

Chestnut-collared Longspur (*Calcarius ornatus*): A Technical Conservation Assessment



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SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF CHESTNUT-COLLARED LONGSPUR

Status

Chestnut-collared longspurs (*Calcarius ornatus*) are locally abundant breeding birds of the shortgrass and mixed-grass prairies of the Great Plains. In Region 2 USDA Forest Service lands, they commonly breed only on the Pawnee National Grassland in Colorado and the Thunder Basin National Grassland in Wyoming. They winter mostly south of Region 2. Continent-wide, the population of chestnut-collared longspurs has been declining at 2.0 percent per year (1966 – 2001 Breeding Bird Survey [BBS]; Sauer et al. 2001). The greatest declines, however, occurred long before the initiation of the BBS: “When the northern prairies became the great wheat-producing region of the continent, the amount of grassland available for the Chestnut-collar was reduced proportionately” (Fairfield 1968). The chestnut-collared longspur is ranked by various state, federal, and private conservation organizations as a grassland “species of concern,” “high priority,” “imperiled,” with “pressing needs,” “state imperiled,” or a species of “conservation concern.”

Primary Threats

Loss of native mixed-grass and shortgrass prairies to agriculture and development on the breeding grounds—and on the wintering grounds—is the greatest threat to chestnut-collared longspurs. Although most of the rangeland loss to agriculture was historical, more recent losses are not insignificant. In Colorado, for example, 3.8 percent of the shortgrass and mixed-grass prairie east of the Rockies was lost to agriculture and urban expansion from 1982 to 1997 (Seidl et al. 2001). Habitat loss from increasing oil and gas development, especially in Wyoming, and the associated negative impacts of disturbance and fragmentation also pose a threat to chestnut-collared longspurs. Fire suppression, increasing recreational activities, and the use of pesticides are somewhat lesser threats. Any absolute changes in first-year survival or fertility rates will have major impacts on population dynamics.

Primary Conservation Elements, Management Implications and Considerations

Grazing management is the primary land management tool available to resource managers. While heavy grazing can be detrimental on arid grasslands, in the more mesic northern parts of its range the chestnut-collared longspur may require moderate to heavy grazing to maintain habitat condition. Prescribed burns may be necessary in some areas to maintain the stature of breeding habitat and to reflect the historic spatial extent and temporal pattern of prairie wildfires. A major conservation issue in the 21st Century, especially in Region 2, will be managing and mitigating the negative impacts of rapidly increasing oil and gas development.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the Rocky Mountain Region (Region 2), USDA Forest Service (USFS) (**Figure 1**). The chestnut-collared longspur is the focus of an assessment because it has been added to the Regional Forester's Sensitive Species List (Revised 2003). Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or habitat capability that would reduce its distribution (FSM 2670.5 [19]). A sensitive species may require special management, so knowledge of its biology and ecology is critical.

This assessment addresses the biology and conservation of the chestnut-collared longspur throughout its range, with emphasis on Region 2.

This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, biologists, other agencies, and the public with a thorough discussion of the biology, ecology, conservation, and management of certain species based on current scientific knowledge. The assessment goals limit the scope of the work to critical summaries of information needs. Although the assessment does not seek to develop prescriptive management recommendations, it does develop the ecological context upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore it discusses

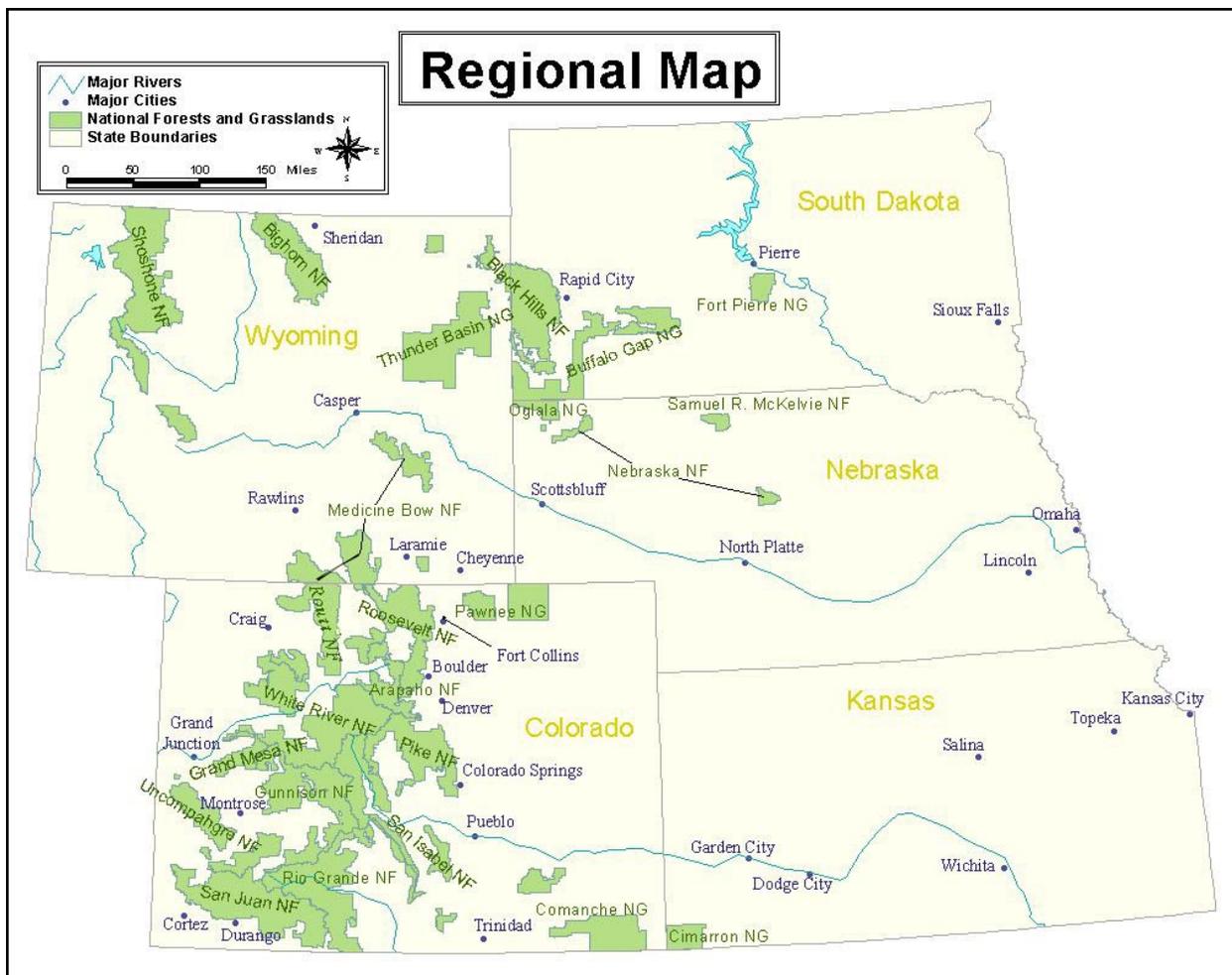


Figure 1. Regional map of USDA Forest Service Region 2. National grasslands and forests are shaded in green.

and evaluates management recommendations currently in use or proposed elsewhere.

Scope

This assessment examines the biology, ecology, conservation, and management of the chestnut-collared longspur with specific reference to the geographic and ecological characteristics of the Rocky Mountain Region. Although some of the literature on the species originates from field investigation outside the region, this document places that literature in the ecological and social context of the Rocky Mountain Region. Similarly, this assessment is concerned with reproductive behavior, population dynamics, and other characteristics of chestnut-collared longspur in the context of the current environment. The evolutionary environment of the species is considered in conducting the syntheses, but placed in a current context.

In producing the assessment, I reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on chestnut-collared longspur are referenced in the assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. Non-refereed publications or reports were used when refereed information was unavailable, but these were regarded with greater skepticism. Unpublished data (e.g., Natural Heritage Program records) were important in estimating the geographic distribution. These data required special attention because of the diversity of persons and methods used in their collection.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, it is difficult to conduct experiments that produce clean results in the ecological sciences. Often, we must rely on observations, inference, good thinking, and models to guide our understanding of ecological relations. In this assessment, I note the strength of evidence for particular ideas, and describe alternative explanations where appropriate.

Publication of Assessment on the World Wide Web

To facilitate their use, species conservation assessments are being published on the Region 2 World Wide Web site. Placing the documents on the Web makes them available to agency biologists, managers, and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Species conservation assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the Society for Conservation Biology, employing two recognized experts on this or related taxa. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

Chestnut-collared longspurs are endemic breeding birds of the mixed-grass and shortgrass prairies of the Great Plains. The species is not federally listed or a candidate for listing under the Endangered Species Act. Due to a decline in abundance on both the breeding and wintering grounds however, it has received the following conservation status rankings:

- ❖ Natural Heritage Program (NHP) global rank of G5 (globally secure, but indication of contraction of historic breeding and winter ranges and long-term population declines)
- ❖ USDA Forest Service Region 2 Sensitive Species
- ❖ U.S. Fish and Wildlife Service (USFWS) Bird of Conservation Concern throughout its breeding and wintering ranges (ranked nationally in USFWS Regions 2 and 6, and in all Bird Conservation Regions where the species occurs) (U.S. Fish and Wildlife Service 2002)
- ❖ Partners in Flight (PIF) Species Assessment Breeding Scores of 21 and 22 (moderately

high priority) for the Wyoming Basin and Central Shortgrass Prairie physiographic areas (S86 and S36, respectively)

- ❖ Wyoming Species of Special Concern (pressing needs)
- ❖ Wyoming NHP rank of S2B/SZN (breeding population in state is imperiled; no non-breeding occurrences)
- ❖ Partners in Flight (PIF) Priority Bird Species in the Wyoming Basin, Physiographic Region 86
- ❖ Colorado NHP rank of S1B/SZN (breeding population in state is critically imperiled; no non-breeding occurrences)
- ❖ Nebraska Species of Concern with a NHP rank of S2 (state imperiled)

Rocky Mountain Bird Observatory (RMBO) has designated this species as a priority for monitoring in its “Monitoring 2000”, and it is targeted by RMBO’s Shortgrass Prairie Project.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Laws, regulations, and management direction

Although the chestnut-collared longspur is on the Regional Forester’s Sensitive Species List, there are no existing legal mechanisms, management plans, or conservation strategies that apply specifically to this species. It is protected by several laws that apply to most wildlife species, including the Migratory Bird Treaty Act (1918), the National Forest Management Act (1976), and the Neotropical Migratory Bird Conservation Act (2000). The Migratory Bird Treaty Act prohibits, with certain exceptions, the pursuit, hunting, capture, killing, taking, sale, purchase, transport, receipt for shipment, or export of any migratory bird, or the nest or eggs of such birds (16 U.S.C. 703; <http://laws.fws.gov/lawsdigest/migtrea.html>). Furthermore, treaties formed as a result of the Act require the federal government to protect ecosystems of special importance to migratory birds against pollution, detrimental alterations, and other environmental degradations.

The National Forest Management Act and its implementing regulations and policies require the

USFS to sustain habitats that support healthy, well-distributed populations of native and desired non-native plant and animal species on National Forest System lands. Legally required activities include monitoring population trends of management indicator species in relationship to habitat change, determining effects of management practices, monitoring the effects of oil and gas development and off-road vehicles, and maintaining biological diversity. By policy, sensitive species designation is a tool to ensure that species with identifiable viability concerns are conserved.

The Neotropical Bird Conservation Act provides grants to U.S., Latin American, and Caribbean organizations for the conservation of birds that breed in the U.S. and winter south of the U.S.-Mexico border. It encourages habitat protection, education, research, monitoring, and the long-term protection of Neotropical migratory birds (<http://laws.fws.gov/lawsdigest/neotrop.html>).

The standards and guidelines of the Forest Service Government Performance Results Act ensure that resources are managed in a sustainable manner. The National Environmental Policy Act requires agencies to specify environmentally preferable alternatives in land use management planning. Additional laws with which USFS management plans must comply are the Endangered Species, Clean Water, Clean Air, Mineral Leasing, Federal Onshore Oil and Gas Leasing Reform, and Mining and Minerals Policy acts; all are potentially relevant to chestnut-collared longspur conservation.

National monitoring and conservation-related programs relevant to the chestnut-collared longspur include the North American Breeding Bird Survey (BBS) and the Monitoring of Avian Productivity and Survivorship Program (MAPS), and the Audubon Christmas Bird Count (CBC). The BBS (<http://www.mbr-pwrc.usgs.gov/bbb/intro00.html>), which started in 1966, is a nationwide (including southern Canada) effort of >3,500 roadside avian surveys conducted during the breeding season. The main objective of the BBS is to estimate long-term trends in avian populations. MAPS was created in 1989 to assess and monitor the reproductive success and population dynamics of >120 species of North American landbirds (<http://www.birdpop.org/maps.htm>). Based on banding and constant-effort mist-netting, MAPS data are used to describe spatial and temporal patterns in species’ reproductive success and population trends with regard to landscape-level habitat characteristics, weather, and species’ ecological characteristics. Goals are to monitor and identify causes of population decline, to maintain

healthy populations, and to evaluate the effectiveness of management and conservation actions. The CBC began in 1900, and today, includes over 1900 nationwide counts. CBCs are all-day censuses of early-winter birds designed to monitor status, distribution, and trends of early-winter birds across the Americas.

Enforcement of existing laws and regulations

Enforcement of existing laws and regulations appears to be adequate. On the Pawnee National Grassland, for example, “intensive and extensive” monitoring of management indicator species began in 1997. This includes USFS data collection and cooperative research agreements with Colorado State University, USFWS, Colorado NHP, and RMBO. Ongoing prescribed burns on the grassland may reduce the shrub component and thus benefit chestnut-collared longspurs. Additionally, public access has been restricted during vulnerable seasons to eliminate disturbance to threatened and endangered species, including the mountain plover (*Charadrius montanus*); this should have also benefited chestnut-collared longspurs. Road closures to improve wildlife habitat were not effective, however, due to budgetary constraints. Grazing allotments were monitored to evaluate rangeland health and to determine long-term trends; adjustments were made in allotment management. In Wyoming, the Thunder Basin Land and Resource Management Plan includes two key objectives pertinent to chestnut-collared longspur conservation: 1) ensuring long-term grassland health, and 2) maintaining and enhancing the viability of native plant and animal species. Specifically, grazing will be varied, with broad resource emphasis, range vegetation emphasis, and natural-appearing-landscape emphasis; few to no prairie dog (*Cynomys* spp.) areas will be controlled with pesticides; certain prairie dog complexes will be managed for black-footed ferret (*Mustela nigripes*) reintroductions; some areas will be protected for research, education, biological diversity, and wilderness; and off-road travel will be restricted. To minimize oil and gas activities on the Thunder Basin National Grassland, required mitigation includes noise limits on oil and gas production facilities, distance restrictions from certain vegetation types of concern, minimizing drill site traffic and vegetation disturbance, and reclamation of the production sites.

USFS challenges on shortgrass and mixed-grass prairies include:

- ❖ an increasing urban population and its accompanying desire for recreation,

conflicting with livestock grazing on range allotments

- ❖ incomplete inventories of roads and trails, which limit knowledge related to grassland fragmentation issues
- ❖ maintaining species viability
- ❖ dealing with the increasing impact of oil and gas drilling activities
- ❖ managing for desired plant species composition, structure, and pattern in grasslands
- ❖ monitoring for plant, animal, and ecosystem processes and functions
- ❖ maintaining sustainable community relationships and ecosystem functions
- ❖ using grazing to achieve desired vegetative conditions

Biology and Ecology

Systematics and species description

The chestnut-collared longspur is a sparrow-sized passerine in the family Emberizidae. The smallest of the longspurs, it is a heavy, stocky bird, 13 to 16.5 cm long and weighing 17 to 23 g (Hill and Gould 1997). It has a small, acutely conical bill, short, rounded wings, and an elongated hallux nail, giving the “longspur” its name. The tail pattern is diagnostic: white outer tail feathers and dark inner feathers appear as a black triangle in flight. Chestnut-collared males have a black crown and breast (sometimes tipped with chestnut), yellowish cheeks (some individuals white), black shoulder patch (inner coverts), and a characteristic deep chestnut hindneck or collar. Breeding females are drab gray-brown overall and streaked with dusky feathers on the breast and belly. Occasionally, they may show a dull, obscure chestnut collar, and some may have black underparts, rather closely resembling males (J. Lloyd personal communication 2004). In winter, the male’s black and chestnut colors are veiled by buffy feather tips; winter females are similar to breeding females, but their colors are even more muted, with buffy feather tips and blurry streaks on the breast (Hill and Gould 1997, Sibley 2000).

The species is monotypic. Sibley and Pettingill (1955) reported a hybrid between McCown's longspur (*Calcarius mccownii*) and chestnut-collared longspur. No geographic variation or subspecies have been described (Hill and Gould 1997).

Distribution and abundance

The distribution of chestnut-collared longspur breeding populations is disjunct, corresponding to the now fragmented distribution of the shortgrass and mixed-grass prairies of the Great Plains and the southern fringe of the Canadian Prairie Provinces. Chestnut-collared longspurs breed from southern Alberta, Saskatchewan, and Manitoba, south to northeastern Colorado and (formerly) extreme western Kansas, and east through North Dakota, South Dakota, and western and north-central Nebraska to western Minnesota (**Figure 2**; Hill and Gould 1997, American Ornithologists' Union 1998). They breed throughout most of North Dakota, except the southeast (Stewart 1975, Robbins et al. 1986). In South Dakota chestnut-collared longspurs are absent from the Black Hills; they breed throughout the rest of the state, but only locally in the easternmost and southernmost areas (Pettingill and Whitney 1965, Peterson 1995). In Wyoming, chestnut-collared breed most commonly in the northeast and southeast (Oakleaf et al. 1992); in Nebraska, they breed in the northwest (Johnsgard 1979); and in Colorado, they are known to breed in Weld and Washington

counties in the northeast (Andrews and Righter 1992, Pantle 1998). The species is most numerous (breeding) in southern Alberta, north-central Montana, central North Dakota, and north-central South Dakota (**Figure 2**; Sauer et al. 2001).

The USFS Region 2 state with the highest average relative abundance of chestnut-collared longspurs is South Dakota, with 21.98 individuals per route (BBS survey data; Sauer et al. 2001). Survey-wide, the average relative abundance of chestnut-collared longspurs was 9.83 individuals per route. Densities (birds per ha) on occupied sites on the eastern Pawnee National Grassland in Colorado in 1997 and 1998 were 0.95 ± 0.52 SD ($n = 8$ sites) and 0.70 ± 0.50 ($n = 7$ sites), respectively (S. Skagen personal communication 2004). Including sites where longspurs did not occur, densities in the same years were 0.47 ± 0.60 ($n = 16$ sites) and 0.31 ± 0.48 ($n = 16$ sites), respectively. Notably, chestnut-collared longspurs did not occur on any of ten Conservation Reserve Program (CRP) sites surveyed in 1999. Hanni et al. (2003) reported densities of 5.1 birds per km^2 on the Pawnee National Grassland. According to the Colorado Breeding Bird Atlas, there are an estimated 565 to 1,161 breeding pairs occurring in 1 percent of the survey blocks (Kingery 1998).

