Effects of Livestock Grazing on Grassland Birds in Capitol Reef National Park, Utah

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National Park Service
U.S. Department of the Interior

Colorado Plateau Research Station
at Northern Arizona University

Northern Arizona University

National Biological Survey
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ABSTRACT

Passerine birds and vegetation identified within grassland study areas in Capitol Reef National Park and an adjacent Bureau of Land Management (BLM) Resource Area in south-central Utah were investigated from 1989-91 to assess impacts by cattle grazing. No previous work had addressed impacts of cattle grazing on grassland birds within this portion of the Colorado Plateau geographic province. During 1989-90 bird species were observed using grassland communities that appeared to be sensitive to cattle grazing. Within two study areas, one grazed by cattle during winter and the second un-grazed year round, differences in aboveground vegetation structure were identified that correlated with bird community characteristics. Grazed treatment sites were significantly ($p \leq 0.05$) lower in bird species richness, bird species relative abundance, and bird density than ungrazed control sites. The most dramatic habitat changes observed between grazed and ungrazed areas included less complex vertical structure, simpler horizontal patterning, and lower overall plant cover at grazed versus ungrazed sites ($p \leq 0.05$).

The relationship between bird species richness and vertical vegetation structure documented during 1989-90 was tested using a mensurative field experiment in 1991. Bird and vegetation transects were established along a habitat gradient from low to high vertical vegetation complexity. A linear relationship was identified correlating vertical vegetation complexity and bird species richness along 1 km line transects.

CHAPTER I: INTRODUCTION

Capitol Reef National Park is located in the Canyonlands Section of the Colorado Plateau Physiographic Region (Baars 1983, Hintze 1986, Thornbury 1965). The Colorado Plateau encompasses approximately 52,000,000 ha and extends throughout southern Utah, northern Arizona, northwestern New Mexico, and southwestern Colorado (Fig. 1). Uplifted 60-80 million years ago during the Laramide Orogeny, the Canyonlands Section consists of spectacular sandstone canyons and terraced plateaus interupted by laccolithic intrusions, rolling grasslands and river valleys (Barnes 1978, Hintze 1986).

Capitol Reef National Park (CARE) was established in 1971 to protect unique features of the Waterpocket Fold, a 160 km north-south tending monocline typical of the complex geomorphology of the Colorado Plateau (Billingsley et al. 1987, Smith et al. 1963). The park's flora displayed a rich diversity influenced by a unique biogeographic location at the intersection of several floristic provinces (Heil et al. 1993). Cattle grazing has been present in CARE since the late 1800s, particularly in the large grasslands located along the eastern park boundary (Pickford 1966). Heil et al. (1993) suggested that cattle grazing has had profound effects on grassland communities in CARE, altering species composition. The purpose of this study was to describe the effects of livestock grazing on grassland birds and their associated vegetation in Capitol Reef National Park.

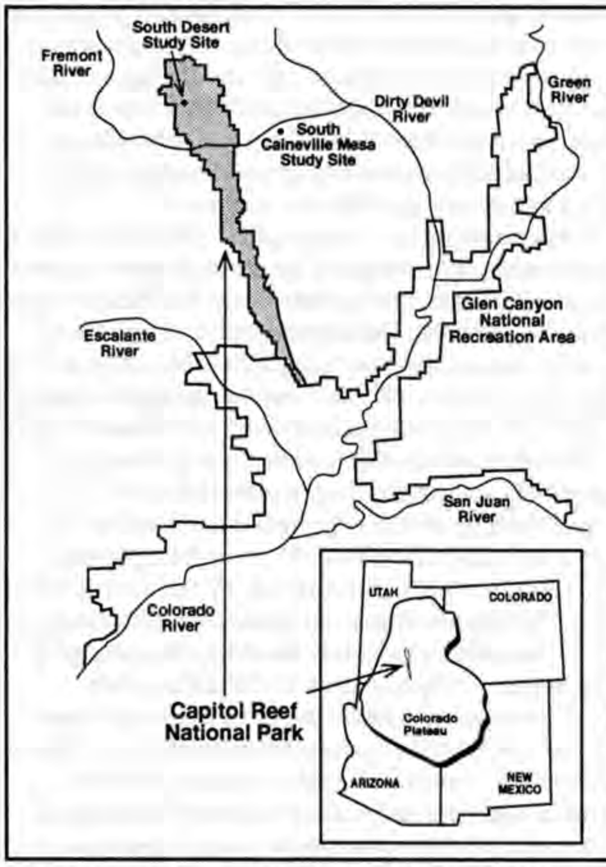

Figure 1. Location of Capitol Reef National Park within the Colorado Plateau, and location of South Desert and South Caineville Mesa study sites.

Background Information

Livestock grazing began in the vicinity of Capitol Reef during the late 1880s when Mormon settlers began local ranching operations. Grazing reached a peak in the area during the early 1900s when an estimated 344,000 cattle and 2,926,000 sheep were in southern Utah (Pickford 1966). The legislation that created Capitol Reef National Park called for a phase-out of grazing commencing 10 years after park establishment and confirmed perpetual trailing rights through the park. In 1981, concern over the loss of grazing privileges caused the Utah Cattleman's Association, representing local livestock owners, to lobby Congress to allow cattle grazing to continue (Henderson 1985). A compromise was eventually reached (PL 97-341, 1982) that permitted grazing to continue until 1994 at current levels and mandated scientific investigations to quantify potential impacts of livestock on the park's cultural and natural resources. In 1989, new legislation modified the 1982 compromise by allowing permittees to sell their grazing rights to the National Park Service or to continue livestock grazing for their lifetime and the lifetime of one heir. Through this legislation 70 percent of the Animal Unit Months (AUMs) in Capitol Reef were purchased, leaving approximately 1500 AUMs actively grazed.

Current grazing in the park is focused within three active allotments: Cathedral, Hartnet, and Sandy III; totalling approximately 35,499 ha within park boundaries. The allotments supported 1,500 AUMs during fall-spring grazing by cattle during this study. Over 100 adult and juvenile cattle were observed using the South Desert study area in the northern district of the park during the early breeding season for passerines. It is likely that actual use by cattle is higher than the official numbers authorized due to poor fencing and frequent trespass (Rosenstock 1993).

In 1984, the Academy provided a final report that called for 10 studies investigating the grazing issue in Capitol Reef. In 1992 Congress planned to re-evaluate the park grazing issue using information gained from research projects proposed by the National Academy of Sciences and administered by the National Park Service. This study addressed the potential impacts of livestock grazing on the bird fauna of the park. No previous studies quantifying the potential impacts of livestock grazing on the avifauna and related plant communities had been conducted.

Avian Monitoring

Because of their conspicuous and mobile behavior, birds are often used as indicators of environmental change (Adams and Barrett 1976, Jarvinen and Vaisanen 1979, Morrison 1986). From a cost-effective viewpoint, birds are considered good indicators of environmental change (Root 1967, Franzreb and Ohmart 1978, Verner 1984). Avian monitoring has, therefore, been widely used as an approach for evaluating impacts of management practices on public lands (Johnson 1981, Severinghaus 1981).

Balda (1975) stated that an approach which links impacts to specific birds or suites of birds at a local scale of study will be most beneficial to land managers. Studies that attempt generalizations across large scales (e.g., western grasslands or Great Basin shrubsteppe) may overlook proximate factors that determine local population status (Van Horne 1983). Site specific studies that identify local (e.g., within a National Park) habitat linkages are needed. Although Behle (1986) summarized bird distributions in the canyon-lands area, no systematic studies of bird habitat relationships have been conducted on the birds in Capitol Reef.

Livestock Grazing Impacts on Birds

Researchers typically investigate the impacts of grazing on bird species by either comparing populations on adjacent study plots exhibiting different levels of grazing (Kantrud 1981, Mosconi and Hutto 1982), on sites before and after grazing (Duff 1979), or a combination of these strategies (Bock et al. 1984). It is common to describe avian responses (e.g., distribution or relative abundance changes) to grazing effects on vegetation because livestock are thought to influence birds indirectly by changes in vegetation structure or floristics.

Several studies have documented negative impacts (i.e., habitat loss, population reduction, and species loss) to avian species by intensive grazing of upland and grassland ecosystems (Dambach and Good 1940, Ryder 1978, Reynolds and Trost 1980, Bonham 1972, Wiens 1983, Knopf 1987); others have shown positive responses (i.e., population increases) by avian species (Kirsch and Higgins 1976, Crouch 1982, Bock and Webb 1984).

Plant community architecture is an important factor in bird habitat selection (MacArthur et al. 1962, Hildén 1965). In general, birds are believed to respond proximately to the physical structure of the habitat, a niche dimension which provides courtship areas, nesting substrates, foraging perches, thermal and escape cover. Birds are also believed to respond to habitat areas indirectly through cues to potential reproductive success or availability of prey (Lack 1933, Hutchinson 1953, Hildén 1965, Wiens 1969, James 1971, Wiens and Rotenberry 1981).

Concentrated grazing pressure has been shown to affect the structure and distribution of vegetation used by birds (Hutchings and Stewart 1953, Holmgren and Hutchings 1972, Knopf and Cannon 1982, Medin 1986, Sedgewick and Knopf 1987, Knopf et al. 1988). Responses in bird distribution and abundance have been correlated with livestock induced changes to plant vigor, growth form, and species composition (Townsend and Smith 1977). Heavy grazing by cattle can reduce food resources, nesting areas, and habitat diversity (Behnke and Raliegh 1978, Evans and Krebs 1977).

