# VEGETATION, BREEDING BIRD, AND SMALL MAMMAL BIOMASS IN TWO HIGH-ELEVATION SAGEBRUSH RIPARIAN HABITATS

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## ABSTRACT

*Two riparian areas, one in Nevada (Deer Creek) and one in Idaho (Summit Creek), were compared on the basis of vegetation, breeding bird, and small mammal characteristics. The two study areas had, except for geomorphology, many similar environmental characteristics, yet the biological communities differed widely in many attributes. Plant physiognomy was strikingly different, and total plant biomass differed by 25-fold. There was no overlap of riparian breeding bird species between areas. Various breeding bird and small mammal population measures differed between the two areas in their response to grazing. Overall, the natural variation between the two areas far exceeded the variation introduced by the grazing of cattle.*

## INTRODUCTION

Concentrations of factors such as water, nutrients, sediments, and organic matter in riparian areas permit development of biotic communities that are more diverse and productive than those of the surrounding uplands (Hubbard 1977; Jahn 1978; Thomas and others 1979). These productive ecosystems exhibit an almost unending variety of differences associated with geomorphology, stream type, elevation, and climate as well as variability in response to management stress.

Livestock grazing in riparian ecosystems has been a recent management concern in the Western United States (Swanson 1988). Cattle prefer riparian areas for the quality and variety of forage, for easy accessibility, for shade, and for a generally reliable source of water (Gillen and others 1985; Martin 1979; Skovlin 1984). Several studies have reported adverse effects of cattle grazing on riparian vegetation, and recovery of vegetation when grazing is modified, reduced, or eliminated (Knopf and Cannon 1982; Platts and Raleigh 1984; Rickard and Cushing 1982; Skovlin 1984; Taylor 1986). These vegetation changes may in turn be reflected in small wildlife population changes (Kauffman and others 1982; Taylor 1986).

The objectives of this study were to (1) investigate similarities and dissimilarities of riparian areas otherwise alike in a number of environmental conditions, and (2) examine their response to grazing stress. We compared vegetation, breeding bird, and small mammal characteristics on two riparian areas, one in Nevada (Deer Creek) and one in Idaho (Summit Creek). Sampling was conducted on sites grazed by cattle and on comparable adjacent sites protected from grazing.

## STUDY AREAS

The two study areas were similar in elevation (1,890 to 1,980 m), precipitation (~250 mm), ecological zone (sagebrush), and in an early or midsummer to late-summer grazing pattern. The most apparent environmental difference between the two sites was geomorphology.

### Deer Creek

The Deer Creek (DC) site is located 55 km north of Wells, in northeastern Nevada. The small stream originates from springs and flows in a narrow, V-shaped canyon cut into mid-Tertiary rhyolitic rock. Soils are generally fine-textured, ranging from shallow on steep residual slopes to very deep on relatively level alluvial fans and floodplains (Platts and others 1988). The riparian areas seldom exceed 25 to 50 m in width.

The stream was closely bordered by clumped stands of aspen (*Populus tremuloides*), willow (*Salix* spp.), and other deciduous shrubs. The herbaceous component was dominated by Kentucky bluegrass (*Poa pratensis*), bluebunch wheatgrass (*Agropyron spicatum*), and sedges (*Carex* spp.). The gallerylike riparian area appeared as an island surrounded by an upland plant community dominated by big sagebrush (*Artemisia tridentata*). With the exception of the big sagebrush/upland type, community types within the Deer Creek study area were considered as components of a riparian complex (Winward and Padgett 1989) typified by aspen, willow, and Kentucky bluegrass.

Narrow floodplains with dead and downed aspen are common in the study area. These remnants of aspen communities were once flooded by beaver impoundments that drowned the trees.

The study was conducted within a large (40+ ha) cattle exclosure, fenced 11 years previously (trespass grazing

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did occur on several occasions), and on an adjacent area selected on the basis of topographical and vegetational type similarities with the exclosed area. The construction of the exclosure across the narrow Deer Creek canyon served as a drift-fence reducing the cattle use of the grazed portion of the study area (upstream side of the exclosure), compared to previous years.

## Summit Creek

The Summit Creek (SC) study area is 41 km north of Mackay in Custer County, ID. Summit Creek originates from springs and flows through a gently sloping, basinlike valley bounded on the east by the Lemhi Range and on the west by the Lost River Range. The mountain ranges are rugged and serrated, and chiefly composed of limestone, dolomite, quartzite, shale, and schist (Kirkham 1927). Microrelief in many parts of the riparian area is hummocky, with soils high in total salts (USDA SCS 1987). The riparian zone seldom exceeds 50 to 100 m in width.

For this study, we consolidated plant communities into three general community types: sagebrush (*Artemisia* spp.)/upland, mat muhly (*Muhlenbergia richardsonis*)/hummock, and mesic herbaceous. The sagebrush/upland type occupies the gentle slopes and terraces adjoining the riparian zone. The dominant shrubs are low sagebrush (*Artemisia arbuscula*) and threetip sagebrush (*A. tripartita*), with occasional individuals of green rabbitbrush (*Chrysothamnus viscidiflorus*), gray horsebrush (*Tetradymia canescens*), and big sagebrush. The mat muhly/hummock and mesic herbaceous types were considered components of the riparian complex. The hummocky areas are dominated by herbaceous species, most notably mat muhly and thick-spiked wheat grass (*Agropyron dasystachyum*). The stream is closely bordered by mesic herbaceous communities of Kentucky bluegrass, beaked sedge (*Carex rostrata*), and Baltic rush (*Juncus balticus*).

The study of Summit Creek was conducted within a 122-ha exclosure, constructed 14 years earlier, and on a comparable adjacent riparian area grazed by cattle. Occasional trespass grazing has occurred in the fenced area.

# METHODS

Two 600- by 150-m sites (9-ha), one in the exclosure and the other in the adjoining grazed area, were sampled for vegetation and other characteristics in August 1988 (DC) and 1989 (SC). For each of the grazed and ungrazed situations, the riparian complex contained 40 (SC) to 60 (DC) sample locations.

