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The Effects of Management Practices on Grassland Birds—Chestnut-Collared Longspur (*Calcarius ornatus*)

Chapter X of

The Effects of Management Practices on Grassland Birds

Professional Paper 1842–X
Version 1.1, March 2022

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

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Background photograph: Northern mixed-grass prairie in North Dakota, by Rick Bohn, used with permission.

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By Jill A. Shaffer,[1] Lawrence D. Igl,[1] Douglas H. Johnson,[1] Marriah L. Sondreal,[1] Christopher M. Goldade,[1,2] Melvin P. Nenneman,[1,3] Travis L. Wooten,[1,4] and Betty R. Euliss[1]

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The Effects of Management Practices on Grassland Birds

Edited by Douglas H. Johnson,[1] Lawrence D. Igl,[1] Jill A. Shaffer,[1] and John P. DeLong[1,5]

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[1]U.S. Geological Survey.

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DAVID BERNHARDT, Secretary

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
decimeter (dm)	3.937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
hectare (ha)	2.471	acre
square kilometer (km^2)	247.1	acre
hectare (ha)	0.003861	square mile (mi^2)
square kilometer (km^2)	0.3861	square mile (mi^2)
	Mass	
gram (g)	0.03527	ounce (oz)
kilogram (kg)	2.202	pound (lb)

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

$$°F = (1.8 \times °C) + 32.$$

Abbreviations

AUM	animal unit month
BBS	Breeding Bird Survey
CRP	Conservation Reserve Program
CV	coefficient of variation
DNC	dense nesting cover
LSI	Landscape Shape Index
n.d.	no date
PCP	Permanent Cover Program
SD	standard deviation
spp.	species (applies to two or more species within the genus)

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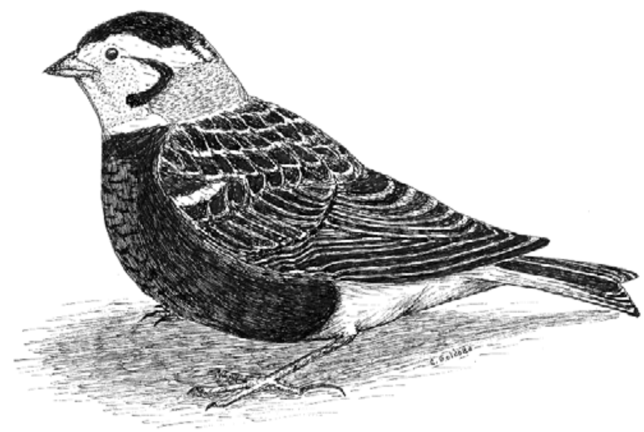
Capsule Statement

Keys to Chestnut-collared Longspur (*Calcarius ornatus*) management are providing and maintaining native pastures with fairly short overall vegetation and sparse litter accumulation but with areas of taller and denser vegetation and accumulated litter for nesting, and tailoring grazing intensity to local conditions. Chestnut-collared Longspurs have been reported to use habitats with 10–77 centimeters (cm) average vegetation height, 1–50 cm visual obstruction reading, 15–67 percent grass cover, 5–16 percent forb cover, less than (<) 6 percent shrub cover, 1–44 percent bare ground, 6–63 percent litter cover, and <7 cm litter depth. The descriptions of key vegetation characteristics are provided in table X1 (after the "References" section). Vernacular and scientific names of plants and animals follow the Integrated Taxonomic Information System (https://www.itis.gov).

Breeding Range

Chestnut-collared Longspurs breed from southern Alberta to southern Manitoba, south to west-central Colorado, and east through North Dakota and South Dakota to extreme western Minnesota (National Geographic Society, 2011). The relative densities of Chestnut-collared Longspurs in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data (Sauer and others, 2014), are shown in figure X1 (not all geographic places mentioned in report are shown on figure).



Chestnut-collared Longspur. Illustration by Christopher M. Goldade, used with permission.

Suitable Habitat

During the breeding season, Chestnut-collared Longspurs use level to rolling mixed-grass and shortgrass prairie uplands, and, in drier areas, moist lowlands (DuBois, 1935; Fairfield, 1968; Owens and Myres, 1973; Stewart, 1975; Wiens and Dyer, 1975; Kantrud and Kologiski, 1982; Igl and others, 2018). They prefer open prairies and avoid excessively shrubby or woody areas (Arnold and Higgins, 1986; Grant and others, 2004; Igl and others, 2008). However, scattered shrubs and other low vegetation, such as Canada thistle (*Cirsium arvense*), rocks, and fences, also are used as perches for singing (Harris, 1944; Fairfield, 1968; Creighton, 1974; Creighton and Baldwin, 1974). Grasslands with dense litter accumulations are avoided (Renken, 1983; Berkey and others, 1993; Anstey and others, 1995).

In order of preference, Chestnut-collared Longspurs use native pastures, followed by other grazed grasslands, hayland, and cropland (Fairfield, 1968; Owens and Myres, 1973; Maher, 1974; Stewart, 1975; Johnsgard, 1980; Faanes, 1983; Anstey and others, 1995; Skeel and others, 1995; Davis and Duncan, 1999; Igl and others, 2008). Other habitats used by Chestnut-collared Longspurs include road and railroad

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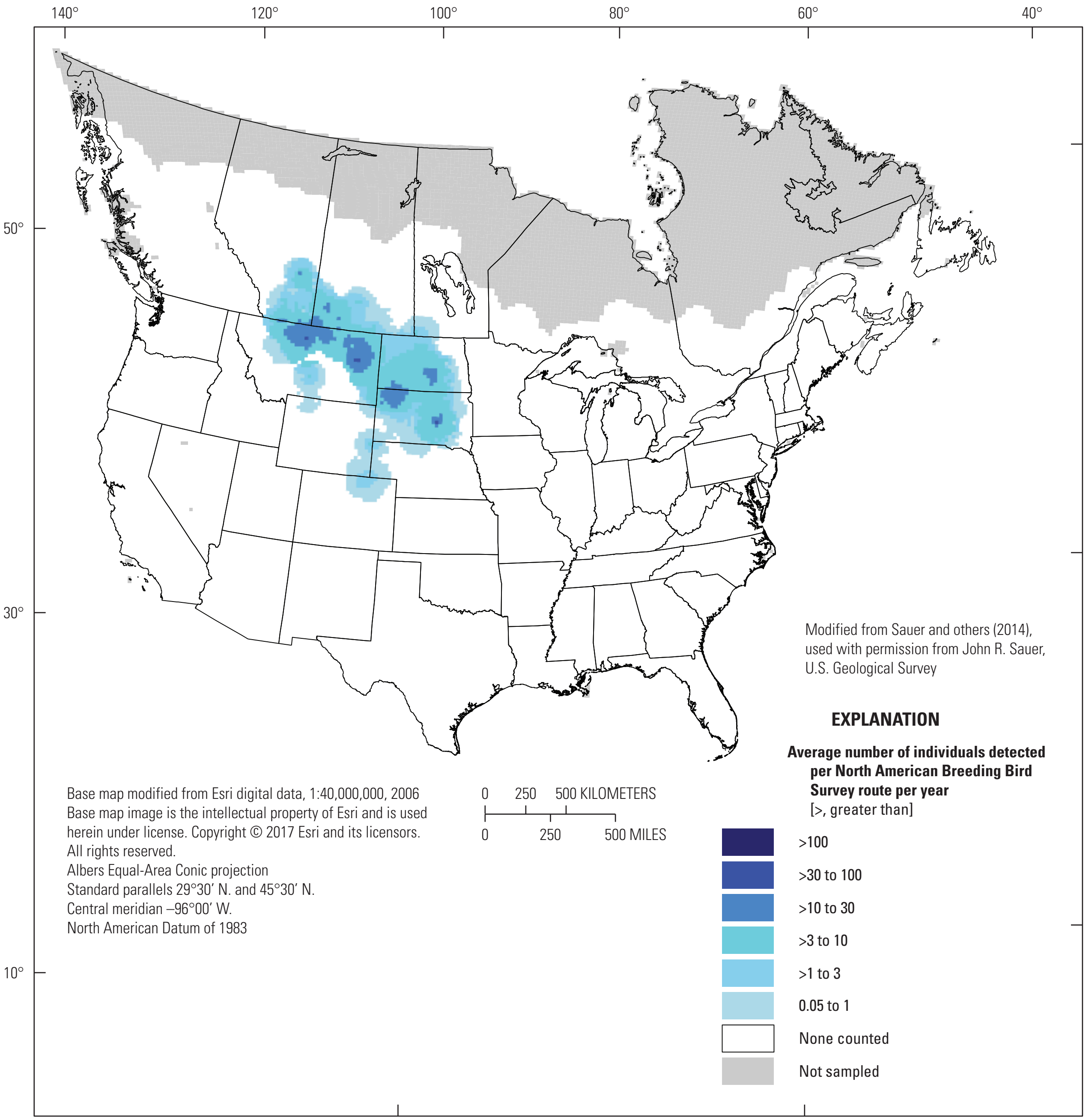

Figure X1. The breeding distribution of the Chestnut-collared Longspur (*Calcarius ornatus*) in the United States and southern Canada, based on North American Breeding Bird Survey (BBS) data, 2008–12. The BBS abundance map provides only an approximation of breeding range edges.

rights-of-way and waste and idle areas, such as fence borders and mowed aircraft landing strips (DuBois, 1935; Fairfield, 1968; Stewart, 1975; Igl and others, 2008).

