

Chapter 12

Rangeland Songbirds



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Abstract Songbirds that occur across the diverse types of North American rangelands constitute many families within the Order Passeriformes, and hundreds of species. Most are declining, and many are considered potential indicator species for rangeland ecosystems. We synthesized information on the natural and life history, habitat requirements, conservation status, and responses to management of songbirds associated with North American grasslands and sagebrush steppe, two of the most geographically extensive types of rangelands. We provide a more targeted examination of the habitat associations and management considerations for two focal species, the grassland-obligate grasshopper sparrow (*Ammodramus sava-narum*) and sagebrush-obligate Brewer’s sparrow (*Spizella breweri*). Grassland- and sagebrush-obligate species rely on expansive stands of grasslands and sagebrush, respectively, and we discuss how key ecological processes and rangeland management approaches—grazing, fire, and mechanical treatments—influence rangeland songbirds. Rangeland management practices can affect breeding songbirds considerably, primarily through the resultant structure and composition of vegetation, which influences the availability of preferred nesting substrates, refugia from predators, and foraging success. Optimal management strategies to limit negative consequences to rangeland songbirds will depend on the target species and local topoedaphic and climatic conditions. The maintenance of large, contiguous patches of native habitats and restoration of previously degraded areas will help facilitate the population persistence of rangeland-associated songbirds. Maintaining structural heterogeneity of habitats within landscapes, moreover, can facilitate local species diversity. Information pertaining to periods outside of the nesting stage is severely lacking for

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most species, which is concerning because effective management necessitates understanding of threats and limiting factors across the full annual life cycle. Moreover, information on disease effects and prevalence, the effects of a changing climate, and how both may interact with management strategies, also comprise key gaps in knowledge.

Keywords Brewer's sparrow · Conservation · Grasshopper sparrow · Grassland songbirds · Habitat · Management · Sagebrush songbirds

12.1 Life/Natural History and Population Dynamics

The songbird species that inhabit North American rangelands have relatively fast life histories, with first breeding attempts typically occurring in the first year of adulthood. The distributions of some species are restricted (e.g., Baird's sparrow [*Centronyx bairdii*]; Green et al. 2020), whereas the distributions of other species span multiple continents (e.g., horned larks [*Eremophila alpestris*]; Beason 2020). Most rangeland songbirds are migratory, and territorial on breeding grounds. Primary foods include arthropods during the breeding season and seeds during the winter. The annual life cycle of rangeland-associated songbirds can be classified as nesting, post-fledging, fall migration, over-wintering, and spring migration.

12.1.1 Nesting

Songbird males establish breeding territories shortly after arriving on breeding grounds in spring. Males often have elaborate courtship songs, and many combine songs with aerial displays. Song dialects can vary regionally, and males of some species (e.g., Brewer's sparrow [*Spizella breweri*] and grasshopper sparrow [*Ammodramus savannarum*]) have different song types for pre- and post-pairing. Most species are socially monogamous at least within a breeding season, though some such as the bobolink (*Dolichonyx oryzivorus*) and dickcissel (*Spiza americana*) are polygynous, a mating system in which the desirable males will pair with more than one female (Renfrew et al. 2020; Temple 2020). Even for socially monogamous populations, extra-pair paternity can be common (e.g., Danner et al. 2018).

Nest placement is variable, with some species nesting on the ground amidst vegetation, and others within shrubs or trees. Nest structures typically are open or domed cups, constructed with sticks, grasses, forbs, and/or sedges, and lined with finer material such as rootlets, mammal hair or feathers of other species. Females lay one egg per day until clutch completion, and clutch sizes vary from approximately 2–7 eggs. Eggs develop and remain viable within a specific range of temperatures regulated by incubation (Deeming 2001). Incubation is conducted primarily by females, although males contribute in some species, and females are sometimes provisioned

with food on the nest by their mates. Incubation periods typically range from 10 to 13 days for open-cup nesters, whereas cavity nesters incubate for longer periods. The incubation for the juniper titmouse (*Baeolophus ridgwayi*), for example, is approximately 17 days (Cicero et al. 2020). Nestlings are altricial and highly dependent upon parental care for food and thermoregulation. Nestling periods range from 8 to 14 days for most species, and young are almost always fed by both parents.

Songbird nest survival varies across habitat conditions, sites, and years. The primary source of nesting mortality is predation from a wide variety of species including snakes, rodents, mustelids, canids, domesticated or feral cats (*Felis catus*), raccoons (*Procyon lotor*), raptors, shrikes (*Lanius* spp.) and even ungulates including deer (*Odocoileus* spp.) and elk (*Cervus canadensis*) (Pietz and Granfors 2000; Renfrew and Ribic 2003; Hethcoat and Chalfoun 2015a; Lyons et al. 2015). Many songbirds also experience brood parasitism by the brown-headed cowbird (*Molothrus ater*) (Shaffer et al. 2019a), though some species such as sage thrashers (*Oreoscoptes montanus*) remove cowbird eggs from their nests (Reynolds et al. 2020). Other causes of nesting failures include extreme weather events, such as snowstorms or hail (Hightower et al. 2018), and anthropogenic activities.

12.1.2 *Post-fledging*

Songbird nestlings typically depart nests before they are fully capable of flight. Mortality from predation or inclement weather during the early post-fledging period can therefore be high for most if not all species (e.g., Fisher and Davis 2011; Hovick et al. 2011). Fledglings are fed by parents for at two least weeks after leaving the nest, achieving adult body mass within about a month (Jones et al. 2018). Family groups likely rely on habitats with sufficient cover to shelter young from predators and the elements (Fisher and Davis 2011). Unfortunately, the post-fledging period for many songbirds rarely is studied (Davis and Fisher 2009; Ribic et al. 2018, 2019), and estimates of post-fledging habitat use and survival are lacking. Where studied, estimates of fledgling survival range from 26 to 36% (Yackel Adams et al. 2006; Berkeley et al. 2007; Hovick et al. 2011; Young et al. 2019). Nestling body condition and wing development, which vary with food availability and provisioning rates, tend to be positively related to post-fledging survival (Yackel Adams et al. 2006; Jones et al. 2017; Jones and Ward 2020).

12.1.3 *Non-breeding*

Most songbirds inhabiting North American rangelands during the breeding season are migratory, although some populations inhabiting southern areas are year-round residents. Adults typically complete a full molt of their feathers towards the end of the nesting season, and migrants often form large, single, or mixed-species flocks for

southward migration. The length of migration distances ranges from short to long, with many species over-wintering in the southwestern U.S. and northern Mexico (e.g., chestnut-collared longspur [*Calcarius ornatus*]), and others that migrate to South America (e.g., bobolink and dickcissel). Flocks periodically use migratory stopover habitats to forage and rest. Over-wintering migrants tend to use habitats similar in structure to their breeding habitats (Igl and Ballard 1999; Hovick et al. 2014).

12.1.4 Survival and Sources of Mortality

Songbird nests are depredated by a wide variety of species (see Nesting section). For most songbird species, much less is known about predator species and rates of predation during the post-fledging, migratory, and over-wintering periods, though many species of raptors (e.g., accipters, falcons) are known to kill adult songbirds (Lima 2009). Fledglings are consumed by raptors, corvids, shrikes, snakes, and mammals (Yackel Adams et al. 2006; Berkeley et al. 2007; Hovick et al. 2011; Young et al. 2019). Free-ranging domestic and feral cats kill billions of songbirds in North America each year (Loss et al. 2013a). Other sources of adult mortality of songbirds include collisions with buildings, vehicles, guy wires extending from communication towers, and wind turbines (Longcore et al. 2012; Loss et al. 2013b; Erickson et al. 2014).