## Vegetation

A 50- by 50-cm (0.25-m$^2$) quadrat was located at each of the systematically positioned sample locations. Canopy cover (Daubenmire 1959) was ocularly estimated for the total of each plant lifeform (graminoid, forb, shrub) and recorded in percentage as the midpoint of one of eight cover classes (0-1, 1-5, 5-10, 10-25, 25-50, 50-75, 75-95, 95-100). Percentages of litter, rock, bare ground, and lichen-moss were similarly estimated. The vegetative height (excluding flower and seedhead height) of each graminoid, forb, and shrub nearest the center of each quadrat was recorded.

Biomass of graminoids, forbs, and small shrubs was determined by clipping vegetation from ground level upward within a vertical projection from the 0.25-m$^2$ quadrats. Clipped materials were bagged, ovendried, and weighed. A 3- by 3-m (9-m$^2$) plot, concentric to each 0.25-m$^2$ quadrat, was used to sample biomass of large shrubs. Basal diameter, maximum height, and species were recorded for each shrub stem rooted within the plot. For willow clumps, average stem diameter and average stem height were recorded instead of individual stems. Biomass of willows and other large shrubs was estimated by use of the equations of Brown (1976). Height and diameter at breast height (d.b.h.) were recorded for each tree stem rooted within 10- by 10-m (100-m$^2$) plots concentric to each 0.25-m$^2$ quadrat. Biomass of aspen was estimated by the Chicken Creek equations of Bartos and Johnson (1978).

## Breeding Birds

The sites were censused for breeding birds using the spot-map method (International Bird Census Committee 1970). The census grids were oriented lengthwise along the creek and straddled the stream channel on both the grazed and ungrazed sites. Grid points were surveyed and marked with numbered stakes at 25-m intervals.

One observer (DEM) made 11 (SC) and 13 (DC) census visits to each site from mid-May to mid-June 1988 (DC) and 1989 (SC). Most of the spot-mapping was done from sunrise to early afternoon when birds were most active. To ensure complete coverage, he censused a site by walking within 25 m of all points on the grid. Census routes were varied. Recorded bird observations extended a minimum of 50 m beyond grid boundaries.

At the end of the sampling period, clusters of observations and coded activity patterns on species maps were circled as indicating areas of activity or approximated territories. Fractional parts of boundary territories were included. Oelke (1981) summarized methodological difficulties and other special problems of the mapping method. We followed Hill (1973) for estimates of bird species diversity. Wide-ranging raptorial birds, although commonly seen, were not included in the analysis. Transient species were also excluded.

## Small Mammals

A 1.7-ha trapping grid was located in each of the grazed and ungrazed sites to estimate small mammal populations in midsummer 1988 (DC and SC) and 1989 (SC). Trapping grids were placed near the center of the 9-ha areas established to census bird populations. Each grid measured 225 by 75 m and consisted of 40 trapping stations systematically spaced at 25-m intervals in 10 rows and four columns.

The rectangular grids were positioned lengthwise along the stream and straddled the stream channel. Two

Museum Special mouse traps and one Victor rat trap were placed near each trapping station. Traps were baited with a mixture of peanut butter and rolled oats and examined daily for 5 consecutive days.

# RESULTS AND DISCUSSION

We look at four topics in our study results: herbaceous and shrub vegetation; aspen; breeding birds; and small mammals.

## Herbaceous and Shrub Vegetation

**Deer Creek**—There were not many structural differences in vegetation between the grazed and ungrazed areas at Deer Creek (tables 1 and 2). The most evident difference was in the herbaceous layer where graminoid biomass and graminoid and forb height values were reduced on the grazed site. Graminoid biomass, for example, on the grazed plot was only about half that inside the exclosure. The differences in grass biomass and heights seemed predominantly due to recent livestock grazing rather than to a basic difference in plant growth between the two areas. Forbs exhibited less difference in standing crop biomass and vegetative plant height than did the graminoids.

There were no significant differences in characteristics of small shrubs such as sagebrush between the grazed and fenced areas. There was, however, a large difference between the calculated means of the willow standing crop biomass, but the significance was masked by the extreme variation among samples. The biomass attributed to large shrubs other than willow (currant [*Ribes* spp.], rose [*Rosa* spp.], snowberry [*Symphoricarpos* spp.], and so forth) was significantly higher in the grazed situation. Although one cannot be sure whether this is a response to site or grazing differences, Elmore (1988) described currant replacing willow and alder (*Alnus* spp.) when water tables were lowered in response to grazing or other stresses on the stream channel. Presumably, the reverse may also be true, so that if water tables rise in response to reduced erosion stress and to narrowing of the stream channels, willows may replace currant or rose or other plants.

There was little difference in the number of species per plot between grazed and ungrazed situations; thus grazing has not measurably affected overall plant diversities. Nevertheless, the grazed herbaceous plant compositions appeared to contain more Kentucky bluegrass than plant compositions in the fenced area. Ground cover characteristics were similar between the two areas, except for slightly more bare soil where grazing had occurred.

**Summit Creek**—There were no woody species within the riparian complex of the study area (tables 1 and 2). The most evident structural difference in the vegetation was in height values. Graminoid and forb heights were significantly reduced on the grazed site as were graminoid and forb biomass and graminoid canopy cover. Graminoid biomass on the grazed plot was only about one-eighth that inside the exclosure.

There was more bare soil, rock, and lichen-moss cover on the grazed area (table 2). A small but significant increase in plant species occurred on the ungrazed area. A grazing-induced shift toward Kentucky bluegrass from sedges was apparent on the wet streamside areas.

