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Paul B. Kannowski, *Editor*
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THE COVER AND ITS ARTIST

The scene on the cover is repeated throughout the Great Plains in late spring when bumble bees pollinate purple loco flowers. This sketch was drawn by Bonnie Heidel of Mandan for this volume. Bonnie, a plant ecologist with the North Dakota Natural Heritage Inventory, has illustrated plants and animals for the U.S. Fish & Wildlife Service, the Minnesota DNR, and the North Dakota Chapter of The Wildlife Society. Her drawing was rendered from a scene at a prairie remnant in the Red River valley of North Dakota.

Grassland Habitat Management Using Prescribed Burning in Wind Cave National Park, South Dakota

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Fire is one of the natural forces under which grasslands in Wind Cave National Park (WCNP) evolved (Gartner 1975, 1977; Gartner et al. 1978). Periodic natural fires maintained the vegetation in an early successional stage of development and were important in determining the location of the prairie-forest border, With the feeling that fire is man's enemy and the resulting sophisticated fire fighting equipment and techniques that have been developed, natural fires have soon been suppressed. This has enabled areas of ponderosa pine (*Pinus ponderosa*) to expand throughout the Black Hills of South Dakota, decreasing the area of mixed-grass prairie. Vegetative fuels have sometimes increased to dangerous levels as a result. In order to alleviate these problems, efforts have been made by the Park to restore fire as a natural part of the ecosystem. The primary fire management goals of the Park include: 1) reduction of ponderosa pine encroachment, 2) reduction of excessive vegetative fuels, and 3) propagation of native shrubs, forbs, and grasses and the removal of exotic plant species (Lovass 1976).

In September 1973, personnal of Wind Cave National Park began conducting annual burns. Several studies on the effects of fire in the Black Hills have since been conducted. Early studies emphasized responses of prairie and forest vegetation to prescribed burning. To complete our understanding of fire's role, information was needed regarding effects of fire on bird and small mammal communities within grasslands of the Park. That led to a four-year (1980-83) investigation on fire ecology and fire's effect on the vertebrates of the Park and their food and cover supply.

METHODS

This study was conducted within grassland communities of Wind Cave National Park, South Dakota (Fig. 1). The Park covers 11,353 ha of prairie, forested ridges, canyons, and mountains, located in the southeastern foothills of the Black Hills. It is predominantly a prairie park including a wide variety of both tall- and short-grass species as well as cool and warm season grasses.

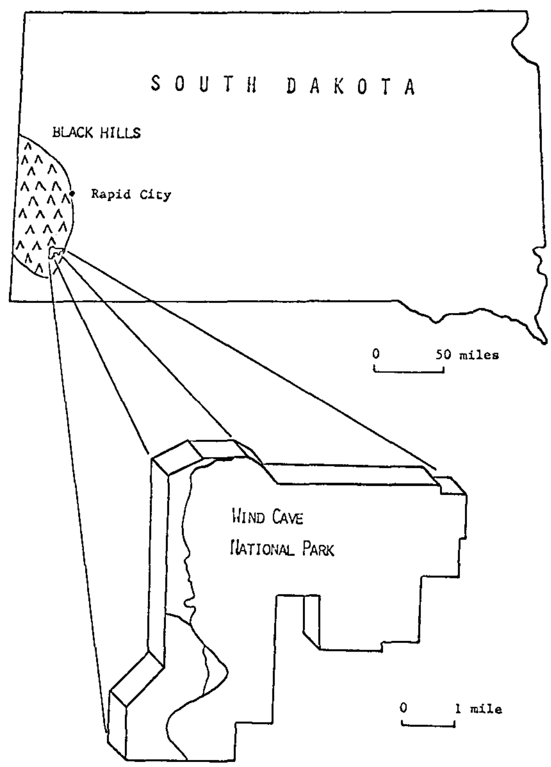

Fig. 1. Location of Wind Cave National Park in the Black Hills of South Dakota.

Two study areas were chosen in 1980 because of prescribed burning activities scheduled for the spring of 1981. The Bison Flats study area consists of mixed-grass prairie, with short grasses prevalent and scattered ponderosa pine stands. Cool season grasses were dominant in the Red Valley study area with trees limited to riparian stands. Study transects were established throughout mixed-grass prairies in WCNP prior to the 1980 summer censusing. One control and one burn transect were established in each area. Transects were 805 m long. Metal stakes were placed 60.4 m from the transect line to define 10 ha census strips. Breeding bird surveys, small mammal censuses, insect surveys, and vegetative sampling were conducted within those designated boundaries.

Vegetative Analysis

Canopy-coverage method as described by Daubenmire (1959) and quadrat clipping method described by Kershaw (1973), Mueller-Dombois and Ellenberg (1974), and Goldsmith and Harrison (1976) were used for vegetative analysis. A 9 x 7 grid was centered on each transect line. The nine rows were spaced evenly over the 805 m transect at 101 m intervals. Each row contained seven stations 20 m apart, making a total of 63 stations per plot.

A 1.0 x 0.5 m Daubenmire frame was used at each station to make two coverage estimvates. Each reading was made approximately 2 m right or left of the center line, parallel to the row. Percentage of ground cover by species was then approximated as the observer stood directly over the frame. An estimate was made of percent bare ground and percent dead material present.

After coverage estimates were made, vegetation was clipped to within 1.3 cm of the ground and placed in a paper bag. Later, each sample was separated by species and number of items counted. Samples were then air dried and weighed.

Breeding Bird Census

Estimates of breeding bird densities were calculated using the line transect method developed by Emlen (1971), 1977), foregoing determination of a cue frequency as suggested by Mikol et al. (1979). On field maps observers recorded the location of each bird detected within the 10 ha belt transect. Right angle distance was then estimated and recorded on field forms. Frequency histograms were prepared for 10 m intervals and "effective width" of censusing determined for each species (Mikol 1980). Density was calculated by dividing the number of observations of each species by effective width times distance. Two five-day censuses were conducted at sunrise between 25 May and 29 June. The Man-Whitney test was used to interpret differences in peak singing male densities under pre-burn and post-burn conditions as well as differences between burn and control areas.

Small Mammal Census

The capture-recapture method was used to evaluate effects of fire on small mammal populations. One Sherman live trap of rat size was placed at each station on a 7 x 5 grid centered on the transect line. Rows were approximately 33.5 m apart and each contained five stations 20.1 m apart. Thirty-five traps were used per 1.7 ha transect during each trapping session.

Traps were pre-baited with peanut butter for three days prior to the five-day census period. Traplines were checked daily with all captured animals toe-clipped, identified to species, sexed, aged, and weighed before being released. Population estimates were calculated using the weighted mean method (Begon 1979). Moses' test of extreme reactions was used to determine if differences in pre-burn and post-burn densities were significant ($P < 0.05$) among sites.

Insect Survey

Two insect surveys were made, a vegetative sweep and a combined vegetation and ground survey. Vegetative sweeps were taken by walking center lines of the bird census transects. Vegetation was swept with an insect net at five step intervals. Insects collected were transferred to alcohol vials for later identification and counting. Surveys consisted of 100 sweeps per transect.

The combined vegetative sweep and ground survey used ten 1.22 x 1.22 m plots. Insects discovered were placed in alcohol vials for later identification and counting.

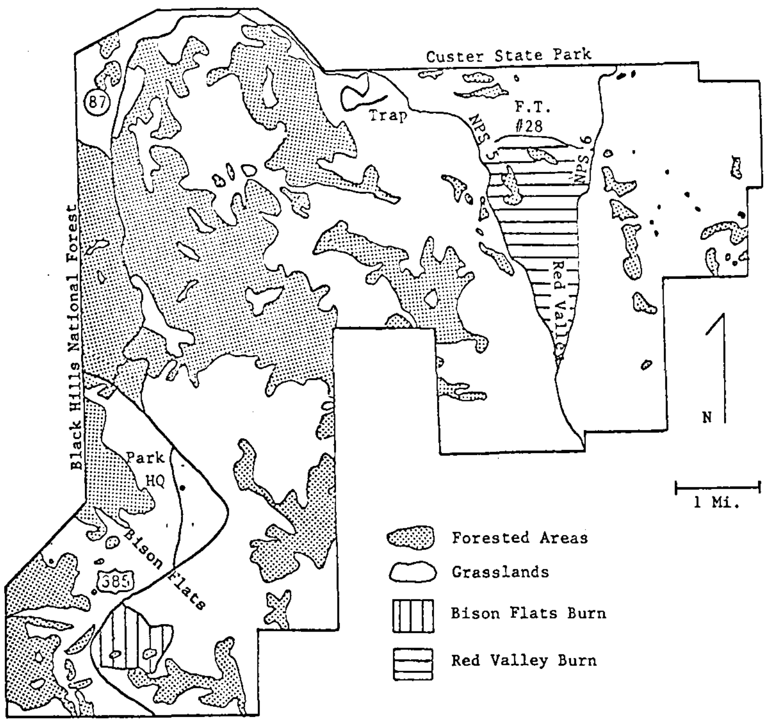

Fig. 2. Location of areas prescribed burned in April 1981 within Wind Cave National Park.

Burning Treatments

The Red Valley burn occurred on 1 April 1981 and covered 444.5 ha of mixed-grass prairie and 54.4 ha of forest land (Fig. 2). Burning began at 1010 hours with the firing of the perimeter of the burn completed by 1315 hours. The fire spread rapidly eastward and by 1530 hours had completely burned itself out in the grassland areas, but fires continued to burn for several days in the forested areas. The temperature was 62°F with a relative humidity of 24 percent and a wind of 9 mph from the west.

Bison Flats was burned on 23 April 1981 and covered 159 ha of mixed-grass prairie and 20.2 ha of forest land. Burning began at 0940 hours with the perimeter of the burn area, excluding the northern boundary, ignited. Firing was completed at 1415 hours. Due to the late burn, many of the cool season species of grasses had already began to green up resulting in a slow spreading fire, requiring strip firing of the grassland portion of the burn. This was completed by 1530 hours. The temperature was 66°F with a relative humidity of 33 percent and a wind of 7 mph from the northwest.

RESULTS AND DISCUSSION

Plant Response

Weaver and Albertson (1956) recognized four major seral stages in Great Plains grasslands. Those are first weed stage, second weed stage, early native grass stage, and late grass stage. Because of intense heat from dry fuel present, fall widlfires set succession back to the transition between the first weed stage and the second weed stage (Fig. 3). Neither of the 1981 spring burns in WCNP moved succession back to an early seral stage as do fall fires. The Bison Flats burn, in late spring when active forb and cool season growth had begun, did more to enhance warm season grasses present on the area than to set succession back (Table 1). The Red Valley burn, which was completed before vegetation had begun growth, set succession back to the transition between the second weed stage and early native grass stage. Perennial species, such as green needlegrass (*Stipa viridula*), needle-and-threat grass (*Stipa comata*), little bluestem (*Andropogon scoparies*), and western wheatgrass (*Agropyron smitthii*), decreased in percent of ground-coverage the year of the fire but then showed rapid increases the two years following the fire (Table 2). Bare ground-coverage increased 26 percent immediately after the fire but with the resulting increased plant production the amount of bare ground decreased 29 percent to below pre-burn estimates by 1983, two years after the burn.

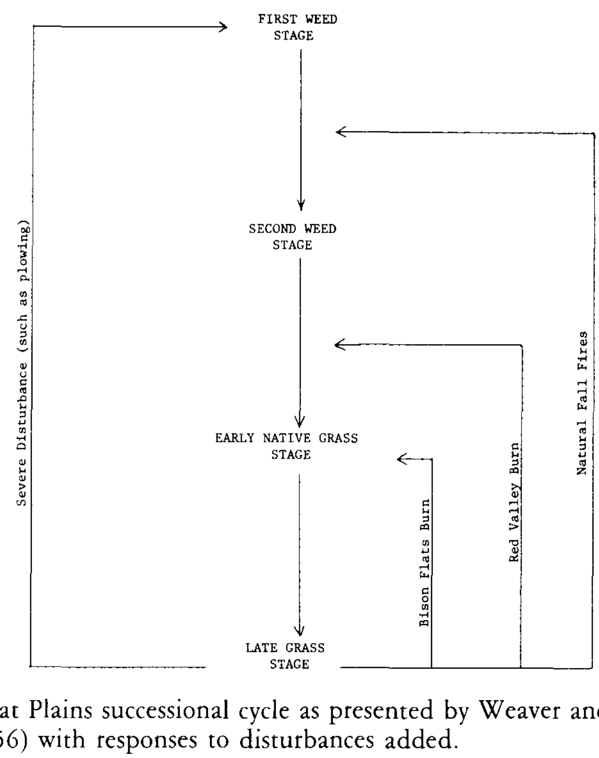

Fig. 3. Great Plains successional cycle as presented by Weaver and Albertson (1956) with responses to disturbances added.

Table 1. Estimates of ground-coverage for range species found on the Bison Flats study area, 1980-83 (percent, n = 126).

	Control				Burn			
	1980	1981	1982	1983	1980	1981	1982	1983
Annuals								
Japanese Brome	0.1	0.1	1.1	7.9	0.1	0.1	0.6	1.0
Perrennials								
Green Needlegrass	0.4	0.9	0.2	0.1	0.2	1.0	0.0	0.0
Needle-and-thread Grass	6.1	7.2	0.2	4.1	6.6	5.8	0.0	6.7
Little Bluestem	6.0	8.2	6.2	2.1	7.0	4.5	0.6	4.2
Kentucky Bluegrass	3.3	3.2	7.8	13.5	6.4	2.6	5.3	2.8
Western Wheatgrass	0.7	1.7	3.6	5.0	1.2	3.2	3.5	1.9
Common Buffalograss	0.0	0.0	0.6	0.2	0.0	0.0	0.3	0.9
Blue Grama	1.2	1.9	2.1	0.0	4.4	5.8	1.2	0.0
Sedge	23.5	19.7	26.1	33.6	14.5	13.2	13.2	26.6
Other Grasses	0.6	0.8	1.4	0.2	0.3	1.2	2.9	4.6
Forbs								
Louisiana Sagewort	0.7	0.2	0.2	0.5	1.5	1.2	1.0	1.1
Fringed Sagebrush	1.8	2.5	4.5	5.3	2.8	1.8	2.2	7.6
Scurfpeas	1.8	2.1	6.4	7.2	2.9	4.8	2.6	4.5
Other	3.6	5.5	8.8	4.8	5.3	6.2	6.6	5.1
Bare Ground	32.7	28.6	25.0	16.0	35.9	45.2	56.3	32.1

Measurements of other vegetative parameters further showed the effect of the April 1981 prescribed burning treatments. Frequency of perennials (Table 3) decreased 25 percent but their air-fried biomass (Table 4) increased 38 percent meaning fewer but larger, hardier plants. Annuals, in contrast, increased in numbers on both the controls and burns, but on the burns with little increase in biomass, meaning more smaller, less hardy plants. The native forbs, such as Louisiana sagewort (*Artemisia ludoviciana*), fringed sagebrush (*Artemisia frigida*), and scurfpeas (*Psoralea* spp.), increased in both density and biomass on the burns. The exotic forb, sweet clover (*Melilotus* spp.), was negatively affected by the burning treatments in the Red Valley study area. It accounted for up to 19 percent of the ground-coverage on the control, but was not found on the burned area (Table 2).