At Matador, Saskatchewan, chestnut-collared longspur densities ranged from 0.7 to 1.2 breeding pairs per ha (mean = 0.9) in grazed plots and from 0.0 to 0.2

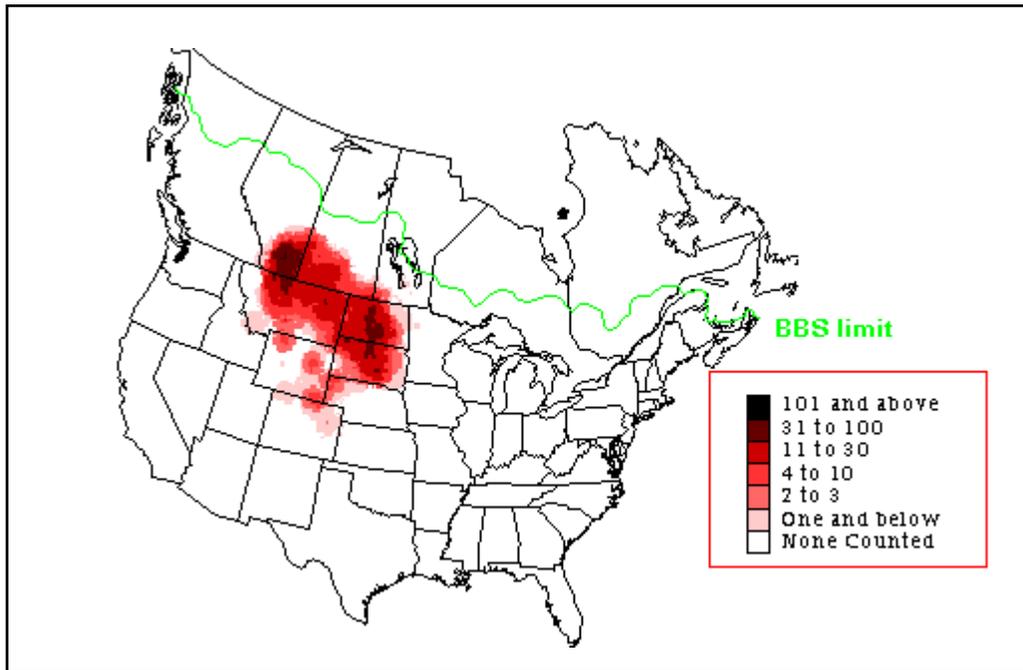


Figure 2. Relative breeding season distribution and abundance (average number of birds per route) of chestnut-collared longspur based on BBS data from 1982 to 1996.

pairs per ha (mean = 0.1) in ungrazed plots (Maher 1973). The number of longspurs declined over time in plots protected from grazing, and eventually, longspurs disappeared from ungrazed plots. In southeastern Alberta, densities ranged from 1.1 to 1.4 breeding pairs per ha (mean = 1.2) on a site grazed from June through October at one cow-calf unit per 22 ha (Hill and Gould 1997). Hanni et al. (2003) reported densities of 49.4 birds per km² on the Fort Pierre National Grassland (USFS Region 2), and 94.9 birds per km² on the Grand River National Grassland (USFS Region 1).

Winter distribution extends from central Arizona, northern New Mexico, southeastern Colorado, central Kansas, and west-central Oklahoma south to northern Sonora, Chihuahua, Zacatecas, San Luis Potosi, and southern Texas (Howell and Webb 1995, Hill and Gould 1997, American Ornithologists' Union 1998). Chestnut-collared longspurs may winter as far west as California and as far north as northeastern Colorado and southwestern Nebraska, but this would be rare (Andrews and Righter 1992, Hill and Gould 1997); rare winter records also include the Dakotas, Iowa, Minnesota, and Illinois. Highest winter densities occur in eastern New Mexico and western Texas (**Figure 3**). On 20 wintering sites in Oklahoma and Texas, chestnut-collared longspurs were among the most abundant species on nine of the sites, with densities ranging from 5 to 166 individuals per 100 ha (Grzybowski 1982). Christmas Bird Count data reveal major annual shifts in the distribution and abundance of wintering

populations, presumably due to fluctuating weather patterns and conditions on the wintering grounds. For the 1989-2001 period, total numbers seen per party hour ranged from a low of 0.092 (608 individuals) to a high of 0.432 (1623 individuals) (**Figure 3**; National Audubon Society 2002). Grzybowski (1982) reported dramatic fluctuations in abundance as well, with longspurs abundant in some years and absent in others; variable rainfall and changing cultivation and grazing practices from year to year were thought to be responsible.

The breeding distribution of chestnut-collared longspurs has decreased with the destruction of native prairie grasslands (Fairfield 1968, Semenchuk 1992). Their breeding range formerly included western Kansas, where it was reported as "abundant" in 1871 (Allen 1872 in Baird et al. 1905), but is now absent (Thompson and Ely 1992); western Minnesota, where it was once a common summer resident, but now only two small populations still occur (Wyckoff 1986a, 1986b, Janssen 1987); and the prairies along the Platte River of Nebraska (Heermann 1843 in Baird et al. 1905). In addition, the species may formerly have been more abundant across its present range.

Similar declines are thought to have occurred on the species' winter range. Contraction of wintering distribution in Texas has been attributed to a reduction in overall numbers of chestnut-collared longspurs (Oberholser 1974). In Texas, longspurs were reported in flocks near San Antonio in the 1800s (H. E. Dresser

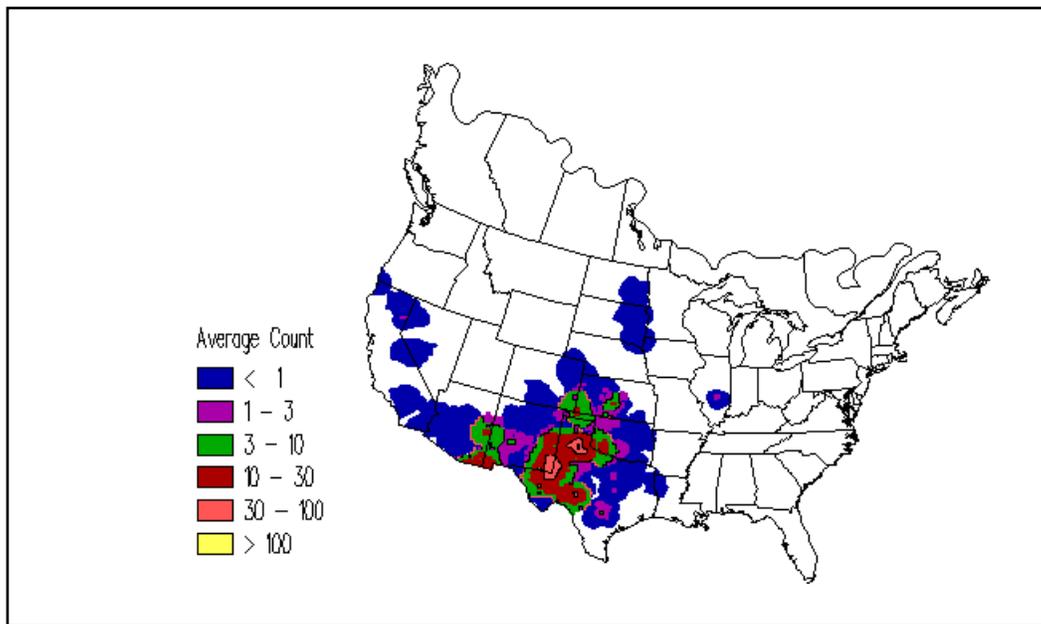


Figure 3. Relative winter season distribution and abundance (average number of birds per count circle) of chestnut-collared longspur based on Christmas Bird Count data from 1982 to 1996.

in Baird et al. 1905) and were formerly common winter residents south to Brownsville, but by 1974 they were reported as only casual south of 30° N latitude (Oberholser 1974).

Population trend

Historically, the breeding range has contracted, and a long-term population decline is evident (Roberts 1936, Stewart 1975, Salt and Salt 1976, Gollop 1978, McNicholl 1988). These declines have been attributed to the conversion of native prairies to agriculture (Fairfield 1968, Gollop 1978, McNicholl 1988) and are likely to continue as more native rangeland is converted to cropland (Robbins et al. 1986) and urban development (Fairfield 1968). A patchy breeding distribution combined with opportunistic shifts to areas recently burned, mowed, or grazed may render BBS data unreliable for this species (Hill and Gould 1997). Nevertheless, BBS data from 1966 to 2001 indicate that survey-wide (U.S. and southern Canada), chestnut-collared longspurs are declining at an annual rate of 2.0 percent per year ($P = 0.01$; **Figure 4**). Other statistically significant ($P \leq 0.05$) declines by region (where $n > 25$ BBS routes), include North Dakota (1.6 percent per year; $P = 0.05$; **Figure 5**) and South Dakota (6.8 percent per year; $P = 0.01$; **Figure 6**). Marginally significant declines ($0.05 < P \leq 0.10$) occurred in the Great Plains Roughlands Physiographic Stratum (3.6 percent per year; $P = 0.10$), the Central BBS region (2.1 percent per year; $P = 0.07$), USFWS Region 6 (includes USFS Region 2 states plus Utah, Montana, and North Dakota; 2.1 percent per year; $P = 0.07$), and the U.S. (2.1 percent per year; $P = 0.07$). All other state or physiographic strata trend estimates were non-significant (Sauer et al. 2001). The BBS trend estimates map (**Figure 7**) suggests that the declines are occurring for the most part in USFS Region 2 states, plus Montana and North Dakota. The RMBO's species monitoring plan (Leukering et al. 2000) lists the population trend of the chestnut-collared longspur as "uncertain" in Colorado.

Activity pattern

Chestnut-collared longspurs depart their wintering grounds in late February and March, with migration extending into early to late April (Arizona, New Mexico, Texas, Oklahoma, Kansas; Phillips et al. 1964, Fairfield 1968, Oberholser 1974, Baumgartner and Baumgartner 1992, Thompson and Ely 1992, Hill and Gould 1997). Migrating stragglers may be encountered

as late as early May (Arizona; Phillips et al. 1964) to mid-May (California; Small 1994). They arrive in numbers on the breeding range in April (Saskatchewan and Wyoming; Maher 1973, Dorn and Dorn 1990), mid-April (Colorado; Andrews and Righter 1992), mid-April to mid-May (Manitoba and South Dakota; Cleveland et al. 1988, South Dakota Ornithologists' Union 1991), late-April (North Dakota and Minnesota; Stewart 1975, Janssen 1987), and mid- to late-April (Alberta; Semenchuk 1992). Males leave the wintering grounds before females (Oklahoma; Sutton 1967) and are the first to arrive on the breeding grounds (Hill and Gould 1997). Regionally, spring arrival dates show little variation, but late, cold springs may delay the arrival of chestnut-collared longspurs on the breeding grounds (Maher 1973).

The breeding season extends from early March (south) to mid-August (Hill and Gould 1997). The median first-egg date in an Alberta study was 14 May, the median nest-leaving date (Saskatchewan) was 28 June, and the latest nest-leaving date for a second or later brood (Saskatchewan) was 16 August (Maher 1973, Hill and Gould 1997).

Fall departure dates from the breeding grounds are variable, extending from mid- to late September (Minnesota and Canadian Prairie Provinces; Maher 1973, Salt and Salt 1976, Janssen 1987, Cleveland et al. 1988), September (Wyoming, South Dakota; Dorn and Dorn 1990, South Dakota Ornithologists' Union 1991), and September and October (North Dakota; Fairfield 1968). A few individuals may linger until mid-November (Minnesota; Janssen 1987). Arrival dates on the wintering grounds occur from October to December, peaking mid-October to early November (Hill and Gould 1997).

Chestnut-collared longspurs migrate and winter in flocks (Hill and Gould 1997). On the breeding grounds, they begin flocking (juveniles first, then adults) mid-July to mid-August (Harris 1944); by early September, flocks of 20 to 50 birds may be observed (Maher 1973). Flocks forage in ditches, dry sloughs, and rough ground outside of the breeding areas (Harris 1944).

On the breeding grounds, chestnut-collared longspurs are active throughout the daylight hours (Hussell 1972), with an average night rest period of 7 hours (range = 6 hours, 50 min. to 7 hours, 10 min.; $n = 4$).

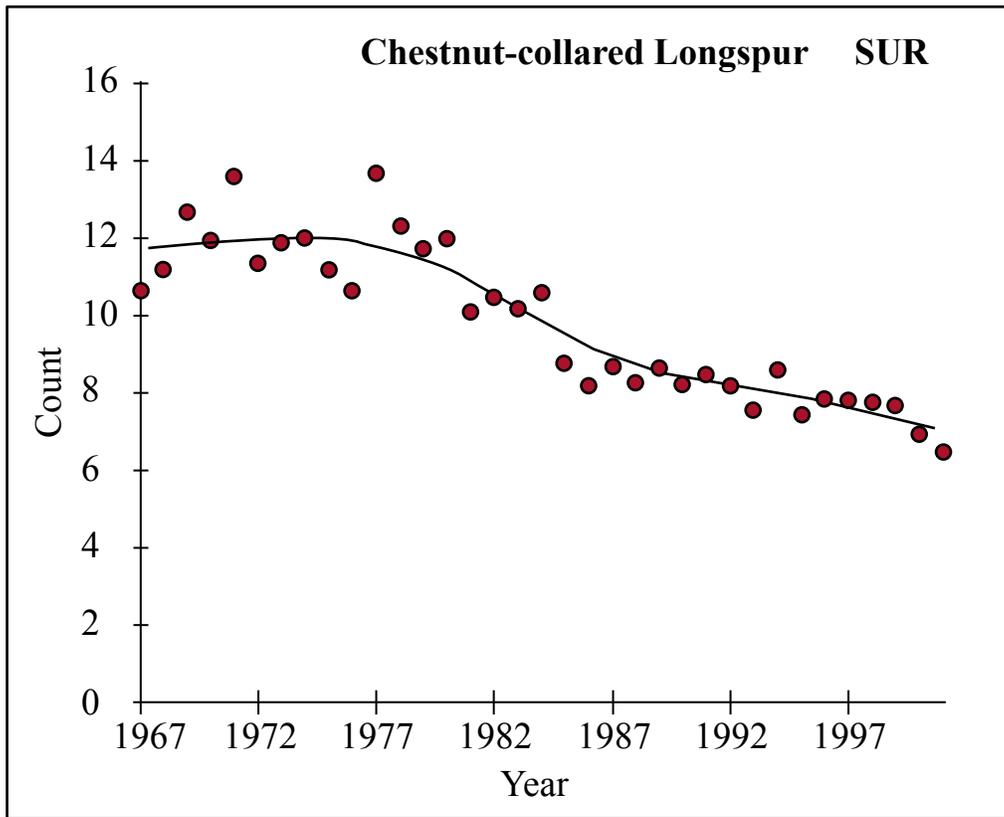


Figure 4. Population trend (average number of birds per route) of chestnut-collared longspur survey-wide (U.S. and Canada) from 1967 to 2001.

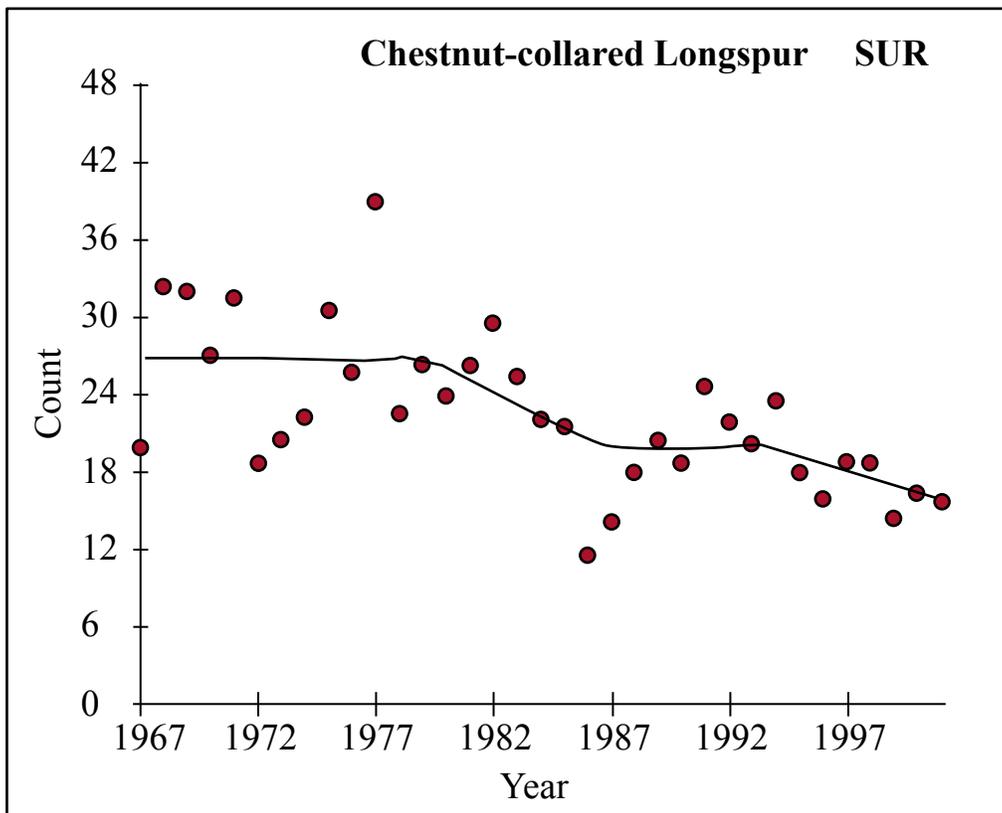


Figure 5. Population trend (average number of birds per route) of chestnut-collared longspur in North Dakota from 1967 to 2001.

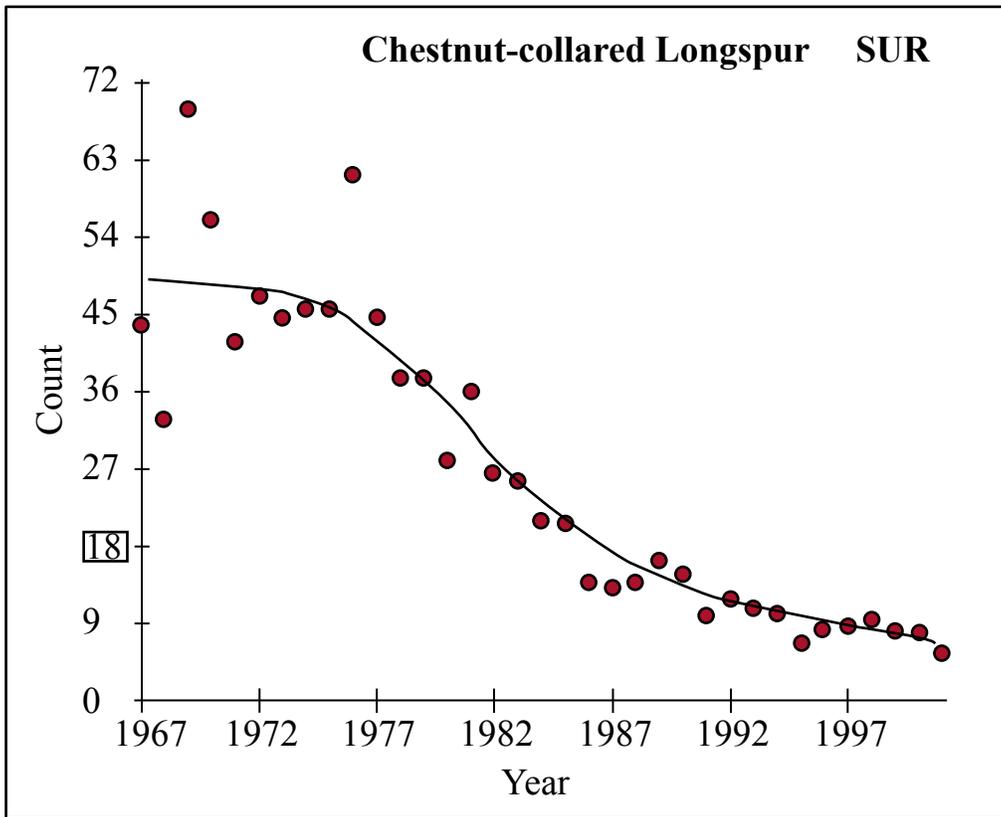


Figure 6. Population trend (average number of birds per route) of chestnut-collared longspur in South Dakota from 1967 to 2001.