**Table 1**—Herbage and shrub biomass

| | Biomass ($g/m^2$) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ungrazed | | | | | | Grazed | | | | | | | |
| Plant group | Live | | Dead | | Total | | Live | | Dead | | Total | | *P* (totals)[1] | |
| | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* |
| Grass | 131.3 | 245.9 | 65.1 | 136.8 | 196.4 | 382.7 | 74.5 | 46.7 | 23.7 | 0 | 98.2 | 46.7 | [2]<0.01 | <0.01 |
| Forb | 16.5 | 33.3 | .1 | — | 16.6 | 33.3 | 13.3 | 14.7 | 0 | 0 | 13.3 | 14.7 | .20 | <.01 |
| Total herbage | 147.8 | 279.2 | 65.2 | 136.8 | 213.0 | 416.0 | 87.7 | 61.4 | 23.7 | 0 | 111.5 | 61.4 | <.01 | <.01 |
| Small shrub | | | | | | | | | | | | | | |
| Foliage | 13.8 | — | — | — | 13.8 | — | 18.6 | — | — | — | 18.6 | — | .44 | — |
| Wood | 23.4 | — | 3.1 | — | 26.5 | — | 24.8 | — | 11.7 | — | 36.5 | — | .43 | — |
| Total | 37.2 | — | 3.1 | — | 40.3 | — | 43.4 | — | 11.7 | — | 55.1 | — | .42 | — |
| Large shrub | | | | | | | | | | | | | | |
| Willow | | | | | | | | | | | | | | |
| Foliage | 73.9 | — | — | — | 73.9 | — | 63.3 | — | — | — | 63.3 | — | .74 | — |
| Wood | 1,810.9 | — | 5.6 | — | 1,816.5 | — | 646.8 | — | 9.8 | — | 656.6 | — | .41 | — |
| Total | 1,884.8 | — | 5.6 | — | 1,890.4 | — | 710.1 | — | 9.8 | — | 719.9 | — | .41 | — |
| Nonwillow | | | | | | | | | | | | | | |
| Foliage | 6.2 | — | — | — | 6.2 | — | 128.1 | — | — | — | 128.1 | — | .01 | — |
| Wood | 8.3 | — | 13.8 | — | 22.1 | — | 440.3 | — | 10.0 | — | 450.3 | — | .06 | — |
| Total | 14.5 | — | 13.8 | — | 28.3 | — | 568.4 | — | 10.0 | — | 578.4 | — | .04 | — |

[1]*n* = 60 on Deer Creek, 40 on Summit Creek.
[2]Probability associated with unpaired *t*-tests. Probabilities less than 0.10 suggest a significant difference between grazed and ungrazed areas.

**Table 2**—Ground cover and miscellaneous characteristics

| Item | Ungrazed | | Grazed | | $P$[1] | |
|---|---|---|---|---|---|---|
| | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* |
| Cover (percent) | | | | | | |
| Bare | 5.6 | 6.6 | 9.6 | 15.2 | [2]0.08 | 0.03 |
| Litter | 29.5 | 5.8 | 25.2 | 5.7 | .20 | .94 |
| Rock | 2.1 | .1 | 4.0 | .6 | .22 | .04 |
| Lichen-moss | <.1 | .1 | .1 | 1.0 | .58 | .02 |
| Grass | 56.0 | 77.4 | 54.7 | 67.4 | .72 | .06 |
| Forb | 7.6 | 16.3 | 6.6 | 14.2 | .54 | .47 |
| Shrub | 4.2 | 0 | 5.2 | 0 | .59 | — |
| Plant height (m) | | | | | | |
| Grass | .37 | .22 | .25 | .05 | <.01 | <.01 |
| Forb | .16 | .08 | .12 | .03 | .06 | <.01 |
| Shrub | 1.35 | — | 1.46 | — | .61 | — |
| Species per 0.25 m² | | | | | | |
| Grass | 2.28 | 3.82 | 2.40 | 3.22 | .30 | .02 |
| Forb | 1.60 | 2.95 | 1.37 | 2.55 | .24 | .19 |
| Shrub | .33 | 0 | .43 | 0 | .36 | — |

[1]$n$ = 60 on Deer Creek, 40 on Summit Creek.
[2]Probability associated with unpaired $t$-tests. Probabilities less than 0.10 suggest a significant difference between grazed and ungrazed areas.

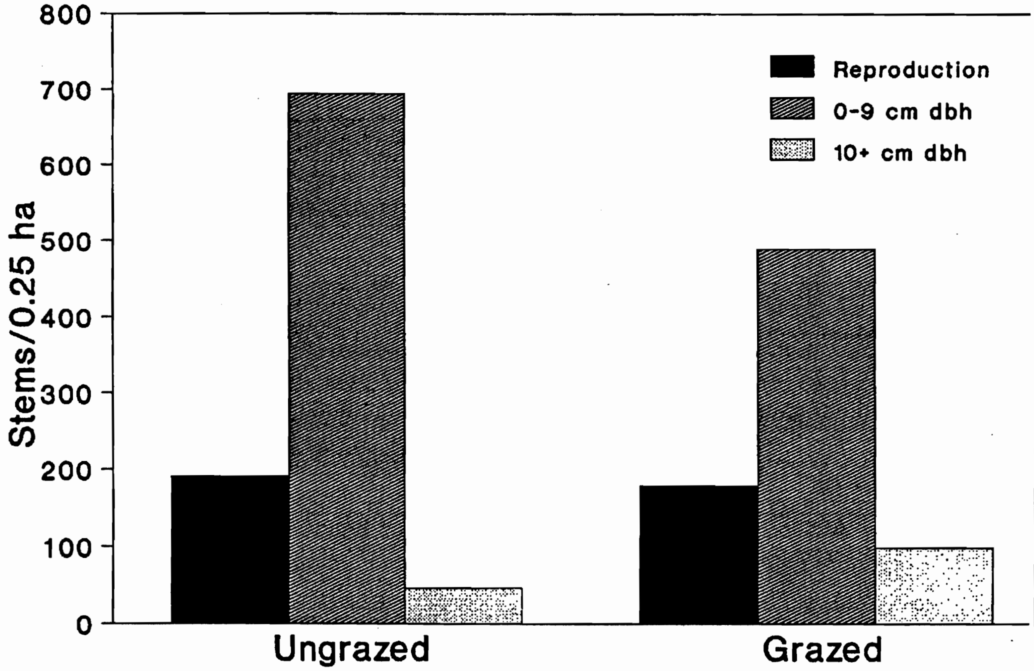


**Figure 1**—Size class distribution of aspen stems within Deer Creek aspen stands.

# Aspen

**Deer Creek**—Although a grazing management change of only 11 years at Deer Creek would not likely affect a stand of large, mature aspen trees, it apparently caused a change in the young age classes of aspen. A very heavily grazed area adjacent to the Deer Creek site plots had no sapling-sized trees. However, both the grazed site and the ungrazed site had substantial numbers of sapling-sized aspen (up to 9 cm d.b.h. and about 6.5 m tall), the largest of which were dated by tree-ring counts to the year of fence construction (fig. 1).

