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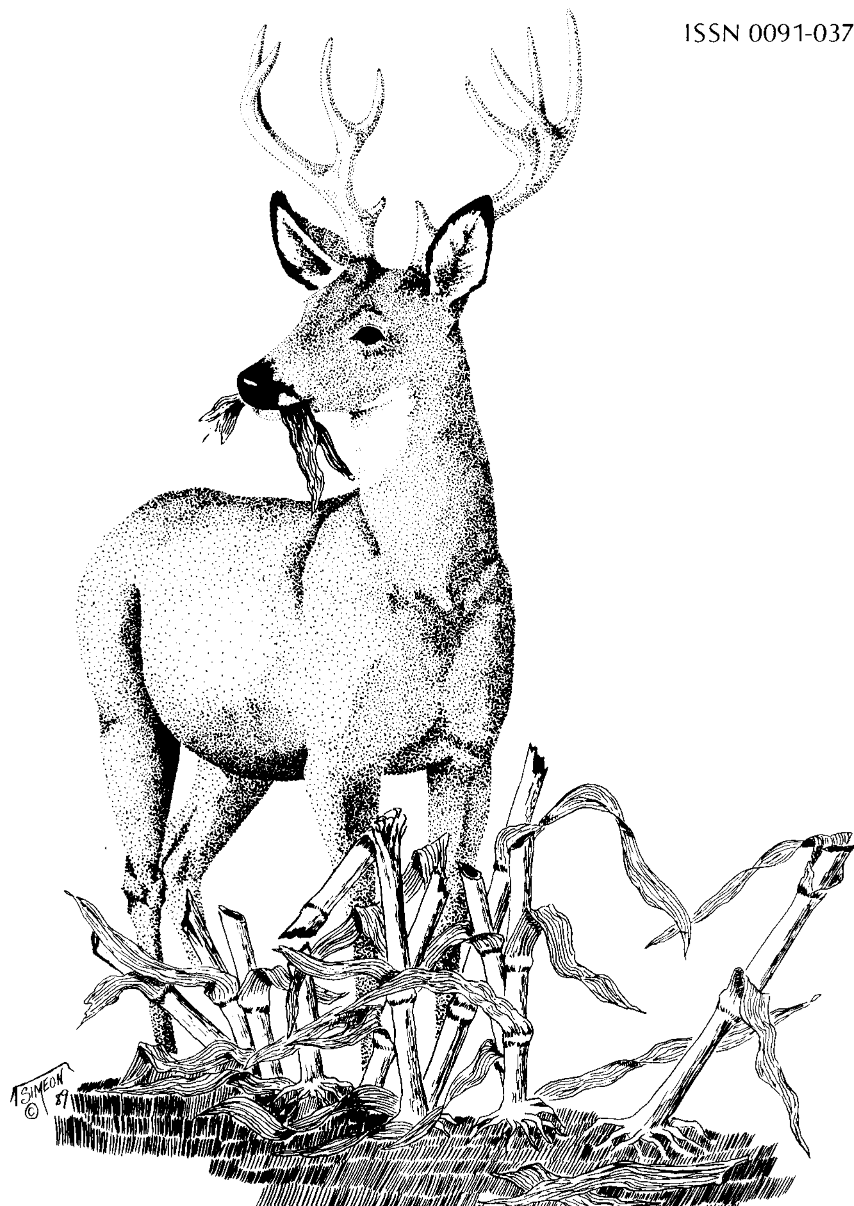

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Duck Nesting on Islands at J. Clark Salyer Refuge in North Dakota, 1983-1984

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ABSTRACT — Duck nesting use of four islands in Pool 320 on J. Clark Salyer National Wildlife Refuge (NWR), North Dakota, was studied during 1983 and 1984. Eight species of ducks primarily selected cool-season, introduced grasses and rank, dense forbs for nesting sites. Blue-winged teal (Anas discors), gadwalls (*A. strepera*), and mallards (*A. platyrhynchos*) comprised 87.6% of 210 found nests. Nesting success averaged 58%, nest abandonment 2.4%, and nest densities 22.9 nests/ha/yr for all species combined. Mink (*Mustela vison*) were the major nest predators. Predator control may further increase nesting success on these islands. About 30 years after construction, man-made islands were used by nesting ducks as readily as a nearby natural island.

Low mammalian predation has been the major factor contributing to dense nesting concentrations and high nesting success on some islands (Duebbert et al. 1983). As grasslands continue to be converted to grain crops, waterfowl use of islands for nesting sites in the Prairie Pothole Region may increase, either naturally or through active management. Years ago, Hammond and Mann (1956) proposed construction of artificial islands as a management technique to overcome loss of nesting habitat. However, they also pointed out that having a land mass surrounded by water does not guarantee its acceptance by waterfowl nor higher nesting success. J. Clark Salyer NWR has numerous islands scattered throughout the various refuge impoundments. Our objective was to determine use of three constructed and one natural island by nesting waterfowl, including nest density, success, and adjacent vegetative cover associations.

STUDY AREA

The study was conducted in Pool 320 on J. Clark Salyer NWR, McHenry County, North Dakota. The refuge extends southward along the Souris River from the Canadian border. The 23,595-ha refuge consists of 38% wetlands and 62% uplands. The 1735-ha Pool 320 consists of open water areas mixed with extensive stands of cattail (*Typha* spp.) and soft-stem bulrush (*Scirpus validus*) (plant names follow Barkley 1977). Open-water zones contain large beds of pond-weeds (*Potamogeton pectinatus*, *P. pusillus*, and *P. richardsoni*). Water depth in Pool 320 during our study period varied from 30.5 to 76.2 cm.

We studied four islands in Pool 320. Ding Island, a 2.8-ha natural island, was surrounded by emergent aquatic vegetation, predominantly softstem bulrush and cattail. Several associations of coarse weeds, tall nettle (*Urtica dioica*), Canada thistle (*Cirsium arvense*), tumbling mustard (*Sisymbrium altissimum*), and giant ragweed (*Ambrosia trifida*), were visually obvious on Ding Island. The remainder was covered with grass/forb/woody communities that included smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), wild blue lettuce (*Lactuca oblongifolia*), sweet clovers (*Melilotus albus* and *M. officinalis*), and Canada anemone (*Anemone canadensis*). Woody cover consisted of wild rose (*Rosa woodsii*), a small stand of willow (*Salix bebbiana*), several box elder (*Acer negundo*) and grees ash trees (*Fraxinus pennsylvanica*), and one small chokecherry shrub (*Prunus virginiana*).

Three islands were constructed in 1955 by pushing up river bed material with a caterpillar-type tractor and were named Gadwall Island (0.8 ha), Cormorant Island (0.7 ha), and Otto Island (0.3 ha). Each island was approximately 30 m wide and 150 m long. Dominant plant communities visually obvious on these islands were tall nettle, Canada thistle, wormwood (*Artemisia absinthium*), and wild rose. Grass/forb communities included sweet clovers, western wheatgrass (*Agropyron smithii*), and white sage (*Artemisia ludoviciana*). The islands were restored structurally and planted with a mixture of western wheatgrass, sweet clover, and alfalfa (*Medicago sativa*) in 1978 by refuge personnel.

Precipitation on the refuge during 1983 and 1984 totaled 43.3 cm and 43.1 cm, respectively. From 1978 to 1988, average precipitation for the area was 40.6 cm. Thus, soil moisture during our study was adequate for normal vegetation development.

METHODS

Breeding Pair Composition

Breeding duck pair counts were conducted by refuge personnel on sample tracts within the refuge's wetlands management district according to methods described by Hammond (1969).

Nest Searches

The entire area of the four islands was intensively searched by two people flushing hens from nests by dragging 30.5 m of rope with aluminum cans attached at 0.6-m intervals with lengths of wire. The flushing device was dragged lengthwise across each island, with an approximate overlap of 6.1 m on each dragging pass. After each rope search of Ding Island, we searched shrub cover by walking among the few stands. The other three islands were not subjected to this additional search because no woody species were present. Nest searches were conducted weekly beginning on 23 May and were continued until one week after the last nest was found on each island, which was the third week of July each season.

Nests were marked by inserting a 5.1-cm square plastic flag on a 0.9-m wire into the ground approximately 1.8 m west of each nest. Ducks were identified to species when flushed from a nest. Identification was confirmed using breast feather criteria (Broley 1950). Data collected at each nest included duck species, vegetation composition, number of eggs, and stage of embryo development (Weller 1956).

Nests were rechecked weekly. Predated or abandoned nests were examined as to the probable cause; in other nests eggs were counted, incubation state assessed, and the eggs covered before leaving the site.

Fate of nests was identified by obvious signs or methodology of nest destruction (Rearden 1951). Nests were recorded as abandoned if they contained the same number of eggs from the previous week, eggs were cold, and were still covered with nest material. However, all nests found with the nest bowl covered and with cold eggs may not have been abandoned because females may have been killed away from nest sites. Nests with cold, uncovered eggs, and having the same number of eggs as found during previous searches, were recorded as unsuccessful, as were those that showed signs of predation. A clutch considered successful if at least one duckling left the nest. Success and densities of nests were calculated according to Klett et al. (1986).

Vegetative Sampling

We sampled vegetative cover along transects on each island during 1983 and 1984 using the canopy-coverage method (Daubenmire 1959). We surveyed vegetation during the second and third week of July at about the time of maximum plant development.

Ding Island was divided into three transects, each parallel to the long axis of the island. One transect followed the center of the island, and two transects were located at the midpoint of the area from the center to each side of the island. The man-made islands were divided into two transects parallel to the long axis, and extending the entire length of each island. All transects started and ended at the land/water interface. The first sampling point along each transect began at the land/water interface, and subsequent points were located every 10 m. A Daubenmire quadrat frame (20 cm x 50 cm) was randomly placed at sampling points parallel to one side of each transect line and canopy coverage by plant species was estimated.

Each island also was intensively seached for plant species composition and a plant species list was compiled (Aufforth 1985).

RESULTS AND DISCUSSION

Breeding Pair Composition

During 1983 and 1984, blue-winged teal comprised 27.4% and 23.7%, gadwalls 12.1% and 11.6%, respectively, of the refuge duck population. Blue-winged teal were the most abundant species both years; gadwalls ranked third in 1983, with redheads (*Aythya americana*) second. In 1984, gadwalls ranked fifth following blue-winged teal, ruddy ducks (*Oxyura jamaicensis*), mallards, and redheads.

Duck Nesting Use On Islands

A total of 210 nests of eight duck species was found on islands during 1983 and 1984 (Table 1). Blue-winged teal and gadwall nests comprised 39.5% and 38.6%, respectively, of all nests found. Of eight duck species nesting on islands, blue-winged teal, gadwall, and mallard comprised 87.6%. The remaining five species, northern pintail (*A. acuta*), northern shoveler (*A. clypeata*), green-winged teal (*A. crecca*), American wigeon (*A. americana*), and lesser scaup (*Aythya affinis*), comprised less than 6% each of all nests found, respectively.

Table 1. Number of duck nests found per island on J. Clark Salyer NWR, North Dakota.

	Ding		Gadwall		Cormorant		Otto			
Species	1983	1984	1983	1984	1983	1984	1983	1984	Total	(%)
Blue-winged teal	34	41	0	5	0	2	1	0	83	(39.5)
Gadwall	25	27	2	18	3	5	0	1	81	(38.6)
Mallard	4	7	1	3	3	2	0	0	20	(9.5)
Northern pintail	3	1	0	2	0	1	0	0	7	(3.3)
Northern shoveler	1	3	0	0	0	0	0	0	4	(1.9)
Green-winged teal	1	1	0	0	0	0	0	0	2	(1.0)
American wigeon	0	0	0	1	0	0	0	1	2	(1.0)
Lesser scaup	0	1	1	9	0	0	0	0	11	(5.2)
Total	68	81	4	38	6	10	1	2	210	(100.0)

Nesting Success

Overall nesting success for 1983-84 was 58%, approximately four times the rate (15%) necessary to maintain a mallard population (Cowardin et al. 1985) and more than twice the rate (24%) of duck production found in another island study on J. Clark Salyer Pool 326 during 1982-83 (Willms and Crawford 1989). Nesting success varied considerably among all species but less so among blue-winged teal and mallards (Table 2). Numbers of nests and nesting success also were quite variable between years and among islands (Table 3); however, overall nesting success was 54% or greater on all islands. According to chi-square analyses, nest success rates did not vary significantly among the three major islands (Ding, Gadwall, Cormorant) in 1983 ($P = 0.678$), 1984 ($P = 0.103$) but was marginally different for both years combined ($P = 0.065$). Overall nest success between 1983 and 1984 was significantly different ($P = 0.004$). We are unable to explain the year effect except the noticeable increase in nests from 4 to 38

Table 2. Duck nesting success (%) on four islands on the J. Clark Salyer NWR, 1983 and 1984.

	1983		1984		Total	
Species	N	(%)	N	(%)	N	(%)
Blue-winged teal	35	(53)	48	(58)	83	(56)
Gadwall	30	(40)	51	(73)	81	(57)
Mallard	8	(50)	12	(50)	20	(50)
Northern pintail	3	(0)	4	(25)	7	(17)
Northern shoveler	1	(0)	3	(100)	4	(75)
Green-winged teal	1	(100)	1	(100)	2	(100)
American wigeon	0	(0)	2	(100)	2	(100)
Lesser scaup	1	(100)	10	(90)	11	(98)
Total	79	(46)	131	(66)	210	(58)

and in nesting success from 25% to 79% from 1983 to 1984 on Gadwall Island (Table 3) may have been a response of ducks to the large increase in density of sweet clover (*Melilotus* spp.) on this island.

A gadwall nest occurred in a rather unique site on Ding Island. Earlier human use of Ding Island is evidenced by several short cement foundations and a 1.8-m deep "root" cellar. The cellar was covered with a canopy of tall nettle (*Urtica dioica*) and sweet clover. In June 1983 a gadwall successfully nested at the bottom of this cellar.

Table 3. Number of duck nests and nesting success (%) on four islands on J. Clark Salyer NWR, 1983 and 1984.

	1983		1984		Total	
Island	N	(%)	N	(%)	N	(%)
Ding	68	(47)	81	(59)	149	(54)
Gadwall	4	(25)	38	(79)	42	(74)
Cormorant	6	(50)	10	(60)	16	(56)
Otto	1	(0)	2	(100)	3	(67)
Total	79	(46)	131	(66)	210	(58)

Nesting Failures

Most predation occurred between 1 and 21 June each year. Six percent of 88 nesting failures were attributed to abandonment, averaging 2.8% per year, and 94% to other causes (Table 4). Unknown determination of nest failures was a result of finding nests uncovered, eggs cold, and nest bowls undisturbed. Many of these missing females probably were dead, but we could not attribute any losses to a specific predator. One nest on Ding Island in 1983 was destroyed during searching operations.

Table 4. Causes of duck nesting failures on four islands at J. Clark Salyer NWR, 1983 and 1984.

	Ding		Gadwall		Cormorant		Otto		Total	
	1983	1984	1983	1984	1983	1984	1983	1984	N	(%)
Mink	12	16	3	5	1	4	1	0	42	(48)
Ring-billed gulls	1	1	0	0	0	0	0	0	3	(3)
Raccoon	0	0	0	1	0	0	0	0	1	(1)
Search Operations	1	0	0	0	0	0	0	0	1	(1)
Abandoned	4	0	0	1	0	0	0	0	5	(6)
Unknown	18	16	0	1	1	0	0	0	36	(41)
Total	36	33	3	8	3	4	1	0	88	(100)

Of the known causes of nesting failures, mink (*Mustela vison*) were the primary predators (Table 4). Although mink sign was present on all islands, only Otto Island, which was 300 m from the mainland, had an active den. On 28 June 1983, a mink was observed on Ding Island killing newly hatched blue-winged teal. Several dead ducklings were found near the nest. One duckling was struggling in the nest bowl with severe bites on its head. A freshly killed female, presumably the one from this nest, was 1 m from the nest. Females found dead were usually close to their nests and had severely bitten heads and upper necks. Usually in these occurrences, nest bowls were undisturbed and eggs were bitten open; small teeth marks were visible on shell edges. We attributed these failures to mink predation because ordinarily a mink does not molest the nest structure during predation activities (Rearden 1951). Several male blue-winged teal also were found dead on the islands with their heads and necks severely bitten.

