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Movements of Adult Striped Bass Tracked in Wilson Reservoir, Kansas

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ABSTRACT — Fifteen striped bass, *Morone saxatilis* (Walbaum), weighing between 2.03 and 4.34 kg, were implanted with ultrasonic transmitters and tracked in Wilson Reservoir, Kansas, from April 1980 to July 1981. During the wintering season (November-March), the fish were located in the upper portion of the reservoir and the lower portions of the incoming river. In the spawning season (April-June), some of the striped bass seemed to concentrate near the dam and, late in April, migrated upstream into the upper reaches of the river. Late in that season the fish returned to the area of the dam in the lower reservoir. The striped bass remained in the lower reservoir throughout the feeding season (July-October). Five biological centers of activity were identified and have been characterized by various combinations of sharp drop-offs, submerged trees, and close proximity to the old river channel. Average rates of movement were highest during the spawning season, slowed until mid-feeding season, then increased gradually, reaching moderately high rates in the wintering season.

In recent years a number of investigations have been conducted on the movements and distribution of striped bass, *Morone saxatilis* (Walbaum), in reservoirs. Striped bass were observed in the deep-water pool of Lake Texoma, Oklahoma-Texas, during summer and early fall (Summers 1982). Studies in Keystone Reservoir, Oklahoma (Summerfelt and Mosier 1976), and Lake Powell, Utah-Arizona (Gustaveson et al. 1984), included the identification of probable spawning sites. Seasonal patterns of movement were reported for striped bass in J. Percy Priest Reservoir, Tennessee (Stooksbury 1977), Keystone Reservoir, Oklahoma (Combs and Peltz 1982), and Watts Bar Reservoir, Tennessee (Cheek et al. 1985).

Researchers have reported that high water temperatures and low concentrations of dissolved oxygen influence the selection of summer habitat by striped bass in Cherokee Reservoir, Tennessee (Schaich and Coutant 1980, Waddle et al. 1980), Lake Texoma, Oklahoma-Texas (Matthews et al. 1985), Lake Jordan and Miller's Ferry Reservoir, Alabama (Moss 1985), and Watts Bar Reservoir (Cheek et al. 1985).

The Kansas Department of Wildlife and Parks initially stocked striped bass in Wilson Reservoir in 1965; subsequent releases have been made at eight other Kansas reservoirs. Although not all of these introductions were successful, important striped bass fisheries have developed at Wilson, Cheney, and Glen Elder reservoirs.

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Because there is no published information on the seasonal movements of this species in Kansas, a study was conducted to monitor adult striped bass in Wilson Reservoir. In addition to potentially improving angler harvest, this information could be used to locate sexually mature fish. The popularity of striped bass, and more recently, white bass (*Morone chrysops*) x striped bass hybrids, has created a need for a reliable source of brood fish to meet stocking demands. The ability to locate sexually mature fish also will enable the manager to evaluate growth and population structure. The objectives of this study were to examine (1) the seasonal distribution of striped bass in Wilson reservoir, (2) the habitat utilized by striped bass, and (3) the location of prespawning striped bass.

STUDY AREA

Wilson Reservoir is a 3600-ha flood control and recreational impoundment located on the Saline River near the center of Kansas. The dam, a rolled earthfill embankment, was completed in 1964, and the reservoir was filled to multipurpose (conservation) pool of 462 m mean sea level in March of 1973. The reservoir has a length of about 25 km, a maximum depth of 24 m, and about 160 km of shoreline. The storage capacity at multipurpose pool is 306 million m^3.

The entire water mass mixes throughout the summer; there is no permanent stratification, and dissolved oxygen has always been detected throughout the water column. Specific conductance has been increasing since impoundment and was near 4000 μmhos in 1984. Because the impounded Saline River had etched its way through sandstone and limestone formations, Wilson Reservoir has abundant structural features and sandy areas, in addition to mudflats.

METHODS

Fifteen adult striped bass were implanted with ultrasonic transmitters and tracked from April 1980 to July 1981 (Table 1). Ten were caught in gill nets near the dam in April 1980 (Fig. 1) and were released in Brewer's Cove following surgery. Another was caught in the area northwest of Minooka Park by an angler in June 1980 and, after being implanted, was released in the marina at Wilson State Park. Four striped bass were gill-netted in the oxbow of the river in February 1981 and were released in the oxbow.

The striped bass implanted with transmitters during April and June of 1980 were anesthetized in a solution of 25 mg quinaldine per liter of water. Because of cold water temperatures, the concentration was reduced to 12.5 mg per liter for the implantations in February. Scales were removed from a 2-cm by 4-cm area slightly anterior to the anus and a 3-cm incision was made. After the transmitter was inserted, the body wall was stitched closed. The fish were immediately returned to the water and observed while they recovered from the anesthesia. The ultrasonic equipment was developed by Don Brumbaugh (Sonotronics of Tucson, AZ). The transmitters were 65 mm by 16 mm, weighed 19.5 gm in air, 7.5 gm in water, and had a volume of 12 ml. Each had a unique pulse rate.

Table 1. Information from striped bass implanted with ultrasonic transmitters and tracked in Wilson Reservoir, Kansas, 1980-1981.

Fish Number	Date released	Length (cm)	Weight[a] (kg)	Period tracked (days)	Number of days located
514	22 Apr. '80	69.4	3.86	258	10
600	22 Apr. '80	66.7	3.43	—	—
663	22 Apr. '80	67.1	3.49	70	8
799	16 Apr. '80	63.5	2.97	—	—
875	22 Apr. '80	72.2	4.34	445	28
942	22 Apr. '80	63.8	3.01	4	1
1043	22 Apr. '80	59.3	2.42	3	1
1107	22 Apr. '80	55.9	2.03	33	1
1196	22 Apr. '80	55.9	2.03	328	22
1388	16 Apr. '80	67.8	3.60	334	31
600A	1 June '80	69.6	3.90	—	—
600B	21 Feb. '81	68	3.7	22	2
663A	21 Feb. '81	73	4.5	76	3
1293	21 Feb. '81	65	3.2	22	3
1468	21 Feb. '81	65	3.2	69	3

[a]Calculated from length-weight regression formula for Wilson Reservoir striped bass (McCloskey 1980)

Searching frequently was initiated where a fish was last located. A grid-shaped search pattern often was used, the grid lines being approximately 65 m apart. At other times, it seemed prudent to follow only the old river channel or the shoreline. During the periods of ice cover, the hydrophone was lowered through holes in the ice.