12.1.5 Seasonal Movements and Dispersal

Movement and dispersal data are rare for most rangeland songbirds. Historically, the logistical challenges of safely radio-tracking very small birds were an impediment. Recent technological advances, however, have enabled the manufacture of smaller, lighter transmitters and light-level geolocators that record the movements and locations of small birds across time upon recapture. Soon after independence, immature birds join post-breeding flocks of adults, leave their natal area, and begin moving with pre-migratory flocks (e.g., Temple 2020). An understanding of the connectivity between the breeding grounds and particular migration routes or over-wintering areas is lacking for most grassland and sagebrush songbird species. Site fidelity, or the repeated return, to breeding sites varies across species, habitats and locations. Juveniles sometimes return to the general area where they were born (natal philopatry; e.g., Renfrew et al. 2020). Some species appear to be facultatively nomadic on breeding grounds between years (e.g., chestnut-collared longspur and lark bunting [*Calamospiza melanocorys*]), likely as an evolved response to shifting habitat suitability associated with the unpredictable influences of fire, drought, and the movements and grazing of bison (*Bison bison*) herds (Green et al. 2019).

12.1.6 Population Dynamics

Whereas offspring mortality during the nesting (e.g., Kerns et al. 2010; Hethcoat and Chalfoun 2015b; Verheijen et al. 2022) and post-fledging (e.g., Young et al. 2019) periods can be high, a lack of research encompassing the full annual life cycle constrains an understanding of which life stages tend to be most limiting for rangeland songbirds (Marra et al. 2015). Because most songbirds have relatively fast life histories, the influence of reproductive success (clutch size, nest survival, post-fledging survival) on population growth likely is high (Saether and Bakke 1997). Nest density also may influence population growth, as avian productivity within an area is the product of per capita nest survival and density (Pulliam et al. 2021). Moreover, carryover effects from over-wintering grounds and migratory stopover sites can affect the timing and reproductive success of songbirds via the interaction between arrival times and food availability, and the condition of adults at the onset of nesting (Bayly et al. 2016).

12.2 Current Species and Population Status

Most populations of songbirds that breed within North American rangelands are declining, some drastically, concomitant with broad-scale habitat loss and alteration (Table 12.1; Rosenberg et al. 2019; Sauer et al. 2020). For example, of 34 species of New World sparrows, which include scrub-successional, aridland, and grassland species, 17 exhibited significant declines and 27 had negative trend estimates (Sauer et al. 2013). Moreover, numbers of grassland and aridland birds declined by an estimated 55% and 23%, respectively, during 1970–2017 (Rosenberg et al. 2019).

12.3 Population Monitoring

There is no monitoring program devoted specifically to rangeland songbirds, though many populations are monitored as part of broader efforts. The North American Breeding Bird Survey (BBS) and Christmas Bird Count (see Chap. 11) are used frequently to assess the status and general trends of rangeland songbirds (Table 12.1). Laurent et al. (2012) provide details on these and other national and regional programs, such as the Strategic Multi-scale Grassland Bird Population Monitoring Protocol (SMGBPM) and Monitoring Avian Productivity and Survivorship (MAPS). The SMGBPM uses counties as management units and was developed because of the concern that BBS may underestimate grassland bird numbers in some areas. MAPS utilizes a network of mist-netting efforts and mark-recapture analyses to assess demographic parameters including annual survival and productivity of North American birds over time. Citizen-science programs include eBird, which is an online database

Table 12.1 Representative songbird species inhabiting the major (but not all) vegetation types (Barbour and Billings 2000) composing North American rangelands

Vegetation type	Typical songbird species	Conservation status	
		PIF score	BBS trend (%)
<i>Grasslands</i>			
Tallgrass prairie	Bobolink (<i>Dolichonyx oryzivorus</i>)	14	– 1.5
	Eastern meadowlark (<i>Sturnella magna</i>)	11	– 2.6
	Henslow's sparrow (<i>Centronyx henslowii</i>)	15	– 1.9
N. mixed-grass prairie	Baird's sparrow (<i>Centronyx bairdii</i>)	15	– 0.9
	Chestnut-collared longspur (<i>Calcarius ornatus</i>)	15	– 2.5
	Sprague's pipit (<i>Anthus spragueii</i>)	14	– 3.2
S. mixed-grass prairie	Cassin's sparrow (<i>Peucaea cassinii</i>)	11	– 0.4
	Dickcissel (<i>Spiza americana</i>)	11	– 0.6
	Lark sparrow (<i>Chondestes grammacus</i>)	10	– 1.2
Shortgrass prairie	Horned lark (<i>Eremophila alpestris</i>)	9	– 1.9
	Lark bunting (<i>Calamospiza melanocorys</i>)	12	– 3.7
	Thick-billed longspur (<i>Rhynchophanes mccownii</i>)	15	– 2.1
Palouse prairie	Grasshopper sparrow (<i>Ammodramus savannarum</i>)	12	– 2.5
	Vesper sparrow (<i>Poocetes gramineus</i>)	11	– 0.8
	Western meadowlark (<i>Sturnella neglecta</i>)	10	– 0.9
Warm deserts and grasslands	Loggerhead shrike (<i>Lanius ludovicianus</i>)	11	– 2.6
	Cactus wren (<i>Campylorhynchus brunneicapillus</i>)	12	– 1.3
	Rufous-crowned sparrow (<i>Aimophila ruficeps</i>)	11	0.4
<i>Shrublands</i>			
Sagebrush ^a	Brewer's sparrow (<i>Spizella breweri</i>)	11	– 0.9
	Sagebrush sparrow (<i>Artemisiospiza nevadensis</i>)	10	– 1.2
	Sage thrasher (<i>Oreoscoptes montanus</i>)	11	– 0.4
Juniper-pinyon	Juniper titmouse (<i>Baeolophus ridgwayi</i>)	11	+ 0.1
	Pinyon jay (<i>Gymnorhinus cyanocephalus</i>)	14	– 2.1

(continued)

Table 12.1 (continued)

Vegetation type	Typical songbird species	Conservation status	
		PIF score	BBS trend (%)
	Black-throated gray warbler (<i>Setophaga nigrescens</i>)	13	– 0.7

Species are listed only once across types even though they may be found in several. See Vickery et al. (1999) for a more complete list of obligate and facultative grassland and arid shrubland birds. Conservation status is indexed by the Partner’s in Flight (PIF) Avian Conservation Assessment Database maximum continental combined score (Partners in Flight 2021) and the range-wide Breeding Bird Survey trend during 1966–2019 (% population change per year; Sauer et al. 2020). The PIF score integrates information about the global population size, distribution, threats, and trends. Scores range from 4 to 20, with higher values associated with greater concern. Species with scores of 14 or higher, or with a concern score of 13 and a steeply declining population trend, are those most at risk of extinction without significant conservation actions to reverse declines and reduce threats

^aSagebrush steppe and Great Basin sagebrush types combined

of bird observations, and NestWatch, which focuses on reproductive success. Finally, several facilitated databases, including the Avian Knowledge Network, store data that land managers, scientists, and others can access for research and conservation (Laurent et al. 2012).

Monitoring programs vary in their degree of statistical rigor, spatial inference, and limitations. Selection of monitoring data on which to base research or management decisions should therefore depend on the desired metrics (e.g., occupancy, distribution, abundance trends over time, productivity, species richness) and precision. The BBS, for example, was established in 1966 and has been valuable for documenting general population trends of over 400 North American bird species. Surveys, however, are conducted as annual roadside routes, which may under-sample species sensitive to human infrastructure. Current protocols also do not account for potential spatiotemporal differences in the probability of detecting birds. The Integrated Monitoring in Bird Conservation Regions, coordinated by the Bird Conservancy of the Rockies, incorporates randomized sampling and was designed to provide robust estimates of avian occupancy and density across time and multiple spatial scales.

