most important factor influencing populations of songbirds. High-quality reproductive habitat may differ from high-quality foraging habitat (Dale 1984; Martin 1989).

Nesting success is at least as important to population demographics as breeding density. Factors that affect nesting success include nest predation rates, nest parasitism by Brown-headed Cowbirds and other brood parasites, forage availability for both reproducing adults and juveniles, and environmental or climatic factors. These factors are all affected by vegetation characteristics in nesting territories and at nest sites.

High breeding densities may not equate to high reproductive output. For example, McCoy et al. (1999) found that although Red-winged Blackbirds and Dickcissels nest at high densities in Conservation Reserve Program (CRP) fields in Missouri, reproductive output from nests in these habitats is not sufficient to maintain the populations. Populations in the CRP fields are only maintained by immigration from more productive habitats.

Baker et al. (2000) found a correlation between nest success and vegetation cover. Hughes et al. (1999) found that Dickcissel nest success is highest in grasslands with more litter, and more live and dead vegetation cover in Kansas. Wray and Whitmore (1979) found that Vesper Sparrow nest success is positively correlated with vertical diversity and amount of litter in West Virginia.

Nest Predation

Nest predation is often the most important cause of reproductive failure in songbirds (Dion et al. 2000), and predation rates differ with predator community and habitat type (Thompson and Burhans 2003). Adaptations to reduce nest predation losses include locating nests at sites not easily accessed by predators, spacing nests away from neighbours, using cryptic nest sites, or nest defence (Martin 1995). Most songbirds rely on minimizing nest accessibility or nest detection to reduce predation rates.

Martin (1989) reviewed a number of papers examining nest predation rates of North American birds and found 16 of 19 papers reported lower predation rates in nests with concealing foliage than in nests without concealing foliage. Songbird predation rates in grasslands appeared to be less influenced by cover; only one of three papers reported increased predation of songbird nests related to decreased cover. Models for predicting predation rates for Missouri grassland songbirds found lower predation and nest parasitism rates for nests with increased concealing cover and increasing nest height (Budnik et al. 2002). Although vander Haegen et al. (2002) found that habitat fragmentation has the most effect on predation rates of grassland birds; they also found that increased vegetation cover reduces predation rates. Murray and Best (2003) found that nest predation rates are lowest in fields that have not been mowed, with more concealment by vegetation.

These findings are consistent with findings for grassland riparian areas. Predation rates are higher in grazed riparian areas than ungrazed in Pennsylvania (Popotnik and Giuliano 2000) and Nevada (Ammon and Stacey 1997). Riparian nesting birds select areas with higher vegetation volume than is typically available, probably as a response to the reduced nest predation and parasitism risk in these habitats (Powell and Steidl 2002).

In contrast to these studies, Dion et al. (2000) found higher predation rates on songbird nests with more grass cover in North Dakota grasslands. They also found that predator type varied with vegetation type, with small mammals depredating nests more in denser vegetation than bird or medium-sized mammal predators. Small mammal predators are probably selecting habitats with dense vegetation where their exposure to avian predators in minimized.

Habitat attributes influence the composition of predator communities, as well as predator efficiency. Corvid predators are more common in fragmented habitat in eastern Washington, whereas small mammals are the most common predator in continuous habitats (vander Haegen et al. 2002). Foraging efficiency of Raccoons is reduced with increased volume of vegetation (Bowman and Harris 1980). Likewise, nest predation rates on Hermit Thrush nests is lower in habitats with many potential nest sites than in habitats with few potential nest sites, presumably because more search time is required to locate nests (Martin and Roper 1988).

The addition of supplemental food for nest predators does not affect survival rates of songbird nests in Georgia, but the species predating nests shifts to avian and small mammal predators from large and medium-sized mammal predators (Jones et al. 2002). Johnson and Temple (1990) found that nest predation is highest near the edge of grasslands, in smaller grassland patches, and in recently burned grasslands.

Vegetation complexity around nests has been shown to influence predation rates of ground-nesting songbirds (With 1994; Ammon and Stacey 1997; vander Haegen et al. 2002), although egg and hatchling loss to predators varies with the suite of predators in the habitat (Dion et al. 2000) and with the availability of alternative prey (Ackerman 2002). In most studies of grassland nesting birds, increased vegetation complexity around the nest generally reduces nest predation rates (Delong et al. 1995; Patterson and Best 1996; Ammon and Stacey 1997; vander Haegen et al. 2002; Watters et al. 2002). Bowman and Harris (1980) found that search times and depredation rates on artificial nests by Raccoons increases with increasing heterogeneity of vegetation. In their study, predation rates do not differ between partially and totally concealed nests, suggesting that predation rate is more related to the increased search times required in a complex habitat than to the degree of concealment that habitat provides. Some birds use concealing vegetation to hide their approach to the nest, including the Vesper Sparrow.

Not all studies of songbird nest predation have shown a difference in predation rates with increasing habitat complexity. Vickery et al. (1992) found that Striped Skunk predation on ground-nesting or shrub-nesting birds does not differ with vegetation structure, cover, or proximity to edge. McCown's Longspur nests near shrubs experience much higher predation rates than nests further from shrubs (With 1994). The main predator in the study area, ground squirrels, selectively use areas with overhead cover to reduce predation risk from raptors, so they more frequently encounter nests close to shrubs. Different predator communities may result in different predation patterns.

Brood Parasitism

Cowbird brood parasitism can have a large effect on the productivity of songbird populations (Newman 1970; Greene 1999). Staab and Morrison (1999) found that brood parasitism by Brown-headed Cowbirds is lower in riparian habitats with taller riparian vegetation, more vegetation volume around the nest, and more visual obstruction below the nest. Non-parasitized nests have more than 50% concealing vegetation more often than expected, whereas parasitized nests have 50% concealment less often than expected. Gougen and Mathews (1999) found no difference in parasitism rates between grazed and ungrazed pinyon-juniper sites in New Mexico, but the vegetation structure is not different between the sites. Johnson and Temple (1990) found that brood parasitism by Brown-headed Cowbirds is highest in areas closest to grassland edge.

Cowbird density increases with proximity to cattle grazing (Gougen and Mathews 1999; Kostecke et al. 2003). Likewise nest parasitism rates are higher closer to cattle grazing sites, although Cowbirds will forage at distances more than 12 km from breeding sites (Gougen and Mathews 2001). Cowbirds foraged in different areas but did not change nesting areas after cattle grazing was halted in a study area in Texas (Gougen and Mathews 2001; Kostecke et al. 2003). Although these Cowbirds continued to use the same nesting site despite the long commute, their reproductive output decreased with increasing commute distance.

Although Vesper Sparrows are apparently an uncommon host for Brown-headed Cowbird brood parasitism in B.C. (Campbell et al. 2001), they are common hosts in other parts of North America (vander Haegen and Walker 1999).

Food availability

Food availability can affect densities and survival of breeding birds. McEwen et al. (1972) found that spraying to reduce grasshoppers reduces the density of grassland birds even when spray concentrations do not directly cause bird mortality. George et al. (1995) found no difference in bird abundance with a variety of pesticide treatments, suggesting that effects on bird communities of pesticide treatments is related to food reduction rather than direct pesticide effects. Likewise, Cody (1981) found that both bird community abundance and insect abundance are related to annual rainfall in Arizona. Miller et al. (1994) found that Savannah Sparrow densities and nest success do not differ between years with abundant and scarce grasshoppers, but clutch sizes are smaller when food is less abundant. Savannah Sparrows shift to other food sources when grasshoppers are not readily available. Northern Oriole densities doubled after an outbreak of tent caterpillars in Manitoba (Sealy 1980). Ovenbird territory size decreases when food items are abundant; this could lead to higher breeding densities (Zach and Falls 1975). In Idaho shrub-steppe, reduced prey densities reduce the growth of Sage Thrasher and Brewer's Sparrow hatchlings (Howe et al. 1996). In Colorado, total grasshopper abundance is directly related to the vegetation biomass (Capinera and Sechrist 1982).

In Iowa, Rodenhouse and Best (1994) found that Vesper Sparrows whose territory spanned two habitat types preferentially foraged where crop residue is greatest and insects are presumably more abundant. Gonnet (2001) found that the abundance and diversity of seed-eating songbirds in Argentina is less in grazed pastures than in ungrazed pastures, presumably because grazing reduces food availability.

Habitat patch size

The size of the habitat patch appears to affect the suitability of the habitat for grassland birds in some areas and for some species (Johnson and Temple 1990; Herkert 1994; Johnson and Igl 2001). In Florida, Grasshopper Sparrows in the interior of habitat patches produce more young than those at the edges of the patch (Perkins et al. 2003). In Wisconsin, several species are more abundant in larger habitat patches than small patches (Renfrew and Ribic 2002). Landscapes with larger grassland patches also harbour more species than those with small grassland areas (Best et al. 2001).

Abiotic Influences on Nest Success

Nests of some species were abandoned during high temperatures, suggesting that the energetic cost of maintaining nest temperature is too high (George et al. 1992). Increased cover is known to regulate temperatures at nest sites (Nelson and Martin 1999). Egg temperatures higher than 38°C are usually lethal to developing bird embryos (With et al. 1994). Incubating birds can increase nest-tending times and shade the eggs during high temperature periods to prevent overheating. However, adults are unable to forage during nest tending and must rely on mates to provide food or do without. This can result in poorer body condition of adults, poorer nutrition of hatchlings, and decreased post-fledging survival. Several species select nest sites that limit maximum temperatures at the nest (Nelson and Martin 1999). Vesper Sparrow nests are usually located northeast of vegetation clumps so that nests receive morning sun but are shaded during the afternoon, thereby limiting the maximum temperatures at the nest and the length of time the nest exceeds lethal temperatures (Nelson and Martin 1999). The height and density of this shading vegetation affects the maximum temperatures at the nest (Nelson and Martin 1999). Vesper Sparrow nests located adjacent to vegetation more than 50 cm tall and providing more than 90% visual cover have lower maximum nest temperatures and exceed the presumed critical maximum for a shorter period than nests with lower and sparser vegetation.

Summary of Vesper Sparrow Habitat Requirements

From the above discussion, it is clear that grazing can affect habitat suitability for Vesper Sparrows in many ways. Nesting density of Vesper Sparrows generally decreases with grazing in

B.C. and other shrub-steppe or bunchgrass grasslands, probably because decreased resource availability requires a larger territory. Nest success also decreases with decreased vegetation complexity and height because the risk of nest predation and brood parasitism increases, as well as the energetic costs required for nest thermoregulation.

In B.C., grasslands with vegetation at least 8 cm high in the spring lead to higher Vesper Sparrow densities. Residual clumps of vegetation taller than this will provide high-quality nest sites where the energetic costs of nest thermoregulation will be minimized.

1.4.3 Grassland waterfowl with emphasis on the Blue-winged Teal

All waterfowl species found in B.C. are migratory; many species winter in the southern U.S. or Mexico and some species winter along the B.C. coast. Some waterfowl species breed at their highest densities in grassland wetlands in B.C. including the Wood Duck, Green-winged Teal, Mallard, Northern Pintail, Blue-winged Teal, Cinnamon Teal, Northern Shoveler, Gadwall, American Wigeon, Canvasback, Redhead, Ring-necked Duck, Lesser Scaup, White-winged Scoter, Common Goldeneye, Barrow's Goldeneye, Bufflehead, and Ruddy Duck (Campbell et al. 1990).

In B.C., Blue-winged Teal reach the highest breeding densities in the Cariboo-Chilcotin, but breeds across the province in a wide variety of habitats. Nests in B.C. are usually situated on the ground and are usually associated with wetlands, ponds, and lakes (Campbell et al. 1990). One to 12 eggs are laid between early May and the end of June, but most nests have 6 to 11 eggs. Incubation takes 23 or 24 days.

Response of Waterfowl to Grazing

Ground-nesting waterfowl species may nest in vegetation along wetland or pond edges, in upland sites some distance from water, or even in vegetation over the water (Hines and Mitchell 1983a,b), and grazing can affect both the density and the success of these nests. Many waterfowl species preferentially nest in areas with dense concealing vegetation. For example, Lokemoen et al. (1989) found that nest density of Mallard, Gadwall, and Blue-winged Teals is correlated with visual obstruction ratings of habitats. Mallard and Gadwall densities are highest in habitats with high visual obstruction ratings. Blue-winged Teal select nest sites with more vegetation cover than non-nest sites, and this selection is thought to offer more concealment for the nest (Gloutney and Clark 1997). Gadwall nests in Saskatchewan have vegetation cover of 25% or more of vegetation at least 30 cm tall and are well concealed from view from the sides (Hines and Mitchell 1983b).

Grazing, by reducing vegetation volume, reduces the visual obstructions in the habitat. This can lead to reduced densities of waterfowl nesting pairs as seen in upland sites in Montana (Gjersing 1975) and in North Dakota (Kruse and Bowen 1996). Removal of cattle from islands in Quebec, with the corresponding increase in vegetation density, resulted in increased waterfowl nest density and success (Lapointe et al. 2000). Grazing has been shown to decrease nest density of

Blue-winged Teal (Kruse and Bowen 1996; Lapointe et al. 2000), presumably because the density of vegetation is decreased (Lokemoen et al. 1989). If properly timed, grazing does not have to affect waterfowl nest density. Early spring grazing in Montana, where vegetation recovered before waterfowl nesting, did not affect nest density (Gjersing 1975).

Grazing also reduces nest success of some waterfowl species. Grazing decreases the productivity of Blue-winged Teal nests in Montana (Gjersing 1975) and Quebec (Lapointe et al. 2000). Nest trampling by cattle is a significant cause of waterfowl nest failure on grazed islands in Quebec (Lapointe et al. 2000).

Nest Success

Many waterfowl species, including the Blue-winged Teal, have experienced declines in nest success over the past 60 years (Beauchamp et al. 1996). Loss of breeding habitat leading to increased nest densities in the remaining habitat, together with increased risk of predation, may be one of the causes of these declines (Sovada et al. 2001). Waterfowl recruitment has increased by about 30% since initiation of the Conservation Reserve Program in North and South Dakota (Reynolds et al. 2001). These reserves are areas set aside for long-term undisturbed grass cover rather than annual crops.

Several studies have found that waterfowl nest success increases with denser and taller foliage in the habitat surrounding the nest (Kirsch 1969; Duebbert and Kantrud 1974; Pasitschniak-Arts and Messier 1995; Ignatiuk and Duncan 2001). Blue-winged Teal nest success increases with increasing vegetation density (Ignatiuk and Duncan 2001). Removal of vegetation around waterfowl nests reduces nest success in Iceland (Bengston 1972).

In Manitoba, over-water Mallard nests are more successful than upland nests, but have higher rates of brood parasitism by Redheads (Arnold et al. 1993). In Saskatchewan, nests on islands are more successful than other nest site locations, presumably because it is difficult for nest predators to reach the islands (Hines and Mitchell 1983a). Wetlands surrounded by large grasslands have higher duck nest success than those surrounded by cultivated areas (Phillips et al. 2003).

