

# Effects of Livestock Grazing on Neotropical Migratory Landbirds in Western North America

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**Abstract** — Livestock grazing is a widespread and important influence on neotropical migratory birds in four major ecosystems in western North America: grasslands of the Great Plains and Southwest, riparian woodlands, Intermountain shrubsteppe, and open coniferous forests. We have reviewed available literature on avian responses to grazing in these habitats. Among 35 plains species for which data are available, 9 responded positively to grazing, 8 responded negatively, 8 showed a graded response, from generally negative in shorter grasslands to generally positive in taller grasslands, while 8 were unresponsive or inconsistent. A similar comparison for riparian woodlands revealed that 8 of 43 species responded positively to grazing, while 17 were negatively affected, and 18 were unresponsive or showed mixed responses. Data for shrubsteppe habitats are much more limited, but only 3 of 23 species probably have been positively affected, at least by current grazing practices, while 13 probably have been negatively influenced, and at least 7 species showed mixed responses. Virtually nothing is known about effects of grazing on birds of coniferous forests. Most species negatively influenced by grazing have been those dependent on herbaceous ground cover for nesting and/or foraging. Given the ubiquity of livestock in the American West, species dependent upon lush ungrazed ground cover are at risk, and doubtless already are at population levels far below historical levels. Protection and restoration of riparian habitats is of particular importance, because of their limited geographic extent, and the extraordinary abundance and diversity of their neotropical migrants. There is an urgent need for long-term, well-replicated, field studies comparing bird populations in grazed and ungrazed shrubsteppe and montane coniferous forest habitats.

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## INTRODUCTION

Of all the issues facing public land managers in western North America, none is more contentious than grazing by domestic livestock. This is in part because of competing economic, social, and conservation interests involved. In this sense, the grazing issue is analogous to the controversy surrounding harvest of old growth timber. However, a complicating factor unique to grazing is that herbivory by native hooved mammals has been an important, natural, ecological and evolutionary force in certain non-forested ecosystems, including

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many in central and western North America (e.g., Stebbins 1981, McNaughton 1986). To be sure, domestic livestock have greatly increased the influence of grazing in most of these ecosystems historically, and this influence has been particularly destructive to those ecosystems where native grazing ungulates were scarce or absent (e.g., Mack and Thompson 1982, Milchunas et al. 1988, Schlesinger et al. 1990). Nevertheless, it is possible to argue that, for certain habitats, livestock grazing simulates a natural ecological event, and one which native flora and fauna tolerate or perhaps even require. Therefore, assertions about consequences of grazing must be habitat and species-specific, and to be credible they should be based on quantitative data resulting from carefully designed and executed field studies. Livestock grazing is the most widespread economic use of public land in the American West. For example, approximately 86 million hectares of federal land in 17 western states are used for livestock production (Sabadell 1982). Grazing is the primary land-use in four habitat types important to western neotropical migratory birds: 1) Great Plains and Southwest grasslands, 2) Intermountain region shrubsteppe communities, 3) meadows and understory associated with montane conifer forests, and 4) riparian communities. Our objective is to provide a succinct management-oriented overview of the species-specific avian responses to grazing in these habitats. Our conclusions are based on studies of bird populations in areas experiencing different levels of grazing, or, in cases where we lack such information, on known effects of livestock on vegetation, and known habitat requirements of the birds.

## GRASSLANDS OF THE GREAT PLAINS AND SOUTHWEST

### The Region and Its Avifauna

The Great Plains are one of the largest grassland biomes on earth, extending from the Rocky Mountain Front Range east to forests and woodlands of the central U. S. and Canada, and from the Canadian prairie provinces south to desert and semidesert grasslands surrounding the Chihuahuan Desert. We include southwestern grasslands as part of the region because of their strong floral and evolutionary ties to grasslands of the central and northern plains (Axelrod 1985). Within the region, precipitation increases from west to east, while temperature increases from north to south, with the result that grasslands to the south and west are increasingly water-stressed. Following these climatic gradients, comparatively lush tallgrass prairie and prairie-parkland occur east of the 100th meridian, with mid-height mixed-grass steppe in the northwestern plains, shortgrass steppe in the west-central plains, and desert and semidesert grasslands in the Southwest (Bailey 1978).

The Great Plains achieved their maximum treeless extent only within the past few thousand years, and they remain vulnerable to invasions by shrubs and trees (Sauer 1950,

Daubenmire 1978). Density and variety of birds are low in plains grasslands, compared to most forested ecosystems. This has been attributed to their recent evolutionary origin, low productivity, structural simplicity, and ecological instability (Mengel 1970, Wiens 1974, Cody 1985). The typical plains grassland supports 200-400 birds/km<sup>2</sup>, including 2-5 sparrow-like species, a meadowlark or other blackbird relative, a shorebird, a grouse, frequently a dove, and 1-3 birds of prey (Wiens 1974, Cody 1985).

### Effects of Livestock Grazing on Vegetation

Drought, fire, and ungulate grazing were and are the major ecological and evolutionary forces determining dynamics of Great Plains ecosystems (Anderson 1982). Millions of bison (*Bison bison*) once occupied the plains, and we suspect (but cannot know) that they, along with periodic fires, imposed on the region a broad-scale mosaic of grasslands in various stages of post-fire and post-grazing ecological succession. Introduction of domestic livestock greatly increased the importance of grazing, relative to drought and fire, in determining the nature of Great Plains grasslands. This was particularly the case in relatively humid sites, and/or in places where bison were scarce or absent (Milchunas et al. 1988).

In general, livestock on Great Plains ecosystems have reduced fire frequency and intensity through consumption of fine fuels, thereby encouraging invasions by woody plants, and to favor short-stature sodgrasses (e.g., *Buchloe*, *Hilaria* spp) over taller, less grazing-tolerant, bunchgrasses (e.g., *Agropyron*, *Stipa* spp.). However, the nature and magnitude of these effects have varied greatly across the plains. Fires play a critical role in keeping tallgrass prairies free of woody vegetation (Gibson and Hulbert 1987). By consuming burnable fine fuels, livestock have caused many tallgrass sites to become woodlands or shrublands. In arid parts of the Southwest, where there were no bison, historical livestock grazing degraded many grasslands into permanent desert scrub (Schlesinger et al. 1990). In certain mixed-grass ecosystems, livestock grazing favored short-stature sodgrasses over taller bunchgrasses that otherwise would dominate the landscape (e.g., Bock and Bock, in press). However, in shortgrass steppe, low-stature and/or sod-grasses that tolerate grazing are the same plant species able to survive frequent droughts, so that here livestock may have little or no impact on grassland structure or species composition (Milchunas et al. 1988).

### Response of Grassland Neotropical Migrants to Grazing

We found published data on responses of 35 neotropical migrants to livestock grazing in Great Plains ecosystems (Table 1). In all studies listed, data were presented on relative abundances of birds in moderately or heavily grazed grasslands, compared either ungrazed or lightly grazed sites. There is an obvious problem with these qualitative assessments of grazing

**Table 1. — Responses to livestock grazing by neotropical migratory birds breeding and/or wintering in grasslands of the North American Great Plains and Southwest.<sup>1</sup>**

**Species usually responding positively to grazing:**

Killdeer ( <i>Charadrius vociferans</i> )	Northern Mockingbird ( <i>Mimus polyglottos</i> )
Mountain Plover ( <i>Charadrius montanus</i> )	Lark Sparrow ( <i>Chondestes grammacus</i> )
Burrowing Owl ( <i>Athene cunicularia</i> )	Black-throated Sparrow ( <i>Amphispiza bilineata</i> )
Common Nighthawk ( <i>Chordeiles minor</i> )	McCown's Longspur ( <i>Calcarius mccownii</i> )
Horned Lark ( <i>Eremophila alpestris</i> )	

**Species usually responding negatively to grazing:**

Northern Harrier ( <i>Circus cyaneus</i> )	Cassin's Sparrow ( <i>Aimophila cassini</i> )
Short-eared Owl ( <i>Asio flammeus</i> )	Savannah Sparrow ( <i>Passerculus sandwichensis</i> )
Common Yellowthroat ( <i>Geothlypis trichas</i> )	Baird's Sparrow ( <i>Ammodramus bairdii</i> )
Botteri's Sparrow ( <i>Aimophila botteri</i> )	Henslow's Sparrow ( <i>Ammodramus henslowii</i> )

**Species usually responding positively, at least to moderate grazing in taller grasslands, but responding negatively, at least to heavier grazing in shorter grasslands:**