Sweet clover was removed by the spring burn in WCNP, but to manage for other plant species may require burning at a different phenological time (as well as taking into account aspect, moisture conditions, wind conditions, and whether the fire is heading, flanking, or backing). If managing for rhizomatous species

Table 2. Estimates of ground-coverage for range species found on the Red Valley study area, 1980-83 (percent, n = 126).

	Control				Burn			
	1980	1981	1982	1983	1980	1981	1982	1983
Annuals								
Japanese	2.1	3.6	10.0	17.2	0.8	0.3	4.2	39.3
Perennials								
Green Needlegrass	2.4	2.1	1.6	0.8	4.2	3.2	0.0	2.0
Needle-and-thread Grass	5.9	8.4	1.6	2.3	8.9	5.5	0.0	7.9
Little Bluestem	2.6	3.6	5.2	0.0	6.4	4.1	1.2	0.6
Kentucky Bluegrass	5.9	5.7	15.5	40.1	4.0	1.3	2.9	5.6
Western Wheatgrass	4.0	6.7	8.0	1.5	3.7	6.5	7.1	16.0
Common Buffalograss	6.4	4.0	1.7	0.0	1.7	2.7	4.8	0.2
Blue Grama	0.3	0.7	1.9	0.0	1.2	1.2	5.8	5.8
Sedge	3.4	3.7	3.2	1.6	6.9	7.2	3.1	1.2
Other Grasses	2.5	3.0	0.7	0.0	1.3	2.1	1.5	0.9
Forbs								
Louisiana Sagewort	0.3	0.1	0.3	0.9	0.2	0.1	0.7	0.2
Fringed Sagebrush	1.1	1.1	3.0	5.3	1.1	0.3	0.3	0.4
Scurfpeas	2.1	2.6	7.5	2.5	2.4	3.5	3.7	3.1
Other	1.8	4.6	19.6	13.0	3.4	3.6	8.0	2.1
Bare Ground	24.7	21.3	16.6	15.1	23.5	39.4	49.0	15.2

over shrubs and fine-leaved bunchgrasses, burning must occur in the fall (Blaisdell 1953). Conversely, if managing for annual grasses over perennial bunchgrasses, burning must occur in the summer (Wright and Klemmedson 1965). Burns at WCNP are conducted in the spring when there is less chance of a fire escaping because of the moist ground conditions. This limited their plant species management to plants positively affected by spring burns, such as warm season grasses (Wright 1974).

It is important to point out here that fire is a natural, inexpensive alternative to herbicides when attempting to remove unwanted plant species, such as sweet clover in the WCNP grasslands. The natural prairie vegetation is even further stimulated by the fire resulting in a productive, early seral stage grassland.

Park management seeks to prevent uncontrolled fires on parkland and to reduce risk of fires spreading into surrounding private ranchlands. Reductions of dead plant material of 71 and 72 percent respectively were accomplished by 1981 spring burns on Bison Flats and Red Valley study areas, compared to controls.

Table 3. Estimates of frequency of occurrence for range species found on the Bison Flats and Red Valley study areas, 1980-83 (percent, n = 126).

	Bison Flats							
	Control				Burn			
Plant Type	1980	1981	1982	1983	1980	1981	1982	1983
Annuals	4.0	2.8	9.5	43.7	4.4	1.2	7.9	11.1
Perennials	28.7	29.7	28.6	25.3	28.6	31.8	24.0	25.1
Forbs	28.6	31.7	19.0	31.4	34.0	35.2	25.8	35.7
Other	11.5	11.9	11.1	1.6	4.8	11.9	38.1	46.0
	Red Valley							
	Control				Burn			
Plant Type	1980	1981	1982	1983	1980	1981	1982	1983
Annuals	32.9	28.6	25.4	48.4	13.3	6.8	23.8	92.1
Perennials	37.2	30.0	24.7	16.7	36.6	35.3	25.0	25.2
Forbs	24.9	27.0	20.9	23.8	24.1	22.1	17.3	9.4
Other	38.5	27.0	4.8	0.0	17.8	16.3	17.5	6.3

Table 4. Estimates of air-dried biomass for range species found on the Bison Flats and Red Valley study areas, 1982-83 (grams, N = 126).

	Bison Flats			
	Control		Burn	
Plant Type	1982	1983	1982	1983
Annuals	0.42	4.19	0.28	0.39
Perennials	19.95	19.73	8.83	12.15
Forbs	18.04	14.81	13.11	11.32
Other	0.66	0.01	0.42	0.93
	Red Valley			
	Control		Burn	
Plant Type	1982	1983	1982	1983
Annuals	5.50	5.27	2.59	13.08
Perennials	17.17	12.48	12.52	8.62
Forbs	28.40	11.71	8.68	3.24
Other	0.00	0.00	0.29	0.14

Breeding Bird Response

Twenty-two species of birds were observed on the WCNP grasslands during the breeding bird census. The grasshopper sparrow (*Ammodramus savannarum*) was the only bird significantly affected ($P < 0.05$) by the burning treatments, decreasing in numbers immediately after the fire (Table 5). The western meadowlark (*Sturnella neglecta*) generally decreased after the burns while the vesper sparrow (*Pooecetes gramineus*) was positively affected. Reasons for the reductions in singing male grasshopper sparrows include loss of nesting cover (removal of dead material and important plant species) and loss of food source (reduction in insects and seeds). There was 50 percent less total insects available on the Bison Flats burn and 71 percent less total insects available on the Red Valley burn as a food source (Table 6). Duration of the reduced numbers appears to last no longer than two or three breeding seasons after treatment. The 1983 density estimates for the burned areas were often greater than the 1980 pre-burn estimates indicating the long term benefits of prescribed burning.

Mammal Response

The prairie deer mouse (*Peromyscus maniculatus bairdii*) and thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) were the dominant small mammal species present (Table 7). Prescribed burning resulted in immediate increases in deer mice densities the year of the burn on the Bison Flats area while ground squirrel densities generally decreased. The resulting increased amount of exposed seeds from the fire's partial removal of the litter layer may have benefitted the prairie deer mice. The increased deer mice density lasted only one season dropping below pre-burn figures by 1983. The lack of seed-eating insects in the burned areas would indicate the seeds were scarce in the area and may have contributed to the decline of the mice.

The bison (*Bison bison*) showed a strong affinity for the WCNP prescribed burn areas. They fed within the confines of the Red Valley burn in 1981 and 1982, moving to another area burned by a wildfire in 1983. Their continual grazing may be important in delaying the normal progression of plant succession on the Red Valley burn.

SUMMARY

A prescribed burning program was initiated at Wind Cave National Park, South Dakota in 1973. A study to evaluate the effect of those treatments on the brid and small mammal communities in the grasslands of the Park was begun in 1980.

The vegetative analysis showed immediate reductions in perennial species and the amount of dead material present after burning with a resulting increase in both two years later. Bare ground-coverage increased immediately after the fire, indicating a loss of protective cover for birds and small mammals. However, the estimates two years after the burn were below the 1980-81 levels.

Twenty-two species of birds were observed on the WCNP grasslands during the breeding bird census. Two species, the grasshopper sparrow and western

Table 5. Estimates of breeding bird densities for the Wind Cave National Park study transects (singing males per hectare, n = 5).

Transect	Status	1980		1981		1982		1983	
		x̄	SD	x̄	SD	x̄	SD	x̄	SD
Bison Flats	Control								
Grasshopper Sparrow		.71	.45	.78	.36	.58	.41	.33*	.45
Western Meadowlark		.67	.82	.33	.42	.55	.50	.29*	.50
Upland Sandpiper		.06	.46	.15	.28	.04	.42	.10	.44
Vesper Sparrow		.12	.35	.00	.00	.06	.40	.16	.22
TOTAL		1.70	.28	1.26	.27	1.23	.30	1.55	30
Bison Flats	April 1981 Burn								
Grasshopper Sparrow		.63	.36	.15*+	.30	.16+	.47	.45+	.30
Western Meadowlark		.30	.39	.13+	.39	.20	.50	1.00+	.44
Upland Sandpiper		.24	.30	.15	.14	.06	.00	.06	.54
Vesper Sparrow		.00	.00	.08	.47	.12	.00	.08	.35
TOTAL		1.51+	.20	.81*+	.14	.60+	.27	1.87+	.22
Red Valley	Control								
Grasshopper Sparrow		.67	.35	.99	.37	.64	.42	.43	.37
Western Meadowlark		.73	.45	.48	.39	.60	.46	.42	.40
Upland Sandpiper		.04	.57	.00	.00	.00	.00	.00	.00
Vesper Sparrow		.06	.40	.00	.00	.00	.00	.00	.00
TOTAL		1.50	.28	1.47	.30	1.26	.32	.93	.27
Red Valley	April 1981 Burn								
Grasshopper Sparrow		.68	.36	.10*+	.32	.71*	.47	.36+	.36
Western Meadowlark		.31	.39	.28	.46	.68*	.45	.46	.36
Upland Sandpiper		.00	.00	.00	.00	.00	.00	.04	.00
Vesper Sparrow		.00	.00	.00	.00	.00	.00	.00	.00
TOTAL		.99+	.28	.38*+	.33	1.41*+	.36	.88+	.25

*Density is significantly different ($P < 0.05$) from the previous year's density.
+Density is significantly different ($P < 0.05$) from the control transect for that year.

Table 6. Total number of insects per order captured by the 100 sweeps per transect and the ten 1.22 x 1.22 m plots per transect methods of sampling, 1983.

	100 sweeps/transect				10 plots			
	Bison Flats		Red Valley		Bison Flats		Red Valley	
Order	Control	Burn	Control	Burn	Control	Burn	Control	Burn
Orthoptera	2	6	3	3	0	2	3	3
Heteroptera	366	128	133	16	442	159	150	28
Neuroptera	1	0	0	0	0	0	0	0
Coleoptera	10	25	8	6	1	18	6	15
Lepidoptera	2	0	1	3	0	1	0	4
Diptera	9	55	28	11	8	21	25	8
Hymenoptera	14	11	0	2	8	5	1	7
TOTAL INSECTS	404	225	173	41	459	206	185	65
Spiders	10	8	3	3	8	9	7	11

Table 7. Estimates of small mammal densities for the Wind Cave National Park study transects (individuals per hectare, n = 5).

Transect	Status	1980 x̄	1980 SD	1981 x̄	1981 SD	1982 x̄	1982 SD	1983 x̄	1983 SD
Bison Flats	Control								
Prairie Deer Mouse		1.23	0.80	0.00	0.00	5.93*	1.02	0.00	0.00
Thirteen-lined Ground Squirrel		1.70	1.02	4.10*	2.71	0.31*	0.63	1.20	0.80
Prairie Vole		0.00	0.00	0.00	0.00	0.62*	0.51	27.71*	3.37
TOTAL		2.93	2.18	4.10	2.71	6.86	0.80	28.91*	2.96
Bison Flats	April 1981 Burn								
Prairie Deer Mouse		0.62+	0.62	3.26*+	0.62	1.54*	0.95	0.00	0.00
Thirteen-lined Ground Squirrel		0.00	0.00	0.00	0.00	0.00	0.00	0.30*+	0.62
Prairie Vole		0.00	0.00	0.00	0.00	0.00	0.00	3.92*+	1.90
TOTAL		0.62+	0.62	3.26*	0.62	1.54*+	0.95	4.22+	1.87
Red Valley	Control								
Prairie Deer Mouse		0.00	0.00	0.00	0.00	0.62*	0.51	0.00	0.00
Thirteen-lined Ground Squirrel		1.03	0.51	0.62	0.62	0.62	0.51	0.00	0.00
Prairie Vole		0.00	0.00	0.00	0.00	0.00	0.00	0.30*	0.62
TOTAL		1.03	0.51	0.62	0.62	1.24	1.08	0.30*	0.62
Red Valley	April 1981 Burn								
Prairie Deer Mouse		0.83+	0.95	3.99+	1.29	0.62*	0.51	0.00	0.00
Thirteen-lined Ground Squirrel		0.62+	1.02	0.00	0.00	0.62*	0.51	0.60+	1.02
Prairie Vole		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL		1.45+	2.33	3.99+	1.29	1.24*	0.62	0.60	1.02

*Density is significantly different ($P < 0.05$) from the previous year's density.
+Density is significantly different ($P < 0.05$) from the control transect for that year.

meadowlark, accounted for the majority of observations during the census work. The grasshopper sparrow was the only bird significantly affected ($P < 0.05$) by the burning treatments, decreasing in numbers immediately after the fire. The western meadowlark generally decreased. Reasons for the reductions in singing males include loss of nesting cover and loss of food source. Duration of the reduced numbers appears to last no longer than two or three breeding seasons after treatment.

The prairie deer mouse and thirteen-lined ground squirrel were the dominant small mammal species present in the WCNP grasslands and immediate increases in deer mice densities with general decreases in ground squirrel densities resulted from the prescribed burns. Seeds, exposed from the fire's partial removal of the litter layer, may have benefitted the prairie deer mouse. The increased deer mice density lasted only one season and the lack of seed-eating insects two years following the burns would indicate that seeds were scarce in the area and may have contributed to the decline of the mice.

The results from this four-year study show that bird and small mammal populations adjust to the fire-altered habitat and that these adjustments appear temporary and will continue to change as the vegetation recovers from the burn. The grassland species have been historically subjected to fire and WCNP is encouraged to continue with its fire program using controlled burns to maintain the grassland-forest habitat typical of the Black Hills.

ACKNOWLEDGMENTS

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LITERATURE CITED

Begon, M. 1979. Investigating animal abundance, capture-recapture for biologists. University Park Press, Baltimore.

