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[Full reference on back page]

LIVESTOCK GRAZING EFFECTS IN WESTERN NORTH AMERICA

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INTRODUCTION

Livestock grazing is the most widespread economic use of public lands in western North America (Platts 1991). Approximately 86 million hectares of US Federal land in 17 western states are used for livestock production (Sabadell 1982). In the American West, grazing by domestic ungulates began in the 1840s, increased rapidly in the 1870s, and peaked around 1890 (Young and Sparks 1985). By 1900 much rangeland vegetation had been altered by the combination of extreme drought and high intensity grazing (Yensen 1981, Young and Sparks 1985). Range-management practices, including grazing systems (Appendix) and fenced pastures, were initiated in the early 1900s to help restore damaged rangelands (Behrke and Raleigh 1979). By the mid-1960s, management by allotment (designated areas for a prescribed number of livestock under one plan of management) had become an accepted practice on public lands, and is still in use today (Platts 1991).

Grazing by domestic livestock is probably the most controversial issue facing managers of public lands in the American West. This controversy is due in part to the competing economic, social, and conservation interests involved. A unique factor to grazing, as opposed to other land uses, is the fact that herbivory by native hoofed mammals has been a natural, ecological, and evolutionary force in certain nonforested ecosystems, including many in central and western North America (Stebbins 1981, McNaughton 1986). Domestic livestock has greatly intensified the influence of grazing in most of these

ecosystems historically, and this influence has been especially damaging 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). Nonetheless, for certain habitats it is arguable that livestock grazing simulates a natural ecological event that some native flora and fauna tolerate, or perhaps require. Therefore, assertions about the effects of grazing on Neotropical migratory birds and other organisms must be habitat and species specific, and based on field data.

Birds generally do not respond to the presence of grazing livestock but to the impacts on vegetation as a result of grazing (Bock and Webb 1984). Cattle compact soil by hoof action, remove plant materials, and indirectly reduce water infiltration, all of which can result in decreased vegetation density (Holechek et al. 1989). In turn, these alterations of the structure and floristics in plant communities are known to affect some breeding bird species negatively, while other species respond positively.

Increased numbers of Brown-headed Cowbirds, created by the presence of cattle, is another indirect impact (i.e., nest parasitism) on many breeding Neotropical migratory landbirds (Robinson et al. Chapter 15, this volume). In presettlement times, cowbirds inhabited the Great Plains of central North America and were associated with giant bison herds of that region. Their range, now encompassing most of North America (American Ornithologists' Union 1983), expanded when Europeans arrived with their livestock and cleared forests (Mayfield 1965).

Cowbirds are now associated with domestic livestock, and are sufficiently numerous to pose major threats to the continued survival of several species that are regularly parasitized (Rothstein et al. 1980, 1984).

Livestock grazing is a primary land-use in four habitats important to Neotropical migrants: (1) grasslands of the Great Plains and Southwest; (2) shrubsteppe communities in the Intermountain region; (3) riparian plant communities of the arid West; and (4) montane coniferous forests. The objectives of this chapter are to evaluate the consequences of grazing by domestic ungulates on migratory landbirds using western habitats, and to provide perspectives on management as it relates to conservation of western Neotropical migrants.

METHODS

We reviewed a variety of federal publications, scientific journals, and unpublished reports for studies regarding effects of livestock grazing on landbird communities in western North America. The synthesized information is presented for Neotropical migrants in the following habitat sections: (1) grasslands, (2) shrubsteppe, (3) riparian, and (4) coniferous forests. We evaluated neotropical migrants as listed by Gauthreaux (1992), which excludes waterbirds and most shorebirds. This list includes landbirds that breed in North America and whose winter ranges predominantly extend into the Neotropics (also known as migratory landbirds).

The results of bird survey data are presented in a tabular format to facilitate comparisons between species and vegetative types. A number of important limitations exist in the information presented in the tables. Sizes and numbers of study sites, and season and intensity of grazing varied among studies. In all of the studies listed, data were obtained on the relative abundances of birds in variously grazed habitats, compared either to ungrazed or to lightly grazed sites. We listed a response as positive or negative only in those cases where the differences between treatments were $> 20\%$.

For every study, we recorded each bird species as one that increased (+), decreased

(-), or was unaffected in abundance as a result of cattle grazing. In each habitat section, we provided a qualitative assessment on patterns in bird responses to grazing. In some cases where data were available, we evaluated differences in bird responses according to grazing intensity and vegetative type (grasslands), and seasonality of grazing (riparian).

When abundance data for species were recorded by two or more studies in shrubsteppe and riparian vegetation, bird responses were analyzed statistically. Abundance data were standardized to evaluate species and guilds most vulnerable to grazing disturbances. We tested the hypothesis that grazing did not affect abundances of species and ecological guilds. Standardized means were tested for differences using a paired *t*-test and derived in the following manner: $Sg = 2Ng/(Nu + Ng)$ and $Su = 2Nu/(Nu + Ng)$; where *Sg* = standardized mean number of individuals or pairs in a grazed treatment, *Ng* = number of individuals or pairs in a grazed treatment, *Nu* = number of individuals or pairs in an ungrazed treatment, and *Su* = standardized mean number of individuals or pairs in an ungrazed treatment. These proportional data were transformed with an arcsine to obtain a normal distribution. This statistical approach was not applied to grasslands because of the graded response shown by many bird species depending on grassland type.

For the guild analyses, species were categorized into groups associated with nest type (open nesting or cavity nesting; appropriate only for riparian habitats), nest location (ground, shrub, or sub canopy/canopy), and foraging behavior (insectivore, carnivore, nectarivore, or omnivore), based on characteristics described by Harrison (1979), Ehrlich et al. (1988), and Marini (1993). Finally, species were evaluated by their migratory status (Tables 12-1, 12-2, 12-3, 12-4; Gauthreaux 1992). In coniferous forest vegetation, we lacked information on any bird responses to livestock grazing. Therefore, we based our conclusions on knowledge about effects of livestock on vegetation, and the known habitat requirements of the birds.

GRASSLANDS OF THE GREAT PLAINS

Characteristics of Grassland Habitats

The Great Plains evolved in the rain shadow of the Rocky Mountains (Daubenmire 1978). Today, grasslands reach from the eastern-most escarpment of that range out to the mixed deciduous forests of the Midwest, and from Alberta and Saskatchewan south to the arid and semi-arid grasslands surrounding and mixed with the Chihuahuan Desert in Texas, New Mexico, southwest Arizona, and northern Mexico. We ascribe to the plains this liberal southern extent because the Chihuahuan Desert grasslands have much in common climatically, floristically, and evolutionarily with their northern counterparts (Axelrod 1985). Furthermore, a number of migratory birds that breed in the northern plains also winter in the southern plains, so-defined, and therefore are influenced by climate and land-use patterns across the region as a whole (e.g., Wiens 1973, Pulliam and Parker 1979, Dunning and Brown 1982). Two striking climatic gradients occur within the Great Plains. The first is a north-south temperature gradient, such that the mean annual number of frost-free days in Canadian grasslands is less than 120, while in the warmest Chihuahuan Desert grasslands it is more than 240 (Visher 1966). Running generally perpendicular to this thermocline is an equally if not more important precipitation gradient, reflective of the diminishing influence of the Rocky Mountain rain shadow eastward on to the plains. Specifically, grasslands to the west and south are increasingly water-stressed, due to declining precipitation and increasing evaporation.

We used Bailey's (1976, 1978) ecoregions of the United States to classify the ecosystems of the Great Plains, which includes three major divisions: prairie, steppe, and Chihuahuan Desert. Prairie grasslands are comparatively tall and moist, and, especially in the south and east, frequently include parklands with scattered trees or tall shrubs. The typical grasses of undisturbed tallgrass prairie include bluestems (*Andropogon* spp.) and switch grass (*Panicum virgatum*). Steppe grasslands are drier, experience more frequent droughts, and are dominated by

shorter grasses than the tallgrass prairies. Dominant species include blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). Northern steppe ecosystems (such as in the western Dakotas, eastern Montana, and the Canadian prairie provinces) frequently support a variety of mid-height bunchgrasses, especially wheatgrasses (*Agropyron* spp.) and needlegrasses (*Stipa* spp.), and fescues (*Festuca* spp.) that are scarce or missing from the comparatively arid shortgrass plains farther south. The Chihuahuan Desert comprises the most arid and heat-stressed part of the Great Plains. Here, grasslands of any sort are hanging on a climatic brink, where environmental perturbations (such as grazing by domestic livestock) can readily convert them into desert shrublands. Desert grassland, dominated by species such as black grama (*Bouteloua eriopoda*), formerly was widespread in the Southwest, but historic overgrazing has converted most of it to desert scrub (Buffington and Herbel 1965). However, in areas with slightly higher annual precipitation, semi-desert grasslands persist in the Southwest, and these are important breeding and wintering habitats for Great Plains grassland birds (Bock and Bock 1988).

The preceding discussion of the subdivisions of the plains is much more than simply a lesson in plant geography, because most Neotropical migrant birds respond differently to livestock grazing in different places. The same amount of grazing that can be used to create ideal habitat for a species in a tallgrass prairie may be equally certain to destroy that same species' habitat in a shortgrass steppe or semidesert grassland. Therefore, management recommendations, derived from data synthesized in this section, should be tailored to the various sorts of grasslands involved.

Historical Perspective and Dynamics of Great Plains Ecosystems

The major forces creating the plains grasslands were, and are, drought, fire and grazing by bison and prairie dogs (Sauer 1950, Stebbins 1981, Anderson 1982). Evidence suggests that many plains grasslands are inherently vulnerable to invasions by woody

plants, and that climate alone cannot sustain them as grassland (Sauer 1950). Fire retards or reverses invasions by trees or shrubs, while grazing encourages them, both by reducing fuels for fire and by facilitating the dispersal and establishment of the woody invaders (Risser et al. 1981, Bock and Bock 1987, 1988, Humphrey 1987, Steinauer and Bragg 1987, Archer 1989).

Historically, drought, fire, and grazing were not equally important in all plains grasslands. For example, fire appears to have been the major force sustaining tallgrass prairies and parklands against the relentless invasions of trees and shrubs (Gibson and Hulbert 1987). Farther west, grasses characteristic of shortgrass steppe ecosystems, such as blue grama and buffalograss, were those short-stature species equally tolerant of the frequent droughts and of grazing by native ungulates, especially bison (Milchunas et al. 1988). By contrast, there were few if any native ungulate grazers in the desert and semidesert grasslands of the Southwest, and here fire probably was a major factor keeping certain desert shrubs from invading these fragile ecosystems (Bahre 1991).

Introduction of domestic ungulates to the Great Plains greatly increased the role of grazing, relative to fire and drought, in determining the nature of the grasslands. In the desert region livestock grazing, perhaps coupled with drought, degraded many grasslands into essentially pure and permanent desert scrub (Bullington and Herbel 1965, Neilson 1986, Schlesinger et al. 1990). Many former tallgrass and mixed grass ecosystems were converted to grasslands dominated by shorter, more grazing-tolerant species (e.g., Bock and Bock 1993). However, shortgrass steppe ecosystems on the central plains may have changed relatively little (Milchunas et al. 1988), as millions of native ungulates (bison) were obliterated and then replaced by millions of exotic ungulates (cattle, horses, and sheep).

Grassland Avifauna

Density and diversity of birds is low in grasslands of the Great Plains, compared to wetlands, riparian woodlands, or adjacent forested ecosystems (Johnsgard 1979, Cody

1985, Knopf 1988). This has been variously attributed to the structural simplicity, ecological instability, and recent origin of the grassland communities (Udvardy 1958, Mengel 1970, Wiens 1973, 1974, Rotenberry and Wiens 1980a, 1980b, Cody 1985).

Total bird densities in the Great Plains grasslands usually range from 200-400 birds/km² (Wiens 1974, Cody 1985). Most tallgrass prairie songbird (passerine) communities include Eastern Meadowlarks, Bobolinks or Dickcissels, and Grasshopper, Savannah, and/or LeConte's Sparrows, with Red-winged Blackbirds and Common Yellowthroats in wetter areas (Cody 1985). Shortgrass steppe songbird assemblages usually include Horned Larks, Western Meadowlarks, Lark Buntings, and McGown's or Chestnut-collared Longspurs. Passerine faunas of mixed grass prairies include elements of both previous types, and they vary with grassland condition. Two species largely restricted to the mixed grass prairie region are Baird's Sparrow and Sprague's Pipit. Most bird species depart plains grasslands in winter but this is not true of semidesert grasslands (Bock et al. 1984). Typical breeding passerines in this habitat include meadowlarks, Horned Larks, and Grasshopper, Cassin's, Botteri's, and Lark Sparrows. Wintering assemblages are dominated by Cassin's, Brewer's, Vesper, and Grasshopper Sparrows, and meadowlarks.

Avian Responses to Livestock Grazing in Grasslands

We found published data about the effects of livestock grazing on 33 Neotropical migrant bird species that breed and/or winter on the Great Plains (Table 12-1). We found no information about the effects of grazing on birds in arid Chihuahuan grasslands, probably because most of these habitats have been grazed out of existence.