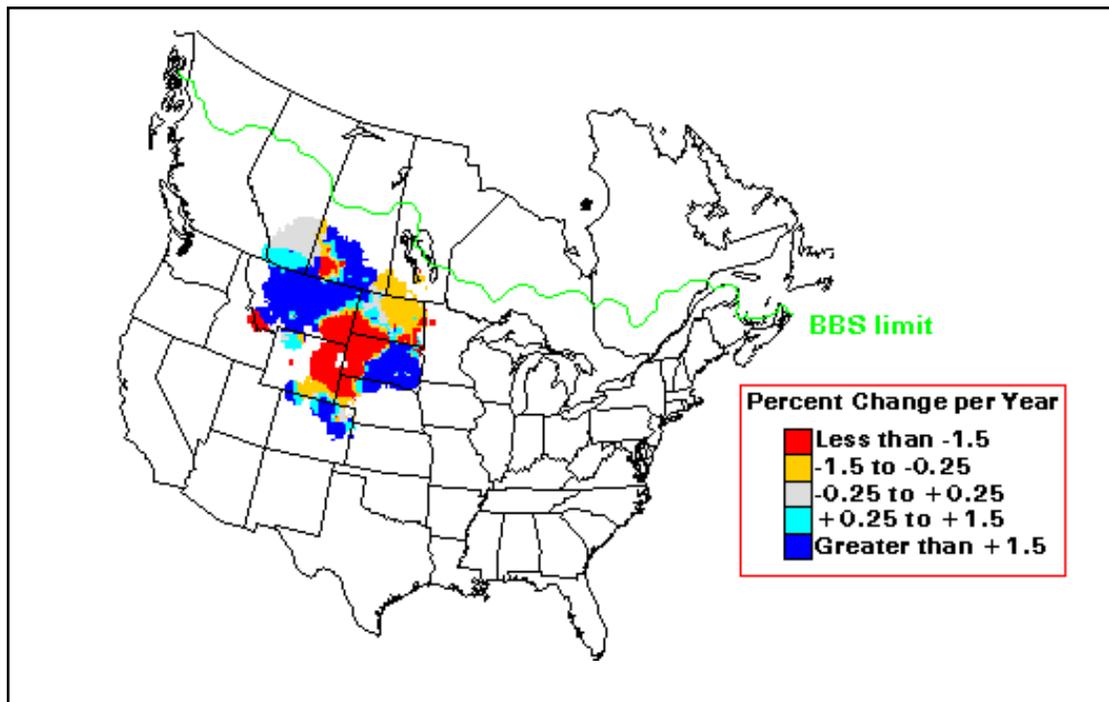


Figure 7. Breeding Bird Survey trend map (average percent population change per year) for chestnut-collared longspur from 1966 to 1996.

Habitat

Habitat associations

Chestnut-collared longspurs are native prairie specialists, preferring level to rolling native mixed-grass and shortgrass uplands, and, in drier habitats, moist lowlands (DuBois 1935, Fairfield 1968, Owens and Myres 1973, Stewart 1975, Wiens and Dyer 1975, Kantrud and Kologiski 1982, Anstey et al. 1995). Breeding habitat is typically mixed-grass or shortgrass prairie, <20 to 30 cm tall, that has been recently grazed or mowed (Fairfield 1968, Owens and Myres 1973). Pastures planted with exotic grasses such as crested wheatgrass (*Agropyron cristatum*) are also used, as are mowed areas such as airstrips (Stewart 1975), but native pastures are preferred. Grazed or mowed tallgrass prairie is also used during the breeding season (Wyckoff 1986b). Compared to McCown's longspur, the chestnut-collared longspur prefers areas with taller grass species such as needlegrasses (*Stipa* spp.) and wheatgrass (*Agropyron* spp.) (Baldwin and Creighton 1972). Common plant associates are fescues (*Festuca* spp.), blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), prairie junegrass (*Koeleria cristata*), wheatgrass, cactus (*Opuntia* spp.), pasture sage (*Artemisia frigida*), and occasional shrubs such as western snowberry (*Symphoricarpos occidentalis*) and silverberry (*Eleagnus commutata*) (Harris 1944, Owens and Myres 1973, Kantrud 1981, Davis 1994).

Chestnut-collared longspurs avoid excessively shrubby areas (Arnold and Higgins 1986) and grasslands with dense litter accumulations (Renken 1983, Berkey et al. 1993, Anstey et al. 1995). In order of preference, chestnut-collared longspurs use native grassland, followed by other grazed grasslands (e.g., those planted with exotics such as crested wheatgrass), followed by hayland (Fairfield 1968, Owens and Myres 1973, Maher 1974a, Stewart 1975, Faanes 1983, Anstey et al. 1995, Skeel et al. 1995, Davis and Duncan 1999).

In Saskatchewan, chestnut-collared longspurs were more frequent in native and seeded pastures than in either hayland or cropland. Within grazed, mixed-grass areas, their occurrence was negatively associated with litter depth and the density of narrow-leaved grasses ≤ 10 cm tall (Davis et al. 1999). In another Saskatchewan study, they were more abundant on native pasture in good condition than in native pasture in poor condition; thus, overgrazing is probably detrimental (Anstey et al. 1995).

In North Dakota mixed-grass prairie, chestnut-collared longspurs prefer moderately to heavily grazed areas (Kantrud 1981, Faanes 1983); grazed areas with sparser vegetation, more bare ground, and less litter than unused areas (Renken 1983, Renken and Dinsmore 1987); grazed or hayed mixed-grass prairie (Stewart 1975); and plant communities dominated solely by native grass (*Stipa* spp., *Bouteloua* spp., *Koeleria* spp., and *Schizachyrium* spp.) (Schneider 1998). Longspurs avoid plant communities dominated by shrubs and introduced grasses (smooth brome [*Bromus inermis*], Kentucky bluegrass [*Poa pratensis*], and quackgrass [*Agropyron repens*]) (Schneider 1998).

Within drier shortgrass habitats, chestnut-collared longspurs prefer wetter, taller, and more densely vegetated areas than McCown's longspurs and horned larks (*Eremophila alpestris*) (DuBois 1937, Strong 1971, Creighton and Baldwin 1974, Kantrud and Kologiski 1982, Wershler et al. 1991). Low, moist areas and wet-meadow zones around wetlands provide suitable habitat in these drier, shortgrass areas (DuBois 1937, Rand 1948, Stewart 1975). In Colorado, chestnut-collared longspurs prefer areas with a heterogeneous cover of shortgrasses and mixed-grasses, only lightly grazed (Giezantner 1970); they were often associated with bunchgrasses (Creighton and Baldwin 1974).

In moister, more thickly vegetated mixed-grass habitat, chestnut-collared longspurs avoid tall, dense vegetation, preferring sparser upland grasslands with more bare ground (Renken 1983, Renken and Dinsmore 1987, Berkey et al. 1993, Johnson and Schwartz 1993, Anstey et al. 1995). In such habitats, some grazing appears to benefit this species, with the caveat that the species is more likely to be present in native grassland with high range-condition scores compared to pastures with low range-condition scores (Wroe et al. 1988, Anstey et al. 1995).

Similarly, breeding occurred more frequently on idle shortgrass and mowed mixed-grass prairie than in moister low meadow zones or pasture in Nebraska (Johnsgard 1980).

Although usually avoided, cultivated fields, fallow fields, stubble, and dense, idle areas may support a small number of chestnut-collared longspurs if the vegetation is of suitable height and density (Fairfield 1968, Owens and Myres 1973, Stewart 1975, Anstey et al. 1995). Unlike in native grasslands, litter depth is positively correlated with the number of productive territories

and total productivity in Alberta croplands (Martin and Forsyth 2003). Conservation Reserve Program (CRP) lands may also be used (Johnson and Schwartz 1993). Other habitats used include waste and idle areas, such as fence borders and mowed aircraft landing strips (DuBois 1935, Fairfield 1968, Stewart 1975).

Native grassland is favored during migration (Kansas; Thompson and Ely 1992). Wintering ground habitats include grasslands, deserts, and plateaus dominated by low grasses and forbs, where the vegetation is <0.5 m high (Raitt and Pimm 1976, Grzybowski 1982). Cultivated fields are commonly used in Texas (Oberholser 1974). Dominant plants include grama grasses (*Bouteloua* spp.), dropseed (*Sporobolus* spp.), needlegrass, big bluestem (*Andropogon saccharoides*), and little bluestem (*Schizachyrium scoparium*). Plant associates in the Chihuahuan Desert wintering areas include black grama (*Bouteloua eriopoda*) and mesa dropseed (*Sporobolus flexuosus*), with scattered soaptree yucca (*Yucca elata*) and low shrubs such as broomweed (*Gutierrezia sarothrae*) (Raitt and Pimm 1976). Grzybowski (1982) reported chestnut-collared longspurs as common in the bluestem-grama prairie (Kuchler 1964) of Oklahoma and the grama-buffalograss plains of Texas. Throughout their winter range, longspurs are associated with isolated water sources (Heermann in Coues 1874); migratory congregations are also common around water sources (Osgood 1903).

Microhabitat

Chestnut-collared longspurs nest in areas of native vegetation, usually <20 to 30 cm in height, but territories usually have taller grasses (e.g., needlegrass, wheat grass) than those of McCown's longspurs (Harris 1944, Fairfield 1968, Owens and Myres 1973). Chestnut-collareds do not normally nest in cultivated fields (Owens and Myres 1973), but they will use "tame" or seeded grazing pastures planted with domestic grasses. Native grasslands are preferred, and chestnut-collareds will opportunistically breed in recently grazed, mowed, or burned areas (Owens and Myres 1973). In Colorado, Creighton and Baldwin (1974) reported that 83 percent of nests ($n = 34$) in native shortgrass prairie were associated with red threeawn (*Aristida longiseta*), which arched over the nests and provided nest cover and concealment.

In Alberta, most nests were exposed on the north and west sides and protected by vegetation on the south and east sides (Hill and Gould 1997). Lloyd and Martin (in press) recently demonstrated a causal

link between variation in longspur nestling growth and variation in nest microclimate arising from nest-orientation preferences. Nests are often placed near cattle dung pats and rocks (Harris 1944, Fairfield 1968), but it is unknown if this is related to a microclimate benefit. Smith and Smith (1966) found that 37 of 38 nests were well concealed in grasses, rose (*Rosa* spp.), sage (*Artemisia* spp.), or western snowberry in Saskatchewan. Chestnut-collared longspurs may be sensitive to ground temperatures and/or ground moisture in selecting territories as is thought to be the case for McCown's longspurs (Felske 1971).

Territoriality

Territories of male chestnut-collared longspurs do not overlap and tend to be clumped together in large, isolated aggregations (Hill and Gould 1997). Territory sizes for two males in Manitoba were about 0.2 ha and 0.4 ha (Harris 1944). In Saskatchewan, territories were about 0.4 to 0.8 ha, increasing to almost 4 ha in marginal habitat (Fairfield 1968). In southeastern Alberta, territories were about 1 ha (Hill and Gould 1997). In South Dakota, territories were about 91 m across (0.65 ha), and no nests were closer together than 91 m (Fairfield 1968). Winter territoriality has not been studied.

Spatial patterns, landscape mosaic, juxtaposition of habitats

Chestnut-collared longspurs prefer large expanses of mixed-grass or shortgrass prairie. In Saskatchewan, for example, minimum area requirements are about 58 ha (Saskatchewan Wetlands Conservation Corporation 1997). Area sensitivity has been well established, and habitat fragmentation is generally thought to be one of the primary causes of avian population decline. Small fragments of grasslands cannot support species that need interior habitats or large expanses of grasslands (Samson 1980, Johnson and Temple 1986), and grassland birds are more likely to occur on large patches of grassland than on small ones (Illinois: Herkert 1994; Maine: Vickery et al. 1994). Herkert et al. (2003) found higher nest predation in small (<100 ha) than in large (>1000 ha) prairie fragments in five mid-continental states. O'Connor et al. (1999) report that grassland bird species are more influenced by habitat patch variables and less by landscape composition than other bird species. Few studies have addressed patch size and fragmentation effects on longspurs, but one study on McCown's longspurs, which is still in progress, did not find differences in longspur abundance in either 1997 or 1998 between fragmented (a 9 km² block of 45 percent

grassland and 55 percent agricultural and CRP lands) and intact (a 9 km² block of 100 percent grassland) sites: 1997, intact = 0.68 ± 0.78 SD birds per ha, fragmented = 0.45 ± 0.48 SD birds per ha, $P = 0.504$; 1998, intact = 0.44 ± 0.53 SD birds per ha, fragmented = 0.52 ± 0.60 SD birds per ha, $P = 0.785$) (S. Skagen personal communication 2004).

Habitat change and causes

The change in the extent of habitat available to chestnut-collared longspurs over time is mostly due to losses to agricultural and urban development, especially the conversion of mixed-grass and shortgrass prairies to cultivated fields (Stewart 1975). Conversion of native prairie to cropland eliminates this species from an area (Owens and Myres 1973). The most significant population declines occurred prior to the initiation of the Breeding Bird Survey. Mixed-grass prairie losses to cropland range from 72 percent to over 99 percent in North Dakota, Nebraska, Alberta, Saskatchewan, and Manitoba (Samson and Knopf 1994). The extent of the loss of shortgrass prairie to agriculture (especially to winter wheat on marginally arable lands) is also significant. In Saskatchewan, for example, only 17 percent of the original native prairie remains; in Wyoming over 20 percent has been lost (Samson and Knopf 1994). Nearly 32 percent of the shortgrass prairie region in the southwestern Great Plains (including 30.7 percent in Colorado, 78 percent in Kansas, 65.4 percent in Nebraska, and 12.1 percent in Wyoming) has been converted to cropland (Knopf and Rupert 1999). More recent rangeland losses to agriculture are smaller by comparison, but not insignificant. In Colorado, for example, 3.8 percent of the shortgrass and mixed-grass prairie east of the Rockies was lost to agriculture and urban expansion from 1982 to 1997 (Seidl et al. 2001).

The second principal cause of habitat change has been the removal of primary, native grazers (bison (*Bison bison*), pronghorn (*Antilocapra americana*), and prairie dogs). The once-heterogeneous, patchy grassland landscape that was a consequence of the intense, uneven grazing by these species is now undoubtedly much altered compared to historical conditions.

Factors on the wintering grounds also may have contributed to breeding ground declines.

Habitat availability relative to occupied habitat

There are no reports of large areas of unoccupied habitat. In winter, longspur distribution patterns shift from year to year, but this is thought to be due to variability the distribution of seed resources (Grzybowski 1982).

Food habits

The diet of chestnut-collared longspurs consists primarily of grass seeds, insects, and spiders. Prey are mostly obtained by walking and picking up seeds and insects off of the ground (Semenchuk 1992), but also by gleaning insects off of vegetation and pulling ripe seeds off of grasses. In a Colorado study, chestnut-collared longspurs captured 48 percent of their food on the ground, 31 percent by gleaning, and 21 percent by flycatching (flushing insects from the ground) (Baldwin and Creighton 1972). Stomach content analysis in Colorado ($n = 4$ adult stomachs) revealed a diet of 51 percent crickets and grasshoppers (Orthoptera), 28 percent seeds (mainly grass), 19 percent beetles (Coleoptera, especially Curculionidae and Chrysomelidae), 1 percent leafhoppers (Homoptera), and 1 percent spiders (Araneida) (Wiens 1973). Adults captured more crickets (Gryllidae) than grasshoppers (Acrididae) and consumed few insect larvae; the mean length of invertebrates consumed by adults was 9.6 mm ($n = 68$) (Wiens 1973). Fairfield (1968) reported 72 percent animal food (beetles, grasshoppers, spiders) and 28 percent seeds (dropseed, needlegrass, wheat, and sunflower [*Helianthus* spp.]) in summer, and 100 percent seeds in winter ($n = 43$ stomachs). In migration and in the southwestern U.S. in winter, chestnut-collared longspurs eat grain (especially wheat in spring) and seeds of dropseed, sunflower, needlegrass, three-awn (*Aristida* spp.), and pigweed (*Amaranthus* spp.) (Oberholser 1974).

Young chestnut-collared larkspurs are fed a greater variety of invertebrate species than the young of many other grassland passerines; invertebrates from 14 different orders were represented in nestling gullet samples at Matador, Saskatchewan (Maher 1974b). Major food items fed to nestlings in Saskatchewan included leafhoppers (8 to 25 percent of total), grasshoppers (30 to 66 percent), spiders (3 to 8 percent),

and larvae of butterflies and moths (Lepidoptera, 9 to 27 percent; $n = 260$ gullet samples). As the season progressed, the importance of caterpillars in the nestling diet declined, while grasshoppers became more important (Maher 1974b).

Breeding biology

Phenology of courtship and breeding

Chestnut-collared longspurs arrive on the breeding grounds from late March to late April, with males preceding females by one to two weeks (Currie 1892, Fairfield 1968, Maher 1973, Johnsgard 1980, O'Grady et al. 1996, Hill and Gould 1997). Birds remain in small groups of five or six birds for one to two weeks prior to the initiation of courtship and territorial establishment. Males begin singing within two weeks and sing and display throughout incubation, but with less intensity than prior to mating; males sing even less when feeding young (Fairfield 1968, Hill and Gould 1997). Singing abates near the end of the breeding season (late July to early August) as pair bonds dissolve and flocks begin to form. Pair formation and initiation of nesting may depend on weather (Hill and Gould 1997).

Nest building begins in late April to mid-May in Alberta (Hill and Gould 1997). Some females apparently initiate the clutch before the nest is complete and have been observed carrying nesting material to the nest site after laying has commenced (Hill and Gould 1997). Egg laying generally begins in early to mid-May with early egg dates being 27 April (Alberta; Hill and Gould 1997), 3 May (Montana; DuBois 1935), 4 May (South Dakota; South Dakota Ornithologists' Union 1991), 6 May (North Dakota; Stewart 1975), and 10 May (Saskatchewan; Maher 1973). Cold springs and late snowstorms may delay breeding; clutch initiation varied from 10 May in 1971 to 26 May 1968 in Saskatchewan (Maher 1973) and from 27 April in 1994 to 12 May in 1995 in Alberta (Hill and Gould 1997). Confirmed first brood initiation in Alberta spanned 39 days (27 April – 4 June; median = 14 May; $n = 3$ years, 76 nests) (Hill and Gould 1997). The earliest fledging dates in Alberta and Saskatchewan were 20 May and 4 June, respectively (Maher 1973, Hill and Gould 1997).

Considering both first and later broods, clutch initiation spanned 74 days (10 May – 23 July; $n = 4$ years) in Saskatchewan and 84 days (27 April – 19 July; $n = 3$ years) in Alberta (Maher 1973, Hill and Gould 1997). Median clutch initiation was 3 June in both Saskatchewan ($n = 111$ nests) and Alberta ($n = 212$ nests). Median hatching and fledging dates

in Saskatchewan were 18 and 28 June, respectively (Maher 1973).

Second broods are not uncommon, and occasional third broods have been reported (Hill and Gould 1997). Second broods may be initiated as early as four weeks following the initiation of a successful first brood and in as little as six days after the first brood has left the nest (mean = 9.7 days, range = 6 to 18; $n = 28$ nests) (Hill and Gould 1997). The median initiation date of second broods in Alberta was 29 June ($n = 3$ years, 38 nests; range = 8 June – 14 July); two third broods were initiated on 13 and 19 July (Hill and Gould 1997). The latest fledging dates are 9 August (Alberta; Hill and Gould 1997), 14 August (Manitoba; Harris 1944), and 16 August (Saskatchewan; Maher 1973).

Pairs will attempt as many as four clutches in a season after successive nest failures. The interval between nest failure and initiation of the next clutch is a little as four days (mean = 5.5 days, range = 4 to 12, $n = 34$ nests) (Hill and Gould 1997).

Courtship and breeding behavior

Courtship and territorial establishment begin with aerial flight displays and flight songs. The male flies upward, circles and undulates, and then sings while descending with the tail spread. Male chestnut-collared longspurs often flap their wings on descent, in contrast to McCown's longspurs (Sibley and Pettingill 1955). Flight displays are generally ≤ 15 m above the ground, lower than those of McCown's, which occur at ≥ 20 m above the ground (Hill and Gould 1997). Songs are usually issued in flight but may occasionally be given from shrubs, fences, rocks, or other low perches, such as Canada thistle (*Cirsium arvense*) (Harris 1944, Fairfield 1968, Creighton and Baldwin 1974). The song perch is often located near the nest (Fairfield 1968). Songs are thought to have a dual function: territorial defense, as neighboring males frequently counter-sing; and mate attraction, as females are often attracted to song playback (Hill and Gould 1997).

During on-the-ground courtship displays, the male fans his wings and tail, erects his nape feathers, and holds his head high; he may then begin a series of head-bowing displays. Successful copulations are almost always initiated by the female as she flies low over the male and lands near him. She then lifts her tail, throws her head back, and rapidly flutters her wings, sometimes holding nesting material in her bill when initiating copulations (Fairfield 1968). Copulation then ensues as the male mounts the female and makes cloacal

contact, fluttering his wings to keep his balance (Hill and Gould 1997). The social pair bond persists throughout the breeding season (Harris 1944). Males defend territories, and even do so when unpaired (Wyckoff 1986b). Females attack and chase intruding females, but it is unknown whether this behavior is related to territory or mate defense (Hill and Gould 1997).