Upland Sandpiper ( <i>Bartramia longicauda</i> )	Chestnut-collared Longspur ( <i>Calcarius ornatus</i> )
Sprague's Pipit ( <i>Anthus spragueii</i> )	Bobolink ( <i>Dolichonyx oryzivorus</i> )
Dickcissel ( <i>Spiza americana</i> )	Redwinged Blackbird ( <i>Agelaius phoeniceus</i> )
Lark Bunting ( <i>Calamospiza melanocorys</i> )	Eastern Meadowlark ( <i>Sturnella magna</i> )
Grasshopper Sparrow ( <i>Ammodramus savannarum</i> )	Western Meadowlark ( <i>Sturnella neglecta</i> )

**Species unresponsive, or showing mixed or uncertain responses to grazing:**

Ferruginous Hawk ( <i>Buteo regalis</i> )	Brewer's Sparrow ( <i>Spizella breweri</i> )
Long-billed Curlew ( <i>Numenius americanus</i> )	Vesper Sparrow ( <i>Pooecetes gramineus</i> )
Mourning Dove ( <i>Zenaidura macroura</i> )	LeConte's Sparrow ( <i>Ammodramus leconteii</i> )
Clay-colored Sparrow ( <i>Spizella pallida</i> )	Brown-headed Cowbird ( <i>Molothrus ater</i> )

<sup>1</sup>References: Baker and Guthery 1990, Bock and Bock 1988, Bock et al. 1984, Duebber and Lokemoen 1977, Graul 1975, Kantrud 1981, Kantrud and Higgins 1992, Kantrud and Kologiski 1982, Krisch and Higgins 1976, Lokemoen and Deubbert 1976, Maher 1979, Owens and Myres 1973, Risser et al. 1981, Ryder 1980, Skinner 1975, Tester and Marshall 1961, Webb and Bock 1990, Wiens 1973.

intensity, but frequently no other information was given. We listed a response as positive or negative only where the differences between treatments appeared > 25%. The studies differed widely in such critical variables as size and replication of plots. Despite these inevitable limitations, the results generally revealed consistent and interpretable patterns.

One group poorly represented in the data set are birds of prey (Table 1). Most hawks and owls have such large home ranges that their densities cannot be meaningfully compared on plots of sizes typically used in these studies. An increased number of large livestock enclosures therefore would have value for research on, as well as conservation of, this component of the Great Plains avifauna. Certain raptors (e.g., Burrowing Owl) clearly require much bare ground, and probably are favored by grazing, while others (e.g., Northern Harrier) select heavier cover of ungrazed or lightly grazed sites (see references in Table 1). The Ferruginous Hawk may require both sorts of habitats: open country for foraging, and lush vegetation for nesting.

Shorebird species have responded variously to livestock grazing, though in general birds in this group prefer to nest in relatively sparse (= moderately to heavily grazed) grasslands (Kantrud and Higgins 1992). Mountain Plovers require sites with minimal vegetation, whereas the Upland Sandpipers require more grass cover. Construction of livestock watering tanks may improve certain arid grasslands as shorebird habitat.

Songbirds show the full range of responses to grazing. At one extreme are species such as Horned Lark, Lark Sparrow, and McCown's Longspur, that doubtless have benefitted throughout the Plains from effects of livestock activity. At the other extreme is a group of songbirds apparently so dependent upon heavy litter cover and grass canopy that their response to grazing has been universally negative. Examples include Savannah Sparrow, Baird's Sparrow, Henslow's Sparrow, and Botteri's Sparrow. A third group appear to require intermediate levels of ground cover, such that grazing creates habitats of their preferred structure in tallgrass and some mixed-grass communities, while it eliminates them in shorter grasslands. The

best-studied of these species is the Grasshopper Sparrow. Other examples include Sprague's Pipit, Bobolink, and Chestnut-collared Longspur.

Among neotropical migrants as a whole, 8 of 35 species showed a weak or inconsistent response to grazing, 9 were positively affected, 8 were negatively affected, and 10 showed some manifestation of a graded response: from positive in taller grasslands to negative in shorter grasslands (Table 1).

### Management Implications and Recommendations

Birds are particularly responsive to changes in the physical structure of habitats in which they nest and forage (Cody 1985). Therefore, livestock potentially have their greatest impact on birds where grazing most changes the habitat physical structure. In the Great Plains, this includes taller rather than shorter grasslands, and certain arid regions of the Southwest where historical grazing converted desert grasslands into desert scrub. However, evidence suggests that every type of North American grassland includes a fauna of grazing-tolerant or grazing-dependent species, and another of species equally intolerant of grazing. Neotropical migratory birds clearly fall into both groups.

Two specific recommendations for management of Great Plains grasslands emerge from these considerations. The first is to substantially increase the amount of public rangeland from which all livestock are permanently excluded. Of particular importance on the Great Plains are National Grasslands, which include more than 1.5 million ha presently managed by the U. S. Forest Service largely for livestock production (West 1990). Many of these areas are managed by applying some sort of rotational grazing, and it could be argued that this imposes on the National Grasslands a mosaic of habitats resembling the prehistoric condition. However, ecological succession in most of these grasslands is far slower than the frequency of grazing rotation, thus leading to relatively uniform vegetative communities. Rather, we believe that permanent livestock exclusion, or at least exclusion for 25-50 years, might allow some of these important grasslands eventually to provide habitat for grazing-intolerant neotropical migrants and other species.

Our second recommendation is to continue a modified version of the Federal Conservation Reserve Program (CRP), to encourage landowners to convert and maintain formerly tilled croplands as grassland planted to native vegetation. Millions of hectares of CRP grasslands have been planted on the Great Plains since 1985, though the majority are dominated by exotic rather than native grasses (Joyce et al. 1991). Nevertheless, CRP grasslands are much more valuable for most wildlife than the croplands they have replaced (Kantrud and Higgins 1992, D. H. Johnson, Pers. comm.).

CRP grasslands remain vulnerable to recultivation, and this decision rightly is in the hands of landowners. However, it would be unfortunate if CRP lands were tilled (setting the successional

clock back to zero), only to be returned to grassland when declining crop prices or future government incentives dictate. It would be much better from a conservation perspective to find ways of making present CRP grasslands valuable to their owners, possibly by encouraging moderate livestock grazing or haying. This would be an especially desirable strategy if it could be coupled with creation of livestock exclosures in other areas such as the National Grasslands.

## RIPARIAN HABITATS

### Avifauna of Riparian Ecosystems

In arid portions of western North America, riparian habitats consist of well-defined, narrow zones of vegetation along ephemeral, intermittent, and perennial streams and rivers. Some riparian communities are dominated by shrubs such as shorter willow (*Salix* spp.) or alder (*Alnus* spp.), but the most conspicuous communities, and those most important to breeding birds, include mature trees such as cottonwood (*Populus* spp.), taller willow, or sycamore (*Platanus* spp., Johnson and Jones 1977). These wooded riparian habitats are particularly valuable to wildlife when adjacent to relatively unproductive steppe, shrubsteppe, and desert communities (Knopf 1993).

Conservation of riparian areas is of great concern because they have extraordinary wildlife value and are vulnerable to disturbance and fragmentation associated with livestock grazing, agriculture, water management, timber harvest, recreation, urbanization, and other land-use activities (e.g., Thomas et al. 1979, Knopf et al. 1988a). Riparian habitats are the most modified land type in the American West (Chaney et al. 1990).

Despite their limited geographic extent (less than 1% of the land area), western riparian habitats are very important to neotropical migratory landbirds (Szaro 1980). The highest densities of breeding birds in all of North America have been reported from southwestern riparian woodlands (Carothers and Johnson 1975, Ohmart and Anderson 1982, Rice et al. 1983). More than 75% (127 of 166) of southwestern bird species nest primarily in riparian woodlands, and neotropical migrants comprise 60% of the 98 landbirds (Johnson et al. 1977). In Idaho, 60% of neotropical migrant landbirds are associated with riparian habitats (Saab and Groves 1992). In northern Colorado, 82% of all nesting species use riparian areas, and 78% (93 of 119) of landbird species are neotropical migrants (Knopf 1985).

Migratory landbirds inhabiting riparian vegetation in western North America are particularly vulnerable to disturbance. Their habitats are so fragmented and limited in distribution that total populations are much smaller than those of most neotropical migrants associated with woodlands of eastern North America (Terborgh 1989). Conservation of neotropical migratory landbirds in the western United States will depend very much on protection and restoration of riparian woodlands.

## Effects of Livestock Grazing on Riparian Habitats

Livestock grazing has caused geographically extensive impacts on western riparian areas (Carothers 1977, Chaney et al. 1990). Grazing tends to be more damaging in riparian bottomlands than in adjacent uplands (Platts and Nelson 1985), especially in arid regions where livestock are attracted to water, shade, more succulent vegetation, and flatter terrain (Platts 1991). Cattle compact soil by hoof action, remove plant materials, and indirectly reduce water infiltration, all of which result in decreased vegetation density (Holechek et al. 1989). Grazing potentially can eliminate riparian areas through channel widening, channel aggrading, or lowering the water table. Because birds are known to be responsive to alterations in structure and floristics of riparian habitats (e.g., Szaro and Jakle 1985), it is not surprising that neotropical migrants are affected by livestock-induced changes in these habitat characteristics (Sedgwick and Knopf 1987, Knopf et al. 1988b).