Despite inevitable variation in the nature of individual studies, the data for most species reveal consistent, ecologically interpretable patterns. Importantly, one of the patterns emerging from our synthesis is that many species respond differently to the effects of grazing in different grassland types, and that certain species may require grasslands in

Table 12-1. Responses to cattle grazing by Neotropical migrant landbirds breeding in grasslands of the North American Great Plains and Southwest.

Species	Migrant Status*	Region	Grassland Type	Grazing Intensity*	Response to Grazing*	Reference
Northern Harrier	B	S. Dakota	Mixed grass	Moderate	-	Duebber and Lokemoen (1977)
		N. plains	Mixed grass	Variable	-	Kantrud and Kologiski (1982)
Ferruginous Hawk	B	N. plains	Mixed grass	Variable	+	Kantrud and Kologiski (1982)
		S. Dakota	Mixed grass		+	Lokemoen and Duebber (1976)
Killdeer	B	Colorado	Shortgrass	Heavy	+	Ryder (1980)
		N. plains	Mixed grass	Moderate	+	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
Mountain Plover	A	N. Dakota	Mixed/tall	Moderate	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	+	Kantrud (1981)
		Colorado	Shortgrass	Heavy	+	Graul (1975)
		Colorado	Shortgrass	Heavy	+	Ryder (1980)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	0	Kantrud and Kologiski (1982)
Upland Sandpiper	A	N. Dakota	Mixed grass		-	Kirsch and Higgins (1976)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Variable	-	Kantrud and Higgins (1992)
		N. Dakota	Mixed/tall	Moderate	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	+	Kantrud (1981)
		Missouri	Tallgrass	Heavy	+	Skinner (1975)
Long-billed Curlew	A	Colorado	Shortgrass	Heavy	+	Ryder (1980)
		N. plains	Mixed grass	Heavy	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	Mixed	Kantrud and Kologiski (1982)
Mourning Dove	B	S. Arizona	Semidesert	Moderate	+	Bock et al. (1984)
		Colorado	Shortgrass	Heavy	0	Ryder (1980)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	0	Kantrud (1981)
Burrowing Owl	A	S. Texas	Tallgrass	Heavy	+	Baker and Guthery (1990)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
		S. Dakota	Mixed grass	Moderate	-	Duebber and Lokemoen (1977)
Short-eared Owl	B	N. plains	Mixed grass	Variable	-	Kantrud and Higgins (1992)
		Colorado	Shortgrass	Heavy	+	Ryder (1980)
Common Nighthawk	A	N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
Horned Lark	B	S. Arizona	Semidesert	Moderate	+	Bock et al. (1984)
		Colorado	Shortgrass	Heavy	+	Ryder (1980)

(continued)

Table 12-1 (cont.)

Species	Migrant Status*	Region	Grassland Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
		Plains	Shortgrass	Heavy	+	Wiens (1973)
		Saskatchewan	Mixed/short		+	Maier (1979)
		Alberta	Mixed grass	Heavy	+	Owens and Myres (1973)
		S. Dakota	Mixed grass	Heavy	+	Wiens (1973)
		N. plains	Mixed grass	Moderate	+	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	+	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	+	Kantrud (1981)
		Oklahoma	Tallgrass	Moderate	0	Risser et al. (1981)
		Oklahoma	Tallgrass	Heavy	+	Risser et al. (1981)
		S. Arizona	Semidesert	Moderate	+	Bock et al. (1984)
Northern Mockingbird	B					
Sprague's Pipit	B	N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		Saskatchewan	Mixed/short		-	Maier (1979)
		Alberta	Mixed grass	Heavy	-	Owens and Myres (1973)
		N. Dakota	Mixed/tall	Moderate	+	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	+	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	+	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		Oklahoma	Tallgrass	Heavy	-	Risser et al. (1981)
		Oklahoma	Tallgrass	Moderate	+	Risser et al. (1981)
		Missouri	Tallgrass	Moderate	+	Skinner (1975)
		S. Arizona	Semidesert	Moderate	-	Webb and Bock (1990)
		S. Arizona	Semidesert	Moderate	-	Bock and Bock (1988)
		Alberta	Mixed grass	Heavy	0	Owens and Myres (1973)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		S. Arizona	Semidesert	Moderate	+	Bock et al. (1984)
		Colorado	Shortgrass	Heavy	-	Ryder (1980)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	+	Bock et al. (1984)
		S. Arizona	Semidesert	Moderate	+	Owens and Myres (1973)
		S. Arizona	Semidesert	Moderate	+	Kantrud and Kologiski (1982)
		S. Arizona	Semidesert	Moderate	+	Bock et al. (1984)
		N. Dakota	Mixed/tall	Heavy	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	0	Kantrud (1981)
Lark Sparrow	A					
Black-throated Sparrow	B					
Lark Bunting	A					
		N. Texas	Shortgrass	Heavy	-	Wiens (1973)
		Colorado	Shortgrass	Heavy	-	Ryder (1980)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	0	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	+	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	0	Kantrud (1981)

Table 12-1 (cont.)

Species	Migrant Status*	Region	Grassland Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Savannah Sparrow	B	Saskatchewan	Mixed/short		-	Maier (1979)
		Alberta	Mixed grass	Heavy	-	Owens and Myres (1973)
		N. Dakota	Mixed/tall	Moderate	-	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		Minnesota	Tallgrass	Moderate	-	Tester and Marshall (1961)
Baird's Sparrow	A	Saskatchewan	Mixed/short		-	Maier (1979)
		Alberta	Mixed grass	Heavy	-	Owens and Myres (1973)
		N. plains	Mixed grass	Moderate	-	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		S. Arizona	Semidesert	Moderate	-	Bock et al. (1984)
		Colorado	Shortgrass	Heavy	-	Ryder (1980)
		N. Texas	Shortgrass	Heavy	-	Wiens (1973)
		S. Dakota	Mixed grass	Heavy	-	Wiens (1973)
		N. plains	Mixed grass	Moderate	-	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	0	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		Oklahoma	Tallgrass	Moderate	+	Risser et al. (1981)
		Oklahoma	Tallgrass	Heavy	-	Risser et al. (1981)
		Missouri	Tallgrass	Moderate	+	Skinner (1975)
		Colorado	Shortgrass	Heavy	+	Ryder (1980)
		Saskatchewan	Mixed/short		+	Maier (1979)
		N. plains	Mixed grass	Moderate	+	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	+	Kantrud and Kologiski (1982)
		S. Arizona	Semidesert	Moderate	+	Bock and Bock (1988)
		Colorado	Shortgrass	Heavy	0	Ryder (1980)
		Saskatchewan	Mixed/short		+	Maier (1979)
		Alberta	Mixed grass	Heavy	+	Owens and Myres (1973)
		N. plains	Mixed grass	Moderate	0	Kantrud and Kologiski (1981)
		N. plains	Mixed grass	Heavy	0	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	+	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	+	Kantrud (1981)
		N. plains	Mixed grass	Moderate	-	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	-	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		N. plains	Mixed grass	Moderate	-	Kantrud and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantrud and Kologiski (1982)
		N. Dakota	Mixed/tall	Moderate	-	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		Minnesota	Tallgrass	Moderate	0	Tester and Marshall (1961)
		Missouri	Tallgrass	Moderate	+	Skinner (1975)
		N. Dakota	Mixed/tall	Moderate	-	Kantrud (1981)
		N. Dakota	Mixed/tall	Heavy	-	Kantrud (1981)
		Missouri	Tallgrass	Moderate	+	Skinner (1975)
		S. Arizona	Semidesert	Moderate	0	Bock et al. (1984)
		Oklahoma	Tallgrass	Moderate	+	Risser et al. (1981)
		Oklahoma	Tallgrass	Heavy	-	Risser et al. (1981)
		Missouri	Tallgrass	Moderate	+	Skinner (1975)
		S. Texas	Tallgrass	Heavy	+	Baker and Guthery (1990)

(continued)

Table 12-1 (cont.)

Species	Migrant Status*	Region	Grassland Type	Grazing Intensity*	Response to Grazing	Reference
Western Meadowlark	II	Colorado N. Texas Saskatchewan	Shortgrass Shortgrass Mixed/dominant	Heavy	-	Ryder (1980) Wiens (1977) Maher (1979)
		Alberta S. Dakota N. plains	Mixed grass Mixed grass Mixed grass	Heavy	0	Owens and Myers (1977) Wiens (1977) Kantnrad and Kologiski (1982)
		N. plains	Mixed grass	Heavy	-	Kantnrad and Kologiski (1982)
		N. Dakota N. Dakota N. plains	Mixed/hall Mixed/hall Mixed grass	Moderate Heavy Moderate	0 0 0	Kantnrad (1981) Kantnrad (1981) Kantnrad and Kologiski (1982)
Brown-headed Cowbird	II	N. plains	Mixed grass	Heavy	0	Kantnrad and Kologiski (1982)
		N. Dakota N. Dakota	Mixed/hall Mixed/hall	Moderate Heavy	0 0	Kantnrad (1981) Kantnrad (1981)

* Status: "A" contains long distance migrants, those species that breed in North America and spend their nonbreeding period primarily south of the United States; Status "II" contains short distance migrants, those species that breed and spend relatively in North America, although some populations winter south of the United States; Status "C" contains those species whose breeding range is largely within the United States; Status "I" contains those species that breed and enter the United States along the Rio Grande Valley and where the Mexican Highlands extend across the United States; based on G. G. Borner, 1979, *ibid.*

* Grazing intensity as reported by original authors in the references list.

* Grazing effects on abundance: + = increase; - = decrease; 0 = no effect, as reported by original authors.

different condition to meet different life requirements (e.g. foraging vs nesting).

We found limited information on the responses of avian predators to livestock grazing, probably because most of these birds have such large home ranges that their densities cannot be compared on plots of the sizes used in typical grazing studies (Bock and Bock 1988). Northern Harriers are characteristic of tall, comparatively lush grasslands (Johnsgard 1979), and they have been found in higher numbers in highly grazed mixed grass prairie in the northern plains (Table 12-1). Short-eared Owls also have responded positively to the presence of substantial ground cover in the same region. By contrast, Ferruginous Hawks showed a mixed response to grazing; apparently preferring to hunt open grasslands but to nest in areas with more ground cover or with scattered large trees. Burrowing Owls usually nest in abandoned prairie dog burrows on the Great Plains and they prefer habitat with much bare ground (e.g., Agnew et al. 1986). Livestock, like bison, facilitate establishment and expansion of prairie dog colonies by

grazing down dense grasslands that the prairie dogs otherwise are unable to occupy (Coppock et al. 1983, Ureck 1984, Ureck and Paulson 1988). The response of Burrowing Owls to grassland grazing therefore has been positive probably due to an increase in prey availability (Table 12-1).

Shorebird species respond variously though, in general, these birds prefer to nest in relatively sparse grasslands (Kantnrad and Higgins 1992). Killdeer and Mountain Plovers nest in such open areas that only heavy livestock grazing appears sufficient to create or maintain their breeding habitat (Table 12-1; see also Grant and Webster 1978, Parrish et al. 1993). In mixed grassland in north-central Montana, Mountain Plovers nested primarily in areas both grazed by cattle and occupied by prairie dogs (Kowles et al. 1982). Long-billed Curlews may prefer grazed areas in steppe grasslands, but more data are needed (Kantnrad and Kologiski 1982). Upland Sandpipers clearly require more grass cover than Killdeer or Mountain Plovers, but evidence exists that this shorebird is flexible in its choice of nesting habitats

(Table 12-1). Response to grazing may be related to grassland type, with effects being neutral or negative in mixed grasslands (e.g., Kantnrad and Kologiski 1982, Kantnrad and Higgins 1992), and positive in tallgrass prairies (Skinner 1975). Shortgrass steppe appears not to be suitable Upland Sandpiper breeding habitat. Upland Sandpipers also may require heavier ground cover for nesting sites than for feeding sites (Kantnrad 1981).

Mountain Plovers are another species that has shown mixed responses to grazing, suggesting that other environmental factors may be more important to this species. For example, abundances of doves in the northern mixed grass prairie varied widely across plots on different soils, regardless of grazing intensities, although ground nests usually were placed in idle versus currently grazed pastures (Kantnrad and Kologiski 1982, Kantnrad and Higgins 1992). However, doves frequently nest in trees across the Great Plains (Johnsgard 1979), and therefore may not be completely dependent upon ground cover for successful nesting. Furthermore, doves have such weak legs and feet that they cannot forage effectively in very heavy ground cover (Leopold 1972). They appear to benefit from grazing, at least in comparatively lush grasslands of southern Texas and southeastern Arizona (Bock et al. 1984, Baker and Gutcher 1990).

Songbirds exhibited the full range of responses to grazing in grasslands of the Great Plains (Table 12-1). At one extreme is the Horned Lark, one of the most widespread birds in the region and one that has been universally positive in its response to grazing. Other, more narrowly distributed, songbirds shown to benefit from grazing include Lark and Black-throated Sparrows, McCown's Longspur, and Dickcissel (moderate grazing only, see Table 12-1). At the other extreme is a group of songbirds that appear negatively affected by grazing wherever they have been studied. This group includes the Common Yellowthroat, and Bortner's, Cassin's, Savannah, Baird's, and Henslow's Sparrows. Western Meadowlarks also have been negatively affected by grazing, although in many cases differences between plots under different grazing regimes have been minor. Western Meadowlarks are one of the most widespread

plains birds, and they appear to tolerate all except the heaviest levels of livestock grazing.