Nest success near wetlands is higher than that of nests in upland sites across the Canadian prairies (Devries et al. 2003), but Gendron and Clark (2002) found no difference in nest success with distance from wetlands. Habitat conditions at the time of the study were excellent and predator densities were low because wetlands in the study areas did not have fish.

Nest Predation

Nest predators can affect the density and success of waterfowl nests. Waterfowl nest success and pair density increases with the removal of predators in North Dakota (Garrettson and Rohwer 2001), and increases the productivity of Blue-winged Teal (Garrettson and Rohwer 2001). Supplemental food introduction does not decrease predation on duck nests in North Dakota (Greenwood et al. 1998).

As with songbirds, nest predators and predation rates are affected by habitat type, although Beauchamp et al. (1996) found that long-term declines in waterfowl nest success are similar among a variety of habitat types with different predator communities. Skunks forage preferentially on waterfowl nests along the edges of wetlands surrounded by agricultural areas, whereas Red Foxes select isolated patches of cover for foraging (Phillips et al. 2003). Vegetation structure, probably affecting nest concealment, affects predation rates on waterfowl nests as seen in an experiment where vegetation removal around waterfowl nests increased predation rates and reduced nest success (Bengston 1972).

Nest success is higher during years when seasonal ponds are abundant in North Dakota than in years when they are scarce (Pietz et al. 2003), probably because nests are denser during years when ponds are less abundant. Phillips et al. (2003) found that waterfowl nest success increases with increasing grassland area around the nest site and Sovada et al. 2000 found that predation rates are lower in large habitat patches than in small patches, again probably because nests are denser when there is less area available for nesting. Weller (1979) found higher predation rates with increasing nest densities in Iowa.

Waterfowl Brood Density and Survival

Many adult ducks forage on vegetation, but ducklings usually feed on aquatic and terrestrial invertebrates. The effect of cattle grazing on vegetation species that are important waterfowl forage are not well studied, but one study in Texas found that the response of the four most common waterfowl forage plants to grazing is inconsistent but that rest-rotation grazing appears to reduce waterfowl foods the least (Whyte and Silvy 1981).

Duckling survival may be more related to the density of invertebrate food sources than to concealment cover. In Manitoba, Murkin et al. (1982) found that Mallard and Blue-winged Teal abundance varies with the density of invertebrate food more than with the proportion of open water. Food availability affects the growth rate and survival of ducklings in North Dakota (Cox et al. 1998). Invertebrate prey density may be more important than vegetative cover for Blue-winged Teal broods (Murkin et al. 1982), although Blue-winged Teal brood density increases with increasing density of shoreline vegetation in South Dakota (Mack and Flake 1980). Blue-winged Teal broods are more abundant in ponds with little shoreline vegetation in Saskatchewan (Mulhern et al. 1985). Diets of Blue-winged Teal in Manitoba are dominated by gastropods and culicids with seeds and vegetation in lesser amounts (DuBowy 1985). The effect of livestock grazing on aquatic invertebrate abundance has not been reported in the literature, but is likely to be insignificant.

Wetland characteristics such as shoreline length and degree of vegetation cover may affect the use of wetlands by waterfowl broods (Mack and Flake 1980), but the response of different waterfowl species may vary. For example, Mulhern et al. (1985) found that Mallard ducklings use wetlands with dense, abundant riparian vegetation, whereas Blue-winged Teal broods use wetlands with little vegetation cover, but rely on diving for escape.

Summary of nesting requirements for Blue-winged Teal

Blue-winged Teal nest density and success are probably the factors most affected by cattle grazing. Providing dense riparian vegetation around lakes, ponds, and wetlands will ensure that nest success is high in these areas, since nests will be obscured and subject to lower predation risk. Maintaining adequate upland nesting cover will also help minimize predation risk by maintaining low nest densities.

Blue-winged Teal do not appear to select for particularly tall vegetation when nesting, but they do prefer dense vegetation. This means that grazing can occur with little impact on the nest site availability and quality for Blue-winged Teal. In areas where Blue-winged Teal nesting is a management priority, riparian and upland vegetation must be given a chance to regrow after they have been grazed.

1.4.4 Sharp-tailed Grouse

Sharp-tailed Grouse, like other grassland grouse species, have undergone a huge range contraction over the past several decades (Flanders-Wanner et al. 2004). Historically, Sharp-tailed Grouse were found across most of central and northern North America, but the distribution has decreased dramatically, particularly in the southern and eastern parts of its range (Johnsgard 2002; Silvy and Hagen 2004). Sharp-tailed Grouse were extirpated from Kansas and Illinois in the early 1900s, from California in the 1920s, from Oklahoma and Iowa in the 1930s, from Nevada, New Mexico, and Oregon in the 1950s and 1960s (Connelly et al. 1998). Distribution in the southern parts of its range is now restricted to small patches of suitable habitat. Sharp-tailed Grouse are non-migratory and occupy a wide range of habitats dominated by grasses and shrubs (Connelly et al. 1998). Winter habitat requirements are more restrictive than spring, summer, or fall habitat needs (Marks and Marks 1988).

Three subspecies of Sharp-tailed Grouse are found in B.C. (Fraser et al. 1999). The two northern subspecies, *Tympanuchus phasianellus caurus* from the northwest and *T. p. jamesi* from the northeast occupy brushy and boggy areas and openings in the boreal forest and are not considered at risk (Fraser et al. 1999). The Columbian Sharp-tailed Grouse (*T. p. columbianus*) is blue-listed in B.C., although an application to list the species under the *Endangered Species Act* in the U.S. was recently rejected (Silvy and Hagen 2004). This subspecies is found west of the Rocky Mountains in the Great Basin and the Columbia Plateau in a variety of grassland, sagebrush, and mountain shrub habitats. In B.C., the Sharp-tailed Grouse has been extirpated from much of the southern parts of its distribution, including the Okanagan, and has declined in much of the remainder of its range in the Thompson Valley and Kootenay Trench (Ritcey 1995). Only in the Cariboo, Fraser Basin, and the Chilcotin Plateau is this species abundant and widespread. Of all subspecies of Sharp-tailed Grouse, the Columbian Sharp-tailed Grouse has declined in abundance the most due to human disturbance (Johnsgard 2002).

Sharp-tailed Grouse begin breeding in early to mid-April; eggs are laid beginning in late April with young beginning to hatch in the middle of May. Nest sites are within a few kilometres of leks (Connelly et al. 1998). Average clutch size is between 10 and 12 eggs, with fertility rates generally exceeding 90%. Only one brood is produced in a year. Hatching rates are generally reported to be high, but nest success may be much lower. After hatching, broods remain closely associated with nest area for several months until the family group disperses before moving into winter habitat in late October.

Predation may be the greatest source of mortality among Sharp-tailed Grouse (Bergerud 1988). Many bird and mammal predators, including Bald and Golden Eagles, Northern Goshawks, Gyrfalcons, Great-horned Owls, Red-tailed Hawks, and Coyotes, are known to prey on Sharp-tailed Grouse. Additionally, Sharp-tailed Grouse are an important gamebird species, and hunting may contribute to high mortality rates in Sharp-tailed Grouse (Ritcey 1995). Sharp-tailed Grouse are susceptible to hunting-related population declines because male, and sometimes female, Sharp-tailed Grouse congregate at dancing grounds (leks) in the fall hunting season (Ritcey 1995). There is some evidence of a dancing ground being abandoned by grouse because of excessive hunting the previous fall (Ritcey 1995).

Brown (1966) suggests that the environmental conditions under which "continental" gamebird species evolved, including both lesser and Greater Prairie chickens, Sharp-tailed Grouse, and Montezuma and Scaled Quail, make them susceptible to population declines because they are less able to increase reproductive output in response to favourable environmental conditions.

Sharp-tailed Grouse breed at dancing grounds called leks. Leks are used every year and usually are located on small rises in grassland or other open areas. Nests are usually located within a few kilometres of the leks (Ritcey 1995). Breeding habitat of the Sharp-tailed Grouse varies considerably but is consistently composed of relatively dense herbaceous cover with scattered shrubs (Connelly et al. 1998). Declines of Sharp-tailed Grouse in Washington correspond to increases in the area of land under cultivation (Buss and Dziedzic 1955) and the corresponding decrease and fragmentation of sagebrush and grassland habitats (McDonald and Reese 1998). Nests are preferentially located at the base of shrubs, but tall bunchgrasses may be used in the absence of shrubs (Giesen and Connelly 1993). Vegetation species composition appears to be less important than the structure of the vegetation during the nesting season.

Kirby and Grosz (1995) found a higher density of Plains Sharp-tailed Grouse nests in lightly grazed pastures than in ungrazed pastures. However, the higher nest density is offset by poorer nest success, so that ungrazed sites produce more offspring per area than grazed pastures. In either grazed or ungrazed areas, grouse place nests near the tallest vegetation available. Likewise, Flanders-Wanner et al. (2004) found that Columbia Sharp-tailed Grouse production is higher in ungrazed than grazed grasslands in Nevada.

Disturbance at lek sites may cause disruptions in breeding. Baydack and Hein (1987) found that grouse leave leks for various disturbances, but remain away only with human presence. Female grouse were not seen at the leks disturbed by humans during their study. A lek in Manitoba was burned and, even though vegetation was substantially altered, grouse began using the lek within two days of the fire (Sexton and Gillespie 1979).

Winter habitat requirements are more specific and the species often relies on riparian areas, deciduous hardwood shrubby areas, or deciduous or open conifer woods. Deciduous trees are used for feeding, roosting, and escape cover. Species most commonly used for both cover and forage in winter include aspen, cherry, saskatoon, sagebrush, snowberry, willow, and birch. Birds may remain on summer range until snow forces them into winter habitats. During severe winters, Sharp-tailed Grouse feeding areas are restricted to hardwood riparian areas, but in milder winters, they forage in a wider range of habitats including grassland areas (Marks and Marks 1988).

Winter foods include the buds of deciduous trees and shrubs. Soopalallie berries provide some high-quality food (Evans and Dietz 1974). Summer foods in Washington were mainly vegetation with few insects (Jones 1966). In Idaho, Sharp-tailed Grouse use sagebrush habitats preferentially and use habitats least modified by cattle grazing (Saab and Marks 1992).

Summary of habitat requirements for Sharp-tailed Grouse

Columbian Sharp-tailed Grouse require structurally complex grasslands or other open areas for nesting. In grassland areas with few shrubs, sufficient residual grass cover over winter must be maintained to allow nest concealment in the spring. Sharp-tailed Grouse begin nesting before substantial grass growth in the spring and therefore require carryover of vegetation to ensure high nest success.

The most important winter habitat component for Sharp-tailed Grouse is woody deciduous vegetation. In the grasslands of B.C., these deciduous shrub and trees are often associated with riparian areas. These habitats need to be managed to ensure that shrub and tree cover is maintained.

2 DISCUSSION

Structural diversity is the single most important attribute of grassland habitats for each of the wildlife species and communities reviewed in this report. Structurally complex grasslands have higher songbird richness and diversity. Nest predation rates for songbirds and waterfowl nesting in grassland and grassland riparian areas are lower in structurally diverse habitats. Brood parasitism rates on grassland songbird nests also decrease with increasing structural complexity. Songbird and waterfowl nest success and productivity increase with increasing vegetation structural diversity. Small mammal communities are more diverse, rich, and abundant in structurally diverse grasslands. Meadow Voles are more abundant in grasslands with higher vegetation biomass up to a threshold level, and have higher body mass, recruitment, and survival rates.

Livestock and wildlife grazing decreases the biomass, vegetative cover, and heights of grazed plants. Low-intensity grazing may not reduce vegetation attributes enough to affect wildlife communities, but many studies show decreases in wildlife species abundance, diversity, and richness with heavy grazing. To ensure that wildlife communities and species are maintained with livestock grazing, management plans must use measures of wildlife habitat attributes as a benchmark for setting the appropriate grazing intensity on grasslands.

Few functional studies have examined the threshold levels of habitat attributes required by grassland wildlife species. The applicability of habitat manipulation experiments conducted in eastern grasslands to B.C. grasslands needs to be verified before any conclusions can confidently be applied here. The structure, productivity, and wildlife communities are sufficiently different among grassland types that threshold habitat attribute levels are likely quite different. Carefully designed and conducted habitat manipulation studies are required to determine critical values for habitat attributes. These critical levels can then be incorporated into range monitoring to determine and modify the effects of livestock grazing on wildlife habitat suitability. In the interim, maintaining structurally diverse grasslands, including dead vegetation from previous growing seasons and vegetation of a range of heights and growth forms, is the best approach to maintaining diverse and healthy grassland wildlife communities.

APPENDIX 1. COMMON AND SCIENTIFIC NAMES OF ANIMAL AND PLANT SPECIES MENTIONED IN THE REPORT

Common name	Scientific name
Amphibians	
Great Basin Spadefoot	*Spea intermontana*
Tiger Salamander	*Ambystoma tigrinum*
Reptiles	
Gopher Snake	*Pituophis catenifer deserticola*
Night Snake	*Hypsiglena torquata*
Racer	*Coluber constrictor*
Short-horned Lizard	*Phrynosoma douglasii*
Western Rattlesnake	*Crotalus oreganus*
Mammals	
Badger	*Taxidea taxus*
California Bighorn Sheep	*Ovis canadensis california*
Columbian Ground Squirrel	*Spermophilus columbianus*
Coyote	*Canis latrans*
Deer Mouse	*Peromyscus maniculatus*
Great Basin Pocket Mouse	*Perognathus parvus*
Meadow Vole	*Microtus pennsylvanicus*
Montane Vole	*Microtus montana*
Mule Deer	*Odocoileus hemionus*
Northern Pocket Gopher	*Thomomys talpoides*
Nuttall's Cottontail	*Sylvilagus nuttallii*
Raccoon	*Procyon lotor*
Red Fox	*Vulpes vulpes*
Western Harvest Mouse	*Reithrodontomys megalotis*
Western Jumping Mouse	*Zapus princeps kootenayensis*
White-tailed Jackrabbit	*Lepus townsendii*
Birds	
American Avocet	*Recurvirostra americana*
American Wigeon	*Anas americana*
Baird's Sparrow	*Ammodramus bairdii*
Barrow's Goldeneye	*Bucephala islandica*
Blue-winged Teal	*Anas discors*
Bobolink	*Dolichonyx oryzivorus*
Brewer's Sparrow	*Spizella breweri breweri*
Brown-headed Cowbird	*Molothrus ater*
Bufflehead	*Bucephala albeola*
Burrowing Owl	*Athene cunicularia*
Canvasback	*Aythya valisineria*
Canyon Wren	*Catherpes mexicanus*
Cassin's Sparrow	*Aimophila cassinii*
Chipping Sparrow	*Spizella passerina*
Cinnamon Teal	*Anas cyanoptera*
Common Goldeneye	*Bucephala clangula*
Dickcissel	*Spiza americana*
Eastern Meadowlark	*Sturnella magna*
Ferruginous Hawk	*Buteo regalis*
Gadwall	*Anas strepera*