Grassland communities are well suited for studying ecological relationships between cattle grazing and birds since the number of species is small, individuals are relatively easy to census, and the effects of disturbance on vegetation structure should be directly measurable (Wiens 1974, 1977). Grassland communities occur throughout the Canyonlands Section (an area encompassing Canyonlands and Arches National Parks, Bridges National Monument, Capitol Reef National Park, and Glen Canyon National Recreation Area; see Barnes 1978 and Hintze 1986) in valley bottoms, isolated "parks", mesa tops, and alluvial or eolian benches. Generally, plant communities are dominated by perennial bunchgrasses interspersed with various desert shrubs on sites characterized by deep sandy loam soils (West and Ibrahim 1968; Kleiner and Harper 1972, 1977a, 1977b; West 1988; Harper and Jaynes 1984; Tuhy and MacMahon 1988). Tuhy and MacMahon (1988) identified relict communities in Glen Canyon National Recreation Area adjacent to CARE that included several mesa tops and remote terraces free of historic or current livestock disturbance. The Mixed-Grassland Community (Romme et al. 1993) was the most common vegetation type found on undisturbed deep sandy loam soils. Inventories conducted in the isolated Hall's Creek Narrows and remote domelands of CARE documented the existence of pristine Mixed-Grassland patches (dominated by *Stipa* species) similar to the relict areas found in adjacent Glen Canyon (Romme et al. 1993). Given deep, sandy loam soils, Mixed-Grassland patches throughout the Canyonlands Section possessed similar structural and floristic properties (Tuhy and MacMahon 1988). Grazing history and soil texture were identified as important factors determining habitat structure of grasslands in the Canyonlands Section (Kleiner and Harper 1972, 1977a, 1977b; Harper and Jaynes 1984).

Objectives

The research project spanned three years (April 1989 through July 1991) and focused on breeding season habitat-use by resident grassland passerines. Briefly, the project study design included:
(1) identification of grazed and adjacent ungrazed grasslands along the eastern boundary of Capitol Reef National Park;
(2) study site selection and transect establishment;
(3) bird and plant inventories; and
(4) statistical comparison among transects.
During 1991, the hypotheses concerning cattle grazing and habitat selection by grassland birds that were generated from the 1989-90 results were tested.

Grassland communities located along the eastern boundary of Capitol Reef have historically experienced heavy cattle use, in contrast to other plant communities found in the park (Heil et al. 1993). This research focused on Capitol Reef grasslands because they had experienced the heaviest cattle use in the park and provided currently grazed treatment sites (Henderson 1985). A simple field experiment was developed by sampling along a habitat gradient of vertical vegetation structure with the gradient also overlaid across sites with different historic and current levels of cattle grazing intensity. This provided means to test hypotheses relating bird community measures to habitat complexity and cattle grazing.

Research goals were accomplished through implementation of the following objectives:

(1) Identification of avian species present at Mixed-Grassland study sites that possessed different levels of cattle use.

(2) Statistical tests of differences in bird and plant communities among study sites with information on species richness, relative abundance and habitat-use.

(3) Identification of vegetation parameters that cattle alter which are important to sensitive bird species.

CHAPTER II: EFFECTS OF LIVESTOCK GRAZING ON GRASSLAND BIRDS

Study Areas

Two study areas were selected after extensive searches for optimal cattle grazing treatment and control areas: South Desert (SOD), in the northern district of Capitol Reef; and South Caineville Mesa (SCM), on the Bureau of Land Management Henry Mountains Resource Area, located approximately 15 km east of SOD. The SCM study site was selected for the comparison based on common physical characteristics, accessibility, grazing history, and proximity to SOD. Mixed-Grassland communities stretched across SCM for approximately 350 ha on well developed sandy loam soils (Meinke 1975). Vegetation, slope, composition, aspect, and occurrence of deep sandy loams similar to SOD were important factors in the selection of SCM as the "control" site for the grazing effects study. The elevation on the mesa-top was approximately 1760 m. Annual precipitation was typically less than 200 mm (Meinke 1975, West 1983). The mesa was lightly grazed by cattle and sheep in winter from the late 1880s until the 1940s (Meinke 1975). No cattle use had occurred since the 1960s. SOD was located in Mixed-Grassland communities that occurred below the Upper South Desert Overlook in Capitol Reef. This area was part of the Hartnet allotment, with approximately 970 AUMs grazed by cattle from 1 November to 31 May each year. Soils were deep to shallow sandy loams derived from Entrada Sandstone cliffs. Elevation was approximately 1770 m.

Bird Population Estimation

Avian species were sampled along transects during April through July, 1989 and 1990. Two line transects were established and monitored in similar Mixed-Grassland communities at each study site. All transects were 1 km in length, marked with 0.5 m metal conduit stakes every 50 m, and placed along the longitudinal axis of the study sites to minimize edge effects. Transects were run 15 minutes after sunrise (following the dawn chorus) until 1100 hours. One observer slowly walked the length of the transect recording all birds seen within 0-25 m, 25-50 m, 51-100 m, and 100-200 m belts along each side of the transect. Each transect was walked twice in the morning, unless inclement weather (e.g., wind >10 mph, or rain) prevented quality counts. Each transect was sampled at least 10 times per season. To avoid mistakes in judging distances and identifying species, only birds seen were counted during a transect run (Emlen 1971, 1977; Kepler and Scott 1981; Mayfield 1981; Scott et al. 1981). In 1990 we flagged perches of birds seen during the transects and returned after the counting sessions to measure vegetation at bird habitat-use sites.

Because the transect areas were open grasslands with few visual obstructions all birds seen within 100 m along a transect were easily observed; therefore, no detectability functions (e.g., Emlen 1977) were generated. Birds seen flying over the transects and nonpasserines were excluded from the analyses (though noted in field notes). The bird transect data allowed calculation of the following bird community parameters:

(1) Bird Abundance = mean number of individuals summed over all species.

(2) Species Abundance = mean number of individuals recorded for each species.

(3) Species Richness = total number of species recorded at each study area.

(4) Species Diversity and Evenness (see Hill 1973, Wiens and Rotenberry 1981) = a measure of bird community composition.

Vegetation Community Sampling

Characteristics of vegetation composition and structure were recorded along each transect. A 30 m tape was stretched in the four cardinal directions from transect conduit markers to locate the center of four sampling units. From the center of each sampling unit, four sampling points were established at 5 m in each of the four cardinal directions. Using a 1X1 m quadrat frame placed with the southwest corner at the sample point, percent cover of bare ground, rock, litter, perennial bunchgrasses, forbs, cactus, and shrubs was recorded (Daubenmire 1959). In addition, the distance to the nearest bunchgrass and shrub, and the height of the nearest bunchgrass and shrub, along with an estimate of the vertical distribution of vegetation (estimated by recording the number of hits of vegetation in height classes 0-20 cm, 21-40 cm,...up to 120 cm on a thin rod placed vertically at each sample point) was recorded. Shrub and grass distances were used to create an index of horizontal patchiness (Roth 1976). The horizontal patchiness of the habitat was determined using the equation: D = 100 SD/x; where SD is the standard deviation and x is the mean of the point-to-plant distances. A high value indicated random plant distribution, medium values indicated clumped distribution, and low values resulted from evenly spaced (e.g., as in an orchard) vegetation. The above measurements were also recorded at each bird habitat-use site identified during transect runs. A total of 20 variables were measured in order to quantify vegetation composition and structure at the study sites.

Statistical Analyses

The vegetation community and bird habitat-use data for each measured variable were summarized and tested for homogeneity of variances and normality (Zar 1984). Most parameters exhibited common variances and only slight departures from normality. Both nonparametric univariate tests (e.g., Mann-Whitney U-statistic) and parametric tests (ANOVA, Regression) were used to test statistical hypotheses (i.e., null hypotheses of no difference between study areas or transects) involving the random variables (Zar 1984). Statistical significance was pre-set at $P \leq 0.05$.

Results

Ten bird species were observed along the transects during the 1989 surveys and nine species in 1990 (Table 2.1). The bird community appeared stable among years on the SCM transects; however, the SOD bird community experienced fluctuations in both composition and abundance. Lark sparrows, vesper sparrows, Say's phoebes, and rock wrens were seen at both study sites, but densities were consistently lower at SOD. Bird abundance was significantly lower at the SOD site, and species richness was greatest at SCM. Species diversity and evenness were similar among study areas in 1990. The high evenness observed for SOD during 1990 reflected the equal contribution among species and tended to inflate the species diversity outcome though few birds were actually observed. No differences in bird abundance or species composition were detected between the SOD transects; however, SCM transect-1 consistently showed greater relative abundance and species richness values than SCM transect-2 for both resident and migrant species (Table 2.2).

Black-throated sparrows and horned larks were the most common species seen on SCM.

Table 2.1. Breeding bird density in individuals/40 ha for passerines identified in Mixed-Grassland communities in South Desert (SOD) and South Caineville Mesa (SCM), Utah 1989-1990.

	1989		1990	
	SOD	SCM	SOD	SCM
Species				
SAPH[1]	0.29	1.00*	0.35	1.00*
ROWR	0.65	0.67 NS	0.54	0.81 NS
BHCB	0.24			
HOLA		5.28*	1.34	9.10 NS
VESP	0.88	1.00 NS	0.69	0.46 NS
BTSP		5.67		8.42
LASP	3.90	2.94 NS	0.73	4.31*
BRSP		0.28		0.53
PUFI	1.39	2.00 NS		2.23
MODO	0.24	0.39 NS		0.57
Pooled Variables				
Total Density	7.59	19.23*	3.65	27.43*
Species Richness	7.00	9.00*	5.00	9.00*
Diversity	3.22	4.77 NS	4.10	4.30 NS
Evenness	0.68	0.82 NS	0.90	0.80 NS

[1] See appendices for bird species acronym definition.
* = $P \leq 0.05$ for two-sample T-test evaluating significant differences between study area mean values in 1989 and 1990.
NS = not significantly different.

Table 2.2. Breeding bird density in individuals/40 ha identified on South Caineville Mesa transects one and two, Utah 1990.

	Transect 1	Transect 2
Species		
HOLA	11.15	7.2*
VESP	0.53	0.15 NS
BTSP	9.15	7.69*
LASP	4.23	4.38 NS
BRSP	0.58	0.00 NS
PUFI	2.85	1.62*
SAPH	1.39	0.62*
ROWR	1.23	0.38*
CHSP	2.00	0.00*
MOBI	0.00	0.61*
Pooled Variables:		
Total Density	33.11	22.65*
Species Richness	9.0	8.0 NS

* = $P \leq 0.05$; Mann-Whitney U-Test.
NS = not significantly different.