Blaisdell, J. P. 1953. Ecological affects of planned burning of sage-brush-grass range on the Upper Snake River plains. U.S. Dep. Agric. Tech. Bull. 1075.

Daubenmire, R. F. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33:43-64.

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.

Gartner, F. R. 1975. Wind Cave National Park grassland ecology. Final report submitted to the National Park Service, Rocky Mt. Reg. Off., Denver, CO.

Gartner, F. R. 1977. Ecological changes on pine grassland burned in fall and spring. Final report submitted to the National Park Service, Rocky Mt. Reg. Off., Denver, Colo.

Gartner, F. R., R. I. Butterfield, W. W. Thompson, and L. R. Roath. 1978. Prescribed burning of range ecosystems in South Dakota. Pp. 687-690 *in* Proc. First Intl. Rangeland Cong., Soc. Range Manage.

Goldsmith, F. B., and C. M. Harrison. 1976. Description and analysis of vegetation. Pp. 85-155 *in* Methods of plant ecology (S. B. Chapman, ed.). Halsted Press, New York.

Kershaw, K. A. 1973. Quantitative and dynamic plant ecology. Edward-Arnold Publishers, London.

Lovaas, A. L. 1976. Introduction of prescribed burning to Wind Cave National Park. Wildl. Soc. Bull. 4(2):69-73.

Mikol, S. A. 1980. Field guidelines for using transects to sample non-game bird populations. U.S. Fish and Wild. Serv., Western Energy and Land Use Team Rep. FWS/OBS-80/58.

Mikol, S. A., J. J. Hickey, J. R. Cary, A. K. Stratmen, and M. E. Lardy. 1979. Comparison of bird-transect estimators in sagebrush and grassland habitats. Pp. 1-87 *in* Estimating breeding bird densities on coal lands in Montana and Wyoming. U.S. Fish and Wildl. Serv., Western Energy and Land Use Team Rep. 79/W3.

Mueller-Dombois, D., and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York.

Weaver, J. E., and F. W. Albertson. 1956. Grasslands of the Great Plains. Johnsen Publishing Company, Lincoln.

Wright, H. A. 1974. Range burning. J. Range Manage. 27:5-11.

Wright, H. A. and J. O. Klemmedson. 1965. Effects of fire on bunchgrasses of the sagebrush-grass region of southern Idaho. Ecology 46:680-688.

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Body Temperatures and Behavioral Activities of Hibernating Prairie Rattlesnakes, *Crotalus viridis*, in Artificial Dens

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INTRODUCTION

Most research on the thermal physiology of reptiles has concentrated largely upon the temperature relationships experienced by them during their season of activity. Our knowledge of the thermal biology of hibernating snakes, however, is still incomplete. A number of recent studies have concentrated on the thermal characteristics and/or their associated activity in winter dens (Brown et al. 1974, Hawley and Aleksiuk 1975, Gillingham and Carpenter 1978, Jacob and Painter 1980, Sexton and Hunt 1980, Sexton and Marion 1981, Sanders and Jacob 1981, Brown 1982). However, little information is available on relationships with immediate environmental variables for any one species (Gregory 1982).

Jacob and Painter (1980) performed the only previous significant report on overwintering body temperatures in the prairie rattlesnake (*Crotalus viridis*) in a telemetric study of six rattlesnakes in a natural den near Moriarty, New Mexico. The present study contributes to our knowledge of the biology of hibernating snakes, and that of *C. viridis* in particular, by (1) reporting body temperatures in relation to surrounding air and surface temperatures in artificial hibernacula, and (2) noting some behavioral activities of prairie rattlesnakes at low temperatures.

METHODS

Twelve rattlesnakes were captured at a den site in eastern Colorado between 12-15 October 1979 and transported to St. Louis, Missouri. During the winters of 1979-80 and 1980-81, they were placed in artificial dens for an experimental analysis of the role of thermal gradients in regulating entry into and exit from hibernacula (Sexton and Marion 1981). Some observations made during the course of this study are reported here.

As artificial dens we used two identical underground bunkers built originally for the storage of ammunition. The walls, floor and ceilings of each were constructed of reinforced concrete. The top, sides and rear of the dens outside were covered with earth and vegetation (grasses, herbs, and low shrubs). Entry was via a heavy steel door. When the door was closed, the interior was light-tight. Floor dimensions were 2.75 x 2.75 m, and the height was 2.45 m. For experimentation purposes, the floor of each bunker was divided into an individually numbered 5 x 5 matrix, each quadrat measuring 75 x 75 cm (Fig. 1).

Experiments were conducted during the winter of 1979-80 by introducing six snakes into each of the two artificial dens. Observations began on 22 October 1979 and ended on 23 April 1980. Snakes in one den (the control) were unconfined. Animals in the other den (the experimental) were confined from 20-27 January to an insulated box placed at a rear corner of the den (quadrat 5) in order to examine the thermal relationships of snakes in smaller and restricted quarters within a den. The box (a cardboard carton 38 x 23 x 20 cm) was insulated on all interior surfaces by 2.5 cm thick fibre board. This box was patterned after optimal hibernation sites within dens (see below) and was designed to enable snakes to modify ambient temperatures. During winter 1980-81, all snakes were confined to the insulated box in the experimental den from 21 December - 23 March. Water was always available but snakes were not fed during hibernation.

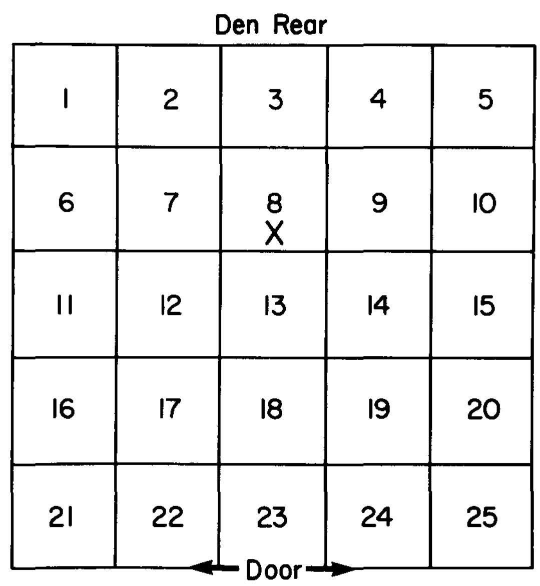

Fig. 1. Location of observational quadrats on floor of artificial dens. The "X" in quadrat 8 locates the standard release point for all snakes after each observation period.

On each of 36 brief visits to the dens, we recorded locations of the snakes by quadrat and measured the surface temperatures (T_s) of the concrete floor at the corner quadrats (1, 5, 21 and 25). These were measured by telethermometer thermistors (Yellow Springs Instrument Co.), maximum-minimum thermometers, and a portable infra-red thermometer (Barnes Instrument Co.). Air temperatures (T_a) within the den and insulated box were measured by telethermometer thermistors. Body temperatures (T_b) of the snakes were measured only once during the first year (on 23 March 1981) in order to minimize disturbance. They are cloacal temperatures obtained by using a Schultheis rapid-registering mercury thermometer. Behaviors of the snakes were also recorded during each visit. At the conclusion of each observation period, all unconfined snakes in the control den were transferred to a standard release point (Fig. 1).

RESULTS AND DISCUSSION

Body Temperature. During winter 1979-80, T_b of snakes in both dens was recorded only once (on 27 January, 1980). At the time of measurement, snakes in the experimental den had been confined to the insulated box. Within the box, T_a was 5°C, while T_a at a comparable height within the den was 3.5°C. Maximum and minimum T_s at quadrat 5 (the location of the insulated box) were 7° and 5°C, respectively. Body temperatures of the six snakes within the box were 6.0, 5.9, 6.1, 6.6, 7.4, and 7.4 ($\bar{x}$ = 6.6°C). Thus, individual T_b ranged from 2.4-3.9°C above the T_a within the den and less within the box. Body temperatures were much more closely correlated with T_s of the den floor. These values of T_b are also within the lowest range observed by Jacob and Painter (1980) for *C. viridis* in a natural hibernaculum (minimum of 6°C recorded).

Snakes in the control den (T_a = 3.5°C) were unconfined. At the time of measurement, five were in areas where the T_s of quadrats had varied between 5 and 8°C. Their body temperatures were 5.8, 6.0, 4.6, 6.0, and 6.0°C. The sixth snake was at quadrat 25 (max. = 7°C, min. = 2°C) and its T_b was 3.4°C. Again T_b of the snakes closely matched T_s. Data from both dens indicate that T_b can be only 2-4°C higher than T_a at maximum.

During the winter 1980-81, all 12 rattlesnakes were placed within the insulated box and the experiment repeated as before. Body temperatures of snakes were again recorded only once, but at a later date (23 March 1981). Air temperature in the box was 7°C and matched T_a at a comparable height within the den. At the bottom of the box T_s was 7°C and the maximum and minimum T_s registered at quadrat 5 were 7.5 and 6.5°C, with a 23 March reading of 7°C. Body temperatures of the 12 snakes within the box ranged from 7.3-9.0°C ($\bar{x}$ = 7.6°C). As in the previous year, there was a very close correlation of T_b of the snakes and T_s.

White and Lasiewski (1971) proposed that overwintering *C. viridis* may sometimes collect in large masses which would elevate their T_b as much as 15°C above ambient. This hypothesis was criticized by Brown et al. (1974) and Aleksiuk (1976) on the basis of the lack of fat body depletion. Recently, Jacob and Painter (1980), using radiotelemetry on hibernating *C. viridis* in a natural den, found an average T_b of approximately 10°C. Brown (1982) reported a similar finding in overwintering *C. horridus*, the timber rattlesnake. Our data for *C. viridis* experimentally maintained in an insulated box within an artificial den likewise do not support the elevated temperature hypothesis of White and Lasiewski. Cloacal temperatures of the confined snakes were above those of the ambient T_a and were slightly elevated over T_s, but the elevation of T_b was far below that predicted by White and Lasiewski (1971).

The restrictive size of the box (especially when it held 12 snakes) and its insulated properties also would argue against a significant increase in metabolic heat by a large mass of rattlesnakes. We expected that ambient temperatures within the insulated box would be appreciably raised if massed snakes had significantly elevated T_b. The insulated box was designed to test this idea. While the snakes were confined to the insulated box in winter 1980-81, T_a and T_s recordings were taken at 14 different intervals. Air temperatures within the box and at a comparable height within the den ranged from 2-7°C through this period, but there was a maximum difference of only 1°C between the two recordings on any date. Surface temperatures inside the box and of the den floor adjacent to the box ranged from 2-8°C and similarly showed a maximum difference of 1°C at any given time.

The physical structure of many dens and the scanty evidence of how individuals actually assemble within a den further argue against a body temperature increase in hibernating rattlesnakes. Noble and Clausen (1936), Brown et al. (1974), and Sexton and Hunt (1980) noted that small groups or isolated individuals of several species of snakes scatter about a den, occupying crevices or holes. We have dug out or entered several natural dens in the short-grass prairie area of eastern Colorado which harbored prairie rattlesnakes. These included an abandoned coal shaft, two cave-like chambers in bluffs, and an abandoned burrow system of an intermediate-sized mammal. There was usually some sort of large chamber, but with smaller fissures or crevices leading into the surrounding walls. No snakes were found within the large chambers, yet snakes were captured at the entrances as they emerged in spring. These observations suggest that, within many dens, the actual hibernation sites are often too small to harbor a large aggregation of the size implied by White and Lasiewski (1971). Thus, significant body temperature increases over ambient temperatures would not be expected.

While examining the above natural den sites at various times in early spring, additional observations were made on the T_b of prairie rattlesnakes emerging from dens. Seven were caught as they were seen actually exiting from den entrances, presumably to bask. Maximum T_b of these individuals was 21°C and minimum 10°C, with $\bar{x}$ = 16.0°C. (The 10°C individual emerged at 1145 hr MST, 14 April 1979; T_a = 11°C). Jacob and Painter (1980) observed that their telemetered wild snakes did not emerge to bask after T_b dropped below 10°C. Our findings agree very well with this value as the minimum T_b at which prairie rattlesnakes will emerge. An ability to emerge at low T_b has been postulated by Jacob and Painter (1980) to enable *C. viridis* to maintain or initiate gonadal development via occasional winter basking prior to spring emergence.

Activity in artificial dens. Snakes were always able to move about within the dens, even at the lowest T_s observed. In the control den between 3 February and 5 March (the coldest period), floor temperatures at the rear of the den varied from 2-6°C, while those at the front ranged from 1-4°C. Yet, snakes released at the standard point after each observation period were able to crawl to the warmest part of the den before the next period of observation. On 6 February all six individuals were coiled at quadrat 5, where the T_s was 4°C (max. = 5°C, min. = 4°C). At this time, the snakes exhibited slow locomotor movements of rectilinear and lateral undulatory types. A single snake was in quadrat 25 on 3 February when the T_s was low (1-2°C). The snake was moving very slowly as we entered the den. Our observations of rattlesnakes moving within a den, even at very low environmental temperatures, support the findings of Sexton and Hunt (1980), who demonstrated that black racers (*Coluber constrictor*) and rat snakes (*Elaphe obsoleta*) were apparently able to thermoregulate behaviorally within a natural den during midwinter. Prairie rattlesnakes shift positions in the artificial den and follow a seasonally reversing thermal gradient (Sexton and Marion, 1981).

Cool snakes exhibited other types of coordination. Animals exposed to a T_s of 3-4°C in the control den exhibited a righting reflex within 2 seconds of being turned on their backs. On 2 March, animals at quadrats 1 and 5 (3-5°C T_s) were able to extend their tongues.

Rattling occurred at surprisingly low environmental temperatures. Snakes on surfaces varying from 6-11°C would rattle without direct physical provocation (eg., being touched), although the initiation of rattling often took place only after a snake had been disturbed by our presence for several minutes. For example, on 10 December, snakes rattled only after one of us entered the den a second time, and on 18 January three minutes of our activity was required to initiate rattling. Animals on substrates in the 3-8°C range, and particularly those at 3-4°C, rattled only when touched. Under such conditions rattling lasted just 2 or 3 seconds and was much lower in frequency.

Few of the animals struck when at low temperatures, although some striking was observed. On 13 November (T_s = 14°C) the strike of one individual was so uncoordinated that it sometimes flipped over on its back. One individual (the largest, weighing 472 g) was noteworthy in its defensive activities at low temperatures. It struck when it was on surfaces as low as 8°C and assumed high intensity defensive postures at a T_s of 5°C. In this position, the head was raised as high as 50 cm above the floor as the snake braced most of its body against a wall. It would do this without being directly disturbed.