Removal of grazing normally results in an increase in aspen reproduction (DeByle 1985). However, the moderation of grazing on the grazed study site, due to the barrier effect of the exclosure fence in the narrow canyon, appears to have also resulted in an increase in aspen reproduction, although in somewhat reduced numbers compared to the exclosure. These saplings should provide a basis for continuation of the aspen stand after the current mature trees senesce. The total lack of the sapling size class in the nearby very heavily grazed area foretells the eventual loss of this aspen stand under current grazing practices.

**Summit Creek**—There were no trees on the Summit Creek study area.

## Birds

**Deer Creek**—We recorded 18 species of birds breeding in the Deer Creek riparian area; 16 species bred on the grazed site and 18 on the ungrazed site (table 3). No meaningful differences were apparent between grazed and ungrazed sites with respect to either the number of breeding bird species or total breeding bird densities. The total number of breeding pairs in the two riparian habitats was virtually identical. Estimates of bird standing crop biomass between the grazed and ungrazed sites were also nearly the same. There was almost complete overlap in the species breeding on the two sites. The most abundant species were the *Empidonax* flycatcher, American robin, house wren, yellow warbler, broad-tailed hummingbird, and white-crowned sparrow. (Scientific names of birds are given in table 3.) Species richness was slightly higher on the ungrazed site, but species diversity was slightly higher on the grazed site, suggesting little meaningful difference between the two sites.

**Summit Creek**—We recorded seven species of birds breeding in the Summit Creek riparian area; six species bred on the grazed site and three species bred on the ungrazed site (table 3). Savannah sparrows and western meadowlarks were found as breeding birds under both grazed and ungrazed conditions. Killdeer, willets, long-billed curlews, and Brewer's blackbirds were territorial only on the grazed area. Red-winged blackbirds nested only on the ungrazed area.

We found little difference between the grazed and ungrazed sites in total breeding bird density (table 3). But estimates of total bird biomass differed markedly. Biomass on the grazed site was almost twice that on the ungrazed site (table 3). The difference in total biomass was due to the presence of large shorebirds (killdeer, willet, long-billed curlew) that were breeders only on the grazed site. Species richness and our estimate of bird species diversity (the reciprocal of Simpson's index) were larger on the grazed site, again as a result of the presence of the three shorebirds that established breeding territories only on the grazed site.

Red-winged blackbirds were found as breeding birds only on the ungrazed plot (table 3). Conversely, Brewer's blackbirds were territorial only on the grazed site. Nests of the red-winged blackbird were bound to tall, coarse stalks of beaked sedge found in thick stands near the stream. Heights of beaked sedge communities at the grazed site were considerably reduced as a result of livestock grazing, thereby essentially eliminating potential nesting habitat for red-winged blackbirds. Nests of Brewer's blackbirds were on the ground in tussocks of grasses and forbs or beside clods of dry manure.

## Small Mammals

**Deer Creek**—Eleven species of small mammals were trapped (table 4). Of these, deer mice, western jumping mice, least chipmunks, and Great Basin pocket mice accounted for 82 percent of the total number of individual animals caught. (Scientific names of small mammals are in table 4.) Other species were trapped irregularly or in smaller numbers. Five species, including Townsend's ground squirrel, northern pocket gopher, bushy-tailed woodrat, montane vole, and long-tailed vole, were trapped only in the ungrazed habitat.

The total number of small mammals was a third higher in the ungrazed habitat than on the grazed site. Further, small mammal standing crop biomass, species richness, and species diversity values were also higher inside the exclosure. Each of the 11 species recorded during the study was trapped in the protected site. Only six species were trapped in the grazed habitat.

**Summit Creek**—Six species of small mammals were trapped during two seasons of study at Summit Creek (table 4). Deer mice and montane voles accounted for over 94 percent of the individual animals. Each species was trapped on both grazed and ungrazed study sites. Other species were caught irregularly and in smaller numbers. Four species—vagrant shrews, water shrews, northern pocket gophers, and Great Basin pocket mice—were trapped only in the ungrazed habitat.

Estimated small mammal density was approximately a third higher in the grazed habitat (table 4). Total biomass values were similar between the grazed and ungrazed sites. However, small mammal species richness and our estimates of small mammal species diversity were larger within the exclosure. Each of the six species recorded during the study was trapped in the ungrazed habitat. Only two species were trapped in the grazed habitat—deer mouse and montane vole.

## Deer Creek and Summit Creek Comparison

Differences between Deer Creek and Summit Creek were quite striking. The differential in total ungrazed plant biomass was approximately 25 times (fig. 2). This was due largely to the occurrence of aspen at Deer Creek, although substantial biomass of riparian shrubs occurred there as well (fig. 3). No woody plants were found in the Summit Creek riparian zone.

An unexpected result in the bird communities was that no overlap occurred in riparian nesting bird species. The riparian nesters were completely different between Deer Creek and Summit Creek. A strong component of shorebirds was found on the grazed Summit Creek site; this resulted in an increase in bird species and biomass for that site over the ungrazed site (figs. 4 and 5). A similar response did not occur at Deer Creek.

