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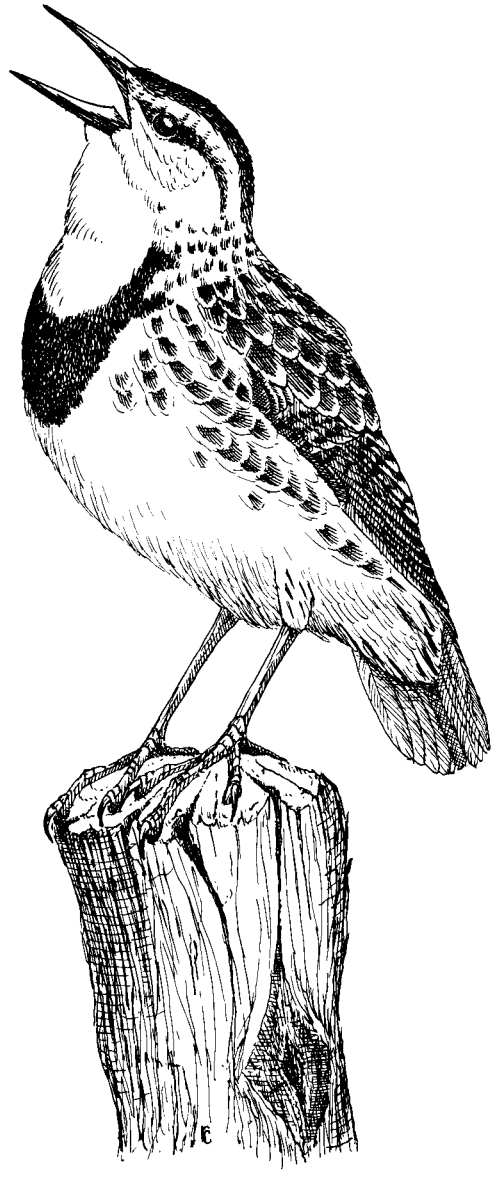

THE PRAIRIE NATURALIST

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THE PRAIRIE NATURALIST

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

The western meadowlark is a common sight on the Northern Great Plains, often perching on fence- and sign-posts to sing. It is one of our earliest returning migrants, frequently weathering late season snow storms after it arrives.

This pen-and-ink rendering was drawn by D. Randall Crooke of Mandan. Randy is Senior Environmental Specialist at the Falkirk Mine near Underwood, ND, a lignite coal mine which is currently involved in reclaiming prairie pothole wetlands. Randy coordinates the reclamation of these important wildlife habitats.

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Effects of Fire on Nutrient and Energy Concentration of Five Prairie Grass Species[1]

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ABSTRACT — Nutrient and energy concentration of little bluestem (*Andropogon scoparius*), big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and side-oats grama (*Bouteloua curtipendula*) were evaluated in a reestablished bluestem-dominated prairie. Comparisons were made among unburned areas and areas burned from one to four consecutive years. Phytomass calcium and magnesium were lower and potassium, phosphorus, zinc, manganese, and energy concentration higher in the unburned area. Potassium, calcium, manganese, iron, and total nitrogen in the soil were substantially higher after burning, Burning frequency and burning recency affected the nutrient concentration in all five species as well as the energy concentration of big and little bluestem and Indiangrass.

The results of this study show that, in bluestem-dominated prairies, burning affected nutrient cycling and the amount of energy stored in above-ground plant biomass; effects differed depending on fire frequency and recency. With the exception of phosphorus, soil nutrients were increased by burning, thus the short-term effect of fire was to increase available plant nutrients. The species- and nutrient-specific effects of fire on nutrient uptake suggest that fire has the potential to effect long-term changes in species composition in nutrient limited ecosystems.

Fire is a natural component of the tall-grass prairie ecosystem. Research on the effects of fire on grassland vegetation was summarized by Daubenmire (1968) and by Kozlowski and Ahlgren (1974) but effects on nutrient cycling, such as fire-induced changes in nutrient uptake and its potential to alter plant species composition, have not been fully evaluated. Fire-induced differential nutrient uptake may alter competitive relationships among species in nutrient-limited environments. Such alterations in competitive relationships may, over sufficient time, alter the vegetative composition of the community. Further, variations in burning, such as fire frequency, may result in somewhat different plant communities. An understanding of the effects of fire on plant and soil nutrients, therefore, is important in understanding the vegetative dynamics of fire-adapted grassland ecosystems.

Koelling and Kucera (1965) reported that fire decreases nitrogen and iron concentrations in plant tissue. Potassium, phosphorus, and calcium were variously found either to increase or decrease with burning; no change was reported for magnesium. This 1965 study evaluated the effects of a single fire, however, and

[1]This study fulfilled part of the requirements of the M.A. degree in Biology (Plant Ecology) of the first author.

did not address the effects of different fire frequencies. Hadley and Kieckhefer (1963) considered the effects of fire frequency on productivity, including energy concentration, but did not evaluate nutrient concentrations. The energy concentration of living shoots of big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*) were significantly, although only slightly, higher (0.58% and 0.64% respectively) in frequently burned areas than in those burned less frequently. This 1963 study, however, used areas burned with uneven time periods both between treatments and between the last treatment and the time of evaluation. There was, thus, the possibility that effects shown may not be primarily the consequence of fire frequency. The present study was designed to more closely control treatment times.

This study was initiated to ascertain the extent to which fire, and variations in burning, alter nutrient cycling and energy storage in a tall-grass prairie with the assumption that substantial differences would suggest the potential for long-term changes in species composition. While nutrients were the principal focus of this study, energy concentration was included to assess any potential fire-associated relationships between these parameters.

MATERIALS AND METHOD

Study Site

The study was conducted at Allwine Prairie Preserve, a 65-ha reestablished grassland research area situated in the tall-grass prairie region of eastern Nebraska. The study site was on an upland portion of the preserve dominated by big bluestem (*Andropogon gerardii*, 45% canopy cover), little bluestem (*Andropogon scoparius*, 11% cover), Indiangrass (*Sorghastrum nutans*, 10% cover), side-oats grama (*Bouteloua curtipendula*, 9% cover), and switchgrass (*Panicum virgatum*, 3% cover) (Bragg 1978; nomenclature from Great Plains Flora Association, 1977). Soils of the site are silts and silty clay loams (Bartlett 1975). Monthly precipitation averages 71 cm from April through July (U.S. Dep. Commerce 1979).

Fire Treatment

From 1976 to 1979, four contiguous 10m x 15m quadrats were burned at different frequencies. Quadrat 1 was burned once in 1977. Quadrat 2 was burned twice, once in 1977 and in 1978. Quadrat 3 was burned three times, once in 1977, 1978, and 1979. Quadrat 4 was burned four times, once in 1976, 1977, 1978, and 1979. All burning treatments were in late April. The unburned control, designated "Quadrat 0", was separate from the others because previous fires had burned the entire upland. Quadrats 1-4 were on a nearly level hilltop. Quadrat 0 was located lower on the slope of the same hill. The authors acknowledge that, although plant species composition was essentially the same on upland and slope sites, differences in soil and plant nutrients may be attributable to topographic differences alone. The potential contribution of including an unburned area, however, was felt to outweigh any such differences

so long as this caution was included. The overall treatment plan provided for evaluation of (1) general fire effects by comparing the unburned quadrat with Quadrats 1-4 combined, (2) fire frequency by comparing Quadrats 1-4, and (3) fire recency by comparing among Quadrat 1, Quadrat 2, and Quadrats 3-4 combined.

Evaluations

Vegetation — In 1979, plants were collected from each of the quadrats using procedures described by Milner and Hughes (1968). Samples of each species were collected when that species was in flower. Side-oats grama was collected in August and big and little bluestem, Indiangrass, and switchgrass were collected in September. Each quadrat was divided into five equal-sized sections; one section was centrally located and the others approximated the four quarters of the quadrat minus the area of the center section. Except as indicated below, one 500-g (field weight) sample of each species was collected from within each section. For statistical purposes, each quadrat section was considered to be an independent sampling unit. Switchgrass was absent from Quadrats 3 and 4, only enough for one sample could be obtained from Quadrat 2, and only enough for two samples could be collected from Quadrat 1. Side-oats grama biomass was low in all quadrats; therefore, all plants found within a quadrat were combined to give one sample of this species for each quadrat.

The previous years' litter, standing dead, and flowering culms were removed from each sample and discarded. Samples were then oven-dried at 77 C for 48 hr. Approximately 10g dry mass of each sample was sent to the Plant Analysis Laboratory, University of Nebraska-Lincoln, to determine nutrient concentrations of calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) using the dry-ash method (Allen et al. 1974) as well as to determine total (Kjeldahl) nitrogen. The remainder of the sample was retained for caloric determination.

Energy concentration was measured only for big and little bluestem and Indiangrass because of inadequate amounts of switchgrass and side-oats grama. Each sample was cut into 2-3 cm segments, thoroughly mixed, then ground with a Wiley Mill using 60-mesh-to-the-inch screen. The ground material was thoroughly mixed again before making five pellets for each species, one from each section of each quadrat. Pellets weighed 0.8 to 1.0 g. Caloric value was determined with a Parr Adiabatic Bomb Calorimeter.

Statistical comparisons between samples were made using Analysis of Variance and Fisher's Least Significant Differences (LSD) at the 95% confidence level. Regressions were run for total N, K, Mn, P and caloric values onto fire frequency for big and little bluestem and Indiangrass. These elements and species were selected for more detailed analysis because they indicated tendencies to increase or decrease with fire frequency as determined visually from dice-grams (Sokal and Rohlf 1969).

Soil — Fourteen cyclindrical soil cores, 1.5 cm in diameter and 15-20 cm deep, were collected from each quadrat in October 1979 using procedures described by Hooker et al. (1976). Soil samples were air-dried for seven hours, then sent

to the Soil Testing Laboratory, University of Nebraska-Lincoln, for analysis. Soil samples were analyzed for soil texture, cation exchange capacity, and total (Kjeldahl) nitrogen. Phosphorus concentration was analyzed using the Bray-1 test; Mn, Zn, Cu, and Fe were analyzed by DTPA Extraction and K, Mg, Ca, and Na were analyzed by soil extraction (North Central Regional Soil Testing Committee 1975). Sodium was evaluated as part of routine analysis procedures for other nutrients and is included for information even though plant Na concentration was not determined.

RESULTS

Vegetation

Significant differences in plant nutrient concentrations were found between burned and unburned areas, between areas burned at different frequencies, and between recently burned areas and others burned less recently (Tables 1-5).

General Fire Effects — The effect of burning was evaluated by comparing values from the unburned quadrat with average values calculated by combining data from the four burned quadrats. Burned plots showed a significant increase of K in little bluestem, of P in little and big bluestem and Indiangrass, of Zn in little bluestem and Indiangrass, and of Fe in Indiangrass (Tables 1-3, Fig. 1). Significant decreases in the burned plots were noted for Ca and Mg in little and big bluestem. Substantial changes in other nutrients were also noted for certain species (Table 5). Two consistent effects of burning were noted for all species: (1) soil P decreased and phytomass P increased, and (2) Zn in both soil and plant matter increased. In general, changes in plant nutrient concentration occurred despite differences in soil nutrients in the unburned and the burned quadrats (Table 6).

The dominance of big and little bluestem and the scarcity of side-oats grama, Indiangrass, and switchgrass, are consistent with the proportions of these species reported by Bragg (1978). The absence of switchgrass in the most frequently burned quadrat is an observation worth noting although an assessment of such changes in species composition was not an intended part of the study.

Fire Frequency — Regression analysis indicated significant increases with fire frequency for Mn in big bluestem, little bluestem, and Indiangrass: $r = 0.481$, 0.655, and 0.717, respectively ($P < 0.05$); other regressions were not significant. While not statistically evaluated, there were additional species-specific trends towards increases in other nutrients, most notably Fe in side-oats grama and big bluestem and Cu in big bluestem (Table 5). Several elements decreased, including P in all species evaluated and total N for all but side-oats grama. The amount of change, however, was not as great for those nutrients decreasing as for those increasing in concentration.

Burning Recency — Concentrations of most elements were lower in most species in recently burned quadrats (Tables 1-5). In contrast to less recently burned quadrats (1-2), recently burned quadrats (3-4) had significantly lower concentrations of P in big bluestem and Indiangrass, Mg in Indiangrass, and total N

Table 1. Nutrient concentration and energy content of little bluestem: means ± S.E. Significant differences based on Fisher's LSD ($P < 0.05$) are indicated by different levels of horizontal underlining: statistical similarity within a treatment area is indicated by common horizontal underlining. % = percent dry weight.

Parameter	Quadrat				
	0 (unburned)	1 (burned 1 yr)	2 (burned 2 yrs)	3 (burned 3 yrs)	4 burned 4 yrs)
cal/g	3888 ± 57.4	3985 ± 21.5	4063 ± 31.5	4054 ± 9.17	4074 ± 15.5
K(%)	0.45 ± 0.021	0.66 ± 0.037	0.63 ± 0.027	0.64 ± 0.040	0.62 ± 0.036
Ca(%)	0.52 ± 0.013	0.34 ± 0.030	0.34 ± 0.035	0.34 ± 0.032	0.30 ± 0.022
Mg(%)	0.15 ± 0.005	0.11 ± 0.007	0.12 ± 0.010	0.10 ± 0.009	0.12 ± 0.008
P(%)	0.04 ± 0.001	0.08 ± 0.003	0.09 ± 0.006	0.08 ± 0.003	0.08 ± 0.002
Total N(%)	0.52 ± 0.013	0.52 ± 0.020	0.47 ± 0.023	0.43 ± 0.024	0.45 ± 0.012
Zn(ppm)	8.7 ± 0.70	11.7 ± 0.55	11.7 ± 0.74	13.8 ± 0.50	13.2 ± 0.53
Cu(ppm)	1.42 ± 0.120	1.62 ± 0.086	1.82 ± 0.107	1.72 ± 0.066	1.26 ± 0.060
Fe(ppm)	53.2 ± 2.49	45.2 ± 2.68	44.9 ± 2.20	46.2 ± 2.90	51.1 ± 3.75
Mn(ppm)	16.2 ± 1.50	14.9 ± 1.23	16.2 ± 2.49	19.6 ± 1.51	25.9 ± 1.24

Table 2. Nutrient concentration and energy content of big bluestem: means ± S.E. Significant differences based on Fisher's LSD ($P < 0.05$) are indicated by different levels of horizontal underlining: statistical similarity within a treatment area is indicated by common horizontal underlining. % = percent dry weight.

Parameter	Quadrat				
	0 (unburned)	1 (burned 1 yr)	2 (burned 2 yrs)	3 (burned 3 yrs)	4 (burned 4 yrs)
cal/g	3945 ± 18.7	4019 ± 6.22	3741 ± 30.7	4016 ± 73.5	4029 ± 50.6
K(%)	0.52 ± 0.055	0.68 ± 0.029	0.59 ± 0.032	0.78 ± 0.047	0.72 ± 0.032
Ca(%)	0.60 ± 0.045	0.43 ± 0.022	0.54 ± 0.028	0.38 ± 0.024	0.42 ± 0.038
Mg(%)	0.17 ± 0.004	0.14 ± 0.004	0.16 ± 0.009	0.13 ± 0.008	0.12 ± 0.007
P(%)	0.05 ± 0.005	0.10 ± 0.009	0.10 ± 0.004	0.07 ± 0.002	0.07 ± 0.002
Total N(%)	0.58 ± 0.020	0.53 ± 0.039	0.53 ± 0.020	0.40 ± 0.012	0.42 ± 0.015
Zn(ppm)	11.6 ± 1.18	12.6 ± 0.31	11.4 ± 0.51	15.1 ± 0.83	13.0 ± 0.67
Cu(ppm)	1.40 ± 0.045	1.12 ± 0.224	4.26 ± 2.490	2.56 ± 0.893	1.60 ± 0.164
Fe(ppm)	36.3 ± 4.24	29.5 ± 1.42	40.6 ± 2.61	50.8 ± 6.77	38.5 ± 3.12
Mn(pmm)	13.3 ± 0.82	8.9 ± 1.46	8.7 ± 1.13	14.6 ± 1.57	12.1 ± 1.20

Table 3. Nutrient concentration and energy content of Indiangrass: means ± S.E. Significant differences based on Fisher's LSD ($P < 0.05$) are indicated by different levels of horizontal underlining: statistical similarity within a treatment area is indicated by common horizontal underlining. % = percent dry weight.