12.4 Habitat Associations

Songbird species inhabiting the grasslands and arid shrublands of North America (see Table 12.1 for representative species) include habitat specialists (or “obligates”) and those that are open-country generalists. The thick-billed longspur (*Rhynchophanes mccownii*), for example, is a shortgrass-prairie specialist with a restricted distribution (With 2021). By contrast, the western meadowlark (*Sturnella neglecta*) inhabits a wide variety of open habitat types and agricultural fields throughout the entire western

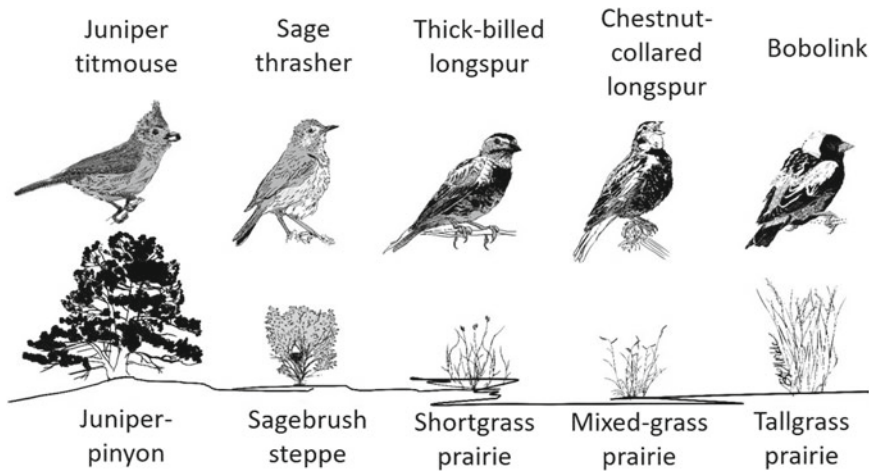


Fig. 12.1 Artistic rendering of representative songbird and plant species within five of the major rangeland types in North America. Plant species from left to right include western juniper (*Juniperus occidentalis*), big sagebrush (*Artemisia tridentata*), buffalo grass (*Bouteloua dactyloides*), blue grama (*Bouteloua gracilis*), and big bluestem (*Andropogon gerardii*). Assemblages are organized by relative longitude. Artwork by Bethann Merkle. Source photograph credits include Jack Parlapano (titmouse), Tayler Scherr (thrasher), Rick Bohn (chestnut-collared longspur), Dan Casey (thick-billed longspur), Dave Lambeth (bobolink), Sarah McIntire (juniper), and Anna Chalfoun (sagebrush). Other plant photos drawn from open sources

portion of North America (Davis and Lanyon 2020). The assemblage of songbird species that occupies a given site varies by geographic location, vegetation type, habitat structure, and extent of habitat degradation (Fig. 12.1).

The habitat preferences of rangeland songbirds evolved based on the conditions most associated with successful survival and reproduction (Nelson et al. 2020). Such preferences often are scale-dependent (Chalfoun and Martin 2007; Lipsey et al. 2017; Box 12.2). Several species may inhabit the same area but primarily nest or forage within more differentiated niches (Grinnell 1917). Such differences likely arose to limit competition for nest sites and food. Within mixed-grass prairie, for example, the nest sites of sympatric songbirds are distributed across microhabitat gradients ranging from shorter, sparser vegetation (e.g., thick-billed longspur) to taller, denser grasses (e.g., western meadowlark; Fig. 12.1). The vertical and horizontal partitioning of nest sites within an area may benefit the reproductive success of co-occurring songbird species by reducing predator search efficiency (Martin 1993). The maintenance of microhabitat heterogeneity within landscapes is therefore a key management consideration. Boxes 12.1 and 12.2 provide more in-depth descriptions of habitat associations for two focal species, a grassland-obligate songbird (grasshopper sparrow) and a sagebrush-steppe obligate (Brewer's sparrow).

12.5 Rangeland Management

The primary ecological processes and management practices that influence rangeland songbirds are grazing, fire, and mowing, whereas mechanical management practices include the application of herbicides and pesticides, mowing, chaining, and disking (reviewed in Shaffer and DeLong 2019). Some management interventions, such as bison grazing and fire, often are geared towards mimicking historical disturbance regimes (see Chaps. 6 and 8), whereas mechanical management practices may be used to produce similar outcomes but within faster time frames. These management approaches may be used singly or in combination (e.g., patch-burn grazing). Ecological processes and management practices influence local avian biodiversity primarily through their effect on vegetation structure and composition. A management approach will have variable outcomes depending on timing, intensity, and frequency. Timing, or seasonality, refers to when during the year a management approach is applied. Intensity refers to the degree to which a management approach is applied. In terms of fire, intensity is the amount of heat produced (Chap. 6), whereas for grazing, intensity refers to the number of grazing animals and length of time grazing occurs, or how much biomass is removed. Frequency refers to how often ecological processes or management practices have been applied, either within or among seasons (Chap. 4).

Management approaches depend on goals, and outcomes often are site- or species-specific. Management guidance for individual species is summarized in the accounts constituting Johnson et al. (2019). Thorough coverage of management approaches for grasslands bird species can be found in Sample and Mossman (1997), whereas management considerations pertaining to sagebrush species can be found in Paige and Ritter (1999) and Walker et al. (2020). The two case studies in this chapter (Boxes 12.1 and 12.2) illustrate the complexity of the decisions involved in the application of ecological processes and management practices that maintain and create habitat for specific songbird species.

12.5.1 Grazing

Direct effects of livestock grazing on rangeland songbird species are rare and include trampling of eggs, nestlings, or adults, and in some cases apparent predation (Nack and Ribic 2005; Bleho et al. 2014). Nest destruction by livestock generally increases with grazing intensity during the nesting season, though for some species of songbirds, the creation of habitat via grazing may offset the minimal nest losses (Owens and Myres 1973; Bleho et al. 2014). Indirect effects of livestock grazing include alteration in vegetation structure (e.g., decreased litter cover, increased bare ground) and composition (e.g., dominance of some plant species over others). Such changes can lead to altered insect food availability or nest predation risk (Johnson et al. 2012). Indirect effects of grazing therefore tend to be more impactful than direct effects

in influencing whether grazed rangelands comprise high-quality nesting habitat (Cody 1985; Martin and Possingham 2005). Additional indirect effects of grazing may include increased nest parasitism by brown-headed cowbirds or increased nest predator populations, via the addition of water, feed, and carcasses (Goguen and Mathews 1999, 2000; Coates et al. 2016). However, parasitism rates within grasslands also are influenced by the landscape matrix within which pastures are located. Brown-headed cowbirds may be less likely to parasitize nests of grassland songbirds where tree cover on the landscape is greater and nests of woodland species are readily available as alternative cowbird hosts (Pietz et al. 2009; Hovick and Miller 2013).

Livestock grazing can be used to manipulate vegetation to create desired conditions for rangeland songbirds (Derner et al. 2009; Bleho et al. 2014). The effects of grazing on vegetation, however, can be highly variable and affected by grazing regime (Chap. 4), livestock characteristics (species, breed, sex, age, and genetic factors), precipitation (amount, seasonality), current vegetation structure and composition, soil characteristics, historical land use, and presence and types of other disturbances (Briske et al. 2008; Sliwinski and Koper 2015; Lipsey and Naugle 2017). Thus, prior to implementing a grazing system within any given year to obtain a desired vegetation structure (e.g., habitat outcome; Pulliam et al. 2020, 2021), the characteristics of that grazing system may need to be modified based on the region's expected precipitation and other aforementioned factors.