A small colony of ring-billed gulls (*Larus delawarensis*) was nesting 0.4 km from the islands in emergent vegetation. One active gull nest was found 4.6 m from an active lesser scaup nest that hatched successfully. Only three duck nests were destroyed by avian predators and were presumed destroyed by gulls because no other potential avian predators were seen in the vicinity.

Although one raccoon (*Procyon lotor*) was observed in 1984, the lack of other sign indicated that they were not common visitors on islands.

Nest Densities

Nest densities averaged 17.2 and 28.5/ha for 1983 and 1984, respectively (Table 5). Total nest density for all islands was significantly different (P = 0.021) between 1983 and 1984 according to a two-tailed paired t-test analysis. Duebbert (1966) found 27.8 and 43.0 gadwall nests/ha on Ding Island in 1956 and 1957, respectively. Nest densities for all islands increased from 1983 to 1984 and averaged 22.9 nests/ha/yr (Table 5), which is more than twice the mean annual nest density (8.7) reported on 22 nearby islands during 1982-83 (Willms and Crawford 1989). Our only large yearly increase in nesting density was in 1984 on Gadwall Island, where lesser scaup were a major contributor.

In our study the highest average nest density occurred on Gadwall Island, the second largest island (Table 5). Gadwall and Ding islands are approximately the same distance (640 m) from the mainland. Giroux (1981) found that islands farthest from the mainland had greater nest densities.

Cormorant Island was intermediate in island size and nest density (Table 5). Cormorant Island was located 930 m from the mainland.

The smaller Otto Island contained only one duck nest in 1983 and two nests in 1984 and exhibited similar cover to Gadwall Island but did not approach the nest densities. Otto was closer to the mainland (180 m) and 183 m from a popular fishing area on the Souris River. Although the public was restricted from fishing within 183 m of Otto Island, we suspect adjacent human activities may have contributed to low nest densities there.

Table 5. Duck nest density per island on J. Clark Salyer NWR, in 1983 and 1984.

Island	Island size (ha)	1983 No. of nests	1983 Nests/ha	1984 No. of nests	1984 Nests/ha	Mean nests/ha/yr
Ding	2.8	68	24.3	81	28.9	26.6
Gadwall	0.8	4	5.0	38	47.5	26.3
Cormorant	0.7	6	8.6	10	14.3	11.5
Otto	0.3	1	3.3	2	6.1	4.7
Total	4.6	79	17.2	131	28.5	22.9

Nest Association with Plant Species

Seventy-three plant species were found on the islands (Aufforth 1985); however, only 12 had mean canopy coverage values 2% or greater (Table 6). Of all species, only Canada thistle occurred in 2% or greater coverage on all four islands.

Ding Island exhibited several distinct plant communities and had a generally non-random distribution of smooth brome grass patches over the entire island. Distinct communities of Bebb's willow, box elder, wolfberry (*Symphoricarpos* occidentalis), tall nettle, tumbling mustard, Canada thistle, and giant ragweed also were present. The willow community was a narrow band, 15.2 m wide and 91.4 m long, on the northwest corner of the island. The box elder community comprised only a few short trees on the east end.

The three constructed islands were all seeded to a mixture of one-third western wheatgrass, one-third sweet clover, and one-third alfalfa in 1978. These seedings had a variable success rate of establishment (Table 6). Wild rose bushes also were successfully planted as seedlings from collections on the refuge uplands. Gadwall Island had a distinct monotypic community of western wheatgrass on the higher portion and sweet clover communities on the side slopes. Otto Island was similar, but with sweet clover interspersed throughout in small patches. Cormorant Island exhibited almost no success to the seeding mixture and characteristically had many species of cool-season invader plants, but the primary cover was wormwood. Although the most visually apparent invader plant on all three islands was wormwood, many species of invader perennials were present but in less than 2% coverage (Aufforth 1985).

Gadwalls selected nettle/thistle communities for nesting sites (Table 7) and high use of these areas often resulted in nests close to each other. No other ducks nested in these communities. Miller and Collins (1953) recorded a nesting preference by gadwalls and mallards for nettles in California, as did Drewien and Fredrickson (1970) in South Dakota. The association of rank, dense cover, (e.g., nettles/thistle), for gadwalls was noted by Duebbert (1966), Dwernychuk

Table 6. Mean Daubenmire-frame cover values for plant species that had an average value of 2% or greater on islands on J. Clark Salyer NWR, 1983 and 1984.

Plant species	Ding Island	Gadwall Island	Cormorant Island	Otto Island
Western wheatgrass	0.0	22.2	0.0	34.4
Wormwood	0.0	0.0	34.5	0.0
Smooth brome	39.8	0.0	0.0	0.0
Canada thistle	4.4	9.5	11.3	21.9
Wild barley (*Hordeum jubatum*)	0.0	2.3	0.0	2.4
Sweet clover	0.0	5.0	4.4	38.1
Kentucky bluegrass	9.0	4.8	0.0	0.0
Pale smartweed (*Polygonum lapathifolium*)	0.0	2.4	0.0	2.5
Rose	0.0	0.0	6.2	0.0
Tumbling mustard	2.4	0.0	0.0	0.0
Wolfberry	2.2	0.0	0.0	0.0
Tall nettle	2.2	2.0	0.0	0.0

Table 7. Percentage of nests associated with various plants on four islands on J. Clark Salyer NWR in 1984.

Species	Plant (% of available cover)								
	Nettle/ thistle (12.8)	Brome (10.0)	Sweet clover (10.8)	Tumbling mustard (0.6)	Western wheatgrass (14.1)	Wormwood (8.6)	Rose (1.6)	Wolfberry (0.6)	Kentucky bluegrass (3.5)
Gadwall	41.2	27.5	13.7	3.9	7.8	5.9	0.0	0.0	0.0
Blue-winged teal	0.0	75.5	2.0	0.0	10.2	2.0	0.0	0.0	10.2
Mallard	0.0	54.6	36.4	0.0	0.0	9.1	0.0	0.0	0.0
Lesser scaup	0.0	10.0	0.0	0.0	90.0	0.0	0.0	0.0	0.0
Northern pintail	0.0	25.0	0.0	0.0	50.0	0.0	25.0	0.0	0.0
Northern shoveler	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Green-winged teal	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
American wigeon	0.0	0.0	0.0	0.0	50.0	0.0	0.0	50.0	0.0

(1968), Vermeer (1968), and Willms and Crawford (1989). Island nesting ducks also are attracted to dense, broad-leaved forb nesting sites (Long 1970, Dwernychuk and Boag 1972).

In our study, 48% of the 1984 duck nests occurred in smooth brome. Smooth brome-dominated communities provided nesting sites for seven duck species, except American wigeon. Duebbert (1982) found that plant communities supporting the greatest density of waterfowl nests were cool-season, introduced grasses, primarily quackgrass (*Agropyron repens*), crested wheatgrass (*Agropyron cristatum*), and smooth brome.

Wolfberry communities, comprising only 0.6% of available canopy cover, were used little by nesting ducks (Table 7). Woody communities did not show any attraction for nesting ducks even though the willow community on Ding Island appeared to provide ideal concealment and protection from predation. Several dense areas (15.2 m x 15.2 m) of wolfberry had only one duck nest. Lesser scaup nested almost exclusively on Gadwall Island and all nest sites were dominated by western wheatgrass. We were unable to determine why lesser scaup selected only one island for nesting. However, all islands were separated from dense cattail communities by approximately 50 m of open water except Ding Island, where about 50% of the shoreline was within 15.2 m of cattail stands.

SUMMARY AND MANAGEMENT SUGGESTIONS

Three islands constructed in 1955 on J. Clark Salyer NWR were accepted by nesting ducks as readily as a nearby natural island. Average nesting success (58%) and nest densities (22.9 nests/ha) on the islands were much higher than that reported for ducks nesting in upland habitats in the Prairie Pothole Region (Higgins 1977, Johnson et al. 1978).

We agree with Bellrose and Low's (1978) recommendation that construction of new islands and management of cover on existing islands should receive greater emphasis in waterfowl management.

Construction of islands should be included as a budget item wherever the physical conditions of waterfowl management areas or wetlands are suitable. Higgins (1986) provided guidance on the relation of island size, placement, and durability. Construction of small (0.2 ha) islands is relatively economical (Jones 1975, Johnson et al. 1978, Lokemoen 1984). Construction also offers island placement options that may restrict mammalian predation.

Mammalian and avian predation is still a concern to island nesting waterfowl. Most predation in our study occurred during 1-21 June. Therefore, a concerted effort to remove predators prior to and during this period should enhance waterfowl production.

Manipulation of vegetative cover on islands is another management option which may increase use by nesting waterfowl. However, research of waterfowl response to cover manipulation on islands, such as controlled burns, grazing, cultivation, and other techniques, is virtually nonexistent. Giroux (1981) reported that nesting waterfowl selected stands of broad-leaved annuals and perennials mixed with grasses. Waterfowl selected similar sites on islands in Pool 320 in our study. Thus, the normal succession of plants on islands should be interrupted periodically by management techniques (e.g., burning, reseeding) to provide optimal nesting sites.

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Production of Tall-Grass Prairie Herbs Below Eastern Redcedar

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ABSTRACT – Eastern redcedar (*Juniperus virginiana*) is an important invader of Great Plains grasslands because trees reduce rangeland forage production. Studies conducted at two tall-grass prairie sites in Nebraska estimated that herbaceous biomass production under the tree canopies averaged 83% less than in the interstitial zone. Reductions in light (averaging 85%) and soil water (11.5%) are two possible reasons for these changes.

Eastern redcedar (*Juniperus virginiana*) is an undesirable species on Great Plains grasslands because it reduces grazing potential on rangelands (Engle 1985). Eastern redcedar are increasing in number and distribution across the Great Plains (Martin and Crosby 1955, Owensby et al. 1973, Ferguson and Lawson 1974). This spread has been attributed to reductions in naturally occurring wildfires, an increased seed source resulting from the use of the species in shelterbelt plantings, and reduced competition due to overgrazing (Beilmann and Brenner 1951, Bragg and Hulbert 1976, Van Haverbeke and Read 1976). The economic impact of eastern redcedar, in terms of lost forage productivity and expensive methods of control, underscores the importance of understanding its relationships with understory herbaceous vegetation.

Gehring (1983) reported that canopy cover in the herbaceous layer was less under eastern redcedar than in the adjacent tall-grass prairie. In a similar study, Kaul et al. (1983) studied species composition of stands beneath closed-canopy eastern redcedar, which had previously existed as mid-grass prairie sites, and found that only the shade-tolerant littleseed ricegrass (*Oryzopsis micrantha*) was regularly present in the understory. These authors speculated that eventual closure of the eastern redcedar canopy would eliminate all the prairie species.

The objectives of this study were to: (1) quantify change in forage production caused by mature eastern redcedar trees, and (2) quantify the influence of mature eastern redcedar tree canopies on soil water content and understory light levels as compared to interstitial areas receiving minimal influence from the trees.

MATERIALS AND METHODS

Understory Herbaceous Biomass

The first study site was on a Morrill clay loam soil (fine-loamy, mixed, mesic Typic Argiudoll) derived from glacial outwash and located near Raymond, NE (T11N R6E Sec. 11). The second location was near Ashland, NE (T13N R10E Sec. 33) on Ida silt loam [fine-silty, mixed (calcareous), mesic Typic Udorthent]

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formed in loess. Both sites were dominated by species common to tall-grass prairie, and both were previously grazed but neither was grazed by domestic livestock during the study period.

Twelve eastern redcedar trees were selected randomly within an area of about 1 ha at each site. Tree canopy diameters ranged from 1 to 3.5 m, heights from 2 to 5m, and ages from 17 to 25 years based on increment cores. All trees at each site were on a uniform slope and aspect. Average stand density was approximately 40 trees/ha at both sites. Two transects were established per tree, intersecting at the tree stem and radiating out from the tree stem at the cardinal directions. Two sampling points were located along each transect: one point midway between the stem and canopy edge and the second at a distance 2.5 times the canopy radius from the tree stem and at least 10 m from the nearest adjacent tree.

Current year above-ground production was estimated by clipping at ground level from a 0.1-m^2 frame at each transect point and weighing the resulting oven-dry plant material. Clipping occurred twice during 1984 (12 June and 4 August) and 1985 (7 June and 20 August), coinciding with maximum cool- and warm-season plant production (Schacht and Stubbendieck 1985).

Separate analyses were conducted for the four life-form combinations (cool-season forbs, cool-season graminoids, warm-season forbs, and warm-season graminoids). The experiment was conducted as a factorial treatment arrangement of a randomized complete block experimental design. Treatment combinations consisted of two sites, two years, two treatments (canopy-covered and interstitial zones), and four transect orientations. The trees at each site were the blocking variable, and the experimental unit was the clipped frame. Analyses of variance with Fisher's protected least significant differences tests were used (Steel and Torrie 1960).

Soil Water Content and Understory Light Intensity

Soil water content was measured 6-7 times per summer via a Bouyoucos soil moisture meter with gypsum blocks buried 20 cm deep and 20 cm outward radially from each of the two reference points along the southerly oriented transect at each tree. Field resistance values were converted to soil water content (kg/kg) after calibration, following Gardner (1965).

Because soil water content depends on previous precipitation events, it was defined *a priori* that significant differences between understory and interstitial soil water content levels appearing at any one sampling date during a growing season would be valid evidence that the two are to be considered different, regardless of the statistical outcome for the other dates.

Photosynthetic active radiation (PAR, 400-700 nm) was measured with a Li-Cor Line Quantum Sensor (Model 185) between 1145 and 1245 hr on 26 August 1985, a cloudless day. Measurements were made at the points with the gypsum blocks by placing the sensor on the ground surface. The experimental design and analysis paralleled that of the soil water content study.

RESULTS AND DISCUSSION

Understory Herbaceous Biomass

Dominants were similar on both sites. Interstitial graminoids included big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), Scribner dichanthelium (*Dichanthelium oligosanthes* var. *scribnerianum*), needleleaf sedge (*Carex eleocharis*), and western wheatgrass (*Agropyron smithii*). Interstitial forbs included western ragweed (*Ambrosia psilostachya*), western yarrow (*Achillea millefolium*), prairie goldenrod (*Solidago missouriensis*), and hoary vervain (*Verbena stricta*). Graminoids in the canopy zone included Japanese brome (*Bromus japonicus*), Kentucky bluegrass (*Poa pratensis*), and sun sedge (*Carex heliophila*). Canopy zone forbs included rough falsepennyroyal (*Hedeoma hispidum*), pepperweed (*Lepidium densiflorum*), prostrate spurge (*Euphorbia prostrata*), marestail (*Conyza canadensis*), and yellow woodsorrel (*Oxalis stricta*).

The analysis of variance procedure detected no interactions or main effect differences in production among the cardinal directions. Therefore, the data were analyzed again with the direction term pooled. Analyses indicated no biologically significant two-way or three-way interactions between year, site, or understory location. Interest in the analysis of the main effects was, therefore, directed toward the understory location term, and tests showed that differences in production existed between canopy and interstitial zones for all life-form, year, and site combinations (Table 1). The average difference was a reduction of 83% in the canopy zone.

Soil Water Content and Understory Light Intensity

Soil water content was greater in the interstitial zone on all dates when a difference between understory locations was detected (Table 2). Differences in soil water content were more common during the 1985 season. The average reduction in the canopy zone soil water content for both sites and years was 11.5%. Table 2 also indicated that soil water content underneath the tree canopy consistently came closer to, and more often was depleted to below − 1.5MPa water potential for both sites and years. Water potential of the canopy zone was at or below − 1.5MPa and was significantly lower than that of the interstitial zone on two sampling dates in 1985 at Ashland. This situation occurred on one sampling date in 1984 and on four dates in 1985.

Differences in soil water content between understory locations usually occurred following periods of precipitation. When soils dried out (e.g. August 1984), water levels at the two understory locations converged to a low value. Lower soil water levels under the tree canopy might have resulted from interception and entrapment of precipitation by the tree foliage and litter or withdrawal of soil water by the tree roots. Skau (1960) indicated that Utah juniper (*Juniperus osteosperma*) canopies intercepted and held about 40% of the precipitation, and Scholl (1971) stated that soils underneath canopies were highly resistant to wetting because of decomposing tree litter. Jameson (1970) reported that the basal area of blue grama (*Bouteloua gracilis*) was reduced by root competition for moisture with oneseed juniper (*Juniperus monosperma*).