Parameter	Quadrat				
	0 (unburned)	1 (burned 1 yr)	2 (burned 2 yrs)	3 (burned 3 yrs)	4 (burned 4 yrs)
cal/g	4044 ± 7.0	4049 ± 16.3	4118 ± 8.5	4150 ± 10.6	4085 ± 8.3
K(%)	0.74 ± 0.017	0.72 ± 0.010	0.68 ± 0.017	0.77 ± 0.019	0.79 ± 0.011
Ca(%)	0.34 ± 0.008	0.30 ± 0.015	0.34 ± 0.018	0.25 ± 0.010	0.28 ± 0.003
Mg(%)	0.10 ± 0.005	0.08 ± 0.002	0.08 ± 0.005	0.06 ± 0.002	0.06 ± 0.002
P(%)	0.03 ± 0.002	0.07 ± 0.003	0.07 ± 0.003	0.06 ± 0.002	0.06 ± 0.001
Total N(%)	0.30 ± 0.007	0.32 ± 0.010	0.32 ± 0.012	0.30 ± 0.014	0.28 ± 0.006
Zn(ppm)	17.6 ± 1.09	29.2 ± 1.35	28.1 ± 0.80	26.6 ± 0.52	27.9 ± 0.73
Cu(ppm)	1.24 ± 0.133	1.04 ± 0.093	1.12 ± 0.049	1.20 ± 0.134	1.16 ± 0.068
Fe(ppm)	19.0 ± 1.37	27.5 ± 2.50	26.4 ± 1.41	26.4 ± 1.10	27.5 ± 1.24
Mn(ppm)	7.3 ± 0.51	10.7 ± 0.78	11.7 ± 1.59	11.9 ± 2.46	28.5 ± 2.42

Table 4. Nutrient concentration in switchgrass and side-oats grama: means ± S.E. (where indicated). % = percent dry weight.

Parameter	Switchgrass[1]			Side-oats Grama				
	Quadrat			Quadrat				
	0 (unburned)	1 (burned 1 yr)	2 (burned 2 yrs)	0 (unburned)	1 (burned 1 yr)	2 (burned 2 yrs)	3 (burned 3 yrs)	4 (burned 4 yrs)
K(%)	0.52 ± 0.052	0.62 ± 0.000	0.62	0.58	0.56	0.57	0.58	0.59
Ca(%)	0.36 ± 0.034	0.34 ± 0.007	0.43	0.36	0.29	0.34	0.30	0.34
Mg(%)	0.14 ± 0.015	0.14 ± 0.006	0.14	0.13	0.13	0.14	0.14	0.15
P(%)	0.08 ± 0.018	0.10 ± 0.004	0.08	0.05	0.10	0.10	0.08	0.08
Total N(%)	0.41 ± 0.047	0.42 ± 0.036	0.44	0.50	0.54	0.52	0.50	0.55
Zn(ppm)	6.5 ± 1.58	11.8 ± 0.28	11.7	17.9	23.0	25.0	26.1	25.0
Cu(ppm)	0.94 ± 0.210	0.90 ± 0.140	0.80	1.30	1.30	1.20	1.10	1.30
Fe(ppm)	23.7 ± 4.07	24.4 ± 5.09	24.90	22.90	25.50	29.40	33.70	38.90
Mn(ppm)	6.9 ± 1.07	10.2 ± 2.05	9.1	18.6	19.2	21.0	19.5	19.2

[1]No data for Quadrats 3-4

Table 5. Effect of fire on nutrient concentration in five grass species. Values shown are percent changes from the unburned quadrat or from the quadrat with the lowest fire frequency or oldest burn.
LBS = little bluestem, BBS = big bluestem, IND = Indiangrass, SWG = switchgrass, SOG = side-oats grama.

Nutrient	Species and Type of Fire Comparison												
	Fire[1]					Fire Frequency[2]				Fire Recency[3]			
	LBS	BBS	IND	SWG	SOG	LBS	BBS	IND	SOG	LBS	BBS	IND	SOG
K	+42	+33	0	+19	−1	−6	+6	+10	+5	−4	+10	+8	+4
Ca	−36	−26	−14	+7	−12	−12	−2	−7	+17	−6	−7	−12	+10
Mg	−25	−19	−30	0	+8	+9	−14	−25	+15	0	−11	−25	+12
P	+106	+70	+117	+13	+80	0	−30	−14	−20	0	−30	−14	−20
Total N	−10	−19	+2	+5	+6	−14	−21	−13	+2	−15	−23	−9	−3
Zn	+45	+12	+59	+81	+38	+13	+3	−4	+9	+15	+12	−7	+11
Cu	+13	+70	−9	−10	−6	−22	+43	+12	0	−8	+86	+13	−8
Fe	−12	+10	+42	+4	+39	+13	+31	0	+53	+8	+51	−2	+42
MN	+18	−17	+115	+40	+6	+74	+36	+290	0	+53	+50	+89	+1

[1]Fire = Average value from Quadrats 1-4 (Quadrats 1-2 for switchgrass) minus value for Quadrat 0.
[2]Fire Frequency = Value from Quadrat 4 (higher frequency) minus value from Quadrat 1 (lowest frequency). Switchgrass was not evaluated.
[3]Fire Recency = Average value of Quadrats 3-4 (most recently burned) minus average value of Quadrat 1 (oldest burn). Switchgrass was not evaluated.

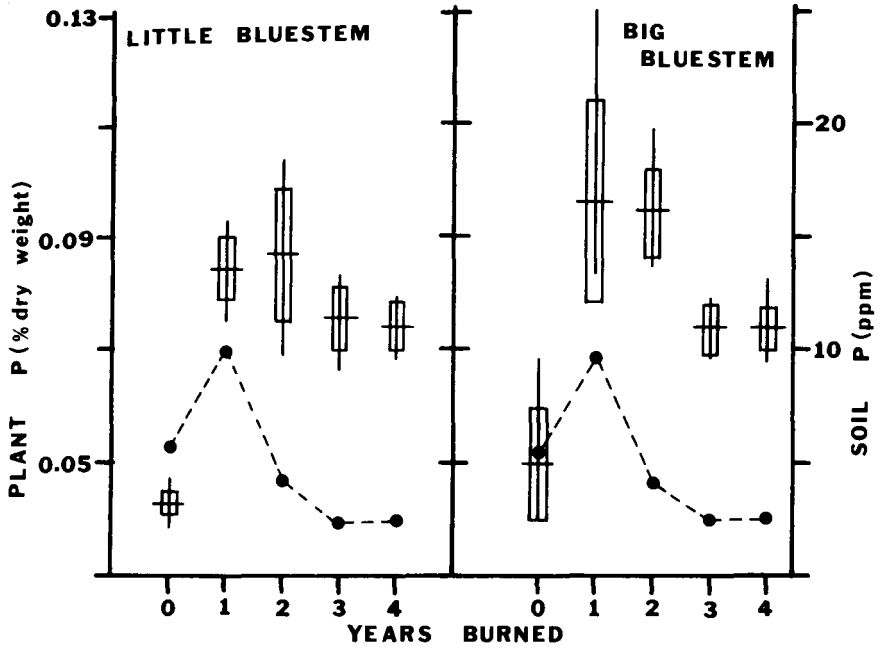

Figure 1. Phosphorus in plant matter (dicegrams) and soil (dashed lines). Vertical line of dicegram connects maximum and minimum values, horizontal line represents mean value, and bar indicates ± 2 SE.

in big bluestem (Fig. 1). Recent burning resulted in significant increases of K in big bluestem and Indiangrass and of Zn in big and little bluestem (Tables 1-3).

Species-Specific Nutrient Uptake — The proportion of nutrients in the five grasses evaluated differed (Tables 1-4). Based on combined data from all quadrats, the greatest concentration of Ca was found in big bluestem, K and Zn in Indiangrass, P in side-oats grama, and Fe in little bluestem. The lowest concentrations of Ca were noted in side-oats grama, Mg, P, and total N in Indiangrass, and Cu and Fe in switchgrass. Of the five species evaluated, big and little bluestem were most similar with respect to the effect of fire on nutrient concentration. These species differed only in concentrations of Mn and Fe.

Energy Concentration — The energy concentration of big and little bluestem and Indiangrass averaged 4028 cal/g (1.07×10^{12} J/Kg) for all treatments. Energy concentration was significantly higher with burning than without (4% increase) (Tables 1-3). Moreover, regression analysis of energy concentration of fire frequency indicated significant, positive, linear relationships in little bluestem ($r = 0.531$, $P < 0.05\%$) and big bluestem ($r = 0.476$, $P < 0.05\%$).

Table 6. Soil characteristics. % = percent dry weight.

Parameter	Quadrat (= No. of Years Burned)				
	0	1	2	3	4
Exchange capacity (meq/100g)	18.81	24.62	25.61	26.04	23.63
K(meq/100g)	0.40	0.44	0.51	0.61	0.71
Ca(meq/100g)	4.72	9.71	9.71	9.31	8.74
Mg(meq/100g)	4.90	5.80	5.60	5.10	4.60
Na(meq/100g)	0.15	0.15	0.15	0.15	0.35
Mn(ppm)	8.9	14.7	14.1	14.9	11.2
Cu(ppm)	1.14	1.11	1.16	1.22	1.26
Fe(ppm)	14.0	20.3	24.2	34.1	32.3
Zn(ppm)	0.28	0.19	0.28	0.36	0.33
P(ppm)	5.8	9.7	4.0	2.2	2.2
Total N(%)	0.043	0.081	0.104	0.132	0.137
Textural class	Silty loam	Silty clay loam	Silty clay loam	Silty clay loam	Silty clay loam

Soil

Differences in soil characteristics were also noted, some perhaps due to differences in location but many apparently in response to burning (Table 6). Cation exchange capacity was substantially lower in the unburned than in any of the burned treatments. Ca, Fe, Mn, and total N were also lower in the burned quadrats.

Progressive increases occurred in K, Cu, Fe, Zn, and total N, from the least to the most frequently burned quadrat. Ca, Mg, and P, however, decreased with increasing burning frequency. The decrease in P with burning frequency was substantially greater in recently burned than in less recently burned quadrats (Fig. 1).

DISCUSSION

This study indicates that nutrient cycling and plant energetics in bluestem prairie are affected by burning in general and specifically by fire frequency and recency. Energy concentration generally increased in response to burning, a result similar to that reported for big bluestem by Hadley and Kieckhefer (1963). The average of 4028 cal/g (1.07×10^{12} J/Kg) in plant biomass in the present study is comparable to the 4601 cal/g (1.22×10^{12} J/Kg) recorded by Hadley and Kieckhefer (1963) in a similarly burned area.

Nutrient storage, and presumably nutrient uptake, as well as energy stored in above-ground phytomass varied depending on (1) species of plant, (2) soil nutrient concentration, (3) type of element, and (4) time lapsed since the last fire. Moreover, the effects of a single fire on soil and plant nutrient concentration are detectable for several years following burning. For example, three years after burning, the concentration of K in little bluestem in Quadrat 1 remained greater than in the unburned area. (Table 1).

Fire alters the pattern of nutrient cycling in tall-grass prairie. The general effect of fire shown in the present study was to increase K, P, Zn, Cu, Fe, and Mn and to decrease Ca and Mg in the current year's grass biomass. Kucera and Ehrenreich (1962) noted similar results for Ca and Mg but found K to be lower and P to remain unchanged by fire in a tall-grass prairie. Their study, however, did not separate fall plant biomass by species. The decline in Ca differs from increases reported by Smith and Young (1959) in little bluestem.

More specifically, the data from this study show that fire frequency and recency alter nutrient cycling, at least in part, by affecting the nutrient concentration of prairie plant species. The most notable responses to fire frequency were increases in Mn, Fe, and Cu concentration although smaller changes in other nutrients were also noted. Mg, for example, increased and decreased in concentration with the direction of change differing among species. Kucera and Ehrenreich (1962), however, reported that for combined species in a tall-grass prairie, the Mg content of plant matter was slightly although not significantly less with frequent burning.

Burning recency influenced plant nutrient concentrations, particularly P and total N which were lowest in recently burned quadrats. These results, however, differ from those of Koelling and Kucera (1965) in which P and N, as well as K and Mg, in plant biomass were lower two years after burning than during the year of the fire. Koelling and Kucera's study, however, did not involve the same degree of fire frequency that was a part of the present study; the most recently burned quadrats in the present study were also the most frequently burned ones.

Cation exchange capacity and Ca, Fe, Mn, and total N concentration in soils differed between the burned and the unburned areas although it is unclear whether this represents soil differences, the effect of burning, or both. The four adjacent burned quadrats, however, were located on a level upland, were within the same soil type, and had the same management history. Differences noted between these quadrats, therefore, best represent the effects of burning. One such effect, for example, is the progressive increase in total N, Cu, Fe, and Zn in the soil with increased fire frequency.

The soil is the nutrient source for plants; thus plant uptake, measured as nutrient concentration, was expected to be reflected in changes in soil nutrient concentration. While not conclusive, the results of this study indicate several such plant-soil nutrient interactions. Because of possible significant preburn differences between burned and unburned areas, this relationship can best be considered by comparing the four burned quadrats. Three types of fire effects are supported by the data from these quadrats. The first occurs when the quantity

of the nutrient released by burning exceeds the ability of the plant to take it up; thus both soil and plant nutrient concentration increase. Such a response is shown by Zn concentration in all species, by Mn in all but big bluestem, and by Fe in all but little bluestem. The second type of effect occurs when a nutrient is released at a rate equal to or less than the plant demand. In this instance soil nutrient concentration declines but plant concentration increases. Such a response was shown with P for all species. The third effect occurs when nutrients are released but some effect of burning reduces the availability or the ability for plant uptake; thus soil nutrients increase but plant nutrient concentration decreases. This response was observed for Ca concentration in all species except switchgrass and for Cu in all but big and little bluestem. A fourth effect would be one resulting in a decrease in both soil and plant nutrients. Such a response was not noted in this study but it would occur, for example, when nutrients are volatilized or when erosion or deep percolation removes nutrients.

Except for P, fire increased the amount of nutrients in the soil despite enhanced uptake by plants. Therefore, the overall conclusion from these results is that the availability of soil nutrients in the study area was not substantially affected by fire-induced alterations in nutrient cycling during the short period of time encompassed by this study. Long-term effects, however, were not evaluated, but the fire-induced variations in nutrient cycling noted suggest that such effects may be important.

ACKNOWLEDGMENTS

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Food Habits of Juvenile Gizzard Shad in Open-water and Near-shore Habitats of Melvern Reservoir, Kansas

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ABSTRACT – Food habits were determined for juvenile gizzard shad (*Dorosoma cepedianum*) collected from two different habitats in Melvern Reservoir, Kansas, during mid-July of 1984. Gizzard shad longer than 30 mm collected from near-shore habitat had consumed primarily detritus while those from open-water habitat had consumed primarily filamentous algae. Zooplankton was infrequently consumed by gizzard shad in both habitat types, including fish less than 30 mm in length.

Gizzard shad (*Dorosoma cepedianum*) are important prey in many reservoir fish communities (Noble 1981). Young gizzard shad (less than 25 mm total length) have been shown to consume primarily zooplankton (Barger and Kilambi 1980, Van Den Avyle and Wilson 1980, Cramer and Marzolf 1970). Gizzard shad longer than 25 mm have been shown to feed on phytoplankton, zooplankton, bottom sediments, and suspended detritus (Barger and Kilambi 1980, Bodola 1965, Wickliff 1945).

Light penetration in water, and therefore phytoplankton production, is known to be limited to some extent by high levels of abiogenic turbidity (Wetzel 1975). Adams et al. (1983) suggested that the food web in some turbid reservoirs (e.g. Tuttle Creek Reservoir, Kansas) may be based primarily on allochthonous organic matter. Most young-of-the-year (YOY) gizzard shad in Melvern Reservoir, Kansas, had moved from open water to the near-shore habitat by the time they reached 30-40 mm (Willis 1985), thus suggesting a possible change in feeding habits. The purpose of this study was to determine and compare the food habits of juvenile gizzard shad collected from these habitats.