Long- and short-term monitoring of the effects of grazing on vegetation structure is important in terms of assessing the effects of grazing on avian abundance, community composition, and reproduction (Pulliam et al. 2021). Short-term effects include the reduction of herbaceous cover or height of vegetation, which can affect songbird species dependent on litter and grass cover for nest concealment. Long-term effects can manifest as altered composition of plant species or reduced vegetation productivity of a site (Briske et al. 2008). For example, repeated livestock grazing can affect shrub and tree establishment, thereby affecting songbird species dependent on non-herbaceous vegetation (Bock et al. 1993). Accordingly, rangeland songbird species may respond differently to grazing-induced changes over time (e.g., Johnson et al. 2011; Sliwinski and Koper 2015). Most species that are affected negatively by grazing are those that are dependent on relatively dense herbaceous ground cover or heavy shrub cover for nesting and foraging. The responses of species in sagebrush and montane coniferous habitats to livestock grazing, however, remain understudied.

Albeit not yet well understood, native grazers such as bison and prairie dogs (*Cynomys* spp.) may influence songbirds and their habitats differently than livestock (Allred et al. 2011a). The abundance of vesper and grasshopper sparrows in Montana were more abundant in pastures grazed year-round by bison compared with those that were grazed seasonally by cattle, although the abundance of 7 other songbird species and diversity measures did not vary by grazing type (Boyce et al. 2021). The grazing and fossorial activities of prairie dogs have played an influential role in the maintenance and composition of grassland and arid shrubland communities and can facilitate co-occurring bird species (Duchardt et al. 2019, 2021; Chap. 15).

12.5.2 *Fire*

As with grazing, the direct effects of fire on songbird species include the destruction of nests and young. Indirect effects involve altered vegetation characteristics as influenced by the timing, intensity, and frequency of fire applications (Chap. 6). In most rangeland systems, fire will reduce the biomass of live and dead herbaceous vegetation and shrub or tree cover, depending on fire intensity, and stimulate regrowth of herbaceous species through nutrient recycling (Sample and Mossman 1997). Responses of rangeland songbirds to fire are a function of each species' preferences for the resultant post-burn vegetation conditions, and responses may change with time since fire as vegetation recovers. Grassland songbirds occur in fire-evolved ecosystems that historically had more frequent fires than sagebrush ecosystems (Chap. 6). Prescribed fire, therefore, is applied more frequently in grasslands to maintain songbird habitat than in shrubsteppe.

The timing of prescribed burning is an important consideration. Prescribed fire applied outside of the breeding season precludes the destruction of nests and allows for vegetation regrowth before the nesting season (Higgins 1986; Sample and Mossman 1997). Spring burns, however, can be most effective at suppressing the spread of invasive plant species by damaging plants during a vulnerable growth stage (Shaffer and DeLong 2019).

The consideration of historical fire-return intervals within regions and rangeland types is critical for the maintenance of songbird habitat. For example, in low-elevation, xeric sagebrush habitats, the invasion of nonnative annual grasses such as cheatgrass (*Bromus tectorum*) increases fuel loads, fire frequency, extent, and severity; and reduces shrub cover, which affects habitat suitability for shrub-dependent birds (Knick et al. 2005; Pilliod et al. 2017). Even in fire-dependent grasslands, fire-return intervals shortened relative to historical regimes can result in changes in the composition and structure of vegetation, with resultant reduced habitat quality for some grassland songbird species (Zimmerman 1997; Reinking 2005; With et al. 2008). For example, annual fires can eliminate the residual cover used as avian nesting substrates. Conversely, lengthened fire-return intervals, and especially the suppression of wildfires, may cause the expansion of woody vegetation into previously vast expanses of grassland and high-elevation sagebrush steppe (Grant and Murphy 2005; Nosen et al. 2006; Anderson and Steidl 2019).

12.5.3 *Mowing*

Mowing uniformly reduces vegetation height, woody vegetation, and litter (Herkert et al. 1996; Sample and Mossman 1997). Mowing can therefore be implemented as a management tool for some grassland songbirds that prefer such conditions, both within the current harvest year (Mabry and Harms 2020) and occasionally the subsequent year (Igl and Johnson 2016). However, mowing can have direct negative

effects on ground-nesting songbirds if conducted during the breeding season because nests may be abandoned or destroyed, or incubating adults, eggs, nestlings, and recently fledged young may be killed (Bollinger et al. 1990). Indirect effects of mowing include the reduction of invertebrate populations that serve as important prey for breeding birds (Zalik and Strong 2008). Plant species composition also can be affected over longer time scales with repeated mowing (Sample and Mossman 1997; Allen et al. 2001).

Effects of haying on songbirds depend on the timing and frequency of disturbance. Traditional hayland practices employed by agricultural producers aim to maximize the amount and quality of forage and typically involve an early initial cutting and one or more subsequent harvests that coincide with the avian breeding cycle, which can negatively affect avian reproductive success. Fields that are mowed multiple times within a breeding season and with short intervals between mowing may therefore cause complete avian reproductive failure (Rodenhouse et al. 1995). Conservation-focused haying strategies aim to avoid negative effects on birds by conducting operations after the nesting period (after mid-July or August, depending on location), haying periodically but not annually, and leaving portions of fields un-mowed (Shaffer and DeLong 2019).

12.5.4 Managing for Heterogeneity

A primary goal of livestock producers is to facilitate livestock growth via the maximal consumption of vegetation, which depending on management can decrease vegetation heterogeneity (variation in plant species composition and structure; Chaps. 8 and 9). Such practices can promote the dominance of a few plant species that are valuable to domesticated livestock but do not necessarily facilitate biological diversity. Traditional grazing systems (Chap. 4) wherein beef production is a primary objective, and without the use of fire, can therefore be insufficient in providing the vegetation heterogeneity required to support a diverse local suite of grassland birds (Sliwinski et al. 2019, 2020). In some situations, increasing the habitat heterogeneity within the overall landscape or region for biodiversity may entail managing for conditions that are rare or absent in surrounding areas.

In some grassland ecosystems of the Great Plains, patch-burn grazing, also known as pyric-herbivory, has been promoted as an alternative rangeland management strategy that aims to increase vegetation heterogeneity and avian and vegetation biodiversity while maintaining profitability for livestock producers (Fuhlendorf and Engle 2001; Allred et al. 2011b; Neilly et al. 2016). Patch-burn grazing entails shifting mosaics of burned patches designed to influence grazing distribution and increase vegetation heterogeneity (Fuhlendorf et al. 2006). Where fire is not a feasible management option, local habitat heterogeneity can be enhanced by herding, strategic placement of salt, minerals, or fencing, or alteration of stocking rates and season of use (Scasta et al. 2015; Sliwinski et al. 2019). The extent to which grazing may be used to increase local habitat heterogeneity will depend also on the spatial and

habitat use of cattle, which tend to vary with factors such as topography, soils, water, and stocking rate (Bailey 2005; Rivero et al. 2021; Chap. 4). Cattle tend to decrease habitat selectivity under high stocking rates, which can increase habitat homogeneity (Rivero et al. 2021).

In sagebrush steppe, habitat heterogeneity within a landscape that provides for the entire suite of songbirds may be facilitated through shifts in the relative dominance of woody versus herbaceous vegetation, and promoting both sagebrush and other shrub species in patches of various heights (Knick et al. 2008; Hanser and Knick 2011; Miller et al. 2017). Heterogeneity in plant structure and composition in sagebrush-dominated systems can be influenced by grazing management (Veblen et al. 2014) or reintroduction of fire into communities (e.g., mountain big sagebrush) that have experienced prolonged fire exclusion both of which can help maintain plant diversity (Manier and Hobbs 2006; Davies and Bates 2020). If sagebrush-obligate songbirds (Brewer's sparrow; sagebrush sparrow, *Artemisiospiza nevadensis*; sage thrasher, *Oreoscoptes montanus*) are of primary management interest, the prioritization of areas with relatively tall shrubs (50–200 cm) and high (greater than > 25%) shrub cover is paramount (Chalfoun and Martin 2007; Martin and Carlson 2020; Reynolds et al. 2020). Given the extensive loss of sagebrush habitat range-wide, and the agricultural value of areas within the sagebrush steppe consisting of more mesic, well-drained soils, such conditions have become rare (Knick et al. 2008).