Female chestnut-collared longspurs probably select the nest site and then build the nest alone in a rounded hollow excavated in the ground (Bailey and Niedrach 1965). Males may pick up pieces of grass when accompanying nest-building mates, but there is no evidence that this material is ever incorporated into the nest. The female collects most nesting material on territory within 20 m of the nest site (Fairfield 1968) and is often accompanied by the male. Nests can be completed within as little as four days. The nest is an open cup, thin-walled, but tightly woven (Harris 1944) and is usually under a clump of grass and often beside a cattle dung pat. Most nests are constructed entirely of grasses, with occasional leaves or herbaceous stems sometimes incorporated, and are lined with hair, feathers, and/or rootlets (DuBois 1935, Fairfield 1968). Outside diameter x outside depth of nests averages 8.8 x 5.1 cm ($n = 7$) and inside diameter x inside depth averages 6.0 x 4.3 cm ($n = 9$) (Fairfield 1968). A new nest is built for each nesting attempt, with only one record of nest reuse (Hill and Gould 1997). New nests are located near previous nests (mean = 31.5 m; range = 0.9 to 68.0; $n = 55$).

Eggs are generally white, gray, or pale buff, marked with brown, reddish-brown, or purple spots, blotches, or scrawls (Harris 1944, Fairfield 1968). They are oval, rarely elliptical or spherical, and average 18.7 mm (range = 16.2 to 20.8) x 14.2 mm (range = 12.7 to 15.9) ($n = 90$ eggs; Fairfield 1968). Egg mass is 2.0 g, about 10 percent of female mass (Sadler and Maher 1974).

Eggs are laid on successive days (Harris 1944) in the early morning (0600-0730 CST in Saskatchewan and 0455-0530 MST in Alberta) (Fairfield 1968, Hill and Gould 1997). Intraspecific nest parasitism has not been reported. Only females develop a brood patch and incubate (DuBois 1935, Harris 1944) although there is one record of a male repeatedly sitting on a nest with eggs over a period of several days (Wyckoff 1983); the fact that female plumage occasionally closely resembles that of males leaves this record open to question (J. Lloyd personal communication 2004) Incubation begins when the clutch (3 to 5, rarely 2 or 6 eggs) is completed (DuBois 1935). However, asynchronous hatching (up to

49 hours; Hussell 1972) suggests that the female may begin incubating before clutch completion.

The incubation period is 10 to 12.5 days (DuBois 1935, Harris 1944) with a recorded maximum of 15 days (Hill and Gould 1997). Creighton and Baldwin (1974) reported a mean incubation period of 11.9 days ($n = 26$ nests); inclement weather may cause extended incubation. Males do not generally feed incubating females on the nest, but there is one report of a male approaching an incubating mate with a mouthful of insects (Fairfield 1968). J. Lloyd (personal communication 2004) reports incubation feeding at three of 50 video-taped nests. Males typically perch in the general vicinity of the nest during incubation, appearing to “stand guard” (Bailey and Niedrach 1938, Harris 1944, Wyckoff 1983). Females usually do not flush from the nest unless an observer is <1.5 m from the nest. Once flushed, they perform distraction displays, fluttering through the grass with wings spread. Following incubation breaks, females approach the nest warily, foraging or preening near the nest before walking to the nest and resuming incubation. Males often follow females to nest sites (Fairfield 1968, Hill and Gould 1997). In Alberta, incubating females spent 46.7 percent of their time on the nest with mean incubation bouts of 12 min., 41 sec. and mean incubation breaks of 16 min., 3 sec. ($n = 20$ females observed for 11 hours, 45 min.) (Hill and Gould 1997).

Hatching of the entire clutch is reported as occurring over a period of 33.3 hours (range 25 to 49, $n = 3$ clutches; Hussell 1972). Individual eggs hatch in 1 to 1.5 hours (Moriarty 1965) although Harris (1944) noted one case in which hatching of one egg required more than half a day. Adults dispose of eggshells by eating them or by carrying them away from the nest.

The newly hatched young are altricial, covered with a buffy, gray down, and their eyes are closed. Mean mass at hatching is 1.9 g (Sadler and Maher 1974) to 2.1 g (range = 1.3 to 2.7; $n = 36$; Hussell 1972, Hill and Gould 1997). By day two, young gape for food in response to noise near the nest, by day six they gape in response to the wave of a hand, by day seven nestlings call in response to parents bringing food, and by day nine the young are moving around in the nest and preening (Fairfield 1968). Young leave the nest at a mean mass of 15.1 g, or 74.5 percent of adult mass, and may be as old as 60 days before attaining full adult mass (Sadler and Maher 1974). Asynchronous hatching often gives rise to differences in nestling growth rates, resulting in death of the smallest nestling in some nests.

Both parents brood the nestlings, but females do 95.3 percent of all brooding ($n = 109$ hours observation; Hill and Gould 1997). For the first two to three days after hatching, females may brood for up to 50 percent of daylight hours. The young are brooded less as nestlings grow older; and by day 6, only 14.5 percent of the female's time is spent brooding, while the male spends <1 percent of his time brooding (Hill and Gould 1997). Adults shelter the young from the sun in extreme heat by straddling the nest with wings partly spread (Hill and Gould 1997).

Both parents feed the young. In Alberta on day 6 of the nestling phase, males made 6.2 ± 3.5 (SD) feeding trips per hour (range = 0 to 14, $n = 52$) and females made 5.5 ± 2.7 (SD) trips per hour (range = 0 to 13, $n = 52$). Male and female feeding trips combined varied from 1 to 21 feeding trips per hour (mean = 11.6 ± 4.5 [SD], $n = 52$) (Hill and Gould 1997).

Both parents remove fecal sacs and either eat them or carry them away from the nest (Harris 1944) dropping them 20 to 40 m from the nest (Hill and Gould 1997). Parents also remove dead nestlings from the nest (DuBois 1937, Fairfield 1968).

Young leave the nest at 10 days (range = 9 to 14 days) after hatching ($n = 36$ longspur young; Harris 1944, Moriarty 1965). Both adults feed fledglings, but the female reduces or ceases her care of young if she initiates a subsequent brood. In such cases, the male provides most of the fledgling care. Fledglings continue to receive food for about 14 days after leaving the nest, and as long as 22 days (Hill 1998). Parents will not feed older fledglings unless they beg noisily (Harris 1944); adults may chase off older begging fledglings. At 10 days, fledglings cannot fly, and remain crouched in the grass waiting for food from adults. Young are capable of short, labored flights at 11 to 12 days (Harris 1944). Young remain on or near their natal territory until late in the breeding season. By late July, immature birds begin to form flocks (Harris 1944). Young birds apparently do not return to natal breeding areas as extensive banding of nestlings ($n = 325$) in Alberta has failed to document any returns (Hill and Gould 1997).

Site and mate fidelity

Male chestnut-collared longspurs either display stronger philopatric tendencies or have higher survivorship than females (Hill and Gould 1997). Of 30 banded males, 20 (67.7 percent) returned to breed the next year and five of 18 (27.8 percent) returned for two subsequent years; only 21 of 65 (32.3 percent)

females returned the following year and only seven of 35 (20.0 percent) returned in two subsequent years. Of the birds that did return to the study site, 85 percent of the males ($n = 20$) and 43 percent of the females ($n = 21$) returned to the same territory; of the birds that did not return to the same territory, females moved twice as far as males from their previous territory (Hill and Gould 1997). Males that are unsuccessful in securing a mate in the previous season were noted to switch to a new territory (Wyckoff 1986b). Natal philopatry is low; of 325 nestlings banded in Alberta, none were resighted in subsequent years (Hill and Gould 1997). There is no specific information on fidelity to wintering site. Winter site fidelity would appear to be low as winter distribution patterns shift from year to year, likely due to variability the distribution of seed resources (Grzybowski 1982).

The social pair bond persists throughout the breeding season (Harris 1944), but birds may take new mates in the event of the disappearance (death) of the original mate (Hill and Gould 1997). Evidence of between-season mate fidelity is scant; of eight cases where both members of the pair returned to the breeding grounds in a subsequent season, four pairs reunited (50 percent) and four pairs divorced and mated with new partners (Hill and Gould 1997).

Demography

Genetic issues

The chestnut-collared longspur is monotypic, and no geographic variation or subspecies has been described (Hill and Gould 1997). Sibley and Pettingill (1955) reported a hybrid between chestnut-collared and McCown's longspurs. Chestnut-collared longspurs are socially monogamous, and polygyny has not been reported. Female-female aggression may prevent males from becoming socially polygynous (Fairfield 1968) with monogamy likely enforced by mated females, as suggested by observations of agonistic responses to intruding females attempting to associate with the territorial female's mate. Nevertheless, extra-pair copulations are not uncommon: 5.9 percent of successful copulations ($n = 17$) in Alberta were extra-pair copulations, 17.6 percent ($n = 85$) of nestlings were extra-pair young, and 32 percent ($n = 25$) of all nests contained at least one extra-pair young (Hill and Gould 1997). Second broods were more likely to have at least one extra-pair young (60 percent; $n = 10$) than first or replacement broods (13.3 percent; $n = 15$). Of those nests ($n = 8$) in which extra-pair paternity occurred, 60.5 percent of nestlings were extra-pair young.

The continued fragmentation of mixed-grass and shortgrass habitats may have genetic consequences. Fragmentation isolates populations, increases the likelihood of local extinctions, decreases the probability of colonization, and genetically isolates populations. This leads to increased probabilities of inbreeding and genetic drift, and a lowering of genetic diversity. Fragmentation can potentially turn continuous populations into “metapopulations of semi-independent demes”, which gradually disappear (Risser 1996).

Recruitment, survival, immigration, age at reproduction

Chestnut-collared longspurs probably breed at one year of age, although this has not been documented. They breed annually and are not known to skip years between breedings (Hill and Gould 1997). Birds continue to renest throughout the breeding season if previous attempts are not successful. Second broods after successful first nestings are not uncommon, and occasional third broods have been reported (Strong 1971, Hill and Gould 1997). Competition for food from feeding parents between first and second broods is apparently uncommon, but Hill (1998) reported one such instance: all nestlings of a second brood died of starvation, apparently because one fledgling from the first brood out-competed its second-brood siblings for food. However, Hill (1998) did not find any indication that brood reduction was more common in second than in first broods.

The clutch size is most often three to five eggs; occasionally two or six eggs are laid (DuBois 1935, Harris 1944, Maher 1973, Hill and Gould 1997). The mean clutch size is 4.07 eggs ($n = 407$ clutches, 4 different studies), and the modal clutch size is four eggs (67.3 percent of all clutches); 19.4 percent and 11.3 percent of clutches contained five and three eggs, respectively (Hill and Gould 1997). In Colorado, Creighton and Baldwin (1974) reported a mean clutch size of 3.53 ($n = 26$ nests), and Strong (1971) reported a mean of 3.3 ($n = 16$). Clutches initiated mid-season tend to be larger than those initiated early or late in the season (Maher 1973), but the differences are not statistically significant (Hussell 1972).

Four different studies reported hatching success (number of nestlings per number of eggs): 77.1 percent in Alberta ($n = 254$ nests; Hill and Gould 1997), 79.5 percent in Manitoba ($n = 8$ nests; Harris 1944), 76.0 percent in Colorado ($n = 26$ nests; Creighton and Baldwin 1974), and 75 to 76 percent in Colorado ($n = 16$ nests; Strong 1971). Fledging success (number

of fledglings per number of nestlings) in Alberta was reported as 62.2 percent (488/784), and it was 91.4 percent (32/35) in Manitoba. Reproductive success (number of fledglings per number of eggs) was 48.0 percent (488/1017) in Alberta and 72.7 percent (32/44) in Manitoba. Nest success (percent of nests that fledged ≥ 1 young) was reported as 55.9 percent (142/254 nests) in Alberta, 45.0 percent in Manitoba ($n = 57$ nests; Davis 1994), 44.9 percent in Montana ($n = 352$ nests; J. Lloyd personal communication 2004), and 47.3 percent in Colorado ($n = 26$ nests; Creighton and Baldwin 1974). In Alberta, a mean of 3.4 young fledged from each successful nest, and in Manitoba, 3.5 young left each successful nest.

Using the Mayfield estimate (Mayfield 1975), egg and nestling mortality rates in a Saskatchewan study ($n = 111$ nests, 3 years) during the egg, hatching, and nestling phases were 0.272, 0.062, and 0.545, respectively (Maher 1973). Total mortality was 0.689, giving a survival rate from laying to fledging of 0.311. Daily egg, hatching, and nestling mortality rates over three years ranged from 0.037 to 0.140, 0.013 to 0.063, and 0.030 to 0.090, respectively. Most of the egg (97 percent) and nestling (72 percent) mortality was attributed to predation (Maher 1973). S. Skagen (personal communication 2004) reported daily survival estimates (eggs and nestlings combined) on the eastern Pawnee National Grassland of Colorado for 1997, 1998, and 2001 as 0.906 ($n = 14$ nests), 0.960 ($n = 16$), and 0.941 ($n = 7$), respectively. Nest success (proportion of nests fledging ≥ 1 young) was reported as 0.114, 0.426, and 0.257 for the same three years, respectively. In a four-year study in Montana, J. Lloyd (personal communication 2004) reported daily survival rates during the laying, incubation, and nestling phases as 0.942 ± 0.028 SE ($n = 37$ nests), 0.960 ± 0.006 ($n = 224$ nests), and 0.944 ± 0.006 ($n = 211$ nests), respectively, yielding an overall Mayfield-estimated success of 30.8 percent.

In a marked population in southeastern Alberta, Hill and Gould (1997) reported that of 156 breeding females over a three-year study period, 80 (51.3 percent) raised one brood, 26 (16.7 percent) raised two broods, 2 (1.3 percent) raised three broods, and 48 females (30.8 percent) were unsuccessful. Females rearing one, two, and three broods produced 3.6 ± 0.9 (SD) young, 6.9 ± 1.3 young, and 9.0 ± 0.0 young, respectively. Successful females raised a mean of 1.3 broods (range = 1.2 to 1.5) per season ($n = 3$ years). There is no information on lifetime reproductive success in this species.

Male reproductive success is confounded by extra-pair paternity: six of 14 males, for which paternity

was examined (Alberta), had extra-pair young (Hill and Gould 1997). The average number of young that were sired by the male and that fledged from successful nests ($n = 25$) was 2.8 while the total number of fledged young was 3.4. The increase in individual male reproductive success as a result of gaining paternity in other males' nests has not been assessed.

There has been only one study (Alberta) of an extensively marked population of chestnut-collared longspurs, but there were few band recoveries (Hill and Gould 1997). Therefore, our knowledge of lifespan, survivorship, and immigration/emigration between populations for this species is limited. Two longspurs banded as adults in Alberta survived to at least the age of four, five of 18 males and seven of 35 females survived to at least the age of three, and 20 of 30 males and 21 of 65 females survived to at least the age of two.

Young birds apparently emigrate from the local area where they fledge as no birds banded as nestlings ($n = 325$) were resighted in the years subsequent to banding (Hill and Gould 1997). Some adults may emigrate, but many are philopatric and return to their previous breeding area (see Breeding behavior, site fidelity, and limitations of site availability on breeding). Population sex ratios and the proportion of the population that breeds are unknown. The possible existence of "floaters" in chestnut-collared populations is also unknown although Wyckoff (1986b) noted that pairing success of territorial males varied from 79 to 100 percent, suggesting an excess of males in some years.

Ecological influences on survival and reproduction

Chestnut-collared longspur survival and distribution may be limited by food availability, at least in the winter: avian granivore biomass was positively correlated to seed abundance in Oklahoma and Texas ($r = 0.78$; Grzybowski 1982). Climatic instability and variation in rainfall create perturbations in productivity, plant species composition, and physiognomic structure (Albertson and Weaver 1944). Productivity is reduced in arid, dry years, lowering seed productivity and likely influencing the distributions of granivorous birds, including longspurs. Much of the structure of avian communities in both winter and summer may be determined by winter resources and the climatic factors that affect them (Pulliam and Enders 1971, Fretwell 1972, Wiens 1974, Raitt and Pimm 1976). Additionally, xeric conditions can magnify the effects of grazing on plant productivity, and changing cultivation practices can completely change the distribution

of winter food resources. Raitt and Pimm (1976) suggest that late-season floods can drastically alter the distribution of seeds and that seed-eating birds should be highly clumped, reflecting the distribution of dense aggregations of seeds. These factors result in a clumped distribution of seed resources, which influences the distribution of wintering birds. The mobility of gregarious, foraging grassland birds allows them to undergo local movements that permit the opportunistic exploitation of localized seed-rich patches (Raitt and Pimm 1976).

During the breeding season, severe and unstable climate patterns are thought to erode the normally close coupling of arthropod abundance with vegetation. Thus, features other than prey abundance and territory-wide vegetation characteristics may drive habitat selection in longspurs, including microclimate at the nest, predation risk, and more efficient foraging in certain microhabitats (Martin 1986).

Spacing, defense and size of area, and population regulation

Chestnut-collared longspur territories are discrete and are aggressively defended by males against conspecific males; males defend territories even when unpaired (Wyckoff 1986b). Fights between males along territory boundaries are common early in the breeding season and less common as the season progresses. Females attack and chase intruding females, but it is unknown whether this behavior is related to territory or mate defense (Hill and Gould 1997). Territories do not overlap, but males may intrude on neighboring territories during disputes. Aggressive interactions are so common that "the territory has no definitely marked boundary, but merges into an area of unclaimed ground" (Harris 1944). Social mates spend >90 percent of their time within 10 m of each other before and during egg laying and then less time as the breeding season progresses. Pairs nest and generally forage within territory boundaries, but both sexes may forage outside the territory, especially when feeding offspring (Hill and Gould 1997). In an Alberta study, off-territory foraging areas were typically dirt roads and cultivated fields adjacent to grassland breeding areas.

Territories tend to be clumped together in large, isolated aggregations (Hill and Gould 1997). Territory sizes for two males in Manitoba were about 0.2 ha and 0.4 ha (Harris 1944). In Saskatchewan, territories were between about 0.4 and 0.8 ha, increasing to almost 4 ha in marginal habitat (Fairfield 1968). In southeastern Alberta, territories were about 1 ha (Hill and Gould

1997). In Saskatchewan, minimum area requirements were about 58 ha (Saskatchewan Wetlands Conservation Corporation 1997). Renests and second brood nests are generally placed near earlier nests (Harris 1944): the average distance between first and subsequent nests in Alberta was 31.5 m (range = 0.9 to 68.0; $n = 55$ territories; Hill and Gould 1997).

Birds are probably not territorial during the winter as flocks form after the breeding season and are reported on the wintering grounds (Hill and Gould 1997). Spacing within winter flocks has not been described. The role that dominance hierarchies may play in the settlement of males on the breeding grounds is unknown.

Dispersal

Juvenile longspurs tend to remain on or near the natal territory until near the end of the breeding season. By late July, immatures begin to form flocks (Harris 1944), and by early September, flocks of 20 to 50 birds may be observed (Maher 1973). Adult longspurs also join in flocks on the breeding grounds, but after immatures. Longspurs then migrate south in flocks (Hill and Gould 1997).

Young birds apparently do not return to their natal breeding areas, as extensive banding of nestlings ($n = 325$) in Alberta has failed to document any returns (Hill and Gould 1997). Adults, however, are philopatric to the breeding grounds. In an Alberta study, 67.7 percent of males ($n = 30$) and 32.3 percent of females ($n = 65$) returned to breed the next year; five of 18 males (27.8 percent) and seven of 35 females (20.0 percent) returned for two subsequent years (Hill and Gould 1997). Of the birds that did return to the study site, 85 percent of males ($n = 20$) and 43 percent of females ($n = 21$) returned to the same territory (Hill and Gould 1997). Of the birds that did not return to the same territory, females moved twice as far as males from their previous territory.

Source/sink, demographically linked populations

There is no evidence of source-sink dynamics in this species. Because there has been only one long-term study of a marked population and few recoveries of banded individuals, there is no information on the possible linkage of populations or metapopulation dynamics.