Table 1. Herbaceous plant production (kg/ha) in interstitial (Int.) and canopy zones.

	1984			1985		
	Location		%	Location		%
Life-form	Int.	Canopy	Difference	Int.	Canopy	Difference
Raymond Site						
Forbs:						
Cool-season	330	25	92[1]	478	40	92[1]
Warm-season	237	10	96[1]	163	40	89[1]
Graminoids:						
Cool-season	892	157	82[1]	1217	72	94[1]
Warm-season	1933	138	93[1]	2901	195	93[1]
Ashland Site						
Forbs:						
Cool-season	240	56	77[1]	133	49	63[1]
Warm-season	60	16	76[1]	100	22	78[1]
Graminoids:						
Cool-season	1698	549	68[1]	751	253	66[1]
Warm-season	2541	597	76[1]	2489	548	80[1]

[1]All differences between the interstitial and canopy zones were with a probability of a greater T = 0.10, as determined by Fisher's protected least significant difference tests.

Full light intensities at the two sites were within 1% of each other (1480 and 1460 microeinsteins/m^2/s at the Ashland and Raymond sites, respectively). The canopy zone was found to have 85% lower PAR levels than the interstitial zone at both sites (Table 3).

The pattern of reduced understory light and soil water content under the eastern redcedar canopies may be at least partially responsible for the lowered biomass production found in those locations. However, no cause and effect explanation is warranted, because eastern redcedar has been shown to influence other biological and physical soil factors, including higher pH (Spurr 1940, Arend and Collins 1949, Arend 1950), greater surface calcium content (Broadfoot 1951, Vimmerstedt 1968), higher surface organic matter, lower bulk density, and greater infiltration rates (Broadfoot 1951).

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Table 2. Average gravimetric water content (kg/kg) during 1984 and 1985.

Date	Ashland		Raymond	
	Canopy	Interstitial	Canopy	Interstitial
1984				
16 June	0.19	0.19	0.21	0.21
30 June	0.19	0.20	0.21	0.22
22 July	0.12	0.12	0.13[1]	0.11[1]
05 August	0.08[1]	0.08[1]	0.11[1]	0.11[1]
19 August	0.08[1]	0.08[1]	0.11[1]	0.11[2]
30 October	0.11	0.14[2]	0.12[1]	0.20[2]
1985				
31 May	0.18	0.19[2]	0.19	0.24[2]
16 June	0.11	0.12	0.12[1]	0.16[2]
08 July	0.08[1]	0.08[1]	0.16	0.17
28 July	0.15	0.16	0.21	0.23[2]
26 August	0.10[1]	0.14[2]	0.13[1]	0.22[2]
07 September	0.08[1]	0.09[1]	0.14[1]	0.16[2]
21 September	0.10[1]	0.15[2]	0.14[1]	0.23[2]

[1]Values are $\leq$ critical moisture level (0.10 kg/kg for Ashland and 0.14 kg/kg for Raymond, unpublished data on file at the Soil Conservation Service, National Soils Laboratory, Lincoln, Nebraska)
[2]Mean values are greater for that site/date combination, as determined by Fisher's protected least significant difference tests with a probability of greater T = 0.05.

Table 3. Photosynthetically active radiation (PAR; light level microeinsteins/m^2/s), measured at ground level on 26 August 1985.

Site	Interstitial	Canopy	% Difference
Ashland	575	88	85[1]
Raymond	400	61	85[1]

[1]Significant with a probability of greater T < 0.01, as determined by Fisher's protected least significant difference tests.

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Habitat Breadth of Nongame Rodents In the Mixed-Grass Prairie Region of North Central Kansas

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ABSTRACT — Habitat breadth for eight species of rodents was estimated for different mixtures of native and disturbed sites in north central Kansas in 1966, 1976, and 1981. Deer mice (*Peromyscus maniculatus*) and hispid pocket mice (*Chaetodipus hispidus*) exhibited the greatest habitat breadth and occupied sites ranging from native prairie to cropfields and would, therefore, be little affected by habitat disturbance. Plains harvest mice (*Reithrodontomys montanus*) were the most restricted in distribution and would be severely impacted if their preferred habitat (upland mixed-grass prairie) was altered, but little affected by other disturbances. Northern grasshopper mice (*Onychomys leucogaster*), western harvest mice (*Reithrodontomys megalotis*), prairie voles (*Microtus ochrogaster*), thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*), and cotton rats (*Sigmodon hispidus*) exhibited moderate habitat breadth. In contrast to other species, cotton rats would be little affected by most alterations of native habitats as they tend to be associated with rank, weedy herbaceous vegetation. Western harvest mice were the most variable in habitat breadth as they ranked first in 1966 and fifth in 1976 and were not captured in 1981.

Nongame wildlife in the Great Plains and Midwest continue to be impacted as native habitats are altered by agricultural practices and non-agricultural land development (e.g., Bowles 1981). Influences of changes in land use are often species-specific, with severity of impact related to patterns of habitat use and life history characteristics of each species. Geier and Best (1980) used an index of habitat breadth to identify habitat-generalists (i.e., species that use many different habitats) and habitat-specialists (i.e., species that are restricted to one or a few habitats) among an array of small mammal species using riparian communities in Iowa. Using their basic technique, we examined habitat breadth for eight rodent species in north central Kansas in 1966, 1976, and 1981 in habitats ranging from cropfields and fencerows to native mixed-grass prairie.

STUDY SITES AND METHODS

In 1966, small mammals were sampled in ungrazed limestone breaks mixed-grass prairie (traplines = 2), ungrazed upland mixed-grass prairie (3), ungrazed sandy mixed-grass prairie (1), grazed short-grass upland (2), and a 5-year old-field (2) in Lincoln, Osborne, and Russell counties in north central Kansas (Kaufman and Fleharty 1974). Limestone breaks and upland mixed-grass sites were dominated by big bluestem (*Andropogon gerardii*), little bluestem (*A. scoparius*), and sideoats grama (*Bouteloua curtipendula*). Tall dropseed (*Sporobolus asper*)

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and little bluestem were common in sandy mixed-grass prairie. Predominant grasses in grazed upland short-grass prairie were blue grama (*B. gracilis*), sand dropseed (*S. cryptandrus*), and buffalo grass (*Buchloe dactyloides*). The grazed old-field was dominated by red threeawn (*Aristida longiseta*) and green foxtail (*Setaria viridis*), with other weedy grasses also present. Traplines consisted of 20 stations with a 15.2-m interstation interval. Three Museum Special snap traps baited with chewed rolled oats were placed at each station. Each trapline was set for four consecutive nights during July-September 1966.

In 1976, small mammals were sampled in grazed limestone breaks mixed-grass prairie (traplines = 6), grazed lowland mixed-grass prairie (10), a 15-year old-field (4), a 5-year old-field (2), post-harvest wheatfields (6), and grazed planted grass (5) in Lincoln and Russell counties, Kansas (Kaufman and Kaufman 1982). Limestone breaks were dominated by blue grama and little bluestem. Lowland mixed-grass prairie sites were dominated by buffalo grass and western wheatgrass (*Agropyron smithii*). The 15-year old-field was dominated by weedy perennial grasses, whereas predominant plants in the 5-year old-field were weedy annual forbs and grasses that formed a tall, dense herbaceous canopy, but left the surface relatively free of cover. Wheatfields from which winter wheat had been harvested in late June were dominated by standing stubble (15-40 cm tall). Several weedy forb and grass species were present and locally common. The last habitat was a variable one consisting of cropfields that had been reseeded to native grasses. These sites were dominated by native grass species, although one site included introduced smooth brome (*Bromus inermis*). Each trapline consisted of 20 stations with a 20-m interstation interval. Two snap traps per station, either two Museum Special traps or one Museum Special and one Victor mouse trap, were baited with peanut butter. Each trapline was set for four consecutive nights during 11-19 August 1976.

In 1981, small mammals were sampled in grazed breaks mixed-grass prairie (traplines = 2), grazed upland mixed-grass prairie (6), fencerow (4), post-harvest wheatfield (4), and ungrazed planted grass (2) in Lincoln and Russell counties. Limestone breaks were dominated by blue grama and little bluestem. Plant species composition in the upland varied among lines but generally consisted of native short and mid-height grasses, e.g., buffalo grass, gramas (*Bouteloua* spp.), and western wheatgrass. Fencerows were situated between grazed mixed-grass upland and winter wheatfields that had been disked about one month before trapping. These fencerows were dominated by a mixture of weedy forb and grass species. Wheat stubble (15-40 cm) dominated the post-harvest wheatfields, with numerous weedy forbs and grasses also present. Planted grass consisted of native tall and mid-height grasses planted in an upland old-field over 10 years earlier. Each trapline consisted of 20 stations, two Sherman live traps (7.6 x 8.9 x 22.6 cm) per station, with a 15-m interstation interval. Traps were baited with peanut butter and set for three consecutive nights during 23-29 July 1981. Animals were marked for individual recognition and released at point of capture.

Relative density for each species in each habitat was estimated as average number of individuals caught per trapline. Indices of habitat breadth were computed for each species using the reciprocal of Simpson's diversity index ($B = 1/\Sigma p_i^2$, where p_i is the proportion of the sample in the jth habitat; Geier and Best 1980). Minimum B is 1.00 and occurs when a species is caught in only one habitat, whereas maximum B is equal to the number of habitats sampled and occurs when equal numbers of individuals are caught in all habitats. We calculated a standardized habitat breadth, B_H, as (B − minimum b)/(maximum B − minimum B) or $B_H = (B - 1.00)/(B_{max} - 1.00)$. B_H ranges from 0.00 when a species uses only one of the habitats to 1.00 when it is present in equal densities in all habitats sampled. Use of B_H allows direct comparisons of habitat breadth among years and studies even when the number of habitat categories differ among data sets.

RESULTS

The deer mouse (*Peromyscus maniculatus*) was the most abundant of 11 species of small mammals, 59% of the 871 individuals captured (Table 1). Less common species, ranked in descending order of abundance, were the hispid

Table 1. Relative densities (individuals/trapline) of *Peromyscus maniculatus* (Pm), *Chaetodipus hispidus* (Ch), *Onychomys leucogaster* (Ol), *Reithrodontomys megalotis* (Rm), *Sigmodon hispidus* (Sh), *Spermophilus tridecemlineauts* (St), *Microtus ochrogaster* (Mo), and *Reithrodontomys montanus* (Ro).

Year	Habitat	Lines	Pm	Ch	Ol	Rm	Sh	St	Mo	Ro
1966	Limestone breaks	2	20.0	4.5	0	3.5	0	0	2.0	0
	Mixed-grass	3	7.0	1.0	0.3	4.7	2.7	1.0	1.7	0.3
	Sandy mixed-grass	1	16.0	3.0	8.0	5.0	2.0	0	3.0	0
	Short-grass	2	2.0	3.5	1.0	2.0	0.5	0	3.0	0.5
	Old-field	2	1.0	1.0	0	3.5	1.0	0.5	1.0	2.5
	Mean		9.2	2.6	1.9	3.7	1.2	0.3	2.1	0.7
1976	Limestone breaks	6	8.8	3.3	1.2	0.3	0	0.3	0	0
	Mixed-grass	10	8.5	2.3	0.9	0.4	0.1	0.5	0.2	0.3
	15-year old-field	4	5.3	0.8	0.3	0	0	0.5	0	0
	5-year old-field	2	25.5	2.5	2.5	0	3.0	0	0	0.5
	Wheat stuble	6	14.7	0.7	2.2	1.0	0.7	0	0.8	0.2
	Planted grass	5	8.2	2.6	0.4	1.2	4.4	0.4	0.6	0
	Mean		11.8	2.0	1.2	0.5	1.4	0.3	0.3	0.2
1981	Limestone breaks	2	10.0	0.5	2.0	0	0	4.0	0	0
	Mixed-grass	6	2.5	0.2	0.7	0	0	0.7	0	0
	Fencerow	4	3.8	0.5	0.5	0	0.3	1.5	0	0
	Wheat stubble	4	8.0	0.3	1.8	0	0.3	0	0.3	0
	Planted grass	2	5.5	0	0.5	0	0	0	0	0
	Mean		6.0	0.3	1.1	0	0.1	1.2	0.1	0

pocket mouse (*Chaetodipus hispidus*, 11.1% of all individuals), northern grasshopper mouse (*Onychomys leucogaster*, 7.6%), western harvest mouse (*Reithrodontomys megalotis*, 6.3%), hispid cotton rat (*Sigmodon hispidus*, 5.5%), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*, 3.8%), prairie vole (*Microtus ochrogaster*, 3.6%), plains harvest mouse (*R. montanus*, 1.4%), Elliot's short-tailed shrew (*Blarina hylophaga*, 0.8%), white-footed mouse (*P. leucopus*, 0.5%), and house mouse (*Mus musculus*, 0.3%). Habitat breadth was not examined for *B. hylophaga* since it was caught only in fencerow habitat in 1981, *P. leucopus*, a woodland rodent, since it was caught only in one grassland habitat near trees in 1966, and *M. musculus* since it was an introduced species caught only in cropfield and fencerow habitats in 1981.

Hispid pocket mice and deer mice, with average values of B_H of 0.70 and 0.66, demonstrated the greatest habitat breadth during this study (Table 2). Even though B_H in 1966 and the average B_H for all three years was higher for pocket mice than deer mice, deer mice were more abundant than pocket mice in all habitats except shortgrass in 1966. Plains harvest mice exhibited the lowest average B_H (0.16), whereas the other species grouped within a small intermediate range of values (0.34-0.46). Variation in habitat breadth among the three sets of habitat conditions was low for all species except grasshopper mice, western harvest mice, and prairie voles (standard deviation in Table 2). The large variation in B_H for prairie voles and western harvest mice probably was caused by relatively uniform use of sites studied in 1966 and a general low in abundance in 1981. In contrast, the high level of variation in B_H for grasshopper mice was due to an extremely low value of B_H recorded in 1966 when densities were low in all but the one sandy site sampled.

Table 2. Estimates of habitat breadth B_H by species and year with mean and standard deviation (SD) for the three samples.

Species	1966	1976	1981	Mean	SD
Cheatodipus hispidus	0.72	0.77	0.60	0.70	0.09
Peromyscus maniculatus	0.49	0.71	0.78	0.66	0.15
Onychomys leucogaster	0.08	0.62	0.67	0.46	0.32
Reithrodontomys megalotis	0.91	0.43	—	0.45[1]	0.45
Microtus ochrogaster	0.85	0.29	0.00	0.38	0.44
Spermophilus tridecemlineatus	0.20	0.58	0.26	0.35	0.20
Sigmodon hispidus	0.52	0.26	0.25	0.34	0.15
Reithrodontomys montanus	0.17	0.31	—	0.16[1]	0.15

[1]Assumes that B_H = 0.00 in 1981, which would be true if one individual had been caught or if numerous individuals had been caught in only one habitat.

DISCUSSION

Use of different types of traps and techniques (removal versus nonremoval trapping) can influence the capture success of small mammals (e.g., Smith et al. 1975). However, effects of any procedure should influence species-specific trapping success somewhat proportionately in all habitats and not greatly alter our within-year estimates of habitat breadth. Therefore, differences in species-specific estimates of habitat breadth recorded in 1966, 1976, and 1981 likely reflect habitats sampled each year. Our estimates of B_H may underestimate the true habitat breadth when a species is at a general low in abundance because chance factors can more readily influence the presence or absence of a species in habitats sampled. However, we cannot document any cases in which low values of B_H were due only to low density since each of our three sets of habitats were sampled in only one year.