STUDY AREA

Melvern Reservoir is located 36 km northeast of Emporia, Kansas. It is a flood control and water resource development lake on the Marais des Cygnes River. It controls a drainage of 102,000 ha, and has a surface area of 2800 ha at conservation pool. Maximum and mean depths are 23 and 7 m, respectively. Secchi transparencies in early summer typically range from 13 cm in the upper end to 46 cm in the lower end. In late summer, transparencies typically range from 30 cm in the upper end to 76 cm in the lower end.

METHODS

Young-of-the-year gizzard shad (the only clupeid found in the lake) were collected on 13 July from open-water habitat for analysis of food habits. These fish were captured in water of 4-6 m with a Tucker trawl (mouth = $1m^2$, mesh size = 0.505 mm) towed just beneath the surface at approximately 1.2m/sec. On 16 July, YOY gizzard shad from near-shore habitat were collected by electrofishing (220 volt, direct current). These fish were collected within 10 m of the shoreline and were taken from water of 0.3-1.5 m. Both samples were collected between 0800 and 1000 hours.

Gizzard shad were immediately preserved in 25 to 50% solutions of ethyl alcohol; no regurgitation was observed. The fish were grouped by 5-mm (total length) length groups starting at 16-20 mm. Contents of the foreguts (esophagus and gizzard) for up to 10 fish from each length group were examined. The contents of each foregut were viewed individually in a Sedgwick-Rafter counting cell at 100X. Frequency of occurrence was noted for food categories. The volumetric percentage of each food category was visually estimated to the nearest 5%, and means for each length group were therefore rounded to the nearest 5%. When means were less than 3%, the category was assigned a value of "less than 5%" so that minor occurrences could be noted. A mean of 0% thus indicates that a food category did not constitute 5% of the food volume for any of the fish in that length group. Percentages for food categories within a length group did not always add to 100 because of rounding.

RESULTS AND DISCUSSION

Filamentous algae, organic detritus, and inorganic material (mostly fine sand) constituted at least 90%, by volume, of food taken by juvenile gizzard shad in near-shore habitat. In open-water habitat, filamentous algae and organic detritus comprised 95% or more, by volume, of food ingested by fish longer than 25 mm. Volumetric percentages of filamentous algae and organic detritus for fish of 16-20 and 21-25 mm were 75 and 80%, respectively. The remaining percentages for these two smaller length groups were dominated by diatoms. The value of frequency-of-occurrence data (Tables 1 and 2) appears to be documentation of low-occurrence food categories. All subsequent discussion concerns only the volumetric data.

In open-water habitat, filamentous algae steadily increased in importance for gizzard shad from 16-40 mm, with a slight decrease in importance thereafter (Table 1). The segment of the diet made up of organic detritus generally decreased as the length of the specimens increased until the fishes reached 40 mm. Diatoms were taken by fish of 16-35 mm, and decreased in importance as length increased. Neither cladocerans and copepods nor rotifers comprised 5% of the diet of any length group. Sand grains were not found in any gizzard shad taken from the open water.

In near-shore habitat, the portion of the diet composed of filamentous algae generally decreased as the length of specimens increased (Table 2). Organic detritus steadily increased in importance for fishes from 21-75 mm. Rotifers always

Table 1. Food of gizzard shad collected from open-water habitat of Melvern Reservoir, Kansas. Both frequency of occurrence (F) and % by volume (V) are listed for all food categories.

	Length group (mm)															
	16-20		21-25		26-30		31-35		36-40		41-45		46-50		51-55	
Food categories	F	V	F	V	F	V	F	V	F	V	F	V	F	V	F	V
Filamentous algae	100	15	100	30	100	50	100	65	100	95	100	90	100	85	100	80
Diatoms	100	25	90	20	90	5	80	<5	100	0	100	0	83	0	56	0
Cladocerans and copepods	20	0	10	0	100	0	20	0	100	0	0	0	33	0	22	0
Rotifers	60	0	50	<5	90	<5	80	<5	100	0	100	<5	100	<5	100	<5
Organic detritus	100	60	100	50	100	45	100	35	100	5	100	10	100	15	100	15
Inorganic material	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of fish		10		10		10		5		1		4		6		9

Table 2. Food of gizzard shad collected from near-shore habitat of Melvern Reservoir, Kansas. Both frequency of occurrence (F) and % by volume (V) are listed for all food categories.

	Length group (mm)											
	21-25		26-30		31-35		36-40		41-45		46-50	
Food categories	F	V	F	V	F	V	F	V	F	V	F	V
Filamentous algae	100	55	100	45	100	40	100	35	100	35	100	25
Diatoms	100	0	60	<5	60	0	60	<5	50	0	50	0
Cladocerans and copepods	100	0	70	<5	70	<5	70	<5	60	<5	67	<5
Rotifers	100	5	100	5	100	5	100	5	100	5	100	5
Organic detritus	100	40	100	50	100	50	100	55	100	60	100	55
Inorganic material	0	0	90	0	100	0	100	<5	100	<5	100	10
Number of fish		1		10		10		10		10		6

Table 2. Continued.

	Length group (mm)											
	51-55		56-60		61-65		66-70		71-75		76-80	
Food categories	F	V	F	V	F	V	F	V	F	V	F	V
Filamentous algae	100	35	100	30	100	25	100	15	100	10	100	25
Diatoms	60	0	75	0	80	0	80	0	75	0	50	0
Cladocerans and copepods	60	0	50	0	40	0	80	0	50	0	75	0
Rotifers	100	5	100	5	100	5	100	10	100	5	100	5
Organic detritus	100	55	100	50	100	60	100	65	100	75	100	60
Inorganic material	100	5	100	15	100	10	100	10	100	10	100	10
Number of fish		5		4		5		5		4		4

comprises 5-10% of the diet, but may have been incidentally consumed with the detrital materials. Both diatoms and the cladoceran and copepod group never comprised 5% of the diet for any length group. Inorganic material (mostly fine sand) was first volumetrically visible in the 36- to 40-mm group and was present thereafter.

Contrary to the findings of several authors (Barger and Kilambi 1980, Van Den Avyle and Wilson 1980, Cramer and Marzolf 1970), zooplankton was infrequently consumed by the smaller (less than 25 mm) YOY gizzard shad collected during this study. This may have been due to zooplankton scarcity at the time of the study. Zooplankton densities in Melvern Reservoir, as indicated by trawling, were much higher in early May than they were when this study was conducted.

Organic detritus found in near-shore fish was coarse and often identifiable as plant parts, suggesting that it came from bottom materials. The presence of sand in the near-shore fish also indicated bottom feeding activity. In contrast, the detritus in open-water fish was finely divided and was probably taken by suspension feeding. Detrital feeding at some life stage of the gizzard shad has been noted (Bodola 1965, Jester and Jensen 1972, Pierce et al. 1981).

This study demonstrates the need for a longer and more in-depth food habit analysis of YOY gizzard shad in Melvern Reservoir. The interrelationships of changes in plankton density and abiogenic turbidity with diet and diet trends of larval and juvenile gizzard shad need to be studied as was done to some extent by Barger and Kilambi (1980) in Beaver Reservoir, Arkansas. A need also exists to refine the visual estimation technique used for food-habit analysis. Estimates of the quantity of inorganic material (sand), suspended detritus, and nonsuspended detritus might be more accurate if the sucrose density-gradient method (Lammers 1962) were used to separate the particles.

This study also has general implications for food-habit studies of fish populations — fish should probably be collected from various habitat types. If gizzard shad had been collected from only one of these habitats at Melvern Reservoir, the results of the food-habits analysis would have been much different.

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Changes in Breeding Blackbird Numbers in North Dakota from 1967 to 1981-82

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ABSTRACT – Red-winged blackbirds (*Agelaius phoeniceus*), yellow-headed blackbirds (*Xanthocephalus xanthocephalus*), and common grackles (*Quiscalus quiscula*) were censused in 1981-82 in North Dakota in the 130 quarter sections (160 acres) censused in 1967 by Stewart and Kantrud (1972). The number of breeding adult male red-winged blackbirds was estimated to be 29.0% lower ($P = 0.002$) in 1981-82 than in 1967; the statewide breeding population was estimated at 1,512,000 in 1981-82. This decrease has been more than compensated for by the number of breeding adult male yellow-headed blackbirds, which have increased 4.7-fold ($P = 0.12$) to an estimated 962,000 statewide in 1981-82. Grackles increased 71.4% ($P = 0.002$) since 1967 to an estimated 573,000 pairs statewide. The 1981-82 estimate of 3.1 million breeding "pairs" of these three species in North Dakota compares with 2.7 million estimated by Stewart and Kantrud (1972) in 1967, or 14.3% ($P > 0.5$) more. Wetland habitats (7.8% of the area sampled) were preferred over upland habitats by breeding red-wings and yellow-heads. Densities of breeding red-wings were 17 times greater in wetlands than uplands and yellow-heads bred exclusively in wetlands. Grackles preferred farmsteads, shelterbelts, and groves, where densities were 16 times greater than in wetlands.

Red-winged blackbirds (*Agelaius phoeniceus*), yellow-headed blackbirds (*Xanthocephalus xanthocephalus*), and common grackles (*Quiscalus quiscula*) are responsible for multi-million dollar losses annually to ripening sunflowers (*Helianthus annuus*) in the Dakotas (Henne et al. 1979, DeHaven 1982). Much of this loss is caused by blackbirds that breed within 100 mi of where the damage occurs (Besser et al. 1984). For this reason, many parties are interested in the status of breeding blackbird populations in North Dakota, the state with the largest amount of prairie wetlands remaining in the contiguous United States (Shaw and Fredine 1971).

In 1967, Stewart and Kantrud (1972) censused 130 randomly selected legal quarter-sections (160 acres, 64.75 ha) in North Dakota (Fig. 1) and estimated the breeding populations of red-winged and yellow-headed blackbirds and common grackles in that state at 2,637,000 "pairs" (2,092,000 red-wings, 204,000 yellow-heads, and 341,000 common grackles). Estimates of red-wings and yellow-heads were considered minimums for these polygynous species, because each territorial male was considered to represent only one pair. To obtain information on the more recent status of breeding populations of these three species, we censused the same sampling units in 1981-82.

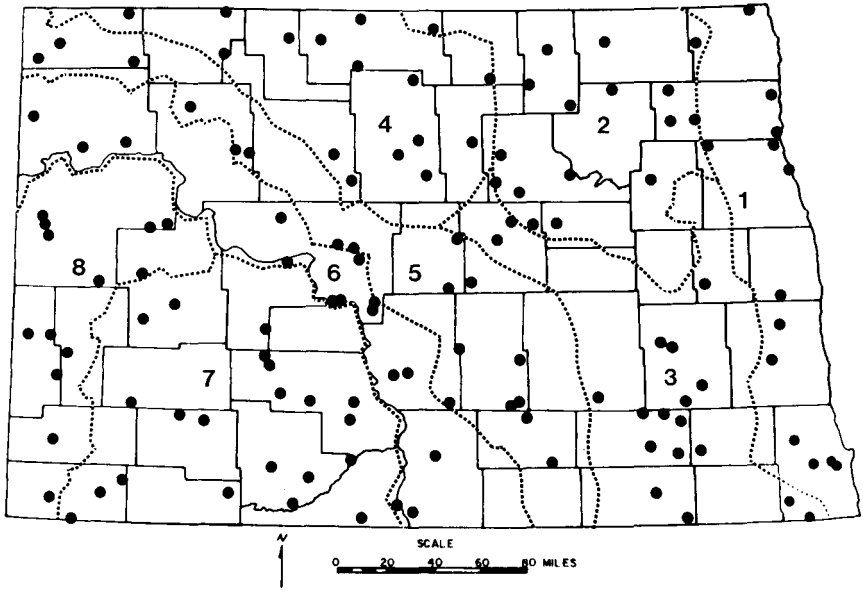

Figure 1. Biotic stratification of North Dakota (dotted lines) and distribution of sample units (solid circles). Strata numbered as follows: (1) Agassiz Lake Plain, (2) Northeastern Drift Plain, (3) Southern Drift Plain, (4) Northwestern Drift Plain, (5) Missouri Coteau, (6) Coteau Slope, (7) Missouri Slope, (8) Little Missouri Slope (From Stewart and Kantrud 1972).

METHODS

In 1981, the 68 quarter-sections sampled by Stewart and Kantrud in the Missouri Coteau and the Southern, Northeastern, and Northwestern Drift Plains physiographic regions of North Dakota were censused between 28 May and 24 June (the 60 most southern blocks from 28 May to 8 June). In 1982, the remaining 62 blocks in the Agassiz Lake Plain, and Coteau, Missouri, and Little Missouri Slopes regions were censused between 29 May and 9 June. The 1981-82 census dates included the times found best for censusing territorial male red-winged blackbirds in North Dakota (Besser and Brady 1984); 50 of the 130 sample units in 1967 were also censused within these dates, but 50 were censused earlier (average nine days) and 30 were censused later (average seven days). As the census covered two breeding seasons, to minimize small year-to-year variations in breeding blackbird numbers (8.3% $\pm$ SE 3.7) for red-winged blackbirds in the Dakotas from 1964-68 and 1979-81 (Besser et al. 1984), the four physiographic regions in North Dakota (the Missouri Coteau, and the three Drift Plain regions) that were most densely populated by blackbirds in 1967 were all censused in 1981. In 1967, these regions contained 72.7% of all blackbirds; 70.8% of the red-wings, 98.9% of the yellow-heads, and 68.8% of the grackles.

Methods employed in this census were similar to those employed by Stewart and Kantrud (1972). Twin 440- x 880-yard strips were censused by walking the mid-point of the strip (220 yards from each edge of the strip). If any land area on the strip was not visible with binoculars because of rolling terrain, trees, or shrubs, the observer adjusted his position to ensure as complete a count as practical. The point of departure from the mid-point of the strip was marked to allow the observer to return to that point. The perpendicular distances to feeding adult male red-wings and yellow-heads and adult grackles were estimated, so that the number of breeding birds that were not on territory could be estimated by formulas developed by Burnham et al. (1980). Acreages of each habitat in each sampling unit were determined by pacing or were visually estimated. Paired t-tests were used to determine the significance of changes in numbers of breeding red-wings and grackles per sampled units in 1967 and 1981-82; because most yellow-heads were found on only a few sampling units, the significance of changes in numbers for this species was determined by the Wilcoxon (1945) signed-rank test.

RESULTS AND DISCUSSION

Red-winged blackbirds

The number of breeding male red-winged blackbirds observed in the 130 sample units decreased by 29.0% ($P = 0.002$), from 980 in 1967 to 696 in 1981-82 (Table 1). The statewide population for North Dakota in 1981-82 was estimated at 1,512,000 ($\pm$ SE 187,000) "pairs" (Table 2). Numbers in the three well-drained (Slope) southwestern physiographic regions declined by 56.9% ($P = 0.001$) compared to 21.6% ($P = 0.08$) in the less well drained remainder of the state.

Yellow-headed blackbirds

The number of breeding male yellow-headed blackbirds seen in the 130 sample units increased 370% ($P = 0.12$), from 94 in 1967 to 443 in 1981-82 (Table 1). The population for North Dakota in 1981-82 was estimated at 962,000 ($\pm$ SE 430,000 "pairs" (Table 2). The 200 yellow-head males counted in one sample unit (3 miles south of Hurdsfield, Wells County) were more than double those counted in all 130 units in 1967. Counts of yellow-head males in three other units also exceeded the number (31) counted in the most densely populated unit in 1967.

Unfortunately both the 1967 and the 1981-82 estimates have wide confidence limits, because yellow-heads are colonial and were absent from most sampled units. However, the census data suggest that yellow-heads probably are replacing red-wings in North Dakota marshes, as forecast by the studies of Orians (1961) in Washington and Robertson (1972) in Ontario. In 1967, Stewart and Kantrud (1972) estimated a combined red-wing and yellow-head population of 2,333,000 breeding males of these predominately marsh-nesting blackbird species in North Dakota. In 1981-82, there were an estimated 2,474,000 breeding red-wing and yellow-head males in North Dakota or 6% more than in 1967. The

decrease of an estimated 617,000 breeding red-wing males has apparently been more than offset by the increase of an estimated 758,000 yellow-head males during this period.