When a fish was located, a Lowrance Fish Lo-K-Tor or a Lowrance LRG-1510B Trueline Recorder was used to measure depth of the water. When possible, the boat was positioned over the fish and the position of the fish in the water column was ascertained.

The locations of fish were determined by triangulation. Two adjacent angles were measured with a marine sextant and locations of the fish were plotted on a map of Wilson Reservoir (12.65 cm = 1 km) using a three-armed protractor. The clustering of numerous locations in certain areas revealed "biological centers of activity." These were defined by Ables (1969) as clumping resulting from unequal intensity of habitat use. The geographic centers ("centers of activity") of the biological centers of activity were computed using a method devised by Hayne (1949).

Rate of movement was estimated by measuring the straight line distance between two successive sitings and dividing by the time interval. Most intervals

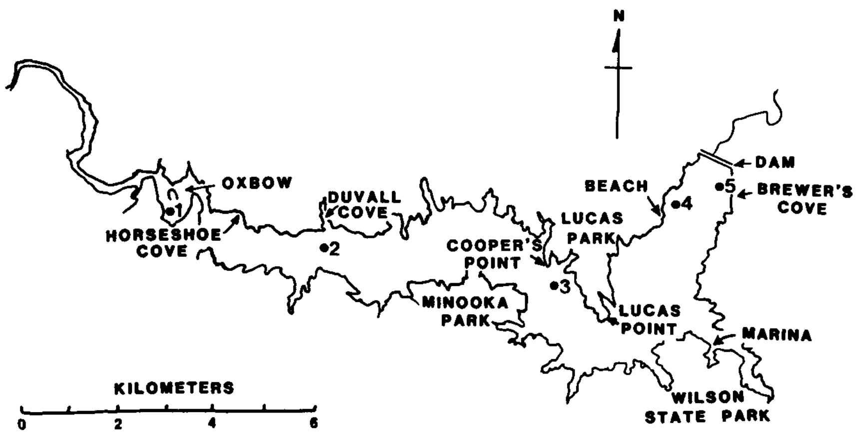

Figure 1. Map of Wilson Reservoir, Kansas, showing five centers of activity of striped bass, 1980-1981.

were less than one hour and none used in the calculation of rate of movement was longer than six hours. Because the fish seldom, if ever, traveled in a straight line, any calculation of the rate of movement is an underestimate.

Twice each month, temperature profiles were compiled to detect possible stratification, whereas dissolved oxygen concentrations were checked six times during this study. Hourly barometric pressures were obtained from the Russell Flying Service of the U.S. Civil Aeronautics and Space Administration. This facility is located about 16 km southwest of the oxbow.

RESULTS

Individual fish were located on 113 days, but only five fish were found more than three days. Fish #1388 was located most often (31 days) and fish #875 was monitored for the longest period (445 days).

Distribution and Movements

When Nichols and Miller (1967) described the movements of striped bass in the Potomac River, they divided the year into three seasons: the spawning season (April to June), the feeding season (July to October), and the wintering season (November to March). These seasons and the corresponding patterns of movement reported by Nichols and Miller (1967) seem to fit the patterns of movement of striped bass in Wilson Reservoir. The five fish located during the feeding season were in the lower portion of the reservoir, which extends from the dam to Minooka Park. With one exception, the seven fish, located during the wintering season were in the upper portion of the reservoir, which is that portion between Minooka Park and the oxbow. The fish ranged throughout the reservoir during the spawning season.

The average depths of water occupied by striped bass during each season were compared using Kramer's extension of Duncan's multiple range test. There was a significant difference ($P < 0.01$) between the feeding season and the other seasons. The fish occurred in water with a mean depth of 12.5 m during the feeding season and 7.2 m during the wintering season. The mean depth of 5.3 m calculated for the spawning season may be misleading because the striped bass were located throughout the reservoir at this time at depths of 0.9 to 18.3 m.

Early in the 1980 spawning season, two striped bass (#1043 and #1388) swam over 19 km from Brewer's Cove to the oxbow within three days. Striped bass are not known to spawn in Wilson Reservoir, but eight of the ten fish implanted with transmitters during April, 1980, were located in the river during the spawning season. Five of them moved at least 800 m upstream from the oxbow and fish #1043 was located 6.8 km upstream from the oxbow. After leaving the oxbow the striped bass moved back to the vicinity of the dam over a period of a few weeks.

During the 1980 feeding season striped bass remained in the lower portion of the reservoir. They seldom were detected near the surface or the bottom, but were located near a mean depth in the water column of 7.5 m. Linear regression analysis revealed no relationship ($P > 0.05$) between barometric pressure and the position of the fish in the water column.

Early in the 1980-1981 wintering season, fish #514 entered the upper reservoir and was tracked near Duvall Cove until the position of the transmitter became stationary in January. Striped bass #1196 was located in the upper reservoir near Horseshoe Cove in February. Also, during these months, fishermen were catching striped bass in the oxbow.

During February, four additional striped bass (#600B, #633A, #1293, and #1468) were gill-netted in the oxbow, implanted with transmitters, and released. In mid-March, these four fish were located in the southwest corner of the oxbow along with fish #1196 and #1388. A few days later, each of the four was again located in the oxbow and tracked while they left the oxbow and entered the upper reservoir. Three days later, another fish (#875) was located in the lower reservoir.

Although fish were not located during April (the first month of the 1981 spawning season), one of the four fish (#1468) implanted at the oxbow was found near the dam on 1 May. Seven days later, another of the four fish (#663A) was located in the river and tracked as it swam downstream to the oxbow. Fish #875 was found again in the lower reservoir, near the swimming beach, during June and July.