Although deer mice were three or more times as abundant as pocket mice in any year, B_H values indicated that the hispid pocket mouse and deer mouse were the habitat generalists of the eight species studied. B_H values in 1976 and 1981 suggested that grasshopper mice are also habitat generalists in north central Kansas. It is uncertain whether the extremely low B_H of grasshopper mice in 1966 is reflective of a general pattern of use of these habitat types or whether the value was unusually low. The latter seems likely. Hispid pocket mice and grasshopper mice are commonly found in areas with open vegetation such as upland and breaks habitats (Andersen and Fleharty 1967, Abramsky et al. 1979). High values of B_H for both pocket mice and grasshopper mice in 1976 and 1981 were consistent with previous observations since these mice used cropfields and old-fields as well as native prairie sites. Deer mice are usually common in habitats with a bare soil surface and open vegetation such as cropfields (Fleharty and Navo 1983 and references therein), grazed prairie (e.g., Grant et al. 1982), burned prairie (Kaufman et al. 1988, Snyder and Best 1988, and references in both), mowed prairie (Lemen and Clausen 1984) and early, non-woody successional stages (Heideman et al. 1983, Hingtgen and Clark 1984).

Thirteen-lined ground squirrels also are typically found in areas with open vegetation such as upland and breaks habitats (Andersen and Fleharty 1967, Abramsky et al. 1979). However, in comparison to deer mice, pocket mice, and grasshopper mice, B_H for ground squirrels in 1976 and 1981 was low due to their absence from cropfields.

Western harvest mice and prairie voles are usually most abundant in habitats with lush vegetation (Abramsky 1978, Abramsky et al. 1979, Fleharty and Navo 1983). B_H was high for both western harvest mice and prairie voles in 1966 when sites were ungrazed or only lightly grazed grasslands. Estimates of habitat breadth in 1976 and 1981 (harvest mice were not recorded in 1981) were low because we sampled habitats with relatively open vegetation conditions resulting from disturbance by farming and cattle ranching. Presumably, however, low abundance in the general region of the study area and not just in the habitats sampled contributed to our lack of captures of these species in 1981.

The preference of cotton rats for dense, rank herbaceous vegetation (Fleharty and Mares 1973, Fleharty and Navo 1983) was evident in their relatively high abundance in ungrazed upland and sandy mixed-grass native prairie in 1966; in ungrazed planted native grasses, 5-year old-fields, and wheat stubble in 1976; and fencerows and wheat stubble in 1981. Because cotton rats prefer the disturbed subset of habitats sampled, B_H was especially low in 1976 and 1981. The use of disturbed sites probably was important in the recent invasion of the cotton rat into north central Kansas from the northern presettlement limit of their range in Oklahoma. The first records of cotton rats as far north as our study area were made in 1949 (Cockrum 1952).

Plains harvest mice had the narrowest habitat breadth of any native grassland rodent in our study. These mice usually were captured in upland prairie and young old-fields, but not in breaks sites and only infrequently in most other habitats. Andersen and Fleharty (1967) found this small mouse to be associated with light to moderately grazed upland prairie sites with little to no litter. Lack of plains harvest mice in 1981 was consistent with the low trapping effort in preferred habitats, although they were expected in mixed-grass prairie sites based on data from 1966 and 1976.

Deer mice, hispid pocket mice, and grasshopper mice, because of their broad habitat distributions, including cropfields, old-fields, and restored grasslands, should be less affected by additional perturbations to native grassland habitats than would other rodents. In fact, creation of sites with open soil and weedy herbaceous vegetation by farming and other land management practices should continue to provide favorable habitat conditions for these species. Based on density, however, cropfields typically provide conditions much more suitable for deer mice than even pocket mice or grasshopper mice. In contrast, plains harvest mice, the least abundant of species considered herein, would be severely impacted by destruction of upland mixed-grass prairie. Other species exhibited moderate habitat breadth, used both natural and disturbed sites, and would be intermediate in their responses to future changes in native habitats in north central Kansas. Of all species, cotton rats would be least impacted by the destruction of native grassland habitats and most impacted by large-scale clean farming.

Sample size influences the estimation of species diversity (Pielou 1975) as well as habitat breadth since it is the reciprocal of Simpson's diversity index. Therefore, biologists using habitat breadth indices in wildlife conservation issues (Geier and Best 1980) should invest in sufficient collecting effort to obtain reasonable estimates of habitat-specific density for all species including those at low densities. A large array of specific habitats (rather than a limited number of very generalized habitat classes) should be sampled over multi-year periods to strengthen the generality of observed patterns of habitat breadth. Further, a standardized index (e.g., B_H) should be used to facilitate comparison among years and studies since habitat breadth (B) increases as the number of habitats in which the species is present increases. Finally, indices of habitat breadth should not be used to the exclusion of density in nongame wildlife management decisions because habitat breadth is an index that is based on the relative abundance of a species in an array of habitats and not the absolute abundance in those habitats (e.g., if the deer mouse had been one-fifth as abundant in breaks, mixed-grass, and sandy mixed-grass in 1966, then its B_H would have been higher than that of the pocket mouse in 1966).

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Unionid Molluscs in the Big Bend Reach of the Platte River, Nebraska

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ABSTRACT — Historically, the Platte River in Nebraska was, for the most part, a braided stream with a constantly shifting bottom. Bivalve molluscs are not typically found in this type of habitat and thus are not common in the Platte River.

During the summer of 1988, six species of unionid mussels were collected by the author from a channel of the Platte River in Hall County, Nebraska. Two additional species were collected by others from the Platte River in Dawson County. All of the specimens were collected within the Big Bend reach of the Platte River, which extends from Lexington to Grand Island, NE. *Quadrula quadrula* was the most abundant species sampled and *Potamilis ohiensis* was the least abundant.

Little is known about the unionid fauna of the Big Bend reach of the Platte River. More than 80 species of unionids were recorded in Nebraska during the 19th century (Aughey 1877). Later, the listing of R.H. Wolcott's collection of Nebraska shells (Walker 1906) added to the knowledge of mussel distribution. However, no mention of the Platte River was made in either report.

Species distributions described by Burch (1975) are helpful in determining which species should be present along the Platte. Baker (1898) believed that a molluscan fauna would be supported in any region with ponds or sources of flowing water. Parmalee (1967), however, stated that a constantly shifting bottom will limit or prevent the establishment of mussel beds. Physical, chemical, and biological factors also affect the distribution of mussels (Cvancara 1983).

Burky (1983) discussed a number of papers dealing with the physiological sensitivity of freshwater bivalves. Mussels may be adversely affected by man's alteration of riverine habitat even when other organisms are not (Matteson 1955). Because mussels are sensitive to most environmental changes, they are useful indicators of general water quality.

Whooping cranes (*Grus americana*), which annually migrate through the Big Bend reach of the Platte, are known to utilize mussels as a major component of their diet on their wintering grounds on the Texas Gulf coast (Blankenship 1976). When small wetlands adjacent to the Platte were more abundant, mussels may have been an important component in whooping crane diets during migration (Currier et al. 1985). Platte River Whooping Crane Habitat Maintenance Trust personnel suggested that a study of the kinds of mussels present and their habitat affinities would provide important information regarding the management of Platte River wetlands for cranes and other migratory species.

The objectives of this study were (1) to identify mussel species present in the Big Bend reach of the Platte River, and (2) to describe the general habitat characteristics of those species.

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STUDY AREA

The Big Bend reach of the Platte River extends roughly from Lexington to Grand Island, NE. Within this area, there is a main central channel 250-550 m wide. Narrower, deeper channels parallel the main channel to the north and south throughout much of the Big Bend reach. The primary collection site was located on the south channel, southeast of the town of Wood River, in T9N, R12W, sections 26 and 27, Hall County, NE, on land owned and managed by the Platte River Whooping Crane Habitat Maintenance Trust (hereafter referred to as the "Trust site"). Mussels were also collected at the "Lilley site," a few miles downstream on the same channel, just above its confluence with the main channel (Fig. 1).

In the central Platte River valley, Quaternary alluvial sediments overlay the Ogallala, Niobrara, and Pierre Formations. The Ogallala Formation is both porous and highly permeable and acts as a water reservoir. Low permeability chalk, limestone, and marine shales make up the Niobrara and Pierre Formations (Hurr 1981).

The dominant topographical features are alluvial bottomlands, river terraces, and gently sloping, rounded hills. The hardly discernible south valley wall is a narrow band of low sand dunes. The average rise in the river from east to west is about 1.3 m per kilometer.

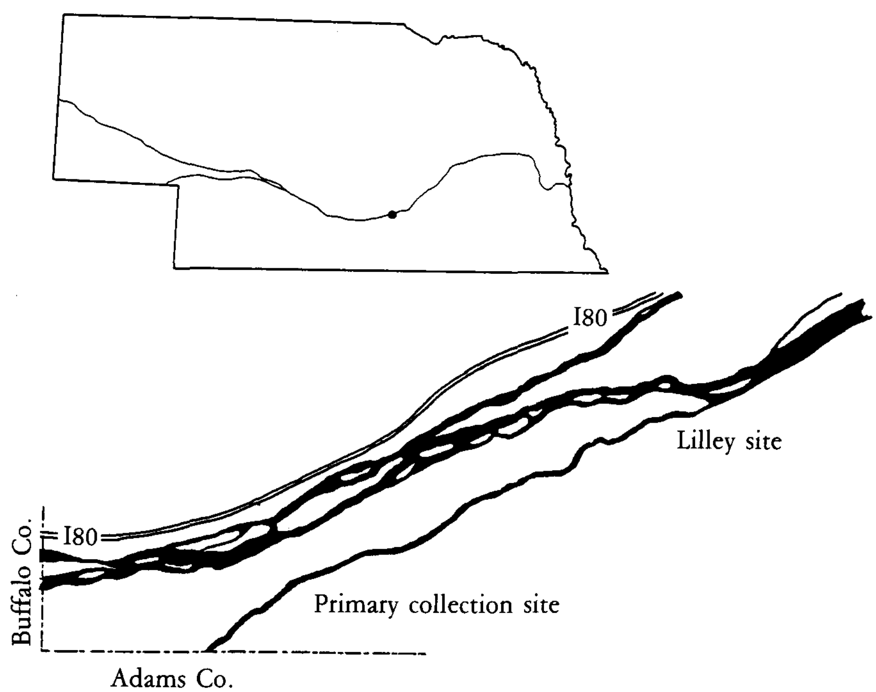

Figure 1. Collection sites on the Platte River in Hall County, Nebraska.

Major soils in the drainage area are alluvial, bordered by chernozem and sandhills. Land use in the area is predominantly irrigated cropland and cattle-feeding operations.

Stevens (1978) has classified the climate in central Nebraska near Grand Island as "semihumid," with an average precipitation of 570 mm.

Flow in the Platte is primarily controlled by spring snowmelt in the Rocky Mountains and local precipitation. Streamflow has been significantly altered over time by the storage and diversion of water for irrigation and electrical generation. Today, the river channel is 10-70% of its 1865 width (Williams 1978).

The flows in the south channel are affected by discharge in the Platte and local runoff, including that from Elm Island and a number of tributary creeks originating in the uplands just south of the river. Groundwater seepage also plays a role in maintaining the flow in the south channel (personal observation). Flows range from near zero in mid-summer to overflowing following local rains or rapid snowmelt. Flowing water temperature in the south channel averaged 9°C cooler than the main channel during the summer months of 1988, probably a result of groundwater upwelling.

In addition to flowing-water habitat, a number of gravel pit and farm pond impoundments are also found along the south channel. Some of these impoundments are bisected by the channel, whereas others are adjacent to the channel.

MATERIALS AND METHODS

Field collections and habitat characterizations were conducted during periods of low flow in the summer of 1988. Hours of collection varied from early morning to evening. The cooler evening hours, however, were the most productive as more mussels were evident above the substrate at that time. Mussels were located and collected by walking the stream. In areas where turbidity obscured the bottom, specimens were located with hands or feet. Mussels buried below the substrate surface were located with a small rake. Live mussels were measured, identified, and photographed in the field, and replaced immediately. Dead specimens were collected and retained for positive identification. Manuals by Buchanan (1980), Burch (1975), and Parmalee (1967) were used in the identification. A representative group was sent to Alan C. Buchanan of the Missouri Department of Conservation for positive identification. Additional specimens found by Lynn E. Noel in Dawson County were identified by Dorothy Beetle-Pilmore. Field data, including observations on substrate, stream width and depth, water temperature, bank shading, aquatic vegetation, and associated animal life, were also collected.

ANNOTATED LIST OF SPECIES

A total of 168 specimens was collected. Another 94 specimens were removed, measured, and replaced. In this list, the scientific name of each species is followed by the common name, the fish host species for the glochidia, and notes relating to the specimens:

Anodonta imbecilis (Say 1829). Paper pondshell. Fish host species: creek chub (*Semotilus atromaculus*) and green sunfish (*Lypomis cyanellus*) (Buchanan 1980). This species was found most often only as an empty shell. Generally, the shell was not broken but merely lying open, indicating death by factors other than predation, e.g., desiccation. The specimens were most common at the primary study site, with live specimens found in various substrates at water depths of less than 10 cm.

Anodonta grandis grandis (Say 1829). Floater. Fish host species: carp (*Cyprinus carpio*), yellow perch (*Perca flavescens*), bluegill (*Lypomis macrochirus*), rock bass (*Ambloplites rupestris*), white crappie (*Pomoxis annularis*), and 17 other fish species (Buchanan 1980). This species was found in greater numbers at the Lilley site. The shells of dead specimens were often cracked or broken, but seldom showed teeth marks. Most specimens were found in association with sandy substrates.

Lasmigona complanata complanata (Barnes 1823). White heelsplitter. Fish host species: carp, green sunfish, largemouth bass (*Micopterous salmoides*), and white crappie (Buchanan 1980). This species appeared to be the most often selected by predators. Most dead specimens and many live specimens showed damage from teeth marks. Often, the larger shells were deformed due to growth around the damaged areas. Very large specimens, up to 15 cm in length, were found at the Lilley site. Most of the large specimens were well embedded in a silty bottom in turbid pools, approximately 50 cm deep and 10 m wide. The primary collection site for this species was an unshaded stretch of channel, adjacent to an active gravel operation and just upstream from the main channel. This species was also collected by Lynn E. Noel in 1988 from the main channel of the Platte near Elm Creek, NE.

Potamilis ohiensis (Rafinesque 1820). Pink papershell or fragile heelsplitter. Fish host species: white crappie and freshwater drum (*Aplidinotus grunniens*) (Buchanan 1980). Two live specimens collected were found in a silty-sand substrate in tree-shaded water approximately 10 cm deep. The three dead specimens found appear to have been broken by predators. This was the least abundant species sampled.

Quadrula quadrula (Rafinesque 1820). Maple leaf. Fish host species: flathead catfish (*Pilodictus olivaris*) (Buchanan 1980). This was the most numerous species in the study area. It was found in all substrate types and at all depths. Live specimens were often found where water had receded, exposing the substrate. Other species found in the same conditions had died. Few predated (broken) shells were found. Only two specimens were found at the Lilley site. The Lilley specimens, however, were the largest collected.

Strophitus undulatus undulatus (Say 1817). Squawfoot. Fish host species: creek chub, green sunfish, largemouth bass, and Rio Grande killifish (*Fundulus zebrinus*) (Buchanan 1980). Most specimens found were live and were collected in shaded, shallow water areas, with a gravelly-sand substrate. This species was rarely collected. The only species collected less frequently was *Potamilis ohiensis*.

The following specimens were collected from the Platte River in Dawson County by Lynn E. Noel on 5 May 1988.

Leptodea fragilis (Rafinesque 1820). Fragile papershell.

Anodontoides ferussacianus (Lea 1834). Cylindrical papershell.

DISCUSSION

Six species of mussels are now known to inhabit the south channel of the Platte River in Hall County, Nebraska. The most common species in the study area was the Maple leaf (*Quadrula quadrula*). A population of mussels distributed over a larger area was found a few miles downstream at the Lilley site. This section of the south channel runs through or adjacent to an active gravel mining operation, which has been in existence for approximately 60 years. Over much of the south channel no mussels were found. Further investigation, however, is warranted.

On the rippled, moving bottom of the main channel, live mussels are apparently absent. During another study conducted in June 1988, when flows were very low, biologists walked transects across the Platte's main channels at three-mile intervals from Lexington to the mouth of the Platte at the Missouri River. Although a small number of broken shells was collected, no live mussels were found. The shells were worn and undoubtedly had been transported by the stream. Therefore, it was not possible to identify the origin of these mussels.