Black-throated sparrows were absent from SOD during both years. Horned larks, black-throated sparrows, lark sparrows, Say's phoebes, mourning doves, and rock wrens formed a widespread species assemblage in 1989 at ungrazed Mixed-Grassland communities, and this pattern was observed again on SCM in 1990. Vesper sparrows, Brewer's sparrows, and chipping sparrows were seen on several transect runs but did not remain in the grasslands through the breeding season. These species were recorded only during the first half of the survey period and nested in other habitats.

Vegetation Patterns

Floristic and structural differences were detected in vegetation between SOD and SCM Mixed-Grassland communities at both micro- and macro-site scales (Tables 2.3, 2.4). Micro-site measurements refer to individual vegetation plots, whereas macro-site measurements combine plots to describe transect scale characteristics. In 1989 and 1990, SCM showed greater overall grass and shrub coverage than SOD. Indian ricegrass (*Oryzopsis hymenoides*) was the dominant plant species in the SCM grasslands, with galleta grass (*Hilaria jamesii*) and needle-and-thread (*Stipa comata*) dominant in small patches. In contrast, the SOD transects possessed greater bare ground coverage with grasses distributed in isolated clumps or "pedicels" interspersed by russian thistle (*Salsola kali*) and broom snakeweed (*Gutierrezia sarothrae*). Alkalai sacoton (*Sporobolus airoides*), sand dropseed (*Sporobolus cryptandrus*), and blue-grama grass (*Boutelouagracilis*) dominated the SOD study site (Table 2.3). Galleta grass dominated a few micro-sites on the SOD transects, and indian ricegrass was found in the understory of scattered *Sporobolus* pedicels.

The macro-site patchiness index (Roth 1976) indicated that the horizontal arrangement of individual grasses and shrubs was similar between the study sites; however, vertical habitat complexity was significantly different between sites (Table 2.4). Shrubs and grasses were shorter at SOD than those at SCM, and grasses and shrubs on SCM showed a more complex vertical distribution (e.g., more vegetation layering and greater overall canopy coverage) than the SOD grasslands (Fig. 2). The vertical complexity of the SCM transects was evident in the greater vertical height of grasses and shrubs, greater total cover, and large variation observed in the height of individual plants.

No difference in the distribution or structure of the vegetation was observed between transects within the SOD study site; however, floristically the transects differed. Transect number two

Table 2.3. Micro-site plant characteristics of Mixed-Grassland communities at South Desert (SOD) and South Caineville Mesa (SCM), Utah, 1989-90. Values expressed as mean value with one standard error in parentheses.

Feature	Study Site SOD (grazed)		SCM (ungrazed)	
Ground Cover (%)				
Bare ground	79.3	(1.1)	58.0	(1.3)*
Litter	4.5	(1.8)	9.3	(2.2)*
Rock	0.6	(0.4)	0.8	(3.1) NS
Grass:				
Oryzopsis hymenoides	1.2	(0.1)	12.2	(7.4)*
Hilaria jameseii	4.2	(0.8)	6.6	(0.5)*
Others (1)	8.4	(1.3)	2.2	(1.0)*
Totals	13.8	(1.1)	21.0	(1.2)*
Forbs	0.7	(0.1)	3.0	(0.3)*
Shrubs	1.0	(0.3)	7.8	(2.1)*
Cactus	0.2	(0.2)	1.5	(0.5)*
Semi-shrub				
Gutierrezia sarothrae	2.2	(3.1)	0.0	(0.0)*

Statistical significance: * = $P < 0.05$. NS = not significant.

(1) Others = *Sporobolus* spps., blue grama grass (*Bouteloua gracilis*), and threeawn (*Aristida purpurea*). They were not identified individually in the field sampling.

Table 2.4. Macro-site characteristics of Mixed-Grassland communities at South Desert and on South Caineville Mesa, Utah, 1989-90. Expressed as mean value with one standard error in parentheses.

Feature	Study Site SOD (grazed)		SCM (ungrazed)	
Vegetation Height (cm)				
Grass	8.8	(5.8)	24.5	(13.4)*
Shrub	12.0	(8.3)	30.1	(13.2)*
Heterogeneity Index (%)				
Grass	73.9	(1.4)	72.0	(1.1) NS
Shrub	67.7	(0.1)	72.0	(1.1) NS
Vertical Density (Total Hits)	1.1	(1.0)	3.3	(0.3)*
Total Live Cover	16.3	(1.1)	33.2	(1.8)*
Total Cover **	20.8	(1.2)	42.5	(1.8)*

Statistical significance: * = $P < 0.05$; NS = not significant.

** Total Cover = litter plus all above ground living vegetation.

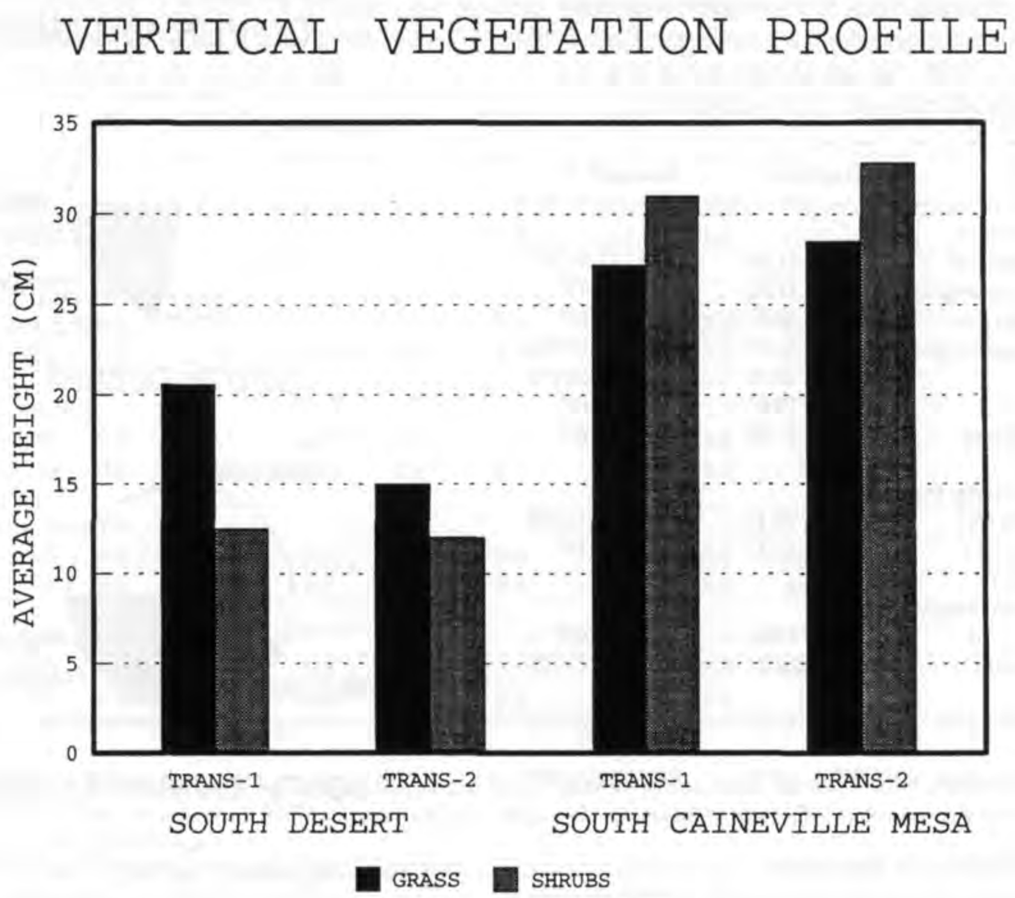

Figure 2. *Vertical profile of grasses and shrubs at South Desert and South Caineville Mesa, Utah, 1990.*

possessed more Alkalai sacaton than transect number one. This may have been a result of soil differences between the transects. Greater soil salinity could allow *Sporobolus* spp. to dominate certain micro-sites (Rosenstock 1993).

The SCM study site had significant differences in perennial bunchgrass coverage between the two transects (Table 2.5). Indian ricegrass and galleta grass reached greater cover values on transect one. The higher cover by shrubs on transect two may have accounted for the lower overall grass coverage values. The differences in vegetation height and coverage observed between the SCM transects paralleled the overall differences seen between SCM and SOD (Figs. 2, 3). In general, the SCM study site possessed a more vigorous appearance, with greater litter and vegetation cover, and more vertical development than the SOD study site.

Bird/Habitat Associations

Bird habitat-use sites were measured for four species at SCM and two species at SOD (Tables 2.6, 2.7). The habitat-use experimental units were compared to random habitat experimental units within each study site to identify use patterns (i.e., bird habitat selection) unique to grazed and ungrazed locations. Black-throated sparrows, horned larks, and lark sparrows were abundant on SCM in 1990, but the same species were rarely observed in SOD. Habitat-use patterns of these species were identified to illuminate important vegetation parameters that cattle may alter and which could explain their absence in SOD.

Black-throated sparrows were found in areas with greater plant cover, taller shrubs and perennial bunchgrasses, and greater cactus coverage than present at the random sample points. In all, seven variables were significantly different

Table 2.5. Comparison of vegetation variables between transect one and two on South Caineville Mesa, Utah, 1990. Values shown are the mean with one standard error in parentheses.

Feature	Transect 1	Transect 2
Ground cover:		
Bare ground	56.6 (1.5)	59.4 (2.0) NS
Indian rice-grass	14.9 (1.5)	9.5 (1.7)*
Galleta grass	8.3 (0.7)	4.9 (0.6)*
Blue-grama grass	1.1 (0.8)	3.2 (1.8) NS
Forbs	1.8 (0.3)	1.5 (0.3) NS
Shrubs	5.0 (0.8)	10.0 (4.0)*
All Grasses	24.3 (1.3)	17.6 (1.8)*
Heterogeneity index:		
Grasses (%)	71.0 (0.1)	75.0 (0.1) NS
Shrubs (%)	69.0 (0.1)	74.0 (0.1)*
Vegetation height:		
Grass (cm)	22.7 (13.3)	26.4 (13.6)*
Shrub (cm)	30.4 (13.2)	29.9 (13.2) NS
Vertical density	3.2 (1.6)	3.3 (1.8) NS
Total live cover (%)	34.0 (6.7)	32.3 (14.5) NS

* = P < 0.05; NS = not significant.