Livestock management systems differ in their seasons and intensities of grazing. Year-long and summer grazing have proven particularly damaging to riparian vegetation (Kauffman and Krueger 1984, Platts 1991), whereas moderate late-fall or winter grazing may have relatively little impact (Sedgwick and Knopf 1987, 1991). In late fall and winter, water levels typically are low, stream banks are dry, and vegetation is dormant, thus minimizing the effects of trampling, soil compaction, erosion, and browsing (Rauzi and Hanson 1966). However, fall-winter grazing should be carefully controlled to leave protective plant cover for the following spring stream-flow periods (Clary and Webster 1989).

Livestock can damage riparian systems in early fall. Given the opportunity, cattle will concentrate in riparian areas at this season, because adjacent upland vegetation is dry and less palatable. As herbaceous cover is depleted, livestock will shift to browsing riparian shrubs (especially willow) before leaf drop, reducing residual cover needed for stream bank maintenance during subsequent high spring flows (Clary and Webster 1989, Kovalchick and Elmore 1992).

Short-term, early spring grazing may also help maintain riparian vegetation relative to summer grazing (Clary and Webster 1989). Early season grazing can result in better distribution of livestock use between riparian and upland zones, because upland vegetation is succulent at this time, and because livestock may avoid the wetter riparian environment.

Two difficulties in evaluating impacts of grazing on riparian ecosystems are 1) a shortage of long-term studies (Sedgwick and Knopf 1991), and 2) uncertainty as to pre-livestock condition of plant communities. Existing riparian vegetation may prove resilient in the presence of livestock, at least for several years. However, in the long-term, species composition, structural diversity, width of the riparian zone, and succession patterns of riparian woodlands may be affected further by the influence of livestock on establishment and survival of tree seedlings (Glinski 1977, Ohmart and Anderson 1986). This is an area of much-needed additional research. Ornithological studies

described in the following section involved comparisons of existing riparian habitats experiencing different levels of grazing. They do not account for the possibility that certain riparian plant communities might ultimately be eliminated by grazing.

## Response of Riparian Neotropical Migrants to Grazing

We know of nine published studies providing quantitative comparisons of abundances of 68 neotropical migrants in western riparian ecosystems experiencing different levels of livestock grazing (Table 2); six compared grazed to ungrazed sites, two used sites with different intensities of grazing, and one involved sites grazed at different seasons. Despite small sample sizes and differences in quantity and nature of data in the various studies, their results provide generally consistent and biologically meaningful insights into the responses of riparian neotropical migrants to grazing.

Forty-three species were evaluated by two or more studies. For these, we listed species as responding positively or negatively to grazing if their mean abundances differed between treatments by  $> 25\%$ , and if both ( $n = 2$ ) or a majority ( $n = 3$  to 8) of comparisons were consistent in the direction of response to grazing (Table 2). By these criteria, 8 species have been positively influenced by grazing, 17 species have been negatively affected, and 18 species were unresponsive or showed inconsistent or uncertain responses.

Distribution of species among three response groups generally reflects what is known of their habitat requirements. Species responding positively to grazing included aerial foragers associated with open habitats (e.g., Lewis' Woodpecker, Mountain Bluebird), ground foragers preferring areas with relatively little cover (e.g., American Robin, Killdeer), or, in one case, a species directly attracted to livestock Brown-headed Cowbird).

Most neotropical migrants negatively impacted by livestock grazing were species that nest and/or forage in heavy shrub or herbaceous ground cover (e.g., Common Yellowthroat, Lincoln's Sparrow), and/or that may be especially vulnerable to cowbird parasitism (e.g., Willow Flycatcher; Sedgwick and Knopf 1988). In addition to the 17 taxa listed in Table 2, at least 7 more species with similar habitat requirements probably also have been harmed by grazing in riparian ecosystems. Three of these were evaluated in only one of 9 studies, but showed strongly negative responses: Veery (*Catharus fuscescens*), Nashville Warbler (*Vermivora ruficapilla*), and Fox Sparrow (*Passerella iliaca*). Other species showed uncertain or inconsistent responses to grazing, based on limited published data, but almost certainly would be negatively affected by grazing, based on what is known of their habitat requirements. Conspicuous among these species that require further study are the Yellow Warbler (see Taylor and Littlefield 1986), American Redstart, Gray Catbird, and Yellow-breasted Chat.

**Table 2. — Responses to livestock grazing by 43 neotropical migratory bird species breeding in riparian habitats in the western United States, for which data are available from at least two studies.**<sup>1</sup>

**Species usually responding positively to grazing:**

Killdeer ( <i>Charadrius vociferans</i> )	American Robin ( <i>Turdus migratorius</i> )
Lewis' Woodpecker ( <i>Melanerpes lewis</i> )	Brewer's Blackbird ( <i>Euphagus cyanocephalus</i> )
House Wren ( <i>Troglodytes aedon</i> )	Brown-headed Cowbird ( <i>Molothrus ater</i> )
Mountain Bluebird ( <i>Sialia currucoides</i> )	Pine Siskin ( <i>Carduelis pinus</i> )

**Species usually responding negatively to grazing:**

American Kestrel ( <i>Falco sparverius</i> )	Chipping Sparrow ( <i>Spizella passerina</i> )
Calliope Hummingbird ( <i>Stellula calliope</i> )	Dark-eyed Junco ( <i>Junco hyemalis</i> )
Willow Flycatcher ( <i>Empidonax traillii</i> )	White-crowned Sparrow ( <i>Zonotrichia leucophrys</i> )
Cedar Waxwing ( <i>Bombycilla cedrorum</i> )	Lincoln's Sparrow ( <i>Melospiza lincolni</i> )
Yellow-rumped Warbler ( <i>Dendroica coronata</i> )	Redwinged Blackbird ( <i>Agelaius phoeniceus</i> )
MacGillivray's Warbler ( <i>Oporornis tolmiei</i> )	Northern Oriole ( <i>Icterus galbula</i> )
Wilson's Warbler ( <i>Wilsonia pusilla</i> )	American Goldfinch ( <i>Carduelis tristis</i> )
Common Yellowthroat ( <i>Geothlypis trichas</i> )	Cassin's Finch ( <i>Carpodacus cassinii</i> )
Savannah Sparrow ( <i>Passerculus sandwichensis</i> )	

**Species unresponsive, or showing mixed or uncertain responses to grazing:**

Mourning Dove ( <i>Zenaidura macroura</i> )	Warbling Vireo ( <i>Vireo gilvus</i> )
Yellow Warbler ( <i>Dendroica petechia</i> )	Broad-tailed Hummingbird ( <i>Selasphorus platycercus</i> )
Northern Flicker ( <i>Colaptes auratus</i> )	Yellow-breasted Chat ( <i>Icteria virens</i> )
American Redstart ( <i>Setophaga ruticilla</i> )	Red-naped Sapsucker ( <i>Sphyrapicus nuchalis</i> )
Eastern Kingbird ( <i>Tyrannus tyrannus</i> )	Black-headed Grosbeak ( <i>Pheucticus melanocephalus</i> )
Tree Swallow ( <i>Tachycineta bicolor</i> )	Rufous-sided Towhee ( <i>Pipilo erythrophthalmus</i> )
Song Sparrow ( <i>Melospiza melodia</i> )	Western Wood-pewee ( <i>Contopus sordidulus</i> )
Gray Catbird ( <i>Dumetella carolinensis</i> )	Western Meadowlark ( <i>Sturnella neglecta</i> )
Brown Thrasher ( <i>Toxostoma rufum</i> )	Western Tanager ( <i>Piranga ludoviciana</i> )

<sup>1</sup> References: Crouch 1982, Knopf et al. 1988b, Medin and Clary 1990, 1991, Mosconi and Hutto 1982, Pate et al. 1978, Schulz and Leininger 1991, Sedgwick and Knopf 1987, Taylor 1986.

Certain foraging and nesting guilds have been affected by grazing more than others, in ways that are consistent with impacts of livestock on their habitat requirements. As a group, cavity-nesters have been essentially unaffected, whereas open-nesting birds were significantly influenced by grazing practices (Good and Dambach 1943, Butler 1979, plus references cited in Table 2). Aerial, bark, and canopy insectivores have been less influenced by grazing than species feeding on nectar, insects, or seeds in the understory or on the ground (see references in Table 2, plus Szaro and Rinne 1988).