The highest densities of mussels at the Trust site were located in a narrow, 50-cm-wide channel directly below a beaver dam in a tree-shaded, silty-gravel substrate. Stream flow was very slow and water depth averaged 5 cm. A forest, approximately 30-40 years old, of medium growth and low understory, abutted the stream. Banks were covered with vegetation and had not been grazed. The streambed lacked aquatic vegetation. Irrigated rowcrops were planted within a few meters of the stream to the north. A fenced pasture bordered the stream a few meters to the south.

Less than 1 km downstream on the Trust site, few clams were found, probably because the streambed there was disturbed by cattle. Runoff from a nearby road and from the surrounding fields may also contribute to the lack of mussels there. The substrate in this area contained more silt and less gravel than the area directly below the beaver dam. There were fewer trees shading the south bank, and cattle were allowed complete access to the stream, leaving little or no bank vegetation. Aquatic algae were abundant in this downstream area.

In many places where mussels were not found along the south channel, row crops were cultivated within a few meters of the stream. Trees had been removed and the channel was no longer shaded. In Illinois, Matteson (1955) found that clams were nearly eliminated from small streams in areas where cultivation of adjacent land caused excessive siltation. Water temperature also increased in these areas as shade trees were removed.

Other narrow channels of the Platte in the Big Bend reach that were searched indicated no evidence of live mussels. These river segments varied from the Trust and Lilley sites primarily in their greater amount of aquatic algae.

The rapid decline of flow within the channel that occurred a number of times during the summer of 1988 was an important direct cause of death for many mussels. The substrate was exposed on a number of days when air temperatures were over 35°C, leaving the mussels susceptible to rising body temperatures, oxygen deprivation, or desiccation. Exposure of the riverbed also increased the susceptibility of individuals to depredation. Evidence of raccoon (*Procyon lotor*) and muskrat (*Ondatra zibethicus*) predation was noted. Muskrats were observed at every visit. Predation is likely a secondary biological factor in the survival of mussels but it may be an important factor in localized populations, especially among thin-shelled mussels living in shallow water (VanCleave 1940). Most of the shells that were broken by predators were thin-shelled, whereas most of the surviving, deeply buried mussels were heavy-shelled.

Mussel distribution is also highly dependent on the distribution of host fish. Because mussels are sessile organisms, dispersal upstream for their young must be facilitated by some mobile organism. The glochidia of most species of unionids are dispersed by specific fish hosts. Environmental conditions may be ideal for a species to exist at a certain site, but if these conditions are unsuitable for its host fish, the species will not be found there (Matteson 1955).

Two additional unionid species were collected from the Platte River near Elm Creek, in Dawson County, Nebraska, during the same period as this study. These collections suggest that additional species may be present within the Big Bend reach of the Platte River.

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Population Characteristics of Rock Bass in Three Northeastern South Dakota Lakes

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ABSTRACT — Rock Bass (*Ambloplites rupestris*) were collected with modified-fyke nets from three South Dakota lakes to document characteristics of each population. The rock bass population in Lake Kampeska had a high proportion of large fish (> 180 mm) and inconsistent recruitment. The population in Pickerel Lake had a moderate proportion of large fish and consistent recruitment. Amsden Lake had a low-density rock bass population. Growth was above average and condition high in all three lakes. Summaries of size structure, age structure, growth rates, condition factors, and catch rates may prove useful as comparative data for future rock bass investigations in South Dakota and for making regional assessments in surrounding states.

The western extent of the native range of rock bass (*Ambloplites rupestris*) is the Minnesota River drainage (Bailey and Allum 1962). Rock bass have become established in several eastern South Dakota lakes. We are aware of no documentation for population characteristics of rock bass in South Dakota waters. Carlander (1977) did not include South Dakota data in his summary of northern populations of rock bass. Therefore, the objective of this study was to document population characteristics of rock bass in South Dakota.

METHODS

This study was conducted on two natural lakes (Kampeska and Pickerel) and one impoundment (Amsden) in northeastern South Dakota. The watersheds for the lakes are predominantly agricultural lands. Locations and characteristics of each lake are presented in Table 1.

Rock bass were sampled in late May and early June 1989, using single-lead, modified-fyke nets having 1.2- x 1.2-m frames and 1.2- x 22.9-m leads with a bar mesh size of 13 mm. Fyke nets were set overnight at pre-determined, randomly-chosen sites. Random sites were selected by premapping 20 equidistant locations about the shoreline contour using a chartometer and public boat launches as random starting points. Two nets at Kampeska and one at Pickerel were omitted from the sample due to human disturbance. Rock bass were measured for total length (mm) and weight (g). Scales were removed at a point slightly dorsal to the lateral line and slightly anterior to the spiny dorsal fin (Jearld 1983).

Catch rates (number and kg of fish/net night) were used as an index of abundance (Hubert 1983). The random selection of net locations allowed for the comparison of catch rates among lakes by representing various habitats within a lake and reducing worker bias toward "preferred habitat". Non-selective setting of nets, however, typically introduces high variability due to the habitat differences

Table 1. Location and characteristics of three South Dakota lakes from which rock bass were collected.

Characteristics	Lake		
	Kampeska	Pickerel	Amsden
County	Codington	Day	Day
Surface area (ha)	1949	386	95
Maximum depth (m)	4.4	13.1	7.3
Alkalinity (ppm)	238	221	238
Dominant shoreline substrate	gravel/sand	gravel/rubble	silt/sand
Sport fish present[a]	BBH, SMB, WAE, WHB, WHC	BBH, BLC, LMB, NOP, SMB, WAE, YEP	BBH, BLC MUS, SMB, WAE, YET

[a]BBH = black bullhead (*Ictalurus melas*), BLC = black crappie (*Pomoxis nigromaculatus*), LMB = largemouth bass (*Micropterus salmoides*), MUS = muskellunge (*Esox masquinongy*), NOP = northern pike (*E. lucius*), SMB = smallmouth bass (*M. dolomieui*), WAE = walleye (*Stizostedion vitreum*), WHB = white bass (*Morone chrysops*), WHC = white crappie (*P. annularis*), YEP = yellow perch (*Perca flavescens*).

within the lake. Thus, 80% as well as 95% confidence intervals were calculated and used for analyses.

Length-frequency histograms were constructed to evaluate size structure of rock bass. In addition, length-frequency data were quantified using proportional stock density (PSD) and relative stock density of preferred-length fish (RSD-P) (Anderson and Gutreuter 1983). PSD is the percentage of stock-length fish that are also quality length, and RSD-P is the percentage of stock-length fish that are also preferred length. Minimum stock (S), quality (Q), and preferred (P), lengths for rock bass are 100, 180, and 230 mm, respectively. Confidence intervals were applied to stock density indices as suggested by Gustafson (1988).

Age was determined from fish scale impressions made on acetate slides. Age-structure histograms were composed to examine recruitment. Age-and-growth data were determined by back-calculation using a digitizing pad and microcomputer program (Frie 1982). A standard "a" value of 20 mm was used (Carlander 1982).

Relative weights (Wr) were calculated and used as an index of body condition (Wege and Anderson 1978). Wr is calculated by dividing the actual weight of a fish by a standard weight (Ws) for a fish of that length. The Ws equation used was $\log_{10}Ws = -4.883 + 3.083\log_{10}L$ (Covington et al. 1983), where Ws = weight in g and L = total length in mm. Condition factors (K_{TL}) were also calculated (Lagler 1956) for comparison with the Minnesota standards reported by Carlander (1977).

RESULTS AND DISCUSSION

The length frequencies (Fig. 1) and stock density indices (Table 2) of rock bass collected were dissimilar among the three lakes. The Kampeska sample was dominated by large individuals, as reflected by a PSD and RSD-P of 98 and 40, respectively. Rock bass in Pickerel Lake were distributed over a broader length range up to 200 mm, after which numbers declined. Quantitatively, a PSD and RSD-P of 34 and 1, respectively, describe these characteristics. The length-frequency distribution of rock bass in Amsden Lake indicated a poorly-structured population. The PSD and RSD-P for rock bass in Amsden Lake were 50 and 0, respectively, but sample size was low.

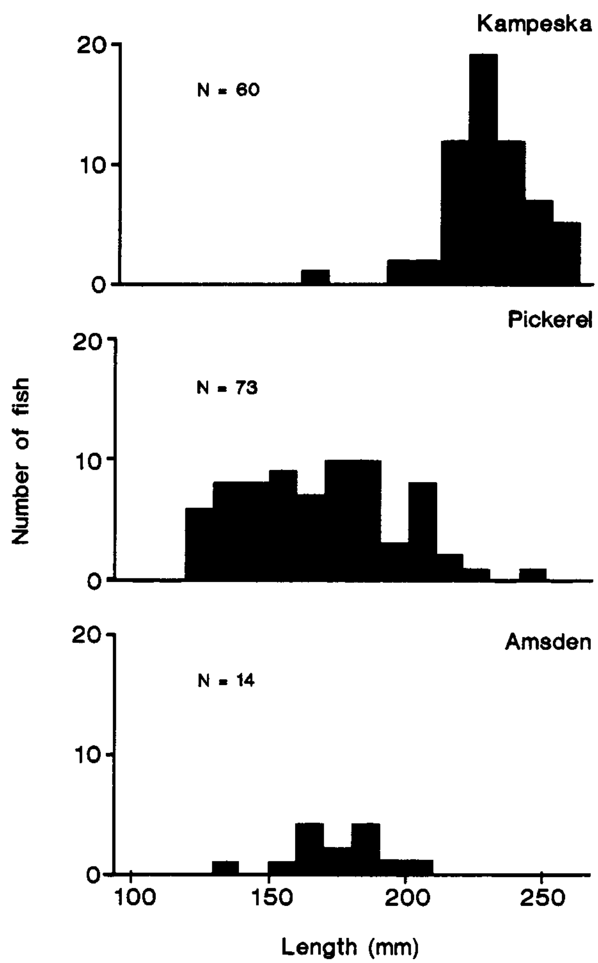

Figure 1. Length frequency of rock bass collected with modified-fyke nets from three South Dakota lakes.

Table 2. Stock density indices[a] and 95% confidence intervals for rock bass collected from three South Dakota lakes.

Lake	PSD	RSD-P
Kampeska	98 ± 8	40 ± 14
Pickerel	34 ± 10	1[b]
Amdsen	50 ± 38	0[b]

[a]PSD = proportional stock density and RSD-P = relative stock density of preferred-length fish
[b]sample size was insufficient to calculate confidence interval

Rock bass in Kampeska Lake had variable year-class strength, with recruitment being low in recent years (Fig. 2). The 1982 year class contributed over 50% of the total catch, and the 1981 and 1980 year classes contributed an additional 25%. The most recent year classes, 1983 to 1986, contributed only about 20% of the total catch. In contrast, recruitment at Pickerel Lake appeared to be more consistent as the year-class contributions to the total catch took a somewhat stepwise decline. Only three year classes of rock bass, 1984-1986, were collected at Amsden Lake, with the 1985 year class comprising the majority of the catch.

Rock bass in all three populations had above-average growth (Table 3). At age 2 and beyond, rock bass in these South Dakota lakes had a mean length greater than the mean length at age presented by Carlander (1977) for rock bass in northern lakes.

Condition of rock bass in these three South Dakota lakes was high (Table 4). All mean *Wr* values met or exceeded the desirable range of 95-105 suggested by Anderson (1980). Mean K_{TL} values were within the average range (2.02-2.32) of Minnesota standards reported by Carlander (1977).

Table 3. Mean back-calculated length at age for rock bass collected from three South Dakota lakes and mean length at age for northern lakes reported by Carlander (1977).

	Mean back-calculated length (mm) at age								
Lake	1	2	3	4	5	6	7	8	9
Kampeska	43	80	117	152	183	205	220	225	252
Pickerel	39	77	127	172	194	217	232	244	—
Amsden	45	96	145	179	202	—	—	—	—
Northern lakes	42	70	99	124	150	180	196	211	219

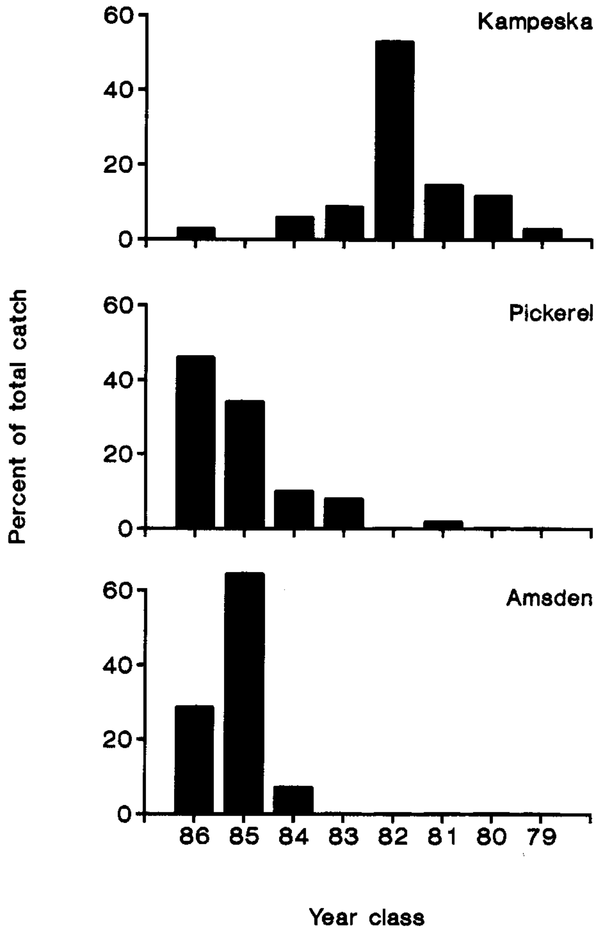

Figure 2. Age structure of rock bass collected with modified-fyke nets from three South Dakota lakes.

Catch rates (number/net night) were similar for Kampeska and Pickerel lakes (Table 5). Biomass/net night was about twice as high at Kampeska as at Pickerel Lake because of the larger fish collected at Kampeska. Catch rates at Amsden Lake were relatively low. Thus, the low sample size at Amsden was likely due to low population density, not lack of sampling effort.

Size structure and population density appear to be largely influenced by recruitment. Kampeska rock bass had a high PSD, a result of low recruitment in recent years. Size structure will vary in the future depending on recruitment

Table 4. Condition, both relative weight (*Wr*) and K_{TL}, of rock bass collected from three South Dakota lakes. Both condition factors were calculated in three size categories and as an overall mean. Sample sizes are in parentheses.

Lake	Condition factor	Size category[a]			
		S-Q	Q-P	P-M	Combined
Kampeska	*Wr*	105 (1)	113 (15)	111 (18)	112 (34)
	K_{TL}	2.09	2.32	2.42	2.29
Pickerel	*Wr*	98 (33)	105 (6)	135 (1)	101 (50)
	K_{TL}	1.95	2.14	2.80	2.03
Amsden	*Wr*	111 (8)	106 (6)	—	109 (14)
	K_{TL}	2.21	2.14	—	2.18

[a]S = stock length (100 mm), Q = quality length (180 mm), P = preferred length (230 mm), and M = memorable length (280 mm)

Table 5. Mean catch rates (number/net night and kg/net night), including 80% and 95% confidence intervals (CI), for rock bass collected in modified-fyke nets from three South Dakota lakes.

Lake	Net nights	Type	Mean	80% CI	95% CI
Kampeska	18	Number	3.3	±1.6	±2.6
		Biomass	0.9	±0.4	±0.7
Pickerel	19	Number	3.8	±1.9	±3.0
		Biomass	0.4	±0.2	±0.3
Amsden	20	Number	0.7	±0.4	±0.6
		Biomass	0.1	± <0.1	±0.1

patterns. If recruitment remains low, population density will decrease as older fish die. Rock bass in Pickerel Lake had moderate size structure and consistent recruitment. With above-average growth and consistent recruitment, we would have expected to find more larger rock bass (e.g., $\geq$ 200 mm) in Pickerel Lake. We do not know whether selective angler harvest or inconsistent recruitment caused the lack of larger individuals. Based on catch-rate data, rock bass in Amsden Lake appeared to exist at a lower density than in the other two lakes. Both yellow perch (*Perca flavescens*) and black crappies (*Pomoxis nigromaculatus*) were abundant in Amsden Lake, leading to speculation that interspecific competition may impede reproduction or recruitment. The mean length at annulus for rock bass in Amsden Lake was higher than in the other two lakes, and exceeded the Carlander (1977) mean for northern lakes. Thus, growth apparently was not affected by interspecific competition.