Grasshopper Sparrow	*Ammondramus savannarum*
Green-winged Teal	*Anas crecca*
Henslow's Sparrow	*Ammodramus henslowii*
Hermit Thrush	*Catharus guttatus*
Horned Lark	*Eremophila alpestris*
Hudsonian Godwit	*Limosa haemastica*
Lark Sparrow	*Chondestes grammacus*
Lesser Scaup	*Aythya affinis*
Long-billed Curlew	*Numenius americanus*
Mallard	*Anas platyrhinchos*
Mourning Dove	*Zenaida macroura*
Northern Bobwhite Quail	*Colinus virginianus*
Northern Mockingbird	*Mimus polyglottos*
Northern Oriole	*Icterus galbula*
Northern Pintail	*Anas acuta*
Northern Shoveler	*Anas clypeata*
Ovenbird	*Seiurus aurocapillus*
Prairie Falcon	*Falco mexicanus*
Redhead	*Aythya americana*
Red-winged Blackbird	*Aeglaius phoeniceus*
Ring-necked Duck	*Aythya collaris*
Ruddy Duck	*Oxyura jamaicensis*
Sage Grouse	*Centrocercus urophasianus*
Sage Thrasher	*Oreoscoptes montanus*
Savannah Sparrow	*Passerculus sandwichensis*
Sharp-tailed Grouse	*Tympanuchus phasianellus*
Short-eared Owl	*Asio flammeus*
Sprague's Pipit	*Anthus spragueii*
Swainson's Hawk	*Buteo swainsoni*
Upland Sandpiper	*Bartramia longicauda*
Vesper Sparrow	*Pooecetes gramineus*
Western Meadowlark	*Sturnella neglecta*
White-winged Scoter	*Melanitta fusca*
White-throated Swift	*Aeronautes saxatalis*
Willow Flycatcher	*Empidonax traillii*
Wilson's Warbler	*Wilsonia pusilla*
Wood Duck	*Aix sponsa*
Yellow-breasted Chat	*Icteria virens*
Yellow Warbler	*Dendroica petechia*
Plants	
alfalfa	*Medicago sativa*
aspen	*Populus tremuloides*
big sagebrush	*Artemisia tridentata*
birch	*Betula spp.*
cherry	*Prunus spp.*
juniper	*Juniperus spp.*
willow	*Salix spp.*
pinyon	*Pinus pinyon*
saskatoon	*Amelanchier alnifolia*
bluebunch wheatgrass	*Pseudoroegneria spicata*
snowberry	*Symphoricarpos spp.*
soopolallie	*Shepherdia canadensis*

ANNOTATED BIBLIOGRAPHY

Ackerman, J.T. 2002. Of mice and Mallards: positive indirect effects of coexisting prey on waterfowl nest success. Oikos 99:469-480.

Mallard nest success is positively correlated with rodent abundance. A threshold rodent density appears to exist where increasing the density does not result in additional nest success. Nest cover density, nesting density, and predator activity were also examined, but did not explain the observed patterns of nest success. Rodent populations appear to buffer waterfowl nests.

Adler, G.H. 1987. Influence of habitat structure on demography of two rodent species in eastern Massachusetts. Can. J. Zool. 65:903-912.

Massachusetts. Microtus *declines with increasing woody vegetation, and increases with increasing herb cover. Microhabitat structure influences population density more than other population characteristics.*

Adler, G.H., and M.L. Wilson. 1989. Demography of the Meadow Vole along a simple habitat gradient. Can. J. Zool. 67:772-774.

Yarmouth, Massachusetts. The number of voles and the survival rates of the voles increases with increasing grass cover until an asymptote is reached. Grass cover is a predictive measure of environmental suitability for Meadow Voles. Vole density increases until grass cover reaches 14 to 37%. On sites with the lowest grass cover, no voles were trapped in some sessions, whereas at the high grass cover sites, voles were trapped in all sessions.

Allen, J.N. 1985. The ecology and behavior of Long-billed Curlew in southwestern Washington. Wildl. Monogr. 73:3-67.

Short-grass sites are preferred presumably because this allows cooperative predator detection and eases movement for feeding by chicks.

Alpe, M.J., J.L. Kingery, and J.C. Mosley. 1999. Effects of summer sheep grazing on browse nutritive quality in autumn and winter. J. Wildl. Manage. 63:346-354.

Idaho. Domestic sheep grazing in early summer improves the autumn and winter nutritive quality of red-stemmed ceanothus, ninebark, rose, and snowberry, whereas late summer grazing by sheep decreases the nutritive quality of ceanothus and ninebark. The effects of livestock grazing on browse quantity were not reported.

Ammon, E.M., and P.B. Stacey. 1997. Avian nest success in relation to past grazing regimes in a montane riparian system. Condor 99:7-13.

Northern Nevada. Predation rates on artificial nests in a grazed riparian area were significantly higher than in an adjacent area ungrazed for 30 years. Vegetation had lower vertical diversity and lower willow abundance on the grazed side.

Apps, C.D., N.J. Newhouse, and T.A. Kiney. 2002. Habitat associations of American Badgers in southeastern British Columbia. Can. J. Zool. 80:1228-1239.

British Columbia. Badgers are positively associated with glaciolacustrine and glaciofluvial, bruisolic and regosolic soils, and negatively associated with colluvial podsolic and luvisolic soils. Badgers select grassland, agricultural and linear clearings and avoid forested habitats.

Arnold, T.W., M.D. Sorenson, and R.J.J. 1993. Relative success of overwater and upland Mallard nests in southwestern Manitoba. J. Wildl. Manage. 57:578-581.
Manitoba. Nest success is higher for overwater nests than upland nests, but have a higher nest parasitism rate from redheads. Parasitized nests have fewer Mallard eggs and have lower egg success than non-parasitized nests.

Austin, D.D., and P.J. Urness. 1986. Effects of cattle grazing on Mule Deer diet and area selection. J. Range Manage. 39:18-21.
Mule Deer diet composition, nutrition, and area used for foraging do not change between livestock grazed and ungrazed areas for tame deer. Nevertheless, deer prefer to forage on areas ungrazed by livestock when at low densities.

Baker, B.W., T.R. Stanley, and G.E. Plumb. 2000. Nest predation on Black-tailed Prairie Dog colonies. J. Wildl. Manage. 64:776-784.
North Dakota, Wyoming. Nest predation rates are higher and vegetation is more uniform and less dense on prairie dog colonies than off of them. Nest success is correlated with nest cover.

Baker, D.L., and F.S. Guthery. 1990. Effects of continuous grazing on habitat and density of ground-foraging birds in south Texas. J. Range Manage. 43:2-5.
South Texas. Eastern Meadowlarks are more abundant under moderate grazing than heavy grazing pressure. Mourning Doves are more abundant under heavy grazing pressure. Bobwhite density is low under either grazing regime.

Banfield, A.W.F. 1974. The mammals of Canada. Toronto, University of Toronto Press.

Baydack, R.K., and D.A. Hein. 1987. Tolerance of Sharp-tailed Grouse to lek disturbance. Wild. Soc. Bull. 15:535-539.
Carberry, Manitoba. Disturbances were applied to Sharp-tailed Grouse leks during the breeding season and the number of grouse using the leks was monitored. No differences in number of male grouse using the lek were seen except for human presence. When humans were present, grouse attempted to return to the lek, but left once human presence was noted. No female grouse were seen at any of the disturbed leks but were heard regularly at undisturbed leks.

Bazzaz, F.A., and J.A.D. Parrish. 1982. Organization of grassland communities. Pp. 233-254 *in* Estes, J.R., Tyrl. R.J, and J.N. Brunken (eds.). Grasses and Grasslands: Systematics and ecology. University of Oklahoma Press, Norman, Oklahoma.

Beauchamp, W.D., R.R. Koford, T.D. Nudds, R.G. Clark, and D.H. Johnson. 1996. Long-term declines in nest success of prairie ducks. J. Wildl. Manage. 60:247-257.
Review Article. Thirty-seven studies of nest success in waterfowl were reviewed. Nest success declined for five waterfowl species between 1935 and 1992. Late nesting species (Gadwall, Northern Shoveler, and Blue-winged Teal) declined less than early nesters (Mallard and Northern Pintail). Population declines in Mallard, Northern Pintail and Blue-winged Teal

corresponded to declines in nest success, but Gadwall and Northern Shoveler populations have not declined even though nest success has. Nest success decreased equally in grassland and parkland areas even though the suite of predators in these habitats is very different.

Bechard, M.J. 1982. Effect of vegetative cover on foraging site selection by Swainson's Hawk. Condor 84:153-159.
Cultivated fields are not used for foraging before harvest even though they account for most of the home range and support abundant prey.

Beck, J.L., and D.L. Mitchell. 2000. Influences of livestock grazing on Sage Grouse habitat. Wild. Soc. Bull. 28:993-1002.
Review article. Both positive and negative direct and indirect effects of grazing on Sage Grouse habitat are reviewed. Indirect effects have probably had more influence on the decline in Sage Grouse population. Indirect effects include reduction in area of sagebrush through conversion to grassland, introduction of weeds, Sage Grouse forage reduction by reduced forb abundance, and abandonment of herbicide-treated nesting areas. Direct negative effects include increased densities of ground-squirrel nest predators under heavy grazing, and nest and egg abandonment or trampling.

Beldon, E.L., E.S. Williams, E.T. Thorne, H.J. Harlow, K. White, and S.L. Anderson. 1990. Effect of chronic stress on immune system function of Rocky Mountain Bighorn Sheep. Biennial Symposium of the Northern Wild Sheep and Goat Council 76-91

Bengston, S.A. 1972. Reproductive and fluctuations in size of duck populations at Lake Myvatn, Iceland. Oikos 23:35-58.

Bergeron, J.-M., and L. Jodoin. 1994. Comparison of food habits and nutrients in the stomach contents of summer- and winter-trapped voles (*Microtus pennsylvanicus*). Can. J. Zool. 72:183-187.
Quebec. The same plant species are used in summer and winter in differing proportions and the nutritive value of the plants vary seasonally. Winter stomach contents have lower crude protein, phenolics and higher levels of non-structural carbohydrates. The ratio of protein to phenolics does not vary with season. Voles at the low densities in the study do not face nutritional constraints during winter. At higher densities, foraging may become constrained.

Bergerud, A.T. 1988. Population ecology in North American grouse. Adaptive strategies and population ecology in northern grouse. A. T. Bergerud, and M. W. Gratson. Minneapolis, Minnesota, University of Minnesota Press. Vol. 2:578-685.

Berry, M.E., and C.E. Bock. 1998. Abundance of diurnal raptors on open space grasslands in an urbanized landscape. Condor 100:601-608.
Prey abundance is the most limiting factor for several raptor species including Swainson's Hawk, Red-tailed Hawk, and American Kestrel. Degree of urbanization is less important if prey is abundant.

Best, L.B. 1972. First-year effects of sagebrush control on two sparrows. J. Wildl. Manage. 36:534-544.

Montana. Roundup was used to reduce or eliminate sagebrush cover. Brewer's Sparrows declined only in plots where sagebrush was eliminated. Vesper Sparrow densities did not change in sprayed or unsprayed plots.

Best, L.B., T.M. Bergin, and K.E. Freemark. 2001. Influence of landscape composition on bird use of rowcrop fields. J. Wildl. Manage. 65:442-449.
Iowa. Bird species abundance is higher in landscapes with more grassland block cover or more wooded block-cover and strip-cover.

Birney, E.C., W.E. Grant, and D.D. Baird. 1976. Importance of vegetative cover to cycles of *Microtus* populations. Ecology 57:1043-1051.
Oklahoma, South Dakota, Colorado, Minnesota. A minimum threshold of vegetative cover is required to support sufficient density and allow sufficient population growth of Microtus *to enable a multi-year cycle. These findings apply to tallgrass, mixed grass, and shortgrass habitats. Cover levels below the threshold can support low density, breeding populations. In Oklahoma, Meadow Vole populations in habitats with less than* $250 g/m^2$ *of vegetation undergo population cycling, whereas populations in habitats with more than* $300 g/m^2$ *of cover did. In Minnesota, capture rate increased sharply in habitats with more than about* $500 g/m^2$.

Bissonette, J.A., and M.J. Steinkamp. 1996. Bighorn Sheep response to ephemeral habitat fragmentation by cattle. Great Basin Naturalist 56:319-325.
Cattle-caused displacement of sheep. Sheep core range and distance to escape terrain both decreased with decreasing proximity to cattle.

Bock, C.E., and J.H. Bock. 1999. Response of winter birds to drought and short-duration grazing in southeastern Arizona. Conservation Biology 13:1117-1123.
Arizona. Ungrazed exclosures had taller grass, and higher basal area cover, canopy cover, and reproductive canopy cover of grass than adjacent grazed sites one year after a drought had ended. Differences persisted in the second year after the drought ended, but these differences were less pronounced. Ground foraging, seed-eating birds (19 species) were less abundant on grazed grasslands but the number of other species (24) were not different among grazed and ungrazed sites in winter.

Bock, C.E., J.H. Bock, W.R. Kenney, and V.M. Hawthorne. 1984. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. J. Range Manage. 37:239-242.
Arizona. A site, ungrazed since 1968, had more cover of grass, herbs, and shrubs than an adjacent site that had been continuously grazed over that time. The grazed site had a more abundance of birds in summer, but lower species richness. Small mammals were more abundant in ungrazed sites. Grasshopper Sparrows and Cassin's Sparrows (and Chipping Sparrow in winter only) were significantly more abundant in both summer and winter on ungrazed sites, whereas quail, doves, flickers, Horned Larks, Northern Mockingbirds, and Lark Sparrows were more abundant in the grazed sites. Vesper Sparrows, only found on the site in winter, did not differ in abundance between grazed and ungrazed.

Bock, C.E., and B. Webb. 1984. Birds as grazing indicator species in southeastern Arizona. J. Wildl. Manage. 48:1045-1049.
Arizona. Horned Larks and Lark Sparrow are more abundant in grazed plots, but Grasshopper Sparrows and Cassin's Sparrows are absent from grazed plots.

Bodie, W.L., and W.O. Hickey. 1980. Response of wintering Bighorn Sheep to a rest-rotation grazing system in central Idaho. Bienn. Symp. Northern Wild Sheep and Goat Council 2:60-68.
When cattle grazed year-long, Bighorns prefer to use areas not grazed by cattle. Under a rest-rotation grazing system, sheep prefer pastures grazed early season or after being rested and the use of ungrazed exclosures decreased.

Bollinger, E.K. 1995. Successional changes and habitat selection in hayfield bird communities. Auk 112:720-730.
New York. Fields planted to legume-dominated vegetation changed over time to communities patchily vegetated by grasses. Bobolink density in the field increased logarithmically with field age. Upland Sandpipers, Eastern Meadowlarks, Grasshopper Sparrows, and Henslow's Sparrows were most abundant in the oldest fields. Abundance of Savannah Sparrows did not change with field age. Community richness and diversity increased linearly with field age.