A fourth, and particularly interesting, group of songbirds includes species that apparently require or prefer intermediate amounts of grass cover. They have benefited from grazing in tallgrass and some mixed grass communities, but declined or disappeared in the presence of grazing in shorter grasslands. Perhaps the best-studied example is the Grasshopper Sparrow (Table 12-1), a species experiencing widespread population declines (Robbins et al. 1993). Grasshopper Sparrows were negatively affected by grazing in shortgrass, semidesert, and certain mixed grass communities (Ryder 1980, Kantnrad and Kologiski 1982, Bock et al. 1984), but they have responded positively at least to moderate grazing in tallgrass prairies (Skinner 1975, Risser et al. 1981). Other species that have exhibited a similar pattern include Sprague's Pipit, Lark Bunting, Chestnut-collared Longspur, Bobolink, Red-winged Blackbird, and, perhaps, Eastern Meadowlark. Finally, some songbirds have shown weak, inconsistent responses to grazing in different parts of the plains. These include Clay-colored, Brewer's, and Vesper Sparrows, and Brown-headed Cowbird (Table 12-1). At least for Clay-colored and Brewer's Sparrows, distribution and abundance patterns appear to be more strongly associated with shrub than with grass cover.

No obvious relationship existed between migratory status and responsiveness to grazing among the 35 grassland species (Table 12-1). First, while most are listed as Neotropical migrants (Gauthreaux 1992), the great majority in fact winter across the southern portion of North American continent (Knopf 1994). Only four of the 35 are long-distance migrants that winter entirely outside the region (Upland Sandpiper, Common Nighthawk, Dickcissel, and Bobolink). Furthermore, pairs of species with generally similar breeding and wintering distributions often have shown very different responses to grazing. For example, Chestnut-collared and McCown's Longspurs both breed in the northern Great Plains and winter in the south-central United States and northern Mexico; grazing usually has favored the former, while the latter has shown a graded

response. Vesper and Savannah Sparrows both breed widely across North America, and winter across the southern United States from California to Florida; the former appears generally unresponsive to grazing, while the latter usually has been negatively affected (Tables 12-1 to 12-4).

Breeding Bird Survey data suggest that grassland birds as a group are showing greater population declines than any other avian assemblage in North America (Robbins et al. 1993; Knopf 1994a). This probably is attributable to habitat modifications including livestock grazing, in addition to fire suppression, prairie dog control, cultivations, and planting exotic grasses.

SHRUBSTEPPE OF THE INTERMOUNTAIN REGION

Characteristics of Shrubsteppe Habitats

Shrubsteppe habitats in western North America are characterized by woody, mid-height shrubs and perennial bunchgrasses (Fauntin 1946; Danbennie 1978; Deely et al. 1981; Tisdale and Hironaka 1981; Short 1986). Shrubsteppe typically is arid with annual precipitation over much of the region averaging less than 36 cm (Danbennie 1956; Richard and Vaughan 1988; Rogers and Rickard 1988). Periodic drought, extreme temperatures, wind, poor soil stability and only fair soil quality (Fauntin 1946; Wrens and Dyer 1975; Short 1986) manifest a stressful environment for biotic communities.

The shrubsteppe has been delineated in various ways (Kneuder 1964; Wrens and Dyer 1975; Risser et al. 1981). Major differences depend on the inclusion of salt desert shrublands of the Great Basin, shrubsteppe of the southwestern United States, or pinon-juniper types (Short 1986).

Historical Perspective and Dynamics of Shrubsteppe Habitats

Major changes in native shrubsteppe vegetation, particularly the rapid loss of forbs and grasses, took as little as 10-15 years under severe overgrazing that accompanied early

settlement of the West (Kennedy and Doten 1901; Coffman and Stewart 1940; Brougham and Harris 1967; McNaughton 1979; Wed 1979). Some plant species may have been extirpated from the region or driven to extinction, but we assume that most of the species present today were also important historically (Healy et al. 1981; Tisdale and Hironaka 1981).

Little doubt exists that sagebrush (*Artemisia* spp.) has always been an important component of the Intermountain landscape (Vale 1975; Braun et al. 1976), with a variety of sagebrush vegetative types dominating large areas (McArthur and Welch 1986). Other important shrubs include saltbush (*Atriplex* spp.), rabbitbrush (*Chrysothamnus* spp.), and bitterbrush (*Purshia tridentata*) (West 1979; Tisdale and Hironaka 1981; Yensen 1981; McArthur and Welch 1986). The region is characterized by perennial bunchgrasses (also known as caespitose grasses) including the genera *Alopecurus*, *Poa*, *Stipa*, *Elymus*, and *Festuca* (Fauntin 1946; West 1979; Yensen 1981). Few rhizomatous or sod-forming grasses occur and they play only a minor role in the ecosystem, in contrast to the prairies farther east (Mack and Thompson 1982).

Domestic livestock grazing has caused major changes in plant species composition of shrubsteppe habitats including loss of the cryptogam layer from trampling, loss of native seral grasses, reduced perennial grass cover, reduced forb cover, increased shrub cover, and invasion by exotic species, particularly cheatgrass (*Bromus tectorum*) (Yensen 1981).

Prior to European settlement, cryptogams such as the lichen *Parmelia chlorocarpa* (Mack Cracken et al. 1983), covered all undisturbed soil surfaces not populated by vascular plants. Because of the permanent loss of this layer through trampling by domestic livestock (Pronlon 1955; Danbennie 1974; Mack and Thompson 1982), we do not know what role this stratum played in the original ecosystem. Increased soil temperatures, increased erosion, lower soil moisture, lower productivity and a lower rate of seedling establishment are likely negative consequences of the loss of cryptogams (Mack Cracken et al. 1983).

Because herbaceous species are more palatable than shrubs during the growing season, grazing tends to increase shrub cover, and decrease palatable forbs and grasses (Pfeiffer 1932; Coffman and Stewart 1940; Smith 1967; Tisdale et al. 1969; Smith and Schmitz 1975; Page et al. 1978; Ryder 1980; Blaschell et al. 1982). More intense grazing will eliminate even less palatable species and lead to domination by woody, unpalatable and spiny species (Ellison 1966).

Generally, cattle grazing favors shrubs and forbs over grasses while sheep grazing shifts the balance towards grass (Allred 1941; Costello and Turner 1941; Tisdale 1947; Cooper 1953; Robertson 1971; Urness 1979). Season of use is also an important influence in shrubsteppe. For example, heavy spring sheep grazing reduces grasses and increases sagebrush, whereas heavy fall sheep grazing has the opposite effect (Craddock and Fosling 1938; Mueggler 1950; Ellison 1960; Laycock 1967). Livestock grazing can also increase the density of junipers (Coffman and Stewart 1940; Woodbury 1947; Springfield 1976; Little 1977) and reduce vegetation diversity (Wrens and Dyer 1975; Reynolds and Rich 1978).

While exotic animals are found essentially everywhere in the shrubsteppe, it is clear that their dominance increases with disturbance such as livestock grazing. Penner (1938) and Young et al. (1979) submit that cheatgrass, at least, cannot significantly invade healthy shrubsteppe habitats.

Evaluation of Grazing in Shrubsteppe Habitats

Shrubsteppe habitats did not covolve with large herds of grazing animals, and plant species are not adapted to withstand severe or continuous grazing (Mack and Thompson 1982). Post-Pleistocene native ungulates in shrubsteppe only included American bison and pronghorn. Bison numbers were estimated at 40 million when Europeans arrived (England and DeVos 1969) but it is unlikely that large herds occurred west of the Rockies (Custalson 1972; Grayson 1977). Few prehistoric bison records exist from the Columbia Plateau (Schroell 1973) and records are rare

elsewhere in the region (Mack and Thompson 1982).

Caespitose grasses depend on seed production rather than rhizomes or stolons to maintain their populations. The effects of grazing, both removal of vegetation and mechanical damage from trampling, are more serious for caespitose species (Mack and Thompson 1982). Consequently, sagebrush-perennial bunchgrass communities are adapted to small, dispersed groups (typified by pronghorn, mule deer and elk). Although these species form groups on winter ranges, they largely rely on woody vegetation at that time of year. This lack of adaptation to concentrations of large herbivores has led to "striking susceptibility" of shrubsteppe vegetation to the impact of domestic ungulates (Larson 1940; Tisdale 1961; Dyer 1979; Mack and Thompson 1982).

Classic approaches to grazing management in shrubsteppe habitats are discussed by Stoddart et al. (1975) and Laycock (1983), with novel strategies infrequent, controversial and slow to be substantiated (Savory and Parsons 1980; Savory 1988). The most noteworthy long-term trend on public land in shrubsteppe has been the reduction of destructive season-long cattle grazing where animals are released in early spring and removed in late fall (Appendix).

Multiple-use rest-rotation systems (Appendix, Stoddart et al. 1975) have become popular for cattle and are a significant improvement in cattle management for shrubsteppe habitats. The rest rotation method typically produces more uniform grazing across the landscape rather than areas of high use and areas of little or no use. The system also requires more fencing, water developments, prescribed burns, seedlings or other manipulations. Ultimately, more cattle may be allowed in an allotment.

Shrubsteppe Avifauna

While more than 50 species of neotropical migrants breed in this region, the shrubsteppe bird community typically has 2-7 regular breeding species. Densities vary between 100 and 600 individuals/km² with over half the individuals at a site belonging to the most

common species. Irregular precipitation patterns in shrubsteppe habitats have resulted in annual redistributions of individual birds, locally and regionally (Wiens and Rotenberry 1981a, Wiens 1985).

Certain associations exist between bird species and particular plant species, perhaps in response to arthropod abundance or availability (Wiens and Rotenberry 1981b). Some shrubsteppe birds show a high degree of selectivity for grass seeds of certain species (Goebel and Berry 1976). Thus, selective removal of particular plant species by livestock could have direct effects on individual bird species.

Avian predators occupying shrubsteppe habitats are influenced by their small-mammal prey. Small-mammal community composition, densities and distribution vary with vegetation structure (Feldhamer 1979, Rogers and Hedlund 1980, Gano and Rickard 1982, McGee 1982) and species diversity declines as grazing intensifies (see Kochert 1989). However, the specific ecological relationships between small mammals and shrubsteppe raptors are essentially unknown.

Avian Responses to Livestock Grazing in Shrubsteppe Habitats

We found information from 15 studies that evaluated grazing effects on 34 Neotropical migrants that breed in shrubsteppe vegetation (Table 12-2). Birds considered in this evaluation range from sagebrush obligates to much more widespread species that are only peripherally associated with shrubsteppe (see references in Table 12-2). In a qualitative assessment of grazing effects on shrubsteppe birds, 12 species responded positively, 12 negatively, and 10 species showed no clear response.

The referenced studies reported abundance information on 31 migrant species and only 14 of those were evaluated by two or more studies (Table 12-3), thus limiting conclusions based on quantitative data. No species or ecological guild showed significant differences ($P < 0.05$) in abundances between grazed and ungrazed treatments. Of the 34 species evaluated, only six are considered long-distance migrants and 28 short-distance migrants (Gauthreaux 1992). Combined

in groups, neither long-distance migrants [standardized means 0.81 vs 1.20 (grazed vs ungrazed), $T = 1.01$, $P = 0.33$] nor short-distance migrants [standardized means 1.00 vs 0.99 (grazed vs ungrazed), $T = -0.09$, $P = 0.92$] appeared particularly vulnerable to livestock grazing. These results should be viewed with caution considering the little quantitative data available and a lack of information about pristine shrubsteppe habitats (i.e., no controls from which to judge grazing effects).

Most studies were conducted with cattle on a short-term basis during the growing season (references in Table 12-2). Effects of other kinds of livestock (McKnight 1958, Hanley and Brady 1977) during other times of the year might differ substantially. Nevertheless, we make some tentative conclusions based on the limited published information, and knowledge about the effects of grazing on vegetation and the known habitat requirements of the birds.

Wiens and Dyer (1975) suggested that the 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 passed. Such thresholds may have passed historically, when livestock were first introduced into the region. However, virtually no pristine ecosystems exist where this hypothesis might be tested. As a result, our conclusions about the effects of grazing on Neotropical migrants must be largely speculative.

Distinguishing between historical and current livestock impacts is important when categorizing bird responses to grazing. For example, species requiring shrubs as nest sites may have benefitted from early, grazing-related increases in shrubs across the West. They may now be harmed by heavy grazing that removes herbaceous cover. Brewer's Sparrows may be an example, and we consider this species to be negatively affected by grazing (Tables 12-2 and 12-3).

Brewer's Sparrow populations have declined significantly both in the western United States and over their entire range during the last 25 years (Robbins et al. 1993, Peterjohn et al., chapter 1, this volume). As this species is the most typical, widespread

Table 12-2. Responses to cattle grazing by Neotropical migrant landbirds breeding in shrubsteppe habitats of western North America.