### Management Implications and Recommendations

More than any other western habitat, riparian woodlands are centers of high diversity and abundance of neotropical migratory birds. Livestock grazing is a widespread impact on these ecosystems, and one to which many neotropical migrants have responded negatively. Therefore, livestock management decisions about riparian habitats will significantly affect many neotropical migrants.

Further research is needed to refine our understanding of the relationships between neotropical migrants and grazing in riparian ecosystems. First, more studies are needed on long-term effects of grazing on riparian vegetation (Sedgwick and Knopf 1991). Second, avian abundance data do not tell the whole story with regard to habitat suitability. Equally important, but rarely reported, are data on reproductive success and survivorship in different habitats (Van Home 1983). Finally, more information is needed on the importance of riparian habitats to wintering and migrating, as well as nesting, neotropical migratory birds (Mosconi and Hutto 1982). Despite these limitations to current knowledge, the following general management recommendations are unlikely to change:

First, it is critical to consider condition of riparian areas when implementing grazing systems, and, when practical, to manage riparian woodlands separately from adjacent uplands (Platts 1991). Where livestock must have access to riparian zones for water, restricted-access fencing can localize and minimize their impacts on streambanks and riparian vegetation. Development of alternate water sources also could help reduce concentration of livestock in riparian zones. When uplands and riparian zones must be managed together, grazing strategies should be keyed to condition of riparian vegetation.

Second, when riparian systems are grazed, moderate use during late-fall and winter, or short-term use in spring, will be less damaging than continuous or growing-season grazing. Fall-winter grazing should be carefully controlled to ensure the maintenance of residual plant cover.

Third, degraded riparian habitats may require complete rest from livestock grazing to initiate the recovery process. In systems requiring long-term rest, the necessary period will be highly variable depending upon the situation (Clary and Webster 1989). Management also should consider rehabilitating damaged riparian areas through revegetation with native species.

Fourth, given their scarcity, fragility, and importance to neotropical migrants and other wildlife, western riparian ecosystems should be excluded from livestock grazing wherever possible. Few species appear to benefit from grazing in these habitats, and those that do are not restricted to riparian communities.

## SHRUBSTEPPE HABITATS OF THE INTERMOUNTAIN WEST

### The Region and Its Avifauna

Shrubsteppe habitats, characterized by woody, mid-height shrubs and perennial bunchgrasses, are distributed in the Intermountain West from eastern Washington south to southern Nevada and northern Arizona, and east to central Wyoming (Daubenmire 1978). The region is characterized by aridity (usually < 20 cm annual precipitation), hot summers, cold winters, wind, low soil stability, and other attributes of a stressful physical environment (Short 1986). It is difficult to reconstruct the prehistoric condition of shrubsteppe biotic communities, because of major changes in vegetation that took place following introductions of domestic grazers (e.g., Cottam and Stewart 1940).

There is little doubt that sagebrush (*Artemisia tridentata*) always has been a major component of many shrubsteppe communities (Vale 1975). Other important shrubs include smaller sages (*Artemisia* spp.), saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp.), and bitterbrush (*Purshia tridentata*; Tisdale and Hironaka 1981). Dominant native perennial bunchgrasses include species in genera such as *Agropyron* (wheatgrasses), *Festuca* (fescues), *Stipa* (needle grasses), and *Poa* (bluegrasses; Jensen 1981). Prior to European settlement, cryptogams such as the lichen *Parmelia chlorochroa* covered undisturbed soil surfaces not populated by vascular plants (MacCracken et al. 1983). Because of loss of this layer through trampling by domestic livestock, we do not know what role it played in the original ecosystems.

Long-term studies by Wiens and Rotenberry have thoroughly documented dynamics of shrubsteppe bird communities (e.g., Wiens and Rotenberry 1981, Wiens 1985).

While more than 50 neotropical migratory birds may breed in various parts of the region, the typical community has 2-7 regular breeders, with 100-600 birds/km<sup>2</sup>, and over half the individuals belonging to the single most common species. The most important shrubsteppe birds are Horned Lark, Sage Thrasher, Brewer's Sparrow, Sage Sparrow, and, in areas with more grass cover, Vesper Sparrow, and Western Meadowlark.

Shrubsteppe bird populations fluctuate independently of one another and of variations in habitat structure, at least at the scales studied (Wiens et al. 1986). There is some association between birds and particular plant species, their seed crops, and, perhaps, their insect faunas (Geobel and Berry 1976, Wiens and Rotenberry 1981). Overall, however, it appears that shrubsteppe bird populations are influenced primarily by extreme and irregular fluctuations in precipitation and ecosystem productivity. Probably as a result, most species are highly opportunistic and ecologically adaptable.

### Effects of Livestock Grazing on Vegetation

Shrubsteppe ecosystems did not evolve with large ungulate herds (Mack and Thompson 1982), and their grasses were evolutionarily unprepared for introductions of domestic grazers. Historical changes in shrubsteppe plant communities can be attributed to two major factors: domestic livestock grazing and facilitated invasions by exotic plants (e.g., Jensen 1981, Mack and Thompson 1982). Resulting changes included 1) loss of the cryptogam layer, 2) loss of native seral grasses, 3) reduction in cover of perennial grasses, 4) reduction in forb cover, 5) increase in shrub cover, and 6) increase in cover of non-native grasses and forbs, particularly cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum asperum*), Russian thistle (*Salsola iberica*), tumbled mustard (*Sisymbrium altissimum*), tansymustard (*Descurainia sophia*), and crested wheatgrass (*Agropyron cristatum*).

Present-day grazing continues to influence species composition and structure of shrubsteppe communities. Because most herbaceous species are more palatable than shrubs during the growing season, grazing tends to increase shrub cover and reduce the understory of palatable annuals and perennials (e.g., Ellison 1960, Tisdale et al. 1969, Ryder 1980). Grazing also facilitates spread of junipers (Little 1977), reduces vegetation diversity (Reynolds and Rich 1978), and encourages spread of exotics such as cheatgrass (Young et al. 1979). Generally, spring and summer cattle grazing favors shrubs and forbs over grasses, whereas other grazing patterns, such as fall grazing by sheep, may have different effects (e.g., Laycock 1967, Urness 1979). Our general conclusions about impacts of livestock on neotropical migrants (Table 3) are based on the known or probable effects of the predominant type of grazing in shrubsteppe communities: by cattle, during the growing season.

**Table 3. — Probable effects of livestock grazing on some neotropical migratory landbirds breeding in shrubsteppe habitats of the Intermountain West.<sup>1</sup>**

**Species probably responding positively to grazing:**

Golden Eagle (*Aquila chrysaetos*)  
Brown-headed Cowbird (*Molothrus ater*)\*

Sage Sparrow (*Amphispiza belli*)

**Species probably responding negatively to grazing:**

Long-billed Curlew (*Numenius americanus*)  
Brewer's Sparrow (*Spizella breweri*)\*  
Vesper Sparrow (*Pooecetes gramineus*)\*  
Ferruginous Hawk (*Buteo regalis*)  
Burrowing Owl (*Athene cunicularia*)\*  
Short-eared Owl (*Asio flammeus*)  
Western Meadowlark (*Sturnella neglecta*)\*

Northern Harrier (*Circus cyaneus*)  
Swainson's Hawk (*Buteo swainsoni*)  
Red-tailed Hawk (*Buteo jamaicensis*)  
Savannah Sparrow (*Passerculus sandwichensis*)  
Grasshopper Sparrow (*Ammodramus savannarum*)  
White-crowned Sparrow (*Zonotrichia leucophrys*)

**Species unresponsive, or showing mixed responses to grazing:**

Mourning Dove (*Zenaidura macroura*)\*  
Horned Lark (*Eremophila alpestris*)\*  
Loggerhead Shrike (*Lanius ludovicianus*)\*  
Sage Thrasher (*Oreoscoptes montanus*)\*

Lark Sparrow (*Chondestes grammacus*)\*  
Black-throated Sparrow (*Amphispiza bilineata*)\*  
Brewer's Blackbird (*Euphagus cyanocephalus*)\*

<sup>1</sup> Emphasis is on cattle grazing during the growing season. Effects of other classes of stock and/or grazing season may differ.

<sup>2</sup> Based on Nydegger and Smith's (1986) observation that increased shrub densities favor jackrabbits, the eagle's primary prey.

\* References for species indicated with an asterisk: Gleason (1978), Medin (1986), Monson (1941), Olson (1974), Page et al. (1978), Reynolds and Trost (1980, 1981), Rich (1986), Rich and Rothstein (1985), and Rotenberry and Knick (1992), Wiens (1985). Information is unavailable for other species, for which our categorizations are based on data about the effects of grazing on habitat characteristics, and known habitat requirements of the birds.