Bollinger, E.K., and T.A. Gavin. 1989. Eastern Bobolink populations: Ecology and conservation in an agricultural landscape. Pp. 497-506 *in* J.M.I. Hagan and D.W. Johnston (eds.). Ecology and conservation of Neotropical migrant landbirds. Woods Hole, MA, Smithsonian Institution Press.
New York. Old hayfields (more than 8 years since planting) with large area and low cover of alfalfa support higher densities of bobolinks than other hayfield types.

Bowen, B.S., and A.D. Kruse. 1993. Effects of grazing on nesting by upland sandpipers in southcentral North Dakota. J. Wildl. Manage. 57:291-301.
North Dakota. Nest density was lower in areas that had received cattle grazing during the nesting season than in areas without cattle grazing during the nesting season. Grazing did not affect nest success.

Bowman, G.B., and L.D. Harris. 1980. Effect of spatial heterogeneity on ground-nest depredation. J. Wildl. Manage. 44:806-813.
Florida. Racoon depredation on artificial nests decreased with increasing spatial heterogeneity. Degree of concealment of nests did not affect depredation rates, suggesting that spatial heterogeneity of vegetation is more important in affecting nest losses than concealment.

Brady, W.W., M.R. Stromberg, E.F. Aldon, C.D. Bonham, and S.H. Henry. 1989. Response of a semidesert grassland to 16 years of rest from grazing. J. Range Manage. 42:284-288.
Grassland vegetation richness increased and cover of midgrass, shortgrass, shrub, and forb species also increased with 16 years rest from grazing in south-central Arizona. Total vegetation cover was not different between grazed and ungrazed areas, but there was more mid-grass cover in ungrazed areas.

Brown, D.E. 1966. Grazing, grassland cover and gamebirds. N. Am. Wildl. Conf. 43:477-485.
Southwest USA. Grassland and grass-shrub dependant gamebirds have experienced reduced distribution and abundance in the American southwest. Mediterranean species, including California, mountain and Gambel's quail, have evolved under large annual variations in vegetation conditions (that is related to precipitation) and are able to undergo rapid population increases under favourable conditions. Continental species, including Prairie chickens, Sharp-tailed Grouse, and Montezuma and Scaled Quail have less pronounced variations in reproductive output and are more dependant on summer precipitation, which is less variable than winter precipitation. Removal of grass cover increases the predation rate on these continental species.

Brown, J.H., and W. McDonald. 1995. Livestock grazing and conservation on southwest rangelands. Conserv. Biol. 9:1644-1647.
Commentary article. Disputes the claims of some papers indicating ecological impacts of grazing. Their points are 1) grasslands evolved under extensive pressure from herbivores, 2) herbivore communities were drastically affected by Aboriginal peoples, 3) ecosystems were further affected by European influences, 4) some rangelands today are seriously degraded, others are in excellent condition, 5) fire, livestock grazing, and a range of abiotic factors (fire and livestock grazing can be manipulated to meet management goals), 6) management objectives are usually to maximize economics rather than to maintain or enhance ecosystem functions. Grazing itself is not the problem, but the management objectives set for grasslands.

Bucyanayandi, J.-D., and J.-M. Bergeron. 1990. Effects of food quality on feeding patterns of Meadow Voles (*Microtus pennsylvanicus*) along a community gradient. J. Mammal. 71:390-396.
Quebec. Meadow Voles select foods with less lignin, phenolics, and condensed tannins and higher protein-to-lignin ratios and protein content. Phenolic content increases with increasing age of meadow. Total phenolics are the best indicator of food quality among nutritional components examined in this study.

Budnik, J.M., F.R. Thompson, and M.R. Ryan. 2002. Effect of habitat characteristics on the probability of parasitism and predation of Bell's vireo nests. J. Wildl. Manage. 66:232-239.
Missouri. Models predicting nest parasitism and predation rates decrease with increased nest concealment, increased nest cover, and increased nest height.

Buss, I.O., and E.S. Dziedzic. 1955. Relation of cultivation to the disappearance of the Columbian Sharp-tailed Grouse from southeastern Washington. Condor 57:185-187.
Sharp-tailed Grouse declined precipitously in southeastern Washington between the 1910s and the 1920s. This decline in grouse numbers coincides with a sharp increase in area under cultivation. Grouse declined from very abundant in the late 1890s and became extirpated within 50 years.

Campbell, C.W., and A.H. Bawtree. 1998. Rangeland Handbook for B.C. B.C. Cattlemen's Association, Kamloops, B.C. 203 pp.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, A.C. Stewart, and M.C.E. McNall. 2001. The birds of British Columbia. Vol. 4. UBC Press. Vancouver, BC.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, G.W. Kaiser, and M.C.E. McNall. 1990. The birds of British Columbia. Vol. 1: Nonpasserines, loons through waterfowl. UBC Press, Vancouver, BC.

Campbell-Kissock, L., L.H. Blankenship, and L.D. White. 1984. Grazing management impacts on quail during drought in the northern Rio Grande Plain, Texas. J. Range Manage. 37:442-446.

Texas. Bobwhite quail are more abundant at sites with more herbaceous cover. More cover is provided by short duration and rest rotation grazing systems than by year-long grazing.

Cannings, S.G., L.R. Ramsay, D.F. Fraser, and M.A. Fraker. 1999. Rare amphibians, reptiles, and mammals of British Columbia., Min. Environ., Lands and Parks, Resour. Inv. Branch, Victoria, BC.

Capinera, J.L., and T.S. Sechrist. 1982. Grasshopper (Acrididae) - host plant associations: response of grasshopper populations to cattle grazing intensity. Can. Entom. 114:1055-1062.

Colorado. Total grasshopper density is positively correlated with vegetation biomass, whereas grasshoppers of the family Oedipodinae (soil eating) are more abundant under low vegetation biomass conditions.

Chapman, E.W., and C.A. Ribic. 2002. The impact of buffer strips and stream-side grazing on small mammals in southwestern Wisconsin. Agric. Ecosys. Env. 88:49-59.

Wisconsin. Ungrazed riparian buffers and managed intensive rotational grazing (MIRG) were implemented to protect stream ecosystems. More small mammal species in greater abundance were found in buffer strips than riparian areas in either conventional or MIRG grazed pastures. Small mammal abundance was highest adjacent to the streams and declined with increasing distance from the stream. Richness did not vary with distance from stream. Meadow Vole densities were higher closer to the stream and significantly higher in ungrazed riparian areas than in either grazing treatment.

Cody, M.L. 1981. Habitat selection in birds: The roles of vegetation structure, competitors, and productivity. BioScience 31:107-113.

Review article. Numerous studies have shown that many bird species select habitat based on vegetation structure. Density of birds may be affected by habitat suitability, interspecific competition, and density-dependant intraspecific competition. Annual rainfall affected bird community composition and abundance in Arizona presumably because insect food was directly related to the rainfall.

Connelly, J.W., M.W. Gratson, and K.P. Reese. 1998. Sharp-tailed Grouse (*Tympanuchus phasianellus*). Page 354 *in* F. Gill (ed.). The birds of North America. Philadelphia, PA. 20pp.

Cooper, J.M. 1998. An inventory of the status of diurnal raptors at risk in the southern grasslands of British Columbia (Ferruginous Hawk, Swainson's Hawk, Prairie Falcon, Peregrine Falcon). B.C. Minist, Environ., Lands and Parks, Wildl. Branch, Victoria, BC. 13pp.

Cox, R.R.J., M.A. Hanson, C.C. Roy, N.H.J. Euliss, D.H. Johnson, and M.G. Butler. 1998. Mallard duckling growth and survival in relation to aquatic invertebrates. J. Wildl. Manage. 62:124-133.
North Dakota. The growth rate of Mallard chicks was positively correlated with the density of aquatic invertebrates and negatively correlated with the variance in daily minimum temperature. Growth rate was correlated with survival of the chicks.

Cram, D.S., D.E. Masters, F.S. Guthery, D.M. Engle, and W.G. Montague. 2002. Northern Bobwhite population and habitat response to pine-grassland restoration. J. Wildl. Manage. 66:1031-1039.
Arkansas. The abundance of Bobwhites in pine-grassland woodlands restored for Red-cockaded Woodpeckers was compared with untreated stands. Stands thinned and burned had the highest density of northern Bobwhite three years after treatment.

Cranford, J.A. 1983. Ecological strategies of a small hibernator, the Western Jumping Mouse *Zapus princeps*. Can. J. Zool. 61:232-240.
Utah. The timing of emergence of the Western Jumping Mouse from hibernation is related to site quality rather than elevation. Vegetative growth is the best predictor of emergence timing, emergence corresponds to soil temperatures. This emergence strategy ensures that food is available on emergence. Foods consisted of green leaves, arthropods, seeds, brown leaves, fungus and flowers.

Dale, B.C. 1984. Birds of grazed and ungrazed grasslands in Saskatchewan. Blue Jay 42:102-105.
Saskatchewan. Higher bird species richness on grazed plots for feeding but more species nested elsewhere. Effects of grazing on avifauna varies with locale and grazing intensity. Vesper Sparrows were detected in only 1 (grazed) out of 7 plots. Vegetation was dominated by bluegrasses and grama-grass.

Dale, B.C., P.A. Martin, and P.S. Taylor. 1997. Effects of hay management on grassland songbirds in Saskatchewan. Wild. Soc. Bull. 25:616-626.
Saskatchewan. Bird communities were assessed on native grasslands, annually-mowed hayfields, and idle hayfields. Baird's Sparrows and Sprague's Pipits were most abundant on native grasslands and least abundant on idle hayfields. Savannah Sparrows were most common on idle hayfields and least abundant on annually-mowed hayfields. Mowing hayfields decreased Savannah Sparrow abundance by 80% for the remainder of the season.

Davis, M.A., D.W. Peterson, P.B. Reich, M. Crozier, T. Query, E. Mitchell, J. Huntington, and P. Bazakas. 2000. Restoring savannah using fire: impact on the breeding bird community. Restor. Ecol. 8:30-40.
Southern Saskatchewan. Insectivorous bird species declined with increasing frequency of controlled burns and an increase in omnivorous species. Bark gleaners, including woodpeckers, increased. Vesper Sparrows, Eastern Kingbirds, Lark Sparrows all increased with burning.

Davis, S.K., and D.C. Duncan. 1999. Grassland songbird occurrence in native and crested wheatgrass pastures of southern Saskatchewan. Studies in Avian Biol. 19:211-218.

Southern Saskatchewan. Vesper Sparrows, Western Meadowlarks, and Savannah Sparrows were found as frequently in seeded pastures as in native pastures. Grasshopper Sparrow was the only species found more often in seeded pastures. Sprague's Pipit and Clay-colored Sparrow were found more frequently in native pastures. Vesper Sparrow presence was negatively correlated with vegetation height and cover of clubmoss. Equal abundance in seeded and natural pastures suggests that these species respond to the structure of the vegetation rather than vegetation species composition.

Delisle, J.M., and J.A. Savidge. 1997. Avian use and vegetation characteristics of conservation reserve program fields. J. Wildl. Manage. 61:318-325.
Nebraska. Breeding bird species in two types of vegetation planting were compared. Neither habitat type was grazed during this study. Common Yellowthroat and Sedge Wrens were more abundant in fields planted to warm-season native grasses than fields planted to cool-season grasses and legumes. Bobolink was more abundant in cool season fields. Vegetation in warm-season grass pastures was taller and denser than in cool-season legume/grass fields.

Delong, A.K., J.A. Crawford, and D.C.J. Delong. 1995. Relationships between vegetational structure and predation of artificial Sage Grouse nests. J. Wildl. Manage. 59:88-92.
Oregon. More cover of tall vegetation and medium height shrubs decreases the risk of nest predation for Sage Grouse.

Demarchi, R.A., C.L. Hartwig, and D.A. Demarchi. 2000. Status of the California Bighorn Sheep in British Columbia. B.C. Minist. Environ., Victoria, BC. 53pp.

Devries, J.H., J.J. Citta, M.S. Lindberg, D.W. Howerter, and M.G. Anderson. 2003. Breeding-season survival of Mallard females in the prairie pothole region of Canada. J. Wildl. Manage. 67:551-563.
Alberta, Saskatchewan, Manitoba. Female waterfowl survival was lowest in areas with low wetland density and was lowest during peak nesting times. Increasing wetland density would have a greater effect on survival rates than upland habitat restoration unless large areas are restored.

Dion, N., K.A. Hobson, and S. Lariviere. 2000. Interactive effects of vegetation and predators on the success of natural and simulated nests of grassland songbirds. Condor 102:629-634.
Eastern North Dakota. Depredated nests had higher grass cover but lower forb cover than successful nests. Nest predators varied among nest habitat types, with small mammals predating nests in heavy cover preferentially, whereas avian predators predated nests that are more open.

Dobkin, D.S., A.C. Rich, and W.H. Pyle. 1998. Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin. Conserv. Biol. 12:209-221.
Southeastern Oregon. Vegetation inside exclosures was dominated by sedges with dry-land grasses only in the uppermost fringes. Shrubs were uncommon. Vegetation outside the exclosures was dominated by shrubs, had low sedge abundance and generally sparse herbaceous cover. Bird species richness and abundance was higher in plots with cattle

excluded, but responses of different bird species varied among treatments. Vesper Sparrows were found only in upland habitats outside the exclosures but with cattle excluded for 4 years. Vesper Sparrows were not found in long-term exclosures with very high vertical herb diversity and abundant shrubs. Northern Pintails, Northern Shoveler and American Avocet were found only inside the exclosures.

DuBowy, P.J. 1985. Feeding ecology and behavior of postbreeding male Blue-winged Teal and northern shovelers. Can. J. Zool. 63:1292-1297.
Delta Marsh, Manitoba. Significant differences in time-activity budgets and diets between the two species indicate a difference in foraging specialization. Shovelers spend most time feeding and most of that is by dabbling in the water column. Teals spend less time foraging and do so mostly by dabbling in mud and picking through vegetation. Shoveler diets are dominated by cladocerans or chironomid larvae, whereas teals eat gastropods, culicids, seeds, vegetation, and chironomids. Shovelers feed little during the summer flightless period and teals feed throughout.

Duebbert, H.F., and H.A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. J. Wildl. Manage. 38:257-265.

Evans, K.E., and D.R. Dietz. 1974. Nutritional energetics of Sharp-tailed Grouse during winter. J. Wildl. Manage. 38:622-629.
South Dakota. Buds and berries are main foods during winter. Seven diet materials were fed ad libidum *to adult grouse including corn, cottonwood buds, hawthorn berries, russian olive, silver buffaloberry, western snowberry and Wood's rose. Metabolized energy was highest with corn diets and lowest for rose. Hawthorn berries were ingested in higher quantities than other foods and cottonwood buds were used least. Females ingested less matter than males. Foods that were consumed in amounts needed to meet 1.5 x basal metabolic rate provided sufficient protein for maintenance. Silver buffaloberry was best tested food with high energy, readily eaten and were available throughout the winter.*

Flanders-Wanner, B.L., G.C. White, and L.L. McDaniel. 2004. Weather and prairie grouse: dealing with effects beyond our control. Wild. Soc. Bull. 32:22-34.
Nevada. The effects of weather and grassland disturbance on Sharp-tailed Grouse were simultaneously assessed using multiple-linear-regression on an ungrazed grassland area at Valentine National Wildlife Refuge. Average temperatures in May and June, and cumulative precipitation from January to July were positively correlated with Sharp-tailed Grouse production, whereas high temperatures in June and high precipitation days (>2.54 mm) in June were negatively associated with production. The resulting model overestimated production rates on a nearby grazed grassland area, indicating that grazing likely reduces overall grouse production. No specific vegetation data is given for either grassland study site.