Captive *C.* viridis from New Mexico maintained in environmental chambers by Jacob and Painter (1980) seem to have been less active at low environmental temperatures. Although the snakes in our study moved slowly and exhibited lesser degrees of gross coordination (less fully-developed behavioral patterns) at cool den temperatures, they were remarkably active. Researchers planning to enter active dens in cold weather should thus be prepared for the possibility of encountering active snakes.

ACKNOWLEDGMENTS

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LITERATURE CITED

Aleksiuk, M. 1976. Reptilian hibernation: evidence of adaptive strategies in *Thamnophis sirtalis parietalis*. Copeia 1976:170-178.

Brown, W. S. 1982. Overwintering body temperatures of timber rattlesnakes (*Crotalus horridus*) in northeastern New York. J. Herpetol. 16:145-150.

Brown, W. S., W. S. Parker, and J. A. Elder. 1974. Thermal and spatial relationships of two species of colubrid snakes during hibernation. Herpetologica 30:32-38.

Gillingham, J. C., and C. C. Carpenter. 1978. Snake hibernation: construction of and observations on a man-made hibernaculum (Reptilia, Serpentes). J. Herpetol. 12:495-498.

Gregory, P. T. 1982. Reptilian hibernation. Pp. 53-154 *in* Biology of the Reptilia, Vol. 13 (C. Gans, ed.). Academic Press, New York.

Hawley, A. W. L., and M. Aleksiuk. 1975. Thermal regulation of spring mating behavior in the red-sided garter snake (*Thamnophis sirtalis parietalis*). Can. J. Zool. 53:768-776.

Jacob, J. S., and C. W. Painter. 1980. Overwinter thermal ecology of *Crotalus viridis* in the north-central plains of New Mexico. Copeia 1980:799-805.

Noble, G. K., and H. J. Clausen, 1936. The aggregation behavior of *Storeria dekayi* and other snakes, with special reference to the sense organs involved. Ecol. Monogr. 6:269-316.

Sanders, J. S., and J. S. Jacob. 1981. Thermal ecology of the copperhead (*Agkistrodon contortrix*). Herpetologica 37:264-270.

Sexton, O. J., and S. R. Hunt. 1980. Temperature relationships and movements of snakes (*Elaphe obsoleta*, *Coluber constrictor*) in a cave hibernaculum. Herpetologica 36:20-26.

Sexton, O. J., and K. R. Marion. 1981. Experimental analysis of movements by prairie rattlesnakes, *Crotalus viridis*, during hibernation. Oecologia (Berl.) 51:37-41.

White, F. N., and R. C. Lasiewski. 1971. Rattlesnake denning: theoretical considerations on winter temperatures. J. Theor. Biol. 30:553-557.

New Vascular Plant Records for North Dakota

Dennis T. Disrud[1]
William T. Barker[2]
Richard H. Warner[3]

Extensive documentation of the vascular flora of North Dakota has been provided by Stevens (1963). Additional records have been documented in papers by Stewart (1970), Barker (1971), and Stevens (1972). The present paper reports 12 species which are new records of the vascular flora of North Dakota.

The locations of voucher specimens for the records cited here are indicated for these collections. The herbaria cited are: North Dakota State University (NDA), the University of Kansas (KANU), the personal herbarium of Dennis Disrud, and the Bismarck Junior College Herbarium. Acronym citations for NDA and KANU follow Holmgren et al. (1981).

Allium canadense L. var. *canadense* was found on native prairie in Tewaukon National Wildlife Refuge, Sargent County, on 27 June 1973 (W. Olson 79, NDA). This species of onion is also known from Clay and Bigstone Counties in western Minnesota and Brookings and Minnehaha Counties in eastern South Dakota.

Carex brunnescens (Pers.) Poir was found in a fen southwest of Towner, McHenry County, on 5 June 1969 (D. Disrud 569, Disrud Personal Herbarium). This species is principally circumboreal and has been reported from Kittson County, Minnesota, and Custer County, South Dakota.

Carex formosa Dewey was found in an aspen woods near Leonard, Richland County, on 7 July 1945 (O. A. Stevens 831, NDA). O. A. Stevens had identified this specimen as *Carex davisii* Schwein and Torr. Wheeler (1981) annotated this specimen as *Carex formosa* Dewey and noted that this is the western-most occurrence of this species. He further noted that the only Minnesota record for this species is from dry deciduous woodlands in Ramsey County.

Carex gynocrates Wormskj. ex Drejer was collected by Disrud in 1969 (D. Disrud 962, Disrud Personal Herbarium) from a fen southwest of Towner, McHenry County. This collection was verified by O. Kolstad of Kearney State College, Kearney, Nebraska.

Carex sterilis Willd. was found in a fen southwest of Towner, McHenry County. Our earliest record, verified by O. Kolstad, was collected on 11 July 1969 (H. Kantrud and R. Stewart s. n., Northern Prairie Wildlife Research Center, accession number 997). Another collection was obtained from the same site on 20 July 1971 (D. Disrud and T. Trana 71, Disrud Personal Herbarium), and has been tentatively identified as *C. sterilis* Willd. According to Wheeler (1981)

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C. sterilis Willd. is easily confused with *C. interior* Bailey. Both species are known from the McHenry County site. Wheeler (1981) and Welby Smith (personal communication) suggest that *C. sterilis* Willd. is an obligatory fen series. The North Dakota occurrence of this species is approximately 200 mi (320 km) further west than previously reported for *C. sterilis* Willd.

Epilobium coloratum Biehler is recorded from Ransom County (S. Stephens 90797, KANU), Richland County (G. Larson 3752, and G. Seiler 2456 and 4590, all at NDA) and Stutsman County (C, Godfread 2838, NDA). All but the Stephens collection were previously identified as *E. adenocaulon* Hausskn.

Erigeron ochroleucus Nutt. var. *scribneri* (Canby ex Rydb.) Cronq. was found in the Killdeer Mountains, Dunn County, in 1961 (C. A. Barr 909, NDA). A note attached to the herbarium sheet indicates that plants taken from the Killdeer Mountains were grown for two years in South Dakota before being pressed and dried. The specimen was identified by Monica Rhode-Fulton in 1982.

Juncus compressus Jacq. was found by R. P. Williams on the sandy banks of the Missouri River in Burleigh County and on the shoreline of the Oahe Reservoir in Emmons County in 1977 and 1976, respectively (R. P. Williams 3510 and 3762, NDA).

Mentzelia pumila (Nutt.) T. & G. was found growing in a scoria outcrop on top of a butte 11 mi north of Marmarth in Slope County on 3 August 1978 by G. Larson (G. Larson 6325, NDA).

Potamogeton crispus L. was found in the tailrace below Baldhill Dam, Barnes County, on 29 August 1975 (G. Larson 5481, NDA). This is an introduced species which is now widespread in the western hemisphere.

Ranunculus flammula L. was found in a wetland in native prairie 10 mi (16 km) south of Lignite, Burke County, on 27 July 1979 (R. P. Williams 4301, NDA). The North Dakota population seems to be disjunct. The species is common in western Montana (Booth and Wright 1959).

Trifolium fragiferum L. was found 15 mi (24 im) south of Bismarck Junior College Herbarium). This European clover was previously reported in the Great Plains from Colorado, Nebraska and Wyoming (Great Plains Flora Association 1977).

LITERATURE CITED

Barker, W. T. 1971. Vascular plants new to North Dakota. Rhodora 73: 58-59.

Booth, W. E., and J. C. Wright. 1959. Flora of Montana Part II. Dep. of Botany and Microbiology, Montana State University, Bozeman.

Holmgren, P., W. Keukan, and E. K. Schofield. 1981. Index Herbariorum. Part I The herbaria of the world, 7th ed. Regum Vegetabile, vol. 106. Bohn, Scheltema & Holkema, Utrecht.

The Great Plains Flora Association. 1977. Atlas of the Flora of the Great Plains. Iowa State University Press, Ames.

Stevens, O. A. 1963. Handbook of North Dakota Plants. North Dakota Institute for Regional Studies, Fargo.

Stevens, O. A. 1972. New records of North Dakota plants. Rhodora 74:389-396.

Stewart, R. E. 1970. New records of vascular plants in North Dakota. Prairie Nat. 3:35-48.

Wheeler, G. A. 1981, A study of the genus *Carex* in Minnesota. Ph.D. Thesis. University of Minnesota, Minneapolis.

Christmas Bird Counts for North Dakota — 1983

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A comment contained in the report on Christmas Bird Counts in North Dakota a year ago noted that the weather was more moderate than it had been in many years. In contrast the first half of the 1983 bird count period recorded record low temperatures. Some areas experienced periods with as many as 10 days with continuously below zero temperatures. Of the 14 counts made in the area in 1983, eight were made during the first half of the period and all of them reported high temperatures for the day that were below zero. Low temperature along with strong winds resulted in a "wind chill" of −58 during the Medora count. "Wind chill" readings as low as −95 were recorded during the first half of the period in some areas of the state.

During the last half of the period weather was more moderate with a temperature as high as 32°F, being recorded at Minot during their count on January 1, 1984.

The 14 areas in which Christmas Bird Counts were made in 1983 are shown in Fig. 1. This is the lowest number of counts made in North Dakota since 1979.

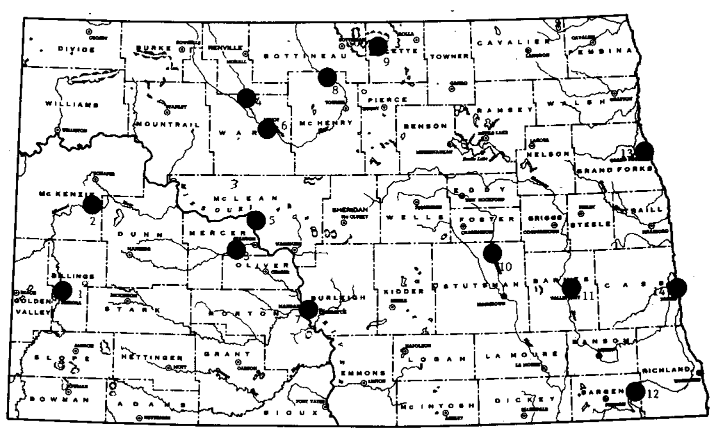

Fig. 1. Location of count areas

1. Medora
2. North Unit, Theodore Roosevelt National Park
3. Hazen
4. Upper Souris National Wildlife Refuge
5. Garrison Dam
6. Minot
7. Bismarck-Mandan
8. J. Clark Salyer National Wildlife Refuge
9. Dunseith
10. Arrowwood National Wildlife Refuge
11. Valley City
12. Tewaukon National Wildlife Refuge
13. Grand Forks-East Grand Forks
14. Fargo-Moorhead

NORTH DAKOTA CHRISTMAS BIRD COUNT — 1983

	Medora 12/17/83	No. Unit T. R. NP 12/18/83	Hazen 12/28/83	Upper Souris NWR 12/30/83	Garrison Dam 12/20/83	Minot 1/1/84	Bismarck-Mandan 12/26/83	J. Clark Salyer NWR 12/21/83	Dunseith 12/31/83	Arrowwood NWR 12/20/83	Valley City 12/17/83	Tewaukon NWR 12/29/83	Grand Forks 12/18/83	Fargo-Moorhead 12/17/83	Number of areas in which observed	Total number of individual birds
Canada Goose														1	1	1
Mallard			163		1600		143				2				4	1908
American Wigeon					2										1	2
Oldsquaw					1										1	1
Common Goldeneye					300		2								2	302
Bufflehead					1										1	1
Common Merganser					150										1	150
Red-breasted Merganser					2										1	2
Bald Eagle					5		1								2	6
Sharp-shinned Hawk							1								1	1
Cooper's Hawk			*												1	*
Northern Goshawk	4	7		4	1		1		4			1	1		8	23
Red-tailed Hawk	2														1	2
Red-tailed (Harlan's) Hawk	2														1	2
Rough-legged Hawk	1				1						1				3	3
Golden Eagle	8	1		1		1	1				2				6	14
American Kestrel	1												3	2	3	6
Merlin		1				1				1					3	3
Prairie Falcon		1					1			1			1		4	4
Gray Partridge			1	7		3	24	6	10		41	21	150	105	10	368
Ring-necked Pheasant	83	31	151	13	114		55	7		16	2	153	1	1	12	627
Ruffed Grouse									1						1	1
Sharp-tailed Grouse	20	41	1	4	36		31	6	26	33	19		16		11	233
Wild Turkey	3		73			3	18	39	16		55				7	207
Glaucous Gull					1										1	1
Rock Dove		2	26	82	16	195	598		90		81		1143	960	10	3193
Eastern Screech Owl	4	*			6	4			2						5	16
Great Horned Owl	2	3	3	7	6	5	3	1	1	1	2	12	4	11	14	61
Snowy Owl											1		5	1	3	7
Barred Owl														1	1	1
Short-eared Owl										1					1	1
Northern Saw-whet Owl														1	1	1
Red-bellied Woodpecker														*	1	*
Downy Woodpecker	2	5	8	4	6	21	20		8	6	27	7	20	60	13	194
Hairy Woodpecker	2		5	4	9	20	24	*	14	4	14	1	28	63	13	188

Northern Flicker													1		1	1
Northern (Yel.-sh.) Flicker			*		1						*				3	1
Horned Lark	22	370	142	10	95		141	1			35	7	4	1	11	806
Blue Jay	1	1	17	2	3	17	8	7	51	20	22	6	14	9	14	178
Black-billed Magpie	41	6	5	13	10	7	10	14	44	7	1				11	158
American Crow													28	179	2	207
Black-capped Chickadee	25	58	70	82	36	206	183	7	197	12	98	5	197	169	14	1345
Boreal Chickadee						3			1						2	4
Red-breasted Nuthatch	1	3	7	1		22	12				2		1	*	9	49
White-breasted Nuthatch	2	3	21	1	5	60	51	1	22	1	17	1	36	70	14	291
Brown Creeper			2			3	1				*		1	19	6	26
Golden-crowned Kinglet													1		1	1
Townsend's Solitaire	4	3					1								3	8
American Robin	507	450			2					2			2		5	963
Varied Thrush														*	1	*
Bohemian Waxwing	690	146	5	29	71	142	11	30	353	16			217	20	12	1730
Cedar Waxwing	68					22	43		6				29	3	6	171
Northern Shrike	3	2		1	1	2	1	2	2		1	4		3	11	22
European Starling	5	10	8	15	7	149	190	*	8		36	25	296	1370	13	2119
Northern Cardinal													1		1	1
American Tree Sparrow	1	24	10		156	16	44	87	2	6	2	92	3		12	443
White-throated Sparrow			4												1	4
Harris' Sparrow										23					1	23
Dark-eyed Junco						8		2	1			3			4	14
Dark-eyed (Slate-col.) Junco	1			1			8						13	32	5	55
Dark-eyed (Ore.) Junco	1						2						2		3	5
Lapland Longspur	3	6	5	13	39		100				20	400	8	24	10	618
Snow Bunting		113	6	180	100	11	303	35	118	485	1484	4	1289	444	13	4572
Red-winged Blackbird					2		2	*		31				250	5	285
Rusty Blackbird				8			8			9			1		4	26
Brewer's Blackbird		1													1	1
Common Grackle				1		*	1							3	4	5
Purple Finch			18			*	19	1	3		4		1	2	8	48
Red Crossbill											8				1	8
White-winged Crossbill						5									1	5
Common Redpoll		1	2	45	8	34	1	100	56	637	*		2	25	12	911
Pine Siskin					51	59	429	94	3	35	1		28	123	9	823
American Goldfinch					22	1	39		9		1			62	6	134
Evening Grosbeak		23				1	7	6	79					2	6	118
House Sparrow	214	113	1099	900	268	1154	2032	18	804	26	1040	318	5428	3810	14	17224
Total Species and Races	30	27	25	25	36	29	41	20	28	22	28	17	35	32		73
Total Individuals	1723	1425	1852	1428	3134	2175	4570	464	1931	1373	3019	1060	8975	7826		40954
Total Observers	10	6	19	5	4	11	20	4	6	4	16	3	25	23		156
Total Number of Hours	33	23	38	18	22	51	45	16	26	16	30	21	51	61		451
Total Number of Miles	304	234	97	194	217	311	225	140	375	60	209	75	475	467		3383

* Seen in count area during count week but not on count day.