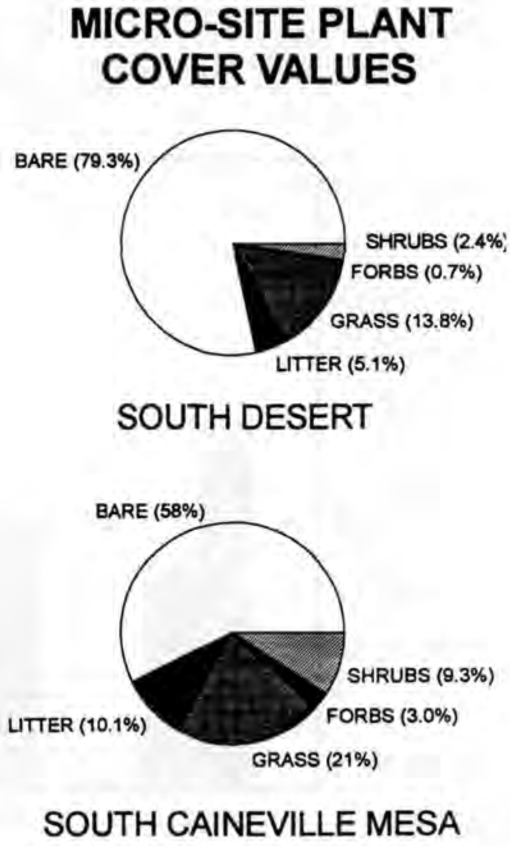

Figure 3. *Vegetation coverage of several life-form categories at South Desert and on South Caineville Mesa, Utah, 1990.*

between use and non-use sites for black-throated sparrows on SCM, so that they showed the greatest habitat selection of all species observed. Horned lark and lark sparrow use-sites were not different from the overall community, indicating an absence of fine-tuned habitat selection by these species on SCM. Vesper sparrows selected sites with greater indian ricegrass and cactus coverage for foraging. Vesper sparrows did not nest on the mesa, using the grasslands as a stop-over location during migration.

Lark sparrows and vesper sparrows showed greater habitat use selectivity at the SOD study area compared to SCM (Table 2.7). Lark sparrow use-sites were different from the overall community for four variables, and vesper sparrow use-sites were different for five variables. Both species selected areas with greater indian ricegrass and cactus cover. Vesper sparrows showed the finest habitat selection, choosing areas with greater perennial bunchgrass cover, less bare ground, and greater total vegetation cover than was available in the general habitat. Vesper sparrows on SCM also used grassy sites characterized by thick indian ricegrass patches interspersed with tall shrubs, and with greater vertical density and a clumped plant distribution.

Discussion and Conclusions

Numerous studies have demonstrated alterations to the structure and composition of grassland communities in response to cattle grazing (Hutchings and Stewart 1953, Holmgren and Hutchings 1972, Bock et al. 1984, Bock and Webb 1984, Medin 1986, Bock and Bock 1993). Approximately 100 adult cows (and 30-40 calves) were observed on the SOD transects during May 1989 and 1990. Close inspection of grasses and shrubs in the study area suggested high grazing use by cattle; for example, individual plans were uniformly cropped, with little aboveground structure remaining. Bock et al. (1984) and Bock and Bock (1993)

Table 2.6. Habitat-use comparison in used and random sites in an ungrazed Mixed-Grassland community at South Caineville Mesa, Utah, 1990. ANOVA and Tukey's Test compared habitat variables at random sites and bird habitat-use sites.

Species	BR	LTR	ORZ	HIL	SB	TOTH	PBD	PBH	SBD	SBH	TLCOV	CACT
Random (n = 44)												
x	58.0	9.3	12.2	6.6	7.6	3.3	72.8	25.2	70.5	27.2	33.2	1.7
SE	1.3	0.3	1.2	0.5	2.1	0.3	0.1	1.0	2.8	1.4	1.8	1.2
Black-throated sparrow (n = 64)												
x	55.3*	8.6	17.0*	6.6	3.5*	3.8	76.0	32.9*	64.7	34.7*	36.1*	4.0*
SE	0.0	0.2	1.3	0.6	0.6	0.3	0.1	2.5	26.9	2.1	0.2	0.6
Horned lark (n = 45)												
x	57.5	9.5	13.1	6.8	6.2	3.9	78.0	23.2	62.3	27.1	32.2	0.2
SE	1.0	0.2	0.9	0.6	0.9	0.2	0.0	0.8	5.6	1.7	1.1	0.6
Vesper sparrow (n = 19)												
x	54.5	9.6	18.7*	5.9	4.0	3.0	76.0	30.2	80.9	28.2	35.5	4.9*
SE	1.1	0.7	2.0	1.2	1.4	0.4	0.1	2.2	10.4	2.7	1.0	1.3
Lark sparrow (n = 45)												
x	55.0	9.6	12.	7.1	5.2	3.2	78.0	27.9	68.5	25.2	32.8	2.0
SE	1.3	0.4	1.3	0.4	0.8	0.3	0.0	1.1	6.6	1.4	1.0	0.4

* = $P \leq 0.05$.
BR = bare ground, LTR = litter, ORZ = indian ricegrass, HIL = galleta grass, SB = shrub, TOTH = vertical density (total hits), PBD = grass patchiness, PBH = grass height, SBD = shrub patchiness, SBH = shrub height, TLCOV = total live cover, CACT = cactus.

Table 2.7. Bird habitat-use comparisons in used and random sites in grazed Mixed-Grassland community at South Desert, Capitol Reef National Park, Utah, 1990. ANOVA followed by Tukey's Test compared habitat variables at random sites and bird habitat-use sites.

Species	BR	LTR	ORZ	HIL	PBG	SB	TOTH	SBD	SBH	PBD	PBH	TLCOV	CACT
Random (n = 44)													
x	79.3	4.5	0.6	4.2	8.3	1.0	1.1	83.0	12.5	68.0	20.6	16.2	0.2
SE	1.1	0.3	0.2	0.8	1.4	0.3	0.1	0.0	0.7	0.0	1.2	1.1	0.1
Lark sparrow (n=25)													
x	77.0	4.6	1.8*	4.3	8.8	0.4	0.5*	71.0*	26.5	63.0	11.9	17.8	1.7*
SE	1.7	0.3	0.1	0.9	1.9	0.1	0.1	0.1	0.9	0.1	0.8	1.8	0.5
Vesper sparrow (n=29)													
x	69.0*	4.0	1.5*	3.8	17.3*	0.5	0.8	79.0	28.6	66.2	12.6	20.1*	3.9*
SE	1.5	0.3	0.3	0.9	1.7	0.9	0.1	1.5	3.8	0.3	1.2	1.5	0.5

* = $P \leq 0.05$.

BR = bare ground, LTR = litter, ORZ = indian ricegrass, HIL = galleta grass, PBG = other perennial bunch grass, SB = shrub, TOTH = vertical density (i.e., total hits), SBD = shrub patchiness, SBH = shrub height, PBD = grass patchiness, PBH = grass height, TLCOV = total live cover, CACT = cactus.

documented similar aboveground disturbance in southern Arizona. Livestock exclosures located at grassland sites in CARE showed greater aboveground structure and plant cover than surrounding grazed areas (Rosenstock 1993).

The vertical component of both perennial bunchgrasses and shrubs was significantly reduced on the grazed treatment area observed during this study. Overall plant cover and vertical development were greater where grazing had been absent for 30 years (Meinke 1975). Bock and Bock (1993) suggested that livestock function as keystone species (Paine 1966) in southwestern grasslands that historically lacked large herds of native ungulates. On the Colorado Plateau, grassland communities protected from cattle grazing were characterized by tall bunchgrasses interspersed with various desert shrubs (West 1983, 1988; Tuhy and MacMahon 1988). In contrast, areas exposed to long-term grazing by domestic herbivores exhibited dramatic reduction in vegetation cover and vertical habitat complexity.

The results of this study suggest that livestock grazing may have caused profound changes within Mixed-Grassland communities distributed along the eastern boundary of Capitol Reef National Park. These grasslands typically included a mixture of tall bunchgrasses and short sod-forming species (Heil et al. 1993). Bunchgrasses are vulnerable to disturbance by grazers and grasslands subjected to long-term grazing are frequently dominated by short sod-forming species (Bock and Bock 1993). Because grasslands of the Colorado Plateau may have existed since the Pleistocene in the virtual absence of large ungulate grazers (Hall 1981), cattle should be considered an exotic influence in this region capable of dramatically altering grassland ecosystems occupied by native wildlife and plants. Cattle grazing will not eliminate native ecosystems in CARE, but it will undoubtedly favor certain forms of plants and animals at the expense of others.

CHAPTER III: HABITAT ASSOCIATIONS OF BIRDS FOUND IN GRASSLAND COMMUNITIES OF CAPITOL REEF NATIONAL PARK

Introduction

The 1989-1990 study results presented in Chapter II of this report suggested that a positive linear relationship existed between bird species richness and habitat structure within CARE grasslands. In particular, vertical vegetation structure appeared to be the limiting factor for several resident bird species including black-throated sparrows, vesper sparrows, brewers sparrows, Say's phoebes, and horned larks. Horizontal plant complexity and configuration appeared to have little affect on bird species richness or abundance.

Cattle grazing apparently caused significant reductions in the vertical component of grass-lands of Capitol Reef National Park. Horizontally, the grazed and ungrazed study sites were similar; in fact, the index of horizontal patterning was not significantly different between the sites, and plant species composition was also rather similar. Therefore, it appeared that cattle grazing removed aboveground structure but left plant species composition and horizontal patterning relatively unchanged.