12.6 Disease

The effects of disease on rangeland songbirds are poorly studied. West Nile Virus has been detected in several rangeland-inhabiting species including the bobolink, brown-headed cowbird, black-chinned sparrow (*Spizella atrogularis*), field sparrow (*Spizella pusilla*), lark sparrow (*Chondestes grammacus*), pinyon jay (*Gymnorhinus cyanocephalus*), and Savannah sparrow (*Passerculus sandwichensis*) (Centers for Disease Control 2016). Avian pox viruses have been recorded for sagebrush sparrow and Savannah sparrow (Martin and Carlson 2020; Wheelwright and Rising 2020). Songbirds are affected by outbreaks of salmonellosis, which has a high mortality rate; however, the extent to which this disease affects rangeland songbirds in particular is largely unknown. Species that congregate in flocks and are exposed to contaminated feces appear to be most at risk. Some rangeland songbirds may therefore be vulnerable, including those that use feeders or roost in groups. Brown-headed cowbirds seem to be particularly at risk and may serve as a reservoir for salmonellosis, possibly influenced by their association with cattle (Tizard 2004).

Parasites, such as bird blowflies (*Protocalliphora* spp. and *Trypocalliphora braueri*), are widespread in songbirds and can inflict serious harm. Effects of blowflies have included reduced nestling survival and fledging success for sage thrashers (Howe 1992), reduced tarsi length for sagebrush sparrow nestlings (Peterson et al. 1986), and retarded feather growth for Savannah sparrow nestlings (Bedard and McNeil 1979). Detrimental effects of ectoparasites on songbird nestlings

can be ameliorated by increased food availability and feeding rates by adults, but exacerbated by environmental conditions that decrease foraging opportunities (e.g., adverse weather; Howe 1992; De Lope et al. 1993; Tripet and Richner 1997). Finally, rangeland songbirds also may experience anemia from haematophagous parasites, to a largely unknown extent (Boyd 1951).

12.7 Ecosystem Threats

12.7.1 *Habitat Conversion and Alteration*

The biggest collective threat to rangeland songbird species is habitat loss, fragmentation, and degradation. Large and rapid declines in grassland and aridland species often are linked to the loss and alteration of habitat on breeding grounds (Sauer et al. 2013; Rosenberg et al. 2019). Historically, agricultural practices, and particularly cropland agriculture, have been the greatest causes of native grassland and sagebrush loss in North America (Knick et al. 2003; Rosenberg et al. 2019). Urban development and sprawl in exurban areas, and development for energy resources, have caused further habitat loss and fragmentation (Marzluff and Ewing 2001; Northrup and Wittemyer 2013). The spread of invasive plant species and woody encroachment also causes degradation in habitat quality for songbird species (Archer et al. 2017).

12.7.2 *Energy Development*

Portions of North American rangelands coincide with on-going energy extraction, including oil, natural gas, and wind (Northrup and Wittemyer 2013). Effects of oil and gas development on rangeland songbirds include reduced abundance, altered habitat use, and reduced reproductive success (Gilbert and Chalfoun 2011; Kalyn Bogard and Davis 2014; Thompson et al. 2015; Chalfoun 2021 and references therein). Habitat alteration associated with energy development activities can alter trophic dynamics among wildlife species and result in decreased reproduction or survival. In Wyoming's sagebrush steppe, for example, the nest success of three sagebrush-obligate songbird species decreased with adjacent surface disturbance from natural gas development (Hethcoat and Chalfoun 2015a, b). Nest failures were attributed primarily to increased abundance of rodent nest predators that were attracted to the re-seeded areas surrounding well pads, pipelines and roads (Sanders and Chalfoun 2018).

Activities associated with energy development simultaneously alter many characteristics within landscapes in addition to the footprint, including human activity, noise, and lighting. Yet, the specific mechanisms underlying avian responses are

rarely tested or understood (Jones et al. 2015; Chalfoun 2021; but see Bernath-Plaistad and Koper 2016; Mejia et al. 2019). Wind facilities can cause both direct (mortality due to turbine strikes; Allison et al. 2019) and indirect (reduced reproductive success, avoidance of suitable habitat; Mahoney and Chalfoun 2016; Shaffer and Buhl 2016; Shaffer et al. 2019b) effects on rangeland songbirds. Solar installations are increasing in parts of the western U.S. and may pose additional management challenges (Loss 2016).

12.7.3 *Invasive Species*

Invasive plant species can affect rangeland songbird habitat in a myriad of ways. Many species of rangeland songbirds occur in areas that contain non-native plants, and use them for various activities including nesting or perching (e.g., Ruehmann et al. 2011; Nelson et al. 2017). Evaluation of the extent to which such use has negative consequences for songbirds, however, has implications for the growth of avian populations (e.g., Ruehmann et al. 2011; Nelson et al. 2018). Moreover, a few species of invasive plants, including cheatgrass, can exert such influence that they change the overall functioning of ecosystems and substantially eliminate or alter songbird habitat (Brooks et al. 2004; Knick et al. 2005; Coffman et al. 2014; Bestelmeyer et al. 2018).

The effects of invasive plants on songbirds include the alteration of habitat structure or composition that can influence habitat use, movements, abundance, survival, or reproductive success in a context- and species-specific manner (Stoleson and Finch 2001; Hovick and Miller 2013; Nelson et al. 2017; Stinson and Pejchar 2018). The abundance of songbirds in the northern mixed-grass prairie, for example, decreased slightly or remained the same with exotic grass encroachment (Pulliam et al. 2020). The cover of exotic grass, however, co-varied with herbaceous biomass. Areas with high leafy spurge (*Euphorbia esula*) in North Dakota decreased the breeding densities of some, but not all, species of grassland songbirds (Scheiman et al. 2003). Similarly, patterns of occurrence of songbirds in Saskatchewan between native pastures and those partially comprised of crested wheatgrass (*Agropyron cristatum*) were mixed (Davis and Duncan 1999). Relationships between songbird reproductive success and invasive plants generally have been neutral or positive (Stinson and Pejchar 2018, but see Lloyd and Martin 2005). Other indirect effects include altered prey availability, because native plants typically support more abundant and diverse invertebrate assemblages (Hickman et al. 2006; Litt et al. 2014) which can influence reproductive parameters such as nestling growth (Lloyd and Martin 2005). However, the nestling mass of Botteri's sparrows (*Peucaea botterii*) and several other species of grassland songbirds was unaffected by invasive grasses (Jones and Bock 2005; Kennedy et al. 2009).

Examples of invasive woody plant species include eastern redcedar (*Juniperus virginiana*) in southern grasslands (Archer et al. 2017), *Pinus* spp. and *Juniperus* spp. in sagebrush communities (Knick et al. 2014), and willow (*Salix* spp.) and aspen

(*Populous tremuloides*) in northern grasslands (Grant et al. 2004). Woody encroachment alters both the vertical and horizontal characteristics of vegetation communities, and in some cases results in monocultures with little to no understory (Frost and Powell 2011; Archer et al. 2017; Nackley et al. 2017). These vegetation changes often cause avian species turnover and shifts in avian community composition (Grant et al. 2004; Anderson and Steidl 2019). Changes in habitat quality can occur within grasslands with woody encroachment via altered nest predation and brood parasitism rates, and decreased food availability and quality (Archer et al. 2017). In the Great Plains, for example, eastern red cedar encroachment has increased the habitat fragmentation of remnant grassland patches, with resultant decreases in the abundance of rangeland songbirds, at least partially to increased rates of nest predation (Coppedge et al. 2001; Engle et al. 2003). Similar fragmentation effects and reduced avian abundances have occurred in areas where western juniper (*Juniperus occidentalis*) has expanded into sagebrush steppe (Noson et al. 2006).