This reduced overall effort was probably due in large part to the adverse weather conditions. A total of 156 observers took part in the 14 counts and a total of 451 hours were spent. This time includes 81 hours at feeders and 11 hours "owling".

One new species and one additional race were added to the state Christmas Count list. The new species was the boreal chickadee, an accidental on the North Dakota bird list. It was seen in two locations — three were found at Minot and one at Dunseith. The additional race was the Harlan's race of the red-tailed hawk. Two of these individuals were seen at Medora. One had been seen near this location, and several in other areas of the state during the preceding fall.

The American kestrel and eastern screech owl were new on the Medora count and the red-breasted merganser was new on the Garrison Dam count. Both the prairie falcon and the northern goshawk were noted as being rare at Grand Forks. The saw-whet owl was unusual at Fargo.

Golden eagles were seen in six areas with a total of 14 birds being recorded. This is the greatest number of areas ever reporting the species in one year. The northern goshawk was particularly notable in numbers with a total of 23 birds being seen. Eight of the 14 areas found the goshawk with a high of seven individuals being seen at Medora, and four each at the North Unit of Theodore Roosevelt National Park, Upper Souris National Wildlife Refuge and at Dunseith. Never before had more than two individuals been seen in any one area.

Wild turkeys were reported from seven areas suggesting that these birds may be becoming more widely distributed. Robins were abundant near the western edge of the state with over 500 seen at Medora and 450 at the North Unit, but they were very low in numbers elsewhere. Red-breasted nuthatches were unusually abundant at Minot.

Both species of crossbill were scarce, each being seen in only one location and in low numbers. Snow buntings and Lapland longspurs were as usual more common in the eastern portion of the state although some snow buntings were seen in each area except Medora.

Small finches were fairly well distributed. However, the American goldfinches were much reduced in numbers from last year. Pine siskins were more numerous as were the common redpoll. The evening grosbeak was seen in six areas but only at Dunseith were numbers significant.

The only species seen in all reporting areas were the great horned owl, blue jay, black-capped chickadee, white-breasted nuthatch and house sparrow.

Comparison of Plankton Populations in Three Discrete Regions of Lake Sakakawea, North Dakota

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Lake Sakakawea, an impoundment of 145,690 surface hectares on the mainstream of the Missouri River in North Dakota, is one of the largest reservoirs in North America. This impoundment has several large arms and many bays of various sizes and depths (Fig. 1).

Fishery biologists and fishermen alike have long recognized differences in the distribution, composition, and abundance of the fishes in the diverse habitats found along the length of this reservoir. For example, one of the greater concentrations of walleye, *Stizostedion vitreum* (Mitchill), are found in the Van Hook Arm where many of the walleye anglers go to fish and where good numbers of walleyes are caught. Rainbow smelt, *Osmerus mordax* (Mitchill), appear to have a distribution somewhat similar to the walleye in that they are relatively more numerous in the Van Hook Arm (Hiltner 1983). The deeper areas of the reservoir downstream near the dam appear to be more suitable for salmonids (Owen 1983).

Such differences in distribution of fishes are easy to document by sampling or simple observations of angler catches but difficult to explain in terms of quantitative ecological data. Many fishery biologists have speculated that basic limnological parameters, especially primary productivity, may be the cause of much of the variation in fish distribution and abundance. A plankton research study, as part of a Master's thesis, was conducted at Lake Sakakawea, North Dakota, during the summer of 1982 to possibly explain some of the differences in the fish population in various areas of the reservoir. The main emphasis of this study was to examine potential intra-reservoir differences in the plankton communities. Data presented here document quantitatively and qualitatively these differences for both phytoplankton and zooplankton.

SITES AND METHODS

Lake Sakakawea is one of the larger man-made reservoirs with nearly 2670 km of shoreline (U.S. Army Corps of Engineers 1977). For the purpose of this study and because of its size, the lake was divided into three discrete regions

(Fig. 1). The Riverdale Region is located on the lower end of the reservoir near the Garrison Dam. The water of this region is typically cold and clear when compared to the rest of the reservoir. Located in the central portion, the Van Hook Region is in effect a broad, relatively shallow, side arm of Lake Sakakawea. This region is approximately 20 km long and 8 to 10 km wide. The Williston Region is located along the upstream reaches of the lake. A noticeable current, relatively warm temperatures, and high turbidity are typical of the water of this region.

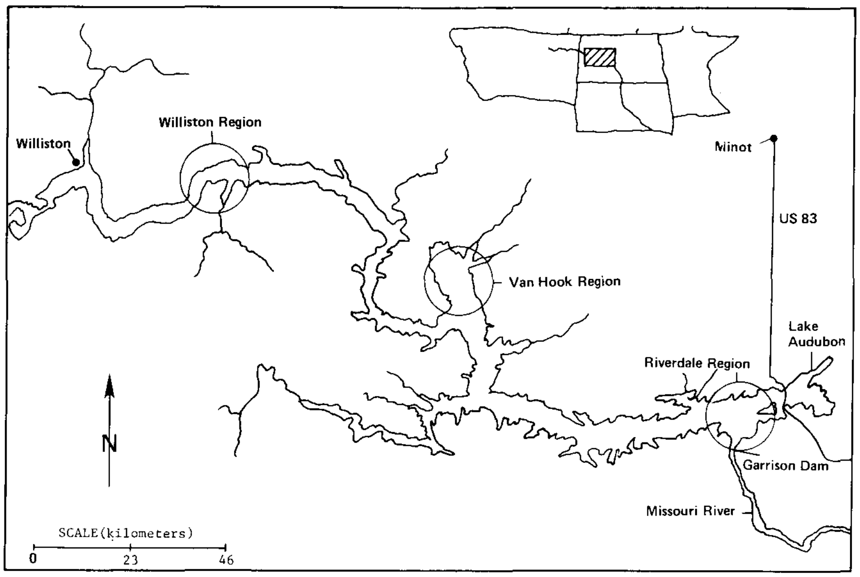

Fig. 1. Lake Sakakawea, located in west-central North Dakota.

Plankton and a limited number of other limnological samples were collected during successive one-week periods in the Riverdale, Van Hook, and Williston Regions of Lake Sakakawea. The three-week sampling cycle was then repeated in the same order four times throughout the summer for a total of 12 weeks during the summer of 1982. Fixed transects were sampled in each region, using similar methods during all four sampling periods. Plankton were collected with a closing Birge plankton net. Vertical tows through the water column were made at three locations along the fixed transects. Generally, only large plankters were examined since the mesh size of the plankton net was 80 microns. Other limnological data procured along the transects included depth and water temperature profiles, and light intensity readings through the water column taken with an underwater photometer.

ANOVA was used in making regional comparisons of plankton means. Also, the Pearson-moment correlation coefficient was used to determine the degree of relationship between two variables.

RESULTS AND DISCUSSION

Summer average plankton concentrations were significantly different among the three regions ($p = 0.0001$, Fig. 2). The Williston Region always had the fewest number of plankters whereas the central portion of the lake, the Van Hook Region, had the highest concentration of plankton throughout most of the summer. Applegate and Mullan (1967) observed a similar situation at Bull Shoals Reservoir, Arkansas, where the greatest abundance of zooplankton was found in the lake's mid-section. At Lake Oahe, South Dakota (the next impoundment downstream from Lake Sakakawea), June (1974) determined that the central region of the reservoir also exhibited the highest primary productivity.

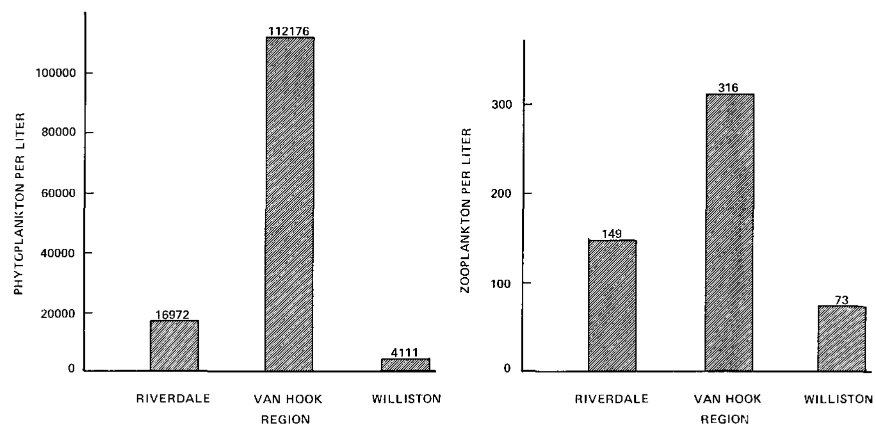

Fig. 2. Average net phytoplankton and zooplankton abundance for three discrete regions of Lake Sakakawea during the summer 1982.

Reasons for the differences in plankton abundance among regions at Lake Sakakawea are not completely understood because other limnological parameters, such as nutrient input, were not examined. The low concentration of plankton in the Williston Region may be partially explained by the rapid flushing rate and the shallow euphotic zone which was less than 2 m deep because of extreme turbidity. Inversely, the high productivity in the Van Hook Region may be attributed to the relatively warm water temperatures, a euphotic zone of 6-8 m, and a suspected lower flushing rate. The flushing rate at the sampling site in the northern end of Van Hook arm would probably be less affected by general water movement through the reservoir than at stations in the Williston and Riverdale areas.

The importance of the regional differences in plankton abundance is reflected in the trophic interactions at all levels of Lake Sakakawea. A co-investigator sampled the fish community of the same three regions and determined that the Van Hook Region also held the highest concentrations of walleye and rainbow smelt (Hiltner 1983). Hiltner also found a major predator-prey relationship between walleye and smelt in the reservoir.

Because the phytoplankton concentrations were positively correlated with the zooplankton abundance (p 0.0001, r = 0.96) and in turn zooplankton are an important food item of the smelt (Dyke, in preparation), the primary productivity of the Van Hook Region may play a large and beneficial role in the distribution and abundance of walleye.

Not only were there regional differences in the abundance of plankton but there were also differences in the composition of the net phytoplankton. The Bacillariophyceae (diatoms) were by far the most common family of net phytoplankton in all three regions but the percent abundance varied. Diatoms composed 97% of the population in the Van Hook Region, 91% in the Riverdale Region, and 56% in the Williston Region (Table 1). The centrale *Melosira* accounted for 69% of the net phytoplankters in the Van Hook Region, 40% in the Williston Region, but only 4% in the Riverdale Region. Sixty three percent of the community in the Riverdale Region consisted of another diatom, *Fragilaria*, but this pennale made up less than 7% of the total in both the Van Hook and Williston Regions.

Diatoms also dominated the phytoplankton population in Lake Sakakawea soon after impoundment (Neel et al. 1963). However, *Asterionella* and the *Cyclotella-Stephanodiscus* group made up a major portion of the diatom community at that time (Neel et al. 1963).

Cowell (1970) also found *Asterionella* and *Stephanodiscus* to be the major genera of diatoms in both Lake Francis Case and Lewis and Clark Lake, South Dakota. *Asterionella* was common in our 1982 collections but only at moderate levels whereas *Stephanodiscus* was virtually absent from all the samples. These findings may not vary greatly from those of the fore-mentioned authors because holoplanktonic forms such as *Asterionella* and *Stephanodiscus* are common year round and are often found in higher concentrations during the winter months, a time period which was not sampled.

No large regional differences were found in the comosition of the zooplankton at Lake Sakakawea (Table 2). *Keratella* and *Polyarthra* were two of the most common genera of rotifers, while the microcrustacea population consisted almost exclusively of *Cyclops* spp, Nauplii larvae, *Daphnia* spp (*D. galeata mendotae*), and *Bosmina longirostris*. Benson (1982) determined that 95% of the zooplankton in South Dakota's Missouri River reservoirs were of three genera, *Cyclops*, *Diaptomus*, and *Daphnia*. In an earlier study of Lake Sakakawea, *Daphnia* and *Diaptomus* were also the most common microcrustaceans (Needham 1961).

Although Lake Sakakawea is one continuous body of water, it is apparent that there are at least three and possibly many more unique aquatic ecosystems within this large impoundment.

Future efforts should include continuation of plankton investigations, monitoring the nutrient budget of Lake Sakakawea, and studies involving predator-prey interactions of fish and aquatic invertebrates.

ACKNOWLEDGMENTS

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Table 1. Number of net phytoplankters per liter in the Riverdale, Van Hook, and Williston Regions, Lake Sakakawea, 1982.