Fleischner, T.L. 1994. Ecological costs of livestock grazing in western North America. Conserv. Biol. 8:629-644.
Review article. Ecological costs of livestock grazing are: 1) alteration of species composition, 2) disruption of ecosystem function, and 3) alteration of ecosystem structure. Species

composition is altered by livestock grazing by active selection for or against a specific plant species, differential sensitivity of plant species to grazing.

Fletcher, R.J. Jr., and R.R. Koford. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. J. Wildl. Manage. 66:1011-1022.
Iowa. Restored tallgrass prairie had similar breeding bird species, richness, and abundance as native grasslands.

Fraser, D.F., W.L. Harper, S.G. Cannings, and J.M. Cooper. 1999. Rare birds of British Columbia., B.C. Minist. Environ., Lands, and Parks, Wildl. Branch and Resour. Inv. Branch. Victoria, BC. 244 pp.

Frawley, B.J., and L.B. Best. 1991. Effects of mowing on breeding bird abundance and species composition in alfalfa fields. Wild. Soc. Bull. 19:135-142.
Southwestern Iowa. Bird abundance decreased after mowing alfalfa fields and remained lower for at least 4 weeks after mowing. Vesper Sparrows nested in alfalfa fields at low densities and with low nest success. Vegetation changes associated with mowing that occurred after territory establishment decreased Vesper Sparrow densities.

Garrettson, P.R., and F.C. Rohwer. 2001. Effects of mammalian predator removal on production of upland-nesting ducks in North Dakota. J. Wildl. Manage. 65:398-405.
North Dakota. Nest success increased with predator removal and during the second year after initiation of trapping, pair density was higher in all trapped blocks. This suggests that predator reduction allowed higher recruitment for some combination of the following factors: 1) elevated duckling production which then returned to natal sites, 2) higher female survival and, 3) greater nest site philopatry caused by higher nest success rates. Blue-winged Teal nests made up 50% of the found nests.

Gayton, D.V. 2003. British Columbia Grasslands: Monitoring vegetation change. Forrex - Forest Research Extension Partnership, Kamloops, BC. 49pp.

Gendron, M., and R.G. Clark. 2002. Survival of Gadwall and Mallard ducklings in southcentral Saskatchewan. J. Wildl. Manage. 66:170-180.
Saskatchewan. Duckling survival and initial brood size is larger for Gadwall than for Mallards, resulting in greater overall production. No difference in survival rates are seen related to distance from wetlands. Wetlands were in excellent condition at the time of the study and predator densities were low because the wetlands are fishless.

George, T.L., A.C. Fowler, R.L. Knight, and L.C. McEwen. 1992. Impacts of a severe drought on grassland birds in western North Dakota. Ecol. Appl. 2:275-284.
North Dakota. Bird density declined during a drought, but most species recovered in the year after end of drought. Species richness declined more on fair condition range than on good condition range. Vesper Sparrow density and nest success was lower in a dry year than years before or after although clutch size did not differ. Vesper Sparrows were the only species whose abundance was affected by range condition (as assessed by ocular estimate of dominant grass species covers). Vesper Sparrow density declines during a drought were moderated by good quality range condition. Declines in most species were attributed to

reduced cover of grassland vegetation. Relatively rapid density recoveries by most species after the drought suggest that declines were the result of a higher proportion not breeding in the drought year and returning the next year, by sufficient recruitment even during the drought to allow populations to recover, and by recruitment from areas that were unaffected by the drought. Low productivity by Vesper Sparrows in the drought was due to nest abandonment that was driven by heat stress, energy constraints, or egg viability. Grasshopper abundance was reduced during the drought, suggesting energy constraints may have played a role, but very high temperatures also coincided with nest abandonment.

George, T.L., L.C. McEwen, and B.E. Petersen. 1995. Effects of grasshopper control programs on rangeland breeding bird populations. J. Range Manage. 48:336-342.
North Dakota, Utah, Colorado, Idaho, and Wyoming. A range of pesticide treatments did not differ in their effect on birds densities. No control plots were assessed so relative difference estimates in bird density can be made only among the herbicide blocks.

Giesen, K.M., and J.W. Connelly. 1993. Guidelines for management of Columbian Sharp-tailed Grouse habitats. Wild. Soc. Bull. 21:325-333.
Review Article. Sharp-tailed Grouse populations have declined in western North America since the early 1900s having been extirpated from Nevada, California, Oregon and having range and distribution restricted elsewhere in its current range. Shrubs are used as security cover for nesting, but where they are absent, tall, abundant bunchgrasses may be used. Reducing the cover and height of bunchgrasses on these sites may reduce nest success.

Gjersing, F.M. 1975. Waterfowl production in relation to rest-rotation grazing. J. Range Manage. 28:37-42.
Montana. Waterfowl pairs were more abundant on pasture that had not been grazed the year previous and decreased in pastures that had been grazed the previous fall. No grazing or grazing only in spring or summer increased the density of breeding waterfowl the next year. Grazing in summer and fall resulted in decreases in breeding pairs the next year in most cases.

Gloutney, M. L., and R. G. Clark. 1997. Nest-site selection by Mallards and Blue-winged Teal in relation to microclimate. Auk 114:381-395.
St. Denis National Wildlife Area, Saskatchewan. Mallard and Teal nests received less insolation than random adjacent sites, but temperature and relative humidity were not different. Microclimate may be less important than other factors in nest-site selection.

Gonnet, J.M. 2001. Influences of cattle grazing on population density and species richness of granivorous birds (Emberizidae) in the arid plain of the Monte, Argentina. J. Arid Environ. 48:569-579.
Argentina. Emberizid abundance and richness were lower in grazed than ungrazed paddocks, as was seed abundance. Structural habitat elements were not different among the paddocks. Seed-eating emberzerids appear to be affected by reduced seed availability in grazed pastures.

Gougen, C.B., and N.E. Mathews. 1998. Songbird community composition and nesting success in grazed and ungrazed pinyon-juniper woodlands. J. Wildl. Manage. 62:474-484.
New Mexico. Vegetation differed little between moderately grazed and ungrazed sites. Nest densities and nest success rates were not different between plots currently grazed and ungrazed for 20 years. Cowbird nest parasitism was high in all plots, probably because of the proximity of cattle.

Gougen, C.B., and N.E. Mathews. 1999. Review of the causes and implications of the association between Cowbirds and livestock. Studies in Avian Biol. 18:10-17.
Due to the long-distance commutes of Cowbirds between nest host sites and feeding areas, livestock removal methods for controlling parasitism rates may not be effective, but requires further research.

Gougen, C.B., and N.E. Mathews. 2001. Brown-headed Cowbird behavior and movements in relation to livestock grazing. Ecol. Appl. 11:1533-1544.
New Mexico. Cowbirds nested in areas away from cattle and commuted more than 3 km, up to 8 km from the nest sites to feeding areas. Cattle presence is required for feeding, but Cowbirds may nest a considerable distance from the feeding area.

Grant, W.E., E.C. Birney, N.R. French, and D.M. Swift. 1982. Structure and productivity of grassland small mammal communities related to grazing-induced changes in vegetative cover. J. Mammal. 63:248-260.
Washington, Montana, Colorado, Oklahoma. Small mammal communities in tallgrass grasslands were more affected by grazing than communities in shortgrass and bunchgrass grasslands. Small mammal community differed little between grazed and ungrazed bunchgrass grasslands, but the level of grazing was not well described but appeared to be light. No species-specific responses were reported.

Greene, E. 1999. Demographic consequences of Brown-headed Cowbird parasitism of Lazuli Buntings. Studies in Avian Biol. 18:144-152.
West-central Montana. In some areas nest parasitism rates reached 70% of Lazuli Bunting nests being parasitized. Of nests parasitized, 90% did not fledge even one Bunting chick. Modelled parasitism threshold for population maintenance of Lazuli Bunting populations is 17% of nests parasitized.

Greenwood, R.J., D.G. Pietruszewski, and R.D. Crawford. 1998. Effects of food supplementation on depredation of duck nests in upland habitat. Wild. Soc. Bull. 26:219-226.
North Dakota. Supplemental foods were placed in duck nesting areas and survival of 1046 duck nests was monitored. Predation rates did not differ with and without supplemental foods although predation by Skunks decreased. Predation by Badger and Franklin's Ground Squirrels increased.

Gregg, M.A., J.A. Crawford, M.S. Drut, and A.K. Delong. 1994. Vegetational cover and predation of Sage Grouse nests in Oregon. J. Wildl. Manage. 58:162-166.

Oregon. Medium height shrub cover was highest at predated and non-predated nest locations than areas around the nest sites or at non-nest sites. Non-predated nests had more cover of tall grass and medium shrubs than predated nests.

Gruver, B.J., and F.S. Guthery. 1986. Effects of brush control and game-bird management on nongame birds. J. Range Manage. 39:251-253.
Texas. Removal of shrubs by herbicide treatment resulted in few changes to nongame bird populations. Habitat management for doves and Bobwhites (creating bare ground patches, constructing brush covers, and supplemental feeding) increased density of nongame birds. Different bird species responded differently to the treatments. Grassland Sparrows (including Cassin's, Clay-colored, Grasshopper and Vesper sparrows) increased with shrub removal and with game bird management. Bushland sparrows (including wintering White-crowned Sparrows) were less abundant when shrubs were removed and did not differ with gamebird management.

Grzybowski, J.A. 1982. Population structure in grassland bird communities during winter. Condor 84:137-152.
Oklahoma, Texas. Sites with similar grazing pressure had similar bird communities in winter. Heavily grazed sites had the highest biomass of wintering birds, but the community was dominated by a few numerous species.

Haire, S.L., C.E. Bock, B.S. Cade, and B.C. Bennett. 2000. The role of landscape and habitat characteristics in limiting abundance of grassland nesting songbirds in an urban open space. Landsc. Urb. Plan. 48:65-82.
Boulder, Colorado. Grassland fragmentation as well as grassland condition affected abundance of grassland birds. Vesper Sparrows were more affected by grassland condition than degree of fragmentation.

Hall, A.T., P.E. Woods, and G.W. Barrett. 1991. Population dynamics of the Meadow Vole (Microtus pennsylvanicus) in nutrient enriched old-field communities. J. Mammal. 72:332-342.
Ohio. Fields treated with commercial fertilizer or dried sewage sludge had lower population densities, rates of recruitment and survivorship in Meadow Voles. Population growth rates were negative in treated plots, although sex ratio did not differ. Vegetation biomass was higher on treated plots, but edible biomass and vegetation species richness was higher on control plots.

Herkert, J.R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecol. Appl. 4:461-471.
Illinois. Habitat patch size strongly influenced bird community richness. Grassland birds were divided into 4 groups based on response to habitat variables: 1) area-sensitive species, 2) edge species, 3) vegetation-restricted species, and 4) Dickcissel. Vegetation-restricted species included Upland Sandpiper and Common Yellowthroat. Savannah Sparrow, Bobolink, and Eastern Meadowlark were considered an area-dependant species and were only found in larger grassland areas. Vesper Sparrow abundance was estimated to have

declined by 22% in the U.S. with losses in Illinois of 2% declines from 1966 to 1991. No significant habitat variables were found that predicted Vesper Sparrow abundance in Illinois.

Herkert, J.R., S.A. Simpson, R.L. Westermeier, T.L. Esker, and J.W. Walk. 1999. Response of northern harriers and short-eared owls to grassland management in Illinois. J. Wildl. Manage. 63:517-523.
Illinois. Northern harriers nested in undisturbed grasslands whereas Short-eared Owls used disturbed grasslands. Vegetation species did not appear to affect nest placement.

Hines, J.E., and G.J. Mitchell. 1983a. Breeding ecology of the Gadwall at Waterhen Marsh, Saskatchewan. Can. J. Zool. 61:1532-1539.
Saskatchewan. Nest success varied among upland, ditchbank, and island sites due mainly to differences in mammalian predation rates. Islands had best nest success and the highest nest densities.

Hines, J.E., and G.J. Mitchell. 1983b. Gadwall nest-site selection and nesting success. J. Wildl. Manage. 47:1063-1071.
Saskatchewan. Nest densities decreased from natural and artificial islands to ditchbanks and uplands. Nests generally had overhead vegetative cover of 25% or higher, vegetation was 30cm or taller, and lateral concealment ratings of 3 or 4. Nest success was positively correlated with vegetation height, canopy cover, and lateral concealment.

Holechek, J.L., R.D. Pieper, and C.H. Herberl. 2001. Range management principles and practice. Prentice Hall, Upper Saddle River, NJ. 587pp.

Holt, D. W., and S. M. Leasure. 1993. Short-eared Owl. Page 62 *in* A. Poole and F. Gill (eds.). The birds of North America. Philadelphia, PA. 24pp.

Hooper, T.D., and M.D. Pitt. 1994. Breeding bird communities and habitat associations in the grasslands of the Chilcotin Region, British Columbia. Dep. Plant Sci., Univ. British Columbia, Vancouver, BC. 108pp.
Chilcotin, B.C. Horned Lark and Vesper Sparrows were the most abundant species observed. Horned Larks were most abundant on high elevation, relatively flat grasslands with short, open vegetation and few shrubs. Vesper Sparrows were most common on sites with tall dense vegetation but with low grass cover. The abundance of beetle, hemipteran, and total arthropod abundance was also related to higher abundances of Vesper Sparrows. Long-billed Curlew abundance was highest on high-elevation sites with short, open vegetation, low shrub cover, high proportion of grasses, and low bare ground cover. Curlew numbers decreased as grazing increased. Vesper Sparrow abundance was highest with a May-June vegetation height of 8-12 cm, vertical vegetation cover of 32-41%, and grass cover of 33%.

Hooper, T.D., and J.-P.L. Savard. 1991. Bird diversity, density, and habitat selection in the Cariboo-Chilcotin grasslands, with emphasis on the Long-billed Curlew. Can. Wildl. Serv. 65pp.
Riske Creek, B.C. Bird density was highest in habitats with the tallest and densest vegetation and lowest in habitats with the shortest, sparsest vegetation. Horned Larks and Vesper Sparrows were the first and second most abundant species detected in point count surveys.

Territories of Vesper Sparrows ranged from 1.5 to 2.5 pairs per 25 ha plot and Vesper Sparrows were only significantly correlated with shrub and bryophyte cover. Abundance also tended to increase with vegetation height and density, but the correlation was not significant.

Hope, G.D., D.A. Lloyd, W.R. Mitchell, W.R. Erickson, W.L. Harper, and B.M. Wikeem. 1991a. Ponderosa Pine Zone. The Ecosystems of British Columbia. *In* D. Meidinger and J. Pojar (eds.), B.C. Minist. For., Res. Branch, Victoria, BC. Sp. Rep. Ser. 6.