We hope the information in this paper will be useful to biologists that study rock bass populations in South Dakota and surrounding states. Certainly these data represent a variety in population types.

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A Proposed Standard Weight (*Ws*) Equation for Sauger

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ABSTRACT — Length-weight data for saugers (*Stizostedion canadense*) were summarized for 49 data sets from 33 populations in 16 states and 2 Canadian provinces to develop a proposed standard weight (*Ws*) equation. The proposed *Ws* equation is $\log_{10}Ws = -5.446 + 3.157 \log_{10}L$, where *Ws* is the weight in grams and L is total length in millimeters. The English equivalent is $\log_{10}Ws = -3.669 + 3.157 \log_{10}L$, where *Ws* is weight in pounds and L is total length in inches. When relative weight (*Wr*) was regressed on length of individual saugers, only 19 of the 49 relationships had slopes that were significantly different from zero. Of the 19, nine had positive slopes and 10 had negative slopes. Thus, *Wr* values calculated with the proposed equation should be independent of length.

Saugers (*Stizostedion canadense*) are popular sport fish in the United States and Canada. Important sport fisheries have been documented in the Missouri River (Nelson and Walburg 1977), Mississippi River (Boland and Ackerman 1983), Great Lakes (U.S. Fish and Wildlife Service 1982), southeastern United States (Hackney and Holbrook 1978), and Canada (Scott and Crossman 1973). Saugers have also been commercially fished (Carlander 1947, Scott and Crossman 1973, Davidoff 1978).

Evaluation of fish condition can provide useful information to make proper management decisions. Wege and Anderson (1978) proposed the use of relative weight (*Wr*) as an index to fish condition. The actual weight of the fish is compared to a standard weight (*Ws*) for a fish of that length. Before *Wr* can be used to assess condition for a fish species, the *Ws* equation must be available. Wege and Anderson developed the first *Ws* equation for largemouth bass (*Micropterus salmoides*) using the 75-percentile weights from the species summary found in Carlander (1977). However, that technique for development of *Ws* equations has not been successful for other species (Willis 1989). Willis (1989) used the mid-point from the range of predicted weights for northern pike (*Esox lucius*) populations collected over a broad geographic range to develop a *Ws* equation. The objective of this study was to develop a *Ws* equation for saugers.

METHODS

Fisheries biologists from the United States and Canada provided 49 sets of length-weight data for saugers. These data were used to develop the *Ws* equation (Fig. 1). All data were evaluated using total length. One data set submitted as fork length was converted to total length using the equation, total length = 7.561 + 1.030 x fork length, developed from a data set that included both fork and total lengths. Length-weight regressions were calculated for each data

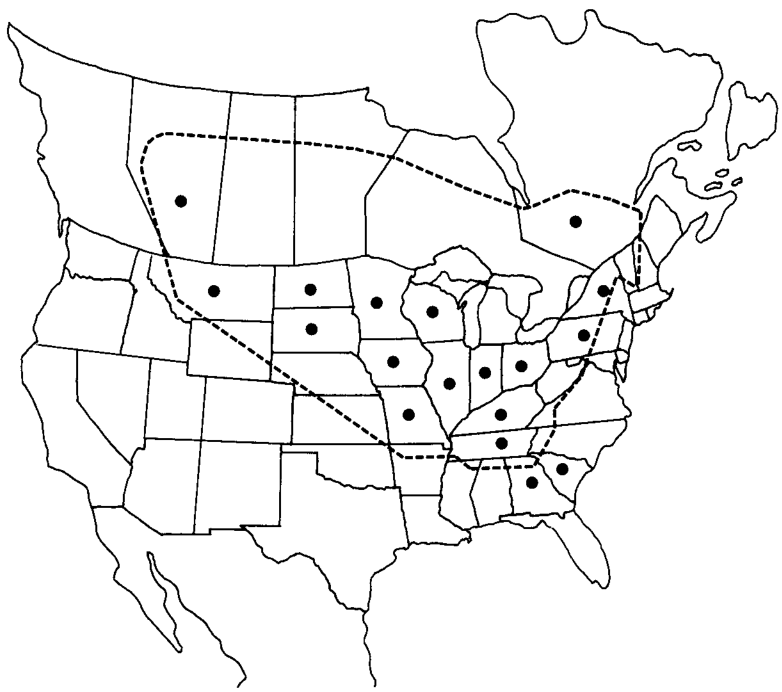

Figure 1. Geographical locations (dots) from which sauger length-weight data were summarized to develop a proposed standard weight (*Ws*) equation. The dashed line represents the native range of saugers (Lee et al. 1980).

set, as suggested by Murphy et al. (In Press), rather than pooling all raw data. The regressions were performed using logarithmic (base 10) transformation of length and weight data.

The proposed *Ws* equation was calculated as suggested by Willis (1989). The estimated weights of saugers at 25-mm intervals were calculated for each data set, but only for the length range of fish included in each regression. The midpoint from the range of predicted weights at each 25-mm interval was then regressed on length to provide the proposed *Ws* equation.

Mean *Wr*, proportional stock density (PSD, Anderson and Gutreuter 1983), and relative stock density of preferred-length fish (RSD-P, Gabelhouse 1984) were calculated for all data sets except two that included only young-of-the-year fish. Minimum stock, quality, and preferred lengths for sauger are 20, 30, and 38 cm, respectively (Gabelhouse 1984). *Wr* values for individual fish were plotted as a function of fish length for the 49 data sets to determine if *Wr* was independent of fish length. All statistical analyses were performed using the Statistical Analysis System (SAS) for personal computers (SAS Institute, Inc. 1985).

RESULTS AND DISCUSSION

Data sets were included from nearly the entire native range of sauger (Fig. 1). In addition, the study included a wide range in size structure of saugers; PSD ranged from 6 to 100 and RSD-P ranged from 0 to 93 (Table 1). Thus, we assume that data sets included nearly the entire range of length-weight data for sauger. All length-weight regressions from the 49 data sets were highly significant ($P < 0.0001$) and all correlation coefficients (r) were higher than 0.95 (Table 1). The range of predicted weights, by 25-mm intervals, increased with length (Table 2).

The proposed standard length-weight equation, formulated from the midpoint of the range of predicted weights by 25-mm length intervals (Table 2), is:

$$\log_{10}Ws = -5.446 + 3.157 \log_{10}L,$$

where *Ws* is weight in grams and L is total length in millimeters. The English equivalent of this equation is:

$$\log_{10}Ws = -3.669 + 3.157 \log_{10}L,$$

where *Ws* is weight in pounds and L is total length in inches.

Murphy et al. (In Press) recommended that the minimum valid length for a *Ws* equation be determined by calculating the variance/mean ratio for $\log_{10}$ weight by centimeter length group. They suggested that the minimum valid length for a species should correspond to the point where variance/mean ratios remain constant. Based on this technique, our proposed *Ws* equation is valid for fish of 70 mm or longer. The small saugers included in our data set were measured to the nearest millimeter and weighed to the nearest 0.1 gram.

To determine whether the *Ws* equation was valid for all lengths of sauger, the *Wr* of individual fish was regressed on fish length for the 49 data sets. Only 19 of the 49 relationships had slopes that were significantly different from zero ($P<0.05$). Of the 19 data sets with slopes significantly different from zero, nine had positive slopes and 10 had negative slopes. These data indicate that *Wr* values calculated with the proposed equation should be independent of fish length.

Thirty-four percent of the 47 sauger data sets that included adult fish had a mean $Wr < 95$, 51% had a mean *Wr* of 95-105, and 15% had a mean *Wr* $\geq$ 105 (Fig. 2). Subjectively, these data indicate that the proposed equation should be useful. Anderson (1980) suggested that 95-105 was a reasonable objective range for *Wr*. Using our proposed standard, only 15% of the data sets were above the objective range and 34% were below.

Mean *Wr* values were correlated with stock density indices for each of the populations. Mean *Wr* was significantly correlated with both PSD ($r=0.378$, $P<0.01$) and RSD-P ($r=0.414$, $P<0.01$). However, the correlation coefficients were low, indicating variability around the regression line. We suspect that much of this variability is due to the wide range in gear types and sampling dates. Saugers were sampled with gill nets, fyke nets, seines, and by electrofishing and angling. Sauger data included in this study were collected from February through December.

Table 1. Length-weight relationships for 49 sauger data sets. All regressions are significant at $\alpha = 0.0001$, and all length-weight equations are base 10 logarithms (PSD = proportional stock density, RSD-P = relative stock density of preferred-length fish).

Water	N	PSD	RSD-P	Length-weight equation	r	Length range (mm)
Saskatchewan River, Alberta (1986)	117	97	46	logW = −4.929 + 2.944 logL	0.964	283-502
Saskatchewan River, Alberta (1987)	80	90	43	logW = −6.034 + 3.372 logL	0.975	250-511
Lake Clarks Hill, Georgia	85	100	80	logW = −5.348 + 3.130 logL	0.975	340-503
Mississippi River, Illinois (1982) (Pool 18)	105	80	42	logW = −5.777 + 3.292 logL	0.990	255-495
Mississippi River, Illinois (1983) (Pool 18)	109	77	45	logW = −6.491 + 3.568 logL	0.994	255-495
Wabash River, Indiana	23	100	52	logW = −4.722 + 2.880 logL	0.972	330-445
Mississippi River (Pool 19), Iowa (Carter 1968)	303	b	b	logW = −5.552 + 3.184 logL	b	152-483
Ohio River, Kentucky	328	57	13	logW = −5.955 + 3.353 logL	0.970	97-518
Mississippi River, Minnesota	57	a	a	logW = −5.940 + 3.332 logL	0.968	122-185
Lake Pepin, Minnesota (1987)	98	a	a	logW = −5.309 + 3.081 logL	0.987	60-120
Lake Pepin, Minnesota (1987)	426	75	42	logW = −5.862 + 3.325 logL	0.988	160-569
Lake of the Woods, Minnesota (1984)	1001	42	4	logW = −5.500 + 3.178 logL	0.969	119-442
Lake of the Woods, Minnesota (1985)	718	39	3	logW = −5.403 + 3.173 logL	0.976	173-429
Lake of the Woods, Minnesota (1987)	513	65	5	logW = −5.450 + 3.161 logL	0.988	173-432
Mississippi River, Missouri (Pools 20-26)	153	28	7	logW = −5.244 + 3.068 logL	0.977	157-445
Lake Sakakawea, Montana	75	97	65	logW = −5.995 + 3.330 logL	0.980	307-549
Yellowstone River, Montana	126	91	40	logW = −6.256 + 3.458 logL	0.985	150-580
Yellowstone River, Intake, Montana	349	93	69	logW = −6.313 + 3.476 logL	0.990	150-560
Lake Champlain, New York	295	100	93	logW = −5.619 + 3.245 logL	0.950	182-548
Lake Sakakawea, North Dakota	84	79	59	logW = −5.192 + 3.026 logL	0.986	187-687
Lake Cowan, Ohio (1982)	313	79	74	logW = −5.344 + 3.125 logL	0.955	107-556
Lake Cowan, Ohio (1983)	483	88	7	logW = −5.709 + 3.272 logL	0.990	130-504
Ohio River, Pennsylvania	21	91	17	logW = −5.682 + 3.230 logL	0.983	287-514
Lake Couloir Fluvial, Quebec	249	90	36	logW = −6.004 + 3.372 logL	0.978	245-547
St. Lawrence River, Quebec (1982)	123	94	46	logW = −5.164 + 3.040 logL	0.953	280-572
St. Lawrence River, Quebec (1984)	110	100	78	logW = −4.211 + 2.711 logL	0.969	320-590
Lake Saint-Louis, Quebec	36	37	13	logW = −5.731 + 3.252 logL	0.987	174-475

Table 1 Continued.

Water	N	PSD	RSD-P	Length-weight equation	r	Length range (mm)
Savannah River, South Carolina	49	100	65	$\log W = -5.905 + 3.331 \log L$	0.973	356-523
Lake Oahe, South Dakota	32	67	44	$\log W = -5.069 + 2.976 \log L$	0.988	178-575
Lake Sharpe, South Dakota	21	91	27	$\log W = -5.756 + 3.256 \log L$	0.993	247-425
Lake Douglas, Tennessee	155	14	6	$\log W = -5.059 + 2.973 \log L$	0.987	115-460
Lake Fort Loudoun, Tennessee (1984)	34	65	65	$\log W = -6.494 + 3.572 \log L$	0.998	172-554
Lake Fort Loudoun, Tennessee (1987)	83	96	49	$\log W = -4.562 + 2.833 \log L$	0.951	228-547
Lake Kentucky, Tennessee (1965)	83	95	53	$\log W = -6.339 + 3.510 \log L$	0.993	156-525
Lake Kentucky, Tennessee (1975)	450	96	42	$\log W = -6.083 + 3.415 \log L$	0.979	168-570
Lake Kentucky, Tennessee (1988)	285	90	83	$\log W = -4.851 + 2.965 \log L$	0.956	224-533
Lake Melton Hill, Tennessee (1975)	101	100	73	$\log W = -4.972 + 2.967 \log L$	0.975	245-542
Lake Melton Hill, Tennessee (1976)	64	98	71	$\log W = -5.093 + 3.017 \log L$	0.972	315-485
Lake Norris, Tennessee	164	94	43	$\log W = -5.740 + 3.242 \log L$	0.950	343-498
Lake Pickwick, Tennessee	138	98	13	$\log W = -5.760 + 3.281 \log L$	0.966	220-416
Tennessee River, Tennessee	130	93	34	$\log W = -6.155 + 3.440 \log L$	0.990	192-495
Lake Watts Bar, Tennessee (1964)	55	28	11	$\log W = -5.197 + 3.045 \log L$	0.977	137-447
Lake Watts Bar, Tennessee (1975)	461	99	64	$\log W = -5.241 + 3.085 \log L$	0.950	219-532
Lake Watts Bar, Tennessee (1976)	38	97	74	$\log W = -7.074 + 3.782 \log L$	0.980	275-502
Lake Watts Bar, Tennessee (1986)	402	96	22	$\log W = -5.901 + 3.338 \log L$	0.963	264-555
Lake Watts Bar, Tennessee (1987)	497	98	38	$\log W = -5.976 + 3.371 \log L$	0.974	265-631
Lake Winnebago, Wisconsin (1986)	304	6	3	$\log W = -5.434 + 3.119 \log L$	0.975	145-469
Lake Winnebago, Wisconsin (1987)	103	41	0	$\log W = -6.243 + 3.449 \log L$	0.973	249-376
Wisconsin River, Wisconsin	209	66	37	$\log W = -6.143 + 3.420 \log L$	0.988	153-533

[a]young-of-year fish [b]not available

Table 2. Range and mid-point of weights predicted from length-weight equations for 49 sauger data sets in the United States and Canada.

Length (mm)	N[a]	Weight range (g)	Mid-point of range (g)
75	1	—	3
100	2	6-7	7
125	5	11-18	15
150	10	18-30	24
175	19	30-63	47
200	22	48-90	69
225	26	73-133	103
250	32	105-170	138
275	37	142-241	192
300	40	170-312	241
325	43	230-397	314
350	46	300-492	396
375	47	363-604	484
400	46	433-731	582
425	45	511-875	693
450	38	598-1037	818
475	36	789-1217	1003
500	30	918-1417	1168
525	22	1062-1669	1366
550	12	1219-1970	1595
575	5	1393-2122	1758
600	2	1641-2450	2046

[a]N = the number of equations that were used to predict weights for each length interval.

Because of the broad geographical range for data sets included in this study, plus the range in population structures, we believe this equation will prove useful in evaluating condition of saugers. We hope the use of this *Ws* equation will aid in the management and preservation of saugers throughout the United States and Canada.