REGION	SAMPLING DATE				
RIVERDALE					
Phytoplankter	May 19	Jun 9	Jul 1	Jul 21	Average (%)
Fragilaria	3814	15150	14050	9596	10652 (62.8)
Melosira	53	995	1268	197	628 (3.7)
Asterionella	77	664	14540	1700	4245 (25.0)
Ceratium	0	0	65	380	111 (0.7)
Cyanophyta	23	0	0	39	16 (0.0)
Other	122	2152	2803	197	1319 (7.8)
Total	4089	18961	32727	12109	16972
VAN HOOK					
Phytoplankter	May 26	Jun 15	Jul 7	Jul 29	Average (%)
Fragilaria	5397	22274	717	607	7249 (6.5)
Melosira	60244	219487	1342	27966	77260 (68.8)
Asterionella	7141	26344	75	58	8405 (7.5)
Ceratium	0	0	641	1902	636 (0.6)
Diatoma	20331	45591	0	0	16481 (14.7)
Cyanophyta	51	0	1231	533	454 (0.4)
Other	2799	2978	257	738	1693 (1.5)
Total	95963	316674	4263	31804	112176
WILLISTON					
Phytoplankter	Jun 2	Jun 23	Jul 14	Aug 2	Average (%)
Fragilaria	74	0	57	7	36 (0.9)
Melosira	2134	574	2447	1386	1635 (39.7)
Asterionella	2166	56	257	160	660 (16.1)
Ceratium	0	0	3	285	72 (1.8)
Cyanophyta	21	89	53	4965	1282 (31.1)
Other	1280	300	130	3	428 (10.4)
Total	5675	1019	2947	6803	4111

Table 2. Number of zooplankters per liter in the Riverdale, Van Hook, and Williston Regions, Lake Sakakawea, 1982.

REGION	SAMPLING DATE				
RIVERDALE					
Zooplankter	May 19	Jun 9	Jul 1	Jul 21	Average (%)
Rotifers	37.3	237.0	385.3	58.3	179.5 (78.4)
Copepods	0.3	15.3	96.3	52.0	41.0 (17.9)
Cladocerans	0.2	0	27.0	7.3	8.6 (3.7)
Total	37.8	252.3	508.6	117.6	229.1
VAN HOOK					
Zooplankter	May 26	Jun 15	Jul 7	Jul 29	Average (%)
Rotifers	485.0	732.0	117.0	34.7	342.2 (71.1)
Copepods	48.0	90.7	67.7	101.0	76.9 (15.9)
Cladocerans	0.7	193.1	48.3	7.3	62.4 (13.0)
Total	533.7	1015.8	223.0	143.0	481.5
WILLISTON					
Zooplankter	Jun 2	Jun 23	Jul 14	Aug 2	Average (%)
Rotifers	49.7	55.0	36.3	153.3	73.6 (64.2)
Copepods	22.0	56.0	27.7	31.0	34.2 (29.8)
Cladocerans	0	6.8	3.3	17.3	6.9 (6.0)
Total	71.7	117.8	67.3	201.6	114.7

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LITERATURE CITED

Applegate, R. L., and J. W. Mullan, 1967. Zooplankton standing crops in an old and new Ozark reservoir. Limnol. Oceanogr. 12:592-599.

Benson, N. G. 1982. Some observations on the ecology and fish management of reservoirs in the United States. Can. Water Res. J. 7:1-25.

Cowell, B. C. 1970. The influence of plankton discharges from an upstream reservoir on standing crops in a Missouri River reservoir. Limnol. Oceanogr. 15:437-441.

Dyke, S. R. In preparation. M.S. Thesis. University of North Dakota, Grand Forks.

Hiltner, R. J. 1983. Comparison of walleye, *Stizostedion vitreum vitreum* (Mitchill), ecology and biology from three discrete areas of Lake Sakakawea, North Dakota, M.S. Thesis. University of North Dakota, Grand Forks.
June, F. C. 1974. Ecological changes during the transitional years of final filling and full impoundment (1966-1979) of Lake Oahe, an Upper Missouri River storage reservoir. U.S. Fish and Wildl. Serv. Tech. Rep. 71.
Needham, R. G. 1961. Survey of plankton and bottom fauna in the Garrison reservoir, tailrace and Missouri River. North Dakota Game and Fish Department, Bismarck.
Neel, J. K., H. P. Nicholson, and A. Hirsch. 1963. Mainstem reservoir effects on water quality in the central Missouri River. U.S. Department of Health, Education, and Welfare, Public Health Service, Kansas City, Mo.
Owen, J. B. 1983. A study of the need for fish hatchery facilities in North Dakota. North Dakota Game and Fish Department, Bismarck.
U.S. Army Corps of Engineers. 1977. Lake Sakakawea, Report. Government Printing Office, Washington, DC.

Note

OBSERVATIONS ON THE NESTING ECOLOGY OF BURROWING OWLS IN CENTRAL NORTH DAKOTA — Information on the nesting ecology of burrowing owls (*Athene cunicularia*) was collected incidental to a study of nesting *Buteo* hawks and great horned owls (*Bubo virginianus*). Forty-nine nesting pairs of burrowing owls were located in Burleigh, Kidder, Logan, and Stutsman counties from April 1977 to August 1979. The study area included three biotic subregions: The Coteau Slope, Missouri Coteau, and Drift Plain as described by Stewart (1975, Breeding birds of North Dakota, Tri-College Center for Environmental Studies, Fargo). Forty-five burrowing owl nest sites were located in the Missouri Coteau and four nest sites were in the Coteau Slope. No burrowing owls were observed in the Drift Plain, an area of intensive agricultural land use.

The nesting season began in late April and early May; April 21 (1978) was the earliest date a nesting pair was observed at its nest site. Forty-four burrowing owl pairs nested in unused ground squirrel burrows in Richardson's ground squirrel (*Spermophilis richardsoni*) colonies. Four ground squirrel burrows located outside colonies were used, as was one burrow previously enlarged by a badger (*Taxidea taxus*). West of the Missouri River the colonial black-tailed prairie dogs (*Cynomys ludovicianus*) provide nesting burrows for burrowing owls (Stewart, op. cit.). The Missouri River is the western range limit for Richardson's ground squirrels and the eastern range limit of black-tailed prairie dogs. These rodents appear to be ecological equivalents with disjunct ranges (Seabloom, et. al., 1978, Vertebrates of southwestern North Dakota: amphibians, reptiles, birds, and mammals, Institute for Ecological Studies, Grand Forks).

Nesting burrows typically had platforms of fine, packed soil at the entrances. These platforms were favorite perches for both adults and nestlings. Burrow entrances were carpeted with shredded cow manure, which may also have served as nesting material (Martin, 1973, Condor 75:446-456). Alternate burrows located near active nesting burrows were also used by the adults, especially males, and newly fledged young. James and Seabloom (1968, Blue Jay 26:83-84) observed the use of from one to three satellite burrows by most burrowing owl families, and some used as many as 10 additional burrows.

The preferred habitat surrounding burrowing owl nest sites consisted of open, heavily grazed, native mixed-grass prairie inhabited by Richardson's ground squirrels. Preference for closely cropped grass appeared to be related to the ground oriented habits of the owl, including increased visibility for hunting. Only four nests sites were located in habitat other than native prairie grasslands. These included three burrows in highway rights-of-way in short tame grass cover, and one burrow near a section line road in a gravel outcropping adjacent to agricultural fields.

Two burrowing owl nests were destroyed: one when a native prairie was plowed, and another during the improvement of a section line road.

Food habits of burrowing owls during the nesting season were assessed by examining freshly caught prey, prey remains, and pellet contents each year. Meadow voles (*Microtus pennsylvanicus*) were the most important prey species. Other prey included unidentified passerine birds, a small plains garter snake (*Thamnophis radix*), northern leopard frogs (*Rana pipiens*), and insects, including beetles from five families (Carabidae, Curculionidae, Scarabaeidae, Silphidae, and Tenebrionidae), grasshoppers (family: Acrididae), and a dragonfly (order: Odonata). Remains of a Richardson's ground squirrel at a burrowing owl nest site may have been carrion, as postulated for a similar report by Coulombe (1971, Condor 73:162-176).

Observed brood size ranged from one to eight chicks at fledging ($\bar{x} = 4.0$; $n = 15$).

Mortality of burrowing owls during the nesting season was noted on five occasions. Three adults were killed by motor vehicles, one on a paved highway and two on gravel roads. Remains of immature burrowing owls were found as prey in a Swainson's hawk (*Buteo swainsoni*) nest, and a ferruginous hawk (*Buteo regalis*) nest.

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Notes on Mortality of American White Pelicans at Chase Lake, North Dakota

John G. Sidle[1], Phillip M. Arnold[2], and Richard K. Stroud[3]

Since 1972, yearly assessment of American white pelican (*Pelecanus erythrorhynchos*) productivity has been made on the two nesting islands (Large Island and Small Island, 0.6 km apart) of the 1774.6-ha Chase Lake National Wildlife Refuge (NWR), North Dakota. Sidle and Ferguson (1982) summarized the status of the colony from 1972-1980, and Table 1 presents population and productivity data for the period 1980-1983. The range of productivity rates (0.34 to 0.68 young fledged per nest) falls within the bounds of productivity values of other American white pelican colonies, but does not reach the higher values reported for colonies in British Columbia (0.85) (Dunbar 1982), Colorado (1.17) (Miller and Ryder 1977), Nevada (1.0) (Anderson 1982), Utah (0.85) (Knopf 1979), and Wyoming (1.14) (Diem 1979), nor the low values (0.0 to 0.09) reported for colonies in British Columbia, Wyoming, and elsewhere. Indeed, the reproductive capacity of the nesting population at Chase Lake appears adequate since the population has increased in recent years (Sidle and Ferguson 1982).

Johnson (1976) cites nest sibling rivalry, starvation, and abandonment of nests and nestlings as possible causes of mortality in 1-2-week-old chicks at Chase Lake NWR. Nearly 100 percent of the second hatchlings (clutch is usually two eggs) perish. After the initial high chick mortality, losses continue at a low rate.

By the first week in August, pods of 5-7-week-old flightless chicks, still dependent on their parents for food, occur on the nesting islands. Since 1980, aerial photography has been used to count the chicks in early August (Sidle and Ferguson 1982). Only a few carcasses of pelicans 5-7 weeks old are visible in the photographs. However, counts of late juvenile carcasses on the nesting islands in late September 1980-1983, after the birds have migrated, indicate that 4-10% of the early August chick population had died before fledging (Table 1). This rate of late juvenile mortality appears to be a normal occurrence at Chase Lake, although such mortality is not reported from other colonies.

Six dead or moribund juvenile pelicans were collected in September 1981 from the refuge islands and examined at the U.S. Fish and Wildlife Service's National Wildlife Health Lab, Madison, Wisconsin. The principal pathological

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Table 1. Productivity of the American white pelican colony on the Chase Lake National Wildlife Refuge, North Dakota, 1980-83

Year	Number of Nests Small Is.	Number of Nests Large Is.	Number of Nests Total	Number of Breeding Birds	Pre-fledgling Chick Pop.*	Pre-fledgling Production Rate	Number of chicks later found dead on islands	% of Pre-fledgling Pop.
1980	1371	4771	6142	12284	4211	0.68	279	6
1981	1544	4282	5826	11652	3475	0.59	349	10
1982	1389	3879	5268	10536	1785	0.34	83	4
1983	2253	3039	5292	10584	—	—	209	—

*Chick population was censused by aerial photography on 10 August 1980, 8 August 1981, and 29 July 1982.

Table 2. Level of *Piagetiella peralis* infestation on 5-7-week-old color-marked American white pelicans during the first week of August at Chase Lake National Wildlife Refuge, North Dakota, 1982 and 1983.

Lice Infestation	1982 Number of examined pelicans Small Island	Large Island	Total	1983 Number of examined pelicans Small Island	Large Island	Total
Heavy	24	50	74(37%)	12	9	21(7%)
Medium	22	17	39(20%)	26	33	59(20%)
Light	54	33	87(43%)	109	104	213(71%)
None	0	0	0	3	4	7(2%)
Total	100	100	200	150	150	300

observations consistently found included emaciation, anemia, gastritis, and parasitism (internal and external). Severe granulomatous inflammatory changes in the stomach were associated with infestation by nematodes (*Contracaecum* sp.). Wobeser et al. (1974) observed *Contracaecum* sp. in one dead pelican from a Saskatchewan pelican colony. Johnson (1976) reported "worms" in both flightless and fledged juveniles from Chase Lake NWR. *Contracaecum* sp. is cosmopolitan and adults typically develop in fish-eating birds and mammals (Hoffman 1967, Yamaguti 1961). Adult pelicans at Chase Lake forage in reservoirs, rivers, and wetlands and return to their colony to feed their young by regurgitation. Prey species include black bullhead (*Ictalurus melas*), yellow perch (*Perca flavescens*), northern pike (*Esox lucius*), and white sucker (*Catastomus commersoni*) (Lingle 1980), which are known to be infected by *Contracaecum* sp. (Forstie and Holloway 1984). Larvae of tiger salamanders (*Ambystoma tigrinum*) were the principal prey species of Chase Lake pelicans in 1976 and 1977 (Lingle 1980) but they are not known to be infected by *Contracaecum* sp. Severe stomach lesions may have contributed to the emaciated condition of the birds by interfering with the normal digestive process or by depressing the will to feed normally.

Numerous chewing lice (*Piagetiella peralis*) were present on the body and in the pouch of the specimens we examined. Clusters of lice typically occur inside the pouch along the surface of both mandibles, on the axillary region of the wing, and at the base of the neck. Bleeding lesions under the clusters commonly are observed on very young pelican chicks. Johnson (1976) reports heavy infestation of *P. peralis* on juvenile pelicans at Chase Lake NWR. Price (1970) lists the occurrences of *P. peralis* at other pelican colonies on the northern Great Plains. Infestations can cause severe ulceration of the pouch with blood loss; heavy louse infestations may be a serious disease of juvenile white pelicans (Wobeser et al. 1974, Samuel et al. 1982). Irritation of the pouch lining due to chewing lice may contribute to the emaciated condition of heavily infested young. Weakened birds may not be able to preen or otherwise rid themselves of lice, thus permitting a greater parasite burden.

During our banding and patagial marking of 200 (100 on each of the islands) and 300 (150 on each of the islands) unfledged pelicans at Chase Lake in the first week of August 1982 and 1983, respectively, we recorded louse infestation as illustrated by Johnson (1976) and Wobeser et al. (1974) (Table 2).