Biological Centers of Activity

The striped bass in Wilson Reservoir were predominantly located near five centers of activity (Fig. 1). These were located in the oxbow (1), south of Duvall Cove (2), between Cooper's Point and Lucas Point (3), near Lucas Park swimming beach (4), and near the east end of the dam (5). The biological center of activity (BCA) between Cooper's Point and Lucas Point has a limestone floor that slopes gradually to a depth of 15.5 m at the old river channel. The other four BCAs are characterized by various combinations of sharp drop-offs, submerged trees, and close proximity to the old river channel.

Three striped bass (#663, #875, and #1388) utilized BCA-5 near the east end of the dam early in the feeding season. One of these fish (#875) later moved across the reservoir to BCA-4 at the Lucas Park swimming beach. Near the end of the season two striped bass (#1196 and #1388) shifted BCAs as they moved into BCA-3 between Cooper's Point and Lucas Point. Early in the wintering season fish #514 moved into BCA-2 near Duvall Cove. Eight different striped bass were located in the oxbow (BCA-1) at various times during the wintering and spawning seasons.

Rates of Movement

When the average rates of movement were calculated for each season (Table 2) and compared using a 2-way analysis of variance, there was a significant difference among seasons ($P < 0.01$) but not between day and night ($P > 0.05$). Comparison of the seasons using Kramer's extension of Duncan's multiple range test indicated a significant difference between each season ($P < 0.01$), but when day and night were tested separately the results were different. For day, the rate of movement was significantly higher ($P < 0.01$) during the spawning season but the difference between the feeding and wintering seasons was not significant ($P > 0.05$). For night, the difference between the feeding and wintering seasons approached significance ($0.10 > P > 0.05$) and may have been significant had the sample size been larger. Although the small sample size for the spawning season may have accounted, in part, for the fast rate of movement, it is probable that the striped bass would be most active at this time.

Table 2. Average rates of movement of striped bass in Wilson Reservoir, Kansas, 1980-1981 (n = number of observations).

	Day (0600-2200)	Night (2200-0600)
Feeding Season (July-Oct.)	0.542 km/hr S.E. = 0.106 n = 48	0.353 km/hr S.E. = 0.112 n = 27
Wintering Season (Nov.-Mar.)	0.733 km/hr S.E. = 0.153 n = 35	0.669 km/hr S.E. = 0.136 n = 24
Spawning Season (Apr.-June)	1.564 km/hr S.E. = 0.291 n = 9	

The striped bass did not maintain a steady rate of movement; they would slow occasionally and then resume swimming at higher speeds. The following rates for fish #1196 (calculated for seven consecutive periods of approximately fifteen minutes duration) exemplify this type of movement: 363 m/hr, 1885 m/hr, 754 m/hr, 1055 m/hr, 188 m/hr, 754 m/hr, and 1005 m/hr.

Data were insufficient to average the rates of movement for every month, but the fish appeared to be most active during the spawning season and least active near the middle of the feeding season. Rates of movement during the wintering season seemed moderately high. There were times when the striped bass did not seem to move, especially during summer and early fall; they could be located in the same area day after day. However, two fish were observed leaving these areas at night. Fish #875, for example, was tracked overnight as it swam more than 2.8 km before returning to the same BCA by morning.

Only for the feeding season could the average rate of movement be calculated for every hour of the day (Fig. 2). The fish seemed to be highly active from early morning until mid-day, and again during late afternoon, especially early and late in the season.

Temperature and Oxygen

The waters of Wilson Reservoir were well-mixed throughout the feeding season and no pockets of cooler water were detected. Water temperatures for virtually the entire water mass exceeded 20°C from mid-June through September. From 16 July to 21 August, the temperatures were above 25°C with less than one degree difference from surface to bottom on those days temperatures were measured. The highest temperature recorded was 27.1°C. Temperature profiles never displayed stratification in the classical sense and the dissolved oxygen concentration was never below 6 ppm when tested.

DISCUSSION

Seasonal Movements

In Wilson Reservoir, utilization of the deep-water areas of the lower reservoir during the feeding season is consistent with the findings of Stooksbury (1977), Schaich and Coutant (1980), Waddle et al. (1980), Combs and Peltz (1982), Summers (1982), and Matthews et al. (1985). Except for those impoundments where water temperatures become excessive in the lower reservoir in midsummer, this pattern of migration to the deeper, lower reservoir following the "spawning run" upstream seems common.

Striped bass in Cherokee Reservoir, Tennessee, were reported to seek cool, oxygenated waters when the summer pattern of high temperature and low dissolved oxygen became too severe (Schaich and Coutant 1980, Waddle et al. 1980). These refuges had temperatures less than 25°C and dissolved oxygen contrations greater than 5 ppm. The striped bass in Lake Texoma (Matthews et al. 1985) were distributed throughout the water column during May and June but later moved upward to avoid anoxic conditions, and were eventually concentrated immediately above the chemocline at depths between 10 and 12 m where

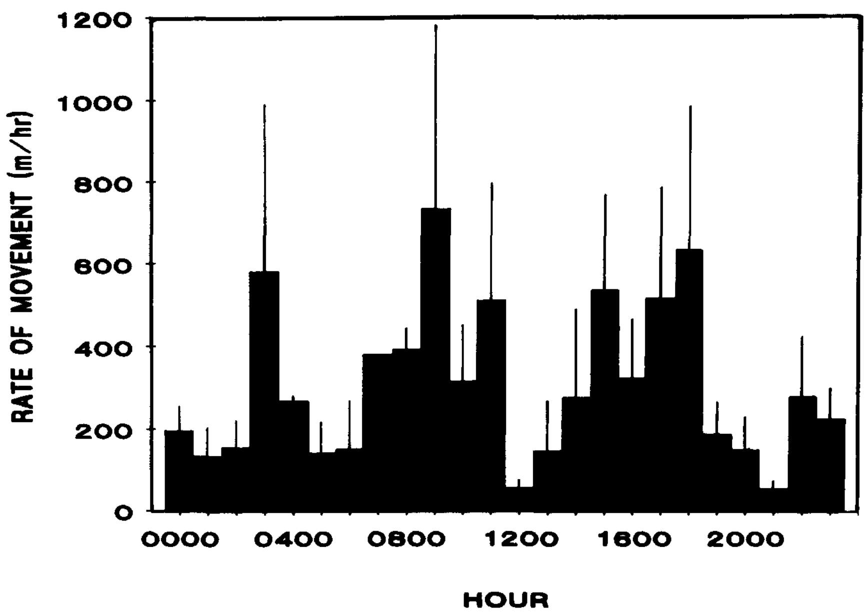

Figure 2. Average hourly rate of movement during the feeding season, July-October, 1980, in Wilson Reservoir, Kansas. Vertical lines represent one standard error above mean.

temperatures were no more than one degree lower than surface temperatures. Stooksbury (1977) reported that from October through April striped bass in J. Percy Priest Reservoir, Tennessee, usually spent periods of inactivity at depths of 6.1-10.7 m, but in the summer, depth range of these fish was reduced by oxygen depletion resulting from stratification.