Species	Migrant Status ^a	Region	Shrubland Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Northern Harrier	B	Nevada	Greasewood/Great Basin wild rye	Heavy	-	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
		Oregon	Various	Variable	-	Kochert (1989)
Swainson's Hawk ^d	A	Idaho	Various	Variable	+	Martin (1987)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
		Oregon	Various	Heavy	-	Littlefield et al. (1984)
Red-tailed Hawk ^d	B	West	Various	Variable	-	Kochert (1989)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Trost (1981)
Ferruginous Hawk	B	West	Various	Variable	Mixed	Kochert (1989)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Trost (1981)
Golden Eagle	B	West	Various	Variable	Mixed	Kochert (1989)
		Idaho	Various	Heavy	-	Kochert (1989)
American Kestrel ^d	B	Nevada	Low sage/Idaho fescue	Heavy	-	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
Prairie Falcon	B	West	Various	Variable	-	Kochert (1989)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Trost (1981)
Long-billed Curlew	A	Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Trost (1981)
Mourning Dove	B	Nevada	Greasewood/Great Basin wild rye	Heavy	+	Page et al. (1978)
		Nevada	Shadscale/Indian ricegrass	Heavy	-	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds (1980)
Buttrowing Owl	A	West	Various	Variable	+	Kochert (1989)
		West	Various	Variable	+	Snyder and Snyder (1975)
		Idaho	Big sage/bluebunch wheatgrass	Variable	Mixed	Rich (1986)
Long-eared Owl	B	Idaho	Big sage	Variable	-	Gleason (1978)
		West	Various	Variable	Mixed	Kochert (1989)
Short-eared Owl	B	Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds (1980)
Common Nighthawk	A	Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Trost (1981)
Common Poorwill	B ^d	Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
Northern Flicker ^d	B	Nevada	Low sage/Idaho fescue	Heavy	0	Page et al. (1978)
		Nevada	Big sage/bluebunch wheatgrass	Heavy	+	Page et al. (1978)
Gray Flycatcher	A	Nevada	Shadscale/Indian ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Trost (1981)
Say's Phoebe	B	Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
Horned Lark	B	Nevada	Greasewood/Great Basin wild rye	Heavy	-	Page et al. (1978)

(continued)

Table 12-3. Standardized relative abundance for 31 species of migratory landbirds. Original data were taken from 15 studies conducted in shrubsteppe habitats. Sample size is the number of studies from which the data were derived. Standard errors (SE) and *P* values were calculated by a paired *t*-test. No species' abundances differed significantly (*P* < 0.05) between treatments.

Species	Forage Guild ^a	Nest Layer ^b	Nest Type ^c	Sample Size	Standardized Mean		SE	<i>P</i> Value
					Grazed	Ungrazed ^d		
Northern Harrier	CA	GR	O	2	0.60	1.40	1.77	0.58
Swainson's Hawk	CA	CA	O	1	1.67	0.33	—	—
Red-tailed Hawk	CA	CA	O	1	0.67	1.33	—	—
Ferruginous Hawk	CA	GR	O	1	0.67	1.33	—	—
American Kestrel	CA	CA	C	2	0.80	1.20	2.21	0.75
Prairie Falcon	CA	CA	C	1	0.00	2.00	—	—
Long-billed Curlew	GI	GR	O	1	0.00	2.00	—	—
Mourning Dove	GI	SH	O	3	0.78	1.22	1.88	0.82
Short-eared Owl	CA	GR	C	1	0.00	2.00	—	—
Common Nighthawk	AI	GR	O	1	0.67	1.33	—	—
Common Poorwill	AI	GR	O	1	2.00	0.00	—	—
Northern Flicker	BI	CA	C	2	1.50	0.50	1.57	0.50
Gray Flycatcher	AI	SH	O	3	1.33	0.67	2.09	0.67
Say's Phoebe	AI	CA	O	1	2.00	0.00	—	—
Horned Lark	GI	GR	O	5	0.42	1.58	0.71	0.07
Tree Swallow	AI	CA	C	1	0.00	2.00	—	—
Rock Wren	GI	GR	C	3	2.00	0.00	0	0
Mountain Bluebird	AI	CA	C	1	2.00	0.00	—	—
Sage Thrasher	FI	SH	O	3	1.76	0.24	0.86	0.11
Loggerhead Shrike	SA	SH	O	4	1.42	0.58	1.01	0.26
Green-tailed Towhee	GI	GR	O	1	0.00	2.00	—	—
Vesper Sparrow	GI	GR	O	5	0.80	1.20	1.54	0.70
Black-throated Sparrow	FI	SH	O	1	1.23	0.77	—	—
Sage Sparrow	GI	SH	O	4	0.93	1.07	0.37	0.69
Brewer's Sparrow	FI	SH	O	6	0.83	1.17	0.69	0.45
Savannah Sparrow	GI	GR	O	1	0.00	2.00	—	—
White-crowned Sparrow	OM	GR	O	3	1.12	0.88	1.08	0.87
Red-winged Blackbird	OM	SH	O	1	0.00	2.00	—	—
Western Meadowlark	GI	GR	O	6	1.00	1.00	1.22	1.00
Brewer's Blackbird	OM	SH	O	3	0.54	1.46	0.63	0.24
Brown-headed Cowbird	OM	—	P	1	1.78	0.22	—	—

^a Foraging guild abbreviations: AI = aerial insectivore; BI = bark insectivore; FI = foliage insectivore; GI = ground insectivore; CA = carnivore; NE = nectarivore; OM = omnivore.

^b Nest layer abbreviations: SH = shrub-nesting species; GR = ground-nesting species; CA = subcanopy/canopy-nesting species.

^c Nest type abbreviations: O = open; C = cavity; P = parasite.

^d Includes lightly grazed and fall-grazed treatments.

and common shrubsteppe bird in many locations, their decline is a major cause for concern in sagebrush ecosystems.

Other shrubsteppe species such as Gray Flycatcher, Rock Wren, Green-tailed Towhee, Sage Thrasher, and Lark and Sage Sparrows have shown no significant population trends over the western United States (Peterjohn et al., Chapter 1, this volume). However, Lark Sparrows and Rock Wrens show significant range-wide declines. Black-throated Sparrows, which inhabit more xeric shrub communities, have also shown significant population declines.

Data for two other species also suggest that

shrubs are changing, whether or not livestock grazing is implicated as a major cause. Long-billed Curlews and Burrowing Owls both breed in habitats characterized by a lack of shrubs and large areas of relatively low vegetation. Both species showed significant population increases between 1966 and 1991 in the western United States (Peterjohn et al., Chapter 1, this volume).

Little information exists on responses to grazing by migratory raptors in shrubsteppe (Kochert 1989). Our designations of raptor species increasing or decreasing in abundance were based on grazing-induced habitat alter-

ations, which affect small mammal populations, nest cover and substrates. Intensive grazing and fire suppression favors encroachment by shrubs and trees (especially *Juniperus* spp.). Ground-nesting raptors (e.g., Northern Harrier, Short-eared Owl, and Ferruginous Hawk) are often negatively affected by grazing practices that reduce nest cover (Duebber and Lokemoen 1977). Raptors and their rodent prey often decrease under conditions with reduced amounts of herbaceous cover and increased shrub densities (see Kochert 1989). Other prey species (e.g., jackrabbits) respond positively to dense shrub conditions (Nydegger and Smith 1986), potentially benefiting their primary predator, the Golden Eagle. Increases in juniper trees could increase availability of nest sites (e.g., Long-eared Owls and Red-tailed Hawks) (Kochert 1989) and perch sites of some raptor species. Another potentially significant indirect effect of grazing on migrants in shrubsteppe is nest parasitism by Brown-headed Cowbirds. However, almost no data are available for shrubsteppe (Rich 1978, Rich and Rothstein 1985) and the degree of impact caused by cowbirds is unknown.

Shrubsteppe birds generally respond negatively after deliberate conversions of native shrub habitats to exotic vegetation for the foraging benefit of livestock (Best 1972, Schroeder and Sturges 1975, Reynolds and Trost 1980, 1981, Castrale 1982). However, some responses may not be detected due to lack of clear population responses due to time lags, site tenacity by individuals and scale of treatment (Wiens and Rotenberry 1985). Thus, short-term before and after surveys in this avian community may be "dangerously misleading" (Wiens et al. 1986).

WESTERN RIPARIAN HABITATS

Characteristics of Riparian Habitats

Riparian zones include assemblages of plant and animal communities occurring at the interfaces between terrestrial and aquatic ecosystems. In arid portions of western North America, riparian areas create well-defined, narrow zones of vegetation along ephemeral, intermittent, and perennial streams and rivers, and are most conspicuous in steppe,

shrubs, and desert regions. The diversity and productivity of these systems compared to surrounding uplands are largely attributable to biotic and nutrient exchanges between aquatic and adjacent upland areas (Gregory et al. 1991).

Western riparian woodlands vary from extensive floodplain forests dominated by cottonwoods (*Populus* spp.) along large rivers to narrow bands of aspen (*Populus tremuloides*) woodlands and willow (*Salix* spp.) thickets along small mountain streams. Plant composition varies geographically and climatically, with higher elevation areas often composed of alder (*Alnus* spp.), birch (*Betula* spp.), and dogwood (*Cornus* spp.). Sycamore (*Platanus* spp.), cherry (*Prunus* spp.), hawthorn (*Crataegus* spp.), and hackberry (*Celtis* spp.) are typically found at lower elevations and in drier climates.

Historical Perspective of Riparian Habitats

The critical and disproportionate value of riparian habitat to wildlife has been recognized only within the last two decades (Johnson et al. 1977, Knopf et al. 1988a). Riparian vegetation is used by wildlife more than any other vegetation type (Thomas et al. 1979). Yet, riparian areas are among the most threatened habitats on the continent because they are favored for many land uses including livestock grazing, agriculture, water management, timber harvest, recreation, and urbanization (e.g., Thomas et al. 1979, Knopf et al. 1988a).

Livestock grazing has caused geographically extensive impacts on western riparian zones (Carothers 1977, Crumpacker 1984, Chaney et al. 1990), and these areas are considered the most modified land type in the West (Chaney et al. 1990). Grazing on riparian bottomlands tends to be more damaging than on uplands (Platts and Nelson 1985), especially in arid regions where water, shade, succulent vegetation, and flatter terrain occur near streams (Behne 1979, Chaney et al. 1990, Platts 1991). Livestock grazing affects riparian habitats by altering, reducing, or removing vegetation, and by actually eliminating riparian areas through channel widening, channel aggrading, or lowering the water table (see Platts 1991).

Table 12-2 (cont.)

Species	Migrant Status ^a	Region	Shrubland Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Horned Lark (cont.)		Nevada	Shadscale/Indian ricegrass	Heavy	-	Page et al. (1978)
		Nevada	Low sage/Idaho fescue	Heavy	-	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds (1980)
		Utah	Shadscale/sand dropseed	Heavy	Mixed	Medin (1986)
		Idaho	Big sage	Not reported	+	Olson (1974)
	Idaho	Various	Variable	+	Rotenberry and Knick (1992)	
Tree Swallow ^d	B	Nevada	Nevada bluegrass/sedge	Heavy	-	Page et al. (1978)
Rock Wren	B	Nevada	Shadscale/Indian Ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Big sage/bluebunch wheatgrass	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
Mountain Bluebird	B	Nevada	Low sage/Idaho fescue	Heavy	+	Page et al. (1978)
Sage Thrasher	B	Nevada	Greasewood/Great Basin wild rye	Heavy	+	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds (1980)
		Idaho	Big sage	Not reported	+	Olson (1974)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds and Rich (1978)
Loggerhead Shrike	B	Nevada	Shadscale/Indian ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Low sage/Idaho fescue	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	0	Reynolds (1980)
		Utah	Shadscale/sand dropseed	Heavy	0	Medin (1986)
Green-tailed Towhee	A	Nevada	Big sage/bluebunch wheatgrass	Heavy	-	Page et al. (1978)
Vesper Sparrow	B	Nevada	Greasewood/Great Basin wild rye	Heavy	+	Page et al. (1978)
		Nevada	Shadscale/Indian ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Low sage/Idaho fescue	Heavy	-	Page et al. (1978)
		Nevada	Big sage/bluebunch wheatgrass	Heavy	-	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	-	Page et al. (1978)
		Idaho	Big sage	Not reported	-	Olson (1974)
Black-throated Sparrow	B	Utah	Shadscale/sand dropseed	Heavy	Mixed	Medin (1986)
Sage Sparrow	B	Nevada	Greasewood/Great Basin wild rye	Heavy	-	Page et al. (1978)
		Nevada	Shadscale/Indian ricegrass	Heavy	-	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds (1980)

Table 12-2 (cont.)