Hope, G.D., W.R. Mitchell, D.A. Lloyd, W.R. Erickson, W.L. Harper, and B.M. Wikeem. 1991b. Interior Douglas-fir Zone. The Ecosystems of British Columbia. *In* D. Meidinger and J. Pojar (eds.), B.C. Minist. For., Res. Branch, Victoria, BC. Sp. Rep. Ser. 6.

Howe, F.P., R.L. Knight, L.C. McEwen, and T.L. George. 1996. Direct and indirect effects of insecticide applications on growth and survival of nestling passerines. Ecol. Appl. 6:1314-1324.

Southern Idaho. Insect prey-base was reduced with insecticide and nestling growth rates and nest survival was monitored. Sage Thrasher and Brewer's Sparrow nestlings grew more slowly in some treatment years, but nest survival and nestlings fledged did not differ between treated and untreated sites. Nestling and growth and survival were only marginally affected by herbicide induced reductions in food abundance.

Hughes, J.P., R.J. Robel, K.E. Kemp, and J.L. Zimmerman. 1999. Effects of habitat on Dickcissel abundance and nest success in Conservation Reserve Program fields in Kansas. J. Wildl. Manage. 63:523-529.

Kansas. Dickcissel nests were associated with vegetation vertical diversity, wooded area surrounding fields and perimeter of field surrounded by woody vegetation. Nest success was associated with live and dead canopy cover and litter cover.

Ignatiuk, J.B., and D.C. Duncan. 2001. Nest success of ducks on rotational and season-long grazing systems in Saskatchewan. Wildl. Soc. Bull. 29:211-217.

Saskatchewan. No difference in nest survival between rotational and continuous grazing systems was seen. Nest success increased with increasing biomass of vegetation on the pastures. 36% of nests in sample were Blue-winged Teal.

Johnsgard, P.A. 2002. Grassland grouse and their conservation., Smithsonian Institution Press, Washington, DC. 157.

Johnson, D.H., and L.D. Igl. 2001. Area requirements of grassland birds: a regional perspective. Auk 118:24-34.

Many species of grassland birds appear to be sensitive to the area of habitat patches. Bobolink, Clay-colored Sparrow, and Baird's Sparrow all selected for large habitat patches. Savannah Sparrow results were equivocal, positive correlation with patch size in some places, negative in others.

Johnson, R.G., and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. J. Wildl. Manage. 54:106-111.

Minnesota. Nest predation rates were lower in recently burned tallgrass prairie, in large patches of grassland and further from wooded edge. Brood parasitism rates were also lower further from forest edge.

Jones, D.D., L.M. Conner, R.J. Warren, and G.O. Ware. 2002. The effect of supplemental prey and prescribed fire on success of artificial nests. J. Wildl. Manage. 66:1112-1117.
Georgia, USA. Neither supplemental prey nor prescribed burning changed the success of artificial ground nests. Supplemental food changed predators with higher avian and small mammal predation. Avian predation was higher on prescribed burned plots and small mammal predation was higher in unburned plots.

Jones, E.N. 1990. Effects of forage availability on home range and population density of *Microtus pennsylvanicus.* J. Mammal. 71:382-389.
Pennsylvania. The percentage of transient voles in a population was directly related to population density. Territory size was inversely related to forage availability and as density increased, proportion of transient females in the population increased. Forage is a factor controlling population density.

Jones, R.E. 1966. Spring, summer and fall foods of the Columbian Sharp-tailed Grouse in eastern Washington. Condor 68:536-540.
Washington. After the precipitous decline of grouse in eastern Washington, diet studies were conducted to help meet management goals for re-establishing grouse in the state. Grouse in the study area were restricted to areas of marginal agricultural potential where cultivation had not occurred. Spring and summer diets were composed mainly of plants including leaves, seeds and flowers with few insects.

Kantrud, H.A. 1981. Grazing intensity effects on the breeding bird avifauna of North Dakota grasslands. Can. Field-Nat. 95:404-417.
North Dakota. Bird richness decreased with increasing grazing, but the total abundance tended to be higher with grazing due to high numbers of a few species in grazed habitats. Density of Vesper Sparrows was highest in the moderately grazed pastures, moderate in heavily and lightly grazed grasslands, and absent from mowed hay fields. Grasslands were dominated by Kentucky bluegrass.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications: A review. J. Range Manage. 37:430-438.
Review article.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983. Effects of late season cattle grazing on riparian plant communities. J. Range Manage. 36:685-691.
Oregon. Most of the sampled vegetation types showed changes in habitat characteristics with grazing. Habitats with a forest canopy showed the least change.

Kirby, D.R., and K.L. Grosz. 1995. Cattle grazing and Sharp-tailed Grouse nesting success. Rangelands 17:124-126.
North Dakota. Nests were more abundant on pastures with rotational grazing than on non-grazed pastures, but nest success was higher in ungrazed pastures. Overall grouse

productivity was higher in ungrazed sites. Vegetation was shorter in grazed grasslands and within the grazed areas, and within both treatments, grouse selected the tallest vegetation available for nesting.

Kirsch, L.M. 1969. Waterfowl production in relation to grazing. J. Wildl. Manage. 33:821-828.

Klatt, B.J., and L.J. Getz. 1987. Vegetation characteristics of *Microtus ochrogaster* and *M. pennsylvanicus* habitats in east-central Illinois. J. Mammal. 68:569-577.
Illinois. Meadow Vole sites were characterized by more total vegetation biomass, higher proportion of grasses (other than Poa*), and by less* Taraxacum *than Prairie Vole sites. Vegetation was also taller at Meadow Vole sites and there was great litter. Differences in habitat preferences may be related to nesting locations: Meadow Voles have surface nests, whereas Prairie Voles have underground nests. Meadow Voles are likely more susceptible to predation when cover is sparse.*

Kostecke, R.M., J.A. Koloszar, and D.C. Dearborn. 2003. Effect of a reduction in cattle stocking rate on Brown-headed Cowbird activity. Wildl. Soc. Bull. 31:1083-1091.
Texas. Cowbirds moved foraging areas but not breeding areas from the study site once cattle grazing was removed. Increased energetic costs of feeding may eventually reduce parasitism rates.

Kruse, A.D., and B.S. Bowen. 1996. Effects of grazing an burning on densities and habitats of breeding ducks in North Dakota. J. Wildl. Manage. 60:233-246.
North Dakota. Spring burning reduced nest densities of Gadwall, spring grazing reduced densities of Gadwall and Blue-winged Teal, but nest success was not affected.

Lapointe, S., J.-F. Giroux, L. Bélanger, and B. Filion. 2000. Benefits of rotational grazing and dense nesting cover for island-nesting waterfowl in southern Quebec. Agric. Ecosys. Env. 78:261-272.
Quebec. Cattle grazing has been cited as the limiting factor for ducks nesting on islands in the St. Lawrence River in Quebec. Pastures that were not grazed for two years and pastures ungrazed and treated to improve nesting cover for waterfowl had more visual obstruction, more residual vegetation, more litter and higher nest densities and nest success. Pastures that were treated to improved cattle foraging had low nest densities and low nest success (trampling and predation were major causes of nest failures).

Leupin, E., D.J. Low, and B. Persello. Census and Life History Observations of the great basin spadefoot toad (*Scaphiopus intermontanus*) breeding populations in the Thompson Nicola Regions. Minist. Environ, Lands and Parks, Wildl. Branch, Victoria, BC, 19pp.
British Columbia. Spadefoots were found in IDFdk1a, IDFxh2, BGxh2, BGxw and PPxh2 biogeoclimatic subzones and variants in B.C. Nature of the vegetation around breeding ponds varied from little emergent vegetation, to native rushes and grasses, to introduced agricultural and weedy species.

Lokemoen, J.T., H.F. Duebbert, and D.E. Sharp. 1989. Homing and reproductive habits of Mallards, Gadwalls, and Blue-winged Teal. Wildl. Monogr. 106:1-28.

North Dakota. Nest success was not compared among habitats, but nest densities of Mallards and Gadwalls were highest in those cover types with highest visual obstruction ratings. Blue-winged Teal nests were at highest density in vegetation of moderate height among a wide range of habitat types.

Lusk, J.J., F.S. Guthery, R.R. George, M.J. Peterson, and S.J. DeMaso. 2002. Relative abundance of Bobwhites in relation to weather and land use. J. Wildl. Manage. 66:1040-1051.
Texas. Bobwhite density was negatively correlated with cattle density as well as number of environmental factors.

Mack, G.D., and L.M. Flake. 1980. Habitat relationships of waterfowl broods on South Dakota stock ponds. J. Wildl. Manage. 44:695-700.
South Dakota. Waterfowl broods of Blue-winged Teals selected ponds with longer shoreline, more cover of bulrushes and spike rushes, and ponds surrounded by a more area of idle grasslands than the ponds not used by teal broods.

Mackie, R.J. 1978. Impacts of livestock grazing on wild ungulates. Trans. N. Am. Wildl. Nat. Resour. Conf. Pp. 462-476.
Direct impacts; reduced forage,

Marks, J.S., and V.S. Marks. 1988. Winter habitat use by Columbian Sharp-tailed Grouse in western Idaho. J. Wildl. Manage. 52:743-746.
Idaho. Sharp-tailed Grouse used mountain shrub and riparian communities in winter. Hawthorn, saskatoon and chokecherry berries were main winter foods. Hawthorn buds were not eaten.

Martin, T.E. 1989. Breeding productivity considerations: What are the appropriate habitat features for management? Ecology and Conservation of Neotropical migrant landbirds. Pp. 455-473 *in* J.M.I. Hagan and D.W. Johnston (eds.). Smithsonian Institution Press, Washington, DC.
Bird abundance does not necessarily equate to either nesting preference or productivity. Habitat choice is related to food availability, thermoregulatory effects of the habitat, and risk of nest predation. Reproductive output may be the strongest influence on population sizes. Nest predation rates from 32 species of Neotropical migrants averaged 43%, Cowbird parasitism averaged 9% and other nest failures averaged 5%. Ground-nesting birds had the higher nest success rates, and lower predation and parasitism rates than shrub or tree nesting species. Sixteen of 19 papers reporting nest predation rates in grassland or marsh had reduced predation rates with increased nest concealment for foliage (6 of 6 for artificial nests, 8 of 9 for waterfowl, 1 of 1 for grouse and doves, and 1 of 3 for songbirds). Factors affecting predation rates include: 1) density and type of vegetation and 2) density and type of predator and nest parasites.

Martin, T.E. 1995. Avian life history evolution in relation to nest sites, nest predation, and food. Ecol. Monogr. 65:101-127.
Review article.

Martin, T.E., and J.J. Roper. 1988. Nest predation and nest site selection of a western population of the hermit thrush. Condor 90:51-57.

Martin, T.L. 1993. The effects of livestock grazing in riparian areas and grassland biodiversity in the Cariboo/Chilcotin. Minist. Environ., Habitat Conserv. Trust Fund, Victoria, BC. 44 pp.
British Columbia. Small mammal communities in grazed and ungrazed riparian areas around pothole wetlands were assessed. Vegetation is characterized by sedges and rushes. Ungrazed riparian areas had more small mammals: two species were trapped in grazed sites (Deer Mouse, Meadow Vole), whereas three species were caught in ungrazed (grazed species plus Western Jumping Mouse). Percent cover of vegetation did not differ between grazed and ungrazed sites, but litter was more abundant in ungrazed sites.

Matlack, R.S., D.W. Kaufman, and G.A. Kaufman. 2001. Influence of grazing by Bison and cattle on Deer Mice in burned tallgrass prairie. Am. Midl. Nat. 146:361-368.
Kansas. Differences in vegetation structure between cattle-grazed and Bison-grazed sites likely caused the increased abundance of Deer Mice at the Bison grazed site. Eastern Woodrat, Western Harvest Mouse, and Least Shrews were found only in ungrazed pastures.

McCoy, T.D., M.R. Ryan, E.W. Kurzejeski, and L.W.J. Burger. 1999. Conservation Reserve Program: Source or sink habitat for grassland birds in Missouri? J. Wildl. Manage. 63:530-538.
Missouri. Net reproductive output of grasshopper and field sparrows and probably Eastern Meadowlarks and American Goldfinches exceeded population maintenance levels in CRP fields. Red-winged Blackbird and Dickcissel reproductive output was much less than required for population maintenance even though these species nested at high densities.

McCullough, S.A., A.Y. Cooperrider, and J.A. Bailey. 1980. Impact of grazing on Bighorn Sheep at Trickle Mountain, Colorado. Bienn. Symp. N. Wild Sheep and Goat Counc. 2:42-59.
Diets of cattle and sheep were similar. Range overlap was small, sheep grazed in areas where cattle use was low except for one range.

McDonald, M.W., and K.P. Reese. 1998. Landscape changes within historical distribution of Columbian Sharp-tailed Grouse in eastern Washington: Is there hope? Northwest Sci. 72:34-41.
Washington. Loss of grassland and sagebrush area with increased fragmentation of these habitat types has led to the decline of Sharp-tailed Grouse in Washington.

McEwen, L.C., C.E. Knittle, and M.L. Richmond. 1972. Wildlife effects from grasshopper insecticides sprayed on short-grass range. J. Range Manage. 25:188-194.
Montana, New Mexico, and Wyoming. Spraying to reduce grasshopper densities resulted in declines in bird density regardless of herbicide used. Some herbicides tested resulted in direct mortality of birds. Even when direct mortality was not seen, bird density declined. Vesper Sparrows declined in sprayed Montana grasslands even when direct mortality was not seen.

McKee, G., M.R. Ryan, and L.M. Mechlin. 1998. Predicting Greater Prairie-Chicken nest success from vegetation and landscape characteristics. J. Wildl. Manage. 62:314-321.

Missouri. Models incorporating litter cover, woody cover, and forb or grass cover were significant predictors of nest success. Nest success with litter cover >25%, with woody vegetation cover >5%, forb cover <5%, or grass cover <25%.