Factors limiting population growth

Chestnut-collared longspurs are infrequent hosts of the brown-headed cowbird (*Molothrus ater*), and brown-headed cowbird brood parasitism is not known to have a major effect on longspur productivity (Friedmann 1963, Fairfield 1968, Hill and Gould 1997). Of 620 longspur nests from eight different locations, 29 (5 percent) were parasitized, ranging from a low of no parasitism in Alberta ($n = 254$ nests; Hill and Gould 1997) to a high of 23 percent parasitism in South Dakota ($n = 62$ nests; Stewart 1975). Chestnut-collared longspurs may occasionally be parasitized by more than one cowbird (Currie 1892, Friedmann 1963, Kondla and Pinel 1971, Saskatchewan Wetlands Conservation Corporation 1997, Davis and Sealy 2000), but they are parasitized less frequently than many other grassland species, likely because most of their nests are initiated before the peak of cowbird egg laying (Davis 1994, Davis et al. 2002). Longspurs possess coarse levels of egg recognition: they accept mimetic eggs, but reject many nonmimetic eggs (Davis et al. 2002). Additionally, the relatively exposed nests of this species may make it difficult for cowbirds to lay eggs undetected. In Manitoba, only one cowbird successfully fledged from eight parasitized nests (mean = 1.4 ± 0.16 [SE] cowbird eggs/parasitized nest), and there appeared to be no detectable effect of parasitism on nest success (Davis 1994). Chestnut-collared longspurs have been observed chasing cowbirds (Fairfield 1968), but whether or not they can prevent cowbirds from laying is unknown. In Saskatchewan, unparasitized nests were significantly farther from cowbird perches than parasitized nests; there was no difference in concealment cover between parasitized and unparasitized nests (S. K. Davis, Saskatchewan Wetland Conservation Corporation, Regina, Saskatchewan, unpublished data).

Both high and low temperature extremes may cause nestling death. In Alberta, ~1.5 percent of all nest failures over a three-year period were weather related ($n = 254$ nests; Hill and Gould 1997). In Manitoba, 8.5 percent of all young that hatched were killed in a single storm ($n = 35$ young; Harris 1944). Nest desertion accounted for 2 percent of egg and 9 percent of nestling mortality in Saskatchewan (Maher 1973), and for 2.6 percent of the nest failures in Alberta ($n = 38$; O'Grady et al. 1996). The impact of climate on prey abundance and availability may influence population growth.

Predation on eggs and nestlings is the single greatest cause of nest failure in this species, with predation rates on nestlings being higher than those on eggs (Maher 1973, O'Grady et al. 1996). In an Alberta study, 50 percent of all nests ($n = 76$) failed, and 82 percent of all nest predation occurred during the nestling stage (O'Grady et al. 1996). Nest predation accounted for 97 percent of egg and 72 percent of nestling mortality in Saskatchewan (Maher 1973), and for 89.5 percent of all nest failures in Alberta; predation on the incubating female accounted for 5.3 percent of nest failures (O'Grady et al. 1996).

Suspected nest predators include long-tailed weasel (*Mustela frenata*), Richardson's ground squirrel (*Spermophilus richardsonii*), thirteen-lined ground squirrel (*S. tridecemlineatus*), badger (*Taxidea taxus*), striped skunk (*Mephitis mephitis*), garter snake (*Thamnophis* spp.), western rattlesnake (*Crotalus viridis*), bull snake (*Pituophis melanoleucus*), and American crow (*Corvus brachyrhynchos*) (Harris 1944, Fairfield 1968, Hill and Gould 1997). Deer mice (*Peromyscus maniculatus*) may also be nest predators as mouse tooth marks have been identified on artificial eggs left in chestnut-collared longspur nests (Hill and Gould 1997). Northern harriers (*Circus cyaneus*) prey on older, more vocal nestlings (Wyckoff 1986b).

Suspected predators of adults and fledglings on the breeding grounds include coyote (*Canis latrans*), red fox (*Vulpes vulpes*), northern harrier, loggerhead shrike (*Lanius ludovicianus*), merlin (*Falco columbarius*), American kestrel (*Falco sparverius*), and burrowing owl (*Athene cunicularia*) (Hill and Gould 1997). Gilman (1910) observed a Cooper's hawk (*Accipiter cooperii*) preying on a longspur flock on the wintering grounds. Chestnut-collared longspurs have been observed mobbing northern harriers, loggerhead shrikes, and burrowing owls, with mobs typically involving four to eight longspurs (Hill and Gould 1997). Individuals and pairs also hover over and dive at ground squirrels near the nest, and incubating females and brooding females and males often perform the distraction display when flushed from the nest (Fairfield 1968, Hill and Gould 1997).

Fragmentation of mixed-grass and shortgrass habitats is a problem that is as potentially severe as the conversion of prairie grasslands to agricultural lands. Fragmentation isolates populations, increases the likelihood of local extinctions, decreases the probability of colonization, and genetically isolates populations, leading to increased probabilities of inbreeding and genetic drift, lowering genetic diversity. Fragmentation

can potentially turn continuous populations into "metapopulations of semi-independent demes", that gradually disappear (Risser 1996).

Life cycle graph and model development

The studies of Hill and Gould (1997) provided the basis for formulating a life cycle graph for chestnut-collared longspur that comprised two stages (censused at the fledgling stage and "adults"). The scanty data on survival suggested highest survival of yearlings (20 of 30 males returning) and lower survival of older birds (five of 12 returning). We further assumed considerably lower survival in the first year, a value for which we solved by assuming λ (population growth rate) was 1.003. This "missing element" method (McDonald and Caswell 1993) is justified by the fact that, over the long term, λ must be near 1 or the species will go extinct or grow unreasonably large. In addition we assumed that first-year reproduction was lower than that of "adult" birds (**Table 1**). From the resulting life cycle graphs (**Figure 8**), we produced a matrix population analysis with a post-breeding census for a birth-pulse population with a one year census interval (McDonald and Caswell 1993, Caswell 2001). The models had two kinds of input terms: P_i describing survival rates and m_i describing number of female fledglings per female (**Table 1**). **Figure 9a** and **Figure 9b** show the numeric values for the matrix corresponding to the life cycle graph of **Figure 8**. The model assumes female demographic dominance so that, for example, fertilities are given as female offspring per female; thus, the fledgling number used was half the total annual production of fledglings, assuming a 1:1 sex ratio. Note also that the fertility terms (F_{ij}) in the top row of the matrix include both a term for fledgling production (m_i) and a term for the survival of the mother (P_i) from the census (just after the breeding season) to the next birth pulse almost a year later. The population growth rate, λ , was 1.003, based on the estimated vital rates used for the matrix. Although this suggests a stationary population, the value was used as an assumption for deriving a vital rate, and it should not be interpreted as an indication of the general well-being of the population. Other parts of the analysis provide a better guide for assessment.

Sensitivity analysis

A useful indication of the state of the population comes from the sensitivity and elasticity analyses. Sensitivity is the effect on population growth rate (λ) of an absolute change in the vital rates (a_{ij} , the arcs in the life cycle graph [**Figure 8**] and the cells in the matrix, **A** [**Figure 9**]). Sensitivity analysis provides several kinds

Table 1. Parameter values for the component terms (P_i and m_i) that make up the vital rates in the projection matrix for chestnut-collared longspur.

| Parameter | Numeric value | Interpretation |
|-----------|---------------|---|
| m_1 | 1.4 | Number of female fledglings produced by a first-year female |
| m_a | 1.9 | Number of female fledglings produced by an “adult” female |
| P_{21} | 0.28 | First-year survival rate |
| P_{32} | 0.67 | Second-year survival rate |
| P_a | 0.42 | Survival rate of “older adults” |

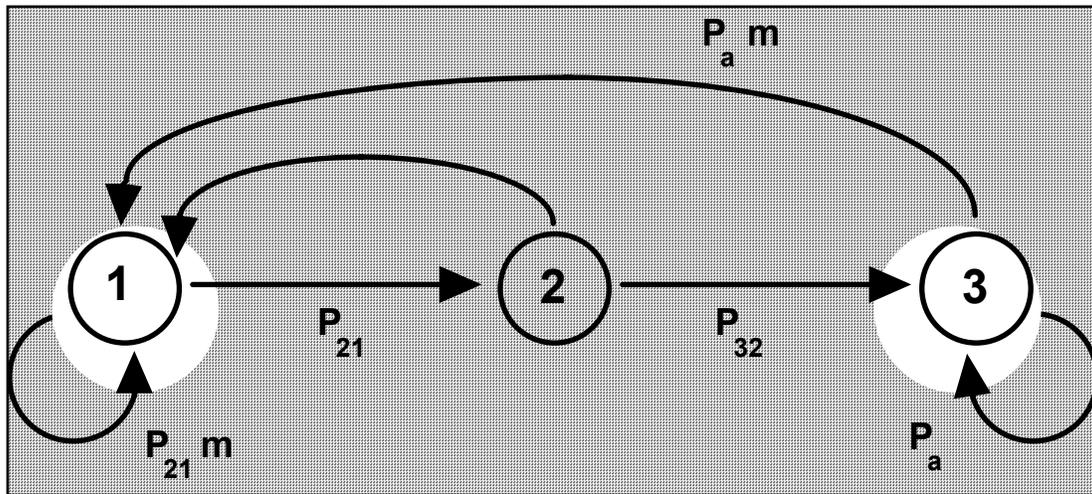


Figure 8. Life cycle graph for chestnut-collared longspur. The numbered circles (“nodes”) represent the three stages (first-year birds, second-year birds and “older adults”). The arrows (“arcs”) connecting the nodes represent the vital rates — transitions between age-classes such as survival (P_{ij}) or fertility (F_{ij} , the arcs pointing back toward the first node).

| | | | |
|---|--------------|--------------|-----------|
| | 1 | 2 | 3 |
| 1 | $P_{21} m_1$ | $P_{32} m_a$ | $P_a m_a$ |
| 2 | P_{21} | | |
| 3 | | P_{32} | P_a |

Figure 9a. Symbolic values for the projection matrix of vital rates, A (with cells a_{ij}) corresponding to the chestnut-collared longspur life cycle graph of **Figure 8**. Meanings of the component terms and their numeric values are given in **Table 1**.

| | | | |
|---|-------|------|-------|
| | 1 | 2 | 3 |
| 1 | 0.393 | 1.27 | 0.796 |
| 2 | 0.28 | | |
| 3 | | 0.67 | 0.42 |

Figure 9b. Numeric values for the projection matrix of vital rates, A (with cells a_{ij}) corresponding to the chestnut-collared longspur life cycle graph of **Figure 8**.

of useful information (see Caswell 2001, pp. 206-225). First, sensitivities show how important a given vital rate is to population growth rate (λ), which Caswell (2001, pp. 280-298) has shown to be a useful integrative measure of overall fitness. One can use sensitivities to assess the relative importance of survival (P_{ij}) and fertility (F_{ij}) transitions. Second, sensitivities can be used to evaluate the effects of inaccurate estimation of vital rates from field studies. Inaccuracy will usually be due to paucity of data, but could also result from use of inappropriate estimation techniques or other errors of analysis. In order to improve the accuracy of the models, researchers should concentrate additional effort on transitions with large sensitivities. Third, sensitivities can quantify the effects of environmental perturbations, wherever those can be linked to effects on stage-specific survival or fertility rates. Fourth, managers can concentrate on the most important transitions. For example, they can assess which stages or vital rates are most critical to increasing the population growth (λ) of endangered species or the “weak links” in the life cycle of a pest. **Figure 10** shows the “possible sensitivities only” matrices for this analysis (one can calculate sensitivities for non-existent transitions, but these are usually either meaningless or biologically impossible - for example, the biologically impossible sensitivity of λ to the transition from Stage 2 “adult” back to being a Stage 1 first-year bird).

The summed sensitivity of λ to changes in survival (65.2 percent of total sensitivity accounted for by survival transitions) was greater than the summed sensitivity to fertility changes (34.8 percent of total). The single transition to which λ was most sensitive was first-year survival (47.4 percent of total). The second most important transition was first-year reproduction (21.8 percent of total). The major conclusion from the sensitivity analysis is that survival rates and both kinds of first-year vital rates are most important to population viability.

| | 1 | 2 | 3 |
|---|-------|-------|-------|
| 1 | 0.489 | 0.136 | 0.157 |
| 2 | 1.065 | | |
| 3 | | 0.186 | 0.214 |

Figure 10. Possible sensitivities only matrix, S_p (blank cells correspond to zeros in the original matrix, A). The λ of chestnut-collared longspur is most sensitive to changes in first-year survival (Cell $s_{21} = 1.065$).and first-year fertility (Cell $s_{11} = 0.489$).

Elasticity analysis

Elasticities are useful in resolving a problem of scale that can affect conclusions drawn from the sensitivities. Interpreting sensitivities can be somewhat misleading because survival rates and reproductive rates are measured on different scales. For instance, an absolute change of 0.5 in survival may be a large alteration (e.g., a change from a survival rate of 90 percent to 40 percent). On the other hand, an absolute change of 0.5 in fertility may be a very small proportional alteration (e.g., a change from a clutch of 3,000 eggs to 2,999.5 eggs). Elasticities are the sensitivities of λ to proportional changes in the vital rates (a_{ij}) and thus partly avoid the problem of differences in units of measurement (for example, we might reasonably equate changes in survival rates or fertilities of 1 percent). The elasticities have the useful property of summing to 1.0. The difference between sensitivity and elasticity conclusions results from the weighting of the elasticities by the value of the original arc coefficients (the a_{ij} cells of the projection matrix). Management conclusions will depend on whether changes in vital rates are likely to be absolute (guided by sensitivities) or proportional (guided by elasticities). By using elasticities, one can further assess key life history transitions and stages as well as the relative importance of reproduction (F_{ij}) and survival (P_{ij}) for a given species. It is important to note that elasticity as well as sensitivity analysis assumes that the magnitude of changes (perturbations) to the vital rates is small. Large changes require a reformulated matrix and reanalysis.

Elasticities for chestnut-collared longspur are shown in **Figure 11**. λ was most elastic to changes in first-year survival ($e_{21} = 29.7$ percent of total elasticity). Next most elastic were first- and second-year reproduction ($e_{11} = 19.1$ percent; $e_{12} = 17.3$ percent of total elasticity). Survival of older birds was relatively unimportant ($e_{12} = 17.3$ percent of total elasticity).

| | | | |
|---|-------|-------|-------|
| | 1 | 2 | 3 |
| 1 | 0.191 | 0.173 | 0.125 |
| 2 | 0.297 | | |
| 3 | | 0.125 | 0.090 |

Figure 11. Elasticity matrix, E (remainder of matrix consists of zeros). The elasticities have the property of summing to 1.0. The λ of chestnut-collared longspur is most elastic to changes in first-year survival ($e_{21} = 0.297$), followed by first- and second-year fertility ($e_{11} = 0.191$, $e_{12} = 0.173$).

The sensitivities and elasticities for chestnut-collared longspur were generally consistent in emphasizing first-year transitions. Thus, first-year transitions, particularly survival rates, are the data elements that warrant careful monitoring in order to refine the matrix demographic analysis.

Other demographic parameters

The stable stage distribution (SSD, **Table 2**) describes the proportion of each stage or age-class in a population at demographic equilibrium. Under a deterministic model, any unchanging matrix will converge on a population structure that follows the stable age distribution, regardless of whether the population is declining, stationary or increasing. Under most conditions, populations not at equilibrium will converge to the SSD within 20 to 100 census intervals. For chestnut-collared longspur at the time of the post-breeding annual census (just after the end of the breeding season), fledglings represent 62.6 percent of the population, yearlings (second-year birds) represent 17.4 percent of the population, and older birds represent

20 percent of the population. Reproductive values (**Table 3**) can be thought of as describing the value of a stage as a seed for population growth relative to that of the first (newborn or, in this case, fledgling) stage (Caswell 2001). The reproductive value is calculated as a weighted sum of the present and future reproductive output of a stage discounted by the probability of surviving (Williams 1966). The reproductive value of the first stage is, by definition, 1.0. A second-year female individual (Stage 2) is “worth” 2.2 fledglings, while older females are worth 1.4 fledglings. The second-year females are the core of the population under this model. The cohort generation time for this species was 2.1 years (SD = 1.1 years).

Stochastic model

We conducted a stochastic matrix analysis for chestnut-collared longspur. We incorporated stochasticity in several ways (**Table 4**), by varying different combinations of vital rates, and by varying the amount of stochastic fluctuation. We varied the amount of fluctuation by changing the standard deviation of the

Table 2. Stable age distribution (right eigenvector). At the census, 63 percent of the individuals in the population should be fledglings. An additional 17 percent will be yearlings (females beginning their second year). The rest will be “older adult” females in their third year or older.

| Stage | Description | Proportion | Mean age (\pm SD) Variant 1 |
|-------|--------------------------|------------|--------------------------------|
| 1 | Fledglings (to yearling) | 0.63 | 0 \pm 0 |
| 2 | Second-year females | 0.17 | 1 \pm 0 |
| 3 | “Older adult” females | 0.20 | 2.7 \pm 1.1 |

Table 3. Reproductive values (left eigenvector). Reproductive values can be thought of as describing the “value” of an age class as a seed for population growth relative to that of the first (newborn or, in this case, fledgling) stage. The reproductive value of the first age-class or stage is, by definition, 1.0. The peak reproductive value (second-year females) is highlighted.

| Age Class | Description | Reproductive value |
|-----------|-------------------------------|--------------------|
| 1 | Fledglings/first-year females | 1.0 |
| 2 | Second-year females | 2.2 |
| 3 | “Older adult” females | 1.4 |

Table 4. Results of four different stochastic projections for chestnut-collared longspur. Stochastic fluctuations have the greatest effect when acting on first-year transitions (Case 3).

| Input/Output Factors | Case 1 | Case 2 | Case 3 | Case 4 |
|------------------------------------|-------------------|-------------------|---------------------------------------|---------------------------------------|
| <u>Input factors:</u> | | | | |
| Affected cells | All the F_{ij} | All the P_{ij} | P_{21} and F_{11} (first year) | P_{21} and F_{11} (first year) |
| S.D. of random normal distribution | 1/4 | 1/4 | 1/4 | 1/8 |
| <u>Output values:</u> | | | | |
| Deterministic λ | 1.003 | 1.003 | 1.003 | 1.003 |
| # Extinctions/100 trials | 1 | 3 | 3 | 0 |
| Mean extinction time | 1,667 | 1,445 | 1,445 | N.a. |
| # Declines/# surviving populations | 34/99 | 56/97 | 62/97 | 3/100 |
| Mean ending population size | 5.6×10^6 | 461,697 | 185,499 | 3.9×10^6 |
| S.D. | 4.6×10^7 | 2.5×10^6 | 533,737 | 1.0×10^7 |
| Median ending size | 26,204 | 3,405 | 2,544 | 815,138 |
| Log λ_s | 0.0004 | -0.0005 | -0.0011 | 0.0020 |
| λ_s | 1.0004 | 0.9995 | 0.9989 | 1.0020 |
| percent reduction in λ | 0.26 | 0.35 | 0.40 | 0.09 |

truncated random normal distribution from which the stochastic vital rates were selected. To model high levels of stochastic fluctuation we used a standard deviation of one quarter of the “mean” (with this “mean” set at the value of the original matrix entry [vital rate], a_{ij} under the deterministic analysis). Under Case 1 we subjected all the fertility arcs (F_{11} , F_{12} , and F_{13}) to high levels of stochastic fluctuations (SD one quarter of mean). Under Case 2 we varied all the survival arcs (P_{21} , P_{32} and P_{33}) with high levels of stochasticity (SD one quarter of mean). Under Case 3 we varied the first-year transitions (P_{21} and F_{11}) with high levels of stochastic fluctuation. Case 4 varied those same first-year transitions, but with only half the stochastic fluctuations (SD one eighth of mean). Each run consisted of 2,000 census intervals (years) beginning with a population size of 10,000 distributed according to the Stable Stage Distribution (SSD) of the deterministic model. Beginning at the SSD helps avoid the effects of transient, non-equilibrium dynamics. The overall simulation consisted of 100 runs (each with 2,000 cycles). We calculated the stochastic growth rate, $\log \lambda_s$, according to Eqn. 14.61 of Caswell (2001), after discarding the first 1,000 cycles in order to further avoid transient dynamics.