Although cultivated fields, fallow fields, stubble fields, and dense, idle areas are generally avoided, these habitats may support a small number of Chestnut-collared Longspurs if vegetation is of suitable height and density (Fairfield, 1968; Owens and Myres, 1973; Stewart, 1975; Anstey and others, 1995; Lokemoen and Beiser, 1997; Igl and others, 2008). In a regional study in Colorado, Kansas, Nebraska, and Oklahoma, Chestnut-collared Longspurs occurred only in shortgrass prairies and never in dryland agriculture or Conservation Reserve Program (CRP) fields (McLachlan, 2007). In a regional study in Minnesota, Montana, North Dakota, and South Dakota, Chestnut-collared Longspurs were more common in cropland than in CRP fields (Johnson and Schwartz, 1993b; Johnson and Igl, 1995). In Alberta cropland, the number of productive territories and total productivity (based on behavioral productivity indices) were positively correlated with stubble count (total number of cut plant stems) (Martin and Forsyth, 2003).

In recent years, several studies have evaluated the use of reproductive indices, such as the one used by Martin and Forsyth (2003), as an alternative to nest searching and monitoring of grassland birds and determined that reproductive indices typically lack the ability to predict nest fate or provide reliable estimates of reproductive performance at the territory or plot level (Rivers and others, 2003; Althoff and others, 2009; Morgan and others, 2010). Martin and Forsyth's (2003) results related to productivity should be evaluated within the context and caveats of the growing body of literature on this topic.

In Saskatchewan, Davis and others (1999) and Davis and others (2016) reported that Chestnut-collared Longspurs occurred more frequently in native and tame pastures than in either hayland or cropland. In southern Saskatchewan, Davis and Duncan (1999) reported that Chestnut-collared Longspurs occurred more often in grazed mixed-grass pastures than in tame pastures of crested wheatgrass (*Agropyron cristatum*). However, Davis and others (1999), Sutter and Brigham (1998), and Davis and others (2016) detected no difference in the frequency of occurrence or abundance of Chestnut-collared Longspurs in native pastures than in tame pastures of crested wheatgrass.

The reproductive success of Chestnut-collared Longspurs may be higher in native grasslands than in tame grasslands. In Montana, Lloyd and Martin (2005) examined differences in reproductive success between Chestnut-collared Longspurs that nested in mixed-grass prairies and longspurs that nested in grasslands planted to crested wheatgrass. The species nested at similar densities in both habitats. However, the probability of a nest surviving a given day was 17 percent lower in stands of crested wheatgrass than in native prairies, and nestlings grew slower and had smaller body mass at fledging. The authors suggested that differences in habitat-specific growth rates generally reflected differences in environmental quality, indicating that the spread of crested wheatgrass habitats has adverse fitness consequences to the species. The average number of young fledged per nest was lower in crested wheatgrass stands because of higher nest predation and decreased likelihood of successful nesting. The lower average was not a result of differences in clutch size or the extent of partial nest losses, because the average number of young fledged from a successful nest was similar in both habitats. Davis and others (2016) reported no difference in clutch size or nest survival in native pastures compared to pastures planted to crested wheatgrass. However, longspurs fledged 0.6 more young per nest in native pastures than in planted pastures.

Local-level vegetation characteristics may affect the occurrence, abundance, and nest placement of Chestnut-collared Longspurs. In southern Alberta, the best predictive model for estimating the density of Chestnut-collared Longspurs included vegetation variables (Koper and Schmiegelow, 2006). Density of longspurs was negatively related to vegetation height, vegetation density, litter depth, and percentage bare ground. In southeastern Alberta, Chestnut-collared Longspur abundance declined with higher values of bare ground and with higher percentages of dead and live grass (Rodgers and Koper, 2017). In grazed mixed-grass prairies in southern Saskatchewan, occurrence of Chestnut-collared Longspurs was negatively associated with litter depth and the density of narrow-leaved grasses that were less than or equal to 10 cm tall (Davis and others, 1999). Also in southern Saskatchewan, Chestnut-collared Longspur occurrence was related to different vegetation measurements in each year of a 2-year study (Davis, 2003a, 2004). In 1 year, occurrence was positively related to vegetation height and negatively related to density of standing dead vegetation 0–10 cm and 30–40 cm above the ground. In the other year, occurrence was negatively related to vegetation height. In Saskatchewan mixed-grass and tame pastures, Chestnut-collared Longspur abundance was positively associated with percentage cover of junegrass (*Koeleria macrantha*) and small clubmoss (*Selaginella densa*) (Davis and Duncan, 1999). In another Saskatchewan study within native mixed-grass and tame pastures, Davis and others (2016) reported that the abundance of Chestnut-collared Longspurs was associated with increased coverage of cow dung but was not associated with any measured vegetation variables. In grazed mixed-grass prairies in southern Saskatchewan, longspur abundance decreased with litter depth and increased in areas where vegetation was characterized by poor plant vigor (that is, an assessment of the structure and appearance of individual plants, the size and appearance of the plant community, and the presence of expected life forms for the given range site). Abundance also increased with range condition (that is, visual estimates of rangeland integrity, including grazing use, plant vigor, and residual cover, as well as measurements of percent dry weight of biomass consisting of plant species that decrease in the presence of heavy grazing and an allowable consideration of plant species that increase in the presence of heavy grazing), but this relationship was weak (Davis and others, 2014). In upland mixed-grass prairies in Saskatchewan, longspur abundance was positively related to forb cover and negatively related to all grass species except prairie reedgrass (*Calamagrostis montanensis*) and junegrass (Molloy, 2014). In lowland mixed-grass prairies, longspur abundance was positively correlated with junegrass. In southwestern Saskatchewan, Henderson and Davis (2014) reported that Chestnut-collared Longspur probability of occurrence and abundance decreased as litter mass (in kilograms per hectare) and vegetation height-density increased.

Within moderately grazed mixed-grass prairies in Saskatchewan, Bleho (2009) evaluated the relationship between Chestnut-collared Longspur abundance and vegetation structure at the plot and pasture levels, whereby plots were 100-meter (m) radius circular areas located within pastures grazed season-long (June to October). Two measures of vegetation patchiness (that is, heterogeneity)—standard deviation (SD) and coefficient of variation (CV)—were evaluated. At the plot level, Chestnut-collared Longspur abundance was positively associated with percentage cover of forbs and of exposed moss and lichens (species names not provided), with the two statistical measures for patchiness of exposed moss and lichen coverage, and with the SD-derived measure for patchiness of forb coverage; abundance was negatively associated with percentage cover of grass. At the pasture level, Chestnut-collared Longspur abundance was positively associated with percentage cover of bare ground and the SD-derived measure for patchiness of bare ground coverage. Within the same mixed-grass prairies studied by Bleho (2009), White (2009) determined that the abundance of Chestnut-collared Longspurs was consistently and negatively related to litter depth, regardless of number of years postburn. Other significant relationships between vegetation and abundance were found, but they depended on number of years postburn and month and were not consistent across years. In another study in mixed-grass prairies of Saskatchewan, Chestnut-collared Longspur abundance was greatest in areas with a thick litter layer and an average of 9-cm tall vegetation and 40–50 percent grass coverage (Kalyn Bogard and Davis, 2014).

In northeastern Montana, Chestnut-collared Longspurs preferred grasslands with lower-than-average herbaceous cover (Lipsey and Naugle, 2017). Chestnut-collared Longspur abundance was positively related to coverage of grass, forbs, and small clubmoss; maximum vegetation height; and several parameters measuring vegetation density, including total vegetation, live vegetation, <10 cm tall, 10–20 cm tall, grass, and litter depth (Lipsey and Naugle, 2017). Chestnut-collared Longspur abundance was negatively related to coverage of bare ground, litter, litter depth, tame grass, and density of forbs. Longspur abundance also was negatively related to the presence of the tame grasses of crested wheatgrass and *Bromus* species (spp.). Within grazed mixed-grass prairies in North Dakota, abundance of Chestnut-collared Longspurs was positively associated with percentage cover of small clubmoss and of bare ground and with plant communities dominated by native grasses (green needlegrass [*Nasella viridula*], needle and thread [*Hesperostipa comata*], blue grama [*Bouteloua gracilis*], junegrass, and little bluestem [*Schizachyrium scoparium*]) (Schneider, 1998). Abundance was negatively associated with vegetation height-density, vegetation density, grass coverage, litter depth, plant communities dominated by Kentucky bluegrass (*Poa pratensis*) and native grasses, and plant communities dominated by shrubs and introduced grasses (smooth brome [*Bromus inermis*], Kentucky bluegrass, and quackgrass [*Elymus repens*]). Presence of Chestnut-collared Longspurs was positively associated with percentage cover of grass and bare ground (Schneider, 1998). In another mixed-grass prairie study in North Dakota, Chestnut-collared Longspurs were present in grasslands with higher litter depth (Grant and others, 2004). Occurrence was not related to maximum vegetation height, coverage of live vegetation, year, or percentage cover of native grass and forb species, Kentucky bluegrass, smooth brome and quackgrass, and tame legumes. In grazed mixed-grass prairies in the Little Missouri National Grassland in North Dakota, longspur densities declined with increasing vegetation height-density (Chepulis, 2016). In native grasslands managed by the U.S. Fish and Wildlife Service in North Dakota, South Dakota, and Montana, longspur densities were not related to floristic composition or vegetation structure variables (Igl and others, 2018). In South Dakota mixed-grass prairies, Chestnut-collared Longspurs were more abundant in early than in late seral stages, and density was positively related to bare ground and negatively related to percentage forb cover (Fritcher and others, 2004). In another South Dakota study within mixed-grass prairies, occurrence of Chestnut-collared Longspurs was negatively associated with visual obstruction reading and percentage cover of tame forbs, primarily yellow sweetclover (*Melilotus officinalis*). The invasion of yellow sweetclover in grasslands caused a sharp decrease in the species' occurrence, as probability of occurrence decreased from 25 percent to <1 percent with an increase in percentage cover of tame forbs from 0 to 50 percent (Greer and others, 2016).