## Response of Neotropical Migrants to Grazing

Unfortunately, there have been no long-term, well-replicated studies comparing the avifaunas of grazed and ungrazed shrubsteppe communities. Wiens and Dyer (1975) suggested that ecological plasticity of many shrubsteppe birds would make them unresponsive to moderate levels of livestock grazing. Major avifaunal shifts may occur only after some threshold of habitat change has been passed. It is likely that such thresholds were passed historically, when livestock were first introduced into the region. However, there are virtually no pristine ecosystems left where this hypothesis might be tested.

As a result of the scarcity of ungrazed shrubsteppe communities not dominated by exotic vegetation, and a paucity of ornithological studies comparing those that do exist, our conclusions about effects of grazing on neotropical migrants are largely speculative. Nevertheless, we are in a position to make some tentative conclusions, based either on limited published information, or on knowledge about effects of grazing on vegetation, and known habitat requirements of the birds (Table 3).

A major difficulty in assigning shrubsteppe birds to grazing response categories is the need to distinguish between historical and current livestock activities. For example, certain birds requiring shrubs as nest sites may have benefitted from grazing-related early increases in woody vegetation, yet may

now be harmed by heavy present grazing that removes understory grasses. Brewer's Sparrow may be one such example, and we only tentatively place it in the "negative" category (Table 3). An ungrazed shrubsteppe in south-central Montana supported Western Meadowlarks and Grasshopper, Lark, and Brewer's Sparrows (Bock and Bock 1987). However, only meadowlarks remained following a wildfire that killed all sagebrush.

By contrast, certain birds responded positively to bare ground and low cover created by grazing in the Great Plains may have declined following historical grazing in shrubsteppe, because of their intolerance for increased shrub cover. Likely examples include Burrowing Owl and Horned Lark, species that doubtless benefit from reduced amounts of herbaceous ground cover, but that may avoid areas of high shrub density.

There is practically no information on responses to grazing by avian predators in the shrubsteppe. Our categorization of the Golden Eagle as a species positively affected by grazing is based solely on the known association of its preferred prey (jackrabbits) with shrubby habitats (Nydegger and Smith 1986). Likewise, our tentative designation of a variety of raptors as species negatively affected by grazing is based on likely associations of their rodent prey with herbaceous ground cover, and, in the case of Northern Harrier, Ferruginous Hawk, and Short-eared Owl, on a requirement for cover for ground nests. Much more work is needed on responses of raptors to grazing in shrubsteppe habitats.



As in Great Plains grasslands and riparian habitats, a number of species nesting in herbaceous ground cover may respond negatively to grazing in shrubsteppe. There are data supporting this conclusion for Vesper Sparrow and Western Meadowlark, and we suspect it would be the case for three other species more peripherally associated with shrubsteppe: Savannah, Grasshopper, and White-crowned Sparrows (Table 3).

Another potentially significant indirect effect of grazing on neotropical migrants is nest parasitism by Brown-headed Cowbirds. The presence of livestock undoubtedly has brought cowbirds into broader contact with shrubsteppe breeding birds. However, almost no data are available on this subject (Rich and Rothstein 1985).

### Management Implications and Recommendations

No aspect of grazing effects on shrubsteppe neotropical migratory birds is well understood. Basic long-term research is badly needed. This research, and interpretation of its results, will be complicated by lack of close coupling between shrubsteppe bird populations and habitat features, and by differences between historical and current effects of grazing. Our lack of knowledge about this ecosystem is particularly unfortunate, because it rapidly is being replaced by exotic, fire-adapted annuals. As much as 25 million ha of shrubsteppe is being converted to a biologically depauperate annual grassland desert (USDA Forest Service 1993). Ultimately, Horned Lark may be the only species that will find these areas suitable for breeding (Rotenberry and Knick 1991).

Traditional grazing practices in shrubsteppe involved destructive continuous growing-season presence of livestock. A noteworthy long-term trend on public land has been replacement of season-long cattle grazing with various rotational grazing systems that can be less damaging to native grasses (Stoddart et al. 1975). Nevertheless, 50% of Bureau of Land Management rangelands remain in fair or poor condition (USDI Bureau of Land Management 1991), and 54% of Forest Service lands are in early or mid-seral stages of ecological succession (U.S. General Accounting Office 1988). These conditions reflect continuing effects of grazing: increased shrub cover, decreased cover of native perennial grasses and forbs, and increased cover of exotic annuals.

Certain historical shrubsteppe communities likely have been entirely eliminated by agricultural conversion. Deeper, more productive soils that supported especially tall stands of sagebrush, for example, undoubtedly were converted to crop production long ago (Symons 1967). The avian component of these habitats and others such as the historic grasslands of eastern Washington and central Oregon are largely unknown.

All of these factors lead us to conclude that there is an urgent need for protection, restoration, and long-term study of shrubsteppe ecosystems (including their avifaunas) dominated

by native perennial grasses, cryptogams, and moderate densities of shrubs, as we suspect these ecosystems existed prior to introductions of domestic livestock.

### MONTANE CONIFEROUS FOREST HABITATS

Virtually nothing is known about impacts of livestock on neotropical migrants associated with western coniferous forests, despite the fact that a significant number of species could be affected. However, the extent, composition, and land-use history of these forests are detailed by various authors contributing to the recent and thorough overview of terrestrial plant communities in North America edited by Barbour and Billings (1988). This body of work provides a useful starting point for a general consideration of likely impacts of grazing on birds in these habitats.

Within forested landscapes in general, the impacts of livestock grazing tend to be concentrated in drainage bottoms, wet meadows, and grassy slopes (Sampson 1980, Willard 1989). In Rocky Mountain forests, the most widespread and heavily impacted communities have been those dominated by ponderosa pine (*Pinus ponderosa*; Peet 1988). These open woodlands historically were characterized by a lush herbaceous understory of perennial graminoids (e.g., *Poa* and *Carex* spp.) and forbs, and by varying densities of shrubs such as currant (*Ribes* spp.), skunkbush (*Rhus trilobata*), and species of *Ceanothus*. Frequent non-catastrophic fire was the most important determinant of plant community structure and composition, prior to introductions of domestic livestock. A major consequence of livestock grazing has been removal of much herbaceous vegetation that provided fine fuels necessary to carry frequent, low intensity fires. Domestic livestock, in conjunction with active fire suppression, have caused a widespread transformation of these woodlands into denser forests with a decreased understory of herbaceous plants. One result of this transformation is the impressive accumulations of heavy fuels in these forests that now produce catastrophic fires resulting in widespread tree mortality (Peet 1988).

At lower elevations, there has been a strong positive correlation between heavy cattle grazing and expansion of juniper (*Juniperus* spp.) woodland (Johnsen 1962, West 1988). Again, grazing reduced cover of grasses, facilitating establishment of juniper seedlings and simultaneously reducing ground fires that otherwise might eliminate woody vegetation. West (1984) concluded that juniper woodlands were open savannahs prior to European settlement, and stressed the role of fire in maintaining this condition. Grazing reduced or eliminated the fires, with the net effect being an increase in tree density in woodlands, as well as expansion of woodlands into former grasslands and shrubsteppe at both higher and lower altitudes. A similar situation has been documented at higher elevations in the Warner Mountains of northeastern California, where past

heavy grazing by sheep appears to have caused both upslope and downslope invasions by pine and fir into grassland and shrubsteppe (Vale 1977).

As in the Rockies, frequent low-intensity fires were extremely important governors of plant communities throughout much of the southern Cascades and Sierra Nevada (Barbour 1988). While fire suppression is known to have influenced forest structure throughout much of this region (Barbour 1988), relatively little attention has been given to historical effects of livestock grazing. An exception is the work of Vankat and Major (1978), who concluded that sheep grazing altered conditions of montane meadows in the southern Sierra Nevada, facilitating invasions by lodgepole pine (*Pinus contorta*). Heavy use of these meadows by sheep led to increased runoff, erosion, and stream entrenchment. The result was a lower water table and a drier meadow where pine seedlings could become established. Similar invasions of conifers into subalpine meadows were coincident with periods of intense grazing in the central Rockies (Dunwiddie 1977).

Fire, livestock grazing, and logging all have contributed importantly to the present community mosaic of the central and northern Cascade Mountains in the Pacific Northwest (Franklin 1988). However, little attempt has been made to tease out specific effects of grazing. As in the Rockies, the effects of livestock grazing may be most important in ponderosa pine forests, which are widely distributed on the east side of the Cascades.

Among the varied altitudinally-distributed forest communities dominated by conifers, those occurring at lower elevations may have been more influenced by livestock grazing, by virtue of their longer snow-free periods. However, this conclusion ignores the extraordinary numbers of sheep that once used the full altitudinal range of habitats in the region. Sheep numbers rose spectacularly between 1865 and 1901, reached a peak in 1910, and have been declining steadily since that time (Thilenius 1975). Grazing was year-round, with flocks moving upslope in spring, following receding snow lines. Although high altitude ecosystems were usable for grazing only during summer, they were subject to extreme grazing pressure for this short period, and it is likely that their present structure is at least partially a consequence of this historic grazing pressure.