Common grackles

Breeding pairs of common grackles on the 130 sample units increased 71.4% (P = 0.002), from 154 in 1967 to 264 in 1981-82 (Table 1); the 1981-82 population for North Dakota was estimated at 573,000 (± SE 94,000) "pairs" (Table

Table 1. Numbers of breeding blackbirds censused in physiographic regions of North Dakota, 1967 vs 1981-1982.

Region	N	Years 1967[a]	Years 1981-82	% change	P
Red-winged Blackbird					
Drift Plains[b]	50	549	389	−29.1	0.02
Slopes[c]	49	204	88	−56.9	0.001
Missouri Coteau	18	145	151	+3.4	0.40
Agassiz Lake Plain	13	82	68	−17.1	>0.50
Total	130	980	696	−29.0	0.002
Yellow-headed Blackbird					
Drift Plains	50	76	220	+189.5	0.51
Slopes	49	1	7	+600.0	0.56
Missouri Coteau	18	17	216	+1170.6	0.33
Agassiz Lake Plain	13	0	0	0	NC[d]
Total	130	94	443	+371.3	0.12
Common Grackle					
Drift Plains	50	105	171	+62.9	0.01
Slopes	49	34	44	+29.4	>0.50
Missouri Coteau	18	1	23	+2200.0	0.07
Agassiz Lake Plain	13	14	26	+85.7	0.43
Total	130	154	264	+71.4	0.002
All Three Species					
Drift Plains	50	730	780	+6.8	>0.50
Slopes	49	239	139	−58.2	0.001
Missouri Coteau	18	163	390	+139.2	0.33
Agassiz Lake Plain	13	96	94	−2.1	>0.50
Total	130	1,228	1,403	+14.3	>0.50

[a]Numbers for physiographic regions ascertained from original field notes.
[b]Southern, Northeastern, and Northwestern Drift Plains.
[c]Coteau, Missouri, and Little Missouri Slopes.
[d]Not calculable.

Table 2. Estimates of statewide numbers of breeding blackbird "pairs" in North Dakota in 1981-82 compared with 1967.

Species	Numbers/mi² sampled (± SE)		Estimated state total[a] (± SE)	
	1981-82	1967	1981-82	1967
Red-winged blackbird	21.42 (± 2.64)	30.15 (± 2.85)	1,511,798 (± 186,607)	2,128,680 (+ 200,896)
Yellow-headed blackbird	13.63 (± 6.09)	2.89 (± 1.17)	962,251 (± 429,914)	204,180 (± 82,458)
Common grackle	8.12 (± 1.34)	4.74 (± 1.08)	573,440 (± 94,391)	334,507 (± 76,211)
Total	43.17 (± 9.31)	37.78 (± 3.57)	3,047,489 (± 657,111)	2,667,367 (± 251,953)

[a]70,594 mi² in North Dakota (Encyclopaedia Britannica, 1970).

2). Grackles had increased in all but one physiographic region. The increase in the number of breeding grackles since 1967 largely accounts for the estimated increase in the total number of sunflower-damaging blackbirds in North Dakota.

Total numbers of the three species of blackbirds

The 1981-82 density of breeding red-wings, yellow-heads, and grackles combined is estimated at 43.2 (± SE 9.3) males/mi² (2.59 km²) resulting in an estimate of 3,047,000 (± SE 657,000) "pairs" of these three species for the state in 1981-82 (Table 2). This is an increase of 14.3% ($P > 0.5$) since 1967. Because many yellow-heads migrate from North Dakota before late maturing sunflower fields are vulnerable (Royall et al. 1971), damage to sunflower from local breeding populations of blackbirds may not be increasing. The probable replacement of red-wings by yellow-heads in marshes can possibly benefit North Dakota sunflower growers suffering damage from these two species.

Densities of blackbirds in various habitats

In May-June 1981-82, wetlands made up 7.8% of the 20,800 acres sampled; 61.3% of the blackbirds were censused in wetlands (Table 3), and wetlands made up 69.3% of their breeding habitat (Table 4). Uplands made up 92.2% of the sampled acreage; 38.7% of the blackbirds were censuses there, but uplands made up only 30.7% of their breeding habitat.

Upland habitats were categorized into non-cropland, cropland with breeding habitat, and cropland with only feeding habitat. Non-cropland made up 33.1% of the area sampled and 23.0% of the blackbirds were censused there; cropland with breeding habitat made up 12.1% of the sampled area and 6.0% of the blackbirds were censused there; and tilled and newly seeded cropland made up 47.0% of the area sampled where 9.8% of the blackbirds were observed feeding. The effect of change in land use on breeding habitats between 1967 and 1981 could not be fully determined, because small wetland acreages within tilled fields and pastures were separated from the chief land use in 1981-82, whereas they were not separated in 1967.

Breeding red-wings and yellow-heads preferred wetland habitats to upland habitats. There were 18.4 times more breeding red-wings per 100 acres (40.5 ha) in wetland habitats as in upland habitats (25.8 vs 1.4; Table 3). There were 9.9 times more red-wings per 100 acres in wetlands than in non-cropland uplands and cropland with breeding habitat (25.8 vs 2.6). Yellow-heads were found nearly exclusively in wetlands. Of the 443 adult male yellow-heads found in the census, 412 (93.0%) were holding territories in wetlands. The 31 individuals recorded in upland habitats were only feeding there. Marshes, lake edges, sloughs, ditches, ponds, and stream courses held 60.3% of the breeding male red-wings and 93.0% of the breeding male yellow-heads, even though composing only 5.1% of the area surveyed.

Breeding grackles preferred upland areas with trees and shrubs to other cover types. Densities of breeding grackles were 16.3 times greater per 100 acres in farmsteads, shelterbelts, and groves than in wetland areas (29.4 vs 1.7; Table

Table 3. Density (number per 100 acres) of blackbirds censused in 2 wetland and 11 upland habitats in North Dakota, 1981-82.

Habitat	Acres		Red-wings	Yellow-heads	Grackles	All three species
	No.	%				
Wetlands						
Marshes, sloughs, potholes, ditches, and stream courses	984	4.7	37.6	41.0	2.2	80.8
Lakes, reservoirs, and ponds	647	3.1	7.7	1.4	0.9	10.0
Subtotal	1,631	7.8	25.8	25.3	1.7	52.7
Uplands						
Non-croplands:						
Grazed pastures and prairie	4,404	21.2	0.3	0.0	0.1	0.4
Ungrazed pastures and prairie	1,110	5.3	2.8	0.1	0.7	3.6
Woodlands and brushlands	500	2.4	0.0	0.0	0.2	0.2
Roadsides, fencerows, railroads	451	2.2	19.3	0.0	2.2	21.5
Farmsteads, shelterbelts, groves	402	1.9	9.2	0.5	29.4	39.1
Rockpiles, gravel and sand pits	20	0.1	40.0	0.0	0.0	40.0
Croplands						
Breeding habitats:						
Weedy stubbles	1,055	5.1	1.6	0.9	0.9	3.3
Alfalfa and other hay lands	793	3.8	4.0	0.0	0.0	4.0
Ripening small grains (>12″)	660	3.2	2.3	0.0	0.3	2.6
Feeding habitats:						
Newly seeded (<12″)	6,225	29.9	0.3	0.1	0.2	0.6
Bare, tilled	3,549	17.1	0.5	0.4	2.0	2.8
Subtotal	19,169	92.2	1.4	0.2	1.2	2.8
Wetlands and Uplands total	20,800	100.0	3.3	2.1	1.3	6.7

Table 4. Use of North Dakota habitats for breeding by blackbirds that damage sunflower, 1981-82.

Habitat	Percent of total			
	Red-wings	Yellow-heads	Grackles	All three species
Marshes, sloughs, potholes, ditches, and stream courses	56.0	97.8	13.0	64.1
Lakes, reservoirs, and ponds	7.6	2.2	3.6	5.2
Total in wetlands	63.6	100.0	16.6	69.3
Farmsteads, shelterbelts and groves	5.6	0.0	69.8	12.5
Roadsides, fencerows, and railroads	13.2	0.0	5.9	7.8
Ungrazed pastures and prairies	4.7	0.0	4.7	3.1
Alfalfa and other hay lands	4.8	0.0	0.0	2.6
Grazed pastures and prairies	2.0	0.0	2.4	1.4
Weedy stubbles	2.6	0.0	0.0	1.4
Ripening small grains (>12″	2.3	0.0	0.0	1.2
Rockpiles, gravel and sand pits	1.2	0.0	0.0	0.6
Woodlands and brushlands	0.0	0.0	0.6	0.1
Total in uplands	36.4	0.0	83.4	30.7
Totals	100.0	100.0	100.0	100.0

3). The May-June dates of the survey were somewhat late for censusing breeding grackles, for we occasionally observed fledged grackles in 1981. The late dates also contributed to the high percentage (31.8%) of grackles found feeding in tilled and newly seeded cropland.

Estimates of feeding blackbirds not seen

While walking strip transects, we observed 85 pairs of breeding grackles feeding, 34 single adult male red-wings, and 19 single adult male yellow-heads in tilled and newly seeded croplands. Perpendicular distance estimates were obtained on 33 (38.8%) of the grackles, 28 (82.4%) of the red-wings, and 5 (26.3%) of the yellow-heads. From the method of Burnham et al. (1980), it was calculated that 58.8% of the grackles and 20.0% of the red-wings feeding on the 220-yard strip transects were not observed. The sample size for yellow-heads was too small to estimate the number of feeding males not seen. When the estimated numbers of breeding blackbirds feeding and not seen are added to those seen, they constitute a negligible 1.0% (7 of 703) of all red-wings, but a substantial 15.9% (50 of 314) of all grackles. These additions increased the estimated blackbird numbers for North Dakota by 124,000 — 15,000 red-wings and 109,000 grackles (Table 5). The estimated state total for 1981-82, therefore, was 1.5 million breeding red-wings, 1.0 million yellow-heads, and 0.7 million grackles or 3.2 million for the three species of blackbirds (Table 4). These ex-

Table 5. Estimates of breeding blackbird numbers in North Dakota in 1981-82, adjusted for feeding breeders not seen.

Species	Density/mi² (± SE)	Estimated state total[a]
Red-wings	21.63 (± 2.67)	1,527,003
Yellow-heads[b]	13.63 (± 6.09)	962,251
Grackles	9.66 (± 1.59)	682,047
Total	44.92 (± 9.69)	3,171,301

[a]70,594 mi² sampled.
[b]No adjustment, mean perpendicular distance of five males sighted was 111 yards.

trapolated estimates for 1981-82 were not compared with estimates made in 1967, as distances to feeding birds were not taken in 1967.

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Rare Animals and Plants of South Dakota

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ABSTRACT — The South Dakota Natural Heritage Program (a cooperative research project of The Nature Conservancy and the South Dakota Department of Game, Fish and Parks), in cooperation with individuals from scientific organizations, academia, and state and federal agencies, has developed an annotated list of rare animals and plants of South Dakota. The list includes 173 species of animals and 213 species of vascular plants which are known or thought to be rare, uncommon, in need of protection or monitoring, or for which more biological information is needed to determine status. All species officially designated as Endangered, Threatened, Proposed, or Candidate for Listing at the state and federal levels are included. Heritage status codes (critically rare, rare, uncommon, status undetermined, historical record only, presumed extirpated) are defined and applied based upon the most current and reliable information. Descriptive categories (peripheral, disjunct, endemic) identify specific distributional patterns within South Dakota and are used where appropriate. Comments include habitat affinities, known records of occurrence, population dynamics, state distribution, known or suspected threats, or management and information needs.

Rarity of species is a result of a number of influences, the most serious of which is habitat loss caused by human actions on the environment. The continued decline of native species throughout the land is accelerating. Only through genuine concern and substantial support for all aspects of our natural heritage will we be able to stem the tide of habitat and species destruction.

The identification, protection, and preservation of our existing natural diversity is a conservation challenge of monumental proportions. Through its scientifically-based state Natural Heritage Programs, The Nature Conservancy has designed a network of systems to establish inventory criteria, data capture and management, preserve selection and design, and natural area stewardship. Essential in initiating protection efforts is the establishment of a biologically sound and reliable database from which priorities are set, objectives and goals are defined, and methods chosen to obtain the desired results. The database generated and managed by the Natural Heritage Program is also useful to developers and decision-makers. By considering Heritage information early in project plans, serious environmental conflicts can be avoided or minimized and unnecessary destruction of our rare fauna and flora can be prevented.

The list that follows includes species which, according to the most current and reliable data, may need protection and are targets for inventory efforts by the South Dakota Natural Heritage Program. Although maintenance of a documented list is but one facet of the Natural Heritage Program, it is the single most important aspect of our continuing efforts to identify significant natural areas in South Dakota. The selection of species is based upon information gleaned

from a variety of sources, including an extensive literature review, examination of museum and herbarium specimens and records, field surveys, and numerous contacts with local, state, regional, and federal sources. In addition, previous lists of rare plants in South Dakota were consulted (Schumacher 1979, Van Bruggen 1980). To date, information has been gathered for insects, pelecypods, vertebrates, pteridophytes, gymnosperms, monocots, and dicots. As the inventory progresses, attempts will be made to include other groups of invertebrates and non-vascular plants. Approximately 30 percent of the listed species (116 of 386) have been assigned a "U" (status undetermined) ranking, indicating that we lack sufficient information for a more refined determination. We do feel, however, that their inclusion is necessary, particularly to serve as important target species for future inventory work. Species intentionally omitted from the list include extinct species, common game species, non-breeding birds, and captive, introduced, or reintroduced species except if any of the aforementioned have been declared as Endangered, Threatened, Proposed for Listing, or Candidate for Listing at either the state or federal level.

The objectives of this effort are: 1) to update existing and out-of-date lists based upon the best available information; 2) to encourage individuals, private organizations, and government agencies to become involved or increase activities in research, conservation, management, and educational programs on behalf of the listed species; 3) to serve as an important conflict-avoidance database for developers and decision-makers whose plans involve our natural resources; 4) to stimulate exchange of new information required to keep the list and the Natural Heritage database dynamic and reflective of current conditions; and 5) to serve as a working document from which Natural Heritage Program priorities for inventory, conservation, and preservation of natural diversity may be established.

The list must be viewed as a dynamic report and is subject to modification as conditions or situations warrant; species will be promoted or demoted in rank, deleted, or added as new information is brought to our attention. We invite input from all persons concerning species they feel should be added to or deleted from the list. We especially would like to be notified of any recent sightings or collections of any listed species. Comments on nomenclature, life history, or any other relevant information will be appreciated.

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Official Designation

Designations were assigned to appropriate species in accordance with official state and federal lists (Federal Register 1980a,b, 1982, 1983, 1984; Office of Endangered Species 1984; Wentz 1979) and appear as follows:

FE: Federal Endangered
FT: Federal Threatened
PE: Proposed Federal Endangered
PT: Proposed Federal Threatened
CL: Candidate for Federal Listing
SE: State Endangered
ST: State Threatened

Heritage Status

Heritage status codes were assigned 1) to indicate the degree of rarity of the species, 2) to indicate the degree of threat to the continued survival of the species, and 3) to aid in establishing priorities for conservation and preservation efforts. The codes are as follows:

A: Critically Rare — in danger of extirpation in the state; very rare or habitat seriously threatened.
B: Rare — known from few sites in the state; species or habitat considered vulnerable or declining.
C: Uncommon — apparently secure in the state at present but warrants monitoring; may be localized or declining.
U: Status Undetermined — possibly rare, declining, or extirpated in the state; more information is needed on present abundance and threats to determine status.
H: Historical Record Only — not reported in the state for more than 50 years but habitat may still exist and rediscovery is possible.
X: Presumed Extirpated — no longer believed to occur in the state; populations or habitat have greatly declined and no recent occurrences are known; rediscovery is unlikely.

Descriptive Category

Descriptive categories were developed to describe certain aspects of the geographical distribution, population dynamics, or behavioral characteristics of a species within South Dakota. The categories (coded in lower case letters and enclosed in parenthesis) are used in conjunction with Heritage Status Codes and are defined as follows:

(p): Peripheral — a species whose occurrence in South Dakota represents the edge of its natural range.

(d): Disjunct — a species whose occurrence in South Dakota represents a separation of the primary contiguous population or a discontinuous distribution.