Within drier shortgrass areas, the Chestnut-collared Longspur prefers wetter, taller, and more densely vegetated areas than the Thick-billed Longspur (*Rhynchophanes mccownii*) and Horned Lark (*Eremophila alpestris*) (DuBois, 1937; Strong, 1971; Creighton, 1974; Creighton and Baldwin, 1974; Kantrud and Kologiski, 1982; Wershler and others, 1991). Low, moist areas and wet-meadow zones around wetlands provide suitable habitat in these areas (DuBois, 1937; Rand, 1948; Giezentanner, 1970a; Stewart, 1975). In Colorado, Chestnut-collared Longspurs preferred areas with heterogeneous cover of short and mid-height grasses, and were associated with bunchgrasses (Creighton, 1974; Creighton and Baldwin, 1974). In moister, more thickly vegetated native or tame grasslands, Chestnut-collared Longspurs avoid tall, dense vegetation, preferring sparser upland grasslands with more bare ground (Renken, 1983; Renken and Dinsmore, 1987; Berkey and others, 1993; Johnson and Schwartz, 1993a; Anstey and others, 1995).

In Permanent Cover Program (PCP) grasslands in Manitoba, Saskatchewan, and Alberta, Chestnut-collared Longspur presence was positively associated with the interaction between ecoregion and narrow-leaved grass contacts in the first decimeter above ground, and the interaction between ecoregion, latitude, and longitude (McMaster and Davis, 2001). Presence was negatively associated with broad-leaved grass contacts in the first decimeter above ground, latitude, longitude, and vegetation height. In CRP grasslands in Montana, North Dakota, and South Dakota, Chestnut-collared Longspur abundance was negatively associated with percentage cover of legumes (Johnson and Schwartz, 1993a).

Chestnut-collared Longspurs prefer grasslands with little or no shrub cover (Arnold and Higgins, 1986; Grant and others, 2004; Bleho, 2009; Lipsey and Naugle, 2017). Grant and others (2004) classified the Chestnut-collared Longspur as a woodland-sensitive species. In southern Saskatchewan, Chestnut-collared Longspur occurrence was negatively related to shrub density in 1 of 2 years (Davis, 2003a, 2004). Within moderately grazed mixed-grass prairies in Saskatchewan, Bleho (2009) reported that longspur abundance at the plot level was negatively related to the percentage cover of shrubs and with the two statistical measures for patchiness of shrub coverage; at the pasture level, Chestnut-collared Longspur abundance was positively related to the CV-derived measure for patchiness of shrub coverage. In northeastern Montana, Chestnut-collared Longspur abundance was negatively related to coverage of shrubs (Lipsey and Naugle, 2017). In North Dakota mixed-grass prairies, Chestnut-collared Longspurs were present in grasslands with no quaking aspen (*Populus tremuloides*) woodland within the radius of 100-m point counts; the species' maximum probability of occurrence never exceeded 25 percent within the study area, and the probability of occurrence declined to <10 percent as woodland cover increased to about 10 percent (Grant and others, 2004). Chestnut-collared Longspurs were present in grasslands with lower percentage cover of shrubs <1 m tall and fewer shrubs greater than (>) 1 m tall than in unoccupied areas (Grant and others, 2004). In another North Dakota study, Chestnut-collared Longspurs preferred areas with <10 percent shrub coverage than areas with 30–80 percent shrub coverage (Arnold and Higgins, 1986). Within grazed mixed-grass prairies in North Dakota, abundance of Chestnut-collared Longspurs was negatively related to the density of low-growing shrubs (for example, prairie wild rose [*Rosa arkansana*], western snowberry [*Symphoricarpos occidentalis*], and silverberry [*Elaeagnus commutata*]), and presence of Chestnut-collared Longspurs was negatively related to the percentage cover of low-growing shrubs (Schneider, 1998). In a statewide study in North Dakota, Igl and others (2008) reported that the Chestnut-collared Longspur avoided using areas with woody vegetation (defined as all native and artificially stocked tree and shrub stands).

In contrast to general vegetation characteristics of the grasslands in which Chestnut-collared Longspurs occupy, the species seems to prefer nest-site locations characterized by greater litter depth and litter coverage and taller and denser vegetation. In Alberta mixed-grass prairies, Chestnut-collared Longspurs selected nest sites with 6 percent denser dead grass and 8 percent more dead grass cover compared to vegetation structure in available but unused habitat (Yoo and Koper, 2017). Nests also were in areas with less lichen or moss (no species provided) than in available but unused habitat; grass height and amount of bare ground, litter depth, crested wheatgrass cover, and shrub cover did not differ between nesting and available but unused habitats. Nest success was not affected by vegetation structure. Nest-site locations in mixed-grass pastures in Saskatchewan were positively related to litter depth, standing dead vegetation 10–20 cm above the ground, vegetation height, percentage cover of cow dung, the density of live grass, forbs, and dwarf shrub coverage and negatively related to the density of live grass 30–60 cm above the ground, bare ground, and the density of live grass 0–10 cm above the ground (Davis, 2003a). In another Saskatchewan study within mixed-grass prairies, nest-site locations were positively associated with litter depth and vegetation density; however, vegetation structure had no effect on nest success (Lusk, 2009). Within the same Saskatchewan mixed-grass prairies, Pipher (2011) determined that Chestnut-collared Longspurs nest locations were positively associated with litter depth, vegetation height, and vegetation height-density and were negatively associated with percentage cover of bare ground. In grazed mixed-grass prairies in Saskatchewan, Smith and Smith (1966) reported that 37 of 38 nests were well concealed in grasses, rose (*Rosa* spp.), sage (*Artemisia* spp.), or western snowberry. The remaining nest was situated in sparse grass that was an average of 10.2 cm tall. In Montana, nest sites were characterized by denser and taller vegetation and slightly greater forb coverage relative to random areas, and nest patches had greater small clubmoss coverage than in random areas (Dieni and Jones, 2003). In northeastern Montana and southwestern North Dakota, Bernath-Plaisted and others (2019) found little support that vegetation structure affected Chestnut-collared Longspur nest success. In mixed-grass prairies in South Dakota, daily nest survival was positively associated with increasing litter depth (Berman, 2007).

Seasonal moisture and temperature levels may affect the occurrence of Chestnut-collared Longspurs. In an assessment of BBS data for the conterminous United States, O'Connor and others (1999) reported a negative relationship between Chestnut-collared Longspur abundance and mean annual precipitation. Currie and Venne (2017) analyzed BBS data over a 32-year period to examine whether Chestnut-collared Longspur breeding distribution shifted relative to changes in breeding-season temperature; the authors concluded that the species was not responding to temperature change. Wilson and others (2018) analyzed BBS data over a 48-year period to examine whether Chestnut-collared Longspur breeding distribution shifted relative to changes in a drought index modeled at 1-month and 48-month time scales based on the month of May. Chestnut-collared Longspurs exhibited small annual variation in distribution, with the distribution centroid of the longspur population shifting only 120 kilometers (km) over 48 years and with no indication that short-term spring wetness or long-term drought conditions affected either abundance or distribution. Wilsey and others (2019) compiled avian occurrence data from 40 datasets to project climate vulnerability scores under scenarios in which global mean temperature increases 1.5, 2, or 3 degrees Celsius (ºC). Chestnut-collared Longspurs ranked moderate in vulnerability during the breeding season at a 1.5 ºC increase and ranked high in vulnerability for the other two temperature scenarios, with a projected 95 percent loss of the modeled current breeding distribution. Peterson (2003) modeled the impact of two climate scenarios—0.5 and 1 percent per year increases in carbon dioxide—on bird species whose geographical distributions were exclusively within the Great Plains, which included the Chestnut-collared Longspur; Peterson (2003) estimated that Chestnut-collared Longspurs would experience a breeding-range contraction and dramatic distributional movements under the two climate scenarios. Using a combination of BBS, eBird (https://ebird.org; Sullivan and others, 2009), and point-count data, Nixon and others (2016) modeled the impact of future climate change scenarios on Chestnut-collared Longspur breeding distribution along the boreal forest–prairie ecotone in Alberta and predicted that longspurs would shift gradually northward within the next 80 years, with only small core areas of stable climate remaining.

In a Montana study, Ritter and Maxell (2011) reported that longspur occurrence was positively related to the mean minimum daily January temperature. In northeastern Montana, Lipsey and Naugle (2017) reported that Chestnut-collared Longspur abundance was negatively related to the total amount of precipitation in the preceding 2 years and to mean growing-season (April–September) temperature. In northeastern Montana and southwestern North Dakota, Bernath-Plaisted and others (2019) found little support that temperature and precipitation variables affected Chestnut-collared Longspur nest success. Based on 13 BBS routes in northern North Dakota, Niemuth and others (2008) determined that Chestnut-collared Longspur abundance was negatively associated with the number of wetland basins containing water in May of the same year and in May of the previous year, but the regional index of dispersion (that is, percentage of 13 BBS routes on which the species was detected) was not affected by the number of ponds containing water or by the Palmer Drought Severity index. In the shortgrass steppes of Colorado, Conrey and others (2016) examined the effect of heat, drought, and precipitation on the likelihood of bird species fledging at least one young. Chestnut-collared Longspur was included with Lark Bunting (*Calamospiza melanocorys*) and Western Meadowlark (*Sturnella neglecta*) in the guild of species nesting in taller grasses interspersed with forbs and low shrubs. The authors concluded that the likelihood for a nest from this guild fledging at least one young was reduced under conditions of drought, high summer temperatures, and stormy days. Scenarios in which temperature increased by 3 °C and precipitation decreased by two additional dry days resulted in nest success decreasing by one-half compared to its current average value.

Area Requirements and Landscape Associations

Male Chestnut-collared Longspur territories are typically <1 hectare (ha). In southeastern Alberta, territories ranged from 0.25 to 4 ha (Bleho and others, 2020). In Saskatchewan, territory size was about 0.4–0.8 ha and increased to almost 4 ha in marginal habitat (Fairfield, 1968). In Manitoba, territory sizes for two males were about 0.2 and 0.4 ha (Harris, 1944). Males and females may forage outside of the territory boundaries, especially when feeding their young (Bleho and others, 2020).