As little as we know about impacts of livestock on western coniferous forests, information is extensive compared to our direct knowledge about effects of grazing on neotropical migratory birds in these habitats. In fact, we can only speculate (albeit with some confidence) that birds most likely to have been negatively affected were 1) species dependent on herbaceous and shrubby ground cover for nesting and/or foraging, or 2) species requiring open savannahs as opposed to closed-canopy forests. Likely examples from the first group would be Nashville Warbler, Fox Sparrow, and Lincoln Sparrow. Examples from the second group would be Lewis' Woodpecker, Violet-green Swallow, and Mountain Bluebird.

Land managers and field biologists have an opportunity to provide information about impacts of grazing on neotropical migrants in western coniferous forests, where virtually none exists currently. We encourage studies both during nesting and migration seasons, especially where comparisons are possible between replicated forested stands with known differences in grazing regimes or grazing histories. Quantitative assessment of vegetation structure and composition should accompany standardized bird counts.

## CONCLUSION

Livestock grazing probably is the most widespread economic land use in western North America, and it is one that potentially affects a large number of neotropical migratory birds. We reject the notion that livestock grazing is either universally detrimental (Ferguson and Ferguson 1983) or beneficial (Savory 1988) to rangelands and their wildlife. However, it does appear that livestock operate as a keystone species (Paine 1966) in many if not most habitats they occupy at economically meaningful densities. That is, livestock are the organisms largely responsible for determining structure and function of ecosystems of which they are a part. The problem with livestock across much of the West today is not with their presence, but with their ubiquity. Those plants and animals, including neotropical migratory birds, intolerant of activities of domestic grazers have comparatively few places left to live. This undoubtedly is true for grasslands that evolved in the absence of large numbers of bison, and for most riparian woodlands. We suspect it is true for shrubsteppe and montane ecosystems, but more field research is urgently needed for these habitats. Protection and restoration of ungrazed ecosystems resembling their prehistoric counterparts as closely as possible must be an essential part of any plan to conserve neotropical migratory birds in western North America.

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## LITERATURE CITED

- Anderson, R. C. 1982. An evolutionary model summarizing the roles of fire, climate, and grazing animals in the origin and maintenance of grasslands: an end paper. Pages 297-308 in *Grasses and grasslands; systematics and ecology* (J. R. Estes, R. J. Tylr, and J. N. Brunken, Eds.). Univ. Oklahoma Press, Norman, Oklahoma.
- Axelrod, D. I. 1985. Rise of the grassland biome, central North America. *Bot. Rev.* 51:163-201.

- Bailey, R. G. 1978. Description of the ecoregions of the United States. USDA Forest Service, Intermountain Region, Ogden, Utah.
- Baker, D. L., and F. S. Guthery. 1990. Effects of continuous grazing on habitat and density of ground-foraging birds in south Texas. *J. Range Manage.* 43:2-5.
- Barbour, M. G. 1988. Californian upland forests and woodlands. Pages 131-164 in *North American terrestrial vegetation* (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.
- Barbour, M. G., and W. D. Billings (Eds). 1988. *North American terrestrial vegetation*. Cambridge Univ. Press, Cambridge, England.
- Bock, C. E., and J. H. Bock. 1987. Avian habitat occupancy following fire in a Montana shrubsteppe. *Prairie Nat.* 19:153-158.
- Bock, C. E., and J. H. Bock. 1988. Grassland birds in southeastern Arizona: impacts of fire, grazing, and alien vegetation. Pages 43-58 in *Ecology and conservation of grassland birds* (P. D. Goriup, Ed.). International Council for Bird Preservation, Publication No. 7, Cambridge, England.
- Bock, C. E., and J. H. Bock. Effects of livestock grazing on cover of perennial grasses in southeastern Arizona. *Conserv. Biol.*, in press.
- Bock, C. E., J. H. Bock, W. R. Kenney, and V. M. Hawthorne. 1984. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. *J. Range Manage.* 37:239-242.
- Butler, D. C. 1979. Effects of a high-density population of ungulates on breeding bird communities in deciduous forest. M. S. Thesis, Colorado State University, Fort Collins, Colorado.
- Carothers, S. W. 1977. Importance, preservation, and management of riparian habitats: an overview. Pages 2-4 in *Importance, preservation, and management of riparian habitat: a symposium* (R. R. Johnson, and D. A. Jones, Tech. Coords.). USDA Forest Service Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- Carothers, S. W., and R. R. Johnson. 1975. Water management practices and their effects on nongame birds in range habitats. Pages 210-222 in *Management of forest and range habitats for nongame birds* (D. R. Smith, Ed.). USDA Forest Service, Gen. Tech. Rep. WO-1. Washington, D. C.
- Chaney, E., W. Elmore, and W. S. Platts. 1990. Livestock grazing on western riparian areas. Produced for the Environmental Protection Agency by Northwest Resource Information Center, Inc., Eagle, Idaho.
- Clary, W. P., and B. F. Webster. 1989. Managing grazing of riparian areas in the Intermountain Region. USDA Forest Service Gen. Tech. Rep. INT-263. Intermountain Research Station, Ogden, Utah.
- Cody, M. L. 1985. Habitat selection in grassland and open-country birds. Pages 191-226 in *Habitat selection in birds* (M. L. Cody, Ed.). Academic Press, New York.
- Cottam, W. P., and G. Stewart. 1940. Plant succession as a result of grazing and of meadow desiccation by erosion since settlement. *Ecology* 34:613-626.
- Crouch, G. L. 1982. Wildlife on ungrazed and grazed bottomlands on the South Platte River, northeastern Colorado. Pages 188-197 in *Wildlife-livestock relationships symposium* (J. M. Peek and P. D. Dalke, Eds.). Forestry, Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.
- Daubenmire, R. 1978. *Plant geography*. Academic Press, New York.
- Duebbert, H. F., and J. T. Lokemoen. 1977. Upland nesting of American bitterns, marsh hawks, and short-eared owls. *Prairie Nat.* 9:33-40.
- Dunwiddie, P. W. 1977. Recent tree invasions of subalpine meadows in the Wind River Mountains, Wyoming. *Arct. Alp. Res.* 9:393-399.
- Ellison, L. 1960. Influence of grazing on plant succession in rangelands. *Bot. Rev.* 26:1-78.
- Ferguson, D., and N. Ferguson. 1983. Sacred cows at the public trough. Maverick Publications, Bend, Oregon.
- Franklin, J. F. 1988. Pacific Northwest forests. Pages 103-130 in *North American terrestrial vegetation* (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.
- Goebel, C. J., and G. Berry. 1976. Selectivity of range grass seeds by local birds. *J. Range Manage.* 29:393-395.
- Gibson, D. J., and L. C. Hulbert. 1987. Effects of fire, topography and year-to-year climate variation on species composition in tallgrass prairie. *Vegetatio* 72:175-185.
- Gleason, R. S. 1978. Aspects of the breeding biology of burrowing owls in southeastern Idaho. MS Thesis, University of Idaho, Moscow, Idaho.
- Gliniski, R. L. 1977. Regeneration and distribution of sycamore and cottonwood trees along Sonoita Creek, Santa Cruz County, Arizona. Pages 116-123 in *Importance, preservation, and management of riparian habitat: a symposium* (R. R. Johnson and D. A. Jones, Tech. Coords.). USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- Good, E. E., and C. A. Dambach. 1943. Effect of land use practices on breeding bird populations in Ohio. *J. Wildl. Manage.* 7:291-297.
- Graul, W. D. 1975. Breeding biology of the mountain plover. *Wilson Bull.* 87:6-31.
- Holechek, J. L., R. D. Piper, and C. H. Herbel. 1989. *Range management: principles and practices*. Prentice Hall, Englewood Cliffs, New Jersey.
- Johnsen, T. N., Jr. 1962. One-seed juniper invasion of north Arizona grasslands. *Ecol. Monogr.* 32:187-207.
- Johnson, R. R., and D. A. Jones (Technical Coordinators). 1977. *Importance, preservation, and management of riparian habitats: a symposium*. USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