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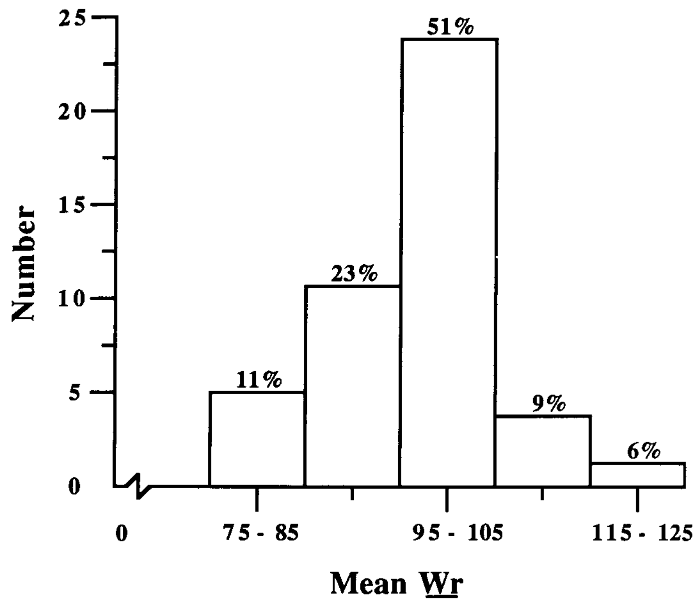

Figure 2. Distribution of mean relative weight (*Wr*) values for 47 sauger data sets. Percentage of data sets in each *Wr* group is indicated above each bar.

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Use of Helicopters for Surveys of Nesting Red-shouldered Hawks

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ABSTRACT — During spring 1985, we flew helicopter surveys in south central Missouri for raptors considered rare by the Missouri Department of Conservation. Survey results indicated helicopters to be particularly effective for locating nests of red-shouldered hawks (*Buteo lineatus*), determining clutch sizes, and obtaining positive identification of various raptor species. Helicopters are especially suitable for red-shouldered hawk surveys because (1) incubation is well-advanced before leaf-out, which allows rapid determination of nesting status; and (2) this species often nests in specific habitats, allowing concentration of flight time in areas potentially most productive. Nest abandonment did not appear to be a problem. Recommendations for surveys are presented.

Red-shouldered hawks (*Buteo lineatus*) have suffered substantial declines throughout much of their range in the eastern United States and Canada. Christmas Bird Count data indicated declines have ranged from 65% to 95% after 1950 in most eastern states (Brown 1964). Wallace 1969), Henny (1972), Kimmel and Fredrickson (1981), and others also have reported declines. Nesting red-shouldered hawks are particularly sparse in some farm-belt states; for instance, Bednarz (1979) estimated only 20 nests existed in Iowa. Population declines stem primarily from logging, construction of reservoirs, and development of agriculture in hardwood forests, particularly bottomland forests (Craighead and Craighead 1956, Henny 1972, Bednarz 1979). Many states now list this species as rare, threatened, or endangered.

Reliable and relatively inexpensive techniques for surveying raptor populations are needed, particularly those that are suitable for wildlife managers and biologists lacking specific training with raptors (Fuller and Mosher 1981). Ground surveys typically have been used to locate nests, but this approach is time-consuming (Kennard 1894, Craighead and Craighead 1956). Playing tape-recorded conspecific vocalizations along transects (Rosenfield et al. 1985) appears suitable for red-shouldered hawk surveys (M. R. Fuller, pers. commun., 1986), but our experience (Cook et al. 1986) indicated that determining the location of nests will still be difficult and time-consuming.

During spring 1985, we conducted helicopter surveys for breeding red-shouldered hawks and other rare raptors at the Ozark National Riverway in Missouri. This technique was particularly effective for locating nests and determining clutch sizes of red-shouldered hawks. We present a preliminary assessment of helicopter surveys for this species and identify several strategies to enhance efficiency in future work.

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STUDY AREA

The Ozark Riverway lies along the Current and Jacks Fork rivers in south central Missouri. Lands owned by the National Park Service form a narrow corridor 215 km in length along the two rivers. In general, topography is rolling, but narrow drainages create relatively rugged relief, particularly in northern portions. South from the confluence of the Current and Jacks Fork rivers, the flood plain broadens considerably, providing suitable habitat for red-shouldered hawks. The Ozark Riverway is within the oak-hickory (*Quercus* spp.-*Carya* spp.) ecoregion (Bailey 1980). These hardwoods are dominant on upland sites, but sycamore (*Platanus occidentalis*) is the primary overstory species on the river bottomlands. Old fields, agriculture lands, and hardwood forests form mosaics of vegetal communities in many portions of the study area.

METHODS

A Bell Jet Ranger was used for raptor surveys. Two observers rode in the back seat. Back doors were removed to improve visibility. An observer who was familiar with the riverway rode next to the pilot. This front seat observer helped navigate the aircraft, plotted locations of raptor observations, and searched for nests and flying raptors.

Surveys were conducted on April 8 and 9, using two different flight patterns. The flight pattern used the first day emphasized maximal coverage of the study area. We flew back and forth across the flood plain at 45° angles to the river. Where the flood plain was relatively narrow, we generally flew over the river looking laterally into the trees on each side of the aircraft. Flight speed was 42-58 kph; height above trees was 20 to 50 m. We flew a more intensive flight pattern the second day. The helicopter was flown in a series of parallel transects located approximately 75-100 m apart and perpendicular to the river. These transects crossed the entire flood plain including a small portion of adjacent uplands. Aircraft speed averaged 15-33 kph; height above the trees was generally 5-20 m. Slower speeds, lower altitudes, and the more intensive flight pattern allowed observers to look down for nests located in major forks in trees rather than observing laterally across the flood plain. When nests were located, eggs were counted while hovering over the nest, and the species identified from adults on the nest or flying in the immediate vicinity.

RESULTS AND DISCUSSION

Eleven nests of red-shouldered hawks were located along approximately 100 km of surveyed river bottomlands. Clutch counts were obtained on nine of eleven nests (incubating adults did not flush from two nests). Clutch size averaged 2.95 eggs per nest (range 2-4). The helicopter also flushed three Cooper's hawks (*Accipiter cooperi*), one osprey (*Pandion haliaetus*), and at least five broad-winged hawks (*Buteo platypterus*). All are listed as rare species in Missouri.

The intensive method used the second day was more productive compared to the faster method used the first day. We found only one nest the first day and ten nests the second day when using the more intensive method. We reflew approximately 40 km of the riverway on the second day and found four active nests and seven unused nests missed using the faster method.

Nest densities in contiguous, suitable habitat [i.e., level terrain, broad flood plains with wetlands, and mature forests (Stewart 1949, Bednarz 1979, Kimmel and Fredrickson 1981)] generally correspond to densities reported in other studies. Distances between nests in suitable habitat in our study varied between 0.3 and 2 km, corresponding to distances between nests reported by Stewart (1949) (average: 0.9 km) and Hahn (1927) (0.4-0.9 km), and maximum diameters of nesting ranges (0.6-2.6 km) reported by Craighead and Craighead (1956:258-263).

Nest abandonment did not appear to be a problem. Some incubating adults remained on the nest even after the helicopter had hovered several minutes near the treetops. Several hawks left the nest but remained nearby. Others seemed to be attracted to the nest apparently in response to the disturbance and persistently remained nearby during our observations.

Helicopter surveys are a suitable technique for locating and censusing nesting red-shouldered hawk populations based on these preliminary data. The technique is particularly suitable for this species because their incubation is generally well advanced before leaf-out on deciduous trees (Portnoy 1974). Other forest raptor species delay reproduction 1-1.5 months later than red-shouldered hawks (Janik and Mosher 1982), precluding reliable nest detection due to dense forest foliage. However, nests of red-shouldered hawks that breed late might be missed with helicopter surveys conducted just prior to leaf-out.

Habitat preference of nesting red-shouldered hawks allows search efforts to focus on specific habitats, thus minimizing survey costs. Nesting areas generally occur in mature forests near wetlands, often in level terrain (Bednarz 1979, Kimmel and Fredrickson 1981). These habitats can be delineated using topographic maps and aerial photographs. For species whose nests are scattered at low densities over large areas in a variety of habitats (e.g., Cooper's and broad-winged hawks), costs for intensive, complete helicopter surveys might be high relative to the amount of information gathered. Our costs using the intensive method were about $25/km of river (at $300/hour), but cost will vary with the width of flood plains and amount of suitable habitats within them. Most portions of the flood plain surveyed in this study averaged 0.3-0.4 km wide.

RECOMMENDATIONS

Several precautions are important for minimizing disturbance to raptors. Use of helicopters with quiet jet engines (compared to piston engines) and avoiding abrupt approaches reduced disturbance (White and Sherrod 1973). For red-shouldered hawks, flights must be scheduled just prior to leaf-out to maximize nest detection and minimize nest abandonment. In most areas, incubation should be in late stages just before leaf-out, when this species is less susceptible to nest abandonment (Portnoy 1974).

Hovering near the nest to count eggs or to identify species might be particularly disturbing to nesting hawks. We found this typically required 2-3 minutes per nest. Time spent hovering can be reduced by using binoculars to count eggs. Observers should be familiar with coloration of red-shouldered hawk eggs, and use this as an aid for identifying species-use of the nest. Observers will have to identify hawks based on dorsal features of the plumage, rather than ventral features. Familiarity with dorsal characteristics will reduce time hovering near nests or adult birds.

To maximize nest detection, we suggest intensive surveys conducted at slow speeds, facilitating intensive, vertical searching for nests. We believe fixed-winged aircrafts fly too high and fast for locating nests. The most suitable light conditions occur from mid-morning until mid-afternoon on sunny days. Stratifying areas based on habitat quality will save time. For example, we spent considerable time following narrow forest corridors which typically do not contain nests (Bednarz 1979).

Pilot and aircraft selection are critical for helicopter surveys (White and Sherrod 1973). Efficient helicopter flights to locate red-shouldered hawks' nests require flying near treetops at slow speeds. Such a flight pattern is difficult, particularly in gusty winds. Pilots should fully understand this requirement and have adequate experience. Because flying near treetops allows only minimal vertical distance for recovery, the aircraft must have sufficient power to compensate for thermals and wind shifts.

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Notes

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DISTRIBUTIONAL RECORDS OF THE GREAT PLAINS RAT SNAKE IN DINOSAUR NATIONAL MONUMENT — The great plains rat snake (corn snake), *Elaphe guttata emoryi*, was first recorded in Dinosaur National Monument (Uintah County, Utah) in 1982 (Bury, 1983, Herpetol. Rev. 14:123). The Bury record is the only published account of the species in the vicinity of Dinosaur National Monument. This isolated sighting represents the northernmost record west of the continental divide. It extends the potential range of the species by approximately 100 km from the nearest sighting in Utah and 160 km from the nearest sighting in Colorado (ibid.). Conversations with monument biologists did not indicate any other known sightings in the monument area.

On 7 June 1985 we captured a specimen 82 cm in length at the confluence of Jones and Ely creeks in Jones Canyon of the monument. On 5 June 1987 we captured another specimen, 64 cm in length, along Jones Creek 0.8 km north of Jones Hole Campground (both sightings in Uintah County Utah). The 1985 sighting appears to have been in nearly the same locale as the Bury record. The 1987 sighting is 2.4 km south of the 1985 sighting and the Bury record. Because we were in a national monument, both snakes were retained only long enough to identify, photograph (Denver Wildlife Research Center library photograph numbers 85001 and 87001), and release.

These additional sightings confirm that the Bury record is not an incidental sighting and a population of great plains rat snake exists in Jones Canyon of Dinosaur National Monument. — *Richard M. Engeman, Denver Wildlife Research Center, P.O. Box 25266, Denver, CO 80225-0266, and Angelika Engeman, DER Travel, 425 S. Cherry, Denver CO 80222.*

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FIRST RECORD OF NOMINOTYPICAL *INCISALIA POLIA* (LEPIDOPTERA, LYCAENIDAE) FOR NORTH DAKOTA — The hoary elfin (*Incisalia polia* Cook and Watson) has heretofore been known in North Dakota only from the Killdeer Mountains in Dunn County (Royer 1988, Butterflies of North Dakota, Minot State University, Minot, ND, p. 53). The population there is referable to the small, dark, western subspecies *I. p. obscura* Ferris and Fisher. It occupies virtually all of the south mountain at altitudes sufficient to sustain a carpet of bearberry (*Arctostaphylos uva-ursi*), the species' universal larval host. The brief two-week Dunn County flight occurs in early May, generally in synchrony with first appearance of blooms of the larval host plant, at which the adults also occasionally take nectar. The species is locally abundant, adults never straying more than a few dozen meters during the brief annual flight.

On 11 May 1989, Paul DeWaal-Malefyt discovered an extensive colony of the larger *I. p. polia* approximately 10 miles north of Towner, in McHenry County. The population was at peak emergence on 13 May, when I took a representative series of 41 examples (see Fig. 1). Whereas *I. p. obscura* occurs in open areas and exposed swales in the Killdeer Mountains, the McHenry County colony was situated in relatively dense aspen woodland. This is interesting in that the species is heliophilic. It was noted, however, that emergence preceded complete foliation of the aspens.

As earlier predicted (Royer, *op. cit.*, p. 53), whereas the Killdeer Mountain population bears close affinity to those in adjacent Rocky Mountain states, the McHenry County population more closely resembles those in forested Manitoba and Minnesota. The modern absence of intervening North Dakota habitat raises interesting questions regarding phylogeny and distribution of these two subspecies in relation to what may originally have been a more continuous distribution of *I. polia* across the northern plains. Further work in Manitoba, Saskatchewan, and northeastern North Dakota, where suitable habitat is still relatively widespread, may help to clarify these relationships. — *Ronald A. Royer, Division of Science, Minot State University, Minot, ND 58701.*

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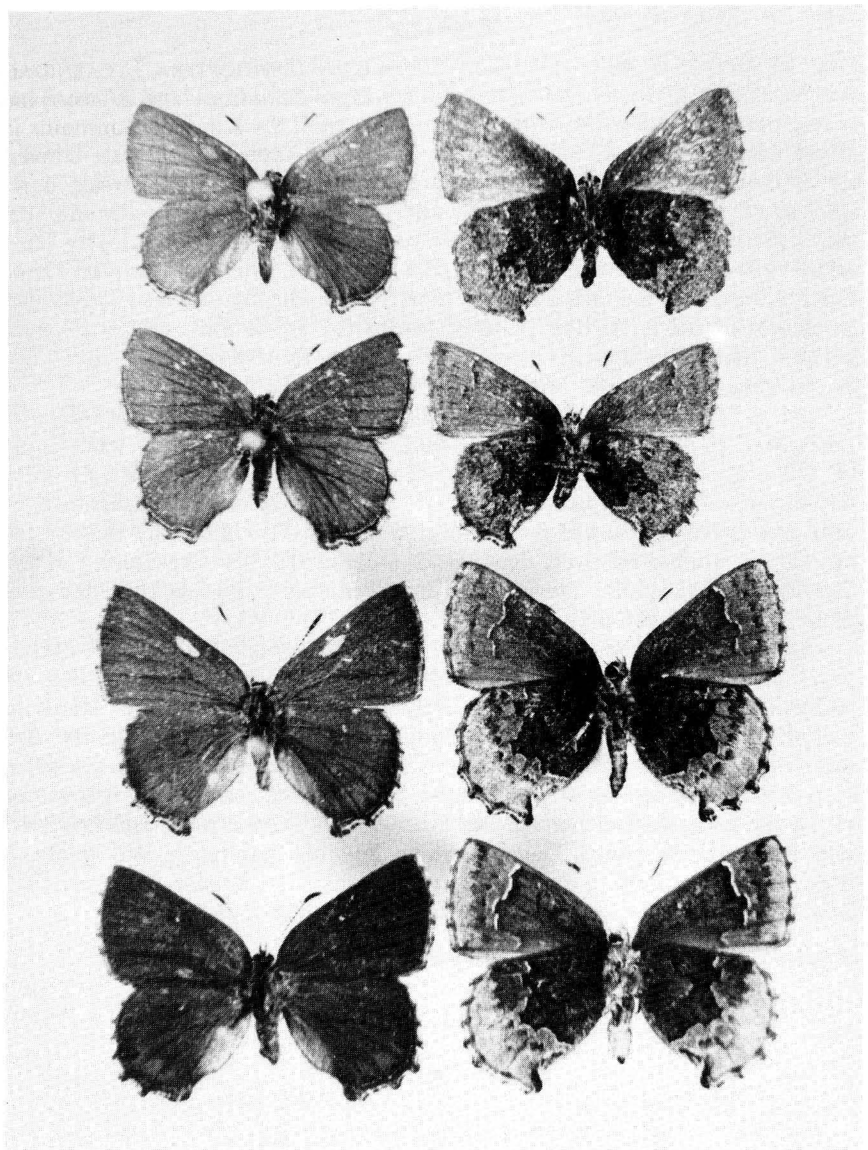

Figure 1. Eight North Dakota examples of *Incisalia polia* Cook and Watson, 1907. The four at top are the western, montane subspecies *I. p. obscura* Ferris and Fisher, 1973; all from the Killdeer Mountains, Dunn County. The four at bottom are nominotypical *polia* from McHenry County, among first examples of that taxon to be found in the state. Data are, from top to bottom, dorsal (left) and ventral (right): *I. p. obscura* males; *I. P. obscura* females; *I. p. polia* males; *I. p. polia* females. All were collected and prepared by the author.