(e): Endemic — a species whose occurrence in South Dakota represents all or a significant portion of its range in the state or in the northern Great Plains region.

Comments

A summary statement for each species presents pertinent information of habitat affinities, known records of occurrence, aspects of population dynamics, general or specific state distribution, known or suspected threats, or management and information needs.

Nomenclature

Common and scientific names of species are consistent with recognized authorities. Sources most commonly consulted were: insects, Federal Register (1984); pelecypods, Burch (1975); fishes, Robins et al. (1980); amphibians and reptiles, Collins et al. (1978); birds, American Ornithologists' Union (1983); mammals, Jones et al. (1979), Hall (1965, 1981); plants, Kartesz and Kartesz (1980), and Barkley (1977).

ANIMAL LIST

INSECTS	Official Designation	Heritage Status	Comments
Hesperia dacotae Dakota skipper	CL	A(e)	Known from a few prairie sites in ne SD.
Nicrophorus americanus American burying beetle	CL	U	Two records from e SD; needs inventory work.
Phyciodes batesi Tawny crescent	CL	A	Restricted to native prairies of the Black Hills.
Speyeria idalia Regal fritillary	CL	B	Scattered records across SD; native prairie habitat declining.
PELECYPODS			
Amblema plicata Three ridge mussel		B	Abundance declining dramatically.
Andodontoides ferussacianis Cylindrical paper shell		B	General decline in numbers.

PELECYPODS	Official Designation	Heritage Status	Comments
Anodonta grandis corpulenta Floater mussel		U	Limited in SD to backwaters of free-flowing Mo. River.
Fusconaia flava Pig-toe mussel		A	Dead shells known from Vermillion and James rivers.
Lampsilis radiata luteola Fat mucket		U	Occurs in Vermillion and James rivers; may be in ne lakes.
Lampsilis teres Slough sand-shell		A	Dead shells only found in Vermillion River in 1975.
Lampsilis ventricosa Pocketbook mussel		U	Occurs in Vermillion and James rivers, may be in ne lakes.
Leptodea leptodon Scale shell	CL	A	Known in SD only from Lewis and Clark Lake.
Ligumia recta a bivalve		U	May be declining.
Potamilus alatus Purple heel-splitter		B	General decline in numbers.
Potamilus ohioensis Fragile heel-splitter		B	General decline in numbers.
Strophitus undulatus Squaw foot mussel		B	General decline in numbers.
Toxolasma parva Liliput shell		A	No live specimens known from SD.
Truncilla donaciformis Fawn-foot mussel		B	General decline in numbers.
Truncilla truncata Deer-toe mussel		B	General decline in numbers.
FISHES			
Acipenser fulvescens Lake sturgeon	CL	A(p)	Known from tailwaters of Gavins Pt. Dam; habitat may be threatened.
Alosa chrysochloris Skipjack herring		U	One 1954 record from tailwaters of Ft. Randall Dam; may occur elsewhere.
Amia calva Bowfin		U	May occur in ne lakes; no recent records.
Anguilla rostrata American eel		U	Migration in Mo. River blocked by dams.
Carpiodes cyprinus Quillback		B	Known in SD from Big Sioux and Minnesota rivers.
Catostomus catostomus Longnose sucker	ST	B	Known in SD from Black Hills streams; may be relict in state.
Couesius plumbeus Lake chub		B(p)	Occurs in Black Hills streams and Little Mo. River; spotty distribution.
Culaea inconstans Brook stickleback		C	Habitat diminishing.
Fundulus diaphanus Banded killifish	SE	A(p)	Very few records for SD.
Fundulus sciadicus Plains topminnow	ST	A(d,e)	Northern disjunct population regionally endemic.
Hiodon tergisus Mooneye		A(p)	Occurs in Big Sioux River; siltation threatening habitat.

FISHES	Official Designation	Heritage Status	Comments
Hybopsis gelida Sturgeon chub	ST	A(p)	Spotty distrib. in Mo. River and large w tribs.; habitat diminishing.
Hybopsis meeki Sicklefin chub	ST	A	High turbidity habitat much reduced by dams in SD.
Hybopsis storeriana Silver chub		B	Known in SD only from Lewis and Clark Lake.
Hypentilium nigricans Northern hogsucker		A(p)	Known in SD from Big Sioux and Yellow Bank rivers.
Ichthyomyzon unicuspis Silver lamprey		U	Known in SD only from lower Mo. River; may be peripheral.
Ictiobus niger Black buffalo		B(p)	Known in SD from Big Sioux River and Lake Mitchell.
Lepisosteus osseus Longnose gar		B	Occurs in large Mo. River tribs., and Big Stone Lake.
Moxostoma erythrurum Golden redhorse		B(p)	Known in SD from extreme e drainages.
Nocomis biguttatus Hornyhead chub		B(p)	Occurs in ne SD; range may be decreasing.
Notropis blennius River shiner		U	Probably confined to Mo. River and lower parts of larger tribs.
Notropis heterolepis Blacknose shiner		B(p)	Habitat threatened; range and population declining.
Notropis rubellus Rosyface shiner		A(p)	Known in SD only from Whetstone Creek and Big Sioux River.
Notropis shumardi Silverband shiner		B	Confined in SD to Mo. River; range declining.
Notropis topeka Topeka shiner		A(e)	Regional endemic; spotty distribution; habitat threatened.
Percina caprodes Logperch		B(d)	Known in SD from ne lakes region.
Percina maculata Blackside darter		B(p)	Occurs in extreme e SD.
Percina phoxocephala Slenderhead darter		A(p)	Known in SD only from Whetstone Creek.
Percopsis omiscomaycus Trout perch	ST	B	Occurs in the Minnesota and upper Big Sioux river drainages.
Phenacobius mirabilis Suckermouth minnow		B(p)	Known primarily in SD from Big Sioux River; spotty distribution.
Phoxinus eos Northern redbelly dace	ST	B	Occurs in e and s-central SD; recent collections needed.
Phoxinus neogaeus Finescale dace	ST	B(d)	Relict population in n Black Hills.
Scaphirhynchus albus Pallid sturgeon	CL,ST	A	Restricted to Mo. River; severe decline in range and numbers due to dams.
Semotilus margarita Pearl dace	SE	A(d)	Regional disjunct population; occurs in extreme s-central SD.
Umbra limi Central mudminnow	SE	A(p)	Habitat vulnerable to destruction or alteration.

AMPHIBIANS	Official Designation	Heritage Status	Comments
Hyla versicolor Gray treefrog		B(p)	Found in ne and se SD; riparian habitat declining.
Necturus maculosus Mudpuppy		U	Population in ne SD lakes uncertain.
Rana blairi Plains leopard frog		B(p)	Known in SD from se and s-central areas; habitat threatened.
Rana sylvatica Wood frog		H	One SD record from Hartford Beach in 1922.
REPTILES			
Cnemidophorus sexlineatus Prairie-lined racerunner		B(p)	Few occurrences in s-central SD.
Diadophis punctatus Prairie ringneck snake		C(p)	Occurs in se SD.
Elaphe vulpina Western fox snake		C(p)	Occurs in se SD.
Emydoidea blandingii Blanding's turtle	ST	U	Only 1 SD record; survey needed; habitat threatened.
Eumeces multivirgatus Northern many-lined skink		B(p)	Occurs in sandhills of s-central SD.
Graptemys pseudogeographica False map turtle	ST	B(p)	Mo. River and tribs. on nw edge of species range.
Heterodon platyrhinos Eastern hognose snake	ST	B(p)	Known best in SD from extreme se region sand dunes along Mo. River.
Holbrookia maculata Northern earless lizard		B(p)	Occurs in sandhill prairies of extreme s-central SD.
Lampropeltis triangulum syspila Red milk snake		B(p)	Scattered few occurrences in SD.
Nerodia sipedon Northern water snake		B(p)	Collected in se SD near Springfield.
Opheodrys vernalis Western smooth green snake		B(p,d)	Black Hills population disjunct, se and ne population peripheral.
Phrynosoma douglassii Eastern short-horned lizard		B	Scattered few occurrences in SD.
Sceloporus graciosus Northern sagebrush lizard		B(p)	Few records from Black Hills.
Sceloporus undulatus Northern prairie lizard		C(p)	Occurs in sandhill prairies of s-central SD.
Storeria dekayi Texas brown snake	ST	H	Only known from 1922 record.
Storeria occipitomaculata occipitomaculata Northern redbelly snake	ST	B(p)	Occurs in e SD.
Storeria o. pahasapae Black Hills redbelly snake		B(e)	Regional endemic of the Black Hills.
Terrapene ornata Ornate box turtle		B(p)	Several records from sandhill prairies of s-central SD.
Thamnophis elegans Wandering garter snake		C(p)	Scattered throughout Black Hills.

REPTILES	Official Designation	Heritage Status	Comments
Trionyx muticus Midland smooth softshell		C	Known in SD from Mo. River; habitat or range may be declining.
Trionyx spiniferus Western spiny softshell	ST	A(p)	Sandy big river habitat threatened.
Tropidoclonion lineatum Northern lined snake	ST	A(p)	Native habitat threatened in e SD.
BIRDS			
Accipiter cooperii Cooper's hawk		B	Restricted to mature forests; population decline.
Accipiter gentilis Northern goshawk		C(d)	Breeding restricted to the Black Hills and Slim Buttes.
Aegolius acadicus Northern saw-whet owl		U	Secretive; may be statewide permanent resident.
Ammodramus bairdii Baird's sparrow		B	Restricted to native prairie in n-central SD.
Ammodramus caudacutus Sharp-tailed sparrow		U	Rare summer resident of wetland edges in the ne.
Ammodramus henslowii Henslow's sparrow		U	Rare summer resident in e SD; spotty distribution.
Ammodramus leconteii Le Conte's sparrow		U	Rare summer resident in e or possibly nw SD.
Anthus spragueii Sprague's pipit		U	Restricted to plains, short-grass prairies of w SD; habitat decline.
Aquila chrysaetos Golden eagle		C	Breeding restricted to w SD.
Ardea herodias Great blue heron		B	Future status of rookeries uncertain.
Asio otus Long-eared owl		B	Utilizes native woodlands and shelterbelts statewide.
Buteo platypterus Broad-winged hawk		A	Few recent records; restricted to deciduous forests; habitat decline.
Buteo regalis Ferruginous hawk	CL	C	Restricted to grasslands; gradual habitat decline.
Buteo swainsoni Swainson's hawk	CL	C	Common summer resident of grasslands; nesting records needed.
Butorides striatus Green-backed heron		B	Scattered records for e SD.
Calcarius mccownii McCown's longspur		U	Formerly abundant, no recent nests found.
Caprimulgus vociferus Whip-poor-will		B	Restricted to riparian forests in e SD.
Carpodacus cassinii Cassin's finch		U	Rare breeder in the Black Hills.
Casmerodius albus Great egret		B	Rookeries recently discovered in ne SD.
Catharus fuscescens Veery		B	Breeding restricted to Black Hills and ne; utilizes dense thickets.

BIRDS	Official Designation	Heritage Status	Comments
Charadrius melodus Piping plover	PT	A	Population decline; restricted to Mo. River and ne saline wetlands.
Charadrius montanus Mountain plover	CL	X	Last breeding records from Black Hills circa 1929.
Cinclus mexicanus American dipper		C	Restricted to high quality streams in the Black Hills.
Contopus borealis Olive-sided flycatcher		U	Rare breeder in higher elevations of the Black Hills.
Coturnicops noveboracensis Yellow rail		U	May nest in e SD wetlands.
Dryocopus pileatus Pileated woodpecker		U	May nest in ne SD; only winter records so far.
Egretta caerulea Little blue heron		A	Rare breeder in e SD wetlands.
Egretta thula Snowy egret		B	Rookeries recently discovered in e SD.
Egretta tricolor Tricolored heron		U	May nest in e SD.
Falco columbarius Merlin		B	Rare breeder in Black Hills and Harding County.
Falco mexicanus Prairie falcon		A	Formerly abundant, restricted to isolated areas of w SD.
Falco peregrinus Peregrine falcon	FE,SE	A	No recent nesting known; population declining; rare migrant.
Grus americana Whooping crane	FE,SE	A	Very rare migrant.
Haliaeetus leucocephalus Bald eagle	FE,SE	A	May nest in SD; winters along Mo. River; surveys needed.
Hylocichla mustelina Wood thrush		U	Utilizes river bottom forest; habitat declining.
Larus californicus California gull		B	One rookery known.
Lophodytes cucullatus Hooded merganser		B	Restricted to ne SD lakes.
Loxia curvirostra Red crossbill		C	Migrant and wintering statewide; scattered nesting records.
Mergus merganser Common merganser		B	Common transient; rare breeder; two nest records: 1874 and 1984.
Mimus polyglottos Northern mockingbird		U	Rare breeder, scattered documentation.
Mniotilta varia Black-and-white warbler		U	No nests observed; utilizes stream-side forests.
Nucifraga columbiana Clark's nutcracker		U	May nest in the Black Hills.
Numenius americanus Long-billed curlew	CL	U	Shows 50-year decline, uses short-grass plains; need breeding records.
Nycticorax nycticorax Black-crowned night-heron		C	Rookeries located in e SD wetlands; habitat decline.
Nycticorax violaceus Yellow-crowned night-heron		A	No nests found, may nest in river bottom forests.

BIRDS	Official Designation	Heritage Status	Comments
Oreoscoptes montanus Sage thrasher		A	Restricted to sw sagebrush communities; few recent records.
Pandion haliaetus Osprey	ST	H	Rare migrant; former breeder.
Parus bicolor Tufted titmouse		U	Restricted to extreme e SD stream-side woods and thickets.
Phalaenoptilus nuttallii Poor-will		B	Utilizes w SD rock outcrops and woody draws.
Picoides tridactylus Three-toed woodpecker		B	Restricted to the Black Hills.
Piranga olivacea Scarlet tanager		A	Restricted to river bottom or stream-side forests; habitat decline.
Plegadis chihi White-faced ibis		B	Rookeries recently discovered; two locations.
Podiceps auritus Horned grebe		B	Utilizes wetlands in e SD.
Podiceps grisegena Red-necked grebe		B	Restricted to lakes and larger wetlands of ne SD.
Polioptila caerulea Blue-gray gnatcatcher		A(p)	May nest in se SD.
Rallus elegans King rail		B	Utilizes wetlands in e SD.
Scolopax minor American woodcock		B	Restricted to mature forests and thickets of e SD.
Sialia sialis Eastern bluebird		B	Rare statewide resident.
Sitta pygmaea Pygmy nuthatch		A	Restricted to pine forests of the Black Hills.
Spizella breweri Brewer's sparrow		C	Restricted to sagebrush communities of nw and sw SD.
Sterna antillarum athalassos Interior least tern	FE,SE	A	Nests on Mo. River gravel bars and w tribs.; population declining.
Sterna hirundo Common tern		B	Utilizes ne lakes.
Tryngites subruficollis Buff-breasted sandpiper	ST	U	Rare migrant; e SD.
Tyto alba Common barn-owl		B	Rare permanent resident.
Vireo flavifrons Yellow-throated vireo		B	Utilizes stream-side forests in ne and se SD.
MAMMALS			
Clethrionomys gapperi Gapper's red-backed vole		C	Occurs sparingly in ne SD and widespread in Black Hills.
Cryptotis parva Least shrew		B(p)	Suitable grassland habitat in s-central SD undergoing conversion.
Felis concolor Mountain lion	ST	A	Spotty distribution in Black Hills and Badlands.