- Johnson, R. R., L. T. Haight, and J. M. Simpson. 1977. Endangered species vs. endangered habitats: a concept. Pages 68-79 in R.R. Johnson, and D. A. Jones (Technical Coordinators). Importance, preservation, and management of riparian habitats: a symposium. USDA Forest Service, Gen. Tech. Rep. RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. preceding reference.
- Joyce, L. A., J. E. Mitchell, and M. D. Skold, editors. 1991. Proceedings, the Conservation Reserve - yesterday, today, and tomorrow. USDA Forest Service, Gen. Tech. Rep. RM-203. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- Kantrud, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. *Can. Field Nat.* 95:404-417.
- Kantrud, H. A., and K. F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. *Prairie Nat.* 24:67-84.
- Kantrud, H. A., and R. L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grasslands of the northern Great Plains. USDI Fish and Wildlife Service, Wildl. Res. Rep. No. 15, Washington, D. C.
- Kauffman, J. B., and W. C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management: a review. *J. Range Manage.* 37:430-438.
- Kirsch, L. M., and K. F. Higgins. 1976. Upland sandpiper nesting and management in North Dakota. *Wildl. Soc. Bull.* 4:16-20.
- Knopf, F. L. 1985. Significance of riparian vegetation to breeding birds across an altitudinal cline. Pages 105-111 in *Riparian ecosystems and their management: reconciling conflicting uses* (R. R. Johnson, C. D. Ziebell, D. R. Patton, P. F. Ffolliott, and R. H. Hamre, Tech. Coords.). USDA Forest Service, Gen. Tech. Rep. RM-120. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- Knopf, F. L. 1993. Conservation of avian diversity in riparian corridors. *Bird Conserv.*, in press.
- Knopf, F. L., R. R. Johnson, T. Rich, F. B. Sampson, and R. C. Szaro. 1988a. Conservation of riparian ecosystems in the United States. *Wilson Bull.* 100:272-284.
- Knopf, F. L., J. A. Sedgwick, and R. W. Cannon. 1988b. Guild structure of a riparian avifauna relative to seasonal cattle grazing. *J. Wildl. Manage.* 52:280-290.
- Kovalchik, B. L., and W. Elmore. 1992. Effects of cattle grazing systems on willow-dominated plant associations in central Oregon. Pages 111-119 in *Proceedings of a symposium on ecology and management of riparian shrub communities* (W. P. Clary, E. D. McArthur, D. Bedunah, and C. L. Wambolt, Compilers). USDA Forest Service, Gen. Tech. Rep. INT-289. Intermountain Forest and Range Experiment Station, Ogden, Utah.
- Laycock, W. A. 1967. How heavy grazing and protection affect sagebrush-grass ranges. *J. Range Manage.* 20:206-213.
- Lokemoen, J. T., and H. F. Duebbert. 1976. Ferruginous hawk nesting ecology and raptor populations in northern South Dakota. *Condor* 78:464-470.
- Mack, R. N., and J. N. Thompson. 1982. Evolution in steppe with few large, hooved mammals. *Am. Nat.* 119:757-773.
- Macracken, J. G., L. E. Alexander, and D. W. Uresk. 1983. An important lichen of southeastern Montana rangelands. *J. Range Manage.* 36:35-37.
- Maher, W. J. 1979. Nestling diets of prairie passerine birds at Matador, Saskatchewan, Canada. *Ibis* 121:437-452.
- McNaughton, S. J. 1986. On plants and herbivores. *Am. Nat.* 128:765-770.
- Medin, D. E. 1986. Grazing and passerine breeding birds in a Great Basin low-shrub desert. *Great Basin Nat.* 46:567-572.
- Medin, D. E., and W. P. Clary. 1990. Bird and small mammal populations in a grazed and ungrazed riparian habitat in Idaho. USDA Forest Service Res. Pap. INT-425. Intermountain Research Station, Ogden, Utah.
- Medin, D. E., and W. P. Clary. 1991. Breeding bird populations in a grazed and ungrazed riparian habitat in Nevada. USDA Forest Service Res. Pap. INT-441. Intermountain Research Station, Ogden, Utah.
- Mengel, R. M. 1970. The North American Central Plains as an isolating agent in bird speciation. Pages 280-340 in *Pleistocene and recent environments of the central Great Plains* (W. Dort and J. K. Jones, Eds.). University of Kansas Press, Lawrence, Kansas.
- Milchunas, D. G., O. E. Sala, and W. K. Lauenroth. 1988. A generalized model of the effects of grazing by large herbivores on grassland community structure. *Am. Nat.* 132:87-106.
- Monson, G. 1941. The effect of revegetation on the small bird population in Arizona. *J. Wildl. Manage.* 5:395-397.
- Mosconi, S. L., and R. L. Hutto. 1982. The effects of grazing on land birds of a western Montana riparian habitat. Pages 221-233 in *Wildlife-livestock relationships symposium* (J. M. Peek, and P. D. Dalke, Eds.). Forest Wildlife and Range Experiment Station, University of Idaho, Moscow, Idaho.
- Nydegger, N. C., and G. W. Smith. 1986. Prey populations in relation to Artemisia vegetation types in southwestern Idaho. Pages 152-156 in *Symposium on the biology of Artemisia and Chrysothamnus* (E. D. McArthur and B. L. Welch, Eds.). USDA Forest Service, Gen. Tech. Rep. INT-200. Intermountain Research Station, Ogden, Utah.
- Ohmart, R. D., and B. W. Anderson. 1982. North American desert riparian ecosystems. Pages 433-479 in *Reference handbook on the deserts of North America* (G. L. Bender, Ed.). Greenwood Press, Westport, Connecticut.
- Ohmart, R. D., and B. W. Anderson. 1986. Riparian habitat. Pages 169-199 in *Inventory and monitoring of wildlife habitat* (A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, Eds.). USDI Bureau of Land Management, Service Center, Denver, Colorado.

- Olson, R. A. 1974. Bird populations in relation to changes in land use in Curlew Valley, Idaho and Utah. MS Thesis, Idaho State Univ., Pocatello, Idaho.
- Owens, R. A., and M. T. Myres. 1973. Effects of agriculture upon populations of native passerine birds of an Alberta fescue grassland. *Can. J. Zool.* 51:697-713.
- Page, J. L., N. Dodd, T. O. Osborne, and J. A. Carson. 1978. The influence of livestock grazing on non-game wildlife. *Cal.-Nev. Wildl.* 1978:159-173.
- Paine, R. T. 1966. Food web complexity and species diversity. *Am. Nat.* 100:65-75.
- Peet, R. K. 1988. Forests of the Rocky Mountains. Pages 63-101 in *North American terrestrial vegetation* (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.
- Platts, W. S. 1991. Livestock grazing. Influences of forest and rangeland management on salmonid fishes and their habitats. *Amer. Fish. Soc., Spec. Publ.* 19: 389-423.
- Platts, W. S., and R. L. Nelson. 1985. Streamside and upland vegetation use by cattle. *Rangelands* 7:5-7.
- Rauzi, F., and C. L. Hanson. 1966. Water uptake and runoff as affected by intensity of grazing. *J. Range Manage.* 35:351-356.
- Reynolds, T. D., and T. D. Rich. 1978. Reproductive ecology of the sage thrasher (*Oreoscoptes montanus*) on the Snake River Plain in south-central Idaho. *Auk* 95:580-582.
- Reynolds, T. D., and C. H. Trost. 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. *J. Range Manage.* 33:122-125.
- Reynolds, T. D., and C. H. Trost. 1981. Grazing, crested wheatgrass, and bird populations in southeastern Idaho. *Northwest Sci.* 55:225-234.
- Rice, J., R. D. Ohmart, and B. W. Anderson. 1983. Turnovers in species composition of avian communities in contiguous riparian habitats. *Ecology* 64:1444-1455.
- Rich, T. D. 1986. Habitat and nest-site selection by burrowing owls in the sagebrush steppe of Idaho. *J. Wildl. Manage.* 50:548-555.
- Rich, T. D., and S. I. Rothstein. 1985. Sage thrashers reject cowbird eggs. *Condor* 87:561-562.
- Risser, P. G., E. C. Birney, H. D. Blocker, S. W. May, W. J. Parton, and J. A. Wiens. 1981. *The true prairie ecosystem*. Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania.
- Rotenberry, J. T., and S. T. Knick. 1991. Passerine surveys on the Snake River Birds of Prey Area. Pages 220-228 in *Snake River Birds of Prey Area, 1991 Annual Report* (K. Steenhof, Ed.). USDI Bureau of Land Management, Boise, Idaho.
- Ryder, R. A. 1980. Effects of grazing on bird habitats. Pages 51-66 in *Management of western forests and grasslands for nongame birds* (R. M. DeGraff and N. G. Tilghman, Comps.). USDA Forest Service, Gen. Tech. Rep. INT-86. Intermountain Forest and Range Experiment Station, Ogden, Utah.
- Saab, V. A., and C. R. Groves. 1992. Idaho's migratory landbirds: description, habitats, and conservation. Nongame wildlife leaflet No. 10. Idaho Wildl., Summer 1992:11-26.
- Sabadell, J. E. 1982. Desertification in the United States. USDI Bureau of Land Management, Washington, D.C.
- Sampson, F. B. 1980. Use of montane meadows by birds. Pages 113-129 in *Management of western forests and grasslands for nongame birds* (R. M. DeGraff, Tech. Coord.). USDA Forest Service, Gen. Tech. Rep. INT-86. Intermountain Forest and Range Experiment Station, Ogden, Utah.
- Sauer, C. O. 1950. Grassland, climax, fire, and man. *J. Range Manage.* 3:16-22.
- Savory, A. 1988. *Holistic resource management*. Island Press, Washington, D.C.
- Schlesinger, W. H., J. F. Reynolds, G. L. Cunningham, L. F. Huenneke, W. M. Jarrell, R. A. Virginia, and W. G. Whitford. 1990. Biological feedbacks in global desertification. *Science* 247:1043-1048.
- Schlesinger, W. H., J. F. Reynolds, G. L. Cunningham, L. F. Huenneke, W. M. Jarrell, R. A. Virginia, and W. G. Whitford. 1990. Biological feedbacks in global desertification. *Science* 247:1043-1048.
- Schulz, T. T., and W. C. Leininger. 1991. Nongame wildlife communities in grazed and ungrazed montane riparian sites. *Great Basin Nat.* 51:286-292.
- Sedgwick, J. A., and F. L. Knopf. 1987. Breeding bird response to cattle grazing of a cottonwood bottomland. *J. Wildl. Manage.* 51:230-237.
- Sedgwick, J. A., and F. L. Knopf. 1988. A high incidence of brown-headed cowbird parasitism of willow flycatchers. *Condor* 90:253-256.
- Sedgwick, J. A., and F. L. Knopf. 1991. Prescribed grazing as a secondary impact in a western riparian floodplain. *J. Range Manage.* 44:369-373.
- Short, H. L. 1986. Rangelands. Pages 93-122 in *Inventory and monitoring of wildlife habitat* (A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, Eds.). USDI Bureau of Land Management, Service Center, Denver, Colorado.
- Skinner, R. M. 1975. Grassland use patterns and prairie bird populations of Missouri. Pages 171-180 in *Prairie: a multiple view* (M. K. Wati, Ed.). Univ. North Dakota Press, Grand Forks, North Dakota.
- Stebbins, G. L. 1981. Coevolution of grasses and herbivores. *Ann. Missouri Bot. Garden* 68:75-86.
- Stoddart, L. A., A. D. Smith, and T. W. Box. 1975. *Range management*. McGraw-Hill Book Co., New York, New York.
- Symons, T. W. 1967. *The Symons report on the Upper Columbia River and the Great Plain of the Columbia*. The Galleon Press, Fairfield, Washington.
- Szaro, R. C. 1980. Factors influencing bird populations in southwestern riparian forests. Pages 403-418 in *Management of western forests and grasslands for nongame birds* (R. M. DeGraff, Tech. Coord.). USDA Forest Service, Gen. Tech. Rep. INT-86. Intermountain Forest and Range Experiment Station, Ogden, Utah.