A large grazing-attributed reduction in the number of small mammal species occurred at both sites (fig. 6). The net effect of this reduction was quite different on the two study sites. On Deer Creek the loss of species on the grazed portion included those animals of greatest body

Table 3—Breeding bird population attributes

| Species | Foraging guild[1] | Nesting guild[2] | Density (pairs/40 ha) Ungrazed | | Grazed | |
|---|---|---|---|---|---|---|
| | | | *DC* | *SC* | *DC* | *SC* |
| American kestrel (*Falco sparverius*) | GFC | SCN | 2.7 | 0 | 0 | 0 |
| Broad-tailed hummingbird (*Selasphorus platycercus*) | FNI | BTN | 12.9 | 0 | 15.6 | 0 |
| Lewis' woodpecker (*Melanerpes lewis*) | ASI | PCN | 1.8 | 0 | 2.2 | 0 |
| Yellow-bellied sapsucker (*Sphyrapicus varius*) | TDO | PCN | 2.7 | 0 | 2.7 | 0 |
| Downy woodpecker (*Picoides pubescens*) | TDI | PCN | 3.6 | 0 | .9 | 0 |
| Northern flicker (*Colaptes auratus*) | GGI | PCN | 3.6 | 0 | 4.0 | 0 |
| Empidonax flycatcher[3] (*Empidonax* sp.) | ASI | BTN | 45.3 | 0 | 33.8 | 0 |
| Tree swallow (*Tachycineta bicolor*) | AFI | SCN | 1.8 | 0 | 2.7 | 0 |
| House wren (*Troglodytes aedon*) | FGI | SCN | 11.1 | 0 | 23.6 | 0 |
| American robin (*Turdus migratorius*) | GGI | BTN | 19.6 | 0 | 16.0 | 0 |
| European starling (*Sturnus vulgaris*) | GGO | SCN | .4 | 0 | 7.6 | 0 |
| Warbling vireo (*Vireo gilvus*) | FGI | BTN | 8.9 | 0 | 2.7 | 0 |
| Yellow warbler (*Dendroica petechia*) | FGI | BTN | 16.0 | 0 | 16.4 | 0 |
| MacGillivray's warbler (*Oporornis tolmiei*) | FGI | BTN | 4.4 | 0 | 0 | 0 |
| Song sparrow (*Melospiza melodia*) | GGO | GRN | 5.3 | 0 | 10.7 | 0 |
| White-crowned sparrow (*Zonotrichia leucophrys*) | GGO | BTN | 9.3 | 0 | 11.6 | 0 |
| Northern oriole (*Icterus galbula*) | FGI | DTN | 5.8 | 0 | 5.3 | 0 |
| Cassin's finch (*Carpodacus cassinii*) | GGG | CDN | 1.8 | 0 | 2.2 | 0 |
| Killdeer (*Charadrius vociferus*) | GGI | GRN | 0 | 0 | 0 | 4.4 |
| Willet (*Catoptrophorus semipalmatus*) | SPI | GRN | 0 | 0 | 0 | 3.1 |
| Long-billed curlew (*Numenius americanus*) | GFO | GRN | 0 | 0 | 0 | 1.8 |
| Savannah sparrow (*Passerculus sandwichensis*) | GFO | GRN | 0 | 39.1 | 0 | 24.9 |
| Red-winged blackbird (*Agelaius phoeniceus*) | GFO | CRN | 0 | 12.0 | 0 | 0 |
| Western meadowlark (*Sturnella neglecta*) | GGI | GRN | 0 | 8.0 | 0 | 6.2 |
| Brewer's blackbird (*Euphagus cyanocephalus*) | GFO | GBN | 0 | 0 | 0 | 17.3 |
| Total pairs per 40 ha | | | 157.0 | 59.1 | 158.0 | 57.7 |
| Total individuals per km² | | | 785 | 296 | 790 | 288 |
| Biomass[4] (g/ha) | | | 218 | 110 | 225 | 217 |
| Species richness (*n*) | | | 18 | 3 | 16 | 6 |
| Species diversity (1/pi²) | | | 7.52 | 2.01 | 8.76 | 3.37 |

[1]After Diem and Zeveloff (1980). GFC = ground feeding carnivore, GGG = ground gleaning granivore, AFI = aerial feeding insectivore, FNI = foliage nectivore-insectivore, TDO = timber drilling omnivore, TDI = timber drilling insectivore, GGI = ground gleaning insectivore, ASI = aerial sally feeding insectivore, GGO = ground gleaning omnivore, FGI = foliage gleaning insectivore.

[2]After Diem and Zeveloff (1980). CRN = cliff, cave, rock, or talus nester, CDN = conifer-deciduous tree nester, SCN = secondary cavity nester, GRN = ground nester, BTN = bush and small tree nester, PCN = primary cavity nester, DTN = deciduous tree nester.

[3]Specific identification of the *Empidonax* flycatcher was not confirmed; most appeared to be the dusky flycatcher (*Empidonax oberholseri*).

[4]Species weights from Dunning (1984).