MAMMALS	Official Designation	Heritage Status	Comments
Felis lynx Lynx	CL	A	Extremely low numbers in w SD.
Glaucomys sabrinus Northern flying squirrel		B(p)	Occurs sparingly in Black Hills; forest harvest may threaten habitat.
Lagurus curtatus Sagebrush vole		B(p)	Occurs in extreme nw SD; habitat not threatened at present.
Lasionycteris noctivagans Silver-haired bat		C	Migrates through, but may reside in Black Hills.
Lutra canadensis River otter	ST	A	Riverine habitat protection needed.
Microsorex hoyi Pygmy shrew		A(p)	Recently rediscovered in SD; a very rare North American mammal.
Microtus longicaudus Long-tailed vole		C(d)	Occurs on mountain slopes in Black Hills; disjunct from western population.
Mustela nigripes Black-footed ferret	FE,SE	A(e)	Regional endemic; few recent SD records; rarest North American mammal.
Myotis evotis Long-eared myotis		A(p)	Very few records in extreme w SD.
Myotis keenii Keen's myotis		B	Spotty distribution in SD; most records from Black Hills.
Myotis thysanodes pahasapensis Fringe-tailed myotis		B(e)	Subspecies endemic to Black Hills; resides in caves and mines.
Neotoma floridana baileyi Eastern woodrat		U(p)	Status uncertain; recent specimens needed.
Perognathus flavescens perniger Plains pocket mouse		B	Known in SD only from extreme se area.
Plecotus townsendii Townsend's big-eared bat		B	Most records from Black Hills; population may be disjunct; very sensitive.
Sciurus carolinensis Gray squirrel		U(p)	Recently sighted in ne and may occur in se SD; field inventory needed.
Sorex arcticus Arctic shrew		H(p)	Last record dated 1877 from Ft. Sisseton.
Sorex nanus Dwarf shrew		A(p)	Known in SD only from sw area; very few records.
Sorex palustris Water shrew		H(p)	Last record dated 1878 from Ft. Sisseton.
Spermophilus spilosoma Spotted ground squirrel		A(p)	Northern edge of range occurs in sw SD.
Sylvilagus nuttallii Nuttall's cottontail		C(p)	Black Hills is eastern limit of this western species.
Synaptomys cooperi Southern bog lemming		U	Little information available; needs study.
Tamias striatus Eastern chipmunk		B(p)	Occurs in extreme ne SD; near western edge of range.
Ursus americanus Black bear	ST	A	Western SD population may be relict or disjunct; habitat decreasing.

MAMMALS	Official Designation	Heritage Status	Comments
Vulpes velox Swift fox	CL,ST	A	Scattered in w SD; habitat decreasing; den site data needed.
Zapus princeps Western jumping mouse		A(p)	Known in SD only from ne area; habitat decreasing.

PLANT LIST

PTERIDOPHYTES

Adiantum capillus-veneris Venus-hair fern	A(d)	Single occurrence along Cascade Creek; observed regularly since 1898.
Adiantum pedatum Maidenhair fern	H	Last collected in 1941 from Spearfish Mountain.
Asplenium trichomanes Maidenhair spleenwort	H	Last collected in 1929 from Mount Rushmore.
Asplenium viride Green spleenwort	B(d)	Few occurrences in n Black Hills; especially on moist limestone.
Botrychium lunaria Moonwort	H	Last reported in 1930 for the Trojan area in the n Black Hills.
Botrychium matricariifolium Matricary grape fern	U	Historically known from the Black Hills; recently found on Ordway Prairie.
Botrychium multifidum Leathery grape fern	B(d)	Few occurrences in meadows of the Harney Peak area.
Botrychium simplex Least grape fern	U	Last collected from the Steamboat Rock area of the n Black Hills.
Cystopteris bulbifera Bulbil bladder fern	A(p)	Since 1965, single known occurrence in Sica Hollow State Park.
Equisetum scirpoides Dwarf scouring rush	B(d)	Few occurrences in moist forested sites and riparian zones of Black Hills.
Isoetes melanopoda Black-footed quillwort	H	Last collected in 1924 from a wetland margin in Mellette County.
Lycopodium obscurum Round-branched ground pine	U	Few old reports from the Black Hills; one recent, unspecific report.
Polypodium vulgare var. *virginianum* Rock polypody	B(p)	Two known occurrences on moist Sioux quartzite cliffs in se SD.
Polystichum lonchitus Holly fern	U	Reported from Roughlock Falls; also occurs in Black Hills of WY.
Polystichum munitum Western sword fern	U	Recently reported but population has apparently been extirpated.
Thelypteris palustris Marsh fern	B	Few occurrences in boggy wetlands of s and ne SD; reported for Black Hills.

GYMNOSPERMS	Official Designation	Heritage Status	Comments
Pinus contorta Lodgepole pine		B(d)	Known site near Nahant; scattered reports elsewhere in Black Hills.
Pinus flexilis Limber pine		B(d)	Known occurrence in Cathedral Spires of Custer State Park.
MONOCOTS			
Acorus calamus Sweetflag		C(p)	Several occurrences in lake and stream margins of ne SD.
Allium drummondii Drummond's wild onion		U	Occurs in s SD where species reaches n edge of range.
Aristida longespica Slimspike threeawn		U	Occurs on sandbars along the lower Mo. River.
Calypso bulbosa Fairy slipper orchid		B	Few occurrences in spruce forests of the Black Hills.
Carex aggregata Clustered sedge		U	Reported for s side of Pickerel Lake; not relocated.
Carex alopecoidea Tawny sedge		B(p)	Few occurrences in riparian woodlands of ne SD.
Carex bella Elegant sedge		A(d)	Single known occurrence in Sunday Gulch; observed regularly since 1924.
Carex brunnescens Brownish sedge		B(d)	Few occurrences in riparian habitats of the s Black Hills.
Carex canescens Gray sedge		B(p)	Few occurrences in boggy sites of the Black Hills.
Carex capillaris Hair sedge		B(p)	Few occurrences in riparian zones and springs of the Black Hills.
Carex concinna Low northern sedge		B(d)	Few occurrences in forests of the Black Hills; only one recent report.
Carex hoodii Hood's sedge		U	Occurs in forests of the Black Hills; common in western U.S.
Carex intumescens Swollen sedge		U	Occurs in riparian zones of the Black Hills; no recent reports.
Carex lacustris Lake sedge		C	Several occurrences in fens and wetlands of s and ne SD.
Carex leptalea Delicate sedge		B	Three known occurrences in spruce wetlands of the Black Hills.
Carex occidentalis Western sedge		U	Recent state record from Harney Peak; occurs primarily in s Rocky Mts.
Carex pedunculata Peduncled sedge		H	Single collection in 1924 from forest at Drywood Lakes.
Carex richardsonii Richardson's sedge		U	Occurs in forests of the Black Hills; rare or extirpated in ND, WY, & IA.
Carex rossii Ross sedge		C(p)	Several occurrences in pine forests of the Black Hills and nw SD.

MONOCOTS	Official Designation	Heritage Status	Comments
Carex rupestris Curly sedge		U	Recently rediscovered on moist ledges of Harney Peak.
Carex sparganioides Bur sedge		H	Last reported in 1928 along lower Big Sioux River.
Carex vesicaria Inflated sedge		U	Few widely scattered reports from moist areas in nw, sw and ne SD.
Carex viridula Greenish sedge		A(p)	Single known site in fen of n-central SD; formerly from the Black Hills.
Cinna arundinacea Stout woodreed		H	Last reported in 1920 for riparian forests of se SD.
Corallorhiza odontorhiza Autumn coral-root		U	Few known occurrences in forests of the n Black Hills.
Corallorhiza trifida Pale coral-root		U	Occurs in moist forests of the Black Hills; a mostly boreal species.
Cypripedium candidum Small white lady's-slipper		A(p)	Thought extirpated in SD until recent rediscovery in ne SD.
Danthonia californica California oatgrass		U	Recent state record from a moist meadow on Terry Peak.
Deschampsia cespitosa Tufted hairgrass		B(p)	Few occurrences in Black Hills riparian zones.
Diarrhena americana American beakgrain		U	Collected along lower Big Sioux River in 1958; not seen since.
Eleocharis rostellata Beaked spikerush		A(d)	Single known occurrence along Cascade Creek; observed since 1966.
Elymus diversiglumis Interrupted wildrye		U	Few occurrences in the Black Hills; taxonomy is uncertain.
Epipactis gigantea Stream orchid		A(d)	Single occurrence along Cascade Creek; observed regularly since 1929.
Eragrostis trichodes Sand lovegrass		C(p)	Several occurrences in sandhills of s SD but documentation is scanty.
Eriophorum gracile Slender cottongrass		H	Last reported in 1897 from fen near Elkton.
Eriophorum polystachion Tall cottongrass		B(p)	Occurs in fens across the state; a rare and threatened habitat.
Erythronium albidum White fawn lily		A(p)	Single recent occurrence in n-facing forest of Union County State Park.
Festuca idahoensis Idaho fescue		U	Reported for w SD but no sites have been verified.
Fimbristylis autumnalis Slender fimbristylis		U	Apparently collected from Minnehaha County but no recent reports.
Juncus alpinus Alpine rush		B	Few occurrences in riparian zones of Black Hills and lower Mo. River.
Juncus articulatus Jointed rush		B	The few recent reports are restricted to along Spearfish Creek.

MONOCOTS	Official Designation	Heritage Status	Comments
Juncus marginatus Margined rush		B	Wetland habitats of Black Hills and s SD; single recent report.
Lilium canadense ssp. *michiganense* Turk's cap lily		A(p)	Two recent occurrences in prairies of se SD; also reported for Roberts County.
Listera convallarioides Broad-lipped twayblade		A(d)	Single known occurrence in n Black Hills; observed since 1967.
Luzula parviflora Small-flowered woodrush		U	Collected from coniferous forest on Deer Mountain in 1975.
Melica subulata Alaska oniongrass		B	Few occurrences in moist, shaded draws of the n Black Hills.
Najas marina Spiny naiad		U	Recently reported for a wetland at Blue Cloud Abbey.
Oryzopsis pungens Shortawn ricegrass		C	Localized in rocky pine forest of the Black Hills but threats not apparent.
Phleum alpinum Alpine timothy		U	Few occurrences in montane meadows of the Harney Peak area.
Platanthera dilatata Northern white orchid		B	Few occurrences in riparian zones of the n Black Hills.
Platanthera leucophaea Prairie fringed orchid	CL	H	Last collected in 1916 from meadows in the Brandon vicinity.
Platanthera orbiculata Round-leaved orchid		H	Last collected in 1929 from Spearfish Canyon.
Poa rupicola Timberline bluegrass		U	Occurs in crevices and on rock ledges of Harney Peak.
Poa sylvestris Sylvan bluegrass		U	Last collected in 1959 from forest in ne SD; also reported for se SD.
Potamogeton amplifolius Large-leaved pondweed		B	Few reports from freshwater streams and lakes of e SD.
Potamogeton vaginatus Sheathed pondweed		B	Few reports from coldwater lakes and streams of ne and Black Hills.
Rhynchospora capillacea Slender beakrush		A	Historically reported for s SD; now known from two fens in ne SD.
Scirpus cyperinus Woolgrass		H	Only historic reports for SD but occurs in Black Hills of WY.
Smilax ecirrhata Upright carrion-flower		U	Reported as occurring in oak forest of Newton Hills State Park.
Sparganium chlorocarpum Green-fruited bur reed		U	Two collections from wetlands near Summit; reported for Custer County.
Spiranthes cernua Nodding ladies' tresses		B(p)	Few occurrences in moist prairies and swales of extreme e SD.

MONOCOTS	Official Designation	Heritage Status	Comments
Spiranthes magnicamporum Great Plains ladies' tresses		U	Few records from moist sandy prairies in s and e SD.
Spiranthes vernalis Twisted ladies' tresses		B(p)	Three reported occurrences in moist prairies of se SD.
Stipa robusta Sleepy grass		U	Few occurrences in pine savannah of s Black Hills.
Trillium cernuum Nodding trillium		B(p)	Few occurrences in maple-basswood forests of ne SD.
Trillium flexipes Declining trillium		U	Apparently collected from forests of ne SD; identity is still in question.
Trillium nivale Snow trillium		B(p)	Apparently now restricted to forests of the Newton Hills area.
Triplasis purpurea Purple sandgrass		U	Occurs in sandhills and dunes of s SD.
Uvularia grandiflora Large-flowered bellwort		B(p)	Few occurrences in undisturbed forests of e SD.
Uvularia sessilifolia Small-flowered bellwort		X	Last reported in 1894 from forest near Vermillion.
Zizania aquatica Wild rice		C(p)	Several occurrences along streams and lakes in e SD; widely planted in 1920s.
DICOTS			
Acer saccharum Sugar maple		B(p)	Few native occurrences in coulees of ne SD.
Adoxa moschatellina Muskroot		B(d)	Few occurrences in cool, moist forest of the Black Hills.
Agastache scrophulariifolia Purple giant hyssop		U	Historically reported for forests of e SD; only two recent records are known.
Agoseris aurantiaca Orange mountain-dandelion		H	Last collected in 1927 from an aspen-birch stand on Terry Peak.
Agrimonia parviflora Many-flowered agrimony		U	Apparently collected from Todd County; no specimens have yet been located.
Agrimonia pubescens Downy agrimony		U	Collected from an oak forest in the Newton Hills area.
Anemone quinquefolia Wood anemone		B(p)	Five known occurrences in maple-basswood forests of ne SD.
Arabis canadensis Sicklepod		B(p)	Few occurrences in rich forests of e SD.
Aralia racemosa Spikenard		B(p)	Few occurrences in rich forests of e SD.
Arnica rydbergii Rydberg's arnica		U	Occurs in montane meadows at higher elevations in the Black Hills.

DICOTS	Official Designation	Heritage Status	Comments
Asarum canadense Wild ginger		B(p)	Two known occurrences in maple-basswood forests of ne SD.
Aster azureus Azure aster		U	Apparently collected from Day County; no specimens have yet been located.
Aster junciformis Rush aster		B	Occurs in fens across the state; a rare and threatened habitat.
Aster pauciflorus Marsh alkali aster		U	Occurs in riparian zones of w SD; typically in alkaline soil.
Aster pubentior Flattop aster		B(p)	Four known occurrences in seepage areas of ne SD.
Aster puniceus Swamp aster		U	Apparently collected from Lawrence and Roberts counties.
Astragalus americanus Rattlepod		B(d)	Few occurrences in forested riparian zones of the Black Hills.
Astragalus barrii Barr's milkvetch		B(e)	Restricted to sw SD, ne WY, and se MT; few known occurrences in SD.
Astragalus miser a milkvetch		H	Last reported in 1895 for the Black Hills.
Cacalia plantaginea Indian plantain		U	Reported for Sica Hollow State Park but not yet verified.
Caulophyllum thalictroides Blue cohosh		B(p)	Few occurrences in undisturbed forests of e SD.
Ceanothus fendleri Fendler's New Jersey tea		H	Last collected in 1929 from Bull Springs area in the s Black Hills.
Chaenactis douglasii Douglas' dusty maiden		U	Two reports from buttes and ridges of Harding County.
Chrysopsis stenophylla Slimleaf goldaster		U	Apparently collected from Yankton Co.; no specimens have yet been located.
Chrysothamnus parryi Parry's rabbit bush		U	Reported for sw SD; no specimens have yet been located.
Clematis hirsutissima Hairy virgin's bower		U	Mixed grass knolls and buttes of Shannon and Fall River counties.
Coreopsis palmata Finger coreopsis		B(p)	Few occurrences in mixed prairie of se SD.
Cornus amomum Pale dogwood		U	Few reports for floodplain forests of se SD.
Cryptantha cana Silver-mounded candleflower		B(e)	Restricted to sw SD, w NE, e WY, and ne CO; few occurrences in SD.
Cryptantha jamesii James' candleflower		U	Single known collection from badlands in Pennington County.
Dentaria laciniata Toothwort		B(p)	Few occurrences in rich forests of e SD.
Draba cuneifolia Wedge-leaved draba		U	Apparently collected from Brookings Co; no specimen has yet been located.