Species	Migrant Status ^a	Region	Shrubland Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Sage Sparrow (cont.)		Idaho	Big sage	Not reported	+	Olson (1974)
		Great Basin	Big Sage	Variable	+	Wiens and Rotenberry (1981b), Wiens (1985)
Brewer's Sparrow	B	Nevada	Greasewood/Great Basin wild rye	Heavy	-	Page et al. (1978)
		Nevada	Shadscale/Indian ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Low sage/Idaho fescue	Heavy	-	Page et al. (1978)
		Nevada	Big sage/bluebunch wheatgrass	Heavy	+	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds (1980)
		Idaho	Big sage	Not reported	-	Olson (1974)
Savannah Sparrow	B	Nevada	Nevada bluegrass/sedge	Heavy	-	Page et al. (1978)
White-crowned Sparrow	B	Nevada	Greasewood/Great Basin wild rye	Heavy	-	Page et al. (1978)
		Nevada	Big sage/bluebunch wheatgrass	Heavy	+	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
Red-winged Blackbird	B	Nevada	Nevada bluegrass/sedge	Heavy	-	Page et al. (1978)
Western Meadowlark	B	Nevada	Greasewood/Great Basin wild rye	Heavy	+	Page et al. (1978)
		Nevada	Shadscale/Indian ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Low sage/Idaho fescue	Heavy	-	Page et al. (1978)
		Nevada	Big sage/bluebunch wheatgrass	Heavy	+	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	-	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	-	Reynolds (1980)
		Idaho	Big sage	Not reported	-	Olson (1974)
		Idaho	Various	Variable	0	Rotenberry and Knick (1992)
		Great Basin	Big sage	Variable	-	Wiens and Rotenberry (1981b)
Brewer's Blackbird	B	Nevada	Shadscale/Indian ricegrass	Heavy	+	Page et al. (1978)
		Nevada	Nevada bluegrass/sedge	Heavy	-	Page et al. (1978)
		Idaho	Big sage/bluebunch wheatgrass	Moderate	0	Reynolds and Trost (1981)
Brown-headed Cowbird	B	Idaho	Big sage/bluebunch wheatgrass	Moderate	+	Reynolds and Trost (1981)
		Great Basin	Various	Variable	+	Rich and Rothstein (1985)

^aStatus "A" contains long-distance migrants, those species that breed in North America and spend their nonbreeding period primarily south of the United States. Status "B" contains short distance migrants, those species that breed and winter extensively in North America, although some populations winter south of the United States.

^bGrazing intensity as reported by original authors in the references listed.

^cGrazing effects on abundance: + = increase; - = decrease; 0 = no effect, as reported by original authors.

^dSpecies forages in shrubsteppe vegetation but nests in other adjacent habitat.

Table 12-4. Responses to cattle grazing by Neotropical migrant landbirds breeding in western riparian habitats.

Species	Migrant Status ^a	Region	Riparian Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Killdeer	B	Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
		Oregon	Willow	Variable	+	Taylor (1986)
		Idaho	Herbaceous	Heavy	+	Medin and Clary (1990)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		Idaho	Herbaceous	Heavy	+	Medin and Clary (1990)
Long-billed Curlew	A					
American Kestrel	B	Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
		Nevada	Aspen/willow	Moderate	-	Medin and Clary (1991)
		California/	Aspen	Not reported	+	Page et al. (1978)
		Nevada				
		Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
Yellow-billed Cuckoo	A					
Common Nighthawk	A	Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
Calliope Hummingbird	A	California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
		Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
		California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
Rufous Hummingbird	A					
Broad-tailed Hummingbird	A	Nevada	Aspen/willow	Moderate	+	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
Belted Kingfisher	B	Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
Northern Flicker	B	California/	Aspen	Not reported	+	Page et al. (1978)
		Nevada				
		Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
		Nevada	Aspen/willow	Moderate	0	Medin and Clary (1991)
		Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
Lewis' Woodpecker	B	Nevada	Aspen/willow	Moderate	+	Medin and Clary (1991)
		California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
Red-naped Sapsucker	B	Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
		Nevada	Aspen/willow	Moderate	0	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
Western Kingbird	A					
Eastern Kingbird	A	Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)

Table 12-4 (cont.)

Species	Migrant Status ^a	Region	Riparian Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Eastern Kingbird (cont.)		Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
Western Wood-Pewee	A	California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
Say's Phoebe	B	Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
Least Flycatcher	A	Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
Willow Flycatcher	A	Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Willow	Variable	-*	Knopf et al. (1988b)
Empidonax sp.	A	Nevada	Aspen/willow	Moderate	-	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
Tree Swallow	B	California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
		Nevada	Aspen/willow	Moderate	+	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
Barn Swallow	A	Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
House Wren	A	California/	Aspen	Not reported	+	Page et al. (1978)
		Nevada				
		Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
		Montana	Cottonwood/willow	Heavy vs light	+	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Cottonwood/willow	Moderate	+	Sedgwick and Knopf (1991)
		Nevada	Aspen/willow	Moderate	+	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
Marsh Wren	B	Oregon	Willow	Variable	+	Taylor (1986)
Ruby-crowned Kinglet	B	Colorado	Willow	Heavy	0	Schulz and Leininger (1991)
Mountain Bluebird	B	California/	Aspen	Not reported	+	Page et al. (1978)
		Nevada				
		Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
Veery	A					
Hermit Thrush	A	California/	Aspen	Not reported	-	Page et al. (1978)
		Nevada				
American Robin	B	California/	Aspen	Not reported	+	Page et al. (1978)
		Nevada				
		Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	0	Taylor (1986)
		Colorado	Cottonwood/willow	Moderate	+	Sedgwick and Knopf (1991)
		Colorado	Willow	Variable	0	Knopf et al. (1988b)
		Nevada	Aspen/willow	Moderate	-	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
Gray Catbird	A					
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)

Evaluation of Grazing Systems in Riparian Habitats

Rangeland grazing practices have been reviewed and evaluated for riparian ecosystems (Platts 1981, Knopf and Cannon 1982, Kaufman et al. 1983, Kaufman and Krueger 1984, Shochin 1984, Clay and Webster 1989, Platts 1991, Sedgwick and Knopf 1991, Kovalchik and Finore 1992). Riparian habitats are known to be detrimentally affected by most grazing practices tested to date. This is not surprising because traditional grazing systems were developed for upland grasses, not for riparian plant species (see Platts 1991 for review).

Grazing systems are evaluated by the intensity and seasonality of use by livestock. Riparian areas generally are grazed most in summer and least in winter (Knopf et al. 1988b, Goodman et al. 1989). The resulting summer concentration of use in riparian zones is particularly damaging due to severe trampling and mechanical damage, soil compaction, and plant consumption by livestock. Thus, year-long and growing-season (spring-summer) grazing are particularly damaging to riparian vegetation (Kaufman and Krueger 1984, Platts 1991), and the associated bird communities (Crouch 1982).

Short-term, early spring grazing may be preferable to summer grazing (Clay and Webster 1989). Early season grazing can result in better distribution of livestock because upland vegetation is succulent at this time and because livestock may avoid the wetter riparian soils (Clay and Webster 1989, Platts 1991). However, impacts of soil compaction may be most severe at this time. Early season grazing, followed by complete removal of livestock, allows regrowth of riparian vegetation before the dormant period in autumn.

As herbaceous cover is depleted or as palatability of alternate forage decreases, livestock will shift to browsing riparian shrubs before leaf drop (Kovalchik and Finore 1992). Therefore, most browsing damage to willows (*Salix* spp.) occurs in late summer and fall (Kaufman et al. 1983, Clay and Webster 1989, Sedgwick and

Knopf 1991, Kovalchik and Finore 1992). Alternatively, light-to-moderate autumn grazing appears to have the least impact on numbers of migratory birds during the breeding season (Kaufman et al. 1982, 1983, Sedgwick and Knopf 1987, Knopf et al. 1988b, Meelin and Clay 1991).

In late fall and winter, water levels typically are low, streambanks are dry, and vegetation is dormant, thus minimizing the effects of trampling, soil compaction, erosion, and browsing (Rauzi and Hanson 1966, Knopf and Cannon 1982, Kaufman and Krueger 1984). However, fall winter grazing should be carefully controlled to leave residual plant cover needed for streambank maintenance during subsequent high spring flows (Clay and Webster 1989).

Kaufman et al. (1982, 1983) evaluated the effects of late season grazing on ten common riparian communities in eastern Oregon by comparing plant and animal communities in enclosed and grazed areas (late August–mid-September, at 1.3, 1.7, 4.0, and 10.0 months). Avian populations in all plant communities appeared to have little differential response to grazing treatments with respect to species richness, density, or diversity. Meadows and Douglas hawthorn (*Crategeus douglasii*) communities were more heavily used by cattle than other riparian communities, shrub use was light except on willow-dominated areas, and use of plant communities with dense canopy cover (black cottonwood [*Populus trichocarpa*], Ponderosa pine [*Pinus ponderosa*], and thin-leaved alder [*Alnus incana*]) was light.

Sedgwick and Knopf (1987) evaluated the impact of fall (October–November) grazing on breeding densities of six Neotropical migrants (House Wren, Brown Thrasher, American Robin, Common Yellowthroat, Yellow-breasted Chat, and Rufous-sided Towhee) associated with the lower vegetative layer of a cottonwood (*P. sargentii*) riparian forest. Moderate, late-fall grazing had no apparent impact on densities of any of the species, implying that proper seasonal grazing of cottonwood bottomlands is compatible with migratory bird use of a site during the breeding season. Common Yellowthroats and Yellow-breasted Chats were the most individual in their habitat association

and most likely to respond negatively to higher levels of grazing.

Knopf et al. (1988b) compared plant and bird communities between healthy (historically winter-grazed) and decadent (historically summer-grazed) willow communities within a year. Population densities of habitat generalists (Yellow Warblers, Savannah Sparrows, and Song Sparrows) differed little between winter-grazed and summer-grazed willow communities. Densities of the species intermediate in habitat specialization (American Robins, Red-winged Blackbirds, and Brown-headed Cowbirds) differed more dramatically, while habitat specialists (Willow Ptarmigan, Lincoln's Sparrows, and White-crowned Sparrows) were absent or accidental incidental willows. Brown-headed Cowbirds showed the greatest tendency to increase in numbers in disturbed, summer-grazed riparian areas. Conversely, high local densities of habitat specialists (and possibly Red-winged Blackbirds) occurred in winter-grazed willow communities.

With prescribed, late-season grazing in a cottonwood floodplain in Colorado, herbaceous and shrub vegetation (excluding willows) appeared to be resilient to cattle grazing, at least during the initial 3 years after grazing began, following 31 years of nonuse (Sedgwick and Knopf 1991). The grazing program for this study was strictly controlled by season and intensity of use within the riparian zone. This is unlike most grazing programs, wherein the riparian zone is included as part of a larger allotment and the use of riparian vegetation often exceeds forage use on the uplands (Platts 1991).

Sedgwick and Knopf (1991) cautioned that even a 4 year study is a relatively brief time to study grazing impacts. Longer-term grazing effects may alter composition, structural diversity, and community succession patterns in riparian systems. For example, they were unable to assess grazing impacts on cottonwood seedling survival because seedlings were so few on their study area. Ginski (1977), however, found that cattle grazing reduced cottonwood seedling establishment along an Arizona stream, and predicted that the future width of the riparian zone would be significantly reduced. Longer term (more than 3 years) studies of dormant-

season grazing may well document alterations of herbaceous communities (Sedgwick and Knopf 1991).

Riparian Avifauna

Western riparian areas are key components of migratory bird habitats during all seasons of the year (Stevens et al. 1977, Henke and Stone 1979, Sauer 1980, Terborgh 1989). Riparian vegetation covers less than 1% of the landscape in the arid West, yet more species of breeding birds are found in this limited habitat than in the more extensive surrounding uplands (Knopf et al. 1988a). Migratory landbirds inhabiting western North America are thought to be particularly vulnerable to disturbance because their riparian habitats are fragmented and limited in distribution, thus probably restricting their total populations below those of their eastern counterparts (Terborgh 1989). Because the contribution of these productive areas to avian diversity is disproportionate to other western habitats, riparian woodlands are critical to overall conservation of the continental avifauna.

The highest densities of breeding birds for North America have been reported from southwestern riparian habitats (Carothers and Johnson 1975, Ohmart and Anderson 1986, Rice et al. 1983). More than two-thirds (127 of 166) of southwestern bird species nest in riparian woodlands, and Neotropical migrants comprise 60% of the 98 landbirds (Johnson et al. 1977). In arid portions of the West, several studies documented that most bird species nest in riparian habitats where Neotropical migrants comprise between 60% and 85% of the landbirds (Knopf 1985, Dobkin and Wilcox 1986, Saab and Groves 1992). Probably most migrant landbirds in the western United States are associated with riparian habitats during the breeding season (cf. Mosconi and Hutto 1982, Ohmart and Anderson 1986).

Avian Responses to Livestock Grazing in Riparian Habitats

We know of nine studies that provide some quantitative comparisons of species abundances in systems that were variously

Table 12.4 (cont.)