The stochastic model (Table 4) produced two major results. First, only high levels of stochastic fluctuations had appreciable detrimental effects. Low level stochastic (Case 4, SD of one eighth) resulted in no extinctions and only three declines. Second, varying the first-year transitions had the greatest detrimental

effects (Case 3, three extinctions and 65 declines). The difference in the effects of which arc was most important is predictable largely from the elasticities. λ was most elastic to changes in the first-year transitions. This detrimental effect of stochasticity occurs despite the fact that the average vital rates remain the same as under the deterministic model — the random selections are from a symmetrical distribution. This apparent paradox is due to the lognormal distribution of stochastic ending population sizes (Caswell 2001). The lognormal distribution has the property that the mean exceeds the median, which exceeds the mode. Any particular realization will therefore be most likely to end at a population size considerably lower than the initial population size. These results indicate that populations of chestnut-collared longspur are somewhat vulnerable to stochastic fluctuations in first-year survival or fertility (due, for example, to annual climatic change or to human disturbance) when the magnitude of fluctuations is high. Nevertheless, the relatively even elasticity values (Figure 11) in the life cycle of chestnut-collared longspurs may, to some extent, help buffer them against environmental stochasticity. Pfister (1998) showed that for a wide range of empirical life histories, high sensitivity or elasticity was negatively correlated with high rates of temporal variation. That is, most species appear to have responded to strong selection by having low variability for sensitive transitions in their life cycles. Chestnut-collared longspur, however, may have little flexibility in reducing variability in first-year transition rates.

Variable early survival, and perhaps fertility, is likely to be the rule rather than the exception.

Potential refinements of the models

Clearly, improved data on survival rates and age-specific fertilities are needed in order to increase confidence in any demographic analysis. The most important “missing data elements” in the life history for chestnut-collared longspur are for first-year transitions, which emerge as vital rates to which λ is most sensitive as well as most elastic. Data from natural populations on the range of variability in the vital rates would allow more realistic functions to model stochastic fluctuations. For example, time series based on actual temporal or spatial variability, would allow construction of a series of “stochastic” matrices that mirrored actual variation. One advantage of such a series would be the incorporation of observed correlations between variations in vital rates. Using observed correlations would improve on our “uncorrelated” assumption, by incorporating forces that we did not consider. Those forces may drive greater positive or negative correlation among life history traits. Other potential refinements include incorporating density-dependent effects. At present, the data appear insufficient to assess reasonable functions governing density dependence.

Summary of major conclusions from matrix projection models:

- ❖ Survival accounts for 65 percent of the total “possible” sensitivity, with first-year survival as the most important (47 percent of total) followed by first-year fertility (22 percent of total). Any absolute changes in first-year rates will have major impacts on population dynamics.
- ❖ First-year survival ($e_{21} = 30$ percent) and first-year fertility ($e_{11} = 19$ percent) account for almost 40 percent of the total elasticity. Proportional changes in first-year transition rates will have a major impact on population dynamics.
- ❖ The reproductive value of “older” females is relatively low. Thus yearling females appear to be the key reservoir of population dynamics under the model formulated here.
- ❖ Stochastic simulations echoed the elasticity analyses in emphasizing the importance of

first-year survival and fertility to population dynamics. In comparison to life histories of other vertebrates, chestnut-collared longspurs appear slightly less vulnerable to environmental stochasticity (because of the buffering effect of a relatively even importance of different vital rates, as assessed by the sensitivities and elasticities).

Community ecology

Predators and habitat use

Predator response to grazing or to fragmentation of prairie habitats and how this might influence reproductive success of chestnut-collared longspurs has not been studied. Trees are not a historical element of the mixed-grass and shortgrass prairie landscapes, and their presence (plantings, treerows, windbreaks) may result in increased cowbird parasitism and predation by providing perches for cowbirds and avian predators such as crows, grackles, and jays. In Saskatchewan, longspurs avoided more densely vegetated roadside habitats and preferred the more sparsely vegetated trailside habitats—possibly because of increased predation risk along roadsides (Camp and Best 1994).

Competitors and habitat use

Breeding chestnut-collared longspurs may occasionally defend their territory or nest against other species, e.g., by chasing lark buntings (*Calamospiza melanocorys*) or horned larks that are foraging near the nest or are encountered within the territory. Chestnut-collared longspurs have been observed both chasing and being chased by horned larks, McCown’s longspurs, Baird’s sparrows (*Ammodramus bairdii*), savannah sparrows (*Passerculus sandwichensis*), gray partridge (*Perdix perdix*), brown-headed cowbirds, and western meadowlarks (*Sturnella neglecta*) (Fairfield 1968, Hill and Gould 1997). However, competition may not be an important limiting factor, as Greer (1988) observed high territorial overlap among chestnut-collared and McCown’s longspurs and horned larks, and a scarcity of interspecific aggression. The food habits of chestnut-collared longspur overlap to some extent with those of McCown’s. In Colorado, grasshoppers and beetles composed 47 percent and 37 percent of the nestling diet by dry weight of McCown’s longspurs, and 57 percent and 33 percent, respectively, for chestnut-collared longspurs. Horned larks fed mostly beetles to nestlings (48 percent dry weight; Creighton and Baldwin 1974). In Saskatchewan, grasshoppers composed 62 to 85

percent, 71 to 75 percent, and 27 to 48 percent of the total diet of McCown's, chestnut-collared, and horned larks, respectively (Maher 1974b).

Competition may be heightened by winter range overlap with Baird's sparrows, McCown's longspurs, savannah sparrows, grasshopper sparrows (*Ammodramus savannarum*), vesper sparrows (*Poocetes gramineus*), and eastern (*Sturnella magna*) and western meadowlarks in particular (Grzybowski 1982), and by initially high post-breeding populations that include many young birds. Competition with rodents for winter seeds may play a significant role in the distribution and abundance of avian granivores (Raitt and Pimm 1976).

Parasites and disease

No diseases have been documented in chestnut-collared longspurs. Fairfield (1968) noted that dead nestlings were often covered with ants and that females picked ants from their nestlings and nests. Fleas (*Ceratophyllus garei*) and blowfly larvae (*Protophthora metallica*) have been found in nests (Hill and Gould 1997).

Symbiotic and mutualistic interactions

Other species that may use habitat in a similar way and respond similarly to threats, management, and conservation activities include the western meadowlark, savannah sparrow, Baird's sparrow, mountain plover, horned lark, lark bunting, McCown's longspur, and Sprague's pipit (*Anthus spragueii*). Chestnut-collared longspurs join in interspecific flocks in migration and winter with horned larks, Lapland longspurs (*Calcarius lapponicus*), Smith's longspurs (*C. pictus*), and Sprague's pipits (Fairfield 1968, Krause 1968, Grzybowski 1982).

Envirogram of ecological relationships

The envirogram emphasizes the effects of weather (especially rainfall), humans, and topography on chestnut-collared longspur resource availability, fecundity, survival, phenology, and predation and competition (**Figure 12**). Climate affects vegetation growth and physiognomy, which in turn are influenced by human impacts of grazing and prairie dog control, which in turn affect longspur food resources and cover. Humans, via oil and gas development, grazing, pesticides, and fire, can severely alter the vegetation structure and composition, both directly and by fragmenting habitats; this can affect longspur fecundity,

survival, and distribution, both on the summering and wintering grounds. Topography, via climate, mediates vegetation structure, which influences both microhabitat at the nest, food resources, and the abundance and distribution of predators and competitors.

CONSERVATION

Threats

Land-use practices

Most of the declines in chestnut-collared longspur populations, both past and present, have been attributed to land-use practices that destroy native prairie (Fairfield 1968, Oberholser 1974, Gollop 1978, McNicholl 1988, Hill and Gould 1997). The loss of native prairie is mostly due to rising agricultural and urban development, especially the conversion of mixed-grass and shortgrass prairies to cultivated fields (Stewart 1975), in which chestnut-collared longspurs only infrequently breed (Owens and Myres 1973). Mixed-grass prairie declines range from 72 percent to over 99 percent in North Dakota, Nebraska, Alberta, Saskatchewan, and Manitoba (Samson and Knopf 1994). The extent of the loss of shortgrass prairie to agriculture (especially to winter wheat on marginally arable lands) is also significant: in Saskatchewan, only 17 percent of the original native prairie remains; in Wyoming over 20 percent has been lost (Samson and Knopf 1994). Nearly 32 percent of the shortgrass prairie region in the southwestern Great Plains has been converted to cropland (30.7 percent in Colorado, 78 percent in Kansas, 65.4 percent in Nebraska, and 12.1 percent in Wyoming; Knopf and Rupert 1999). More recent rangeland losses to agriculture are smaller by comparison, but not insignificant. In Colorado, for example, 3.8 percent of the shortgrass and mixed-grass prairie east of the Rockies was lost to agriculture and urban expansion from 1982 to 1997 (Seidl et al. 2001).

Grazing

The major historical threat to chestnut-collared longspurs was the removal of primary, native grazers (bison, pronghorn, and prairie dogs), which altered grasslands from historic conditions. Chestnut-collared longspurs bred historically at sites that were recently grazed by bison (Owens and Myres 1973, Hill and Gould 1997), and today bison have been replaced by cattle, which are unlikely to mimic historical grazing patterns. Additionally, the areal extent of land once occupied by prairie dogs has been reduced 98 percent (Summers and Linder 1978). Removal of native herbivores has

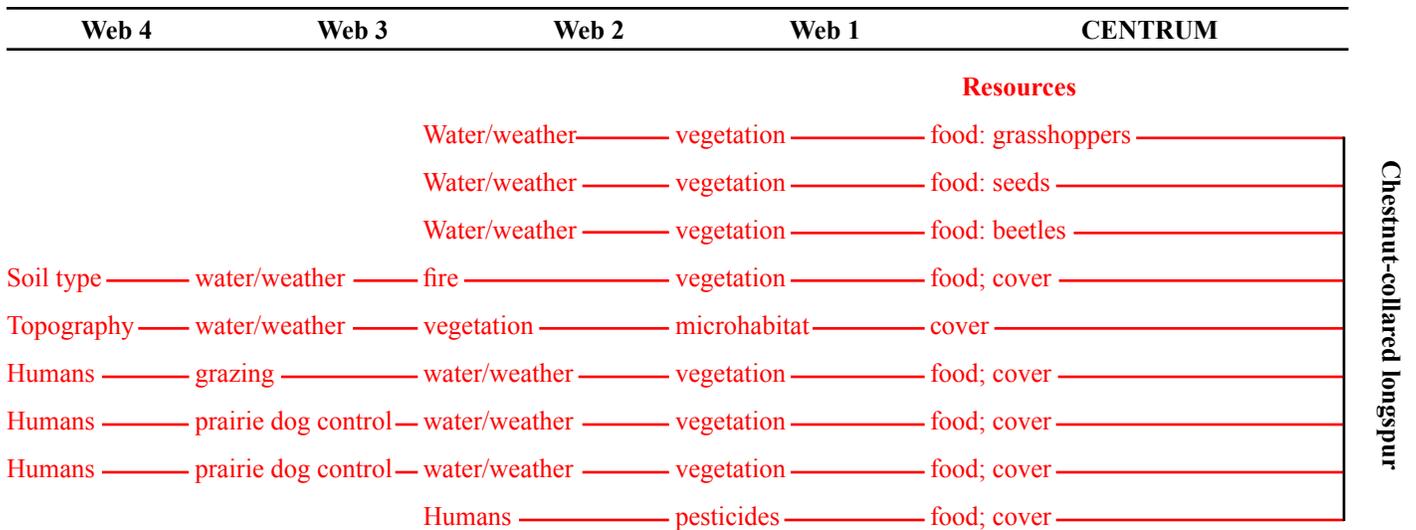


Figure 12a. Resources centrum of the chestnut-collared longspur envirogram.

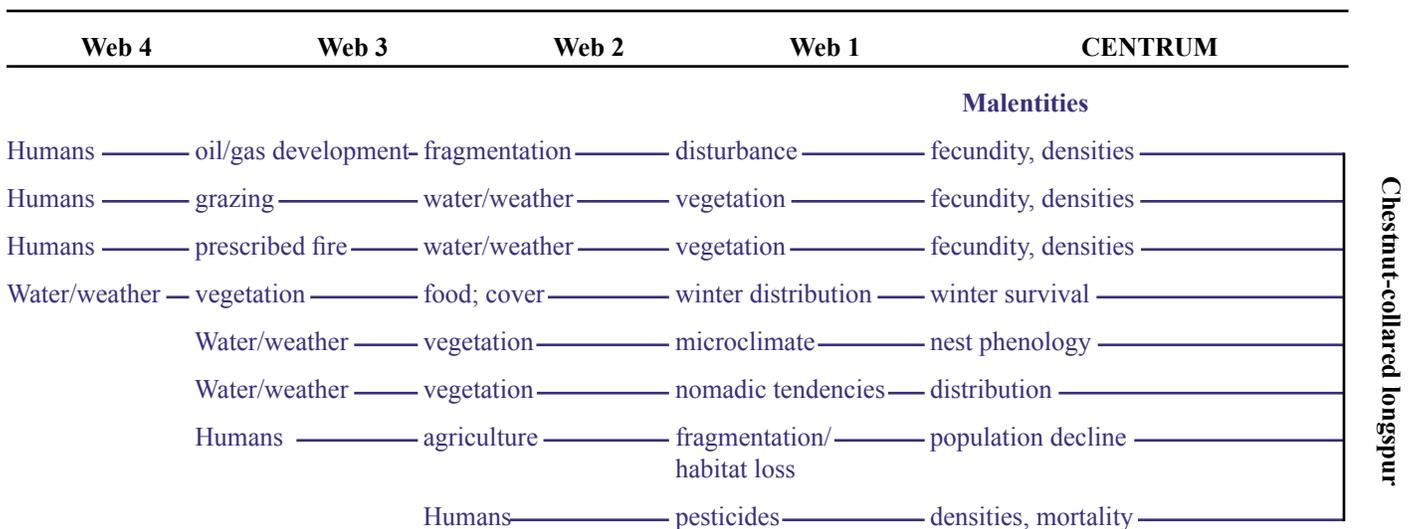


Figure 12b. Malentities centrun of the chestnut-collared longspur envirogram.

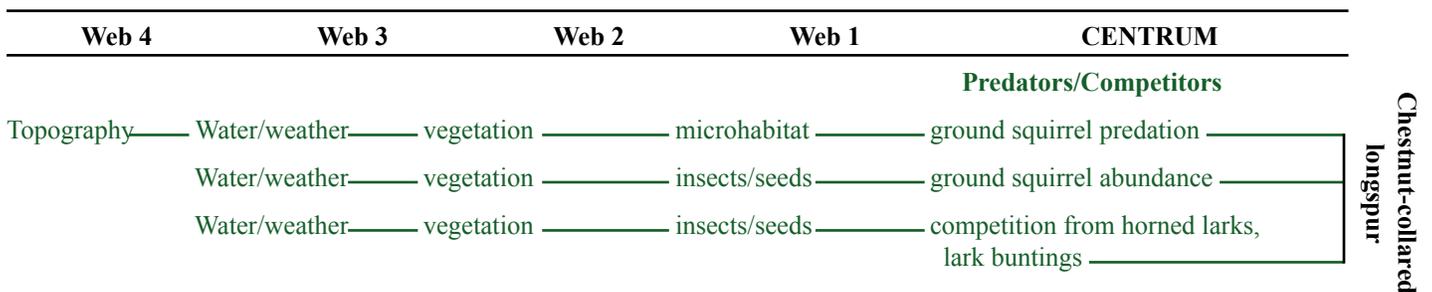


Figure 12c. Predators/competitors centrum of the chestnut-collared longspur.

undoubtedly altered the mixed-grass and shortgrass prairies from the historical, once-heterogeneous, patchy grassland landscape that was a consequence of the intense, uneven grazing by these species.

Because chestnut-collared longspurs are found across such a wide range of climate regimes, from more xeric in the southern parts of their range to more mesic in the north, the grassland prairie systems that they occupy express a similar diversity-- in plant species composition and variety, in vegetation height and density, and in growth form. As a result, one might expect a congruent variation—from xeric to mesic—in plant species' response to grazing and in grazing impacts on longspur habitats. Optimal grazing intensity and appropriate grazing regimes vary according to prairie type and climate regimes.

Overgrazing in drier, shortgrass habitats is a threat to chestnut-collared longspurs. In shortgrass prairies, especially in areas of low precipitation, no grazing, or only light to moderate grazing is tolerated by chestnut-collared longspurs (Ryder 1980). Overgrazing should be avoided in such regions (Strong 1971, Bock et al. 1993, Anstey et al. 1995). Areas where vegetation is already sparse and short from overgrazing are not favored longspur habitats and should be protected to improve their condition (Oberholser 1974).

Grazing in more mesic, mixed-grass habitats may benefit chestnut-collared longspurs (Kantrud and Kologiski 1982, Messmer 1990). Mixed-grass areas or areas where the grass is too tall or thick can be made suitable for breeding chestnut-collared longspurs by implementing moderate grazing (Dechant et al. 1998). In even moister, more thickly vegetated mixed-grass habitat, chestnut-collared longspurs actually avoid tall, dense vegetation, and prefer sparser upland grasslands with more bare ground (Renken 1983, Renken and Dinsmore 1987, Berkey et al. 1993, Johnson and Schwartz 1993, Anstey et al. 1995). In these situations, undergrazing is a threat. In Saskatchewan, the number of longspurs declined over time in plots protected from grazing, and eventually, longspurs disappeared from ungrazed plots. Chestnut-collared longspurs strongly preferred grazed to ungrazed mesic prairie (Maher 1973), and they were more abundant on overgrazed pastures than on lightly grazed, adjacent pastures with taller grass (Fairfield 1968). Grazing moister areas will increase vegetation diversity and patchiness and reduce tall, thick vegetation (Ryder 1980, Kantrud and Kologiski 1982). In such habitats, some grazing appears to benefit this species, with the caveat that the species is more likely to be present in native grassland

with high range-condition scores compared to pastures with low range-condition scores (Wroe et al. 1988, Anstey et al. 1995).

In winter, changing grazing practices, in conjunction with variable rainfall and changing cultivation practices can also threaten longspur population stability. Grzybowski (1982) reported dramatic fluctuations in abundance in winter, with longspurs abundant in some years and absent in others; variable rainfall and changing cultivation and grazing practices from year to year were thought to be responsible.

Fire and fire suppression

Chestnut-collared longspurs bred historically at sites that were recently grazed by bison or disturbed by fire (Owens and Myres 1973, Hill and Gould 1997). Declines in the abundance of chestnut-collared longspurs are at least partly attributed to the restriction of uncontrolled grass fires that serve to maintain the stature of breeding habitat (Krause 1968, Oberholser 1974, Madden et al. 1999). The fragmentation of the mixed-grass and shortgrass prairies by agricultural conversion has prevented extensive, uncontrolled wildfires, and those that do occur are often contained to the smallest area possible (Bent 1968). Only a few studies have investigated the impacts of fire on chestnut-collared longspurs. In Saskatchewan, the abundance of chestnut-collared longspurs declined during the first season after prescribed burning, but during the second year postburn, abundance increased to a level similar to that on grazed pastures (Maher 1973). In South Dakota, spring burning of mixed-grass habitat 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 re-colonized areas that received frequent fires (Madden et al. 1999). Suppression of prairie wildfires has undoubtedly altered the mixed-grass and shortgrass prairies from historic conditions.

Exotic species

Prairie restoration efforts that seeded degraded grasslands with taller, exotic grasses have reduced habitat quality for both chestnut-collared and McCown's longspurs (Samson and Knopf 1994). Early attempts to rehabilitate grasslands included seeding with exotic crested wheatgrasses imported from Siberia and planting trees to control wind erosion (implemented by the Civilian Conservation Corp from 1938 to 1941)

(Samson and Knopf 1994). Throughout their range, chestnut-collared longspurs prefer native grasslands over non-native pastureland that is seeded with exotics (Owens and Myres 1973, Anstey et al. 1995, Davis et al. 1999, Davis and Duncan 1999). In Montana, nest success was ~10 percent lower, fewer nestlings fledged per nest, and nestlings grew more slowly in a crested wheatgrass monoculture than in native, mixed-grass prairie (J. D. Lloyd and T. E. Martin unpublished data). Fields comprised predominantly of smooth brome are unsuitable for chestnut-collared longspurs (Wilson and Belcher 1989), and introduced Kentucky bluegrass and quackgrass were also found to be negatively associated with the abundance of chestnut-collared longspurs (Schneider 1998). In Saskatchewan, chestnut-collared longspurs occurred more often in native mixed-grass pasture than in tame, seeded pastures of crested wheatgrass (Anstey et al. 1995, Davis and Duncan 1999), and Davis et al. (1999) detected greater, but non-significant, differences in frequency of occurrence of chestnut-collared longspurs in native grasslands compared to seeded pastures. Unlike McCown's longspurs, however, chestnut-collared longspurs will use pastures seeded to crested wheatgrass, especially if it is grazed (Sutter and Brigham 1998, Davis et al. 1999, Davis and Duncan 1999).