Chestnut-collared Longspurs have exhibited area sensitivity in occurrence and abundance (Davis, 2004; Skinner, 2004; Berman, 2007; Ribic and others, 2009). In Saskatchewan, Chestnut-collared Longspurs tended to occur in large, uniform patches of dry, native mixed-grass pastures in a patchy landscape that included shrubs, trees, and tame pasture (Skinner, 2004). In mixed-grass prairies in southern Saskatchewan, Davis (2004) concluded that Chestnut-collared Longspurs were area sensitive (that is, preferring larger grasslands over small grasslands), with a minimum area requirement of 39 ha, but other studies by Davis and his colleagues (Davis, 2003a; Davis and others, 2006) indicated that nest survival decreased with patch size despite no relationship between parasitism rates and patch size. In South Dakota mixed-grass prairies, adult density and daily nest survival of Chestnut-collared Longspurs were higher in large (>100 ha) patches than in small (<50 ha) patches, regardless of whether those patches were embedded in landscapes with <40 percent grassland habitats or >50 percent grassland habitats (Berman, 2007).

Chestnut-collared Longspurs may be affected by the composition of the surrounding landscape and by habitat edges. In the dry mixed-grass prairie and northern fescue (*Festuca* spp.) grassland regions in southeastern Alberta, Chestnut-collared Longspur occurrence was positively affected by increasing grassland cover within a 400-m radius of point-count centers (Clements, 2014). In Alberta mixed-grass prairies, the best predictive model for estimating Chestnut-collared Longspur density included positive relationships between density and the amount of grassland in the landscape and a Landscape Shape Index (LSI) to represent fragmentation (that is, length of grassland edge divided by the minimum length of edge that would surround the amount of grassland in a landscape if the grassland were clumped in a maximally compact patch), and negative relationships between density and the length of wetland edge and an interaction between the amount of grassland and LSI (Koper and Schmiegelow, 2006). Positive relationships also were found between longspur density and distance to water, to cropland/forage, and to roads. In another Alberta study, Chestnut-collared Longspur abundance increased as distance to cropland and wetland edge increased; no response to roads was detected (Sliwinski and Koper, 2012). Abundance declined by 25 percent within 1.95 km of cropland edge and 1.05 km from wetland edge. In southern Saskatchewan, nest survival decreased with distance to edge in landscapes consisting of >50 percent cropland (Davis and others, 2006). Chestnut-collared Longspur abundance and occurrence were negatively related to edge-to-area ratio (Davis, 2004). In a Saskatchewan study of native and planted pastures and hayfields, Davis and others (2016) reported that Chestnut-collared Longspur abundance and nest survival increased with the amount of planted pastures within 400 m of study plots; abundance decreased with increasing amounts of hayland. In grazed mixed-grass prairies in the Little Missouri National Grassland in North Dakota, Chepulis (2016) reported that Chestnut-collared Longspur densities were positively associated with the percentage of grassland within 1.6 km of the study-unit boundaries. In South Dakota mixed-grass prairies, Greer and others (2016) reported no association between the occurrence of Chestnut-collared Longspurs and the amount of grassland surrounding the patch up to 3.2 km.

Within the Prairie Pothole Region of Canada, Fedy and others (2018) examined the influence of grassland, cropland, and wetland habitats at four scales (within 400; 800; 1,600; and 3,200 m of BBS stops) on the relative probability of occurrence of Chestnut-collared Longspur. The best model for predicting Chestnut-collared Longspur occurrence indicated that the species' preferred landscapes consisting of tame grasslands and other perennial cropland grown for hay, pasture, or seed within 1,600 m, as well as a combination of native and tame grassland within 1,600 m (Fedy and others, 2018). Using a spatially hierarchical approach with data from more than 32,000 point-count surveys conducted within the Canadian Prairie Provinces and the northern Great Plains of the United States, Lipsey and others (2017) concluded that longspur occupancy was positively related to grass coverage at the broadest (1,492 square kilometers [km^2]) of three scales, and the species selected only dry patches within these landscapes. In mixed-grass prairies in northeastern Montana, Lipsey (2015) evaluated grassland bird distribution and abundance at four spatial extents (0.7, 2.6, 93, and 1,492 km^2). Chestnut-collared Longspur density was lower in landscapes characterized by a low percentage of grassland than in landscapes with large and intact grasslands, despite favorable local conditions based on measurements of vegetation cover and structure. Lipsey (2015) estimated that a grassland of 40,469 ha embedded in a landscape of 40 percent grass would support 19,300 Chestnut-collared Longspurs, whereas the same area embedded in a landscape of 15 percent grass would only support 13,900 Chestnut-collared Longspurs. Using point-count surveys collected over 4 years throughout the northern Great Plains, Dreitz and others (2017) demonstrated that occupancy of Chestnut-collared Longspurs was positively related to latitude, lands in public ownership, and the percentage of grassland habitat within 1-km^2 survey plots. Veech (2006) used BBS data from throughout the Great Plains to characterize the landscape within a 30-km radius of populations of Chestnut-collared Longspurs that were increasing or decreasing; CRP fields constituted a greater proportion of the landscape for increasing populations than for decreasing populations. The proportion of rangeland or of urban lands did not differ between increasing and decreasing populations. Green and others (2019) collected breeding-season occurrence data throughout the western Great Plains of the United States to create a species distribution model for Chestnut-collared Longspur that examined local occupancy, extinction, and colonization in relation to annual variation in habitat conditions. Longspur occupancy within 1-km^2 grid cells was higher in grids with more grassland cover and with higher than average vegetation greenness (as measured by a Normalized Difference Vegetation Index). Extinction (defined as the probability that a grid occupied in 1 year is not occupied in the next year) decreased with increasing grassland cover. Colonization (defined as the probability that a grid not occupied in 1 year is occupied in the next year) also decreased with increasing grassland cover. Longspurs were not widely distributed across the landscape and were locally prevalent, with high turnover rate, but turnover rate was lowest in areas with high grassland cover (Green and others, 2019). Using data from 16,728 point-count surveys in the northern Great Plains, Correll and others (2019) quantified the relationship between grassland habitat specialism and species population trends; the authors determined that species with high specialism rankings, such as the Chestnut-collared Longspur, are vulnerable to declining population trends.

At a landscape scale, the amount of woodland surrounding a grassland patch may affect Chestnut-collared distribution and abundance. Within the Prairie Pothole Region of Canada, Fedy and others (2018) examined the influence of shrubland and woodland habitats at four scales (within 400; 800; 1,600; and 3,200 m of BBS stops) on the relative probability of occurrence of Chestnut-collared Longspur. The best model for predicting longspur occurrence indicated that the species avoided shrubby and wooded landscapes within 3,200 m (Fedy and others, 2018). In North Dakota mixed-grass prairies, Grant and others (2004) reported that longspurs were present in areas with a lower percentage cover of aspen woodland within a 500-m radius of the point-count locations than in unoccupied grasslands. In South Dakota mixed-grass prairies, occurrence and male density were negatively associated with the amount of woody edge surrounding grassland patches (Greer and others, 2016). Probability of occurrence for Chestnut-collared Longspurs was reduced from 20 to 10 percent with an increase in woody edge from 0 to 3.5 percent, and the probability of occurrence was <30 percent if any woody edge was present.

Brood Parasitism by Cowbirds and Other Species

Rates of Brown-headed Cowbird (*Molothrus ater*) brood parasitism of Chestnut-collared Longspur nests are generally low to moderate; published rates of cowbird parasitism (Shaffer and others, 2019a) varied from 0 percent (several studies in Shaffer and others, 2019a) to 23 percent of 62 nests (Stewart, 1975), but rates may vary annually (Davis, 2003b). Chestnut-collared Longspur nests may be multiply parasitized (Currie, 1892; Friedmann, 1963; Kondla and Pinel, 1971; Saskatchewan Wetland Conservation Corporation, 1997; Davis and Sealy, 2000; Davis, 2003b; Igl and Johnson, 2007). Some authors have suggested that cowbird brood parasitism may not have a major effect on Chestnut-collared Longspur productivity (Friedmann, 1963; Fairfield, 1968; Bleho and others, 2020), but in Saskatchewan, where 16.3 percent of 490 Chestnut-collared Longspur nests were parasitized, Davis (2003b) reported that clutch size, number of host eggs hatched, number of host eggs incubated to full term that hatched, number of host young fledged per nest, and number of host young fledged per successful nest were smaller in parasitized than unparasitized nests. Successful nests fledged 0.16 cowbird young. Unparasitized nests did not occur significantly farther from cowbird perches than did parasitized nests, nor was there a difference in concealment cover between parasitized and unparasitized nests (S.K. Davis, Canadian Wildlife Service, Regina, Saskatchewan, written commun. [n.d.]).

Breeding-Season Phenology and Site Fidelity

Chestnut-collared Longspurs arrive on the breeding grounds from late March to late April, with males preceding females by 1–2 weeks (Currie, 1892; Fairfield, 1968; Maher, 1973; Johnsgard, 1980; O'Grady and others, 1996; Davis, 2003b; Lloyd and Martin, 2005; Ellison and others, 2017; Bleho and others, 2020). First clutches are initiated from early to mid-May, and second or replacement clutches may be initiated through late July (DuBois, 1935; Fairfield, 1968; Maher, 1973; Davis, 2003b; Lloyd and Martin, 2005; Jones and others, 2010; Bernath-Plaisted and others, 2019). Chestnut-collared Longspurs produced two broods per season in Colorado (Strong, 1971), and initiation dates of confirmed second clutches in Alberta ranged from early June to mid-July (Bleho and others, 2020). In South Dakota, Berman (2007) reported peak hatch dates of mid- to late June and July. Third broods occur occasionally (Harris, 1944; Bleho and others, 2020). Postbreeding flocks form in mid-August, and flocks forage in cultivated areas, ditches, dry sloughs, and rough ground outside of the breeding areas (Harris, 1944; Lokemoen and Beiser, 1997). Fall migration occurs in September and October (Fairfield, 1968; Maher, 1973; Johnsgard, 1980; Ellison and others, 2017).