Species	Migrant Status ^a	Region	Riparian Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Brewer's Blackbird		Colorado	Cottonwood/Willow	Variable	-	Couch (1982)
Downy Woodpecker	II	Oregon	Herbaceous	Variable	0	Taylor (1986)
Cowbird		Idaho	Aspen	Heavy	+	Medin and Cary (1990)
		California/		Not	+	Page et al. (1978)
		Montana	Cottonwood/	reported	+	Mosconi and Hutto (1982)
		Oregon	pine	light	-	Taylor (1986)
		Colorado	Willow	Variable	-	Knopf et al. (1988b)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		California/	Aspen	Not	+	Page et al. (1978)
		Nevada	Cottonwood/	reported	-	Couch (1982)
		Colorado	willow	Variable	-	Mosconi and Hutto (1982)
		Montana	Cottonwood/	Heavy vs	-	
		Oregon	pine	light	-	Taylor (1986)
		Nevada	Willow	Variable	-	Mosconi and Hutto (1982)
		California/	Aspen	Not	-	Page et al. (1978)
		Montana	Cottonwood/	reported	+	Mosconi and Hutto (1982)
		Colorado	pine	light	-	Schulz and Leininger (1991)
		Montana	Cottonwood/	Heavy vs	+	Mosconi and Hutto (1982)
		Colorado	pine	light	-	Schulz and Leininger (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
		Colorado	Cottonwood/	Variable	-	Couch (1982)
		Montana	willow	Heavy vs	-	Mosconi and Hutto (1982)
		Colorado	Cottonwood/	light	-	Taylor (1986)
		California/	Willow	Variable	-	Page et al. (1978)
		Nevada	Aspen	Not	-	Mosconi and Hutto (1982)
		Montana	Cottonwood/	reported	+	Mosconi and Hutto (1982)
		Oregon	pine	light	-	Taylor (1986)
		Nevada	Willow	Variable	-	Mosconi and Hutto (1982)
		Colorado	Aspen/Willow	Moderate	0	Medin and Cary (1991)
		Colorado	Willow	Moderate	0	Schulz and Leininger (1991)
		Colorado	Willow	Heavy	-	Schulz and Leininger (1991)

^aState = A = variable long distance migrant; those species that breed in North America and spend their nonbreeding period primarily south of the United States. State = B = contains short distance migrants; those species that breed and winter extensively in North America although some populations winter south of the United States.

^bGrazing intensity as reported by original authors in the references listed.

^cGrazing effects on abundance: + = increase; 0 = no effect, as reported by original authors. Species whose abundance differed significantly between treatments, as reported by original authors, are indicated by an asterisk.

grazed by cattle (Table 12.4). These studies were conducted in six states and most were in cottonwood and willow riparian communities. The studies described the impacts of grazing by comparing avian populations on adjacent grazed and ungrazed sites (Page et al. 1978, Couch 1982, Sedgewick and Knopf 1987, Medin and Chary 1990, 1991, Schulz and Leininger 1991), on adjacent sites that were subject to different levels of grazing (Mosconi and

Hutto 1982, Taylor 1986), and on adjacent sites historically grazed during different seasons of the year (Knopf et al. 1988b). Season and intensity of grazing were not always well defined, and the results of four of the studies (i.e., Page et al. 1978, Mosconi and Hutto 1982, Medin and Chary 1990, 1991) are compromised by the complete absence of treatment replications to evaluate the effects of grazing. Despite shortcomings, we generally found consistent

patterns and biologically interpretable responses by many members of the riparian avifauna. These studies reported abundance data on 68 species of Neotropical migrant landbirds (Table 12.4). In a qualitative assessment of all studies combined, nearly half (46%) of these species decreased in abundance with cattle grazing, 29% increased with grazing, and 25% showed no clear response.

Forty-three of the 68 species were evaluated by two or more studies, and used in statistical analyses (see Methods section). Among these, a few species showed significant differences ($P < 0.05$) in abundance between grazed and ungrazed treatments (Table 12.5). Species with significant or near-significant reductions in grazed treatments included Red-winged blackbirds, Common Yellowthroats, and Willow Flycatchers. These species were about 1.5 times more abundant in ungrazed treatments (Table 12.5), indicating that these species are sensitive to changes resulting from livestock grazing. They also experience high rates of nest parasitism (Hulsund 1957, Sedgewick and Knopf 1988, Weatherhead 1989). All three species nest within the shrub layer and, in forested habitats, songbirds that nest in shrubs generally experience the highest rates of nest predation (Martin 1993). Cattle may further increase nest losses by exposing concealed nests to predators by reducing foliage densities or opening dense patches of vegetation to allow predator access (Knopf 1995).

At least seven more species were probably also harmed by grazing in riparian ecosystems. Three of these were evaluated in only one of the nine studies, but showed strongly negative responses: Very, Nashville Warbler, and Fox Sparrow; all are ground or near-ground nesters. Other species showed uncertain or inconsistent responses to grazing, but likely would be negatively affected by grazing, based on knowledge of their habitat requirements. Consensus among these are the Yellow Warbler (see Taylor and Littlefield 1980, American Redstart, Gray Catbird, and Yellow-breasted Chat. Of these species with limited data but expected to decrease

with grazing, only the Very is experiencing population declines in the West and significant continental declines (Robbins et al. 1993, Pechón et al., chapter 1, this volume). Cattle grazing could be one factor contributing to their population declines. American Robins, Killdeer, and Pine Siskins, all habitat generalists, showed the strongest trend of increasing in abundance with grazing. American Robins and Killdeer appear well adapted to human-modified landscapes in the West, e.g., both commonly nest in residential areas and prefer relatively open habitats (DeGraaf et al. 1991, Dobkin 1993). Although Pine Siskins generally prefer coniferous habitats, some are found nesting in western riparian woodlands adjacent to pine forests (Mosconi and Hutto 1982, Schulz and Leininger 1991). This species nests in tree canopies, generally unaffected by livestock grazing in the short term.

Grouping species by nest type, we found that cavity-nesting species appeared least affected by cattle grazing (standardized mean $1.02 \pm 0.97 \pm 0.35$ (grazed vs ungrazed), $T = 0.021$, $P = 0.98$). Although not significant, abundance of open-nesting birds was more reduced by grazing practices [standardized mean $0.89 \pm 1.11 \pm 0.17$ (grazed vs ungrazed), $T = -1.55$, $P = 0.12$]. These results support those of individual studies evaluating short-term grazing effects, in concluding that woodpeckers and other cavity-nesting species are relatively unaffected (Good and Dambach 1943, Mosconi and Hutto 1982) and sometimes increase in grazed pastures (Butler 1979, Medin and Chary 1991). Cavity-nesting birds place their nests in snags and dead limbs, and frequently forage in tree locations (bark) that are generally not used by cattle. Open-nesting species generally experience lower rates of nest success than cavity-nesting species (Martin and Li 1992), and cattle could further increase nest losses through physical damage to the herbaceous and shrub layers where open-nesting species often nest and forage.

Evaluating species by nest location, we found that ground-nesting species were most susceptible to disturbances created by livestock grazing (Table 12.6). Dark-eyed Junco, and White-crowned, Savannah,

Table 12-4 (cont.)

Species	Migrant Status ^a	Region	Riparian Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Cedar Waxwing	B	Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	0	Taylor (1986)
Solitary Vireo	A	Montana	Cottonwood/pine	Heavy vs light	+*	Mosconi and Hutto (1982)
Red-eyed Vireo	A	Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
Warbling Vireo	A	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
		Nevada	Aspen/willow	Moderate	-	Medin and Clary (1991)
		Colorado	Willow	Heavy	+	Schulz and Leininger (1991)
Orange-crowned Warbler	A	Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
Nashville Warbler	A	Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
Yellow-rumped Warbler	B	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
		Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
Yellow Warbler	A	California/Nevada	Aspen	Not reported	+	Page et al. (1978)
		Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Willow	Variable	0	Knopf et al. (1988b)
		Nevada	Aspen/willow	Moderate	0	Medin and Clary (1991)
MacGillivray's Warbler	A	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
		Nevada	Aspen/willow	Moderate	-	Medin and Clary (1991)
		Colorado	Cottonwood/willow	Heavy	+	Schulz and Leininger (1991)
Wilson's Warbler	A	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
		Colorado	Willow	Heavy	-*	Schulz and Leininger (1991)
Northern Waterthrush	A	Montana	Cottonwood/pine	Heavy vs light	-	Mosconi and Hutto (1982)
Common Yellowthroat	A	Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Cottonwood/willow	Moderate	-	Sedgwick and Knopf (1987)
Yellow-breasted Chat	A	Oregon	Willow	Variable	0	Taylor (1986)
		Colorado	Cottonwood/willow	Moderate	-	Sedgwick and Knopf (1987)
American Redstart	A	Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
		Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)

Table 12-4 (cont.)

Species	Migrant Status ^a	Region	Riparian Type	Grazing Intensity ^b	Response to Grazing ^c	Reference
Black-headed Grosbeak	A	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Montana	Cottonwood/pine	Heavy vs light	+	Mosconi and Hutto (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
Lazuli Bunting	A	Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
Green-tailed Towhee	A	California/Nevada	Aspen	Not reported	+	Page et al. (1978)
Rufous-sided Towhee	B	California/Nevada	Aspen	Not reported	+	Page et al. (1978)
		Colorado	Cottonwood/willow	Variable	0	Crouch (1982)
		Colorado	Cottonwood/willow	Moderate	-	Sedgwick and Knopf (1987)
Yesper Sparrow	B	Idaho	Herbaceous	Heavy	-	Medin and Clary (1990)
Savannah Sparrow	B	Idaho	Herbaceous	Heavy	-	Medin and Clary (1990)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Willow	Variable	0	Knopf et al. (1988b)
		Idaho	Herbaceous	Heavy	-	Medin and Clary (1990)
Song Sparrow	B	Montana	Cottonwood/pine	Heavy vs light	-*	Mosconi and Hutto (1982)
		Colorado	Willow	Variable	+	Knopf et al. (1988b)
		Nevada	Aspen/willow	Moderate	+	Medin and Clary (1991)
Chipping Sparrow	B	Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
Dark-eyed Junco	B	Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
		California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
		Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
White-crowned Sparrow	B	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Colorado	Willow	Variable	-*	Knopf et al. (1988b)
		Nevada	Aspen/willow	Moderate	+	Medin and Clary (1991)
		Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
Fox Sparrow	B	California/Nevada	Aspen	Not reported	-	Page et al. (1978)
		Colorado	Willow	Variable	-*	Knopf et al. (1988b)
		Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
Lincoln's Sparrow	A	Colorado	Willow	Variable	-*	Knopf et al. (1988b)
Bobolink	A	Colorado	Willow	Heavy	-	Schulz and Leininger (1991)
Western Meadowlark	B	Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Cottonwood/willow	Variable	+	Crouch (1982)
Yellow-headed Blackbird	A	Idaho	Herbaceous	Heavy	-	Medin and Clary (1990)
		Oregon	Willow	Variable	+	Taylor (1986)
Red-winged Blackbird	B	Colorado	Cottonwood/willow	Variable	-	Crouch (1982)
		Oregon	Willow	Variable	-	Taylor (1986)
		Colorado	Willow	Variable	-	Knopf et al. (1988b)
		Idaho	Herbaceous	Heavy	-	Medin and Clary (1990)
Brewer's Blackbird	B	California/Nevada	Aspen	Not reported	+	Page et al. (1978)

Table 12-7. Standardized relative abundances of seven foraging guilds representing 68 species of Neotropical migrants in grazed and ungrazed habitats. Sample size is the number of occurrences in which a guild was represented in each treatment. Original data were taken from nine studies conducted in western riparian habitats (see Table 12-1). Guilds whose abundances differ significantly (paired *t*-test, $P < 0.05$) between treatments are indicated by an asterisk.

Foraging Guild	Sample Size	Standardized Mean		SE	P Value
		Grazed	Ungrazed*		
Aerial insectivore	24	1.04	0.96	0.43	0.83
Bark insectivore	4	0.89	1.11	1.30	0.88
Carnivore	4	0.58	1.42	0.71	0.21
Foliage insectivore	49	0.91	1.09	0.31	0.44
Ground insectivore	24	1.21	0.79	0.30	0.03*
Nectarivore	5	0.41	1.59	0.66	0.06
Omnivore	64	0.82	1.18	0.25	0.07

*Includes lightly grazed and fall grazed treatments.

Ground insectivores were better represented in grazed areas. Over half the species in this guild are represented by birds (e.g., American Robin, Killdeer) that are well known for their adoption of human-altered habitats. Ground and aerial insectivores were the most commonly found guilds in grazed riparian habitats at various elevations in the Southwest (Szaró and Rinne 1988).

As a group, long-distance migrants (Status A in Table 12-4) appeared more susceptible (Standardized Means 0.86 vs. 1.13 [grazed vs. ungrazed], $T = -1.64$, $P = 0.10$) to disturbances by livestock grazing than short-distance migrants [status B in Table 12-4; standardized means 0.98 vs. 1.01 ± 0.20 (grazed vs. ungrazed), $T = 0.10$, $P = 0.92$]. One explanation for this result could be that many short-distance migrants are cavity nesters, whose nesting sites appear not affected by grazing in the short term. Long-distance migrants also might be more energy stressed upon arrival at the breeding grounds, and thus more vulnerable to human-related disturbances.