- Szaro, R. C., and M. D. Jakle. 1985. Avian use of a desert riparian island and its adjacent scrub habitat. *Condor* 87:511-519.
- Szaro, R. C., and J. N. Rinne. 1988. Ecosystem approach to management of southwestern riparian communities. *Trans. 53rd N. Amer. Wildl. Nat. Res. Conf.*: 502-511.
- Taylor, D. M. 1986. Effects of cattle grazing on passerine bird nesting in riparian habitat. *J. Range Manage.* 39:254-258.
- Taylor, D. M., and C. D. Littlefield. 1986. Willow flycatcher and yellow warbler response to cattle grazing. *Am. Birds* 40:1169-1173.
- Terborgh, J. 1989. *Where have all the birds gone?* Princeton Univ. Press, Princeton, New Jersey.
- Tester, J. R., and W. H. Marshall. 1961. A study of certain plant and animal interrelations on a native prairie in northwestern Minnesota. University of Minnesota Museum of Natural History, Occ. Pap. No. 8.
- Thilenius, J. F. 1975. Alpine range management in the western United States - principles, practices, and problems: the status of our knowledge. USDA Forest Service, Res. Pap. RM-157. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- Thomas, J. W., C. Maser, and J. E. Rodiek. 1979. Wildlife habitats in managed rangelands - the great basin of southeastern Oregon. USDA Forest Service Gen. Tech. Rep. PNW-80. Pacific Northwest Forest and Range Experiment Station, Olympia, Washington.
- Tisdale, E. W., and M. Hironaka. 1981. The sagebrush-grass region: a review of the literature. *For. Wildl. Range Exper. Sta., Bull.* 33. Univ. Idaho, Moscow, Idaho.
- Tisdale, E. W., M. Hironaka, and M. A. Fosberg. 1969. The sagebrush region in Idaho: a problem in range resource management. *Agric. Exp. Sta., Bull.* 512. Univ. Idaho, Moscow, Idaho.
- Urness, P. J. 1979. Wildlife habitat manipulation in sagebrush ecosystems. Pages 169-178 in *The sagebrush ecosystem: a symposium*. Utah State University, Logan, Utah.
- U.S.D.A. Forest Service. 1993. Ecology, management, and restoration of Intermountain annual rangelands. USDA Forest Service, Gen. Tech. Rep., in press. Intermountain Research Station, Ogden, Utah.
- U.S.D.I. Bureau of Land Management. 1991. Public land statistics -1990. U.S. Government Printing Office, Washington, D.C.
- U. S. General Accounting Office. 1988. Rangeland management: more emphasis needed on declining and overstocked grazing allotments. U. S. Government Printing Office, Washington, D.C.
- Vale, T. R. 1975. Presettlement vegetation in the sagebrush-grass area of the Intermountain West. *J. Range Manage.* 28:32-36.
- Vale, T. R. 1977. Forest changes in the Warner Mountains, California. *Ann. Assoc. Amer. Geogr.* 67:28-45.
- Van Horne, B. 1983. Density as a misleading indicator of habitat quality. *J. Wildl. Manage.* 47:893-901.
- Vankat, J. L., and J. Major. 1978. Vegetation changes in Sequoia National Park, California. *J. Biogeogr.* 5:377-402.
- Webb, E. A., and C. E. Bock. 1990. Relationship of the Botteri's sparrow to sacaton grassland in southeastern Arizona. Pages 199-209 in *Managing wildlife in the Southwest* (P. R. Krausman and N. S. Smith, Eds.). Arizona Chapter of the Wildlife Society, Phoenix, Arizona.
- West, N. E. 1984. Successional patterns and productivity potentials of pinyon-juniper ecosystems. Pages 1301-1332 in *Developing strategies for range management* (National Academy of Science). Westview Press, Boulder, Colorado.
- West, N. E. 1988. Intermountain deserts, shrub steppes, and woodlands. Pages 209-230 in *North American terrestrial vegetation* (M. G. Barbour and W. D. Billings, Eds.). Cambridge Univ. Press, Cambridge, England.
- West, T. 1990. USDA Forest Service management of the National Grasslands. *Agric. Hist.* 64:86-98.
- Wiens, J. A. 1973. Pattern and process in grassland bird communities. *Ecol. Monogr.* 43:237-270.
- Wiens, J. A. 1974. Climatic instability and the "ecological saturation" of bird communities in North American grasslands. *Condor* 76:385-400.
- Wiens, J. A. 1985. Habitat selection in variable environments: shrubsteppe birds. Pages 227-251 in *Habitat selection in birds* (M. L. Cody, Ed.). Academic Press, Inc., New York, New York.
- Wiens, J. A., and M. I. Dyer. 1975. Rangeland avifaunas: their composition, energetics, and role in the ecosystem. Pages 146-182 in *Symposium on management of forest and range habitats for nongame birds* (D. R. Smith, Ed.). USDA Forest Service, Gen. Tech. Rep. WO-1. Washington, D.C.
- Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure in shrubsteppe environments. *Ecol. Monogr.* 51:21-41.
- Wiens, J. A., J. T. Rotenberry, and B. Van Horne. 1986. A lesson in the limitations of field experiments: shrubsteppe birds and habitat alteration. *Ecology* 67:365-376.
- Willard, E. E. 1989. Use and impact of domestic livestock in whitebark pine forests. Pages 201-277 in *Symposium on whitebark pine ecosystems* (W. C. Schmidt and K. J. McDonald, Comps.). USDA Forest Service, Gen. Tech. Rep. INT-270. Intermountain Research Station, Ogden, Utah.
- Yensen, D. L. 1981. The 1900 invasion of alien plants into southern Idaho. *Great Basin Nat.* 41:176-183.
- Young, J. A., R. E. Eckert, Jr., and R. A. Evans. 1979. Historical perspectives regarding the sagebrush ecosystem. Pages 1-13 in *The sagebrush ecosystem: a symposium*. Utah State University, Logan, Utah.