DICOTS	Official Designation	Heritage Status	Comments
Draba stenoloba Alaskan draba		U	Reported for mountain peaks in the Black Hills.
Echinocereus viridiflorus Hedgehog cactus		U	Two collections are known from grasslands of the s Black Hills.
Elaeagnus commutata Silverberry		U	Historically found in the Black Hills; currently known from McPherson County.
Erigeron acris Bitter fleabane		U	Few collections from riparian zones of the s Black Hills.
Erigeron formosissimus Beautiful fleabane		U	Occurs in meadows of the Black Hills; often confused with *E. glabellus*.
Erigeron ochroleucus Buff fleabane		B(p)	Few occurrences on Greenhorn limestone along the Black Hills hogback.
Eriogonum visheri Visher's buckwheat		B(e)	Restricted to badlands of central SD and s-central ND; few occurrences.
Euphorbia fendleri Fendler's spurge		U	Few reports from mountain mahogany chaparral and rocky soil of w SD.
Eustoma grandiflorum Tulip gentian		A(p)	Single known occurrence in meadow along Cascade Creek.
Gentiana affinis Rocky Mountain pleated gentian		B(p)	Few occurrences in moist prairies and meadows of the Black Hills and n SD.
Gentiana puberulenta Downy gentian		C	Disjunct in meadows of the Black Hills; uncommon in prairies of e SD.
Gentianopsis procera Small fringed gentian		B(p)	Four known occurrences in fens of ne SD; four historical occurrences.
Geranium bicknellii Northern cranesbill		U	Occurs especially on old burns in the Black Hills.
Geranium maculatum Wild cranesbill		B(p)	Two known occurrences in maple-basswood forests of ne SD.
Gnaphalium viscosum Sticky cudweed		U	Occurs in pine forest at higher elevations in the Black Hills.
Gymnocladus dioicus Kentucky coffee-tree		B(p)	Few native occurrences in in forests of se SD.
Haplopappus armerioides Skyline goldenweed		U	Three collections from buttes in Harding and Butte counties.
Haplopappus multicaulis Branched goldenweed		U	Four records from seleniferous soils in w SD.
Hedysarum occidentale Western sweetvetch		U	Few reports for the Black Hills; the taxonomy of our plants is uncertain.
Hieracium albiflorum White hawkweed		U	Occurs in open pine forests of n Black Hills; the e edge of its range.
Ipomopsis longiflora White-flowered gilia		H	Last collected by Father Buechel near St. Francis.

DICOTS	Official Designation	Heritage Status	Comments
Ipomopsis spicata Spike gilia		C	Several occurrences in mixed prairie of w SD.
Isopyrum biternatum False rue anemone		H	Collected in 1883 from woods near Scotland; also reported for Custer County.
Juglans nigra Black walnut		C(p)	Several occurrences in forests of se SD.
Lactuca floridana Woodland wild blue lettuce		B(p)	Two recent collections from forests of se SD.
Lechea intermedia Pinweed		U	Occurs in pine forests of s Black Hills.
Ledum groenlandicum Leatherleaf		X	Last collected in 1931 from Spearfish Canyon; population extirpated.
Lespedeza capitata Bush clover		B(p)	Few occurrences in tall-grass prairie of se SD.
Lesquerella arenosa var. *argillosa* Secund bladderpod		U	This variety restricted to sw SD, nw NE and adjacent edge of WY.
Lesquerella montana Mountain bladderpod		U	Single report for the Hot Springs area; the ne edge of its range
Leucophysalis grandiflora White groundcherry		X	Last collected in 1932 from Spearfish Canyon; bears may disperse seeds.
Lithophragma glabrum Bulbous woodland star		U	Reported for the n Black Hills; occurs in Black Hills of WY.
Lithospermum caroliniense Hairy puccoon		C	Several occurrences in sandhills prairie of s SD.
Lithospermum latifolium American gromwell		A(p)	Single small population in floodplain forest of Sica Hollow State Park.
Lobelia kalmii Kalm's lobelia		A	Recently rediscovered on two fens in ne SD; two historical collections.
Lomatium nuttallii Nuttall's desert parsley		H	Last collected in 1926 from the s Black Hills.
Menyanthes trifoliata Bog buckbean		A	Single known site in s SD; two historic sites have been altered.
Microseris nutans Nodding false-dandelion		H	Last collected in 1927 from grasslands and meadows near Sturgis.
Microsteris gracilis Pink microsteris		U	Occurs in pine forest and on slopes of w SD; the e edge of its range.
Mimulus floribundus Roundleaf monkey-flower		H	Last collected in 1924 from near Custer.
Monarda pectinata Pony beebalm		H	Last collected in 1924 near St. Francis.
Navarretia intertexta Swamp navarretia		H	Last collected in 1929 near Harding.
Nymphaea odorata White water-lily		H	Last collected in 1890's from pond near East Sioux Falls.

DICOTS	Official Designation	Heritage Status	Comments
Oenothera flava Yellow evening primrose		U	Reported for riparian zones in w SD; single recent site.
Oenothera rhombipetala Fourpoint evening primrose		C	Several occurrences in sandhills and sandy ditches of s SD.
Oxyria digyna Mountain sorrel		U	Recent state record from moist crevices and ledges on Harney Peak
Panax quinquefolius American ginseng		A(p)	Historically in forests of e SD; only two small populations now known.
Parnassia glauca Waxy bog-star		A(p)	Recently rediscovered on a fen in e SD; two historical collections.
Parnassia palustris Northern bog-star		A(p)	Single known occurrence in fen of n-central SD.
Pedicularis procera Long-leaved lousewort		B(d)	Apparently localized in pine forests around Deerfield.
Penstemon nitidus Shining penstemon		U	Recent state record from Sheepherder's Monument; not yet relocated.
Petasites sagittatus Sweet coltsfoot		B(d)	Three reports for spruce wetlands of the n Black Hills; one is verified.
Petrophytum caespitosum Tufted rockmat		C	Occurs on limestone rock outcrops in n Black Hills but threats not apparent.
Phacelia linearis Threadleaf phacelia		U	Two reports for sandy soil of the Black Hills.
Phlox divaricata Woodland blue phlox		X	Occurred in alluvial forests of se SD; historic sites have been altered.
Picradeniopsis woodhousei Bahia		U	Two reports for plains of w SD; a primarily s Great Plains species.
Polanisia jamesii James' clammyweed		C	Several occurrences in sandhills of s SD.
Polygala sanguinea Blood milkwort		U	Apparently collected from Custer Co.; no specimens have yet been located.
Populus angustifolia Narrow-leaved cottonwood		C(p)	Several occurrences along streams of the Black Hills.
Populus balsamifera Balsam poplar		C	Several localized occurrences in the Black Hills and ne SD.
Prenanthes alba White rattlesnake root		B(p)	Few occurrences in alluvial forests of ne SD.
Psoralea linearifolia Slimleaf scurfpea		U	Collected from prairie w of White River; not relocated.
Pyrola picta White-veined wintergreen		B(d)	Few occurrences in spruce forests of n Black Hills.
Pyrola uniflora One-flowered wintergreen		U	Occurs sporadically in spruce forests of the n Black Hills.
Pyrus ioensis Wild crabapple		U	Reported for forests of se SD; no specimens have yet been located.

DICOTS	Official Designation	Heritage Status	Comments
Rhamnus alnifolia Alder buckthorn		U	Few reports for n Black Hills riparian zones; no recent occurrences.
Salix candida Sage willow		A	Three recent occurrences in fens of ne SD and Black Hills.
Salix humilus Prairie willow		H	Last collected in 1923 from Cactus Hills near Sioux Falls.
Salix serissima Autumn willow		A(d)	Two recent occurrences on fens in Black Hills; also reported for Custer County.
Saxifraga cernua Nodding saxifrage		U	Two reports for moist rocks and crevices in the Harney Peak area.
Saxifraga occidentalis Western saxifrage		B(d)	Few occurrences on moist slopes in the n Black Hills.
Scrophularia marilandica Maryland figwort		U	Collected from Turkey Ridge and near Arlington.
Senecio spartioides Broom groundsel		U	Three known collections from slopes in Custer Co.; no recent reports.
Silphium integrifolium Entire-leaved rosinweed		X	Single collection from near Richland; apparently extirpated.
Solidago riddellii Riddell's goldenrod		A(p)	Recently found on a fen in e SD.
Solidago sparsiflora Three-nerved goldenrod		U	Reported for dry rocky slopes of the Black Hills and adjacent plains.
Sorbus scopulina Western mountain ash		B	Few occurrences on forested slopes of the Lead-Deadwood area.
Spiraea alba Meadowsweet		B(p)	Few occurrences in tall-grass prairie and forest edges in e SD.
Taenidia integerrima Yellow pimpernel		H	Last collected in 1883 from Brule County.
Thelesperma megapotamicum Nippleseed		U	Occurs in dry soil of sw SD; a primarily s Great Plains species.
Townsendia exscapa Easter daisy		C	Several reports for exposed sites in grasslands of w SD.
Townsendia grandiflora Largeflower townsendia		C	Several reports for exposed sites in grasslands of sw SD.
Townsendia hookeri Hooker's townsendia		U	Few reports for exposed sites of sw SD.
Trifolium beckwithii Beckwith clover		B(d)	Few occurrences in tall-grass prairies of the northern Prairie Coteau.
Tripterocalyx micranthus Sand puffs		H	Last collected in 1912 from floodplains of nw SD.
Vaccinium membranaceum Mountain huckleberry		B	Two known occurrences on forested slopes of the n Black Hills.
Veronicastrum virginicum Culver's root		B(p)	Few collections from tall-grass prairies of e SD; only one recent report.

DICOTS	Official Designation	Heritage Status	Comments
Viburnum edule Squashberry		B	Few occurrences in spruce forests of the n Black Hills.
Viola macloskeyi Small white violet		U	Occurs in moist spruce forests of the Black Hills.
Viola renifolia Kidneyleaf violet		U	Occurs in cool, moist areas of the Black Hills; also rare in WY.
Viola selkirkii Great-spurred violet		U	Occurs in cool, shaded ravines of the Black Hills.
Xylorhiza glabriuscula Woody aster		C(p)	Few occurrences on seleniferous soils of sw SD; threats not apparent.

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Correction

An error that neither the authors nor the editors caught appeared on page 59 in the article "A checklist of Texas ants" in Volume 17, No. 2. The correction is as follows: Delete all the information after *Pheidole porcula* Wheeler — and substitute the following: — S, SW, W, NW. 6, 7, 8, 10. 25 counties including *Crane, *Jack.

Editor

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Classification of Native Vegetation at the Woodworth Station, North Dakota

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ABSTRACT – Native prairie areas on the Woodworth Station were sampled, classified, described, and mapped. Transect sites were selectively located along different soil moisture gradients. Data were collected from 292 plots using a modified Braun-Blanquet cover estimation technique. Trees and tall shrubs (over 2 m) were not sampled because they made up less than 1% of all cover. Five vegetation classes were established based on growth forms. They were mixed grass, shrub, tall grass, broad-leaved forbs, and trees. Each class is divided into community types based on species composition. The mixed-grass class has blue grama, Kentucky bluegrass, and mixed native grasses. The shrub class is divided into low shrub, shrub grassland, and tall shrub. The tall-grass class includes little bluestem, big bluestem, bluestem Indian-grass, and prairie cordgrass. These results will provide baseline information for long-range plans on habitat management which are being developed for the Woodworth Station.

Description and classification of vegetation provide baseline information for ecological studies concerning wildlife and grassland management. Long-term vegetational surveys and analyses provide supportive baseline data for future management decisions and studies. The Northern Prairie Wildlife Research Center of the U.S. Fish and Wildlife Service has managed a research field station near Woodworth, North Dakota, since 1964. The station's primary purpose is to develop and evaluate land management practices and study their effects on production of waterfowl, other migratory birds, and resident wildlife species. In addition, surveys of upland and wetland habitat conditions as well as waterfowl populations and production have been conducted for 20 years. The success of these studies has depended on well-defined baseline information. Wetlands in the glaciated prairie region have been classified previously (Stewart and Kantrud 1971). Grasslands of North Dakota have been described on a larger scale by Küchler (1964) and Whitman and Wali (1974). In this paper, I describe, classify, and map the native vegetation of the Woodworth Field Station.

STUDY AREA

The Woodworth Field Station covers 2652 acres (1231 ha) on the eastern edge of the Missouri Coteau in south-central North Dakota (Stutsman County). About two-thirds of the area is of glacial till origin. It is characterized by knob-and-kettle topography with mainly Buse, Barnes, and Svea soils. An area of glacial outwash covers the other one-third and has Sioux, Fordville, and Renshaw soils (Omodt et al. 1968).

The continental climate of the study area is cool, temperate, subhumid, and characterized by long winters and warm summers. Although the annual precipita-

tion averages about 43 cm, it varies widely from year to year, and droughts are common. The average temperature ranges from 2.8° C in January to 37.8° C in July.

The native prairie is predominantly mixed grasses with small areas of tall grasses. The native grasslands on about two-thirds of the study area have been under various land management practices such as nonuse, burning, grazing, and mowing. The remaining two-thirds of the uplands has been cultivated. Part of this area has been seeded with mixtures of introduced cool-season grasses and legumes which provide duck nesting cover (Duebbert and Lokemoen 1976). Recently, mixtures of cool-season native grasses have been planted to test their value to nesting ducks (Higgins and Duebbert 1982).

METHODS

Forty-two 30-m transects were selectively established on different soil moisture gradients in stands of grassland that appeared homogeneous. Plot size (1 x 0.5 m) and number were determined by preliminary nested plot results. Plots were located at 3-m intervals marked along a transect rope. Visual estimation of plant cover was recorded on 292 plots using the Braun-Blanquet scale (Braun-Blanquet 1932). Cover refers to the proportion of ground occupied by the areal canopy of species in a plot. The modified cover class system used was as follows:

Cover class	Range of cover (%)	Midpoint (%)
1	0-1	0.5
2	1-10	5.5
3	10-25	17.5
4	25-50	37.5
5	50-75	62.5
6	75-90	82.5
7	90-100	95.0

Midpoint values modified from Mueller-Dombois and Ellenberg (1974) were used in the quantitative analysis.

We collected 277 species of vascular plants during 1979 and 1980. Voucher specimens were deposited in the herbaria at the Northern Prairie Wildlife Research Center in Jamestown and Woodworth Field Station. Nomenclature follows the *Atlas of the Flora of the Great Plains* (Barkley 1977). Information on soils, moisture, land use, slope angle (clinometer), and slope aspect (compass) was recorded for each plot.

Aerial photographs were used to characterize vegetation differences in tone, texture, and pattern. Ground surveys provided identification of the principal vegetation growth forms used in the initial classification. Soil maps published by the USDA Soil Conservation Service were used to locate transect sites within soil groups. A May 1979 NASA flight produced black-and-white aerial photographs that were used to develop the base map. Low altitude, color IR, 24 x 24 cm transparencies in stereo imagery enabled accurate mapping of community boundaries as well as wetlands, trees, and tall shrubs which were not sampled. The final map was developed with the use of a zoom transfer scope.

RESULTS

The vegetation was divided into five plant classes easily identified in the field: mixed grass, shrub, tall grass, broad-leaved forbs, and trees. The data, 150 species and 292 plots, were also classified by the two-way indicator species analysis called TWINSPAN (Hill 1979). Classes were divided into community types using TWINSPAN results for mixed grass and broad-leaved forbs. Shrub and tall-grass classes were divided by species dominance and composition based on transect summary data, as well as subjective impressions of individual transects.

The native vegetation classes for the Woodworth Station are mapped in Fig. 1, with each community's soil type, topographic moisture, and differential species given in Table 1. The station has about 1451 acres (587.8 ha) of native grassland. This area was classified into 1065 acres of mixed grass, 215 acres of shrub, 128 acres of tall grass, 35 acres of forbs, and 8 acres of trees. Further plant community descriptions follow.

Mixed Grass

Blue Grama. — This community occurs on very well-drained, medium-textured soils over coarse sand and gravel. Fifty-one species were recorded, with

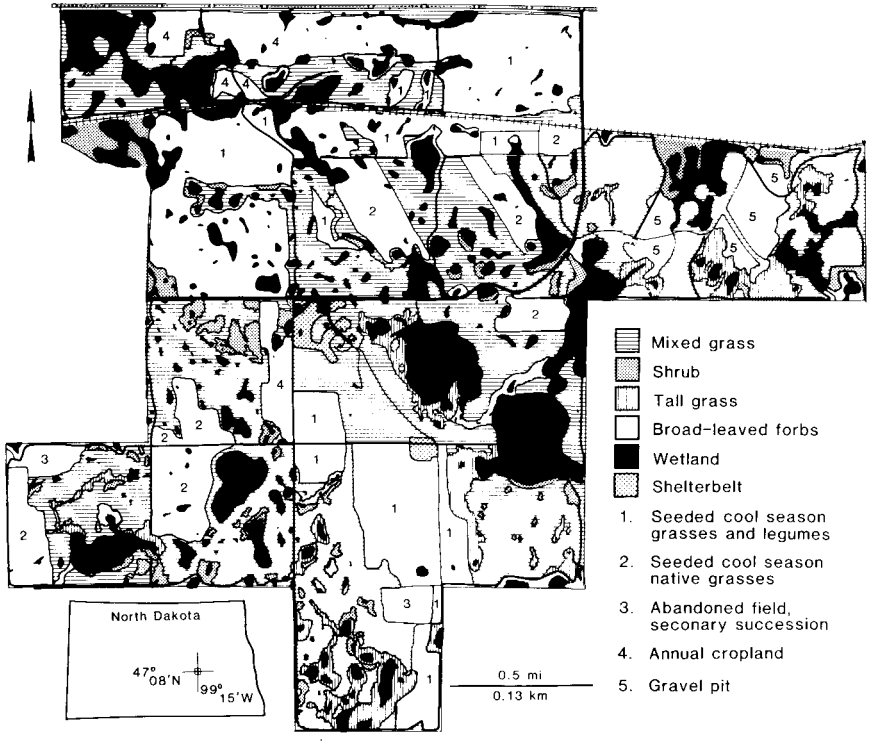

Figure 1. Vegetation map of the Woodworth Field Station.