Birds were most likely affected by cattle grazing through alteration to vertical structure and subsequent effects on specialized habitat resources (i.e., roost, nest and foraging sites, and thermal/escape cover). Given the patterns in vertical habitat structure and bird community composition detected during 1989-90, the research goal in 1991 was to test the hypothesis that a significant linear relationship existed between the grassland bird community and vertical habitat configuration within Capitol Reef grasslands.

The avian habitat-use data collected during 1989-90 suggested that grassland patches with high levels of vertical vegetation structure would contain more bird species and more individual birds than grassland patches with low vertical structure. If the grassland patch was relatively poor in vertical structure, then only the hardiest of birds would occur there (e.g., a more seral species such as the lark sparrow). A further prediction was that the relationship between bird species richness and vertical structure was linear and that a significant positive linear relationship would be detected if a gradient of structural complexity was sampled.

Study Areas

In 1991 seven additional 1 km transects were established along the eastern edge of Capitol Reef in Mixed-Grassland communities representing a gradient of vertical habitat complexity from high overhead cover to virtually no overhead cover. Transects were established at the following sites in Capitol Reef National Park: Rock Springs Bench, in Cathedral Valley, Hartnet Draw and below the Notch in lower South Desert in the northern district of the Park, and at Bitter Creek Divide, the Post, and lower Hall's Creek below the Narrows section (Fig. 4). All of these transects were dominated by Mixed-Grassland communities spread across wide valley bottoms intersected by shrub-lined washes. Average annual precipitation across the region encompassing the study areas was approximately 170 to 200 mm with temperature extremes of below 0 to 40 C. Most precipitation was from late summer thunderstorms or winter storms.

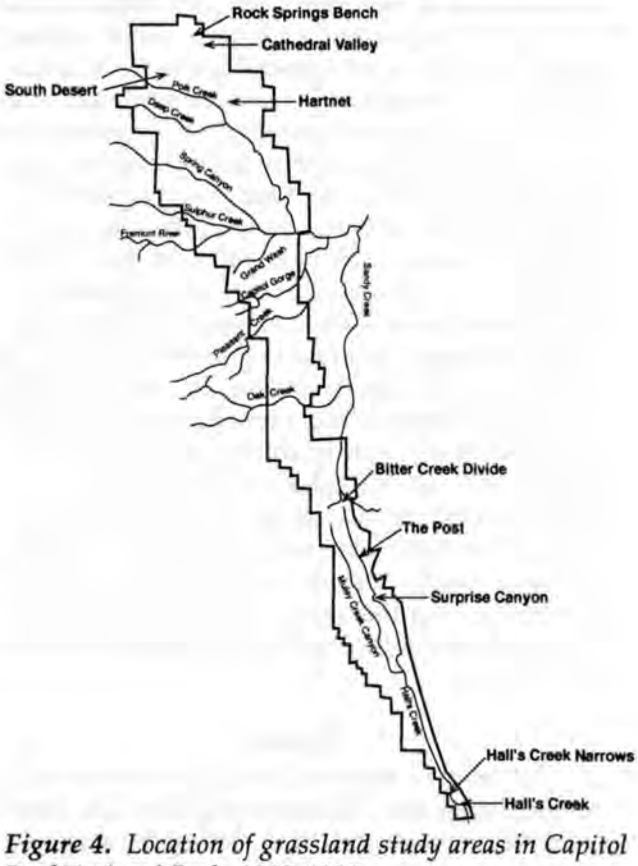

Figure 4. Location of grassland study areas in Capitol Reef National Park, 1989-1991.

Methods

During the 1991 field work, sites were selected in Capitol Reef that represented habitat structural types intermediate between SCM and SOD, forming a vertical vegetation gradient from low to high complexity. The null hypothesis for statistical tests was: H°: "There is no significant linear relationship between bird species richness and vertical habitat structure among the surveyed transects." Vertical vegetation measurements were recorded along transects to assess vertical habitat structure. A vertical density rod was placed at the end of 5-m radii extending in the four cardinal directions from each transect conduit marker. This allowed relatively fast sampling of vertical habitat structure along the transect where birds were observed. Several synthetic vegetation community measures were generated from the density rod: number of layers present, number of total hits on the pole, number of hits per layer, and litter depth.

Avian species were sampled along transects during April through July 1991. One line transect was established and monitored in Mixed-Grassland communities at each study site. All transects were 1 km in length, marked with 0.5 m metal conduit stakes every 50 m, and placed along the longitudinal axis of the grassland sites to minimize edge effects from adjacent habitat types. Transects were run 15 minutes after sunrise (following the dawn chorus) until 1100 hours. One observer slowly walked the length of the transect recording all birds seen within 0-25 m, 25-50 m, 51-100 m, and 100-200 m belts along each side of the transect. Each transect was walked twice in the morning, unless inclement weather (e.g., wind >10 mph, or rain) prevented quality counts. To avoid mistakes in judging distances and identifying species, only birds seen were counted during the transect (Emlen 1971, 1977; Kepler and Scott 1981; Mayfield 1981; Scott et al. 1981). Because the transect locations were relatively open, all birds present along the transect were observed. Birds seen flying over the transects and nonpasserines were excluded from the analyses (though noted in field notes).

Results

Forty-three passerine bird species were observed during the 1991 surveys (Table 3.1). Many of the bird species observed during the surveys nested outside the grasslands but foraged within 200 m of the transects. In order to restrict the analyses to grassland birds, the survey results were divided into two groups: (1) birds seen within a 100 m strip on each side of a transect; and (2) birds observed within 200 m on each side of a transect. Because the grassland study areas were often adjacent to more complex upland habitats (e.g., Pinyon-juniper woodland) or riparian areas, truncating observations at 100 m minimized, as much as possible, confounding edge effects.

Greater than 50 percent of the individuals seen during the surveys were generally considered residents in the grassland communities based on observations of nests or nesting behavior (Table 3.2). Twenty-one and 22 percent were edge or migrant bird species, respectively. The final three percent were riparian bird species seen predominantly along Hall's Creek which flowed close to the small grassland patches surveyed at the extreme southern end of CARE.

Bird counts from 0 to 200 m indicated that a wide variety of bird species were using the grasslands in the vicinity of habitat edges. Resident species dominated the counts, but a large component of birds included migrant and edge species using adjacent upland habitats. Restricting the analysis to within 100 m of transects eliminated many of the edge and migrant birds (Table 3.3). Fifteen species formed the upper 85 percent of all individuals seen including nine residents, five edge, and one migrant species. Residents made up 65 percent of all individuals seen within 100 m of the transects.

Regression analysis between vertical vegetation structure and bird species richness using results from the 0 to 200 m transect strip survey data resulted in a nonsignificant linear relationship (Table 3.4). However, when the regression analysis was performed on the 0 to 100 m transect strips, the result was a significant positive linear relationship between vertical vegetation structure and bird species richness (Table 3.5). Therefore, the null hypothesis of nonlinearity was rejected, and the conclusion was that both bird species richness and bird community composition were functionally related to vertical habitat structure in the Capitol Reef grasslands.

The relatively low r^2 value (0.463), which described the amount of variation in bird species richness explained by its functional linear relationship to vertical habitat structure, indicated

Table 3.1. Passerine birds encountered on transects in Capitol Reef National Park and adjacent BLM lands, April-June 1991.

SPECIES		TRANSECTS*									
		SD	SM	RB	CA	HA	NO	BD	PS	HC	TOTAL
1)	ASFL	0	0	0	0	0	0	0	5	41	46
2)	BCHU	0	7	0	0	0	0	4	1	1	13
3)	BGGN	0	0	0	1	0	0	0	8	21	30
4)	BLGR	0	0	0	0	0	0	0	1	3	4
5)	BRBL	0	1	1	0	2	17	0	0	2	23
6)	BRCO	0	0	0	0	3	0	0	0	3	6
7)	BRSP	3	51	2	2	8	12	27	55	6	166
8)	BTHU	2	8	2	0	5	4	0	4	6	31
9)	BTSP	0	85	2	1	136	0	0	141	12	377
10)	CHSP	0	5	28	0	2	2	19	209	97	362
11)	CLNU	4	0	0	0	0	0	0	0	0	4
12)	HOFI	2	2	0	0	2	0	0	5	87	98
13)	HOLA	8	70	3	0	0	3	0	0	0	84
14)	LABU	0	0	0	0	0	0	0	0	5	5
15)	LASP	17	50	39	42	40	7	33	1	1	230
16)	LEGO	0	0	0	4	3	3	3	3	0	12
17)	LOSH	1	0	0	4	3	3	3	3	0	17
18)	MAWA	0	0	0	0	0	0	0	1	0	1
19)	MOBI	0	0	0	0	0	1	0	4	0	5
20)	MOBL	0	0	0	0	0	0	4	0	0	4
21)	MODO	1	1	1	3	1	2	1	8	50	68
22)	NOOR	0	0	0	0	0	0	0	2	3	5
23)	PIJA	35	0	0	0	0	0	8	0	0	43
24)	ROSW	0	0	0	0	0	1	0	1	0	2
25)	ROWR	16	16	1	1	15	0	57	1	10	117
26)	RUKI	0	0	0	0	1	0	0	7	0	8
27)	SAGE	0	0	0	0	4	0	0	0	0	4
28)	SAPH	6	7	0	4	3	4	11	7	13	55
29)	SASP	0	0	2	0	0	2	0	1	0	5
30)	SATH	0	0	0	2	4	0	11	0	0	17
31)	SCJA	0	0	0	1	0	0	2	3	0	6
32)	SCOR	0	0	0	0	0	2	2	0	0	4
33)	SOVI	0	0	0	0	0	0	0	4	7	11
34)	VESP	3	0	9	4	6	0	0	0	0	22
35)	VGSW	0	11	0	1	3	5	0	0	8	28
36)	VIWA	0	0	0	0	0	0	0	1	0	1
37)	WEKI	0	0	0	0	0	0	0	0	1	1
38)	WEME	0	0	0	3	0	0	24	0	0	27
39)	WETA	0	0	0	0	0	0	0	1	0	1
40)	WHSP	0	0	0	1	2	0	0	54	0	57
41)	WIWA	0	0	0	0	0	0	0	0	2	2
42)	WTSW	0	11	0	0	0	0	0	0	0	11
43)	YRWA	0	0	0	0	17	0	0	0	2	19

* Transects: SD = South Desert; SM = South Caineville Mesa; RB = Rock Springs Bench; CA = Cathedral Valley; HA = Hartnet; NO = The Notch; BD = Bitter Creek Divide; PS = The Post; HC = Hall's Creek.