MONTANE CONIFEROUS FOREST HABITATS

Characteristics of Forested Habitats

Montane coniferous forests of western North America vary in species composition over broad geographic areas in response to the complex interactions produced by climate, elevation, latitude, soils, and the temporal and spatial pattern of disturbance factors

such as fire. A highly simplified characterization for the general pattern of coniferous forest distributions would place juniper and xeric-adapted pine (*Pinus*) woodlands at lower elevations, ponderosa pine (*P. ponderosa*) savannas at moderate elevations providing slightly less xeric conditions, and Douglas-fir (*Pseudotsuga menziesii*) forests and mixed-conifer associations at higher elevations that typically provide more mesic conditions. Throughout the West, lodgepole pine (*Pinus contorta* or *P. murrayana*) forests occur over a wide range of elevations, typically occupying areas following disturbance.

Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) are dominant tree species at high-elevation forests throughout the Rocky Mountains (Peet 1988). Mixed cedar-hemlock pine (*Thuja-Tsuga-Pinus*) forests and grand-fir (*Abies grandis*) Douglas-fir forests also are common at lower elevations in the northern Rockies and interior Northwest.

Jeffrey pine (*Pinus jeffreyi*) dominates mid-montane and lower montane forests in the eastern Sierra. Conifer associations of white fir (*Abies concolor*) incense-cedar (*Libocedrus decurrens*), sugar pine (*P. lambertiana*), ponderosa pine, and Douglas fir comprise the forests along the western slopes of the Sierra (Verner 1980).

Historical Perspective of Coniferous Forests

Many forests of western North America were maintained historically by frequent, low-intensity fires carried by fine herbaceous

fuels (Cooper 1960, Vale 1977, Barbour 1988, Peet 1988). This pattern in western landscapes has been disrupted by recent changes in land-use management (Franklin 1988).

Domestic livestock, in conjunction with active fire suppression, produced a widespread transformation of woodlands into denser forests as a result of increased seedling establishment by woody species, and decreased cover of perennial grasses and other herbaceous plants (e.g., Johnsen 1962, Vale 1977, Vankat and Major 1978, West 1988). In at least some areas, livestock grazing apparently was the primary cause of this transformation, with fire suppression of secondary importance (Rummell 1951, Madany and West 1983). One result accompanying this metamorphosis from savannah to forest is the impressive accumulations of fuels in these forests that now produce fires that are often catastrophic and frequently result in widespread tree mortality (Peet 1988).

At low elevations, there has been a strong positive correlation between heavy cattle grazing and extensive expansion of juniper woodlands (Johnsen 1962, West 1988). Intense grazing by domestic cattle reduces cover and vigor of dominant grasses, and facilitates the establishment of juniper while simultaneously reducing the frequency of ground fires that otherwise would eliminate woody vegetation. When excessive grazing virtually removes the grasses, fires can no longer be carried (and those that occurred were actively suppressed) with a resulting dramatic increase in shrub and tree densities (West 1984). The net effect has been an increase in tree density to create woodlands where open savannah previously occurred and an expansion of these denser woodlands into grasslands and shrubsteppe that were degraded by livestock at both higher and lower elevations.

Intense sheep grazing has altered conditions of subalpine and montane meadows (Dunwiddie 1977, Vankat and Major 1978). Lodgepole pine has successfully invaded montane meadows after the removal of sheep grazing (Vankat and Major 1978). Heavy sheep use led to increased runoff, increased erosion, and stream entrenchment, resulting

in lowered water tables and drier meadows that facilitated conifer seedling establishment (Dunwiddie 1977, Vankat and Major 1978).

Among the varied altitudinally distributed forest communities dominated by conifers (those found at low and moderate elevations—e.g., juniper-pinyon woodlands and ponderosa pine forests) may have been influenced more by livestock grazing by virtue of their longer, snow-free periods each year. However, this conclusion ignores the extraordinary numbers of sheep that once grazed in the forests and on the rangelands of the western United States. Sheep numbers rose spectacularly between 1865 and 1901, reached a peak in 1910, and have declined steadily since that time (Thilenius 1975). Grazing was year-round with flocks moving upslope as they followed the receding snow line in spring. Although the higher altitude ecosystems were usable for grazing only during the summer or late summer snow-free period, they were subject to extreme grazing pressure for the entire brief growing season or until the forage was depleted, whichever occurred first. The intense levels of livestock grazing that typified the late 1800s resulted in greatly increased tree densities that are still visible today in lodgepole pine and subalpine forests.

Evaluation of Grazing Systems in Coniferous Forests

Little information is available about grazing systems in coniferous forests. Within forested landscapes, the impacts of livestock tend to be concentrated in drainage bottoms, wet meadows, and grassy slopes (Willard 1989), although forested areas are frequently used for bedding and shelter (e.g., Warren and Myerud 1991). The effects of grazing on these areas varies depending upon climate, elevation, and floristic composition, although generally the result is decreased species diversity and density of herbaceous and shrubby vegetation. Intense grazing pressure sometimes leads to enhanced establishment of conifer seedlings and (in conjunction with fire suppression) consequent conversion of montane shrub, meadow, and grassland areas to forested habitats.

Table 12-5. Standardized relative abundance for 68 species of migratory landbirds. Original data were taken from nine studies conducted in western riparian habitats. Sample size is the number of studies from which the data were derived. Standard errors (SE) and *P* values were calculated by a paired *t*-test, and species whose abundances differed significantly (*P* < 0.05) are indicated by an asterisk.

Species	Forage Guild ^a	Nest Layer ^b	Nest Type ^c	Sample Size	Standardized Mean		SE	<i>P</i> Value
					Grazed	Ungrazed ^d		
Killdeer	GI	GR	O	4	1.53	0.47	0.62	0.12
Long-billed Curlew	GI	GR	O	1	1.29	0.71	—	—
American Kestrel	CA	CA	C	3	0.41	1.59	0.79	0.18
Mourning Dove	GI	SH	O	4	1.09	0.91	1.00	0.71
Yellow-billed Cuckoo	FI	SH	O	1	1.17	0.83	—	—
Common Nighthawk	AI	GR	O	1	1.41	0.59	—	—
Callipe Hummingbird	NE	CA	O	2	0.14	1.86	0.78	0.20
Broad-tailed Hummingbird	NE	CA	O	2	0.89	1.12	0.44	0.68
Rufous Hummingbird	NE	CA	O	1	0.00	2.00	—	—
Belted Kingfisher	CA	CA	C	1	1.09	0.91	—	—
Northern Flicker	OM	CA	C	5	0.88	1.12	0.68	0.53
Lewis' Woodpecker	AI	CA	C	2	1.30	0.70	0.42	0.38
Red-naped Sapsucker	BI	CA	C	4	0.90	1.10	1.30	0.87
Western Kingbird	AI	CA	O	1	2.00	0.00	—	—
Eastern Kingbird	AI	CA	O	3	0.80	1.20	0.62	0.60
Western Wood-pewee	AI	CA	O	2	0.59	1.41	1.75	0.57
Say's Phoebe	AI	CA	O	1	2.00	0.00	—	—
Least Flycatcher	AI	SH	O	1	2.00	0.00	—	—
Willow Flycatcher	AI	SH	O	3	0.33	1.67	0.72	0.13
<i>Empidonax</i> sp.	AI	CA	O	3	0.87	1.13	0.39	0.56
Tree Swallow	AI	CA	C	3	1.07	0.93	1.82	0.95
Barn Swallow	AI	CA	O	1	0.07	1.93	—	—
House Wren	FI	CA	C	7	1.16	0.84	0.71	0.65
Marsh Wren	FI	SH	O	1	2.00	0.00	—	—
Ruby-crowned Kinglet	FI	CA	O	1	1.00	1.00	—	—
Mountain Bluebird	AI	CA	C	3	1.47	0.53	0.91	0.28
Veery	GI	GR	O	1	0.79	1.21	—	—
Hermit Thrush	GI	SH	O	1	0.00	2.00	—	—
American Robin	GI	CA	O	8	1.31	0.69	0.41	0.09
Gray Catbird	FI	SH	O	2	0.86	1.14	0.28	0.61
Cedar Waxwing	FI	CA	O	2	0.74	1.26	0.55	0.50
Solitary Vireo	FI	CA	O	1	2.00	0.00	—	—
Red-eyed Vireo	FI	CA	O	1	1.05	0.95	—	—
Warbling Vireo	FI	CA	O	4	1.15	0.85	0.93	0.58
Orange-crowned Warbler	FI	GR	O	1	0.00	2.00	—	—
Nashville Warbler	FI	GR	O	1	0.00	2.00	—	—
Yellow-rumped Warbler	FI	CA	O	4	0.68	1.32	1.48	0.58
Yellow Warbler	FI	SH	O	5	1.09	0.91	0.73	0.62
MacGillivray's Warbler	FI	SH	O	4	0.50	1.50	1.57	0.39
Wilson's Warbler	FI	GR	O	2	0.43	1.57	1.24	0.27
Northern Waterthrush	GI	GR	O	1	0.43	1.57	—	—
Common Yellowthroat	FI	SH	O	4	0.45	1.55	0.61	0.10
Yellow-breasted Chat	FI	SH	O	2	1.26	0.74	2.07	0.69
American Redstart	FI	CA	O	2	1.39	0.60	1.78	0.59
Black-headed Grosbeak	OM	CA	O	3	1.07	0.93	1.51	0.93
Lazuli Bunting	OM	SH	O	1	0.00	2.00	—	—
Green-tailed Towhee	GI	SH	O	1	2.00	0.00	—	—
Rufous-sided Towhee	OM	GR	O	3	0.98	1.02	1.81	0.98
Vesper Sparrow	OM	GR	O	1	0.95	1.05	—	—
Savannah Sparrow	OM	GR	O	3	0.71	1.29	0.30	0.18
Song Sparrow	GI	SH	O	3	0.92	1.08	0.63	0.79
Chipping Sparrow	OM	SH	O	2	0.85	1.15	0.19	0.35
Dark-eyed Junco	OM	GR	O	3	0.71	1.29	0.19	0.09
White-crowned Sparrow	OM	GR	O	4	0.36	1.64	0.80	0.10
Fox Sparrow	OM	GR	O	1	0.00	2.00	—	—
Lincoln's Sparrow	OM	GR	O	2	0.23	1.77	1.01	0.28
Bobolink	FI	GR	O	1	0.00	2.00	—	—

336

Table 12-5 (cont.)

Species	Forage Guild ^a	Nest Layer ^b	Nest Type ^c	Sample Size	Standardized Mean		SE	<i>P</i> Value
					Grazed	Ungrazed ^d		
Western Meadowlark	GI	GR	O	2	1.01	0.99	0.01	0.20
Yellow-headed Blackbird	OM	SH	O	1	1.18	0.82	—	—
Red-winged Blackbird	OM	SH	O	4	0.46	1.54	0.35	0.4*
Brewer's Blackbird	OM	SH	O	4	1.31	0.70	1.06	0.43
Brown-headed Cowbird	GI	P	P	5	1.39	0.61	0.81	0.20
Northern Oriole	OM	CA	O	5	0.83	1.17	1.01	0.74
Hooded Oriole	OM	CA	O	1	2.00	0.00	—	—
Western Tanager	FI	CA	O	2	1.34	0.66	1.91	0.63
Pine Siskin	OM	CA	O	2	1.96	0.04	0.40	0.09
American Goldfinch	OM	SH	O	3	0.61	1.39	0.30	0.11
Cassin's Finch	OM	CA	O	5	0.75	1.25	1.17	0.57

^aForaging guild abbreviations: AI = aerial insectivore, BI = bark insectivore, FI = foliage insectivore, GI = ground insectivore, CA = carnivore, NE = nectivore, OM = omnivore.

^bNest layer abbreviations: SH = shrub nesting species, GR = ground-nesting species, CA = subcanopy/canopy-nesting species.

^cNest-type abbreviations: O = open, C = cavity, P = parasite.

^dIncludes lightly grazed and fall-grazed treatments.

and Lincoln's Sparrows were ground-nesting species that experienced the greatest reductions in grazed areas. These ground nesters are also dependent on the grass-forb shrub layer for foraging, making them particularly vulnerable to grazing disturbances (Sedgwick and Knopf 1987).

Canopy-nesting birds were least affected in the short term (Table 12-6). These data support other studies indicating that birds are impacted most by habitat perturbations in the vegetative zone in which they occur (Short and Burnham 1982, Verner 1984). Knopf (1995) noted that in the vertical plain, livestock grazing has little direct impact on birds nesting and foraging in forest canopies. However, cattle trampling and browsing of young trees can limit the number of trees that reach maturity, thus reducing future canopy layers.

Grazing had a differential effect on avian foraging guilds (Table 12-7). Aerial and bark insectivores were probably not greatly affected. Aerial insectivores do not rely upon vegetation for feeding substrates and bark insectivores exploit a substrate generally not used by cattle. In contrast, species dependent upon food resources produced directly (nectarivores) or indirectly (omnivores) by understory plants were less represented in grazed compared to ungrazed treatments. Similar responses to grazing by these guilds were observed on tropical wintering grounds of migratory landbirds (Saab and Petit 1992). Local reductions in nectarivores and omnivores could have widespread ramifications, because these species are important pollinators and seed dispersers, respectively (Feinsinger 1983, Herrera 1984).