Merrill, M.D., K.A. Chapman, K.A. Poiani, and B. Winter. 1999. Land-use patterns surrounding Greater Prairie-chicken leks in northwestern Minnesota. J. Wildl. Manage. 63:189-198. *Minnesota. Leks were associated with smaller amounts of residential farmstead, smaller amounts and smaller patches of forest and greater area of CRP lands. Traditional leks were associated with greater grassland patch size and irregularly shaped grassland and forest patches. Landscape scale management is important for the conservation of Prairie-chickens.*

Milchunas, D.G., W.K. Lauenroth, and I.C. Burke. 1998. Livestock grazing: animal and plant biodiversity of shortgrass steppe and the relationship to ecosystem function. Oikos 83:65-74. *Northcentral Colorado. Responses to grazing are highly variable across classes of organisms; birds appeared to be particularly sensitive to grazing induced changes in vegetation. Community trophic structure differed little among grazing treatments, but the species composition often changed significantly.*

Miller, C.K., R.L. Knight, L.C. McEwen, and T.L. George. 1994. Responses of nesting Savannah Sparrows to fluctuations in grasshopper densities in interior Alaska. Auk 111:962-969. *Alaska. During a year with high grasshopper abundance, 61% of food items brought to the nest were grasshoppers, nest success and clutch size was high. The next year, grasshopper densities were 1/25th of the previous year and no grasshoppers were brought to hatchlings. Nest success was not different between years, but clutch size was smaller the next year. No difference in breeding density was seen between years. Reproductive output was only slightly affected by changed food resource availability.*

Mills, G.S., J.B. Dunning Jr., and J.M. Bates. 1991. The relationship between breeding bird density and vegetation volume. Wildl. Bull. 103:468-479. *Review Article. Breeding bird diversity was strongly correlated with vegetation volume estimates in desert and scrub habitats. The theory that increased vegetation volume provides more resources (greater insect abundance, more nesting sites, more continuous security cover) is supported by the observation that the abundance of wintering seed-eating bird species that are less dependant on vegetation volume, is not affected by vegetation volume.*

Mulhern, J.H., T.D. Nudds, and R.B. Neal. 1985. Wetland selection by Mallards and Blue-winged Teal. Wildl. Bull. 97:473-485. *Saskatchewan. Mallards had wide habitat requirements and used wetlands in proportion to their availability. Blue-winged Teal broods, however, used wetlands with little cover and relied on open water and diving for escape.*

Murkin, H.R., R.M. Kaminski, and R.D. Titman. 1982. Responses by dabbling ducks and aquatic invertebrates to an experimentally manipulated cattail marsh. Can. J. Zool. 60:2324-2332. *Delta Marsh, Manitoba. Cover: water ratios were manipulated to 30:70, 50:50, and 70:30. Invertebrate populations or species composition were not affected by the treatment and dabbling duck densities followed the changes in invertebrate density rather than habitat* *changes. Highest densities of ducks were seen in the 50:50 plots, supporting the hemi-marsh hypothesis.*

Murray, L.D., and L.B. Best. 2003. Short-term bird response to harvesting switchgrass for biomass in Iowa. J. Wildl. Manage. 67:611-621.
Iowa. Totally harvested, partially harvested (in strips), and unharvested switchgrass fields had similar bird species richness and abundance except for Grasshopper Sparrows that were more abundant in harvested field and Sedge Wrens that were more abundant in unharvested fields. Nest predation rates were lower in unharvested fields. Nest parasitism rates did not differ among treatments.

Nelson, K.J., and K. Martin. 1999. Thermal aspects of nest-site location for Vesper Sparrows and Horned Larks in British Columbia. Studies in Avian Biol. 19:137-143.
Riske Creek, B.C. Most nests were situated with a vegetation clump to the southwest (180 to 260 degrees) and these nests experienced lower temperatures than other nests. These nests remained below potentially fatal temperatures because they experienced morning sun, but were sheltered from midday and afternoon sun, whereas other nests did not. Height of the vegetation clump and the amount of cover it provided also influenced temperatures experienced at the nest. Nest with vegetation clumps 57 cm tall had lower maximum temperatures and exceeded lethal temps for less time than nests with vegetation clumps of 33 cm or 16 cm. These differences in thermal environment at the nest may not affect egg survival directly, but the increased requirement of maternal care needed to keep the eggs and hatchlings at sub-lethal temperatures should have long-term survival and energetics implications for adult Vesper Sparrows.

Newman, G.A. 1970. Cowbird parasitism and nesting success of Lark Sparrows in southern Oklahoma. Wildl. Bull. 82:304-309.
Oklahoma. Most of thirty-three nests examined were placed at the base of a shrub or clump of taller vegetation. Fifteen of the 33 nests were parasitized (a total of 18 Cowbird eggs) by Brown-headed Cowbirds of which 3 fledged Cowbirds. Of these nests, 17 out of 45 Lark Sparrow eggs hatched and 9 fledged. In unparasitised nests 42 of 58 eggs hatched and 32 fledged. More ground nests were parasitized than shrub nests and more young were produced from elevated nests.

Nicholson, A., E. Hamilton, W.L. Harper, and B.M. Wikeem. 1991. Bunchgrass Zone. Ecosystems of British Columbia. Pp. 125-137 *in* D. Meidinger and J. Pojar (eds.). Minist. For., Res. Branch, Victoria, BC. Sp. Rep. Ser. 6.

Owens, R.A., and M.T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. Can. J. Zool. 51:697-713.
Alberta. Undisturbed grassland bird communities consisted of Baird's Sparrow, Sprague's Pipits, Savannah Sparrow, Clay-colored Sparrow, and Western Meadowlark. Mowing or grazing reduced or eliminated Baird's Sparrow and Sprague's Pipits, but increased Horned Larks and Chestnut-collared Longspurs. Ploughing under native grasslands eliminated all passerines except Horned Larks. Savannah, Vesper, and Clay-colored Sparrows benefited

from field boundarie.(e.g., fence lines, hedgerows). Vesper Sparrows were significantly more abundant in cultivated and grazed sites than in undisturbed grasslands.

Pasitschniak-Arts, M., and F. Messier. 1995. Risk predation on waterfowl nests in the Canadian prairies: effects of habitat edges and agricultural practises. Oikos 73:347-355.
Southcentral Saskatchewan. Nest survival rate was highest in dense nesting cover and when haying operations were delayed. Upland nest survival is affected by agricultural practices. No specifics on habitat attributes are given.

Patterson, M.P., and L.B. Best. 1996. Bird abundance and nesting success in Iowa CRP fields: The importance of vegetation structure and composition. Am. Midl. Nat. 135:153-167.
Bird abundance and diversity was compared between CRP fields and rowcrop fields. Sixteen species nested in CRP fields and 2 species nested in rowcrop fields. Nest predation was 52% in CRP and 65% in rowcrop fields, mostly by mammalian predators. Vesper Sparrows were significantly more abundant in row crop fields than CRP fields but nested in both habitats. Nest success was 33% with most nest failures due to predation and the remainder due to Cowbird parasitism.

Peles, J.D., and G.W. Barrett. 1996. Effects of vegetative cover on the populations dynamics of Meadow Voles. J. Mammal. 77:857-869.
Ohio. The amount of litter and standing biomass of existing habitat was experimentally depleted and enhanced. Vole body mass, population density and recruitment decreased with reduced cover, but did not rise with artificially increased cover. Leads to the conclusion that there is a threshold amount of cover above which densities are not affected. Unclear whether increased densities, body mass and recruitment were due to increased food abundance or to increased cover, or both.

Perkins, D.W., P.D. Vickery, and W.G. Shriver. 2003. Spatial dynamics of source-sink habitats: Effects on rare grassland birds. J. Wildl. Manage. 67:588-599.
Florida. Core areas (>400 m from grassland edge) acted as sources for Florida Grasshopper Sparrows while edge habitats were population sinks.

Petterjohn, B.G., and J.R. Sauer. 1999. Population status of North American grassland birds from the North American breeding bird survey, 1966-1996. Studies in Avian Biol. 19:27-44.
Review Article. Of the 25 species examined only 3 showed population growth over the past 30 years. Thirteen species declined and 9 showed no change. Grassland birds were the group with the lowest proportion and number of species with increasing populations of all habitat guilds examined. The species that have experienced increases are the Upland Sandpiper, Ferruginous Hawk, and Sedge Wren. Long-billed Curlew, Horned Lark, Sprague's pipit, Vesper Sparrow, Savannah Sparrow, Bobolink and Western Meadowlark are among the species declining.

Phillips, M.L., W.R. Clark, M.A. Sovada, D.J. Horn, R.R. Koford, and R.J. Greenwood. 2003. Predator selection of prairie landscape features and its relation to duck nest success. J. Wildl. Manage. 67:104-114.

North Dakota. Striped skunks selected wetland edges surrounded by agricultural areas over all other habitat types studied. Isolated patches of cover were selected for by Red Foxes. Waterfowl nest success was higher in landscapes with higher grassland proportion.

Pietz, P.J., G.L. Krapu, D.A. Brandt, and R.R.J. Cox. 2003. Factors affecting Gadwall brood and duckling survival in prairie pothole landscapes. J. Wildl. Manage. 67:564-575.
North Dakota. Gadwall chick survival was higher when seasonal ponds were abundant than when they were scarce. Mortality rates were higher during the first 7 days after hatching than for 8- to 30 day-old chicks. Most chick loss was through predation and much of that was by mink.

Pitt, M.D., and A. Allaye-Chan. 1985. The interactions between cattle and California Bighorn Sheep on the Ashnola Mountain Range. B.C. Minist. Agric. and Food, and Agric. Can., Victoria, BC.
British Columbia. Few negative interactions between bighorns and cattle were noted. Forage abundance was adequate on the sheep ranges and bighorns and cattle do not use the same range during the same seasons.

Popotnik, G.J., and W.M. Giuliano. 2000. Response of birds to grazing of riparian zones. J. Wildl. Manage. 64:976-982.
Pennsylvania. Avian abundance and richness were lower in grazed riparian areas than ungrazed. Nest density was higher and nest destruction rate was lower in ungrazed riparian areas, but overall nest success did not differ.

Powell, B.F., and R.J. Steidl. 2002. Habitat selection by riparian songbirds breeding in southern Arizona. J. Wildl. Manage. 66:1096-1103.
Arizona. Most riparian nesting birds selected areas with higher vegetation volume and density than available.

Reed, J.M. 1986. Vegetation structure and Vesper Sparrow territory location. Wildl. Bull. 98:144-147.
Montana. Vesper Sparrow territories were located in areas that had shorter, denser vegetation than adjacent unused sites. Average height of vegetation in used areas was about 24 cm and in unused areas was about 31 cm. Vertical vegetation density was not different between used and unused locations. Used locations had slightly higher grass cover and slightly lower forb cover than unused locations.

Renfrew, R.B., and C.A. Ribic. 2002. Influence of topography on density of grassland passerines in pastures. Am. Midl. Nat. 147:315-325.
Wisconsin. Bobolink and Savannah Sparrows occurred on pastures with more height-density vegetation and less bare ground and in larger habitat patches.

Reynolds, R.E., T.L. Shaffer, R.W. Renner, W.E. Newton, and B.D.J. Batt. 2001. Impact of the Conservation Reserve Program on duck recruitment in the U.S. prairie pothole region. J. Wildl. Manage. 65:765-780.

North Dakota, South Dakota, Montana. Overall duck recruitment is estimated to have increased by 30% and nest success by 46% since the conservation reserve program was initiated. CRP fields have permanent planted grass cover rather than annual harvested crops.

Reynolds, T.D., and C.H. Trost. 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. J. Range Manage. 33:122-125.
Idaho. The structure of the vegetation community was similar among the treatments, dominated by big sagebrush, but the richness of plants was significantly reduced in grazed areas. Small mammal community diversity and density were reduced with grazing in sagebrush habitats. Sagebrush areas supported more breeding species and higher densities of birds, mammals, and reptiles than did adjacent areas planted to crested wheatgrass. Planting to crested wheatgrass and grazing reduced the density of small mammals and allowed only a single breeding bird species, the Horned Lark. Vesper Sparrows were found in low densities in the study area and were seen only in the ungrazed crested wheatgrass site.

Ritcey, R. 1995. Status of the Sharp-tailed Grouse - Columbianus subspecies in British Columbia. Minist. Environ., Lands, and Parks, Wildl. Branch, Victoria, BC. 40pp.

Roberts, G. 1994. Comparison of rodent populations of ungrazed and grazed areas in the Chilcotin grassland subzone BGxw2. Williams Lake, B.C. Minist. Environ., Lands, and Parks. 30pp.
British Columbia. Montane Voles were captured at higher densities in ungrazed grasslands. Deer Mice were captured in grazed and ungrazed grasslands with slightly higher densities in grazed grasslands. Total cover of grasses and sedges in ungrazed grasslands ranged from about 30% on dry, sloped sites to 65% on flat sites. Cover in grazed areas ranged from about 25 to 45%. Horizontal cover was 50 to 78% and vertical cover was 48 to 51% for ungrazed sites (using a modified Robel pole method - 50x50 cm board viewed from 10 m at 30 cm height). Grazed sites had horizontal cover of 46 to 66% and vertical cover of 23 to 40%. Modal grass heights in ungrazed sites were 41 to 45 cm and 18 to 30 cm in grazed sites. Litter in ungrazed sites was 16 to 62% and in grazed sites was 10 to 15%. Montane Vole abundance was related to litter cover.

Rodenhouse, N.L., and L.B. Best. 1983. Breeding ecology of Vesper Sparrows in corn and soybean fields. Am. Midl. Nat. 110:265-275.
Nest losses were due to agriculture operations (27%) and predation (29%). Mean territory size was 1.8 to 3.2 ha (mean 2.3 ha), larger then the 0.5 to 0.7 ha reported by Evans (in Berger 1968) and 0.9 ha by Wiens (1969[3]). Berger (1968) reported that Vesper Sparrow territories are generally larger than other fringillids. Territories in habitats with scarce food or widely dispersed foods are larger than when food is abundant and dispersed. Vesper Sparrow densities were lower than in non-cultivated areas. Early season nests, before new vegetation growth, were always placed in a clump of crop residue, after crops reached 10 cm

[3] Wiens, J. A. 1969. An approach to the study of ecological relationships among grassland birds. *Ornithological Monographs* 8:1–93.

nests were placed at the base of crop plants. Early activities and nests were associated with crop residue patches. After crop tillage began, use shifted to fencerows where residual vegetation was found. No relationship between nest success and vegetation cover was found, but the cover used by sparrows approaching nests was not measured and may affect the ability of nest predators to detect nests. Nest success was low (13%) with high nest destruction early in the season from agricultural activities and nest success increased later in the season after tillage operations were complete. Of all nests lost, 11% were due to nest parasitism (nests were abandoned or produced only Cowbird young), 27% were due to farm equipment damage, 29% were due to predation, and 4% were lost to weather. Only 29% of nests were successful.

Rodenhouse, N.L., and L.B. Best. 1994. Foraging patterns of Vesper Sparrows (*Pooecetes gramineus*) breeding in cropland. Am. Midl. Nat. 131:196-206.
Iowa. Vesper Sparrows whose territories spanned two different crop types preferred foraging in fields with more crop residue (2180 kg/m^2 vs. 530 kg/m^2). These sites were selected because they provided song perches, had more security cover and/or had higher abundance of prey arthropods. Foraging sites were concentrated within the territory and were areas with taller vegetation (areas more than 50 m from weedy or uncropped patches were rarely used for foraging).

Rosenstock, S.S. 1996. Shrub-grassland small mammal and vegetation responses to rest from grazing. J. Range Manage. 49:199-203.
South-central Utah. Large ungrazed habitats with more cover of grasses, taller grass plants, and more surface litter had higher species richness and abundance but not different reproductive activity or biomass.