Coutant (1985) suggested that temperatures exceeding 25°C limit usable habitat, but there was no evidence of this at Wilson Reservoir. The reservoir remained well mixed throughout the feeding season with temperatures exceeding 25°C for approximately two months, reaching the highest measured temperature of 27.1°C. These temperatures were probably not so high as to be restrictive, and no thermal refuges are known to exist in Wilson Reservoir. Despite the absence of restrictive conditions, the striped bass had a tendency to suspend at a mean depth of 7.5 m in waters averaging 12.5 m deep. Thus, when movement is not restricted by water temperature and oxygen concentrations, it may be common behavior for striped bass to suspend in the water column during periods of relative inactivity.

Schaich and Coutant (1980) reported that striped bass in Cherokee Reservoir left refuges in October when temperatures ranged from 20 to 24°C and appeared to disperse in the open reservoir. As water temperatures dropped below 24°C in Wilson Reservoir late in the feeding season, two striped bass moved from the deep water areas of the lower reservoir to the area between Minooka Park and Cooper's Point. This cooling of the water may signal the time that they begin returning to overwintering areas.

Data collected during the wintering season and subsequent spawning season are insufficient to allow for definite conclusions. Because of unstable ice on the reservoir in January and February, only the oxbow and river could be searched. Six of the seven fish located in Wilson Reservoir during the wintering season were in the oxbow, but because there were times when no fish were located here, some of these striped bass may have migrated into other parts of the reservoir. Other striped bass may have overwintered in the main body of the reservoir as did those bass in Watts Bar Reservoir (Cheek et al. 1985).

The ten striped bass initially implanted were captured near the dam in mid-April 1980 and one of these returned to the same area the following March. One of the four implanted during February was located near the dam at the beginning of May. This would agree with the findings of Gustaveson et al. (1984), who studied the spawning of striped bass in Lake Powell, Utah, from 1979 to 1983 and observed aggregations of prespawning striped bass near Glen Canyon Dam from March through early May. Most of the fish left this staging area of Lake Powell simultaneously when the surface water temperature reached 16-19°C. In Wilson Reservoir, many of the striped bass overwintered in the oxbow and upper reservoir, but appeared to return to the lower reservoir to stage. Although Lake Powell and Wilson Reservoir fish stage near the dam, a different pattern was reported by Combs and Peltz (1982) in Keystone Reservoir. During the fall, striped bass migrated to the staging areas in the upper reaches of the reservoir and remained there until the spring spawning run.

The pattern of migration at Wilson Reservoir raises one interesting point: why would the fish return to the dam before moving upstream when they were already in the vicinity of the river? The fish located in the oxbow during the wintering season might represent only a portion of the population. Perhaps a subpopulation of striped bass overwinter in the lower reservoir and only these stage near the dam. However, information from netting and angler harvest has suggested a pattern where most striped bass in the reservoir gradually congregate near the dam early in the spawning season and then suddenly disperse.

Biological Centers of Activity

Stooksbury (1977) observed that striped bass in J. Percy Priest Reservoir, Tennessee, used selected areas and that these areas were used by many fish at different times. These were the areas of greatest activity and Stooksbury termed them home ranges. They occurred in the larger and more open parts of the reservoir and usually near meanders of the old river channel. They usually contained mud flats, submerged islands, cover, and one or more creek channels or tributaries. Combs and Peltz (1982), reported that the striped bass in Keystone Reservoir, Oklahoma, concentrated along inundated river and creek channels and described the areas of concentration as characterized by steep drop-offs, submerged islands, heavy rock rip-rap, and submerged trees. Cheek et al. (1985) believed that when high temperature and low oxygen were not limiting, striped bas in Watts Bar Reservoir, Tennessee, seemed to prefer upper edges of the old river channel when in the main reservoir and structured shorelines when in the riverine portions, orienting toward features that created eddies. During summer, striped bas were observed by Schaich and Coutant (1980) and Waddle et al. (1980) in Cherokee Reservoir, Tennessee, to concentrate in refuges, i.e., areas where the supply of oxygen was higher and the water temperature lower than elsewhere in the reservoir.

The biological centers of activity in Wilson Reservoir are quite similar to the regions preferred by striped bass as reported by Stooksbury (1977), Combs and Peltz (1982), and Cheek et al. (1985). In Wilson Reservoir, selection of habitat during the summer appears to be affected more by the physical attributes of an area than by water temperatures and oxygen concentrations, and it seems that striped bass in general prefer heavily-structured areas.

Rates of Movement

Stooksbury (1977) averaged the rates of movement of the striped bass for each month of his study. The faster rates (250 m/hr and above) occurred during March and April and later in the year during September and October. The rates were relatively low during the winter and summer. In Watts Bar Reservoir, Cheek et al. (1985) noted that mean distances traveled in winter and spring were similar (0.7 and 1.0 km/day) and significantly higher than in summer (0.2 km/day) and fall (0.4 km/day). The reported low mobility during the July-October period was influenced by the size of the cool-water regions of the reservoir.

In Wilson Reservoir, rates of movement were lowest during summer, particularly in July when water temperatures were highest, and then increased until late fall. Although sample sizes were small, rates of movement were moderately high during the winter and even higher in spring, much like those of striped bass in Watts Bar Reservoir.