**Table 4**—Small mammal population attributes

| Species | Foraging guild[1] | Relative abundance (n/100 trap nights) Ungrazed | | Grazed | | Naive density[2] (n/ha) Ungrazed | | Grazed | |
|---|---|---|---|---|---|---|---|---|---|
| | | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* | *DC* | *SC* |
| Vagrant shrew (*Sorex vagrans*) | INS | 0.3 | 0.1 | 0.8 | 0 | 1.7 | 0.3 | 4.4 | 0 |
| Water shrew (*Sorex palustris*) | INS | .0 | .2 | 0 | 0 | 0 | .9 | 0 | 0 |
| Least chipmunk (*Tamias minimus*) | OMN | .8 | 0 | .2 | 0 | 4.4 | 0 | 1.0 | 0 |
| Townsend's ground squirrel (*Spermophilus townsendii*) | OMN | .2 | 0 | 0 | 0 | 1.0 | 0 | 0 | 0 |
| Golden-mantled ground squirrel (*Spermophilus lateralis*) | OMN | 1.2 | 0 | .2 | 0 | 6.2 | 0 | 1.0 | 0 |
| Northern pocket gopher (*Thomomys talpoides*) | HER | .2 | .1 | 0 | 0 | 1.0 | .3 | 0 | 0 |
| Great Basin pocket mouse (*Perognathus parvus*) | GRA | .2 | .1 | .7 | 0 | 1.0 | .3 | 3.5 | 0 |
| Deer mouse (*Peromyscus maniculatus*) | OMN | 5.0 | 2.0 | 4.2 | 5.0 | 26.7 | 7.1 | 22.2 | 17.8 |
| Bushy-tailed woodrat (*Neotoma cinerea*) | HER | .2 | 0 | 0 | 0 | 1.0 | 0 | 0 | 0 |
| Montane vole (*Microtus montanus*) | HER | .2 | 1.6 | 0 | .4 | 1.0 | 5.9 | 0 | 1.5 |
| Long-tailed vole (*Microtus longicaudus*) | HER | .3 | 0 | 0 | 0 | 1.7 | 0 | 0 | 0 |
| Western jumping mouse (*Zapus princeps*) | OMN | 2.8 | 0 | 2.3 | 0 | 15.1 | 0 | 12.4 | 0 |
| Total naive density (n/ha) | | | | | | 60.8 | 14.8 | 44.5 | 19.3 |
| Total standing crop biomass (g/ha) | | | | | | 2,769 | 294 | 855 | 318 |
| Species richness (n) | | | | | | 11 | 6 | 6 | 2 |
| Species diversity ($1/pi^2$)[3] | | | | | | 3.62 | 2.40 | 2.89 | 1.16 |

[1]After Martin and others (1951). INS = insectivore, GRA = granivore, HER = herbivore, OMN = omnivore.
[2]After Johnson and others (1987). Effective trapping area and grid size are assumed to be identical.
[3]After Hill (1973).
[4]Average of 2 years data 1988 and 1989.