Table 3.2. Bird species grouped by residence status from transects conducted within Mixed-Grassland communities in Capitol Reef National Park, April-June 1991.

	Residents	Edge Species	Migrants	Riparian
	BRSP	ASFL	CHSP	BLGR
	BTSP	BCHU	LABU	MAWA
	HOFI	BGGN	LEGO	NOOR
	HOLA	BRBL	MOBI	RUKI
	LASP	BRCO	MOBL	SCOR
	MODO	BTHU	SAGE	SOVI
	SATH	CLNU	WETA	WIWA
	VESP	LOSH	WHSP	VIWA
	WEME	MOBI	SASP	YRWA
		PIJA		
		ROSW		
		ROWR		
		SAPH		
		SCJA		
		VGSW		
		WEKI		
		WTSW		
TOTAL:	1089	438	450	54
PERCENT:	54	21	22	3

See appendices for listing of common names by acronym.

Table 3.3. Bird species abundance for resident, edge, and migrant species observed within a 0 to 100 m survey strip and vertical vegetation profile of transects placed in Mixed-Grassland communities in Capitol Reef National Park.

	Transects[1]									
	SD	SM	RB	CA	HA	NO	BD	PS	HC	TOTAL
Species										
1) ASFL***	0	0	0	0	0	0	0	7	27	34
2) BGGN***	0	0	0	0	0	0	0	10	16	26
3) BRSP**	3	51	2	0	8	10	27	68	6	175
4) BTSP**	0	68	1	0	105	0	0	162	6	342
5) CHSP*	0	4	28	0	2	2	19	209	79	343
6) HOFI**	0	2	0	0	0	0	0	5	57	64
7) HOLA**	1	69	3	0	0	3	0	0	0	76
8) LASP**	6	29	22	34	37	7	25	1	1	162
9) LOSH***	0	0	0	3	1	3	2	6	0	15
10) MODO**	0	1	0	0	0	0	0	9	14	24
11) ROWR***	0	4	0	1	1	0	6	1	4	17
12) SAPH***	1	7	0	3	1	2	7	12	9	42
13) SATH**	0	0	0	2	4	0	1	0	0	7
14) VESP**	2	0	10	4	6	0	0	0	0	22
15) WEME**	0	0	0	3	0	0	3	0	0	6
Vegetation Height Profile[2]	28	168	95	27	39	37	34	182	116	

[1] Transects: SD = South Desert; SM = South Caineville Mesa; RB = Rock Springs Bench; CA = Cathedral Valley; HA = Hartnet; NO = The Notch; BD = Bitter Creek Divide; PS = The Post; HA = Hall's Creek.
[2] Value shown is total number of hits on the vertical sampling rod.
* = Migrants; ** = Residents; *** = Edge species.

Table 3.4. Simple Linear Regression analysis between vertical vegetation structure and bird species richness for all birds seen within 200-m of transects. ($r^2 = 0.174$).

Analysis of Variance					
Source	Sum-of-Squares	DF	Mean Square	F	P
Regression	61.94	1	61.94	1.89	0.20
Residual	294.24	9	32.69		

Table 3.5. Simple Linear Regression analysis between vertical vegetation structure and bird species richness for all birds seen within 100-m of transects. ($r^2 = 0.463$).

Analysis of Variance					
Source	Sum-of-Squares	DF	Mean Square	F	P
Regression	230.47	1	230.47	7.75	0.021
Residual	267.72	9	29.75		

that a more complex model incorporating other predictor variables may have been appropriate. Nevertheless, the regression was significant at $p \leq 0.05$ and supported the research hypothesis relating the bird community to vertical habitat structure.

In order to illuminate the relationship between the bird community and vertical habitat structure developed during regression analysis, the 1989-1991 vegetation and bird data from SCM and SOD were used within a Canonical Correlation Analysis (CCA). The purpose of Canonical Correlation is to analyze the relationship between two suites of variables (e.g., bird community and habitat measurements) using correlation analysis (Gauch 1982). CCA is a useful exploratory tool when an investigator wishes to study the dependency structure between two sets of variables that may be functionally related (Gauch and Wentworth 1976). The original variables are replaced by a smaller number of variables, called the canonical variables, which better exemplify the correlational structure of the data. For an excellent review of CCA in an ecological application, see Gauch and Wentworth (1976). Ultimately, data reduction is the goal of CCA: to redistribute the variance of the original measures into a few pairs or dimensions [e.g., (U1, V1), (U2, V2),...(Uj, Vj)] which capture a large share of the overall variance in the original data. The assumptions of CCA included linearity of the two variable sets and orthogonality of the underlying gradient.

The first step in CCA was construction of a correlation matrix among all variables (both habitat and bird community measures). Pearson Correlation Analysis suggested four resident bird species (black-throated sparrow, horned lark, vesper sparrow, and lark sparrow) met the assumption of independence and would form a suitable bird variable group. Percent cover of bare ground, litter, indian ricegrass, cactus, and vertical complexity and shrub height formed a second suite of independent variables generating a habitat group. These variable groups were entered into the CCA for investigation of their dependency structure.

Black-throated sparrows and horned larks "loaded heavily" (i.e., they had high canonical loadings or weights) on the first canonical dimension (Table 3.6). Cover of bare ground and litter, cover of indian ricegrass, and vertical vegetation structure also loaded heavily on the first dimension. The first canonical dimension suggested that black-throated sparrows and horned larks selected habitat characterized by high vertical grass cover, abundant litter cover, and few areas of bare ground. The second canonical dimension associated vesper sparrows with grassland habitats characterized by ample ground cover, high litter cover, and moderate vertical structure. The third canonical dimension associated lark sparrows with open habitat because both lark sparrows and bare ground loaded heavily on this dimension. Therefore, the CCA gave further support to the association documented in 1989-90 between black-throated sparrows, horned larks, and vesper sparrows and vertically robust grasslands; whereas, lark sparrows were consistantly related to more barren habitats.

Discussion

Avian community structure within a vegetation community has been shown to vary in response to subtle environmental gradients and the behavioral tolerances of species (Lack 1933, Tomoff 1974, Wiens 1985). Bird community diversity can vary with foliage height diversity

Table 3.6. Canonical Correlation Analysis among selected bird and habitat variables collected along transects in South Desert and South Caineville Mesa, 1989-1991. Values given are the Canonical Loadings for the first three Canonical Pairs.

	CCA* Dimensions		
	U1	U2	U3
Variables:			
BTSP	0.978	0.283	-0.479
HOLA	0.620	-0.287	0.163
VESP	0.162	0.928	0.219
LASP	0.257	0.352	0.857
	V1	V2	V3
Bare Ground	-0.815	-0.131	0.434
Litter	0.606	0.408	-0.560
Indian Rice Grass	0.858	0.005	0.211
Cactus	0.575	-0.552	-0.256
Vertical Structure	0.778	0.422	0.091
Shrub Height	-0.359	0.322	0.083

* CCA = Canonical Correlation Analysis.

(MacArthur and MacArthur 1961), horizontal vegetation patchiness (Roth 1976, Willey 1989), and plant species coverage (Wiens and Rotenberry 1981). Bird community diversity and richness often co-vary with vertical and horizontal habitat heterogeneity (Roth 1976). MacArthur (1964) suggested that birds in desert habitats were using fine-tuned habitat selection in response to the complex desert habitats and harsh environmental conditions. For example, Tomoff (1974) documented a positive relationship between breeding bird diversity and the presence of spinescent vegetation in a southern Arizona desert community. I suspect that grassland bird community structure in Capitol Reef was strongly influenced by vertical vegetation structure. Sites that possessed vertically simple structure, with a relatively low and open grassland canopy, supported fewer bird species. Birds that did inhabit the relatively barren sites showed fine-tuned habitat use patterns, often foraging or nesting in rare shrub patches scattered across the open grasslands. These habitat islands were often formed by brush-lined ravines that bisected the grasslands.

Birds apparently respond to vegetation structure and species composition when selecting sites for nest building, foraging, and escape or thermoregulatory cover (Hildén 1965, Wiens 1969, Balda 1975, Franzreb 1978, Rotenberry 1985). The reduction in vertical habitat complexity and total plant cover encountered at the actively grazed site in Capitol Reef (South Desert) may explain the comparatively low bird abundance found there and the absence of black-throated sparrows and spring migrants recorded during 1989 and 1990. Black-throated sparrows selected unique micro-sites for foraging, nesting, and courtship within the grassland on SCM, where seven of 12 habitat use measurements were significantly different between used sites and the overall grassland habitat. This suggested that the SOD site may not have provided the specialized habitat components required by black-throated sparrows for successful reproduction and survival.

Wiens (1974) described the lark sparrow as a seral species, able to exploit a wide range of habitat conditions. Several other authors have classified the lark sparrow as an increaser in response to cattle disturbance (Bock et al. 1984, Bock and Webb 1984). Results from this study support the classification of the lark sparrow as an opportunistic species, capable of surviving in habitats unsuitable for other birds. Habitat selection results for lark sparrows indicated relatively high selectivity at grazed study sites where four of 12 variables were significantly different between bird-use sites and the overall habitat. Both lark and vesper sparrows exhibited fine-tuned habitat selection at grazed study sites. This may have been a response to lower habitat quality at the grazed sites as a direct result of cattle use. Removal of aboveground vegetation by cattle may have decreased opportunities to build nest sites, safely use foraging areas, find thermal or hiding cover, and locate song perches.