It has been observed that striped bass travel in a "rest and go" manner (Koo and Wilson 1972, Stooksbury 1977, Schaich and Coutant 1980), and this pattern was apparent in Wilson Reservoir. Further, Koo and Wilson (1972) and Stooksbury (1977) mentioned that there were times when it seemed that a fish had died because it moved so little. Schaich and Coutant (1980) reported that some of the striped bass in Cherokee Reservoir moved little, but did make short excursions. At times in Wilson Reservoir, especially during mid-feeding season, it appeared that the striped bass were not moving because they could be found in the same area day after day. However, when these fish were tracked overnight they were observed to move from the area and return to the same biological center of activity by morning.

Koo and Wilson (1972) failed to find much difference between day and night behavior in prespawning fish, but reported that a spent female striped bass was more active at night than during the day. Dudley et al. (1977) observed that striped bass moved primarily in the afternoon and early evening while in the spawning area, but after spawning were more active at night. The researches in both of these studies were hesitant to draw any conclusions because of insufficient data. Stooksbury (1977) reported that most activity in the summer occurred in the mornings and evenings. Summers (1982) monitored the movements of four striped bass during June and July. The striped bass moved rapidly away from the dam at sunrise and moved generally northward, up the reservoir, until 0930 to 1000 hr and then swam slowly back toward the dam, arriving there at dusk.

Average rates of movement for each hour of the feeding season for striped bass in Wilson Reservoir indicate that the fish were most active from 0700 to 1200 hr and again from 1400 to 1700 hr with average rates of movement exceeding 250 m/hr. The apparent peak in activity at 0300 hr resulted from a large set of data obtained from a single fish at a time in the season when water temperatures were high and the fish was observed to move primarily at night.

Model for Seasonal Movements

Although any model for the movements of striped bass in Wilson Reservoir must be considered tentative, the following has been developed from the available tracking data. Early in the spawning season striped bass congregate near the dam. Then in late April, they swim to the river upstream from the oxbow. Late in the season they swim back to the lower reservoir, where they establish biological centers of activity. Striped bass may change biological centers of activity as they move up the reservoir later in the feeding season. Early in the wintering season striped bass enter the upper reservoir. Prior to the formation of ice in January and February, striped bass enter the oxbow which they frequent until late March. At this time they return to the staging area near the dam where they prepare for another run upstream.

MANAGEMENT IMPLICATIONS

Prior to this study, age IV and older striped bass were seldom caught during netting activities by fisheries managers in Kansas reservoirs. Although random net catches of these fish have increased because of larger populations, an improved understanding of the seasonal movements has made it easier to selectively sample them. Brood stock collection has not been attempted at Wilson Reservoir, but information derived from this study has been applied to the selection of brood stock collection sites in other Kansas reservoirs.

The greatest management impact of this study has been a significant increase in angler harvest. An 8-month creel census conducted in 1976 revealed a catch of 106 striped bass with a catch rate of 0.001 per hour. During the next census, a 5.5-month survey in 1986, 3000 fish were caught with a catch rate of 0.021 per hour. Anglers made use of the seasonal patterns of distribution to lengthen their striper fishing season. Previously, fishing activity was generally limited to prespawning fish near the dam and ice fishing at the upper end of the reservoir. Also, fishermen applied information on the physical characteristics of the biological centers of activity to locate new fishing spots. The harvest also was influenced by other factors such as an increase in the fishable population, the use of more sophisticated equipment, and increased fishing pressure.

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Growth, Population Structure, and Mortality of Channel Catfish from the Powder River and Crazy Woman Creek, Wyoming

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ABSTRACT — This study was conducted to gain insight into the growth, population structure, and mortality of a lightly exploited population of channel catfish (*Ictalurus punctatus*) in the Powder River and Crazy Woman Creek, in northeastern Wyoming. Sampling with hoopnets was conducted from 6 May through 11 August 1986; 513 pectoral spines were collected and 474 were aged. The estimated ages of channel catfish ranged from 3 to 18 years. The growth rate was similar to that in other areas in the northern Great Plains and Midwest states, but the age structure differed with a large proportion of old fish.

Although the age and growth of channel catfish (*Ictalurus punctatus*) have been examined in various waters of the northern Great Plains and Midwest states, to our knowledge no one has reported on the growth and population structure of a lightly exploited channel catfish stock in a high plains stream. We conducted the present study on fish from the Powder River and Crazy Woman Creek, on the high plains of northeastern Wyoming.

STUDY AREA

The Powder River originates near Kaycee, WY, at the southern end of the Bighorn Mountains and flows into the Yellowstone River near Terry, MT. It drains a lightly populated basin of 34,300 km^2 in northeast Wyoming and southeastern Montana, where agricultural irrigation is the dominant water use. This meandering, highly braided river has numerous oxbows. Because it flows through highly erodable material its water is naturally turbid and saline. Turbidity commonly exceeds 500 Jackson Turbidity Units, and average total dissolved solids exceed 1300 mg/1 (Montana Department of Natural Resources and Conservation 1979). The major tributaries of the Powder River — Little Powder River and Mizpah Creek in Montana and Clear Creek and Crazy Woman Creek in Wyoming — are typically less turbid, having more confined banks and a more stable substrate. Channel catfish tend to migrate upstream in the Powder River and Crazy Woman Creek in spring and return downstream before summer low flows, some moving distances of more than 200 km (Smith 1988).

[1]The Unit is jointly supported by the University of Wyoming, the Wyoming Game and Fish Department, and the U.S. Fish and Wildlife Service.

METHODS

We collected channel catfish in unbaited D-shaped hoopnets with a first hoop 1 m in diameter, and a mesh of 3.8 cm (bar measure) between the first and second hoops and 2.5 cm in the remaining hoops. Of the two sampling sites in the Powder River, one was at Moorehead, MT, 15 km downstream from the Wyoming-Montana state line, and a second was 12 km upstream from the state line; the three sampling sites in Crazy Woman Creek were at the mouth, and 44 and 89 km upstream.

Total length of the fish was measured to the nearest millimeter; the right pectoral spine was removed as suggested by Sneed (1951), and placed in a labeled envelope to air dry until it was sectioned.