Males display stronger philopatric tendencies than females (Bleho and others, 2020). Of 30 males banded in Alberta, 67 percent returned to the previous year's breeding site compared to 32 percent of 65 females; in Saskatchewan, 36 percent of 39 males returned to the breeding site in the subsequent year, compared to 6 percent of 18 females (Bleho and others, 2020). In another Saskatchewan study, 33 percent of 43 geolocator-tagged males returned to the previous year's breeding site, and 33 percent of 11 tagged males were resighted between years (Ellison and others, 2017). Fairfield (1968) reported that three of 1,067 birds banded returned to the location of banding. Ryder (1972) reported that a banded pair in Colorado returned to the same territory the year following banding.

Species' Response to Management

Several studies have evaluated the effects of burning or a combination of burning and grazing on Chestnut-collared Longspur occurrence and abundance. In Saskatchewan, abundance of Chestnut-collared Longspurs declined during the first season after burning, but abundance increased during the second year postburn to a level similar to that on grazed pastures (Maher, 1973). In Saskatchewan mixed-grass prairies, White (2009) evaluated the interaction between burning and grazing on Chestnut-collared Longspur abundance over 2 years. During the first year postburn, Chestnut-collared Longspurs were more abundant in burned prairies, regardless of whether the prairies were grazed or ungrazed. During the second year postburn, abundance was significantly affected by the interaction between burning and grazing such that longspur abundance was lower in unburned-ungrazed prairies and higher and more similar in prairies that were burned-grazed, burned-ungrazed, and unburned-grazed. Within the same Saskatchewan mixed-grass prairies, Richardson (2012) determined that abundance of Chestnut-collared Longspurs was positively related to burning and grazing; abundance decreased over time in burned-grazed and burned-ungrazed pastures. Effects of grazing or burning alone were similar, but a difference in Chestnut-collared Longspur abundance in grazed and ungrazed sites indicated an interaction between disturbances (Richardson and others, 2014). In North Dakota and South Dakota, Chestnut-collared Longspur densities were lower in mixed-grass prairies that experienced rest for more than 5 years than in mixed-grass prairies that were burned-only, grazed-only, or burned and grazed (Igl and others, 2018). In South Dakota, spring burning of mixed-grass prairies provided open areas of short vegetation that were used by Chestnut-collared Longspurs during the first few months postburn, after which use declined (Huber and Steuter, 1984). In North Dakota, Chestnut-collared Longspurs recolonized areas in which frequent fires created short, sparse cover (Madden and others, 1999).

Mowing can improve habitat in mixed-grass areas by decreasing vegetation height and density (Owens and Myres, 1973; Stewart, 1975). Grazed areas, however, usually are preferable to mowed areas (Owens and Myres, 1973; Kantrud, 1981; McMaster and Davis, 2001; Davis and others, 2016). In south-central Saskatchewan, fields that were periodically hayed every 3 years were avoided by Chestnut-collared Longspurs (Dale and others, 1997). In Nebraska, breeding usually occurred more frequently in mowed mixed-grass prairies and shortgrass prairies and less frequently in low-meadow zones or disturbed grasslands such as grazed pastures (Johnsgard, 1980).

Throughout the breeding range of Chestnut-collared Longspur, grazed areas are preferable to ungrazed areas (Felske, 1971; Maher, 1973; Kantrud, 1981; Dale, 1983, 1984; Kantrud and Kologiski, 1983; Renken, 1983; Bleho, 2009; Lusk, 2009; White, 2009; Ranellucci, 2010; Sliwinski, 2011; Ranellucci and others, 2012; Davis and others, 2016). In Saskatchewan, Chestnut-collared Longspurs were almost three times more abundant in grazed pastures than ungrazed pastures (Bleho, 2009; Lusk, 2009), and they were more abundant on native pastures in good condition than in native pastures in poor condition, indicating that good range management is beneficial to this species (Anstey and others, 1995). In mixed-grass prairies in northeastern Montana, Chestnut-collared Longspur abundance was affected by the relationship of cattle use and soil productivity in rangelands: high levels of use by cattle on high-productivity rangeland increased the abundance of longspurs, but model predictions also indicated that longspurs would increase with cattle use of rangeland of any soil condition (Lipsey and Naugle, 2017). Chestnut-collared Longspur abundance also was affected by the relationship between cattle use of rangeland and precipitation: cattle reduced herbaceous cover only when total precipitation in preceding years was low (<50 millimeters; considered a "dry" scenario), which had no effect on longspur abundance. In wetter conditions (>800 millimeters), the measured range of cattle use had little effect on herbaceous cover, but heavier use by cattle under wet conditions was predicted to increase longspur abundance (Lipsey and Naugle, 2017).

Soil type may affect the suitability of grazed grasslands to Chestnut-collared Longspurs. In north-central Alberta, Chestnut-collared Longspurs used moderately to heavily grazed grasslands on wetter, less sandy sites than those used by Thick-billed Longspurs (Wershler and others, 1991). In Colorado, Montana, Nebraska, North Dakota, South Dakota, and Wyoming, densities of Chestnut-collared Longspurs were lowest on lightly grazed, dry ustic aridisol soils and highest on heavily grazed boroll and ustoll typic soils (Kantrud and Kologiski, 1982). On cooler boroll soils, longspur density was significantly higher under typic than aridic moisture conditions. On warmer ustoll soils, longspur densities were significantly higher under typic than aridic moisture regimes.

Grazing intensity, grazing system, and livestock type may influence the nesting success and abundance of Chestnut-collared Longspurs. In a meta-analysis of grazing studies in the Prairie Provinces of Canada, Bleho and others (2014) concluded that cattle-induced nest destruction and abandonment increased with grazing intensity, where grazing intensities varied from <33 percent of available forage used (light), to 33–65 percent used (moderate), to >65 percent used (heavy). Nest survival rate and the probability of a nest not being depredated were not affected by grazing intensity or whether pastures were grazed or ungrazed. In a series of phased studies conducted in the mixed-grass prairies of the Grasslands National Park in southwestern Saskatchewan, the effects of cattle grazing on nest success and abundance were examined (Bleho, 2009; Lusk and Koper, 2013; Molloy, 2014; Sliwinski and Koper; 2015; Pipher and others, 2016; Fischer and others, 2020). Depending on the particular study question, at various times between 2006 and 2012, avian nest success, avian abundance, and vegetation were measured for 2 years prior to the reintroduction of cattle, for the 4 years after cattle were grazed at stocking rates varying from very low (0.25 animal unit month [AUM] per ha) to very high (0.83 AUM per ha), and for 3 years after cattle were removed from pastures. Pasture units contained upland and lowland portions in which upland areas were dominated by perennial graminoids and lowland areas were characterized by having more shrubs and taller forbs than upland areas. Molloy (2014), Sliwinski and Koper (2015), Pipher and others (2016), and Fischer and others (2020) further included ungrazed control pastures to implement a before-after control-impact study. Bleho (2009), Lusk and Koper (2013), Molloy (2014), and Pipher and others (2016) included additional pasture units in the lightly to moderately grazed (0.25–0.55 AUM per ha) Mankato Community Pastures adjacent to Grasslands National Park. Lusk and Koper (2013) reported that grazing had little effect on daily survival rates of nests, whereas Pipher and others (2016) determined that the number of years that a site had been grazed had a negative effect on nest success in 1 of the 2 years studied, with greater nest success in pastures grazed for 2–3 years than in pastures grazed >15 years. Cattle stocking rates did not affect nest-site selection, and Pipher (2011) routinely found nests next to taller clumps of vegetation or cow dung that potentially concealed nests. Bleho (2009) determined that longspur abundance was 2.89 times more abundant in grazed than ungrazed pastures, 2.4 times more abundant in upland than lowland pastures, and 2.75 times more abundant in grazed upland pastures than ungrazed upland pastures. In upland pastures, Molloy (2014) reported that longspur abundance began to increase at stocking rates of about 0.3 AUM per ha), with a minimum of 0.5 bird per point to 3 birds per point at 0.8 AUM per ha. In lowland pastures, longspurs also exhibited a positive effect of stocking rate (Molloy, 2014). Sliwinski and Koper (2015) reported that longspur abundance increased with stocking rate within the first month that cattle were reintroduced to pastures after an absence of 16–21 years, as well as after the first year of grazing. After the second year of grazing, the interaction between quadratic stocking rate and years grazed was not significant, whereas the linear interaction was significant. The increase in longspur abundance was most pronounced at stocking rates >0.6 AUM per ha. Relative to ungrazed pastures, longspur abundance increased at 0.83 AUM per ha by 5 birds per pasture in the first month of grazing, 7 birds per pasture after 1 year of grazing, and 10 birds per pasture after 2 years of grazing. In contrast, there was little change in the number of birds per pasture from the ungrazed pastures to the moderately grazed pastures (Sliwinski and Koper, 2015). Fischer and others (2020) reported that Chestnut-collared Longspur abundance on upland pastures increased as stocking rate increased; this response continued for the 2 years after cattle had been removed from pastures but at lower abundances than during the grazed years. Longspur abundance on grazed pastures surpassed pre-grazing abundance at about 0.45 AUM per ha. On lowland sites, the abundance of Chestnut-collared Longspurs was too low to analyze (Fischer and others, 2020).