12.7.4 Climate Change

By one estimate, 53% of North American bird species are projected to lose more than half of their current geographic range across three scenarios of climate change by the end of the century (Langham et al. 2015). Grassland habitats and birds are expected to be particularly affected by climate change. Nearly half (42%) of grassland breeding bird species were deemed highly vulnerable under a scenario of a 3.0 °C increase in global mean temperature (Wilsey et al. 2019). Sagebrush songbirds similarly have been deemed threatened with respect to changing climate (Fleishman et al. 2014; National Audubon Society 2014; Nixon et al. 2016).

Spatial and temporal variation in precipitation and temperature influence the occurrence, distribution, and reproductive success of rangeland songbird species (Rotenberry and Wiens 1991; Shaffer and DeLong 2019). Years with moderate moisture and temperatures tend to lead to the highest reproductive output for rangeland songbirds, with implications for increasing variation in precipitation regimes (Ludlow et al. 2014; Conrey et al. 2016; Ruth and Skagen 2018). Increasing intensity of storms, such as those producing hail, can result in local mortality of young and adults tending nests (Carver et al. 2017; Hightower et al. 2018). Moreover, increasing temperatures and drought frequency in the western U.S. will likely decrease the productivity of nesting birds (Skagen and Yackel Adams 2012), especially in areas with higher habitat loss (Zuckerberg et al. 2018). Mismatches between the timing of peak availability of invertebrate prey and peak nesting activity also are likely to continue to become more common with a changing climate, which can lower reproductive success (Lany et al. 2016).

12.8 Conservation and Management Actions

12.8.1 *Reversing the Loss and Fragmentation of Native Grasslands and Shrublands*

One aspect central to all wildlife conservation is the necessity to maintain large and relatively intact landscapes, most of which are at least partially composed of private lands. Landscape protection therefore necessitates broad coalitions and partnerships (e.g., Chap. 27).

12.8.2 *Habitat Management*

Given the complexities of the short- and long-term effects of management activities on vegetation and birds in rangelands, and differences in preferred habitat across species, a universal approach to managing rangelands for songbirds does not exist (Duchardt et al. 2019, Shaffer and DeLong 2019). The management practices that facilitate the habitat needs of one species will not necessarily meet the needs of others. Ideal management prescriptions will therefore depend upon specific goals. Because some songbird species are more imperiled than others, a focus on managing for the species of highest conservation concern may be warranted in some scenarios (Herkert et al. 1996). Alternatively, management might focus on sensitive species with limited breeding ranges, and whose core breeding ranges occur within the land manager's jurisdiction. Management suggestions pertaining to individual species can be found in Shaffer and DeLong (2019) and Boxes 12.1 and 12.2 herein. The maintenance of heterogeneity within landscapes can provide the requisite microhabitat diversity for the success of individual songbird species and support a variety of species (Engle et al. 2003; Powell 2006). Patches (e.g., sandy draws) within landscapes consisting of tall shrubs and/or higher shrub cover, for example, support the highest breeding densities of sagebrush-obligate songbird species (Chalfoun and Martin 2007; Williams et al. 2011), and other declining species such as the loggerhead shrike (*Lanius ludovicianus*).

Other factors that influence the effectiveness of management for songbird habitat are regional differences in dominant vegetation types (e.g., warm-season or cool-season grasses), rangeland health (degree of degradation and level of biotic diversity), microclimate, and soil type (Shaffer and DeLong 2019). The previous and current land uses of a management unit also warrant consideration. Rangeland management for the conservation of birds may include ongoing maintenance of extant or degraded native grasslands or shrublands, and restoration of areas that had been converted for another use (e.g., agricultural production) to a more native state. Emulating historic, natural disturbances that resulted in a mosaic of habitats and vegetation structure can facilitate habitat heterogeneity and avian diversity. Resource managers may need to experiment with combinations of management tools at different sites with varying

soil moisture conditions to maintain the array of habitats required to facilitate the biotic diversity of rangeland ecosystems (Ryan 1990).

Given limited resources for conservation, the premise is that management geared towards a single habitat specialist with large home-range requirements, such as the greater sage-grouse (*Centrocercus urophasianus*), can simultaneously protect other co-occurring species of concern often is appealing. The efficacy of relying on such “umbrella species” (Caro 2010), however, partly depends upon the spatial scale at which management is implemented. At broad spatial scales, the reduction of habitat loss and fragmentation certainly may benefit some co-occurring species (Carlisle et al. 2018a). At finer scales, however, the specific resource needs of the umbrella and sympatric species can diverge, and targeted management actions for the umbrella species may be detrimental to other species (Hanser and Knick 2011; Carlisle and Chalfoun 2020). For example, the experimental reduction of sagebrush cover to benefit sage-grouse during the brood-rearing stage led to complete loss of nesting habitat for sagebrush-obligate songbirds (Carlisle et al. 2018b).

Finally, the need to consider the on-going influence of shifting climatic regimes on vegetation and songbird species will be critical for the long-term success of management actions. Adaptive management strategies that accommodate the shrinking and shifting distributions of climate-sensitive species may be one effective mechanism (Langham et al. 2015).

12.9 Research and Management Needs

The remaining informational gaps and research needs for rangeland songbirds are extensive, as most have not received the same level of prioritization as many game species. Experimental and longer-term studies would help clarify the specific habitat factors, disturbances, and management interventions that most affect songbird responses and the underlying mechanisms (Chalfoun 2021). The further development of tools to mitigate the effects of energy development on songbirds is merited (Sanders and Chalfoun 2018; Shaffer et al. 2019b), which will necessitate mechanistic understanding of the effects of different types of energy development on songbird species. Efforts to restore habitats to pre-disturbance conditions and protect native ecosystems most at risk of conversion for new energy extraction will be paramount.

A better understanding of how and why songbird abundance and community composition change in areas affected by invasive plant species and woody-plant encroachment would be useful. The development of statistically rigorous (e.g., Before-After Control-Impact) studies of rangeland songbird species in relation to specific management prescriptions within rangeland types would clarify optimal management approaches. Experimental designs that account for the independent contributions of potentially confounding variables, such as the effects of burning versus grazing, also would be fruitful. Improved understanding of the effects of ecological processes and mechanical management practices on avian abundance and productivity at scales relevant to management (e.g., grazing allotments) would

further clarify optimal management approaches for songbird management (Pulliam et al. 2021). Potential carryover effects of management activities, such as grazing across years, also would provide more holistic understanding (Johnson et al. 2011). In addition, a better understanding of the influence of multiple stressors, including interactions between changing climatic conditions and their effects on songbird habitats, will be critical for the effective management of rangeland songbirds into the future.