Fourteen (14%) of the 100 chicks marked in August on Large Island in 1982 were found dead on the islands in September. Seven had been recorded in August as heavily infested by lice, five lightly infested, and two had a medium level of infestation. Two (2%) of the 100 chicks marked on Small Island in 1982 were found dead on the island in September. One had been previously recorded as heavily infested and the other lightly infested.

Observations and recoveries of the 1982 color-marked birds have been made between North Dakota and wintering areas along the Gulf Coast. Sixteen sightings provided the marker numbers. Of these six had been recorded as heavily infested, seven lightly infested, and three medium, at the time of marking in August. Besides the dead marked birds recovered at Chase Lake, 14 of the 1982 marked birds were found dead at various locations along the pelican's migratory corridor. Of these, nine, four, and one had been recorded previously with heavy, medium, and light levels of louse infestation, respectively.

There does not appear to be a relationship between level of infestation and survival. Ash (1960) reported that while birds can rid themselves of heavy infestations they also can succumb to such infestation depending on the general nutritional condition of the bird. The birds examined from Chase Lake died in an emaciated state. The relative contribution of heavy ectoparasite burdens, tissue damage to the stomach by endoparasites, and starvation due to abandonment by adults requires further assessment.

LITERATURE CITED

Anderson, J.G.T. 1982. Breeding biology of the American white pelican (*Pelecanus erythrorhynchos*) at Pyramid Lake, Nevada. M.S. Thesis. San Francisco State University.

Ash, J. S. 1960. A study of the Mallophaga of birds with particular reference to their ecology. Ibis 102:93-110.

Diem, K. L. 1979. White pelican reproductive failures in the Molly Islands breeding colony in Yellowstone National Park. Pp. 489-496 *in* Proc. First Conf. Sci. Res. Nat. Parks Serv. Trans. Proc. Ser. No. 5. Vol. 1.

Dunbar, D. L. 1982. The breeding ecology and management of white pelicans at Stum Lake, British Columbia. M.S. Thesis. University of British Columbia, Vancouver.

Forstie, M. D., and H. L. Holloway, Jr. 1984. Parasites of fish from the James and Sheyenne Rivers, Jamestown reservoir complex, and Lake Ashtabula in North Dakota. Prairie Nat. 16(1):11-20.

Hoffman, G. L. 1967. Parasites of North American freshwater fishes. University of California Press, Berkeley.

Johnson, R. F. 1976. Mortality factors affecting a white pelican population, Chase Lake National Wildlife Refuge, North Dakota. M.S. Thesis. Michigan Technological University, Houghton.

Knopf, F. L. 1979. Spatial and temporal aspects of colonial nesting white pelicans. Condor 81:353-363.

Lingle, G. R. 1980. Food habits of white pelicans during 1976 and 1977 at Chase Lake National Wildlife Refuge, North Dakota. Wilson Bull. 92(1):123-125.

Miller, G. C., and R. A. Ryder. 1977. Productivity of white pelicans in Colorado. J. Colorado-Wyoming Acad. Sci. 9:41.

Price, R. E. 1970. The *Piagetiella* (Mallophaga: Menoponidae) of the Pelecaniformes. Can. Entomol. 102:389-404.

Samuel, W. M., E. S. Williams, and A. B. Rippin. 1982. Infestations of *Piagetiella peralis* (Mallophaga: Menoponidae) on juvenile white pelicans. Can. J. Zool. 60: 951-953.

Sidle, J. G., and E. L. Ferguson. 1982. White pelican populations at Chase Lake, North Dakota, evaluated by aerial photography. Prairie Nat. 14(1):13-26.

Wobeser, G., G. R. Johnson, and G. Acompanado. 1974. Stomatitis in a juvenile white pelican due to *Piagetiella peralis* (Mallophaga: Menoponidae). J. Wildl. Dis. 10:135-138.

Yamaguti, S. 1961. Systema helminthum. Vol III, Part I. Interscience Publishers, Inc., New York.

Big Game Habitat Use in Southeastern Montana

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INTRODUCTION

The loss of suitable, high quality habitat is a major problem facing big game managers in the western United States. Agricultural, water, road and highway, housing, and recreational development have contributed to loss of natural big game habitat (Wallmo et al. 1976, Reed 1981). In the western United States, surface mining of minerals has great potential to adversely affect localized big game populations (Reed 1981). Helms (1978) discussed negative and positive impacts of mine development on pronghorn (*Antilocapra americana*) in Wyoming. He reported an actual increase in pronghorn populations near Douglas, Wyoming, despite mining developments. Information on mining impacts on other big game species is scarce. To date, not enough time has elapsed to adequately evaluate these impacts, but displacement of big game in the immediate area disturbed by mining is likely (Amstrup 1978).

To adequately assess the impacts of surface mining on big game, data on population levels and habitat use must be collected throughout all phases of mining operations. Bentonite mining has occurred over the last 30 years in southeastern Montana and northeastern Wyoming. Bentonite mining has been much more extensive in Wyoming than Montana. Only a small portion of our study area had been previously mined.

The objectives of our study were to examine big game abundance and habitat use in southeastern Montana prior to extensive bentonite mining.

STUDY AREA AND METHODS

The study was conducted from April 1979 through March 1981 in southeastern Montana immediately west of the town of Alzada and encompasses about 11,300 ha of native rangeland. Elevations range from 1036 to 1128 m, and annual precipitation averages 37 cm.

Plant communities present on the study area were: sagebrush-grasslands, hardwood forest along stream courses, and ponderosa pine (*Pinus ponderosa*) forest at higher elevations. Soils consisted of alluvial clayey deposits and shale

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at higher elevations. Surface deposits of bentonite clay were numerous.

Aerial surveys, using a small fixed-wing aircraft, were made monthly to ascertain big game distribution and abundance. Flights were conducted on two consecutive mornings during the second week of each month. A total count of animals present was attempted by flying the entire area along north-south belt transects (Caughley 1977), 0.5 km wide, at about 60 m altitude. Observers included the pilot and two biologists. Big game observed were counted and identified by species, recorded as to which plant community they originally occupied, and locations plotted on a map.

Big game population densities were calculated as the number of animals per 100 km^2 of each plant community per day. A 3-way analysis of variance was used to test for differences in big game population density among plant communities, big game species, and seasons. Tukey's method was used as a mean separation test to determine which factors accounted for differences ($P \leq 0.05$) in big game densities. December through February comprised the winter season; March through May, spring; June through August, summer; and September through November, fall.

Plant community characteristics were measured during summers 1979 and 1980. Four sample sites were examined in both the sagebrush-grass and hardwood forests, and two sample sites in the pine forest. Sample sites were chosen to be representative of a plant community. The number of replications of sample sites in each plant community were based on community variability and/or the land area occupied. At each sample site, canopy cover of plants was estimated along three 50-m line transects, 30.5 m apart. Fifty quadrats (2 x 5 dm), spaced at 1-m intervals, were examined on each transect (Daubenmire 1959). The number of trees per hectare was estimated by counting all individuals in a 50 x 50-m plot at each sample site. Plant names follow Scott and Wasser (1980).

RESULTS

Vegetation mapping indicated that sagebrush-grass occupied 74% of the study area. The most abundant plants in that type were big sagebrush (*Artemisia tridentata*), common buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), plains pricklypear (*Opuntia polyacantha*), Hood phlox (*Phlox hoodii*), and common yarrow (*Achillea millefolium*). Hardwood forest occurred along stream bottoms and occupied about 14% of the study area. Major plants were boxelder maple (*Acer negundo*), green ash (*Fraxinus pennsylvanicus*), snowberry (*Symphoricarpos* sp.), rose (*Rosa* spp.), brome (*Bromus* spp.), and bluegrass (*Poa* spp.). Pine forest grew on 8% of the study area. It consisted of ponderosa pine, Rocky Mountain juniper (*Juniperus scopulorum*), bur oak (*Quercus macrocarpa*), western wheatgrass (*Agropyron smithii*), blue grama, common yarrow, and starry cerastium (*Cerastium arvense*). About 3% of the study area had been mined for bentonite prior to the initiation of study.

The sagebrush-grass community had the most bare ground. Litter cover was greatest in both forest types. Canopy cover of grasses and carices was greatest in sagebrush-grass and hardwood forest areas. Forb cover was nearly equal among all plant communities, while shrub cover was greatest in hardwood forest and sagebrush-grass areas. Tree density was greatest in the hardwood forest community (Table 1).

Big game observed were mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and pronghorn. Mule deer were the most abundant ($P<0.05$) species on the study area, followed by pronghorn (Table 2). Both mule and white-tailed deer were observed more often in hardwood forest than any other plant community ($P<0.05$). However, mule deer occupation of pine forest was greatest in summer followed by spring, while white-tailed deer occupancy was greatest in fall followed by winter. Pronghorn were observed most often in sagebrush-grass areas but were occasionally seen in the other plant communities. Big game were observed in greater numbers in spring and summer than fall and winter. Differences between years in big game density appeared to be unimportant.

Multiple classification analyses indicated that variation in big game population densities during winter and summer accounted for seasonal differences ($P<0.05$), hardwood forest areas accounted for differences ($P<0.05$) in big game densities among plant communities, and that variation in mule deer density accounted for differences ($P<0.05$) among species.

DISCUSSION

Both hardwood and pine forest communities were important to mule deer in southeastern Montana. However, hardwood forests supported more mule deer than pine forests. Severson and Carter (1978) concluded that hardwood forest habitat was critical to mule deer survival on the northern High Plains. Mackie (1970) stated that pine/juniper woodlands of northern Montana were heavily used by mule deer in summer, and concluded that this was seasonally important habitat. Results of this study indicate that the same relationships exist in southeastern Montana. Severson (1981) discussed these relationships in detail.

White-tailed deer were also most abundant in the hardwood forest community. Zwank et al. (1979) reported that bottomland hardwood forests were critical

Table 1. Canopy cover (%) and tree densities in three plant communities, southeastern Montana, 1979-80.

Categories	Plant community: Hardwood forest $\bar{X} \pm SE$	Sagebrush-grass $\bar{X} \pm SE$	Pine forest $\bar{X} \pm SE$
Bare ground	8 ± 1	21 ± 1	12 ± 2
Litter	30 ± 3	20 ± 5	46 ± 6
Grasses and carices	39 ± 14	40 ± 28	22 ± 4
Forbs	9 ± 4	5 ± 2	5 ± 2
Shrubs	18 ± 6	8 ± 2	2 ± 1
Total Cover[a]	64 ± 5	57 ± 8	37 ± 8
Trees/ha	765 ± 308		354 ± 99

[a]Two dimensional cover values.

Table 2. Mean number of big game animals/100 km^2 observed during aerial surveys in three plant communities over four seasons in southeastern Montana.[a]

Big game species and	plant community	Winter	Spring	Summer	Fall
		Season			
Mule deer					
	Hardwood forest	40[f]	90[agh]	155[bij]	78[dekl]
	Sagebrush-grass	8	6 [a]	1[bc]	1[d]
	Pine forest	31	44[mn]	56[cop]	10[e]
White-tailed deer					
	Hardwood forest	21	6[g]	4[i]	18[k]
	Sagebrush-grass	0	0	0	0
	Pine forest	5	0[m]	0[o]	13
Pronghorn					
	Hardwood forest	0[f]	6[h]	1[j]	0[l]
	Sagebrush-grass	22	28	23	20
	Pine forest	0	2[n]	0[p]	0

[a]Values followed by same letter differed ($\underline{P} < 0.05$) across rows and down columns.

habitat for this species in the midwest. Use of forest communities by white-tailed deer in Oregon was also important (Suring and Vohs 1979). White-tailed deer use of ponderosa pine forest was restricted to fall and winter periods in this study.

Sagebrush-grass areas provide critical habitat for pronghorn on the study area. Use of other plant communities by pronghorn was minimal.

Aerial surveys were conducted only in the morning and habitat use by big game during other parts of the day may change. Steigers (1981) reported a shift in habitat use by mule deer fawns from woody draws by day to open prairie during night in South Dakota.

Commercial grade bentonite occurs in scattered pockets, which has resulted in small, disturbed areas within undisturbed vegetation on the study area. Bentonite mining as currently practiced appears not to have had a serious impact on big game populations on the study area. However, lack of premining data precludes more definite statements. When demand for bentonite is high, it may become profitable to mine lower quality bentonite deposits, which will result in larger areas being disturbed, and thus, potentially cause greater impacts on big game populations.

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LITERATURE CITED

Amstrup, S. C. 1978. Activities and habitat use pattern of pronghorns on Montana and Wyoming coal lands. Proc. Pronghorn Antelope Workshop 8:270-306.

Caughley, G. 1977. Sampling in aerial survey. J. Wildl. Manage. 41:605-615.

Daubenmire, R. 1959. A canopy-coverage method of vegetation analysis. Northwest Sci. 33:43-64.

Helms, B. 1978. Antelope and energy development. Proc. Pronghorn Antelope Workshop 8:206-215.

Mackie, R. J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildl. Monogr. 20.

Reed, D. F. 1981. Conflicts with civilization Pp. 509-535 *in* Mule and black-tailed deer of North America (O. C. Wallmo, ed.). University Nebraska Press, Lincoln.

Scott, T. G., and C. H. Wasser. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, D.C.

Severson, K. E. 1981. Plains habitats. Pp. 459-485 *in* Mule and black-tailed deer of North America (O. C. Wallmo, Ed.). University Nebraska Press, Lincoln.

Severson, K. E., and A. V. Carter. 1978. Movements and habitat use by mule deer in the Northern Great Plains, South Dakota. Pp. 466-468 *in* Proc. First Int. Rangelands Congr. (D. W. Hyder, ed.). The Society for Range Management, Denver.

Steigers, W. D., Jr. 1981. Habitat use and mortality of mule deer fawns in western South Dakota. Ph.D. Dissertation. Brigham Young University, Provo, Utah.

Suring, L. H., and P. A. Vohs, Jr. 1979. Habitat use by Columbia white-tailed deer. J. Wildl. Manage. 43:610-619.

Wallmo, O. C., D. F. Reed, and L. H. Carpenter. 1976. Alteration of mule deer habitat by wildfire, logging, highways, agriculture, and housing developments. Pp. 37-47 *in* Mule deer decline in the west, a symposium (G. W. Workman and J. B. Low, eds.) Utah Agricultural Experiment Station, Logan.