Preparation for sectioning followed closely the method of Ashley and Garling (1980). A microtome was used to section the spines. Sections were taken beginning at the distal end of the basal groove (Sneed 1951) and additional cuts (each 50 mm thick) were made towards the articulating process of the spine. The sections were examined under a binocular microscope by transmitted light. Growth zones appeared as translucent rings alternating with narrow annular rings. False annuli were recognized by their fainter appearance and lack of continuity (Marzolf 1955).

Two observers examined each spine section and recorded the estimated age. If the ages agreed, that age was accepted. When recorded ages differed, a third observer examined the sections, and unless this estimate agreed with one of the previous ones, the median value was accepted as the age of the fish. Back-calculated lengths were not computed due to bias associated with pectoral spine growth (Marzolf 1955, Muncy 1959). Annual total mortality rate and instantaneous rate of mortality were computed from a catch curve (Ricker 1975).

RESULTS

Sampling from 6 May to 11 August 1986 produced 513 pectoral spine samples, of which 474 could be aged. Channel catfish that were collected with seines in the Powder River at the end of their first summer were only about 40 mm long. This observation convinced us that the annulus laid down at the end of the first year of growth was not identifiable; we therefore added one year to each assigned age. Channel catfish in the sample were 3 to 18 years old.

Total lengths of channel catfish in the sample ranged from 223 mm (age 4) to 732 mm (age 13). Average length at specific ages ranged from 257 mm at age 3 fish to 669 mm at age 17. Average length increased with increasing age through age 12, but fluctuated thereafter. The increment in average total length was largest (57 mm) between ages 6 and 7 and smallest (8 mm) between ages 12 and 13.

The number of fish in the age groups began declining beyond age 6 (Table 1). Recruitment to the hoopnets was probably complete at age 6; therefore, only the fish of this age and beyond were used in comparisons with fish of other stocks. The annual total mortality was 25% and the instantaneous mortality rate was 0.29.

Table 1. Total length of channel catfish from the Powder River and Crazy Woman Creek, Wyoming, 1986.

Age (years)	Number of fish	Length (mm) Mean	Range
3	29	257	224-308
4	67	295	223-475
5	66	345	229-456
6	73	388	236-553
7	38	444	330-594
8	39	491	358-676
9	34	544	393-677
10	30	576	423-730
11	30	595	470-719
12	20	622	531-685
13	23	630	534-732
14	13	619	545-696
15	4	651	562-702
16	3	629	585-695
17	3	669	612-717
18	2	665	642-686

DISCUSSION

Despite an agricultural growing season of only 120 days in northeastern Wyoming (Martner 1986), the growth of channel catfish in the Powder River basin was similar to that in other areas in the northern Great Plains and Midwest states with longer growing seasons (Table 2). The average total length at a given age tended to be greater than in the Powder River basin for samples from channelized portions of the Missouri River in Nebraska (Hesse et al. 1978); Pool 9 of the Mississippi River, Iowa (Schoumacher and Ackerman 1965); and the Cedar River, Iowa (Schoumacher and Ackerman 1965). Growth rate appeared to be greater for Powder River fish than for fish from Lake of the Ozarks, Missouri (Marzolf 1955); the Tongue River, Montana (Elser et al. 1977); Lake Sharpe, South Dakota (Elrod 1974); and the Des Moines River, Iowa (Harrison 1957).

The age frequencies in the sample from the Powder River basin differed from those in other northern Great Plains and midwest states (Table 3). Channel catfish older than age 14 were represented only in samples from Lake Sharpe, South Dakota, and the Tongue River, Montana. Assuming that recruitment to the sampling gear was complete at age 6 in all studies, the number of fish in each age class declined abruptly from ages 6 to 13 in most samples. The stock of channel catfish in Lake Huron was an exception: modes occurred at 6 and 10 years

Table 2. Average total lengths for channel catfish at different ages from various waters of the northern Great Plains and Midwest states.

Location and Reference	Age (years)																	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Powder River and Crazy Woman Creek (Present study)				257	295	345	388	444	491	544	576	595	622	630	619	651	629	669
Grand Lake, Oklahoma (Sneed 1951)	71	120	181	248	300	338	429	463										
Lake Dardanelle, Arkansas (Freeze and Tatum 1977)		102	163	230	328	348	374	410	482	533								
Lake of the Ozarks, Missouri (Marzolf 1955)	64	132	193	236	277	318	345	366	376									
Tongue River, below T & Y Dam, Montana (Elser et al. 1977)		127	206	229	272	218	335	373	389	414	450	485	531	531	577	574		
Missouri River, channelized sections, Nebraska (Hesse et al. 1978)	111	171	237	297	353	400	442	473	529									
Lake Sharpe, South Dakota (Elrod 1974)					250	267	295	333	347	381	437	498	444	487	483	599	531	624
Kentucky Lake, Tennessee (Conder and Hoffarth, 1962)			259	284	318	361	401	437	505	587	658							
Mississippi River, Pool 9, Iowa (Schoumacher and Ackerman 1965)				320	391	427	460	518	541	526								
Cedar River, Iowa (Schoumacher and Ackerman 1965)			180	251	307	437	483	523	538									
Des Moines River, Iowa (Harrison 1957)			140	178	218	239	302	307	345	363	368	447						

Table 3. Age structure of channel catfish samples from various waters of the northern Great Plains and Midwest states.

Location and Reference	Age (years) 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Powder River and Crazy Woman Creek (Present study)				29	67	66	73	38	39	34	30	30	20	23	13	4	3	3
Des Moines River, Iowa (Muncy 1959)		27	192	104	57	20	27	35	31	8	1	1		1				
Saginaw Bay, Lake Huron (Lorantas 1982)			1	11	71	93	395	191	35	31	57	21	9	1				
Grand Lake, Oklahoma (Sneed 1951)	3	41	60	42	24	6	6	3	3									
Lake Dardanelle, Arkansas (Freeze and Tatum 1977)		1	4	12	14	25	28	13	10	5								
Lake Carl Blackwell, Oklahoma (Jearld and Brown 1971)	3	2	6	21	34	52	36	34	35	18	10	1	3					
Lake of the Ozarks, Missouri (Marzolf 1955)	53	50	14	66	17	102	64	52	16									
Tongue River, below T & Y Dam Montana (Elser et al. 1977)		2	28	9	21	17	19	6	7	22	13	16	29	24	14	3		1
Missouri River, channelized sections, Nebraska (Hesse et al. 1978)	10	350	419	693	508	93	8	4	50	18	10							
Tuttle Creek Reservoir, Kansas (Klaassen and Townsend 1973)		70	86	86	42	90	37	57	14	7	3							
Western Lake Erie (DeRoth 1965)	665	539	438	282	139	70	25											
Lake Sharpe, South Dakota (Elrod 1974)					5	39	3	6	4	10	5	2	1	3	1	4	1	1
Kentucky Lake, Tennessee (Conder and Hoffarth 1962)			8	10	13	12	5	11	14	10	10							
Mississippi River, Pool 9, Iowa (Schoumacher and Ackerman 1965)				5	30	45	33	16	10	5								
Cedar River, Iowa (Schoumacher & Ackerman 1965)			22	4	11	3	1	1	1									