A lack of information about the demography of most rangeland songbird species across the full annual life cycle (i.e., outside of the nesting period), and which life stage(s) are most affected by habitat changes and the most limiting to population growth greatly hampers understanding of ideal management allocation (Marra et al. 2015). The post-fledging survival, migratory routes, key stopover areas, overwintering locations, and annual survival of most grassland and sagebrush songbird populations remain unknown, partly because of historic limitations on tracking technologies that could be deployed safely on small birds. Because most rangeland-associated songbirds leave the nest prior to being capable of sustained flight (Yackel Adams et al. 2006), habitat requirements, and rates and causes of mortality during the post-fledgling period may be particularly important to understand for threat and population assessments (Yackel Adams et al. 2006; Davis and Fisher 2009; Hovick et al. 2011). Lack of knowledge about the movements and cause-specific mortality of many grassland and shrubsteppe songbird species during migration and winter also inhibits understanding of the relative influence of the breeding versus non-breeding periods on annual survival and therefore population growth (Fletcher et al. 2006). Finally, conditions and processes during particular life stages can carry-over into subsequent stages (Akresh et al. 2021), albeit to an unknown extent for most songbirds inhabiting North American rangelands.

Study of the prevalence and effects of disease (e.g., salmonellosis), endoparasites, and ectoparasites (e.g., blowflies) on the condition and vital rates of rangeland songbirds is in its infancy. Fairly high blow fly loads have been observed on some nestlings in Montana and Wyoming, which can result in partial or complete mortality of the brood (A. Chalfoun, personal observation). Whether particular conditions such as energy development, livestock grazing, or weather influence the susceptibility of songbirds to disease or parasites, and whether such changes scale up to influence populations, remains unclear.

Finally, the importance of understanding and acknowledging the contribution of native peoples' role in wildlife management, and the incorporation of indigenous and local knowledge into management policies, has been emphasized recently by scholars and U.S. legislators (Lam et al. 2020). Such information is rarely incorporated into rangeland management plans, yet such knowledge offers historical insights that may complement and enrich contemporary approaches to sustainable use of landscapes and encourage practices that are more culturally inclusive and holistic (Lam et al. 2020).

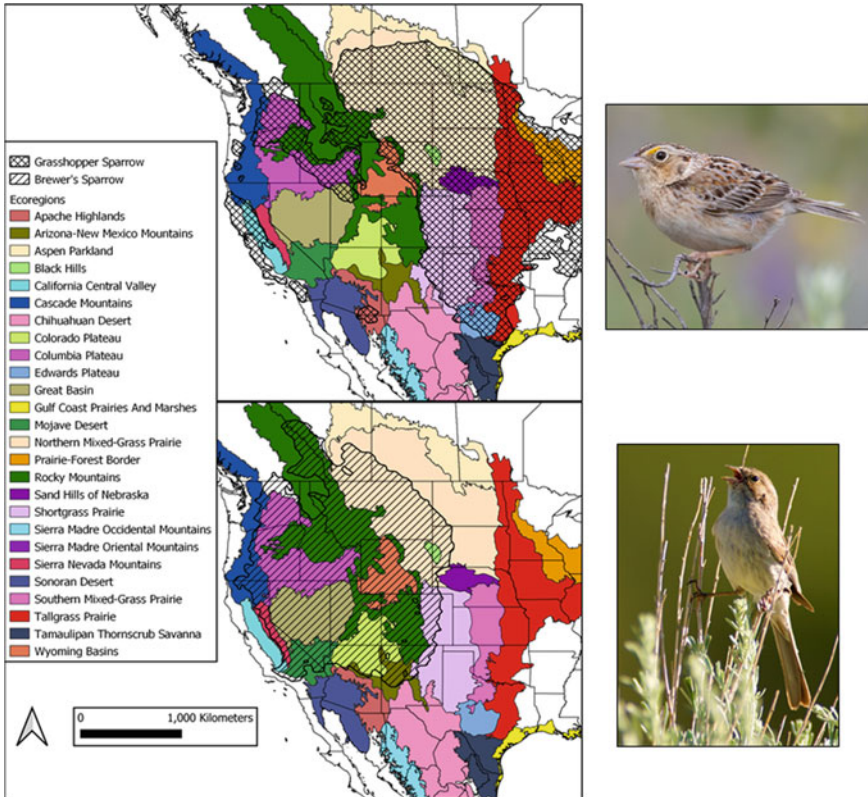


Fig. 12.2 Grasshopper sparrow (*Ammodramus saviannarum*) and Brewer's sparrow (*Spizella breweri*) breeding distributions in relation to rangeland ecoregions of North America. *Photo credits* Blair Dudeck and Dave Showalter

Box 12.1. Grasshopper Sparrow (*Ammodramus saviannarum*)

Habitat Associations

The grasshopper sparrow is a grassland-obligate songbird with a trans-coastal distribution, whose highest breeding densities occur throughout the Great Plains (Vickery 2020; Fig. 12.2). Grasshopper sparrows breed in a variety of native habitats including prairies, desert grasslands, savannahs, and sagebrush steppe, and in nonnative habitats such as planted grasslands (Shaffer et al. 2021). Throughout the grasslands of the Great Plains, grasshopper sparrows tend to avoid areas with woody vegetation (Bakker et al. 2002; Patten et al. 2006; Herse et al. 2018), where the species is reported to be area sensitive [that is, to show a preference for larger extents of grassland; reviewed in Ribic et al. (2009) and Shaffer et al. (2021)]. Within sagebrush steppe, however, the

species is more tolerant of shrubby habitats that include native bunchgrasses in the understory (Holmes and Miller 2010; Earnst and Holmes 2012). Vegetation structure likely influences the habitat decisions of grasshopper sparrows to a greater extent than plant species' composition (Henderson and Davis 2014; Shaffer et al. 2021), as grasshopper sparrows will nest within areas dominated by nonnative grasses such as Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*) (Grant et al. 2004; Shaffer et al. 2021). Structural attributes of vegetation associated with grasshopper sparrow occupancy include intermediate height (8–166 cm), moderate density (4–80 cm visual obstruction reading), moderately deep litter (≤ 9 cm), low-to-moderate bare ground ($\leq 38\%$ bare ground), and low shrub cover ($< 35\%$) (Shaffer et al. 2021). This narrative will focus on management approaches to benefit grasshopper sparrows breeding in grassland habitats and will not discuss management approaches for other ecosystems such as sagebrush.

Rangeland Management

Management approaches that maintain open expanses of grassland benefit the grasshopper sparrow. Typical management approaches for the grasshopper sparrow involve grazing-only or a combination of burning and grazing (Shaffer et al. 2021). Optimal management strategies vary across the species' range depending on how the resultant habitat structure and composition comports with the species' habitat requirements.

The effects of grazing on grasshopper sparrows depend on local factors such as rangeland type, climate, topographic conditions, and landscape composition (Lipsey and Naugle 2017; Vold et al. 2019; Davis et al. 2021). Further considerations include the timing of grazing, grazing intensity (e.g., stocking rate and duration), and livestock type, all of which may influence the abundance and reproductive success of grasshopper sparrows (Shaffer and DeLong 2019; Shaffer et al. 2021). Appropriate intervals between management treatments depend on rangeland type; for example, mesic prairies regenerate litter more rapidly (1–3 years) than dry prairies (4–6 years) and sooner in southern than northern prairies (Swengel 1996). In tallgrass prairies, moderate-to-heavy grazing reduces vegetation biomass and curtails woody encroachment (Ahlering and Merkord 2016). In mixed-grass prairies, light-to-moderate grazing that reduces vegetation height and density and creates patchy areas is compatible with the habitat needs of the grasshopper sparrow, however, heavy grazing can reduce litter depth and cover to unsuitable levels (Shaffer et al. 2021). Nest densities in Palouse prairie decreased with cattle stocking rates, and no nests were found in pastures with the highest stocking rates of 43.2 animal unit months (46% vegetation utilization) (Johnson et al. 2011). Grazing studies within desert grasslands have been very localized (Ruth 2015), and even light grazing can be detrimental if vegetation becomes too short and open for grasshopper sparrow use (Bock and Webb 1984; Bock et al. 1984, 1993). Heavy

grazing in arid grasslands tends to reduce already sparse bunchgrass cover and exclude grasshopper sparrows (Bock and Webb 1984).