Several studies have shown the importance of the vertical profile of vegetation in habitat responses and utilization patterns of grassland birds (Cody 1968; Wiens 1969, 1973, 1974). A gradient of increasing habitat quality appears to extend from the northern district of Capitol Reef, still actively grazed, to southern regions of the park where grazing has been phased out. The grassland communities in the northern district of the park have received 100 years of fall to spring grazing by domestic herbivores, whereas the southern portion of Capitol Reef and SCM currently receive no grazing use. The greater bird species richness and higher bird densities observed on SCM and at the southern park sites may reflect higher habitat quality caused by the removal of cattle grazing.

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LITERATURE CITED

Adams, D. L., and G. W. Barrett. 1976. Stress effects on bird-species diversity within mature forest ecosystems. American Midland Naturalist 96:179-194.

Baars, D. L. 1983. The Colorado Plateau: a geologic history. University of New Mexico Press, Albuquerque. 279 pp.

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. Pp. 59-80 *in* D. R. Smith (Ed.), Symposium on management of forest and range habitats for nongame birds. USDA Forest Service GTR-WO-1.

Barnes, F. A. 1978. Canyon County geology. Salt Lake City, Utah: Wasatch Publishers, Inc. 160pp.

Behle, W. H. 1986. Utah birds: geographic distribution and systematics. Utah Museum of Natural History Occasional Publication No. 5. 147pp.

Behnke, R. J., and R. F. Raliegh. 1978. Grazing and the riparian zone: Impact and management perspectives. Pp. 263-267 *in* R. R. Johnson and J. F. McCormick (Eds.), Proceedings-Strategies for protection and management of floodplain wetlands and other riparian ecosystems. USDA Forest Service GTR-WO-12.

Billingsley, G. H., P. W. Huntoon, and W. J. Breed. 1987. Geologic map of Capitol Reef National Park and vicinity: Emery, Garfield, Millard and Wayne Counties, Utah. Utah Geologic and Mineral Survey, Salt Lake City, Utah.

Bock, C. E., and J. H. Bock. 1993. Effects of long-term livestock exclusion in a semiarid grassland. Pp. 123-133 *in* P. G. Rowlands, C. van Riper III, and M. K. Sogge (Eds.), Proceedings of the first biennial conference on research in Colorado Plateau National Parks. Transactions and Proceedings Series NPS/NRNAU/NRTP-93/10. National Park Service.

Bock, C. E., J. H. Bock, W. R. Kenny, and V. M. Hawthorne. 1984. Responses of birds, rodents, and vegetation to livestock exclosure in a semidesert grassland site. Journal of Range Management 37:239-242.

Bock, C. E., and B. Webb. 1984. Birds as grazing indicator species in southwestern Arizona. Journal of Wildlife Management 48:1045-1049.

Bonham, C. D. 1972. Ecology inventory and data storage-retrieval system for the research ranch. Colorado State University, Range Science Department Science Series 14. 93pp.

Cody, M. L. 1968. On the methods of resource division in grassland bird communities. American Naturalist 102:107-147.

Crouch, G. L. 1982. Wildlife on ungrazed and grazed bottomlands on the South Platte River in northeastern Colorado. Pp. 187-197 *in* J. M. Peek and P. D. Dalke (Eds.), Wildlife-livestock relationships symposium. University of Idaho Forest, Wildlife and Range Experiment Station, Moscow.

Dambach, C. A., and E. E. Good. 1940. The effect of certain land use practices on populations of breeding birds in southwestern Ohio. Journal of Wildlife Management 4:63-76.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Scientist 43-64.

Duff, D. A. 1979. Riparian habitat recovery on Big Creek, Rich County, Utah—a summary of 8 years of study. Pp. 91-92 *in* Proceedings: Forum—grazing and riparian/stream ecosystems. Denver, Colorado: Trout Unlimited, Inc.

Emlen, J. T. 1971. Population densities of birds derived from transect counts. Auk 88:323-342.

Emlen, J. T. 1977. Estimating breeding season bird densities from transect counts. Auk 94:455-468.

Evans, K. E., and R. R. Krebs. 1977. Avian use of livestock ponds in western South Dakota. USDA Forest Service GTR-RM-3.

Franzreb, K. E. 1978. Tree species used by birds in logged and unlogged mixed-coniferous forests. Wilson Bulletin 90:221-238.

Franzreb, K. E., and R. D. Ohmart. 1978. The effects of timber harvesting on breeding birds in a mixed-coniferous forest. Condor 80:431-441.

Gauch, H. G. 1982. Multivariate analysis in community ecology. Cambridge University Press. Cambridge, NY. 298pp.

Gauch, H. G., and T. R. Wentworth. 1976. Canonical correlation analysis as an ordination technique. Vegetatio 33:17-22.

Hall, E. R. 1981. The mammals of North America, 2nd edition. John Wiley & Sons, New York. 1181pp.

Harper, K. T., and R. A. Jaynes. 1984. Some edaphic and compositional characteristics of *Artemesia tridentata* and associated plant communities in southwestern Utah. *In* MacArthur, E., E. Durant, and B. L. Welch (Compilers) Proceedings of a symposium on the biology of *Artemesia* and *Chrysothamnus*; 1984, July 9-13; Provo, Utah. USDA Forest Service GTR-INT-200. 398pp.

Heil, K. D., J. M. Porter, R. Fleming, and W. H. Romme. 1993. Vascular flora and vegetation of Capitol Reef National Park, Utah. National Park Service Colorado Plateau Technical Report Series NPS/NAUCARE/NRTR-93/01.

Henderson, N. 1985. Grazing management of Capitol Reef National Park. National Park Service Report, Natural Resources Office, Capitol Reef National Park, Utah. 82pp.

Hildén, O. 1965. Habitat selection in birds. Annales Zoologici Fennici 2:53-75.

Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. Ecology 54:427-432.

Hintze, L. F. 1986. Geologic history of Utah. University Press, Department of Geology, Brigham Young University. 181pp.

Holmgren, R. C., and S. S . Hutchings. 1972. Salt Desert shrub response to grazing use. Pp. 153-165 *in* C. M. Mckell, J. P. Blaisdell, and J. R. Goodin (Eds.), Wildland shrubs: their biology and utilization. USDA Forest Service GTR-INT-1.

Hutchings, S. S., and G. Stewart. 1953. Increasing forage yields and sheep production on intermountain winter ranges. USDA Circular Number 925.

Hutchinson, G. E. 1953. The concept of pattern in ecology. Philadelphia: Proceedings of the Academy of Science 105:1-12.

James, F. C. 1971. Ordination of habitat relationships among breeding birds. Wilson Bulletin 83:215-236.

Jarvinen, O., and R. A. Vaisanen. 1979. Changes in bird population as criteria of environmental change. Holartic Ecology 2:75-80.

Johnson, D. H. 1981. Application of the guild concept for environmental impact assessment of terrestrial vegetation. Journal of Environmental Management 13:205-222.

Kantrud, H. A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Canadian Field Naturalist 95:404-417.

Kepler, C. B., and J. M. Scott. 1981. Reducing bird count variability by training observers. Studies in Avian Biology 6:366-371.

Kirsch, L. M., and K. F. Higgins. 1976. Upland sandpiper nesting and management in North Dakota. Wildlife Society Bulletin 4:16-20.

Kleiner, E. F., and K. T. Harper. 1972. Environmental and community organization in grasslands of Canyonlands National Park. Ecology 55:229-309.

Kleiner, E. F., and K. T. Harper. 1977a. Occurrence of four major perennial grasses in relation to edaphic factors in a pristine community. Journal of Range Management 30:286-289.

Kleiner, E. F., and K. T. Harper. 1977b. Soil properties in relation to crytogamic ground cover in Canyonlands National Park. Journal of Range Management 30:202-205.

Knopf, F. L. 1987. Conservation of avian diversity in riparian corridors. Bird Conservation Vol. 4.

Knopf, F. L., and R. W. Cannon. 1982. Structural resilience of a *Salix* community to changes in grazing practices. Pp. 198-207 *in* J. M. Peek and P. D. Dalke (Eds.), Wildlife-livestock relationships symposium. University of Idaho. USDA Forest Service Wildlife and Range Experiment Station, Moscow.

Knopf, F. L., J. A. Sedgewick, and R. W. Cannon. 1988. Guild structure of a riparian avifauna relative to seasonal cattle grazing. Journal of Wildlife Management 52:280-290.

Lack, D. 1933. Habitat selection in birds, with special reference to the effects of aforestation on the Breckland avifauna. Journal of Animal Ecology 2:239-262.

MacArthur, R. H. 1964. Environmental factors affecting bird species diversity. American Naturalist 98:387-397.

MacArthur, R. H., and J. W. MacArthur. 1961. On bird species diversity. Ecology 42:594-598.

MacArthur, R. H., J. W. MacArthur, and J. Preer. 1962. On bird species diversity II: Prediction of bird census from measurements. American Naturalist 96:167-174.

Mayfield, H. F. 1981. Problems in estimating population size through counts of singing males. Studies in Avian Biology 6:220-224.

Medin, D. E. 1986. Grazing and passerine breeding birds in a Great Basin low-shrub desert. Great Basin Naturalist 46:567-572.

Meinke, R. J. 1975. A preliminary ecological and historical survey of north and south Caineville Mesas, Wayne, County, Utah. Boulder, CO: Western Interstate Commission for Higher Education. 127pp.

Morrison, M. L. 1986. Bird populations as indicators of environmental change. Current Ornithology 5:429-451.

Mosconi, S. L., and R. L. Hutto. 1982. The effects of grazing on the landbirds of western Montana riparian habitats in grazing practices. Pp. 198-207 *in* J. M. Peek and P. D. Dalke (Eds.), Wildlife-livestock relationships symposium. University of Idaho. USDA Forest Service Wildlife and Range Experiment Station, Moscow.

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist 100:65-75.

Pickford, G. D. 1966. The influence of continued heavy grazing and promiscuous burning on spring-fall ranges in Utah. Ecology 13:159-171.