Recreation

Recreation is increasing in Region 2 (USDA Forest Service 2002), and the negative effects of recreation on bird species composition and nest placement in both national forests and national grasslands have recently been documented (e.g., Miller et al. 1998). Although the sensitivity of chestnut collared longspurs to human recreational activities is uncertain, nest desertion, altered nest placement, and lower feeding rates of young by adults are likely, depending on the intensity and duration of recreation.

Recreational prairie dog shooting may have localized influences on chestnut-collared longspurs where they co-occur. Together with widespread systematic poisoning and land use conversion, black-tailed prairie dog populations have been reduced by 98 percent. Considered a keystone species, the prairie dog is thought to influence the entire grassland community either directly or indirectly. While the association between longspurs and prairie dogs has not been investigated, chestnut-collared longspurs evolved under the intense but uneven grazing of bison, pronghorn, and prairie dogs. The species' sensitivity to other human recreational activities is unknown.

Energy development

Oil and gas exploration can negatively impact wildlife through loss or fragmentation of habitat (well pads, roads, pipelines, storage tanks, power lines, compressor and pumping stations), disturbance (drilling, vehicle traffic), or environmental contamination. New construction for oil and gas exploration—and wind-power development and water well drilling—has intensified in recent years. In the Powder River Basin of western Wyoming, for example, 15,811 oil and gas wells have been approved, and an additional 65,635 are being considered to potentially develop oil and gas reservoirs (Connelly et al. 2004). Habitat loss to such activities has obvious negative impacts on longspur populations. Secondary impacts have been reported for other species. Ingelfinger (2001), for example, found that roads associated with natural gas development in sagebrush steppe reduced the guild of sagebrush obligates by 50 percent within 100 m of roads. Lyon and Anderson (2003) reported lower rates of greater sage-grouse (*Centrocercus urophasianus*) nest initiation in areas disturbed by the vehicle traffic associated with gas wells. Although there have been no specific studies of the disturbance, environmental contamination, or fragmentation effects of oil and gas activities on longspurs, these are likely negative (Knopf 1996).

Application of chemicals

Chestnut-collared longspurs have been shown to be sensitive to a number of pesticides examined for their effectiveness as grasshopper control agents. Significant ($P < 0.05$) declines in longspur numbers occurred between pre-spray and post-spray censuses with the application of BAY 77488 (phenylglyoxylonitrile oxime O,O-diethyl phosphorothioate), Baygon (*o*-isopropoxyphenyl methylcarbamate), and fenitrothion (O,O-dimethyl O-[4-nitro-*m*-tolyl] phosphorothionate) on rangelands in Wyoming and Montana (various application rates); total numbers of grassland birds (including longspurs) declined with the application of diazinon (O,O-diethyl O-[2-isopropyl-4-methyl-6-pyrimidinyl] phosphorothionate) (McEwen et al. 1972). Direct mortality due to insecticide spraying was documented for longspur adults and/or nestlings on plots sprayed with Baygon and diazinon, and for other grassland birds on plots sprayed with BAY 77488 and fenitrothion.

Two additional studies, both in Alberta, investigated the effects of grasshopper control insecticides on the reproductive success of chestnut-

collared longspurs. Martin et al. (1998) reported that the application of Decis 5F, a broad spectrum pyrethroid, (1) did not reduce overall biomass fed to nestlings; (2) did not affect the weight of nestlings at fledging; (3) did not reduce clutch size or nestling survival; (4) but did result in lower hatching success, and; (5) longspurs switched from grasshoppers to alternate insect prey to feed nestlings. The results of this study may be unique, however, because cutworm larvae migrated to the surface as a result of pesticide application, providing a superabundant, artificial food source. In a second study of both Decis 5F and Furadan 480F (a carbamate), Martin et al. (2000) reported that: (1) neither insecticide resulted in a decrease in biomass delivered to nestlings; (2) neither insecticide affected nestling weight or size; (3) neither insecticide affected the number of eggs, nestlings or fledglings produced per nest; (4) the number of grasshoppers in nestling diets was significantly reduced in Decis-sprayed plots, and by two weeks after spraying, adults were foraging almost twice as far from their nests as were birds in control plots to maintain prey delivery rates ($P < 0.05$), and; (5) brain acetylcholinesterase was significantly reduced in most Furadan-exposed birds. Seeds treated with fungicides or other chemicals before planting may also pose a threat (Hill and Gould 1997) as the chestnut-collared longspur feeds on seeds and grains in agricultural areas during migration and on the wintering grounds (Oberholser 1974).

Natural disturbances

Prolonged rainstorms (1.5 days) accompanied by cool temperatures can cause significant nest failure (DuBois 1935, Harris 1944), but such events are part of the climatic influence under which longspurs evolved and are not thought to be a major threat to long-term population stability.

Conservation Status of Chestnut-collared Longspurs in Region 2

Historically, the breeding range of the chestnut-collared longspur has contracted, and a long-term population decline is evident (Roberts 1936, Stewart 1975, Salt and Salt 1976, Gollop 1978, McNicholl 1988). This decline parallels mixed-grass and shortgrass prairie losses to agriculture (mixed-grass: 72 percent to over 99 percent in North Dakota, Nebraska, Alberta, Saskatchewan, and Manitoba; Samson and Knopf 1994; shortgrass: 30 percent in Colorado, 78 percent in Kansas, 65.4 percent in Nebraska, and 12.1 percent in Wyoming; Knopf and Rupert 1999).

Remaining populations show decreasing BBS trend estimates for the period 1966-2001 in some strata of Region 2. Declines are statistically significant ($P \leq 0.05$; where $n > 25$ BBS routes) in South Dakota (6.8 percent per year; $P = 0.01$). Marginally significant declines ($0.05 < P \leq 0.10$) occurred in the Great Plains Roughlands Physiographic Stratum (3.6 percent per year $P = 0.10$), the Central BBS region (2.1 percent per year; $P = 0.07$), USFWS Region 6 (includes USFS Region 2 states plus Utah, Montana, and North Dakota; 2.1 percent per year; $P = 0.07$), and the U. S. (2.1 percent per year; $P = 0.07$). The BBS trend estimates map (**Figure 7**) suggests that the declines are occurring for the most part in USFS Region 2 states, plus Montana and North Dakota. The Rocky Mountain Bird Observatory's species monitoring plan (Leukering et al. 2000) lists the population trend of the chestnut-collared longspur as "uncertain" in Colorado. Because of historic declines in numbers prior to the initiation of the BBS, habitat losses to agriculture and development, and concerns over habitat fragmentation, the species is listed as a species of management concern by a variety of conservation organizations (see Management Status and History). Additionally, it has been added to the Regional Forester's Sensitive Species List (Revised 2003).

The chestnut-collared longspur is a native prairie specialist, restricted to mixed-grass and shortgrass prairies. Preservation and proper management of the shortgrass and mixed-grass prairies remains the primary key to the conservation of chestnut-collared longspur. Viability of this species could be impaired throughout Region 2 by continued fragmentation of habitats, which have altered natural expanses of mixed-grass and shortgrass prairies to a mosaic of pastures variably grazed by cattle and fragmented by agricultural activities and human development (O'Connor et al. 1999). Current management does not appear to be placing demands on the species, with the following major caveats: (1) shortgrass and mixed-grass prairies must be grazed at appropriate levels; (2) prescribed burns may be necessary to maintain vegetation stature and reduce the shrub component on native prairies, and; (3) the long-term effects (fragmentation, disturbance, habitat loss) of oil and gas development on longspur populations are unknown and have not been investigated.

Because much of the chestnut-collared longspur range falls within Region 2 and because this species is restricted to shortgrass and mixed-grass prairies, risks in Region 2 parallel continent-wide risks.

Continued conversion of shortgrass and mixed-grass prairies to cropland, fragmentation of longspur habitats, indiscriminant use of pesticides, prairie fire suppression, and oil and gas development all put the chestnut-collared longspur at risk.

The relatively nomadic nature of this species, however, suggests vagility in terms of natural or anthropogenic habitat disturbances: regionwide distributional shifts in the summer—but especially in the winter—suggest that it has some capability of moving from regions of unsuitable habitat to more preferable habitats, when necessary. The mobility of gregarious, foraging grassland birds allows them to undergo local movements that permit the opportunistic exploitation of localized seed-rich patches, especially in winter (Raitt and Pimm 1976).

Management of Chestnut-collared Longspurs in Region 2

Implications and Potential Conservation Elements

Chestnut-collared longspurs prefer vast areas of native, undisturbed, unfragmented prairie, where native herbivores (bison, pronghorn, and prairie dogs) and domestic cattle combine to mimic historical grazing patterns, and where uncontrolled wildfire or prescribed burning are used to mirror historical fire regimes. Preferred environmental conditions include:

- ❖ native grasslands, usually a mix of short and mixed-grasses
- ❖ open areas of vegetation low in height
- ❖ moist, low areas with taller, thicker grasses in shortgrass prairies
- ❖ a preference for grazed areas in mixed-grass prairies
- ❖ limited cover of shrubs
- ❖ low litter cover
- ❖ low forb cover
- ❖ an average vegetation height of 20 to 30 cm
- ❖ no tall exotic grasses, and
- ❖ no trees.

To replicate the native, historic prairie condition, two primary management tools are available—prescribed fire and grazing by cattle. Cattle grazing and prescribed burning can help to create and maintain the vegetation profile favored by this species, both on the breeding and wintering grounds (Bock et al. 1993, Madden et al. 1999).

Fire

The fragmentation of the mixed-grass and shortgrass prairies by agricultural conversion has prevented uncontrolled wildfires, and those that do occur are often contained to the smallest area possible (Bent 1968). Fire may serve in maintaining the stature of breeding habitat (Bent 1968, Oberholser 1974). Prescribed burns can be used in shortgrass to remove woody vegetation, cactus, and accumulated litter and to improve grazing conditions for livestock, but the grasses recover slowly, requiring 2 to 3 years with normal precipitation (Wright and Bailey 1980). In more mesic mixed-grass prairies, prescribed burns may benefit chestnut-collared longspurs: high densities occurred in a burned prairie two years postburn in a Saskatchewan study (Maher 1973), and longspurs avoided an unburned area and preferred a short, open habitat during the first month after burning in a South Dakota study (Huber and Steuter 1984). In North Dakota, chestnut-collared longspurs re-colonized areas that received frequent fires (Madden et al. 1999).

Grazing

Optimal grazing intensity varies according to prairie type. In the more northerly, more mesic parts of their range, chestnut-collared longspurs prefer grazed areas to ungrazed areas (Felske 1971, Maher 1973, Dale 1983, 1984, Kantrud 1981, Kantrud and Kologiski 1983, Renken 1983). In mixed-grass or wetter prairie areas where grass is too tall or thick for chestnut-collared longspurs, moderate to heavy grazing can effectively improve habitat by providing shorter, sparser vegetation (Kantrud and Kologiski 1982, Messmer 1990). Heavily grazed areas with typic soils, moderately grazed areas with aridic boroll soils, and lightly grazed areas with aridic ustoll soils appear to be ideal longspur nesting habitat in portions of Montana, Wyoming, Colorado, North and South Dakota, and Nebraska (Kantrud and Kologiski 1982).

In Saskatchewan, chestnut-collared longspurs strongly preferred grazed to ungrazed prairie (Maher 1973), they were more abundant on overgrazed pastures than on lightly grazed adjacent pastures with

taller grass (Fairfield 1968), and they were positively associated with prairie junegrass and negatively associated with shrubs (snowberry and pasture sage) (Davis and Duncan 1999). In Alberta, Wershler et al. (1991) reported longspurs in moderately to heavily grazed mixed-grass prairies. Also in Alberta, however, chestnut-collared longspur frequency of occurrence did not differ significantly among four grazing treatments: early-season tame, seeded (grazed from late April to mid-June), early-season native (grazed in early summer), deferred-grazed native (grazed after 15 July), and continuously grazed native (Prescott and Wagner 1996). In mesic mixed-grass habitats in North Dakota, longspur densities were highest on pastures grazed with a twice-over rotation system, and densities decreased with vegetation regrowth on season-long and short-duration pastures (Messmer 1990). Also in North Dakota, chestnut-collared longspurs exclusively used grazed areas with sparser vegetation, more bare ground, and less litter (53.9 percent grass cover, 17.7 percent forb, 27.1 percent litter, and 1.3 percent bare ground) (Renken 1983, Renken and Dinsmore 1987).

In the more southerly, drier shortgrass regions, light to moderate grazing is more appropriate, and heavy grazing may be detrimental (Strong 1971, Creighton and Baldwin 1974, Ryder 1980, Kantrud and Kologiski 1982, Bock et al. 1993, Anstey et al. 1995). In Colorado, chestnut-collared longspurs use lower, wetter areas (Strong 1971) with a mix of shortgrasses (45 percent cover) and mid-grasses (22 percent), forbs (6 percent), sedges (11 percent), and shrubs and cactus (2 percent); bare ground coverage was 12 percent (Creighton and Baldwin 1974). They are more common in low areas of denser, taller grasses, where forb and shrub densities are low and the grazing intensity is light to moderate (20 to 40 percent annual plant growth removed).

Cultivation, seeding, exotics

Throughout their range, chestnut-collared longspurs prefer native grasslands over non-native pastureland seeded with exotics (Owens and Myres 1973, Davis et al. 1999, Davis and Duncan 1999), and they tolerate a wider range of grazing intensities in native versus in tame, seeded pastures (Anstey et al. 1995). In Saskatchewan, for example, chestnut-collared longspurs occurred more often in native mixed-grass pasture than in tame, seeded pastures of crested wheatgrass (Anstey et al. 1995, Davis and Duncan 1999). Davis et al. (1999) detected greater, but non-significant, differences in frequency of occurrence of chestnut-collared longspurs

in native compared to seeded pastures throughout the grassland regions of Saskatchewan. Unlike McCown's longspur, however, the chestnut-collared longspur more frequently use pastures seeded to crested wheatgrass, especially if it is grazed (Sutter and Brigham 1998, Davis et al. 1999, Davis and Duncan 1999). Fields comprised predominantly of smooth brome grass are unsuitable for chestnut-collared longspurs (Wilson and Belcher 1989), and introduced Kentucky bluegrass and quackgrass were also found to be negatively associated with the abundance of chestnut-collared longspurs (Schneider 1998). In Saskatchewan, no significant difference in abundance was found between lightly grazed mixed-grass prairie and lightly grazed stands of crested wheatgrass (Sutter and Brigham 1998).

In North Dakota, chestnut-collared longspur densities were higher in cropland than in the tall, dense vegetation provided by idle CRP fields (Johnson and Igl 1995). However, in Alberta, Manitoba, and Saskatchewan, chestnut-collared longspurs were more common in grasslands enrolled in the Permanent Cover Program (PCP) than in cropland. Also in Alberta, cropland managed with minimum-tillage practices had more breeding territories, a higher frequency of productive territories, and higher total productivity than cropland managed with conventional-tillage practices (Martin and Forsyth 2003). In Alberta, chestnut-collared longspurs were eliminated by cultivation (Owens and Myres 1973). Trees are not a historical element of the mixed-grass or shortgrass prairie landscapes, and trees (plantings, treerows) may result in increased cowbird parasitism and predation by providing perches for cowbirds and avian predators such as crows, grackles, and jays.

Mowing

Mowing can improve habitat for chestnut-collared longspurs in moist, mixed-grass areas by decreasing vegetation height and density (Owens and Myres 1973, Stewart 1975). However, grazed areas usually are preferred to mowed areas (Owens and Myres 1973, Kantrud 1981, McMaster and Davis 1998). In Alberta, Manitoba, and Saskatchewan, chestnut-collared longspur frequency of occurrence was higher in grazed PCP than in hayed PCP (McMaster and Davis 1998). Periodically hayed fields (every three years) were avoided by chestnut-collared longspurs in south-central Saskatchewan (Dale et al. 1997), but in Alberta, mowing was beneficial (Owens and Myres 1973).

Tools and practices

Population or habitat management approaches and their effectiveness

The historical impact of grazing by buffalo, prairie dogs, and pronghorn as an ecological force established the precedent of manipulating cattle grazing as the primary wildlife habitat management tool for mixed-grass and shortgrass prairies. The key management goal for chestnut-collared longspurs is to provide adequate size blocks of short- to medium-height grassland. Mixed-grass areas or areas where the grass is too tall or thick can be made suitable for breeding chestnut-collared longspurs by implementing moderate grazing (Dechant et al. 1998). Areas where vegetation is already sparse and short from overgrazing should be protected, especially in areas of low precipitation. Prescribed prairie burns may be appropriate for historically burned areas where fire has been suppressed. New construction for oil and gas exploration, wind-power development, and water well drilling should be restricted during the breeding season; this is already done in some areas of Colorado, Wyoming, and Utah (Knopf 1996).

Management approaches that benefit the chestnut-collared longspur and address the factors that place this species at risk include:

- ❖ Protect prairie areas from plowing and cultivation (Owens and Myres 1973, Stewart 1975).
- ❖ Provide open, grazed native prairie (Owens and Myres 1973, Anstey et al. 1995, Davis and Duncan 1999). Chestnut-collared longspurs prefer native pastures to all other habitat types and may tolerate a wider range of grazing intensities in native pastures than in other pastures (Owens and Myres 1973, Anstey et al. 1995, Davis and Duncan 1999).
- ❖ Avoid managing for idle, dense vegetation in northern, mesic mixed-grass prairie as chestnut-collared longspur densities decrease with increased mean vertical density, diversity, and litter depth (Renken 1983, Messmer 1990, Johnson and Igl 1995).
- ❖ Reduce shrub density and structure by conducting prescribed burns in late summer or early fall, especially in historically burned areas where fire has been suppressed (Krause 1968, Oberholser 1974, Madden et al. 1999). Longspurs should benefit from such burns, provided that vegetative regrowth is not too tall or dense (Maher 1973, Berkey et al. 1993).
- ❖ Decrease vegetation height and density in northern, mesic, mixed-grass prairie through mowing (Owens and Myres 1973, Stewart 1975). Annual mowing was more beneficial than periodic mowing (once every three years) in northern mixed-grass prairie (Dale et al. 1997).
- ❖ Increase vegetation diversity and patchiness and reduce tall, thick vegetation in mesic, mixed-grass prairie through management of cattle grazing (Ryder 1980, Kantrud and Kologiski 1982). Grazing at a moderate to heavy intensity where grass is too tall or thick for breeding may benefit chestnut-collared longspurs. Messmer (1990) reported the highest densities of longspurs on pastures grazed using a twice-over rotation system, rather than on areas grazed using season-long or short-duration systems.
- ❖ Avoid overgrazing in shortgrass prairies, especially in areas of low precipitation (Strong 1971, Bock et al. 1993, Anstey et al. 1995). PIF recommends grazing shortgrass at moderate intensity in the summer. Areas that are already sparse and short from overgrazing are not favored longspur habitats (Oberholser 1974) and should not be grazed to allow for recovery.
- ❖ Limit insect control where chestnut-collared longspurs occur, as their primary nestling food is grasshoppers. When pest management is required, rapidly degrading chemicals of low toxicity to non-target organisms applied at the lowest application rates possible are recommended (McEwen et al. 1972). Overgrazed and drought-affected areas are more prone to pest outbreaks than ranges maintained in good condition.
- ❖ Provide areas of adequate size to support multiple chestnut-collared longspur territories (0.2 to 4.0 ha per territory, depending on geographic location), as territories tend to be clumped together in large, isolated aggregations (Hill and Gould 1997). Minimum area requirements were

about 58 ha in Saskatchewan (Saskatchewan Wetlands Conservation Corporation 1997).

- ❖ Restore the inherent heterogeneity of native grazing communities and encourage larger grazing allotments to benefit longspurs.
- ❖ Discourage the control of prairie dogs on public lands in southern, shortgrass prairies, as the two species evolved with each other.
- ❖ Encourage the use of bison grazing to create varied habitat mosaics, as these two species also evolved with each other.
- ❖ Avoid planting non-native grass species such as wheatgrasses that may discourage occupancy by longspurs. Where rehabilitation or reclamation of prairie is necessary, seeding should be done with native shortgrass and mixed-grass (e.g., blue grama, buffalograss, prairie junegrass, needlegrass). Seeding CRP lands with native seed, rather than cool-season grasses, and then grazing will provide additional habitat for chestnut-collared longspurs (Knopf and Rupert 1999).
- ❖ Avoid fragmentation of existing tracts of mixed-grass and shortgrass habitat.