of age (Table 3). The discrepancy between the age distribution of channel catfish in the Powder River basin and that of fish from other areas was probably a function of low angler exploitation in the Powder River basin. There is no commercial fishery and angling pressure is light. Of 591 channel catfish tagged with reward tags in summer 1987, only five were returned by fishermen during 1987 (David Gerhardt, University of Wyoming, pers. commun.).

The annual mortality rate for channel catfish from the Powder River basin (25%) was lower than most. Annual mortality rate was 60% in the Missouri River, which supports a sport and commercial fishery (Hesse et al. 1978). In the Sacramento Valley, California, where annual angler exploitation is 30%, a 55% annual mortality rate was observed (McCammen and LaFaunce 1961). It is likely that values for the Powder River basin are close to the natural mortality for channel catfish in this prairie river system.

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Note

FIRST RECORD OF THE LEAST WEASEL IN OKLAHOMA — The least weasel, *Mustela nivalis*, has rapidly extended its range southward from Nebraska during the past 23 years. This small carnivore commonly inhabits grassy lowlands. Although it has been collected from upland prairie sites, habitats along watersheds, rivers, and reservoirs likely provide corridors for range expansion (see Bailey and Terman, 1986, Trans. Kans. Acad. Sci. 89:62-65; Finck et al., 1986, Prairie Nat. 18:153-166, and citations therein).

Presence of the least weasel across much of southern Nebraska suggested that this species was also an inhabitant of northern Kansas. Although there was an unsubstantiated account of a least weasel in Smith County, Kansas, in 1916-1917 (Swan, 1977, Trans. Kans. Acad. Sci. 8:159-160), the first specimen from the state was taken in Marshall County in March 1964 (Jones and Cortner, 1965, Am. Midl. Nat. 73:247). Since 1964, least weasels have been collected from 17 counties near tributaries of the Kansas River system (Bee et al., 1981, Univ. Kans. Mus. Nat. Hist. Publ. Educ. Ser. 7:1-300; Choate et al., 1979, Trans. Kans. Acad. Sci. 82:231-234). Recent records indicate that least weasels have moved even farther southward, apparently along tributaries of the Neosho and Arkansas rivers in southern Kansas, and their occurrence in Oklahoma was predicted by Choate et al. (1988, Prairie Nat. 20:57).

We found a dead least weasel along State Highway 51, 0.9 km N and 6.2 km W of Hulbert, Cherokee County, Oklahoma, on 15 January 1988. This was the first specimen documented for Oklahoma. The location was approximately 260 km southeast of the nearest record for least weasels from Sedgwick County, Kansas (Choate et al., 1988, Prairie Nat. 20:57). Surrounding habitat consisted of lowland pastures, upland woods, and floodplains east of the Fort Gibson Reservoir. Much of the area was moderately to heavily wooded. The specimen, a young adult female (total length 165 mm, tail 32 mm, hind foot 21 mm, ear 9 mm, weight 41.5 g) in brown and white pelage, is housed at the Museum of the High Plains, Fort Hays State University, Hays, KS.

Given the known localities of least weasels in Kansas, there are two likely routes of invasion into Oklahoma. Habitats along the Neosho River provide a direct route from Marion County, Kansas, southeastward into Oklahoma where it feeds Fort Gibson Reservoir. The Arkansas River drainage also provides a continuous route from Sedgwick County, Kansas, southward into Oklahoma, then eastward to the confluence of the Neosho and Arkansas rivers below Fort Gibson Reservoir. Least weasels likely will be found in additional counties of southeastern Kansas, and such findings may provide insight on the direction of range extension. Regardless of the route into Oklahoma, habitats along numerous tributaries and reservoirs of the Arkansas River system provide an abundance of corridors for continued range expansion of least weasels into northeastern Oklahoma. — *Brenda S. Clark and Bryon K. Clark, Oklahoma Cooperative Fish and Wildlife Research Unit, Department of Zoology, Oklahoma State University, Stillwater, OK 74078.*

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Habitat Use by White-Tailed Deer in Prairie-Agricultural Habitat in Montana

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ABSTRACT – We examined home range size and habitat use for white-tailed deer (*Odocoileus virginianus*) occupying prairie-agricultural habitat in east central Montana during 1983-84. Summer home ranges of adult females appeared smaller than winter home ranges. Deer selected riparian habitat, and its interspersion with cropland and rangeland influenced deer distribution and habitat use.

White-tailed deer in the northern Great Plains historically were associated with habitats along major streams and their tributaries (Roosevelt 1885, Koch 1946, Allen 1968). Their distribution extended into upland habitats after the early 1940s (Cook 1945, Allen 1971). Compton et al. (1988) reported that the amount of forest and shrub habitat influenced distribution of deer in riverine environments. Studies by Swenson et al. (1983), Herriges (1986), and Wood (1987) also document a close relationship between white-tailed deer and habitat complexes with agricultural and riparian components. Those studies were more general and extensive, involved irrigated bottomlands where agriculture and riparian components were closely interspersed, or occurred in predominantly rangeland prairie habitat. Comparative data are lacking for upland prairie habitats where riparian draws and non-irrigated cropland are relatively abundant and highly interspersed. Our study focused on habitat relationships of white-tailed deer on more intensively farmed upland prairie in east central Montana to describe habitat relationships and characteristics of this environment important to deer.