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DISPLACEMENT OF WHITE-TAILED DEER BY FLOODING — Bottom lands of the lower Yellowstone River occasionally experience severe flooding as a result of ice break-up during February and March. The extent of mortality and displacement among white-tailed deer (*Odocoileus virginianus dacotensis*) attributable to flooding has not been documented but has been a matter of speculation among local residents, sportsmen, and wildlife managers.

Flooding occasionally occurs when low winter (December-January) temperatures result in formation of a continuous, thick layer of ice, followed by unseasonably warm temperatures during late winter causing rapid snow melt and increased river flow. Thus, the ice breaks up and accumulates at constrictions along the river channel, resulting in extensive flooding. The process is repeated downstream until the river channel is free of ice.

Flooding occurred during two years (1982 and 1986) of a seven-year study of white-tailed deer along the lower Yellowstone River (Dusek et al., 1989, Wildl. Monogr. No. 104). None of 141 deer radio-collared during the study died directly from these floodings. Death would seem likely if an individual were caught up in floodwaters and ice along the river channel. However, two adult females were permanently displaced from annual home ranges during 1986.

The two translocated females (Nos. 8472 and 8473) were marked as fawns on 16 March 1984 near the Elk Island Wildlife Management Area (WMA), located approximately 1.5 km north of Savage, MT. Home ranges of both females included the WMA and adjacent private lands. Their geographical activity centers (GAC's) were approximately 1 km apart. On 27 February 1986, the ice broke up and jammed near the WMA, and the surrounding area was flooded. A deer whose collar fit the description of that of one female (No. 8473) was sighted on a floe. I presume the other also was displaced via an ice floe, because both does were located 24 and 22 km downstream from their respective home ranges near Sidney, MT, on 4 March 1986. Periodic radio-tracking from fixed-wing aircraft indicated that neither doe returned to its original adult home range through November 1986, when both were taken by hunters. As 3-year-olds, both does successfully reared fawns to an age of 4 months in 1986; one (No. 8472) reared triplets, the other (No. 8473) reared a singleton.

Four other deer among the 16 radio-collared deer near the WMA at the time of ice break-up left their home ranges, presumably in response to flooding, but returned prior to 20 March. Two were located on uplands adjacent to the floodplain during the 4 March flight; the other two were not located during that flight.

These observations suggest that all documented movements during this late winter/early spring period resulted from an event of flooding. Emigration of females older than yearlings was rare along the lower Yellowstone; dispersal was documented for only two (both during May-June) of 72 radio-collared females older than 18 months. Temporary forays by deer older than yearlings outside normal home ranges occurred only from late May through July and to a lesser extent during the autumn hunting season during years of no flooding (Dusek et al., ibid.).

An exodus from the area near the WMA by deer in response to flooding also may partially explain a discrepancy between population estimates from a helicopter survey on 24 February 1986 (434 deer) and three subsequent fixed-wing surveys ($\bar{x} = 332$) from mid-March through mid-April. Mortality was not considered an underlying factor because none of the radioed adults died during the period, and there was little difference betwen the proportion of fawns in the population in December 1985 (31%) and that in March-April 1986 (29%).

Flooding may displace deer temporarily or permanently without negatively influencing the population. It is only speculative to suggest displacement increased vulnerability of two permanently displaced does to hunting. However, probability of survival during autumn, calculated from the technique of Heisey and Fuller (1985, J. Wildl. Manage. 49:668-674), was 0.74 for 3-year-old does and 0.70 for all adult does for all years. Reported mortality among translocated wild deer often exceeds 50% but appears highest where potential for human-related hazards, such as highways, predation by dogs, or hunting, is high (McCall et al., 1988, Wildl. Soc. Bull. 16:381-384).

The editorial comments of R. J. Mackie, J. P. Weigand, and A. K. Wood are gratefully acknowledged — *Gary L. Dusek, Montana Department of Fish, Wildlife and Parks, P.O. Box 67, Kalispell, MT 59903.*

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Book Reviews

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COMMON RANGE FORBS OF NEBRASKA

Nebraska Range and Pasture Forbs and Shrubs. James Stubbendieck, James T. Nichols, and Charles H. Butterfield. 1989. Nebraska Cooperative Extension E.C. 89-118. 153 pages. Paper.

This guide to the identification of 96 forbs (broadleaved, herbaceous plants), 15 shrubs, and 4 succulent species (cacti) "selected as the most important on rangeland and pasture in Nebraska," is published as a companion to *Nebraska Range and Pasture Grasses*, which covers 64 grasses and 6 grasslike plants. This book also provides information for these 115 species on values as food for livestock and wildlife, potential for intoxication, responses to grazing or browsing (increasers, decreasers, invaders), ecological and geographical distributions in Nebraska, and historical uses by American Indians and settlers.

Central to the success of this publication are the excellent illustrations by Bellamy Parks Jansen. The well-written introductory section is generously illustrated and explains terms used in plant descriptions better than many botany textbooks. Each species is artistically illustrated with a figure occupying one-third to one-half of the page. Some figures include reduced insets showing overall growth form or enlargements of important features such as flowers or fruits; the latter are needed for groups like the milkvetches (*Astragalus* spp.), where specific differences are otherwise difficult to show.

Although the illustrations are accurately done, there are a few errors in the labeling of figures in the section on plant morphology; a composite head (inflorescence of the Asteraceae) is incorrectly described as a "compound flower," a longitudinal view of the same is labeled a cross-section, and a silicle (the flattened, many-seeded capsule of some mustards) is labeled a 1-seeded silique. These few errors, along with some redundancies and ambiguities in plant descriptions, will largely go unnoticed since readers will rely mainly on the illustrations to identify plants in the field. The only hazard here is that the book is not all-inclusive and in some cases related species can be mistaken for those in the book. The illustration of lambsquarters (*Chenopodium album*), for example, could pass for several other chenopods despite its accuracy. It would be helpful in such instances to note that the plant at hand may not be the one pictured in the book, and that a plant manual, e.g., the *Flora of the Great Plains* (1986. Great Plains Flora Association. University Press of Kansas), may need to be consulted.

Overall, this is a fine reference book. Many readers will find the ethnobotanical information interesting. Natural resource managers will appreciate the information on plant forage values, potentials for toxicity, and populational responses to grazing pressure. Most importantly, this book has value for educating people about the plants in their environment. Although I have not seen the companion publication on graminoid plants, these two books together should provide a handy guide for learning (or teaching) the important plants of pastures and rangelands in Nebraska and neighboring states.—*Gary E. Larson, South Dakota State University, Brookings, SD 57007.*

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NORTH DAKOTA'S WILDFLOWERS

Wildflowers of North Dakota. Paul B. Kannowski. 1989. University of North Dakota Press, Grand Forks, ND. 124 pages. $12.95 (paper).

We knew there were wildflowers somewhere in North Dakota. After all, the wild prairie rose has been endowed with the official title of "State Flower" long before we became acquainted with the state. But little did we know North Dakota could boast of as much natural beauty in wildflowers as is portrayed in Paul Kannowski's *Wildflowers of North Dakota*. This recently published centennial book will be a treasured addition to the library of anyone interested in wildflower species of the Upper Great Plains.

Kannowski offers a heartwarming, personal narrative about how and why he put the book together. In here we became acutely aware of his love for flowers and his desire to share his knowledge and his accumulated library of slides with others.

He provides adequate instruction on how to find wildflowers, then gives an interesting explanation for the Latin names used for the flowers and why they're categorized the way they are. The keys to identifying plant structures and leaf types and arrangements (page 5) are an important guide for using the book.

Portraits of the flowers are arranged in a color sequence beginning with white and following through with yellows, reds, pinks, blues and blue-purples. Each flower is accompanied by a helpful North Dakota map marked with the distribution range of that flower. In addition, below each map is a bar showing the blossoming season. Photographs are brilliant and high quality.

Unfortunately, *Wildflowers of North Dakota* has a major flaw. Kannowski's descriptions of plants are utterly incomprehensible to a beginner. One of the mind-boggling descriptions we find is for the beautiful little bluebell (page 96): "Stem erect, glabrous, 3 to 4 dm tall. Leaves alternate; basal leaves petiolate, ovate to lanceolate, up to 14 cm long and 4 cm wide; stem leaves sessile, lanceolate. Inflorescence a cyme from axils of upper leaves, flowers drooping." And so on. In these first two phrases, we count nine words we must look up. The glossary in the back of the book may be a good idea but doesn't ease our confusion. "Glabrous" isn't in there. "Petiolate" and "cyme" require us to refer to another definition in the glossary to make any sense out of them.

For most of us, this scientific talk is nonsense. Okay, that's why we have pictures. Kannowski's pictures make the book work as a wildflower guide even if the descriptions don't. The photos are vivid and colorful; most were taken close enough to the flower to provide good detail.

In all sincerity, the book is a praiseworthy attempt to provide a field guide for North Dakota's wildflower lovers and potential lovers. For us, it was a revelation to find that North Dakota has seven different species of violets, as well as unusually beautiful wildflowers named torch flower, pasqueflower and spotted touch-me-not. For those who love the unusual, you will find the Mariposa lily and the scarlet gaura. And it's great fun to read the frivolous names: pussy-toes, lady's tresses, buffalo bur, beggar ticks and hog peanut. If those don't inspire you to a nature walk, nothing will.

Wildflowers of North Dakota will educate many about the hidden beauties in our state. While it illustrates only 159 species out of approximately 1,250 that occur in the state, it is sufficient as a starter book for most of us amateurs or pure beginners, both for whom the book is intended.

We hope it will make all North Dakotans interested in wildflowers more keenly aware of what our state has to offer.—*Jane Sinner and Mary Jo Sinner, Bismarck, ND 58501.*

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A POTPOURRI OF PREDATORS

Predators and Predation: The Struggle for Life in the Animal World. Pierre Pfeffer, ed. 1989 English translation (1985 French edition). Facts on File, New York. 419 pages. $50.00 (cloth).

We often think of predators as meat-eating animals that can be recognized by their teeth, claws, beaks, or talons. This volume, which details the predatory habits of a diverse array of species from single-celled organisms to whales, intends to dispel this simplistic view.

The book certainly cannot be faulted for being too narrow in scope. Among the vertebrate classes it presents accounts of 89 species of mammals, 105 birds, 76 reptiles, 11 amphibians, 59 fish, 7 sharks and rays, and a lamprey. Among the invertebrates are 63 insects, 24 crustaceans, 8 gastropods, 7 cephalopods, 7 arachnids, and a smattering of echinoderms, cnidarians (jellyfish, anemones), centipedes, annelids, nematodes, rotifers, sponges, planaria, and protozoans, as well as a few other obscure taxa. Each account begins with some introductory information describing the species and its geographic range, then details the species' diet and some of its predatory tactics, and finally discusses its predators, competitors, and other threats to its existence.

The main problem with the book is finding a particular species. Species accounts are arranged alphabetically, mostly by common name, resulting in obvious problems when there are multiple names for the same species or multiple species with same name. The first species I tried to find was the wolf. It was not listed under W, nor G (gray), nor T (timber). In fact, I could not find it at all until examining the book page by page, whereupon I stumbled across it in the E's (Eurasian wolf). This is the same species of wolf that inhabits North America, but because the book is written and edited by French scientists (and originally published in French), it is heavily biased toward European species and European common names. There are 17 species, including bittern, crayfish and mink, found in the E's under Eurasian or European, but only 2 (the ovenbird and raccoon) whose common names are cataloged under North America. Another problem encountered with common name usage is exemplified by the account of the drill; I looked up this species expecting a West African baboon (similar to the mandrill), but instead found a depiction of a marine snail (which could just as well have been listed as a dog whelk, dog winkle, or horse whelk).

To compound this difficulty of common name arrangement, many species are discussed within the account of another, related, species. All bears except the polar bear, for example, are profiled within the account of the brown bear. Walleyed pike, actually a kind of perch, is mentioned under the account of the northern pike, a true pike. Because there is no index to the species covered in the book, it is frustrating to the point of annoyance to locate any particular species.

The book also has several other disconcerting features. Although a few specific studies are mentioned (giving author and date), there is no literature cited. Even the authors of the various accounts (and there are over 70 authors) are kept a mystery — only their initials are given. Thus, to use the book as a reference, you must simply trust the information given. The book would be of dubious value as a starting point for further investigation.

I also found it disturbing that the book included no pictures (besides the nice one on the dust cover of a brown bear eating a salmon). It is thus sometimes difficult to visualize many of the strange creatures and bizarre predatory habits discussed. Pictures and range maps certainly would have made the book more appealing to thumb through.

On the positive side, the accounts of those species for which I was familiar were generally accurate. Also, there is a sizable quantity of information from which one could pick up some interesting trivia, including the following: Pangolins have keratinized projections in their stomach instead of teeth. Fishermen in China use trained otters to drive fish into their nets, and Arabian sheiks used tame cheetahs as coursing animals. Snapping turtles use their tongue to bait prey. Sea cucumbers can expel their internal organs when chased by a predator. Sand wasps will paralyze but not kill their prey, enabling it to remain fresh for their unhatched larvae. The banded krait, a southeast Asian snake related to cobras, curls into a figure eight, covers it eyes, and becomes rigid, immobile, and hence defenseless when exposed to direct sunlight. A poisonous cone shell (a tropical sea snail) has caused 27 documented human mortalities, but there is considerable distortion (among some truths) in the stories of human attacks by piranhas and pythons. My favorite anecdote regards the Nile crocodile that was found with 50 dog tags in its stomach; considering the small number of dogs that are tagged in that part of the world, one wonders how many dogs these 50 tags represented.

The book also has a very good index of prey. If you wanted to know what animals prey on sponges, jellyfish, or coral, for example, there is a listing of predators and, fortunately, page numbers where they are discussed. I found myself using this index of prey to find some of the predators that I otherwise could not locate.

Overall, I think the authors of the individual accounts did a thorough job, and the concept for this book was a good one. However, the organization of the book severely detracts from its usefulness. If it could be cut apart and rearranged (by taxa), and had pictures, figures, maps, an index and bibliography added, it could be made into a pretty decent reference.—*David L. Garshelis, Forest Wildlife Populations and Research Group, Department of Natural Resources, Grand Rapids, MN 55744.*

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1. Manuscripts on any aspect of the biology of the North American Great Plains and the organisms living in this region will be considered for publication. Studies on grassland habitats in areas outside this region will also be considered.
2. Manuscripts must be based upon information that has not been published elsewhere and must not have been simultaneously submitted to any other journal.
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The Prairie Naturalist is devoted to research on the North American grasslands and their biota. Manuscripts containing original material will be accepted from individuals without regard to membership in the North Dakota Natural Science Society and should be sent directly to the Editor. Allow about six weeks for manuscript review.

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Article in Book: Lack, D. 1964. Population dynamics. Pp. 659-661 *in* A new dictionary of birds (A. L. Thompson, ed.). McGraw-Hill Book Co., New York.

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THE COVER AND ITS ARTIST

Mule deer are very common throughout the western half of North America, and are so named for their large ears. They forage in a variety of habitats, including cornfields.

This pen-and-ink drawing was done by Tina Simeon, a free-lance artist. The native animal life is a favorite subject matter for this self-taught western Nebraska artist.