Rottenberry, J.T., and J.A. Wiens. 1980. Habitat structure, patchiness, and avian communities in North American steppe vegetation: a multivariate analysis. Ecology 61:1228-1250.
Across grasslands in the USA. Bird species responded to environmental conditions more than to the presence or absence of other bird species. Vesper Sparrow abundance was correlated with forb cover, vertical heterogeneity, and litter height. Horned Lark abundance was correlated with forb cover, vertical structural diversity, and increasing horizontal clumpiness.

Saab, V.A., and J.S. Marks. 1992. Summer habitat use by Columbian Sharp-tailed Grouse in western Idaho. Great Basin Nat. 52:166-173.
Idaho. Mean home range size was 1.87 ± 1.14 km^2 and used big sagebrush cover types more than they were available. Shrubby Eriogonum *cover types were avoided. Big sage habitat was characterized by moderate vegetative cover, high plant species diversity, and high structural diversity. Sites with dense cover were used for escape. Grouse selected habitats least modified by livestock grazing.*

Sanders, T.A., and W.D. Edge. 1998. Breeding bird community compositions in relation to riparian vegetation structure in the western United States. J. Wildl. Manage. 62:461-473.

Eastern Oregon. Species richness and abundance was higher in riparian shrubland communities with higher percent cover of shrubs, more vertical diversity in the shrub layer, and greater width. Many species were significantly more abundant in this type of habitat, whereas others were more abundant in herbaceous xeric sites.

Scheiman, D.M., E.K. Bollinger, and D.H. Johnson. 2003. Effects of leafy spurge infestation on grassland birds. J. Wildl. Manage. 67:115-121.
North Dakota. Savannah Sparrow and Grasshopper Sparrow densities were lower in grasslands with high densities of leafy spurge. Bobolink and Western Meadowlark densities were not affected by level of spurge infestation.

Schulz, T.T., and W.C. Leininger. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. Great Basin Nat. 51:286-292.
Colorado. Among birds, only Wilson's Warbler abundance was significantly different between grazed and ungrazed riparian sites (9 in ungrazed and none in grazed). Among small mammals, Deer Mouse was more abundant in grazed sites and Western Jumping Mouse was more abundant in ungrazed sites. Bird community richness was greater in ungrazed sites, but small mammal richness was the same.

Sealy, S.G. 1980. Reproductive responses of northern orioles to a changing food supply. Can. J. Zool. 58:221-227.
Manitoba. Nesting density of Northern Orioles doubled 1 year after a large tent caterpillar outbreak. Density declined to pre-outbreak levels 1 year after the increased food availability. Clutch size and body weight were not different during higher nest density, but hatching failure and nestling death were higher. Total reproductive output was higher for the population when food resources were abundant.

Sexton, D.A., and M.M. Gillespie. 1979. Effects of fire on the location of a Sharp-tailed Grouse arena. Can. Field-Nat. 93:74-76.
Manitoba. Grouse began dancing on a burned historical lek within 2 days of the fire. After the burn, all litter and most live vegetation was consumed.

Silvy, N.J., and C.A. Hagen. 2004. Introduction: Management of imperilled prairie grouse species and their habitat. Wildl. Soc. Bull. 32:2-5.
Initial human encroachment into grassland grouse habitats appeared to benefit Tympanuchus *species by increasing winter forage abundance. However as human-caused alterations to grasslands has increased many grassland grouse populations have declined or been extirpated despite considerable research and management effort.*

Sovada, M.A., R.M. Anthony, and B.D.J. Batt. 2001. Predation on waterfowl on arctic tundra and prairie breeding areas: a review. Wildl. Soc. Bull. 29:6-15.
Prairie nesting waterfowl face a wide range of predators, up to 20 species, and nest predation rates are often high and thought to be the primary factor affecting recruitment. Hen and duckling predation may also be important. Many reproductive strategies to reduce the risk of predation have evolved, including breeding as yearlings, large clutch sizes, ability to re-nest, cryptic plumage, well concealed nests, island or over water nest sites, and

diversionary displays to divert predators. Breeding habitat has been lost through alteration of grassland and wetlands, which also changes the predation risk by concentrating nests and reducing the density of alternative prey. Predator communities have changed with reduction or elimination of large prey, leading to higher densities of waterfowl predators. Increases in woody habitats have led to increased avian predators, including Red-tailed Hawks, Great-horned Owls, and Magpies. Predation risk is higher for female waterfowl, leading to skewed sex ratios. Managing waterfowl predation efforts have taken three main approaches 1) restoration of habitats, 2) isolation of nest sites from predators, and 3) removal of predators. Predation risk increases with proportion of the landscape converted to cropland, so effective reduction in predation rates should focus on habitat restoration. Isolating nests is costly and time consuming and less effective. Predator control has high cost, must be long-term to be effective, and is often socially unacceptable. Restoration of wetlands should focus on areas with large areas of grassland where predation rates should be lower.

Sovada, M.A., M.C. Zicus, R.J. Greenwood, D.P. Rave, W.E. Newton, R.O. Woodward, and J. A. Beiser. 2000. Relationships of habitat patch size to predator community and survival of duck nests. J. Wildl. Manage. 64:820-831.
Minnesota, North Dakota, South Dakota. Nest success tended to be higher in large habitat patches than small patches. Coyote, Skunk, and Badger locations were poorly correlated with habitat type or patch size, whereas Red Foxes were more often found in small patches.

Spraker, T.R., and W.J. Adrian. 1990. Problems with "multiple land use" dealing with Bighorn Sheep and domestic livestock. Bienn. Symp. N. Wild Sheep and Goat Counc. 67-75.
Disease transmission for domestic livestock to wild Bighorn Sheep includes anthrax, Pasturella*, scabies and other viral, clamydial, rickettsial, mycoplasmal, bacterial and parasitic diseases.*

Staab, C.A., and M.L. Morrison. 1999. Managing riparian vegetation to control Cowbirds. Studies in Avian Biol. 18:18-22.

Several common Cowbird host species, including Yellow-breasted Chat and Yellow Warbler, had 32-50% of nests parasitized. Brown-headed Cowbird nest parasitism rates were lower when an obstruction below the nest was closer, there was a higher volume of vegetation at the nest, more larger trees in the area around the nest, and a larger nest tree.

Steenhof, K., and M.N. Kochert. 1988. Dietary responses of three raptor species to changing prey densities in a natural environment. J. Anim. Ecol. 57:37-48.
Idaho. Dietary diversity increased as prey abundance of main prey species declined. Small mammal communities in tallgrass and montane grasslands are more affected by changes in vegetative structure than shortgrass grasslands.

Sullivan, T.P., and D.S. Sullivan. 1984. Influence of range seeding on rodent populations in the interior of British Columbia. J. Range Manage. 37:163-165.
British Columbia. The response of small mammal communities to two levels of grass seed application in harvested forests was examined. Both Deer Mice and vole numbers increased in areas with supplemental food applications in early spring or later in the summer.

Taylor, D.M. 1986. Effects of cattle grazing on passerine birds nesting in riparian habitat. J. Range Manage. 39:254-258.

Oregon. Increased frequency of grazing corresponded to decreased richness and abundance of breeding birds, decreased shrub volume and shrub heights, and decreased richness of breeding birds in riparian areas. Bird species richness was correlated with increasing volume and height of shrubs.

Taylor, D.M., and C.D. Littlefield. 1986. Willow Flycatcher and Yellow Warbler response to cattle grazing. Am. Birds 40:1169-1173.

Oregon. Abundance of Yellow Warbler and Willow Flycatchers increased with decreasing grazing (AUMs).

Temple, S.A., B.M. Fevold, L.K. Paine, D.J. Undersander, and D.W. Sample. 1999. Nesting birds and grazing cattle: Accommodating both in midwestern pastures. Studies in Avian Biology 19:196-202.

Wisconsin. Diversity, nest success, density and productivity of songbirds were highest on ungrazed grasslands. Vesper Sparrows reached highest densities on continuously grazed habitats, but nests were found only on rotational grazed pastures. No habitat measures are given so the height of residual vegetation in the two grazing treatments is unknown. Continuously grazed treatment is described as having " little vegetative cover and were kept closely cropped by cattle."

Tesky, J.L. 1994. *Falco mexicanus.* The fire effects information system (database). W.C. Fisher. U.S. Dep. Agric., For. Serv., Interm. Res. Stn, Interm. Fire Sci. Lab., Missoula, MO.

Thompson, F.R., and D.E. Burhans. 2003. Predation of songbird nests differs by predator and between field and forest habitats. J. Wildl. Manage. 67:408-416.

Missouri. Predation rates by different groups of nest predators differed among habitats. Snake predation was higher in grasslands, and mammalian predation was highest in forests. Predation rates were slightly higher in fields than in forests.

vander Haegen, W.M., M.A. Shroeder, and R.M. DeGraff. 2002. Predation on real and artificial nests in shrubsteppe landscapes fragmented by agriculture. Condor 104:496-506.

Eastern Washington. Landscape fragmentation had the most effect on nest predation rates, but increasing amounts of vegetation around the nest also reduced predation rates. In fragmented landscapes, only vegetation density was a significant factor affecting nest predation rates. Nest predators differed among fragmented and unfragmented landscapes with corvids dominating the predator community in fragmented landscapes, whereas Sage Thrashers and small mammals were the only predators seen in non-fragmented landscapes. Vesper Sparrow predation rates did not differ among continuous and fragmented landscapes and had relatively low predation rates (0.964 and 0.957 daily survival rates in continuous and fragmented landscapes, respectively). Nest success of 4 most common species was 46%.

vander Haegen, W.M., and B. Walker. 1999. Parasitism by Brown-headed Cowbirds in the shrubsteppe of eastern Washington. Studies in Avian Biol. 18:34-40.

Eastern Washington. Nests of only 3 passerine species were parasitized including Vesper Sparrow and Brewer's Sparrow, although, species that abandon a nest if parasitized would not have been detected in this study. Parasitism rates were lower than reported elsewhere, probably because passerines began nesting before Cowbirds arrived at the site.

Vickery, P.D., M.L.J. Hunter, and J.V. Wells. 1992. Evidence of incidental nest predation and its effects on nests of threatened grassland birds. Oikos 63:281-288.
Maine. Striped Skunk predation on ground-nesting birds in sandplain grasslands is thought to be incidental rather than targeted, but resulted in nest losses of 58% and may limit the population of grassland bird species. Predation rates were not correlated with vegetation physiognomy, vegetative cover, or proximity to a forest/grassland edge.

Wallis, C. 1982. An overview of the mixed grasslands of North America. Pp. 195-208 *in* A.C. Nicholson, A. McLean, and T.E. Baker (eds). Proc., Grassland Ecology and Classification Symp. Minist. For., Victoria, BC.

Watkinson, A.R., and S.J. Ormerod. 2001. Grasslands, grazing and biodiversity: Editor's introduction. J. Appl. Ecol. 38:233-237.
Review article. Discusses issues of grazing in grassland areas. Highlights invasion of weeds and woody vegetation that change the nature of grassland habitats, the lack of functional response studies in habitat requirements, and habitat impacts of grazing.

Watters, M.E., T.L. McLash, C.L. Aldridge, and R.M. Brigham. 2002. The effect of vegetation structure on predation of artificial Greater Sage-Grouse nests. Ecoscience 9:314-319.
Southeastern Alberta. Successful nests were surrounded by shorter sagebrush, taller grasses and taller, denser forbs than predated nests. Cover of sagebrush and forbs were the best predictors of nest predation. Lateral cover, provided by forbs and number of sagebrush plants, protected nests from predation by small mammals. Reducing grass heights around artificial nests did not alter predation rates significantly, although predation tended to be higher with trimmed grass.

Weaver, J.E., and F.W. Albertson. 1956. Grasslands of the great plains. Johnsen Publishing, Lincoln, NE.

Welch, B.L. 2002. Bird counts of burned versus unburned big sagebrush sites. U.S. Dep. Agric., For. Serv., Rocky Mtn Res. Sta. 6pp.
Northwestern United States. A burned and seeded Wyoming big sagebrush site had fewer species and lower abundance than unburned sage sites.

Weller, M.W. 1979. Density and habitat relationships of Blue-winged Teal nesting in northern Iowa. J. Wildl. Manage. 43:367-374.
Iowa. Nesting density increased with water depth. Increasing nest densities were negatively correlated with nest success and nest losses were almost entirely due to predation. Increased water depth also resulted in increased wetland area, and the flooded periphery of wetlands was important to teals, probably because these areas harboured abundant invertebrate foods.

Whyte, R.J., and N.J. Silvy. 1981. Effects of cattle on duck food plants in southern Texas. J. Wildl. Manage. 45:512-515.

Texas. The response of forage vegetation species to cattle grazing varied. Rest-rotation grazing systems appeared to favourably affect some forage vegetation.

Wiens, J.A., and J.T. Rottenberry. 1985. Response of breeding passerine birds to rangeland alteration in a North American shrubsteppe locality. J. Appl. Ecol. 22:655-668.
Southern Oregon. Herbicide reduction in sagebrush cover (19-24% to 4-12%, grass cover increased from 1-4% to 10-57%) in southern Oregon resulted in no change in Sage Sparrow abundance. Brewer's Sparrow decreased in the first year after treatment, but recovered in the second year. Sage Sparrow abundance gradually decreased in years after treatment, Brewer's Sparrow abundance fluctuated, Horned Larks increased, and Vesper Sparrows were first seen in the study area. Species response to shrub-steppe structural changes were not well predicted to structure alone, probably because a lag in response due to site fidelity.

With, K.A. 1994. The hazards of nesting near shrubs for a grassland bird, the McCown's Longspur. Condor 96:1009-1019.
Colorado. About half of all nests of McCown's Longspurs were depredated in shortgrass prairies. Nests beside shrubs were 2 to 3 times more likely to be predated than nests associated with other vegetation types. Most nest predation was by ground squirrels that concentrate foraging activities under overhead security cover, so most predation was probably incidental. Eighty percent of nests placed beside shrubs in a moderately grazed pasture were depredated.

Wray, T.I., and R.C. Whitmore. 1979. Effects of vegetation on nesting success of Vesper Sparrows. Auk 96:802-805.
West Virginia. Of 13 habitat variables examined, vertical density, and percent litter were positively correlated with nest success and percent bare ground was negatively correlated. Percent litter at successful nests was 63.17 vs. 53.67 at unsuccessful nests, percent bare ground was 32.93 vs. 44.84 and vertical density was 15.33 vs. 11.64 cm. Seventy-five percent of nests that failed were taken by avian or snake predators and the remaining 25% were mammalian predators.

Yu-Teh, K.L., and G.O. Batzli. 2001. The influence of habitat quality on dispersal, demography, and population dynamics of voles. Ecolog. Monogr. 71:245-275.
Illinois. Habitat was manipulated by varying the amount of food and cover. Cover had a strong effect on the density of vole populations with much higher densities in high cover plots. Supplemental food had a smaller effect on population densities. Survival and reproductive output did not differ among the habitat treatments. Low cover, low food habitats had population extinction, mainly due to emigration rather than mortality.

Zach, R., and J.B. Falls. 1975. Response of the ovenbird (Aves: Parulidae) to an outbreak of the spruce budworm. Can. J. Zool. 53:1669-1672.
Ovenbird nesting territory size decreased with increased food resources.