In contrast to earlier studies in mixed-grass prairies that suggested that rotational grazing systems may achieve desired vegetation heterogeneity for birds (Shaffer et al. 2021), rest-rotation grazing in northern mixed-grass prairies failed to increase grasshopper sparrow abundance, relative to traditional season-long or summer-rotation grazing (Vold et al. 2019). Similarly, rotational grazing systems in the Nebraska Sandhills (Sliwinski et al. 2019, 2020), shortgrass prairies (Davis et al. 2020), and tallgrass prairies (Temple et al. 1999) did not convey population benefits to the grasshopper sparrow. Rotational grazing systems may fail to create sufficient vegetation heterogeneity to be ecologically relevant to bird communities (Sliwinski et al. 2020), especially when other factors such as year, ecological site (Davis et al. 2020), and stocking rate (Sliwinski et al. 2019; Vold et al. 2019) can have greater effects on bird abundance than grazing system. Livestock type also may influence avian abundance, as grasshopper sparrows were more abundant in Montana pastures grazed by bison than in pastures grazed by cattle (Boyce et al. 2021) and equally as abundant in cattle- and bison-grazed pastures in Colorado (Wilkins et al. 2019).

Fire as a management strategy for grasshopper sparrows is more common within Great Plains grasslands than desert grasslands, where burns usually are the result of wildfires (Shaffer et al. 2021). Similar to grazing, the response of grasshopper sparrows to burning will depend on how vegetation structure is affected, which may vary locally by climate, ecosystem or habitat type, type of burn (e.g., prescribed burn versus wildfire), season, frequency, and intensity (Shaffer and DeLong 2019; Shaffer et al. 2021). The effects of burning-only management on the abundance of grasshopper sparrows in mixed-grass and tallgrass prairies have been varied (Madden et al. 1999; Grant et al. 2010; Byers et al. 2017). In desert grasslands, fires that destroy shrubs may be detrimental, as small shrubs are used by grasshopper sparrows as thermal refugia during extremely hot temperatures (Ruth et al. 2020).

The combination of burning and grazing is a common management approach implemented throughout the Great Plains. Geographic variation in management objectives and approaches, study designs, and timing of the application of burning and grazing, however, make a statement of broad generalizations about the effect on grasshopper sparrow abundance or success difficult (Shaffer et al. 2021). Burning and grazing approaches predominate in northern mixed-grass prairies (e.g., Richardson et al. 2014), shortgrass prairies (e.g., Augustine and Derner 2015), tallgrass prairies (e.g., Fuhlendorf et al. 2006), and sand sagebrush grasslands (Holcomb et al. 2014). The patch-burn grazing strategy explained in this chapter's main section is advocated primarily for tallgrass prairies, with a focus on the Flint Hills (Fuhlendorf and Engle 2001). Examinations between the effects of the traditional burning and grazing approach

in the Flint Hills (that is, annual early-spring burns followed immediately by grazing) and the patch-burn grazing approach have yielded variable results on grasshopper sparrow abundance and productivity (Shaffer et al. 2021).

Box 12.2. Brewer's Sparrow (*Spizella breweri*)

Habitat Associations

The Brewer's sparrow often is referred to as a sagebrush-obligate (Rich et al. 2005), along with the sagebrush sparrow (*Artemisiospiza nevadensis*) and sage thrasher (*Oreoscoptes montanus*), although Brewer's sparrows occasionally inhabit other shrubby habitats. Brewer's sparrows are migratory, and overwinter in the southwestern U.S. and Mexico (Knick et al. 2014; Valencia-Herverth et al. 2018). The breeding range of Brewer's sparrows covers most of the extent of North American shrubsteppe, from southern British Columbia, Alberta and Saskatchewan in Canada, south to southern California, southern Nevada, and northern Arizona and New Mexico (Walker et al. 2020; Fig. 12.2).

Brewer's sparrows prefer and are found in the highest breeding densities within landscapes composed of relatively high cover of sagebrush (> 30%) and taller shrubs (Rotenberry and Wiens 1980; Chalfoun and Martin 2007; Walker et al. 2020). Because Brewer's sparrows primarily sing, forage and nest within the shrub layer (e.g., Rotenberry and Wiens 1998; Fig. 12.3), the attributes of the shrub layer are paramount. Brewer's sparrows may be entirely absent from areas with shrub cover $\leq 8\%$ (Walker et al. 2020). Habitat preferences and quality, moreover, are scale-dependent. At smaller spatial scales, Brewer's sparrows preferred and had higher reproductive success in territories and nest patches (5-m radius) with higher shrub density, and particularly densities of potentially suitable nest shrubs (Chalfoun and Martin 2007, 2009).



Fig. 12.3 Brewer's sparrow adult incubating eggs, a clutch of eggs, and a nest in the process of hatching in western Wyoming, USA. *Photo credits* Anna Chalfoun

Brewer's sparrows prefer to forage and place nests in shrubs with live canopies (Peterson and Best 1985; Rotenberry and Wiens 1998; Chalfoun and Martin 2009; Fig. 12.3).

Rangeland Management

As a near sagebrush-obligate, management actions that remove or decrease big sagebrush (*Artemisia tridentata*) cover, including burning (Bock and Bock 1987; Knick et al. 2005; Noson et al. 2006), the application of herbicides (Best 1972; Schroeder and Sturges 1975; Kerley and Anderson 1995), and mechanical treatments (Castrale 1982; Carlisle et al. 2018b) tend to eliminate or reduce the local abundance of the Brewer's sparrow (Walker et al. 2020). Because big sagebrush does not re-sprout after fire, frequent fires increase the cover of annual grasses and reduce sagebrush cover which decreases habitat for sagebrush-obligates including the Brewer's sparrow (Knick et al. 2003). Burning also can negatively affect sagebrush songbirds by promoting the spread of nonnative weeds and the subsequent conversion of shrubsteppe habitats to nonnative annual grasslands. The planting of nonnative grasses following sagebrush removal hinders recolonization by sagebrush and delays or prohibits the recovery of Brewer's sparrow habitat (Reynolds and Trost 1980; McAdoo et al. 1989). Insecticide treatments during the nesting period have the potential to reduce arthropod prey and thereby alter Brewer's sparrow habitat use and productivity (Howe et al. 1996).

Management activities that reduce coniferous encroachment into sagebrush habitats have shown positive effects on sagebrush songbirds (Crow and van Riper 2010). However, habitat treatments traditionally geared towards the reduction of the sagebrush canopy and enhancement of herbaceous understories, thought to benefit the greater sage-grouse (*Centrocercus urophasianus*) and the Gunnison sage-grouse (*Centrocercus minimus*) during the brood rearing period, usually negatively affect sagebrush-obligate songbirds. Mechanical treatments (e.g., roller chopping, disking, mowing,) in Colorado significantly decreased densities of Brewer's sparrows (Lukacs et al. 2015). Moreover, experimental evaluation of mowing effects in central Wyoming resulted in the complete loss of nesting habitat for Brewer's sparrows and sage thrashers (Carlisle et al. 2018b).

Rigorous investigations of the effects of grazing regimes on the Brewer's sparrows have been limited. The abundance of Brewer's sparrows did not differ between rest-rotation versus season-long grazing treatments in Montana (Golding and Dreitz 2017). However, Brewer's sparrow abundance decreased with the highest grazing treatment during a study in southern Idaho and northern Utah, which corresponded with lower shrub cover and higher cover of exotic annuals (Bradford et al. 1998). Brewer's sparrows tend to be less affected by moderate grazing compared with grassland songbirds that are more reliant on the herbaceous understory (Bock et al. 1993).

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