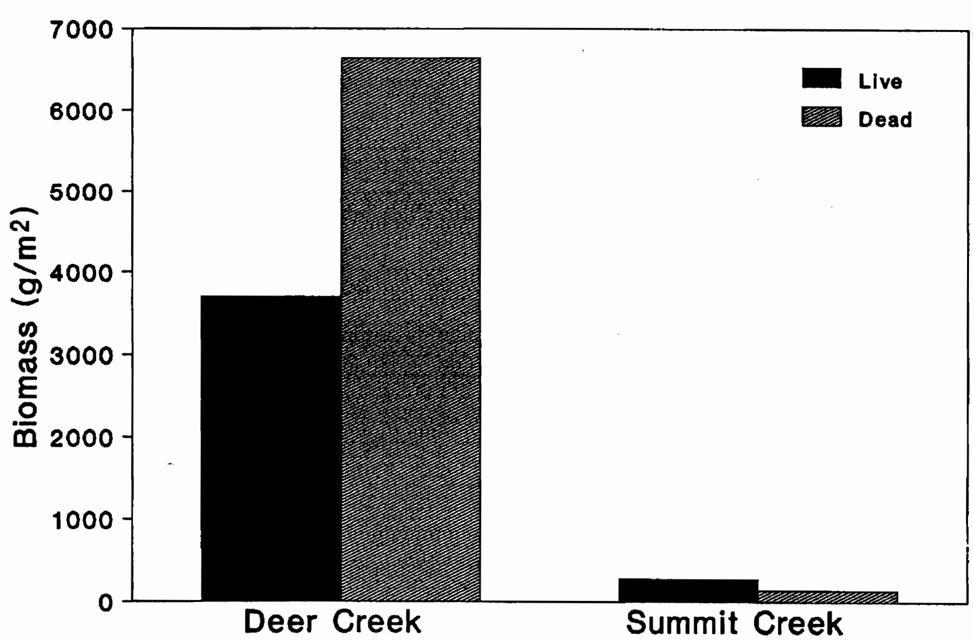


**Figure 2**—Total ungrazed herb-shrub-tree biomass.

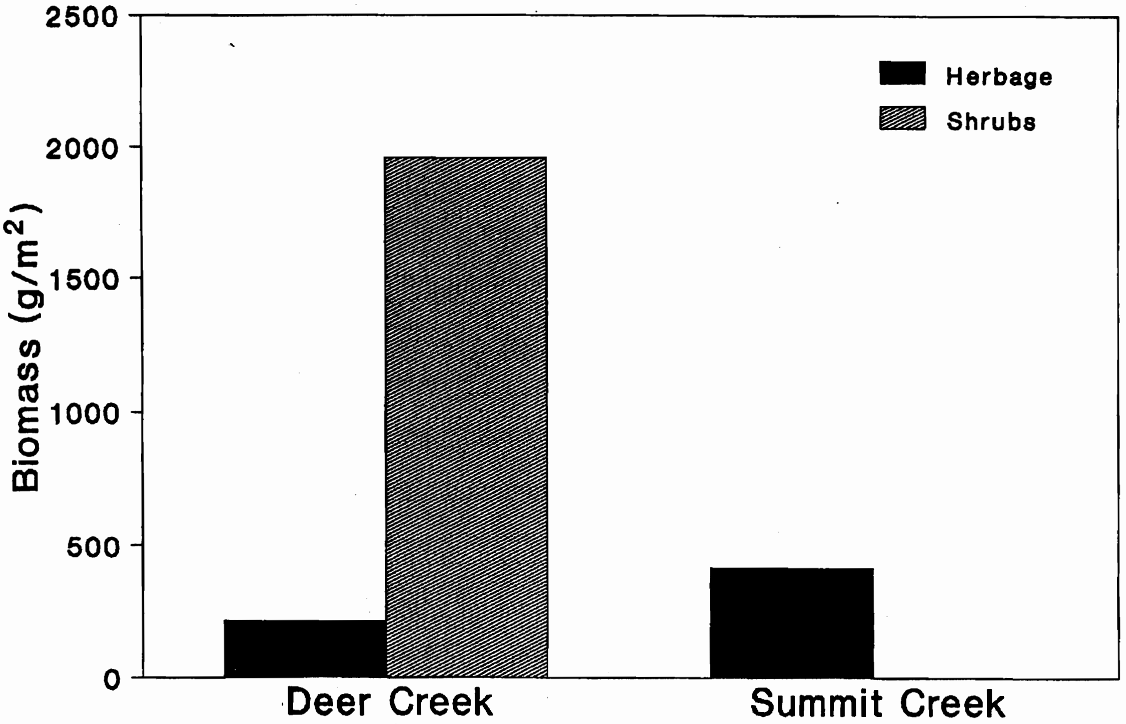


**Figure 3**—Ungrazed herb-shrub biomass.

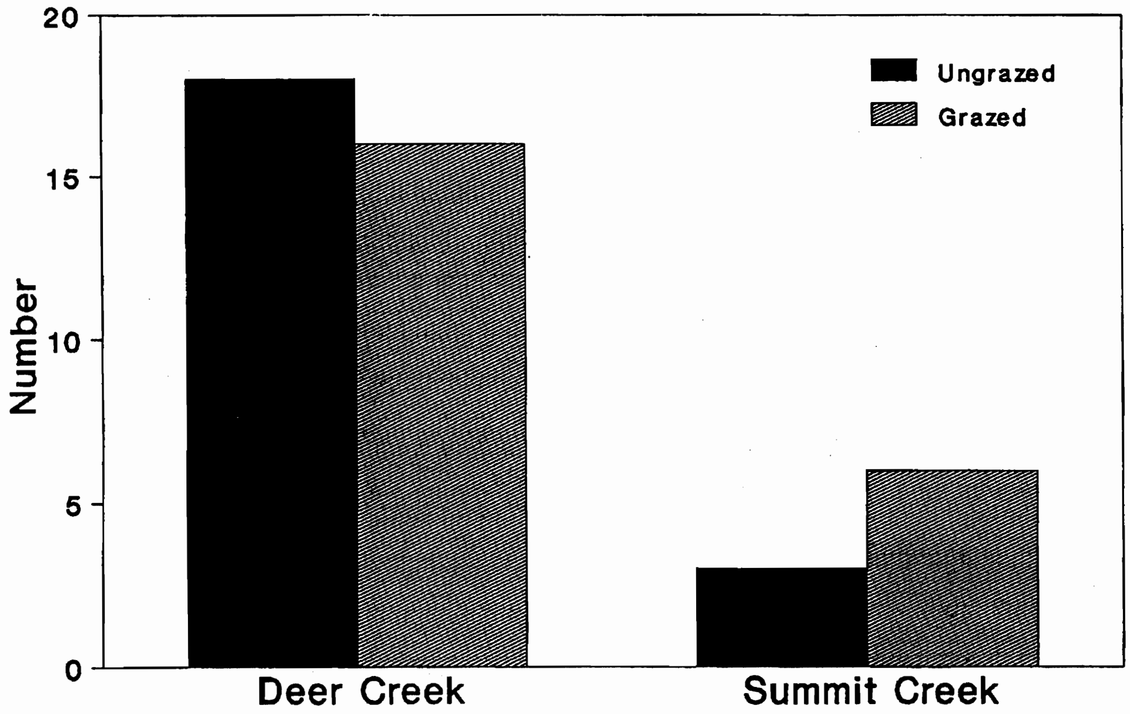


**Figure 4**—Song bird species.

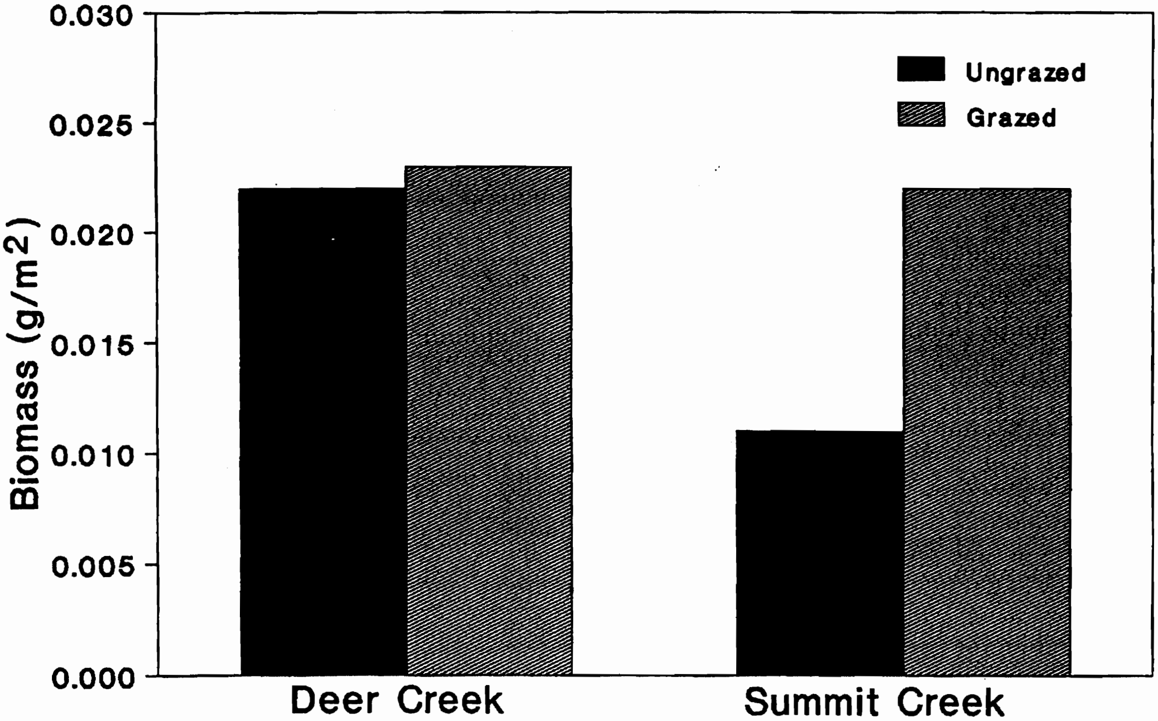


**Figure 5**—Song bird biomass.

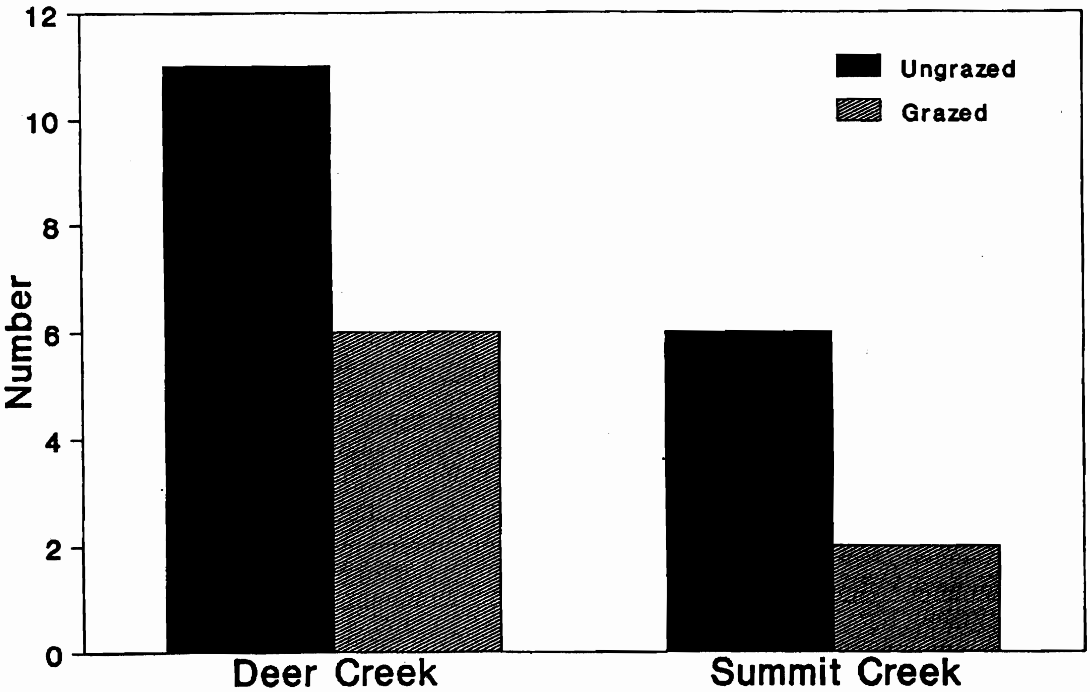


**Figure 6**—Small mammal species.

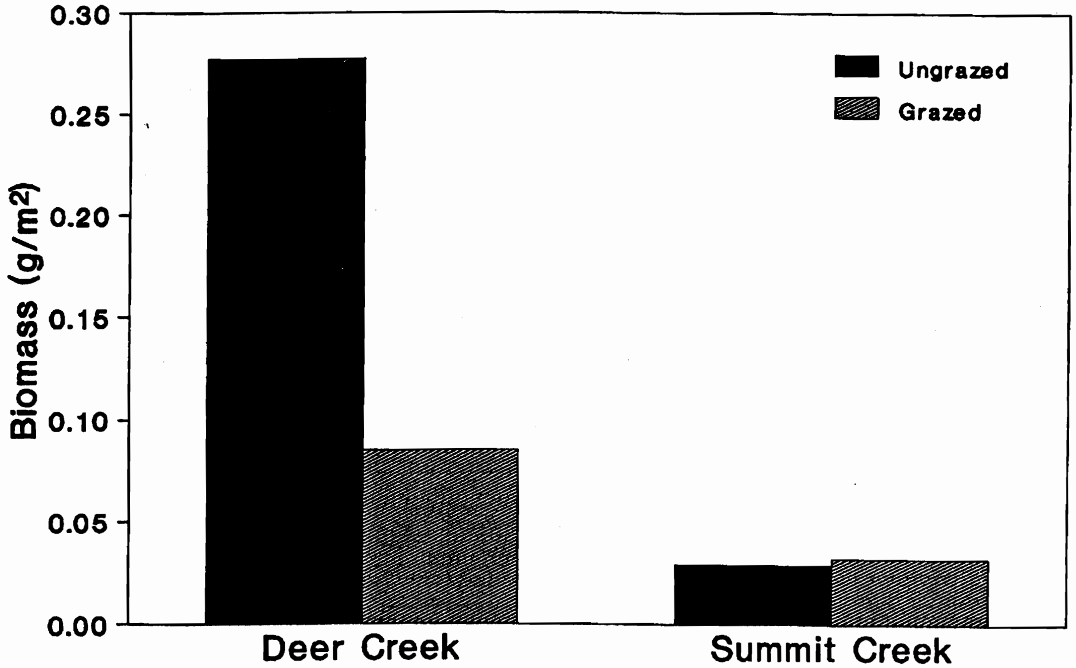


**Figure 7**—Small mammal biomass.

weight, therefore an even larger relative reduction in biomass occurred compared to the ungrazed portion (fig. 7). However, on Summit Creek a shift in populations toward higher total densities in the grazed portions resulted in a similar small mammal biomass for grazed and ungrazed situations on Summit Creek.

## CONCLUSIONS

Vegetation characteristics and grazing responses and small mammal and bird populations could not be predicted for either site based on data from the other, even though many environmental conditions were similar. The areas were alike in elevation, general ecological zone, precipitation, and livestock grazing management. The only major environmental difference between the Deer Creek and Summit Creek sites appeared to be geomorphology. The substantial biological differences between the two areas, therefore, seem to be primarily due to the geomorphic conditions, and far exceeded the variation introduced by the impact of livestock grazing.

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