Table 1. Summary of vegetation classification on the Woodworth study area.

Class	Community	Soil type	Topographic moisture drainage	Differential species[1]	Average % cover
Mixed grass	Blue grama	Sioux Fordville	Excessively drained hilltops, slopes	*Bouteloua gracilis*	26
				Carex spp.	10
				Bare ground	9
				Stipa comata	8
				Chrysopsis villosa	4
				Liatris punctata	2
Mixed grass	Native mixed grass	Buse Sioux Renshaw Barnes	Well-drained gentle slopes	*Bouteloua gracilis*	22
				Stipa comata	16
				Agropyron smithii	12
				Carex spp.	6
				Calamovilfa longifolia	2
Mixed grass	Kentucky bluegrass	Eckman Barnes Buse	Moderately well-drained undulating plains and slopes	*Poa pratensis*	34
				Agropyron smithii	9
				Artemisia ludoviciana	5
				Bromus inermis	5
Shrub	Low shrub	Barnes	Moderately well-drained undulating plains and slopes	*Symphoricarpos occidentalis*	27
				Solidago mollis	12
				Bromus inermis	11
				Helianthus rigidus	10
				Poa pratensis	7
Shrub	Shrub-grassland	Barnes	Moderately well-drained undulating plains and slopes	*Andropogon scoparius*	24
				Helianthus rigidus	14
				Artemisia ludoviciana	8
				Poa pratensis	7
				Stipa comata	6
				Symphoricarpos occidentalis	6
				Elaeagnus commutata	5
				Psoralea argophylla	5
				Galium boreale	3

Table 1. (Continued).

Class	Community	Soil Type	Topographic moisture drainage	Differential species[1]	Average % cover
Shrub	Tall shrub[2]	Barnes	Moderately well-drained undulating plains and slopes	*Prunus virginiana* *Crataegus chrysocarpa* *Symphoricarpos occidentalis*	
Tall grass	Little bluestem	Hamerly Barnes	Moderately well-drained undulating plains and slopes	*Andropogon scoparius* *Muhlenbergia richardsonis* *Stipa spartea* *Elaeagnus commutata* *Galium boreale* *Petalostemon purpureum* *Sporobolus heterolepis*	43 4 4 3 3 3 3
Tall grass	Big bluestem	Svea	Moderately well-drained undulating plains and slopes	*Andropogon gerardi* *Andropogon scoparius* *Artemisia ludoviciana*	32 23 4
Tall grass	Bluestem-Indian-grass	Renshaw	Moderately well-drained undulating plains and slopes	*Andropogon scoparius* *Andropogon gerardi* *Glycyrrhiza lepidota* *Panicum leibergii* *Sorghastrum nutans* (*S. avenaceum*)	49 21 8 7 4
Tall grass	Prairie cordgrass	Svea	Moderately well-drained undulating plains and slopes	*Spartina pectinata* *Andropogon scoparius* *Apocynum sibericum* *Solidago canadensis*	21 19 10 4
Broad-leaved forbs	Lowland forbs	Svea	Moderately well-drained plains and lowlands	*Helianthus maximiliana* *Solidago canadensis* *Andropogon scoparius* *Apocynum sibericum* *Glycyrrhiza lepidota*	13 12 10 9 4
Trees[2]		Svea Gravel pit		*Populus deltoides* *Salix* spp.	

[1]Based on dominant species and TWINSPAN.
[2]Sites not sampled.

60% grass and sedge cover, 29% forbs, and 11% bare ground and rocks. Blue grama (*Bouteloua gracilis*) is the dominant grass and has an average cover value of 22% and seed heads less than 2 dm tall. Needle-and-thread (*Stipa comata*) and western wheatgrass (*Agropyron smithii*) had cover values of 16% and 12%, respectively. Several sedges (*Carex filifolia*, *C. elocharis*, and *C. obtusata*) make up lesser parts of this community. Spring forbs include pasque-flower (*Anemone patens*) and prairie chickweed (*Cerastium arvense*). Blazing star (*Liatris punctata*), golden aster (*Chrysopsis villosa*), and prairie goldenrod (*Solidago missouriensis*) are flowering forbs of late summer. Prairie wild rose (*Rosa arkansana*) is a semishrub that occurs occasionally in this community.

Native Mixed Grass. — This is the most extensive community on the station and occurs on well-drained, medium- to heavy-textured silty loams of the moraines and outwash plains. Diversity of species in samples included 90 grasses, forbs, and shrubs.

Total grass and sedge cover was 59%, forbs 32%, and 9% bare ground and rocks. Blue grama and needle-and-thread had cover values of 26% and 9%, respectively. Prairie sandreed grass (*Calamovilfa longifolia*), green needlegrass (*Stipa viridula*), plains muhly (*Muhlenbergia cuspidata*), and Junegrass (*Koeleria pyramidata*) were sporadically common on some locations. Little bluestem (*Andropogon scoparius*) and side-oats grama (*Bouteloua curtipendula*) may be locally common on slopes. Percent cover of Kentucky bluegrass (*Poa pratensis*) varies with land use.

Many of the forbs are in the Asteraceae family and include golden aster, prairie goldenrod, prairie sagewort (*Artemisia frigida*), white aster (*Aster ericoides*), and blazing star. Others are white sage (*Artemisia ludoviciana*), silky wormwood (*A. dracunculus*), stiff sunflower (*Helianthus rigidus*), prairie thistle (*Cirsium flodmani*), western ragweed (*Ambrosia psilostachya*), yarrow (*Archillea millefolium*), and aggregations of silver-leaf scurf pea (*Psoralea argophylla*). In areas which have been burned, wolfberry or western snowberry (*Symphoricarpos occidentalis*) occurs as small plants about 1.5 dm tall, and the prairie rose is common.

Kentucky Bluegrass. — This introduced perennial grass has become well established on till soil sites which were farmed, overgrazed, or left idle in the past. Generally, forbs and grass species are similar to those in the native mixed-grass community with more Kentucky bluegrass (58% cover). Mean percent cover in this community was 60% grasses and sedges, 39% forbs, and 1% shrubs. Native grasses were western wheatgrass (9%) and needle-and-thread (4%). The most common forbs are white sage and white aster. Northern bedstraw (*Galium boreale*), purple prairie clover (*Petalostemon purpureum*), and red false mallow (*Sphaeralcea coccinea*) are other frequent forbs but have low cover values. Some areas have been invaded with smooth brome (*Bromus inermis*) and yellow sweet clover (*Melilotus officinalis*). Quackgrass (*Agropyron repens*) is a dominant grass in disturbed depressions or low areas, occasionally found in Kentucky bluegrass communities.

Shrub

Low Shrub. — This community refers to stands of dense wolfberry and western wild rose (*Rosa woodsii*) which have a mean height of about 8 dm and are dispersed throughout the grasslands. These stands are most common on the Barnes soil type. Other species include stinging nettle (*Urtica dioica*), Canada thistle (*Cirsium arvense*), and smooth brome. Wolfberry often occurs around the periphery of choke cherry (*Prunus virginiana*) thickets. Kentucky bluegrass and Leiberg panicum (*Panicum leibergii*) are the most common grasses. White sage is frequent in the understory; stiff sunflower and soft goldenrod (*Solidago mollis*) are among other forbs. Overall percent cover is 52% shrubs, 28% forbs, and 20% grass and sedge.

Shrub Grassland. — The shrub-grassland community exists as areas of scattered short woody species with an understory of grasses and forbs. These communities are part of the cover mosaic on all moderately well-drained soils, except in blue grama community type. The average vegetation height was about 5 dm. The most common shrubs are wolfberry and silverberry (*Elaeagnus commutata*). Wolfberry is frequently found with native mixed grasses while silverberry more often occurs with an understory of little bluestem. Common forbs include silver-leaf scurf pea, northern bedstraw, white aster, Canada goldenrod (*Solidago canadensis*), and rigid goldenrod (*S. rigida*).

Tall Shrub. — Tall shrubs make up a very small part of the Woodworth vegetation, probably less than 1% of total cover. They occur as dense thickets, scattered plant groupings, or as single plants. These sites were not sampled as part of the grasslands but were easily located by visual reconnaissance, identified on the photographs, and mapped. Choke cherry and hawthorn (*Crataegus chrysocarpa*) are the most common tall shrubs that form thickets on deep till and moist soil sites, often near wetlands. Several willow (*Salix* spp.) species also form thickets in low moist areas near or in wetlands. The tall shrubs along the southern edge of a large wetland called Fish Lake include hawthorn, tatarian honeysuckle (*Lonicera tatarica*), and climbing bittersweet (*Celastus scandens*). Occasionally a solitary hawthorn or common buckthorn (*Rhamnus catharticus*) may occur on the mixed-grass prairie.

Tall Grass

Little Bluestem. — Communities of little bluestem are dominant on low rolling sites and soil sites which are characterized by an accumulation of lime, particularly if the sites have been burned. Big bluestem (*Andropogon gerardi*) and Indian-grass (*Sorghastrum nutans*) were missing in all locations of this community. Associated grass species were mat muhly (*Muhlenbergia richardsonis*), switchgrass (*Panicum virgatum*), prairie dropseed (*Sporobolus heterolepis*), and porcupine-grass (*Stipa spartea*). Common forbs were stiff sunflower, bastard toadflax (*Comandra umbellata*), white sage, northern bedstraw, and Maximilian sunflower (*Helianthus maximiliani*). Locally common forbs in some areas are wild lily (*Lilium philadelphicum*), northern gentian (*Gentian affinis*), gay-feather (*Liatris ligulistylis*), and white camas (*Zigadenus elegans*).

Big Bluestem. — The big bluestem community is the same as the wetland-low prairie zone described by Stewart and Kantrud (1971). It is found in deep loam with moderately well-drained soils, generally in depressions or around wetland basins. Big bluestem seed heads may reach heights of 2 m. Other grass species in this community are little bluestem, switchgrass, mat muhly, prairie dropseed, foul bluegrass (*Poa palustris*), Leiberg panicum, and sometimes prairie cordgrass (*Spartina pectinata*). Forbs include wild licorice (*Glycyrrhiza lepidota*), purple milkvetch (*Astragalus agrestis*), harebell (*Campanula rotundifolia*), meadow anemone (*Anemone canadensis*), silver-leaf scurf pea, and rigid goldenrod.

Blustem Indian-grass. — This community is found on one site, an area of Renshaw soils with a high groundwater table. The floristic composition is the same as the previous community, except for the presence of Indian-grass which had a mean cover value of 4%.

Prairie Cordgrass. — This community is similar to the wet-meadow zone in the Stewart and Kantrud (1971) wetland classification. It occurs in many of the shallow depressions or low areas adjacent to wetlands. Prairie cordgrass and little bluestem are the dominant species. The prairie cordgrass community is also part of the big bluestem and meadow forb communities. Prairie dogbane (*Apocynum sibiricum*), mat muhly, Canada goldenrod, wild licorice, and sedges (*Carex* spp.) are among the other species.

Broad-leaved Forbs

Lowland Forbs. — This community type occurs in low areas of deep loamy, moderately well-drained soils. Forbs are the dominant cover with a mean of 58%. Species among the 56 recorded include wild licorice, Maximilian sunflower, Canada goldenrod, meadow anemone, prairie dogbane, and panicled aster (*Aster simplex*). Field sow thistle (*Sonchus arvensis*), northern bedstraw, bastard toadflax, Baltic rush (*Juncus balticus*), and several species of *Carex* may be a part of this community. Grasses include little and big bluestem, mat muhly, prairie drop seed, Kentucky bluegrass, and prairie cordgrass.

Trees

A few isolated individual trees exist on the station. They are easily located on the low level color IR photographs but were not mapped due to very small cover areas and scale of map. Tree species were green ash (*Fraxinus pennsylvanica*), hackberry (*Celtis occidentalis*), cottonwood (*Populus deltoides*), and several species of willow (*Salix* spp.).

Vegetation mixed with trees in a gravel pit area included willows, wolfberry, silverberry, and western wild rose. Common forbs were wormwood (*Artemisia absinthium*), western sagebrush (*A. campestris*), prairie sagewort, rigid goldenrod, and little rose (*Chamaerhodos erecta*) (Higgins 1982). Grasses include needle-and-thread and smooth brome.

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Book Review

HOMAGE TO REDWINGS

Redwings. Robert W. Nero. 1984. Smithsonian Institution Press. Washington, D.C. 160 pages. $10.95 (paper).

The red-winged blackbird (*Agelaius phoeniceus*) is one of the most abundant species of birds in the world, outnumbered perhaps only by the Quelea (*Quelea quelea*) of Africa. As the redwing is so numerous and is found throughout most of North America, it is not surprising that this species has been the subject of many studies. Furthermore, because it may sometimes cause

damage to grain crops, it has received even more attention in studies by ornithologists and wildlife control biologists.

Bob Nero has produced in one volume a fine work that is easily read and enjoyed by anoyone interested in wildlife. It is a scientific treatment of the redwing, spiced with personal notes, anecdotes, photographs, and sketches by James Carson.

When reading this document, I could not help but let my memory wander back to the days I spent afield studying redwings in Michigan, Ohio, and Nebraska during 1963-74. The first articles that I read concerning redwings were what I consider classic pieces of ornithological literature by Bob Nero, namely his 1956 paper on redwing behavior and later his 1964 study on comparative behavior of blackbirds, both appearing in the *Wilson Bulletin*. A good share of this new book reviews the findings set forth in those earlier studies. The redwing male and female utilize many postures, feather arrangements, and vocalizations for attracting a mate, defending a territory, and being aggressive toward members of their own or other species.

Accounts of the use of the bright red epaulet of the male and the less striking, but still colorful, epaulet of the female are very interesting. The female redwing is one of the very few female songbirds that sing. The behavior of the male and female going through a courtship, establishing a territory, mating, nesting, and rearing their young, makes their nesting habitat a very interesting place to be, especially in the spring and early summer months.

Redwing males usually have more than one female nesting in their territory. Foreign males may steal a mating with a female, but usually when she has wandered out of her resident male's territory.

Nero describes the different parental behaviors of the male and female. He and other scientists conducted a series of experiments. By moving nests, eggs, and nestlings within territories or to other territories, they began to understand the flexibility of behavior in parents to a changing situation.

The last two chapters of *Redwings* describe the flocking and roosting of redwings. Illustrations are given of flyways and there are descriptions of large fall and winter roosts when redwings are most likely to cause damage to grain crops such as rice, corn, or sunflowers. Biological surveys have demonstrated the food habits of redwings, which eat seeds of weeds and insects that are harmful to crops. However, at other times they may cause significant damage in a local situation. My own personal bias about the control of depredating birds creeps in when I read this section. I believe that Robert Nero discusses the issue of bird control in a very professional manner. Reading between the lines I believe that he would agree with me that, overall, blackbird damage may not really be greater than the benefit they provide.

Readers will find *Redwings* a welcome addition to their bookshelves. It is written by a fine ornithologist who pulls together many environmental, scientific, and general observations into an ecological perspective that man needs in properly managing all natural resources.

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THE NORTH DAKOTA NATURAL SCIENCE SOCIETY

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1984-85 OFFICERS

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INFORMATION FOR CONTRIBUTORS

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