Zwank, P. J., R. D. Sparrowe, W. R. Porath, and O. Torgeson. 1979. Utilization of threatened bottomland habitats by white-tailed deer. Wildl. Soc. Bull. 7:226-232.

BOOK REVIEWS:

MINNESOTA MAMMALS

The Mammals of Minnesota. Evan B. Hazard. 1982. University of Minnesota Press, Minneapolis. 280 pages. $39.50 (cloth), $15.95 (paper).

The publication of Evan Hazard's account of the mammals of Minnesota has been anticipated by naturalists for some time. Earlier accounts over the past century significantly contributed to knowledge of the regional fauna, but all are out of print and in serious need of updating. The pressures of human population and changing land use have had their impact on the mammalian fauna of Minnesota, especially over the past 30 years. The resulting successional changes in northern forests, loss of hardwoods, drainage of wetlands, and agricultural encroachment on the sharply defined prairie-forest ecotone have had significant faunal consequences.

In general, the book is well-written in a clear and lucid style. Anecdotes and a reasonable level of humor add to the interest of the lay reader. Use of technical terminology is extensive, and may discourage the non-professional. However, the glossary is equally extensive, and terms are clearly defined. Illustrations in the text are somewhat disappointing. The line drawings of lateral views of skulls aid little in identification, and many of the scratch-board figures appear unrealistic or are too dark.

Technically, the book is quite accurate. With few exceptions, nomenclature is up to date (chipmunks of the genera *Tamias* and *Eutamias* have been more recently lumped into one genus, *Tamias*). Measurement data are inconsistent with regard to citation of the source; for some species the source is cited, but not so for others. It also appears that recorded measurements were solely from Minnesota specimens, or from limited numbers of specimens in Minnesota collections. It may have been advisable to utilize a broader base of specimens from other museums if data available within the state were limited.

The taxonomic keys are useful, and it is gratifying to find separate keys for skins and skulls. Illustrations in the keys are good, but the author should also have provided a drawing of the principal bones of the mammalian skull.

A book intended for a broad-based readership should have included a section on specimen collection and preservation. References are cited in the text, but may not be available to the student, amateur naturalist, or isolated field biologist.

Hazard's *The Mammals of Minnesota* is a noteworthy effort, and will be a useful addition to the libraries of midwestern naturalists. It will no doubt stand as the basic reference on Minnesota mammals for many years to come.

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PRAIRIE MAMMALS

Mammals of the Northern Great Plains. J. Knox Jones, Jr., David M. Armstrong, Robert S. Hoffmann and Clyde Jones. 1983. University of Nebraska Press. Lincoln. 379 Pages. $32.50 (cloth).

This book is a welcome addition to the general references available on the mammalian fauna of the Northern Great Plains, a region encompassing North Dakota, South Dakota, and Nebraska. No similar book about the mammals of these states has been published since Vernon Bailey's 1926 (not 1927 as shown on pages 2 and 361) publication of the mammals of North Dakota. Situated mid-continent between major landform, climatic, and habitat zones, the Northern Great Plains is a challenging region for the study of mammals. Many mammalian species more adapted to conditions elsewhere have invaded but failed to traverse or establish permanent residency in the region. Numerous pockets of diverse habitat that dot the plains facilitate the establishment of certain mammals, and the massive impact of intensive farming will continue to affect the distribution and abundance of many species. The present book provides a valuable reference and hopefully will stimulate additional work on the mammals of the region.

Mammals of the Northern Great Plains is a handsome 18.5 x 26 cm book printed on high-quality glossy paper and illustrated with 206 black-and-white photos and drawings. Although the text is easy to read and intended for a varied audience, it contains sufficient detail to make it useful to professional mammalogists. A glossary is provided to aid those unfamiliar with some terminology. The book is organized into 27 sections. The first 11 sections (26 pages) introduce readers to the history of mammalian investigations in the region and how these studies are conducted. They also provide descriptions of the environment and informative discussions of mammalian communities and zoogeography. These are followed by a section on the Class Mammalia (primarily on evolution and adaptations), a key to the orders of mammals of the region, and a checklist of the region's 105 native and six introduced mammal species. The bulk of the book (pages 36-346) consists of species accounts arranged by order and family except that introduced species are treated together at the end. Identification keys are furnished with the discussion of each order and family. Diagrams of distinguishing characteristics are inserted as needed to aid in identifying certain mammals. Species accounts provide useful information on taxonomy, distribution, and natural history. The natural history information is current and addresses subjects such as reproduction, food habits, and habitat use; selected references are provided.

Species distribution maps are one of the most useful features of a book of this type, and in this respect the book could have been improved. Range maps are provided for nearly all species but there are inconsistencies. For example, no range map is included for the wolf (*Canis lupus*) because of its "uncertain status" (p. 254) although it was originally distributed over the entire area and there even have been 20th century records. Nevertheless, a joint range map is provided for the marten (*Martes americana*) and fisher (*M. pennanti*) (p. 275), even though the status of both species is less certain than that of the wolf. Shading could have been used effectively to separate past from present distributions. The range maps are "deliberately conservative" (p. 3) and no distribution records are shown except for a few species where data are insufficient to assign a range. Hence, although the range maps provide general information, they are of limited value to professionals interested in documenting range changes.

This book is a must for anyone seriously interested in the mammals of the region.

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A STATE ENVIRONMENTAL DIRECTORY

Environmental Directory for North Dakota, 1984-85 edition. K. Coe, C. Nikolas and R. Stromstad, editors. 1984. Institute for Ecological Studies Special Publication No. 11, Box 8278, University Station, Grand Forks, North Dakota 58202. 109 pages. $4.00 (paper).

This directory is clearly described by its title. It contains four major parts, listing the names, addresses, and telephone numbers associated with North Dakota-related: 1) environmental and professional organizations, 2) state and federal agencies, 3) city and county officials, and 4) environmental facilities. Indices of individuals and of organizations conclude the directory.

Under "Environmental and Professional Organizations" are national groups (only some of which have state or regional offices covering North Dakota), state organizations, and local associations. Omitted are many major national societies, such as American Institute of Biological Sciences, Defenders of Wildlife, and Natural Resources Defense Council, while some included ones, e.g. American Institute of Fisheries Research Biologists, have fewer members and less impact in the state.

The second section lists various federal and state agencies involved in some way or another with environmental matters. The third part gives names and addresses of selected officials in numerous cities and 49 counties (McHenry, McIntosh, and McKenzie are mysteriously missing).

The environmental facilities section includes arboretums and field stations (but not NDSU's Streeter facility), historical societies and museums, fish hatcheries, some national wildlife refuges (evidently only those with full-time personnel), state wildlife management areas (with areas presented to the hundredth acre), national and state parks and historic sites, and federal and state research centers.

Despite numerous typographical errors, incorrect addresses or telephone numbers, and inconsistencies in coverage, this directory is a useful product, and an adjunct to the National Wildlife Federation's annual *Conservation Directory*.

Staff

BIBLIOGRAPHY OF NORTH DAKOTA PLANTS

North Dakota Vegetation: A Bibliography. B. L. Heidel and D. S. Rogers. 1984. Institute for Ecological Studies, University of North Dakota, Grand Forks. Contribution Series No. 4. 48 pages. $2.00 (paper).

The North Dakota National Heritage Program is to be commended for assembling this bibliography. Botanists, range scientists, and others interested in North Dakota vegetation will find it more comprehensive than W. D. Kress's unpublished 1963 work, "Some remarks regarding the ecology of North Dakota together with an initial bibliography of vegetation of the state" (N.D. Institute for Regional Studies, NDSU, Fargo. 27 pages) and more useful than R. H. Pemble et al.'s 1975 publication, "Native grassland ecosystems east of the Rocky Mountains in North America: A preliminary bibliography" (Supplement to M. K. Wali, ed., *Prairie: A Multiple View*. UND Press, Grand Forks. 466 pages).

This new bibliography lists nearly 600 published and unpublished titles. It is especially strong in unpublished theses dealing with vegetation. Although many of the listed titles would not be citable in a publication, they contain valuable information on North Dakota vegetation. Quality is good with a random check of 30 entries yielding only two minor misspellings. The authors have included major publications on the physical environment of North Dakota that are most frequently cited in botanical works. They also provided a cross-reference section divided into 36 subject categories ranging from "Classification and Composition of Grasslands" to "Water Budget and Hydrology."

Birds and mammals do not appear in the subject categories. This is somewhat surprising because several dozen wildlife-oriented titles are listed. In addition, several unpublished theses on wildlife species in North Dakota containing extensive material on vegetation and plant communities could have been cited.

Since the bibliography is an ongoing effort of the North Dakota Heritage Program, it will be periodically updated. Readers are urged to contribute to this effort. The first author can be contacted at Pinehurst Office Park, 1424 West Century Avenue, Suite 202, Bismarck, N.D. 58501.

Any person interested in North Dakota vegetation should not be without this bibliography. In an age of fifty-dollar books, this publication is a real bargain.

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A BIRD BOOK FOR IOWA

Iowa Birds. James J. Dinsmore, Thomas H. Kent, Darwin Koenig, Peter C. Petersen, and Dean M. Roosa. 1984. Iowa State University Press, Ames. 356 pages. $27.95 (cloth).

Every regional book on birds should begin with the statement made by these authors that begins the chapter on Species Status: "The true distribution of birds in Iowa, always changing, will never be completely known." Substitute the name of your region and you will have the truest statement made about regional bird books. This is what makes birding such a fascinating hobby, why regional works are revised over and over again, and why a work such as this is so valuable at present for the state of Iowa.

I remember being asked in the 1970's why we were writing *Minnesota Birds, Where, When and How Many*. Did Minnesota need a new work on bird distribution, considering that T. S. Roberts covered the subject with his monumental treatise *Birds of Minnesota* published in 1932? The answer was an emphatic "yes," a new work was needed. In fact, the one published in 1975 is now out of date and a revision is in preparation!

The authors have prepared an excellent work on the current status of 362 species recorded in Iowa. In the chapter on Definition of Species Status, the categories of occurrence follow the same criteria used in our Minnesota book: i.e., regular, casual, and accidental. The same is true for the frequency terms; abundant, common, uncommon and rare are used throughout the book, as are the criteria of nesting applied to determine whether a species has nested in the state.

On the other hand, I have definite negative feelings about the authors' Classification of Species. The division into eight categories (they say six, but the first is subdivided into three further categories) is cumbersome and in my opinion of little value to the reader. They state that "some authorities writing state bird books have included only species substantiated by existing, well-labeled specimens; others have used all published and even unpublished records. This book takes the middle road." I know of no scholarly, well-researched book on regional distribution that is using unpublished non-verifiable records. I do not feel Iowa has taken the "middle of the road" but has retained the old-fashioned and outmoded term "hypothetical." This term should be deleted from state lists and species that, because of circumstances, cannot be verified beyond a reasonable doubt should be relegated to an appendix or omitted altogether. The Classification of Species as used in *Iowa Birds* should be left for the Iowa Ornithologists' Union Records Committee to use in their work, and not for the reader.

There are excellent chapters on "The Relationship of Birds to Iowa Geography," "History of Iowa Ornithology," and "Breeding and Endangered Species." The Species Accounts that take up the bulk of the book are well done and give a wealth of information on each species in Iowa. Topics covered under each species include status, habitat, spring migration, summer, fall migration, winter, comment, and reference. The latter section is valuable because it is placed within each species account rather than at the end of the book.

At the beginning of the Species Accounts there is a definition of the terms used on the maps. Again, I find the terminology complicated. The use of 12 symbols on two different base maps is just too much for the reader to handle. Why not two symbols showing the current (the last 20-25 years) breeding status of each nesting species; one symbol for positive breeding, the other for inferred breeding?

In general, the authors have done an excellent job in giving us a new up-to-date and accurate picture of Iowa Birds. As can be seen from the above comments, I think they could have done it a little more simply and in a fashion more easily understood by the general birder.

One last comment: it scares me when I look at the price of this book, $27.95, and read on the title page that the "text in this book was printed from camera-ready copy supplied by the authors." Whatever happened to typesetting?

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THE NORTH DAKOTA NATURAL SCIENCE SOCIETY

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SUGGESTIONS FOR CONTRIBUTORS

Manuscripts containing original material will be accepted from individuals without regard to membership in the North Dakota Natural Science Society and should be sent directly to the Editor. Allow about six weeks for manuscript review.

Authors should follow a clear and concise style; the *CBE Style Manual* (4th Edition) is a good reference. Use active voice whenever possible.

Manuscripts should be typewritten on one side of 8½ x 11 inch paper of good quality, double spaced throughout, and have a one-inch margin all around. Pages should be numbered serially. Longer papers may have sections with appropriate headings. The original and one photocopy of the manuscript are required for review purposes. Manuscripts of two or more pages and/or containing tables and figures will be printed as **Articles.** Manuscripts of less than two pages and lacking tables and figures will be printed as **Notes.**

References. Authors cited in the text of **Articles** should be indicated by family name and year of publication in parentheses, e.g. (Wade 1967). When a citation has more than two authors, the name of the first author followed by et al. should be used: (Seabloom et al. 1978). Where two or more papers by the same author(s) have appeared in one year, the style should be: (Stewart 1967a, 1967b).

References cited in the text of **Articles** should be listed at the end of the manuscript under the heading Literature Cited. Journal title abbreviations listed in the latest edition of *Serial Sources for the BIOSIS Data Base* should be used. In a listing for a book the title is not underlined and the number of pages is not included. The correct style is as follows:

Article: Stewart, R. E. 1971. Checklist of birds in North Dakota. Prairie Nat. 3:3-12.

Book: Green, J. C., and R. B. Janssen. 1975. Minnesota birds: where, when, and how many. University of Minnesota Press, Minneapolis.

Article in Book: Lack, D. 1964. Population dynamics. In: A. L. Thompson, ed., A new dictionary of birds. McGraw-Hill, New York.

The same style should be used in **Notes,** but the references are inserted in the body of the text in parentheses rather than listed separately.

Illustrations should be done in black ink on firm paper. They should be identified on the back lightly in pencil with number, author's name, and an indication of the top of the figure. Prints of figures should be sharp, clear, and glossy. Captions should be typed on a separate sheet at the end of the manuscript. Figures must be referenced in the text. Scale should be indicated. Illustrations that do not relate significantly to the text will be deleted.

Tables should be typed on separate sheets and referenced in the text. Authors are encouraged to record data in tabular form but must avoid incorporation of data of little relevance to the readers.

Style Rules for *The Prairie Naturalist* have been prepared and may be obtained by writing the Editor.

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