Reynolds, J. A., and C. H. Trost. 1980. The response of native vertebrate populations to crested wheatgrass planting and grazing by sheep. Journal of Range Management 33:122-125.

Romme, W. H., K. D. Heil, J. M. Porter, and R. Fleming. 1993. Plant communities of Capitol Reef National Park, Utah. National Park Service Colorado Plateau Technical Report Series NPS/NAUCARE/NRTR-93/02.

Root, R. B. 1967. The niche exploitation pattern of the blue-grey gnatcatcher. Ecological Monographs 37:317-350.

Rosenstock, S. S. 1993. Final report, part II: effects of livestock grazing on shrub-grassland small mammal fauna and habitats in Capitol Reef National Park, Utah. Unpublished report prepared for the National Park Service, Capitol Reef National Park.

Rotenberry, J. T. 1985. The role of habitat in avian community composition: physiognomy or floristics? Oecologia 67:213-217.

Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. Ecology 57:773-782.

Ryder, R. A. 1978. Occurrence and habitat requirements of avian species found in the Rocky Mountain Region. Unpublished report prepared for the USDA Forest Service, Rocky Mountain Range and Experiment Station, Fort Collins, Colorado. 284pp.

Scott, J. M., F. L. Ramsey, and C. B. Kepler. 1981. Distance estimation as a variable in estimating bird numbers. Studies in Avian Biology 6:334-340.

Sedgewick, J. A., and F. L. Knopf. 1987. Breeding bird response to cattle grazing in a cottonwood bottomland. Journal of Wildlife Management 51:230-237.

Severinghaus, W. D. 1981. Guild theory development as a mechanism for assessing environmental impacts. Environmental Management 5:187-190.

Smith, J. F., Jr.; L. C. Huff; E. N. Hinrichs; and R. G. Luedke. 1963. Geology of the Capitol Reef area: Wayne and Garfield Counties, Utah. Geological Survey Professional Paper 363. U.S. Government Printing Office, Washington, D. C.

Thornbury, W. 1965. Regional geomorphology of the United States. John Wiley and Sons, New York. 609pp.

Tomoff, C. S. 1974. Avian species diversity in desert scrub. Ecology 55:396-403.

Townsend, T. E., and P. J. Smith. 1977. Proceedings of a seminar on improving fish and wildlife benefits in range management. U.S. Fish and Wildlife Service Program. Washington, D.C. FWS/OBS-77/I.

Tuhy, J. S., and J. A. MacMahon. 1988. Vegetation and relict communities of Glen Canyon National Recreation Area. Unpublished report prepared for the National Park Service, Glen Canyon National Recreation Area, contract no. CX1200-6-B076.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Verner, J. 1984. The guild concept applied to management of bird populations. Environmental Management 8:1-14.

West, N. E. 1983. Southeastern Utah galleta-threeawn shrub-steppe. Pp. 413-421 *in* N. E. West (Ed.), Temperate deserts and semi-deserts, vol. 5, ecosystems of the world. Amsterdam: Elsevier.

West, N. E. 1988. Intermountain deserts, shrubsteppes and woodlands. Pp. 209-230 *in* M. G. Barbour and W. D. Billings (Eds.), North American terrestrial vegetation. New York: Cambridge University Press.

West, N. E., and K. I. Ibrahim. 1968. Soil-vegetation relationships in the shadscale zone of southeastern Utah. Ecology 49:445-456.

Wiens, J. A. 1969. An approach to the study of grassland birds. Ornithology Monographs 8.

Wiens, J. A. 1973. Inter-territorial habitat variation in grasshopper and savannah sparrows. Ecology 54:877-884.

Wiens, J. A. 1974. Habitat heterogeneity and avian community structure in North American grasslands. American Midland Naturalist 91:195-213.

Wiens, J. A. 1977. On competition and variable environments. American Scientist 65:590-597.

Wiens, J. A. 1983. Avian community ecology: an iconoclastic view. Pp. 355-403 *in* A. H. Brush and G. A. Clark, Jr., (Eds.), Perspectives in ornithology. Cambridge, U.K.: Cambridge University Press.

Wiens, J. A. 1985. Habitat selection in variable environments: shrub-steppe birds. Pp. 227-251 *in* M. L. Cody (Ed.), Habitat selection in birds. Academic Press, Inc. 558pp.

Wiens, J. A., and J. T. Rotenberry. 1981. Habitat associations and community structure of birds in shrubsteppe environments. Ecological Monographs 51:21-41.

Willey, D. W. 1989. Effects of livestock grazing on avifauna and habitats, Capitol Reef National Park, Utah. Unpublished report prepared for the National Park Service, Capitol Reef National Park. 68pp.

Zar, J. H. 1984. Biostatistical analysis. Englewood Cliffs, N.J.: Prentice-Hall. 718pp.

APPENDIX I

Common names and associated acronyms of birds appearing in this report. The list includes birds seen in Canyonlands and Capitol Reef National Parks and South Caineville Mesa, Utah.

Common Name	Acronym
ashe-throated flycatcher	ASFL
black chinned hummingbird	BCHU
blue-grey gnatcatcher	BGGN
blue grosbeak	BLGR
Brewer's blackbird	BRBL
brown-headed cowbird	BHCO
broad-tailed hummingbird	BTHU
black-throated sparrow	BTSP
canyon wren	CAWR
chipping sparrow	CHSP
Clark's nutcracker	CLNU
house finch	HOFI
horned lark	HOLA
lazuli bunting	LABU
lark sparrow	LASP
lesser goldfinch	LEGO
loggerhead shrike	LOSH
MacGuillivary's warbler	MAWA
mocking bird	MOBI
mountain bluebird	MOBL
mourning dove	MODO
northern oriole	NOOR
pinyon jay	PIJA
purple finch	PUFI
rough-winged swallow	ROSW
rock wren	ROWR
ruby-crowned kinglet	RUKI
sage sparrow	SAGE
Say's phoebe	SAPH
savanaugh sparrow	SASP
sage thrasher	SATH
scrub jay	SCJA
Scott's oriole	SCOR
solitary vireo	SOVI
vesper sparrow	VESP
violet green swallow	VGSW
Virginia warbler	VIWA
western meadowlark	WEME
western tanager	WETA
white-crowned sparrow	WCSP
Wilson's warbler	WIWA
white-throated swift	WTSW
yellow-rumped warbler	YRWA

APPENDIX II

Common and scientific names of plants identified at South Desert (Capitol Reef National Park) and on South Caineville Mesa (Henry Mountains Resource Area), Utah Spring 1989

I. South Desert, Capitol Reef National Park:

Family/Common name	Scientific name
Grasses:	
indian ricegrass	*Oryzopsis hymenoides*
galleta grass	*Hilaria jamesii*
blue grama	*Bouteloua gracilis*
threeawn	*Aristida purpurea*
alkali sacoton	*Sporobolus airoides*
sand dropseed	*Sporobolus cryptandrus*
Shrubs:	
four-wing saltbush	*Atriplex canescens*
shadscale	*A. confertifolia*
Gardner saltbush	*A. gardneri*
rubber rabbitbrush	*Chrysothamnus nauseosus*
Douglas rabbitbrush	*C. vicidiflorus*
winterfat	*Ceratoides lanata*
broom snakeweed	*Gutierrezia sarothrae*
Bigelow's sage	*Artemesia bigelovii*
Great Basin sagebrush	*A. tridentata*
Torrey mormon tea	*Ephedrea torreyana*
green mormon tea	*E. viridis*
spiny horsebrush	*Tetradymia spinosa*
Forbs:	
globemallow	*Sphaeralcea parvifolia*
curlycup gumweed	*Grindelia squarrosa*
cryptantha	*Cryptantha fulvocanescens*
tansy mustard	*Descurainia sophia*
	Eriogonum spp.
	Senecio spps.
Russian thistle	*Salsola iberica*
	Astragalus spps.
yellow sweet clover	*Melilotus officinalis*
storksbill	*Erodium circutarium*
evening primrose	*Oenothera* spps.
Vernal daisy	*Erigeron pumilus*
Trees:	
Utah juniper	*Juniperus osteosperma*
Pinon	*Pinus edulis*
Fremont cottonwood	*Populus fremontii*
Cactus:	
prickly pear	*Opuntia* spps.
fishhook cactus	*Scherocactus whipplei*

II. South Caineville Mesa, Wayne County, Utah:

Family/Common name	Scientific name
Grasses:	
indian ricegrass	*Oryzopsis hymenoides*
galleta grass	*Hilaria jamesii*
blue grama	*Bouteloua gracilis*
threeawn	*Aristida purpurea*
alkali sacoton	*Sporobolus airoides*
sand dropseed	*Sporobolus cryptandrus*
Shrubs:	
four-wing saltbush	*Atriplex canescens*
shadscale	*A. confertifolia*
Gardner saltbush	*A. gardneri*
rubber rabbitbrush	*Chrysothamnus nauseosus*
Douglas rabbitbrush	*C. vicidiflorus*
winterfat	*Ceratoides lanata*
broom snakeweed	*Gutierrezia sarothrae*
Bigelow's sage	*Artemesia bigelovii*
Torrey mormon tea	*Ephedrea torreyana*
green mormon tea	*E. viridis*
spiny horsebrush	*Tetradymia spinosa*
Forbs:	
globemallow	*Sphaeralcea parvifolia*
curlycup gumweed	*Grindelia squarrosa*
yellow cryptantha	*Cryptantha flava*
cryptantha	*C. fulvocanescens*
tansy mustard	*Descurainia sophia*
	Eriogonum spps.
	Senecio spps.
	Astragalus spps.
evening primrose	*Oenothera* spps.
Vernal daisy	*Erigeron pumilus*
Trees:	
Utah juniper	*Juniperus osteosperma*
Fremont cottonwood	*Populus fremontii*
Cactus:	
prickly pear	*Opuntia* spps.
fishhook cactus	*Scherocactus whipplei*
Wright's fishhook cactus	*S. wrightiae*

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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