Table 12-6. Standardized relative abundances for ground-, shrub-, and canopy-nesting birds in grazed and ungrazed habitats. Sample size is the number of occurrences in which a nest layer was represented in each treatment. Original data were taken from nine studies conducted in western riparian habitats (see Table 12-1). Cavity-nesting species were placed in the canopy layer and Brown-headed Cowbirds were excluded from the analysis. Groups of species in each nest layer whose abundances differ significantly (paired *t*-test, *P* < 0.05) between treatments are indicated by an asterisk.

Nest Layer	Sample Size	Standardized Mean		SE	<i>P</i> Value
		Grazed	Ungrazed ^a		
Ground	33	0.71	1.29	0.32	0.01*
Shrub	48	0.86	1.14	0.29	0.33
Subcanopy/canopy	86	1.02	0.98	0.27	0.78

^aIncludes lightly grazed and fall-grazed treatments.

migrants significantly. Despite limitations to our current knowledge, we offer the following general management recommendations.

Grasslands

First, substantially increase the amount of public rangeland from which all livestock are permanently excluded (Bock et al. 1993). Of particular importance on the Great Plains are the US National Grasslands, which include more than 1.5 million ha presently managed by the US Forest Service largely for livestock production (Lewis 1989, West 1990). Many public rangelands presently are managed by applying some sort of rotational grazing strategy. However, the frequency of rotation is far too high to permit postgrazing ecological succession to proceed to the point where habitat is created for those Neotropical migrant birds (or any other species) generally intolerant of the impacts of grazing mammals. Furthermore, rotational livestock management fails to create heavily grazed habitats that may be required by some species. Therefore, we recommend establishing a system that creates a mosaic of heavily grazed habitats mixed with large (at least 1000 ha), permanent livestock exclosures, which would include a significant portion (perhaps 20%) of public lands presently dedicated to livestock production (Bock et al. 1993).

We are aware of the difficulties involved in designating public land as biological preserves and we recognize the competing interests involved. However, it is also important to recognize the declining agricultural value of many of these lands and their likely increase in value to the public as natural landscape (Popper and Popper 1991). We call only for an effort to restore to these lands something resembling their prehistoric condition. The obvious first step should be to free a portion of these lands from the controlling influence of domestic grazers.

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 grazing lands planted to native vegetation. CRP lands remain vulnerable to recultivation and

this decision rightly is in the hands of the landowners. However, it would be ecologically unfortunate if CRP lands were tilled (setting ecological succession back to zero), only to be returned to grassland when crop prices or future government incentives once again make it economically attractive. From the standpoint of indigenous flora and fauna, it would be much better to find ways of making the CRP grasslands valuable to landowners, perhaps by encouraging moderate amounts of livestock grazing. This strategy would be doubly valuable if it could somehow be coupled with creation of permanent livestock exclosures on the public rangelands, including especially the National Grasslands on the Great Plains.

Third, fire should be reintroduced to many grasslands from which it has recently been excluded, and where it is a natural ecological process.

Fourth, caution should be taken in implementing short-duration grazing as a grassland management tool. Short-duration grazing is advocated as a means of increasing livestock production, while improving rangeland condition (Savory 1988). Most field tests of this grazing system have failed to support either claim (e.g., Weltz and Wood 1986, Heitschmidt et al. 1986, Taylor et al. 1993). Furthermore, we found no studies evaluating the impacts of such high-intensity grazing on ground-nesting birds.

Shrubsteppe

First, exclude or significantly reduce livestock grazing. Although we have not documented likely responses of bird populations to this management change, avian communities are expected to respond positively in a landscape that resembles historical conditions. Where livestock are grazed, the short-term goal should be to maintain adequate herbaceous cover to conceal nests through the first incubation period. This could be accomplished by maintaining current season growth through 15 July, and allowing more than 50% (see Pond 1960) of the annual vegetative growth of perennial bunchgrasses to persist through the following nesting season.

Second, restore perennial bunchgrasses,

forbs, shrubs and plant-species diversity to historical levels. Seedlings of native species, prescribed burns, and fall winter grazing must be more carefully controlled to ensure the maintenance of residual plant cover.

Third, avoid fencing and water developments in circumstances where protection is needed for maintenance of plant communities and for population sources of species of special concern. This could result in the concentration of livestock in some areas while creating de facto protected areas in other locations.

Fourth, eliminate the conversion of shrubsteppe habitats to seedlings of exotic grasses for the purpose of livestock grazing. Attempts should be made to restore burned areas of shrubsteppe to native vegetation rather than exotic seedlings for livestock.

Fifth, determine methods for recovering soil cryptogam layers to increase soil moisture, increase seedling germination, reduce soil erosion, and enhance soil productivity.

Sixth, initiate long-term research that will help us understand the following problems: the direct effects of grazing on shrubsteppe avifauna, the indirect effects on the avifauna mediated through changes in vegetation, the influence of livestock on the distribution of Brown-headed Cowbirds, and the effects of cowbird parasitism on the productivity of breeding birds.

Riparian

First, the condition of riparian areas must be considered critically when implementing grazing systems. Given their scarcity, fragility, and importance to neotropical migrants and other wildlife, western riparian ecosystems should be excluded from livestock grazing wherever possible. Managers should evaluate how local activities alter potential dispersal opportunities for riparian species (Knopf and Samson 1994). Season of use, livestock numbers and livestock distributions must be strictly controlled within riparian zones to implement grazing programs that are compatible with riparian avifauna.

Where livestock must have access to riparian zones for water, restricted-access fencing can localize and minimize their impacts on streambanks and riparian vegeta-

tion. Development of alternate water sources also could help reduce concentration of livestock in riparian zones. When the cost of fencing is prohibitive, uplands and riparian zones must be managed together and grazing strategies should be keyed to the condition of the 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. Nevertheless, 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. Four years after cattle removal from riparian habitat in Arizona, understory vegetation and Neotropical migrants showed dramatic increases in abundance (Krueper 1993). In systems requiring long-term rest, the necessary period will be highly variable depending upon the extent of damage and growth rate of regenerating plant species (Clary and Webster 1989). Damaged riparian areas should be rehabilitated by revegetating with native species.

Coniferous Forest

Land managers and field biologists have an unparalleled opportunity to provide information where none currently exists concerning the impacts of grazing on Neotropical migrants in western coniferous forests. Monitoring of migratory landbirds both during the breeding season and in migration, with attention to matched forested habitats differing in grazing regimes or grazing histories could supply much-needed data. Explicit quantitative assessment of grazing pressure and grazing histories, in conjunction with the collection of appropriate vegetation data will be critically important for assessing the relationships between grazing and Neotropical migrants. For breeding season studies, emphasis should be placed on species that nest and/or forage on or near the ground. Migration-period studies should be focused more broadly on the entire suite of species that utilize coniferous forest habitats as staging areas and for foraging activities.

DISCUSSION

vegetative type, and timing and duration of grazing.

Because of differential responses by Neotropical migrants to grazing, management programs for single species would be difficult to develop and generally cost prohibitive (Knopf 1995). Management of single species would become necessary only when they become outside the breeding season, no quantitative data are available on reproductive or survival success in relation to grazing (Chapter 8, this volume).

An alternative to single species management would be to manage for "ecological guilds." Whereas patterns of bird responses emerged using this approach, at least in riptarian habitats, it would be difficult to apply in all situations and would have to be implemented on a habitat specific basis. For example, in grasslands, several species showed a graded response depending on the grassland vegetative type and grazing intensity. Some species (e.g., Lizard Sandpiper, Grasshopper Sparrow, and Bobolink) tended to be negatively affected in shorter grasslands (at least with heavy grazing), and responded positively to grazing in taller grasslands (at least with moderate grazing). Thus, we still need a management approach that considers individual species, but one implemented with habitat monitoring on a landscape level (Egli et al., Chapter 8, this volume). A combination of species and vegetative community monitoring will help in determining whether population declines are caused by local perturbations. If monitoring indicates no decline, that would indicate that local habitat conditions are not responsible for those declines.

Studies of grazing effects on small land-birds have reported exclusively bird abundance data, primarily during the breeding season, and evaluated only localized, short-term consequences of grazing. Land management legal mandates require long-term, landscape-level considerations that allow only land-use patterns that maintain natural populations, patterns, and processes. Grazing practices may not cause a great short-term change in some bird populations but we do not know the long-term consequences or whether there are widespread ramifications over the landscape. Data on long-term

few studies have been conducted that inadequately address effects of different grazing systems on Neotropical migratory birds. In only a few cases were we able to discuss the effects of seasonality and intensity of grazing in different vegetative types. Few data exist from outside the breeding season, no quantitative data are available on reproductive or survival success in relation to grazing treatment, and no studies have evaluated the effects of grazing on birds using coniferous forests. In addition, historical conditions of many western ecosystems were altered before studies on effects of land-use activities. Therefore, current habitat conditions rarely reflect true controls from which to evaluate grazing effects on migrant birds and other organisms.

Grazing studies often were difficult to interpret. Some studies included detailed quantitative descriptions of birds and vegetation, but many did not. One worker's concept of moderate grazing at one site might be another's idea of heavy grazing at a different site (Wiens 1973). Thus, there is an urgent need to quantify descriptions of livestock use, bird use, and vegetation. Nevertheless, introductions of domestic grazers can depress populations of other species while favoring populations of some species. Grazing appeared particularly detrimental to those species dependent on dense ground cover for nesting and/or foraging, and in riptarian habitat, species apparently vulnerable to cowbird parasitism. Species occurring in the lower vegetation level that consistently declined with grazing across habitats included Northern Harrier, Short-eared Owl, Common Yellowthroat, and Savannah Sparrow.

Species showing little response in the short term were those that generally forage on open ground and in the air, those nesting and foraging in forest canopies (riptarian habitats), and in shrub and riptarian habitats. Species directly attracted to livestock (brown-headed Cowbird). Species that consistently increased with grazing across habitats included Killdeer and Mountain Bluebird. Other species that occurred across habitats showed mixed responses depending on the

In recent decades, a decrease in sheep numbers and an increase in cattle numbers in the western United States has led to decreased livestock use of many previously used coniferous forest areas at higher elevations. Although their numbers are now much reduced compared to the turn of the century, sheep are still the principal livestock using subalpine ecosystems. Cattle are confined generally to elevations below the subalpine zone, while horses (both recreational and legal) can be significant in wilderness areas (Willard 1989).

Avian Responses to Livestock Grazing in Coniferous Forests

We found no studies that specifically evaluated the influence of livestock grazing on Neotropical migrants using coniferous forests in the western United States. Thus, we can only speculate that the birds most likely to have been negatively affected by livestock grazing were: (1) those species dependent on herbaceous and shrubby ground cover for nesting and/or foraging; and (2) species requiring open savannahs as opposed to closed-canopy forests. Likely examples from the first group include the Hermit Thrush, Nashville Warbler, Fox and Lincoln's Sparrows; examples from the second group include the Lewis Woodpecker, Violet-green Swallow, and Mountain Bluebird.

A reduction in suitable nesting and foraging habitats for ground-nesting species may be the most likely form of livestock-induced negative impact experienced by migratory landbirds within western coniferous forests. A second, only slightly less direct, impact of livestock grazing is the decreased availability of nesting and roosting cavities in standing snags as a result of the reduction in fire frequency due to diminished fire fuels. The reduction in fire-caused standing snags and in positive habitat generally must have translated into reduced temporal and spatial availability of potential nest sites for primary and secondary cavity nesters, especially for species such as Mountain Bluebird, which appear to be positive habitat specialists in parts of their range (Hutto, unpublished MS).

reproductive success, in a variety of vegetative cover types, over a broad scale would be a better index of the health of bird populations than abundance data in the short term (e.g., Van Horn 1983).

Species habitat requirements may be different from those predicted by information gathered from a limited area and time of the year, where only part of a species' life-history requirements are met (Mosconi and Hutto 1982). The ideal study would include large replicated areas totally protected from grazing for long periods. We need to assess the influence of livestock grazing in areas that are used for migration and overwintering, not merely for breeding habitats. This is particularly important in riptarian habitats because they are critical for bird migration corridors (Stevens et al. 1977, Szaro 1980, Knopf et al. 1988a).

Clearly most plant and animal communities in the western United States, excluding some grasslands, have not evolved with widespread grazing repeated annually in the same locations. Thus, heavy grazing is likely to harm many species over the long term. Objectives for public lands must consider many other resources. Recently, the needs of wildlife, recreation, water quality, exemplary natural communities and biodiversity have been incorporated into management plans. For any given management unit, the objectives are apt to be specific to that geographic area, being both more complex and more detailed than was the case historically.

Given the ubiquity of livestock in much of the American West, plants and animals important of activities by livestock grazing have relatively few places left to inhabit. This is undoubtedly true for birds and their habitats, which evolved in the absence of large herbivorous mammals. Protection and restoration of ungrazed habitats resembling their prehistoric counterparts must be fundamental to any conservation plan for Neotropical migrants and all other plant and animal species in western North America.

MANAGEMENT RECOMMENDATIONS

Livestock management decisions about western habitats will affect many Neotropical

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