Inventory and monitoring of populations and habitat

Broad-scale information on avian population status includes that of the BBS, CBC, and MAPS programs. These have been discussed in the “Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies” section. At a broad geographic scale, BBS surveys on the breeding grounds provide the information necessary to detect continental trends in distribution and long-term changes in abundance. BBS results may be used as a guide to local or regional management decisions, with several caveats. BBS results are often inconclusive due to difficulties associated with the interpretation of index counts (Sauer 2000). Many species (especially less common species) and habitats are inadequately sampled, and BBS data do not reliably predict population trends at fine geographic scales (Sauer 2000). Because habitat information is not recorded, BBS data have only limited utility for determining avian response to environmental change or management actions. CBC surveys for longspurs on the wintering grounds (Colorado, Nebraska, and Kansas in Region 2, and primarily New Mexico, Texas, and

northern Mexico farther south) may provide insight into long-term, wintering-population trends in distribution and in abundance. Annual variation in observer effort and areal coverage within count circles, the participation of inexperienced observers, and inadequate sampling of habitats can compromise the interpretation and limit the utility of CBC data. The more recently established MAPS program, which collects information on avian productivity, survivorship, and distribution was started in 1989, and demographic information is only beginning to become available.

At smaller, regional scales, point count techniques (variable circular plots: e.g., Reynolds et al. 1980, Hutto et al. 1986, Ralph et al. 1995) or line transect count techniques (Burnham et al. 1980) are recommended to detect population changes in response to management, natural disturbance, or climate change. Because of an early spring migration compared to most passerines and a typical decline in singing and courtship as the breeding season progresses, monitoring activities for this species should begin relatively early. Monitoring could begin shortly after males (~2 to 3 weeks) and females (~1 week) arrive on the breeding grounds (i.e., Colorado: 3rd week in April; Wyoming and Montana: 2nd week in May; Alberta and Saskatchewan: mid-May). Monitoring could continue as long as the estimated clutch initiation span (84 days), but detectability declines as more pairs fledge young and singing and courtship activities diminish. Both line transect and point count distance sampling data may be analyzed with the Windows-based computer package, DISTANCE (Buckland et al. 2001, Thomas et al. 2002). The territory flush technique (Wiens 1969) and spot mapping (International Bird Census Committee 1970) may also be employed at smaller scales. To monitor breeding productivity, assess breeding habitat conditions, and estimate densities at small scales, the BBIRD protocol is often used (Martin et al. 1997). For an overview and details on estimating bird numbers, see Ralph and Scott (1980).

One major caveat regarding chestnut-collared longspur surveys is noteworthy. Sutter et al. (2000) found that roadside sampling (i.e., BBS routes) can lead to biased estimates of abundance of some prairie songbirds. In a Saskatchewan study, they found that chestnut-collared longspurs were more abundant ($P < 0.0001$) along trailsides (trails were defined as a single pair of wheel ruts visually indistinct from surrounding habitat in terms of plant structure and composition) than along roadsides (roads were defined as traveling surfaces with adjacent drainage ditches planted to smooth brome or crested wheatgrass and ending with a fence 11 to 18 m from the traveling surface). Longspurs

avoided the more densely vegetated roadside habitat and preferred the more sparsely vegetated trailside habitat, possibly due to habitat preference, increased predation risk along roadsides (Camp and Best 1994), or disturbance by vehicles (Reijen et al. 1996). Studies using roadside sampling to investigate habitat associations or to assess the size or spatial distribution of chestnut-collared longspur populations may lead to biased or spurious results.

Vegetation and habitat should be characterized in terms of both horizontal and vertical structure. Techniques (e.g., Wiens 1969, Rotenberry and Wiens 1980) should include estimates of horizontal cover (Daubenmire frames: Daubenmire 1959) and estimates of vertical structure (e.g., Robel et al. 1970) by employing vertical rods (counting vegetation contacts) and cover boards (estimating vertical coverage class values within, e.g., 5 cm intervals). Horizontal patchiness may be determined by using the coefficient of variation of vertical structure across horizontal distance (variation in vegetation contacts and coverage class values, above; Rotenberry and Wiens 1980). Long-term avian population monitoring coupled with vegetation data will provide information on long-term avian population trends, habitat relationships, and the effects of land use.

Information Needs

Fragmentation

The influences of landscape factors on reproductive success require more investigation. The consequences of an increasingly fragmented landscape on longspur abundance and reproductive success are virtually unknown. Studies of reproductive success, and prey and predator responses in fragments of various sizes are needed, especially in Region 2. Minimum patch size requirements in different habitat types and physiographic regions are largely unknown.

Fire and grazing

Special emphasis should be placed on the role, effects, and utility of fire and various grazing regimes in rehabilitating and maintaining longspur habitats.

Exotics

In non-native and altered landscapes, the effects of different amounts and species of exotic grasses on longspur reproductive success and pattern of use should be examined.

Habitat restoration

Seeding techniques and preferred grasses for grassland reclamation, restoration, and enhancement should be developed and tested.

Reproduction and foraging

Reproductive success, fecundity, lifetime reproductive success, and how these might change with grazing or habitat fragmentation are needed, especially in Region 2.

Relationship with prey/food populations

The nutritional and energy requirements of longspurs, the nutritional value of winter and summer food items, and how the availability of food changes with habitat alteration are unknown.

Relationship with predators

The response of predators to habitat change (grazing, fragmentation) and how this might impact longspurs are unknown.

Movement patterns

The extent of natal philopatry is limited to research in Canada. Adult dispersal and patterns of emigration and immigration are virtually unknown, limiting our knowledge of population demography. Migration routes and key migration stopover sites and threats to these areas should be studied further.

Prey response to habitat change

Studies of prey response (especially of grasshoppers, a key nestling food) to different grazing regimes, drought and climate change, and prescribed burning are needed.

Demography

Basic information on annual fecundity and lifetime reproductive success is lacking, especially in Region 2. Long-term studies of marked populations are required for better estimates of recruitment, survival, immigration, and emigration. Genetic studies of small, isolated populations are needed to determine levels of genetic diversity and gene flow.

The Colorado PIF Bird Conservation Plan (Colorado Partners in Flight 2000) outlines six

research priorities for the central shortgrass prairie: (1) the interplay of precipitation, habitat condition, and population distributions at the landscape level; (2) the effects of prescribed burning on bird populations; (3) the effects of different grazing regimes; (4) identification of key migratory stopover and wintering areas; (5) effects of prairie dog hunting and sport hunting on bird populations; and (6) patch-size effects and area

sensitivity of shortgrass prairie birds. Additionally, the impacts of new construction for gas and oil exploration, wind-power development, and water well drilling should be investigated. Chestnut-collared longspur fidelity to wintering sites and links between wintering and breeding areas are poorly understood, as are the historic factors affecting longspurs on their winter range. These are items for additional research as well.

DEFINITIONS

Bird Conservation Region — ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues within which bird conservation efforts are planned and evaluated, as endorsed by the North American Bird Conservation Committee. See [Figure 13](#).

Permanent Cover Program (PCP) — A Canadian program that paid farmers to seed highly erodible land to perennial cover; it differed from the Conservation Reserve Program (CRP) in that haying and grazing were allowed annually.

Physiographic Stratum — Breeding Bird Survey regional areas defined on the basis of similar vegetation, soil, and physiographic features and used in the analysis of bird species' population trends and relative abundance (Robbins et al. 1986). Based on Bailey's ecoregions (Bailey 1993). See [Figure 14](#).

Physiographic Area — Partners in Flight planning units defined on the basis of biotic communities and bird distribution; used in bird conservation planning. See [Figure 15](#).

USDA Forest Service Region 2 (Rocky Mountain Region) — Includes parts of Wyoming, Colorado, South Dakota, Nebraska, and Kansas. See [Figure 1](#).

U.S. Fish and Wildlife Service Region 6 (Mountain-Prairie Region) — Includes parts of Wyoming, Colorado, South Dakota, Nebraska, Kansas, Montana, Idaho, and Utah.

U.S. Fish and Wildlife Service Region 2 (Southwest Region) — Includes parts of Arizona, Oklahoma, New Mexico, and Texas.

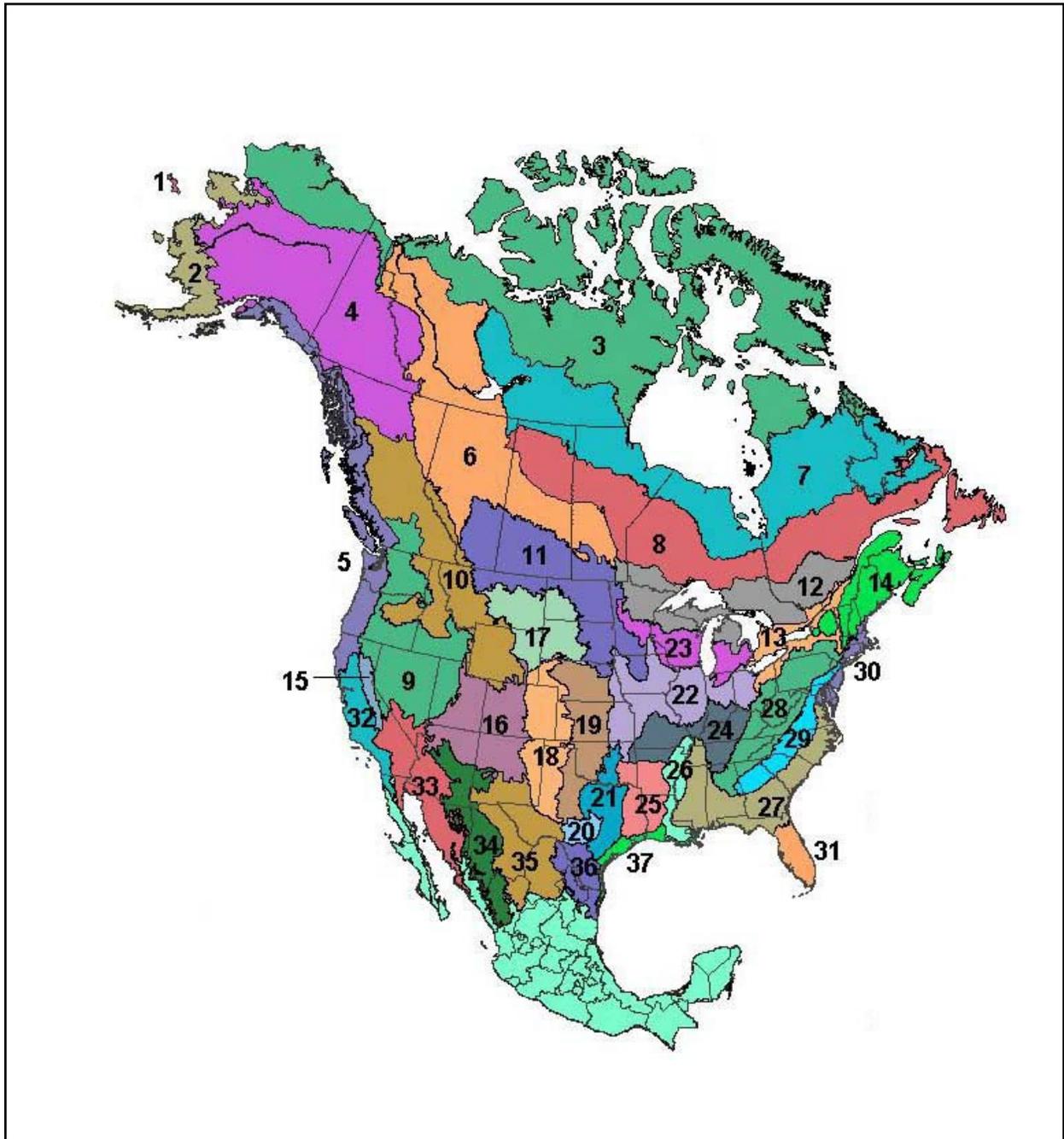


Figure 13. Map of Bird Conservation Regions of the United States. Breeding chestnut-collared longspurs occur chiefly in regions 11 (Prairie Potholes), 17 (Badlands and Prairies), and 18 (Shortgrass Prairie).

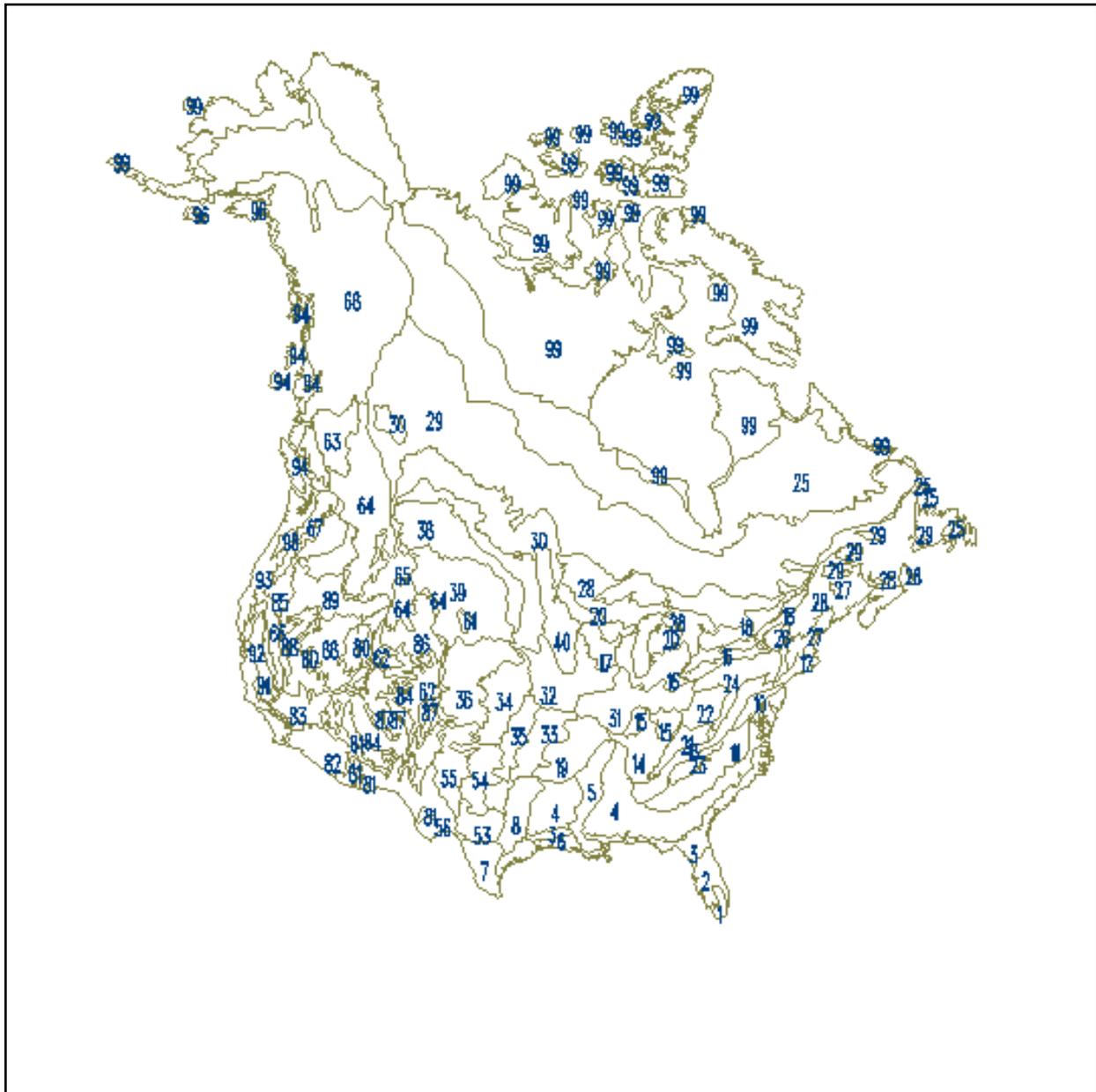


Figure 14. Map of Breeding Bird Survey strata. Breeding chestnut-collared longspurs occur in strata 36 (High Plains), 37 (Drift Prairie), 38 (Glaciated Missouri Plateau), 39 (Great Plains Roughlands), and 86 (Wyoming Basin).

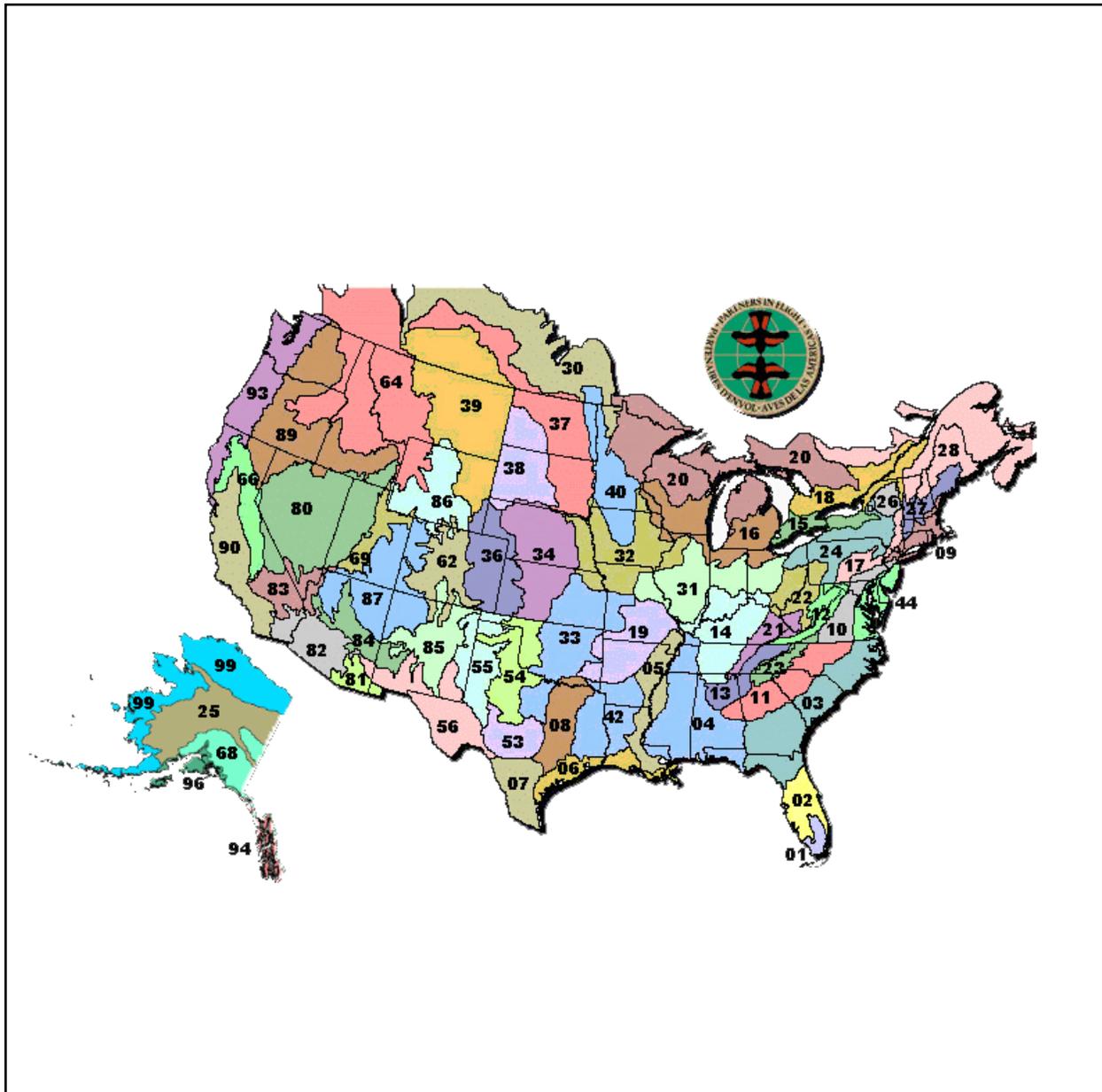


Figure 15. Map of Physiographic Areas as defined by Partners in Flight. Breeding chestnut-collared longspurs occur chiefly in areas 34 (Central Mixed-Grass Prairie), 36 (Central Shortgrass Prairie), 37 (Northern Mixed-Grass Prairie), 38 (West River), 39 (Northern Shortgrass Prairie), and 86 (Wyoming Basin).

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