In other research conducted in southern Saskatchewan, Anstey and others (1995) suggested that Chestnut-collared Longspurs that nest in native pastures may tolerate a wider range of grazing intensities than those that nest in tame pastures, whereas Davis and others (1999) reported that grazing had little effect on the occurrence of breeding Chestnut-collared Longspurs. In mixed-grass prairies in northeastern Montana, models indicated that a 10 percent increase in biomass removed by cattle grazing would result in a 15 percent increase in Chestnut-collared Longspur abundance (Lipsey, 2015; Lipsey and Naugle, 2017). In mixed-grass prairies in south-central North Dakota, densities of Chestnut-collared Longspurs were highest at heavy (35 percent of forage produced in an average year remained, equating to an average grazing rate of 4.2 AUMs per ha) and extreme (20 percent of forage remained, 6.8 AUMs per ha) grazing treatments than at light (65 percent, 1.1 AUMs per ha) or moderate (50 percent, 2.4 AUMs per ha) treatments (Salo and others, 2004). In Colorado, Chestnut-collared Longspurs nested on shortgrass and mixed-grass pastures with low-to-moderate summer grazing (removal of 20–40 percent of the annual plant growth) (Giezentanner, 1970b).

Chestnut-collared Longspurs seem to be fairly tolerant to the type of grazing system (Prescott and Wagner, 1996; Davis and others, 2014; Ranellucci and others, 2012; Golding and Dreitz, 2017). In Alberta, Chestnut-collared Longspur frequency of occurrence did not differ significantly among four grazing treatments: early-season tame (grazed from late April to mid-June), early-season native (grazed in early summer), deferred-grazed native (grazed after July 15), and season-long native (Prescott and Wagner, 1996). In a 2-year study in south-central Saskatchewan mixed-grass pastures, Davis and others (2014) reported no difference in the abundance of Chestnut-collared Longspurs on season-long versus rotational grazing pastures subject to similar grazing intensity (that is, about 1.0 AUM per ha). In Manitoba, densities of Chestnut-collared Longspurs were higher on season-long grazed sites compared to twice-over rotation grazed sites, yet their relative abundances did not differ significantly between the two types of grazed sites (Ranellucci, 2010; Ranellucci and others, 2012). In Montana grasslands dominated by Wyoming big sagebrush (*Artemisia tridentata* subspecies *wyomingensis*) and intermixed with western wheatgrass (*Pascopyrum smithii*), needle and thread, blue grama, and junegrass, Golding and Dreitz (2017) reported that Chestnut-collared Longspurs were equally abundant in areas with season-long grazing and areas with rest-rotation grazing (that is, alternating 2–3 month grazing periods, followed by 15–18 months of rest). Longspur abundance was positively associated with an index of biomass potential (an index that relates abiotic factors, such as soil, climate, and topography, to the expected amount of nontree biomass that can be grown annually). In North Dakota, Messmer (1990) reported highest densities of Chestnut-collared Longspurs on pastures grazed using a twice-over rotation system than on areas grazed using season-long or short-duration systems.

Sliwinski (2011) examined the effect of cattle and American bison (*Bison bison*) grazing on the abundance of Chestnut-collared Longspurs in Saskatchewan. In cattle-grazed pastures, the species' abundance remained stable in currently ungrazed pastures and in pastures stocked at low-to-moderate grazing intensities. However, when cattle stocking rates exceeded 0.4 AUM per ha, Chestnut-collared Longspur abundance increased. In bison-grazed pastures, Chestnut-collared Longspur abundance was 3 times higher in grazed pastures than in ungrazed pastures. Sliwinski (2011) detected no difference in the abundance of Chestnut-collared Longspurs between cattle- and bison-grazed pastures. In North Dakota mixed-grass prairies, Lueders and others (2006) detected Chestnut-collared Longspurs in mixed-grass prairies grazed by cattle but not in pastures grazed by bison. Cattle-grazed pastures had lower vegetation structure and habitat heterogeneity and had not been burned, whereas bison-grazed pastures had a taller vegetation structure, higher habitat heterogeneity, and had been burned. In that same study, Chestnut-collared Longspur density did not change with distance from cattle water developments, despite increases in vegetation height-density and litter depth and decreases in coverage of cow dung and vegetation structural variability associated with reduced grazing pressure farther from the water developments (Fontaine and others, 2004). In Alberta, Yoo and Koper (2017) reported that clutch sizes of Chestnut-collared Longspur nests were larger as the distance from livestock water sources increased.

In North Dakota, Chestnut-collared Longspur densities were higher in cropland than in the tall, dense vegetation provided by idle CRP grasslands (Johnson and Schwartz, 1993b; Johnson and Igl, 1995). In Alberta, Manitoba, and Saskatchewan, however, Chestnut-collared Longspurs were more common in grasslands enrolled in the PCP than in cropland; frequency of occurrence was higher in grazed PCP fields than in hayed PCP fields (McMaster and Davis, 2001). In southern Alberta, Chestnut-collared Longspur abundance increased by at least 0.3 individual per point count per km away from cropland and forage fields (Koper and Schmiegelow, 2006).

In Alberta and Minnesota, Chestnut-collared Longspurs avoided cultivated areas (Roberts, 1932; Owens and Myres, 1973). Also in Alberta, Chestnut-collared Longspurs were more abundant in summer fallow fields than in spring cereal or winter wheat (*Triticum* spp.) fields (Martin and Forsyth, 2003). In 1 of 2 years, Chestnut-collared Longspurs were more abundant in minimum-tilled (planting directly into the previous year's stubble) than in conventionally tilled (multiple cultivations before planting) fields. Spring cereal and summer fallow crops in minimum-tilled fields supported more longspur territories and more productive territories (based on a reproductive index that uses a scoring system of behavior) than in conventionally tilled fields.

Some pesticides may have deleterious effects on Chestnut-collared Longspurs, especially at higher application rates. In Alberta, Chestnut-collared Longspur productivity (hatching success, fledging success, or nest success) was unaffected by spraying of deltamethrin and carbofuran at recommended rates of 6.25 and 132 grams (g) active ingredient per ha, respectively (Martin and others, 1998, 2000). Both insecticides reduced grasshopper (Acrididae) densities in sprayed plots relative to control plots, but foraging adult Chestnut-collared Longspurs maintained feeding rates by providing alternative insect types. However, nestlings in carbofuran-sprayed plots had reduced brain acetylcholinesterase activity. In Montana, numbers of Chestnut-collared Longspurs were unaffected by application rates of 175 g per ha of phenylglyoxylonitrile oxime *0,0*-diethyl phosphorothioate (McEwen and others, 1972). However, application rates of 322 and 651 g per ha caused significant declines of Chestnut-collared Longspur abundance between pre- and postspray censuses, with a greater decline at 651 g per ha. Abundance also declined significantly on areas sprayed with 441 and 672 g per ha applications of fenitrothion. In Wyoming and Montana, longspur abundance did not decline significantly after application rates of 140 g per ha of *o*-isopropoxyphenyl methylcarbamate (McEwen and others, 1972). Application rates of 210 and 280 g per ha, however, did cause longspur abundance to decline significantly. In addition, one adult and three nestlings were found dead, and four active nests were abandoned or were unsuccessful.

Chestnut-collared Longspur abundance seems to be marginally affected by road type or distance to roads. In Alberta, Nenninger and Koper (2018) reported that longspur density increased closer to roads, perhaps in response to shorter and sparser vegetation near roads; Koper and Schmiegelow (2006) reported that longspur density was positively related to distance to roads; and Daniel and Koper (2019) reported that Chestnut-collared Longspur abundance increased beyond 45 m from roads. In other Alberta studies, Sliwinski and Koper (2012) reported no response of longspur abundance to roads; Bernath-Plaisted and Koper (2016) and Daniel and Koper (2019) detected no relationship between clutch size or nest success and distance to nearest road; and Yoo and Koper (2017) concluded that nest success and clutch size were not affected by distance to roads or trails. In southwestern Saskatchewan and southeastern Alberta, Linnen (2008) reported fewer longspurs within 100 m of roads than within 150 m and beyond (maximum distance sampled was 450 m). In lightly to moderately grazed native prairies in Saskatchewan, Chestnut-collared Longspurs were significantly more abundant alongside trails (a single pair of wheel ruts visually indistinct from surrounding habitat in terms of plant structure and composition) than alongside roads (traveling surfaces with adjacent drainage ditches planted to smooth brome and ending with a fence 11–18 m from the traveling surface) (Sutter and others, 2000). Thompson and others (2015) did not detect any avoidance of gravel roads associated with oil drilling activities in western North Dakota.

Several studies in southeastern Alberta that examined the effects of oil and gas extraction on Chestnut-collared Longspur abundance and nesting success detected variable responses to energy infrastructure (Linnen, 2008; Hamilton and others, 2011; Rodgers, 2013; Bernath-Plaisted and Koper, 2016; Ng, 2017; Rodgers and Koper, 2017; Yoo and Koper, 2017; Nenninger and Koper, 2018; Daniel and Koper, 2019). Linnen (2008) reported fewer longspurs within 100 m of oil wells than within 150 m and beyond (maximum distance sampled was 450 m). Hamilton and others (2011) did not find a significant effect of either high densities (6.2 wells per km^2) or low densities (3.5 wells per km^2) of gas and oil wells on abundance of Chestnut-collared Longspurs. Rodgers and Koper (2017) also found no significant relationship between density of shallow natural gas wells (ranging from 0 to 7.7 wells per km^2) and longspur abundance; abundance increased slightly at distances as much as 2 km from shallow natural gas wells but declined at farther distances (Rodgers, 2013). Daniel and Koper (2019) determined that Chestnut-collared Longspur abundance and nesting success declined as gas-well density increased. Abundance decreased above a gas-well density of 2 wells per legal section (with a range from 0 to 36 well pads per km^2). The probability of a nest surviving when the density was 1 well per section was 0.78, whereas the probability of the nest surviving when the density was 20 wells per section was 0.71. Abundance increased as much as 247 m from natural gas wells but was not affected by distance from oil wells. Clutch sizes and nesting success were lowest next to shallow gas wells but proximity to oil wells had no effect on nesting success. Clutch sizes and nesting success increased beyond 35 and 210 m from gas wells, respectively (Daniel and Koper, 2019). Bernath-Plaisted and Koper (2016) examined the effect of several types of oil and gas infrastructure on nest success, including pumpjacks, screwpumps, and compressors, and found no relationship between longspur nest success and infrastructure type. Nenninger and Koper (2018) reported that longspur presence was 2.6 times higher close to pumpjacks but found no effect of screwpumps. Longspur occurrence was independent of the presence of or distance to wells, and longspur abundance did not differ between areas with grid-powered wells and areas with generator-powered wells. Yoo and Koper (2017) reported that nest success was not affected by distance to gas-well structures, and this effect did not vary with well age; nest success also was independent of well density. Clutch size increased as distance to gas wells increased. Clutch sizes declined by two eggs in sites with high densities of new (<15 years old) wells but increased by one to two eggs in sites with high densities of older (>30 years old) wells.

In mixed-grass prairies in southeastern Alberta, Ng (2017) and Ng and others (2019) examined how incubation and parental behaviors of Chestnut-collared Longspurs were affected by three factors of energy extraction: proximity to conventional oil wells and compressor stations, proximity to roads, and industrial noise. Longspurs consistently reduced parental care in the presence of all three factors when compared to control sites (Ng, 2017). Males were sensitive to industrial noise and provisioned nestlings less frequently near active well sites. Females consistently altered their behaviors when they nested near roads and infrastructure; females took longer breaks from incubation, were less attentive to nests, had fewer brood and shade bouts, and provisioned and visited nestlings less at closer distances to roads and to infrastructure. On average, nests within 50 m of roads failed or produced only one fledgling, whereas nests 150 m from roads produced an average of two fledglings and nests 500 m from roads and farther produced three fledglings. On average, at nests 600 m away from roads, the farthest distance evaluated, longspur young fledged nearly a day earlier than nests within 100 m of roads (Ng, 2017). Females nesting near oil infrastructure were older and heavier than females further away, whereas females nesting near roads were smaller; no effects were detected for the relationships of male age, size, or body mass to distance from infrastructure (Ng and others, 2019).

In southwestern Saskatchewan, the effect of natural gas wells on Chestnut-collared Longspurs varied by site (Kalyn Bogard, 2011; Kalyn Bogard and Davis, 2014). At one site, abundance increased with well density but also with distance from wells; the mean detection distance was 50 m, and the species was not detected within 10 m of wells (Kalyn Bogard, 2011). Abundance at this site also was affected by vegetation structure; abundance was greatest in areas where vegetation was about 9 cm tall and grass cover was 45–50 percent. At the second site, abundance was affected only by vegetation structure (grass cover and litter depth). In another Saskatchewan study, Chestnut-collared Longspurs tended to avoid minimal-disturbance gas wells and associated trails, although not significantly so (Linnen, 2008).

In northwestern North Dakota, Chestnut-collared Longspurs exhibited reduced densities within 550 m of single-bore well pads at unconventional oil extraction sites (that is, hydraulic fracturing and horizontal drilling) (Thompson and others, 2015). Using BBS data, Bohannon and Blinnikov (2019) examined the relationship between longspur abundance and habitat fragmentation in western North Dakota and eastern Montana caused by oil-extraction activities. The local longspur population did not significantly decline with increasing edge density (that is, the amount of linear edge per total landscape area).

Wind-energy development may negatively impact Chestnut-collared Longspur distribution and abundance. Beston and others (2016) developed a prioritization system to identify avian species most likely to experience population declines in the United States from wind facilities based on the species' current conservation status and the species' expected risk from wind turbines. The Chestnut-collared Longspur scored a 2.66 out of nine based on 428 species evaluated; 3.56 percent of the Chestnut-collared Longspur breeding population in the United States are exposed to wind facilities. Chestnut-collared Longspurs may avoid wind facilities (Shaffer and Buhl, 2016). At a wind facility in mixed-grass prairies in South Dakota, Chestnut-collared Longspurs exhibited displacement within 300 m of wind turbines during the 2–5-year postconstruction period.

Management Recommendations from the Literature

Chestnut-collared Longspurs prefer open, grazed native pastures to all other habitat types (Owens and Myres, 1973; Anstey and others, 1995; Davis and Duncan, 1999). Skinner (2004) recommended protection and conservation of the largest remaining tracts of native grasslands as a high priority conservation need for area-sensitive species, such as the Chestnut-collared Longspur. Sliwinski and Koper (2012) emphasized the importance of preventing the encroachment of agricultural activities into native prairies as this results in habitat loss and increased edge effects. Berman (2007) also recommended preserving large tracts of native prairie, which were found to have higher daily nest survival. Greer and others (2016) stressed the importance of protecting and managing large, intact native grasslands against encroachment by tame species of grasses and by woody species, both of which alter vegetation structure that renders grassland habitat unsuitable for Chestnut-collared Longspurs. Lloyd and Martin (2005) further stressed that programs that encourage the planting of crested wheatgrass should be discouraged. In grassland areas experiencing woodland encroachment, Grant and others (2004) suggested that managers focus initial restoration efforts on grasslands with <20 percent woodland encroachment because these grasslands would have the most immediate and lasting conservation benefit for grassland birds. Greer (2009) suggested removing woody edges from a grassland landscape; programs that encourage the planting of trees and tall shrubs within grasslands should be discouraged.

Skinner (2004) and Greer (2009) indicated that landscape context should be considered when designing conservation strategies such as preservation of smaller patches of native grasslands and grassland restoration, as these strategies may be more effective in landscapes with large amounts of grassland and low amounts of woodland. Veech (2006) reported that planted grasslands may have some value to Chestnut-collared Longspurs, as the presence of CRP fields in the landscape is beneficial to the population growth of the species. Lloyd and Martin (2005) and Greer and others (2016) recommended that CRP fields be planted to native grass species to provide Chestnut-collared Longspurs with high-quality habitat.

Chestnut-collared Longspur densities decrease with an increase in mean vegetation vertical density, horizontal diversity, and litter depth, so managing for idle, dense vegetation may reduce the species' abundance (Renken, 1983; Messmer, 1990; Johnson and Igl, 1995). Plowing and cultivation may negatively affect Chestnut-collared Longspurs (Owens and Myres, 1973; Stewart, 1975). Burning, however, may benefit Chestnut-collared Longspurs, provided that vegetative regrowth is not too tall or dense (Maher, 1973; Berkey and others, 1993; Richardson, 2012). Frequent burning (every 1–2 years, annual patch burning, with a minimum fire-return interval of 5 years) improves structural heterogeneity for longspurs (Richardson, 2012). Where burning is not allowed, grazing at low-to-moderate levels promotes habitat heterogeneity but is not sufficient to create the heavily disturbed habitat preferred by longspurs. Grazing of burned prairies may confer little additional benefit to longspurs (Richardson and others, 2014). In mixed-grass prairies, mowing may improve longspur habitat by decreasing vegetation height and density (Owens and Myres, 1973; Stewart 1975). Annual mowing was more beneficial to the species than periodic mowing (once every 3 years) in northern mixed-grass prairies (Dale and others, 1997).

Managing stocking rates to achieve optimal grazing intensity for Chestnut-collared Longspurs depends on factors such as grassland type, interannual variability in precipitation levels, and soil productivity (Sliwinski and Koper, 2015; Lipsey and Naugle, 2017). Chestnut-collared Longspurs may tolerate a wider range of grazing intensities in native pastures than in tame pastures (Owens and Myres, 1973; Anstey and others, 1995; Davis and Duncan, 1999). Sliwinski and Koper (2015) suggested that Chestnut-collared Longspurs could be managed with higher stocking rates than those applied to other species of grassland birds. Ryder (1980), Kantrud and Kologiski (1982), and Messmer (1990) also found that moderate-to-heavy grazing in mixed-grass prairies or wetter prairie areas can improve habitat for Chestnut-collared Longspurs. However, because Chestnut-collared Longspurs have been found to nest in areas with greater litter depth and vegetation density than is generally available, continual use of high stocking rates could decrease the suitability of nesting habitat (Lusk and Koper, 2013). Where high stocking rates are regularly used, Sliwinski and Koper (2015) recommended a schedule of pasture rotations to avoid habitat degradation over many years and suggested that decisions about stocking rates should be based on annual precipitation levels. Sliwinski and Koper (2015) determined that the rate of 0.6 AUM per ha was suitable for Chestnut-collared Longspurs during a period of average and above-average precipitation, and Fischer and others (2020) cautioned that these levels may mask grazing effects that would be more apparent in drier years. In dry prairies, especially sparsely vegetated shortgrass prairies, low-to-moderate grazing may be more appropriate than heavy grazing (Strong, 1971; Ryder, 1980; Kantrud and Kologiski, 1982; Bock and others, 1993; Anstey and others, 1995). Fischer and others (2020) further cautioned that continuous application of high stocking rates could force a transition to irreversible and possibly undesirable plant communities; they suggested that grazing at lower stocking rates and allowing for periods of rest from grazing would better allow grasslands to recover from grazing effects. Chestnut-collared Longspur nest success in grasslands that are allowed periodic rest intervals may be higher than grasslands grazed for many years (Pipher and others, 2016).

To benefit a suite of grassland birds that includes Chestnut-collared Longspur, Sliwinski and Koper (2015) and Pipher and others (2016) recommended that land managers use stocking rates to increase heterogeneity in vegetation structure, which can be achieved by using low stocking rates or rest on some pastures and heavy stocking rates on others; the specific stocking rates used will depend on the region and precipitation within a given year. Lipsey and Naugle (2017) suggested that land managers evaluate current cover conditions and provide the cover most limiting for birds at the time of evaluation. Salo and others (2004) recognized that Chestnut-collared Longspur densities were higher in heavily and extremely heavily grazed pastures than lightly or moderately grazed pastures, but grasslands grazed at low-to-moderate rates had greater biomass reserves that benefitted the suite of grassland bird species while maintaining acceptable daily rates of gain for individual cattle. The suite of grassland bird species was best maintained on average at 2.4 AUMs per ha, whereas livestock production and economic benefits to operators were best achieved on average at stocking rates from 2.4 to 4.2 AUMs per ha, adjusted for annual precipitation and soil moisture reserves.

Several studies indicate that Chestnut-collared Longspurs are relatively insensitive to the type of grazing system; the important factor is that grasslands are grazed and not allowed to remain idle for such long periods that vegetation structure becomes too dense or that woody encroachment occurs (Prescott and Wagner, 1996; Ranellucci and others, 2012; Bleho and others, 2014; Davis and others, 2014; Golding and Dreitz, 2017). Bleho and others (2014) cautioned that some grazing systems can cause uniform vegetation structure that may produce unfavorable habitat conditions. As with stocking rate, the effect on vegetation of abiotic factors such as interannual variability in precipitation levels and soil type may be as important in governing the abundance and distribution of bird species as the type of grazing system (Ranellucci and others, 2012; Golding and Dreitz, 2017). Davis and others (2014) recommended that greater effort be taken to improving range condition in pastures categorized as low-to-fair and in maintaining pastures in good condition, rather than focusing on grazing systems. Golding and Dreitz (2017) suggested that a particular grazing system could be used to alter the abundance of individual bird species, but that a single grazing system is unlikely to maintain a suite of grassland bird species.

When invertebrate pest management is necessary, McEwen and others (1972) recommended using rapidly degrading chemicals of low toxicity to nontarget organisms at the lowest application rates feasible. Maintaining range in good condition can reduce the need for pesticide applications, as overgrazed and drought-affected areas are more prone to pest outbreaks.

To reduce the negative effects of conventional oil and gas infrastructure, roads, and industrial noise on Chestnut-collared Longspurs, Ng (2017) recommended minimizing the placement of new wells, transmission lines, and access roads in large patches of minimally disturbed native prairie. Because inactive wells also negatively affect longspurs, Ng (2017) recommended removing nonoperational infrastructure and reclaiming well pads and access roads by planting native grass species. Management actions that minimize noise and human activity may not be as effective as actions that reduce the abundance and density of aboveground infrastructure, including roads (Daniel and Koper, 2019). Such activities include reclaiming abandoned wells and access roads and implementing horizontal drilling techniques that allow well heads to be clustered to eliminate the need for new roads and surface infrastructure (Bernath-Plaisted and Koper, 2016; Daniel and Koper, 2019). Shaffer and others (2019b) developed an avian-impact offset method to guide compensatory mitigation of habitat loss associated with anthropogenic developments such as wind, oil, and natural gas facilities and related road infrastructure. The avian-impact offset method calculates the biological value (measured in terms of avian density) lost when Chestnut-collared Longspur and other species avoid otherwise suitable breeding habitat owing to the presence of the infrastructure. The method converts biological value to the traditional unit of measure (that is, hectares of grassland) in which land is purchased or sold, so that compensatory mitigation can be implemented in the form of conservation easements or grassland reconstruction at the local, regional, or landscape scales (Shaffer and others, 2019b). To this end, Shaffer and others (2019b) applied the models of Niemuth and others (2017) to develop a geospatial tool that identifies locations for placement of compensatory offset sites with equivalent biological value as impact sites. Additionally, the tool can be used prior to the construction of facilities to identify locations that would require little compensatory mitigation if developed, relative to other potential locations.

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Table X1. Measured values of vegetation structure and composition in Chestnut-collared Longspur (*Calcarius ornatus*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.

[cm, centimeter; %, percent; <, less than; ha, hectare; >, greater than; --, no data; DNC, dense nesting cover]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Berman, 2007	South Dakota	Mixed-grass prairie	<50 ha; >50% grassland landscape	73	20[a]	--	--	--	--	--	1.2
Berman, 2007	South Dakota	Mixed-grass prairie	>100 ha; <40% grassland landscape	53	10[a]	--	--	--	--	--	1.1
Berman, 2007	South Dakota	Mixed-grass prairie	>100 ha; >50% grassland landscape	77	12[a]	--	--	--	--	--	0.6
Bleho, 2009	Saskatchewan	Mixed-grass prairie	Ungrazed	--	7.4[a]	15.6	4.5	6.2	4.7	60.9	--
Bleho, 2009	Saskatchewan	Mixed-grass prairie	Cattle-grazed	--	4[a]	17.9	6.9	3.6	8.4	45.2	--
Chepulis, 2016	North Dakota	Mixed-grass prairie	Grazed	41.6–44.2	7.8–8.8[a]	--	--	--	7.8	46.2	1.8–3.6
Creighton, 1974	Colorado	Mixed-grass prairie	Grazed	15.2	--	67	6	0.2	12	--	--
Dale, 1983[b]	Saskatchewan	Mixed-grass prairie	Grazed, ungrazed	--	--	38.5	--	1	11.5	83.3	--
Dieni and Jones, 2003 (nests)	Montana	Mixed-grass prairie	Idle	30.2	1[a]	48.6	15.6	0.9	1	6	6.5
Dieni and Jones, 2003 (nest vicinity)	Montana	Mixed-grass prairie	Idle	24.9	7[a]	--	--	--	--	--	--
Fritcher and others, 2004[c,d]	South Dakota	Mixed-grass prairie	Grazed	26.6–51.8	5.8–17[a]	85.7–91.6	18–26.1	--	1.8–12.9	80.7–94.6	0.9–3.1
Grant and others, 2004	North Dakota	Mixed-grass prairie	Multiple	52	--	--	--	4.7	--	--	4.5
Greer, 2009[d]	South Dakota	Mixed-grass prairie	Multiple	74[e]	6[a]	53.6	20.4	1.3	11	14.2	0.5
Kalyn Bogard, 2011	Saskatchewan	Mixed-grass prairie	Grazed	10.3	--	44.7	9.5	--	43.7	--	0.2
Lueders and others, 2006	North Dakota	Mixed-grass prairie	Cattle-grazed	--	8[a]	29.1[f]	11	0.6	24.7	25.9	1.5
Lusk, 2009[d] (nests)	Saskatchewan	Mixed-grass prairie	Grazed, ungrazed	--	--	20.9	2.6	3.6	0	22.9	1.2

Table X1. Measured values of vegetation structure and composition in Chestnut-collared Longspur (*Calcarius ornatus*) breeding habitat by study. The parenthetical descriptors following authorship and year in the "Study" column indicate that the vegetation measurements were taken in locations or under conditions specified in the descriptor; no descriptor implies that measurements were taken within the general study area.—Continued

[cm, centimeter; %, percent; <, less than; ha, hectare; >, greater than; --, no data; DNC, dense nesting cover]

Study	State or province	Habitat	Management practice or treatment	Vegetation height (cm)	Vegetation height-density (cm)	Grass cover (%)	Forb cover (%)	Shrub cover (%)	Bare ground cover (%)	Litter cover (%)	Litter depth (cm)
Pipher, 2011 (nests)	Saskatchewan	Mixed-grass prairie	Grazed	43.8	--	--	--	--	--	--	1.5
Renken, 1983[b]	North Dakota	Tame grassland (DNC)	Idle, grazed	--	6[a]	53.9	17.7	0	1.3	97.1	1.5
Rodgers, 2013	Alberta	Mixed-grass prairie	--	22.8[e]	--	35.8	11.1	--	2.9	--	0.2
Salo and others, 2004	North Dakota	Mixed-grass prairie	Light grazing intensity	52.9[e]	50.3[a]	--	--	--	--	--	5.3
Salo and others, 2004	North Dakota	Mixed-grass prairie	Moderate grazing intensity	48.3[e]	45.8[a]	--	--	--	--	--	4.6
Salo and others, 2004	North Dakota	Mixed-grass prairie	Heavy grazing intensity	27.1[e]	22.9[a]	--	--	--	--	--	2
Salo and others, 2004	North Dakota	Mixed-grass prairie	Extreme grazing intensity	17.5[e]	7.9[a]	--	--	--	--	--	0.9
Schneider, 1998	North Dakota	Mixed-grass prairie	Grazed	--	6.9[a]	38.4	13.7	--	5.8	--	1.3
Sliwinski, 2011	Saskatchewan	Mixed-grass prairie	Bison (*Bison bison*)- and cattle-grazed	30.8	--	29.9	4.9	--	1.4	34.3	4.7
White, 2009	Saskatchewan	Mixed-grass prairie	Burned, cattle-grazed	37.2	3.5[a]	30.7	6.1	0.7	19.5	14.9	1.6
White, 2009	Saskatchewan	Mixed-grass prairie	Burned, ungrazed	39.4	4[a]	31.4	6.8	0.5	15.4	10.4	1.1
White, 2009	Saskatchewan	Mixed-grass prairie	Unburned, cattle-grazed	41.4	3.4[a]	17.3	7.8	0.4	3.2	47.3	2.1
White, 2009	Saskatchewan	Mixed-grass prairie	Unburned, ungrazed	41.7	7.2[a]	14.8	5.1	2.1	1.6	62.8	5.1

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

[b]The sum of the percentages is >100%, based on the modified point-quadrat technique of Wiens (1969).

[c]Range of averages across seral stages within study area.

[d]The sum of the percentages is >100%, based on methods described by the author(s).

[e]Mean grass height.

[f]Grass and sedge (*Carex* spp.) combined.

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