STUDY AREA

The 103-km^2 study area (Fig. 1) extended along the north side of the Yellowstone-Missouri River Divide in Dawson and Richland counties. Land ownership was predominantly private (98%), with dryland farming a major land use. Livestock, primarily cattle, were grazed on sites that were highly erodible or too steep to farm. Deer density in the study area was estimated as 5/km^2 during spring 1983 (Dusek 1983).

Topography of the area is characterized by the steep escarpment along the Yellowstone-Missouri Divide and rolling terrain of the basin formed by the upper Pasture and Lisk Creek drainages that slope gently to the northwest (Fig.

1). The north edge of the study area includes the deeply dissected drainages of upper Redwater Creek. Permanent water is limited to man-made impoundments. Elevations vary from 951 m on the divide to 762 m along Pasture Creek. The regional climate is semiarid, characterized by marked seasonal fluctuations in temperature and precipitation. Average daily temperatures vary from 21°C in July to − 11°C in January. Mean annual precipitation is 33 cm, most of which falls from April to September (Circle, MT, 52 km southwest, U.S. Department of Commerce 1983-1984). Snow cover generally is not continuous through winter and rarely exceeds 25 cm in depth.

We delineated three broadly different habitats: rangelands, croplands, and riparian draws. Rangelands covered 50% of the study area and included sparsely vegetated badlands along the escarpment of the divide and edges of some of the lower drainages. Patches of Rocky Mountain juniper (*Juniperus scopulorum*) occurred on north-facing slopes, and bunchgrass prairie dominated by needle-and-thread (*Stipa comata*) or little bluestem (*Andropogon scoparius*) occurred on rolling plains below the escarpment. Wheat and barley were the

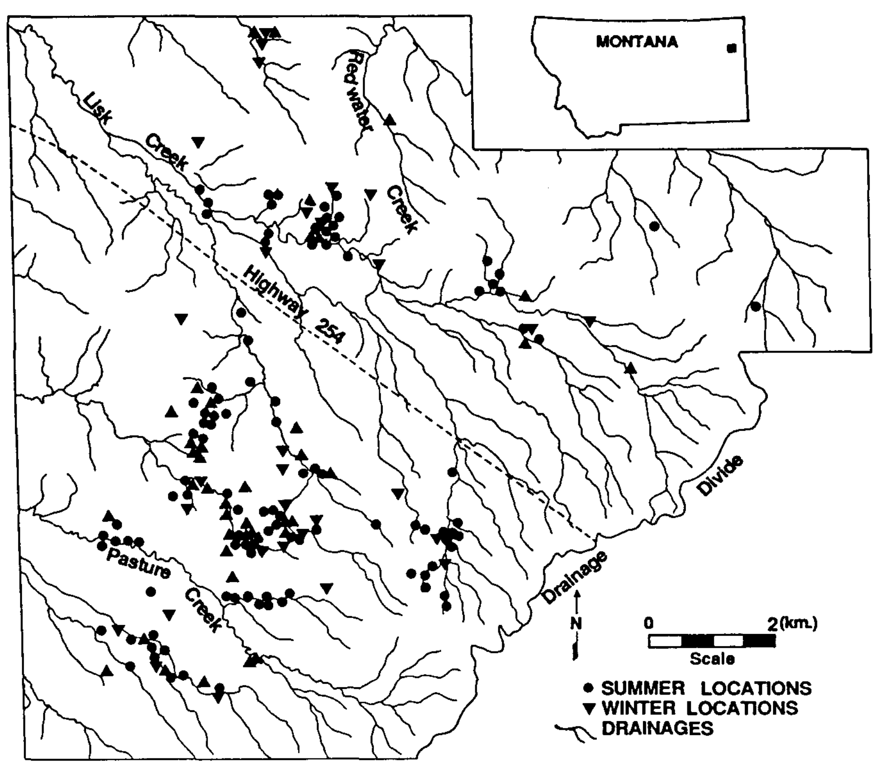

Figure 1. Location and physiographic features of the study area, and seasonal distribution of white-tailed deer, 1983-1984.

major crops grown on cultivated lands (43% of the area). Riparian draws (7%) were dominated by green ash (*Fraxinus pennsylvanica*), eastern cottonwood (*Populus deltoides*), western snowberry (*Symphoricarpos occidentalis*), chokecherry (*Prunus virginiana*), and silver buffaloberry (*Shepherdia argentea*).

METHODS

We captured 49 deer during January 1983, using a helicopter and drive net (Beasom et al. 1980). Fifteen adult (1 year and older) females were fitted with radio-collars; the remainder (13 adult females, 5 female fawns, 4 adult males, and 12 male fawns) were marked with individually recognizable, 10-cm-wide, vinyl neckbands. We attempted to locate all marked deer during 23 flights with a PA-18 fixed-wing aircraft from February 1983 through December 1984. All radio-collared females were electronically located during 17 of those flights. All data were obtained during daylight hours and therefore represent only diurnal patterns, and not diel patterns, of habitat use.

Annual and seasonal home ranges were estimated for each radio-collared female. Home range size was expressed as the area of a convex polygon. Observations generally spanning the period of vegetative growth were treated as summer data (16 April-9 October); those spanning the period of vegetative dormancy (10 October-15 April) were treated as winter data.

Chi-square goodness-of-fit tests and Bonferroni confidence intervals (Byers et al. 1984) were used to determine habitat preference using only data from radio-collared deer. Relative abundance of each of the three habitats was ascertained from cover maps made from orthophotoquads (1:24,000).

To determine the effects of habitat diversity and interspersion on distribution of deer, the study area was divided into 412, 25-ha grid cells (Porter and Church 1987). The amount of each habitat, number of habitats, number of distinct habitat patches, and presence or absence of surface water in each cell were determined. Data from all marked deer were used because habitat complexes were evaluated rather than habitats occupied by individual deer. Analysis of a 25-ha area around individuals should minimize biases attributable to observability. In another study, results from radio-collared and neckbanded deer were not significantly different (Dusek, unpubl. data).

A preliminary evaluation of the data suggested that neither raw nor transformed data readily met assumptions for parametric statistics. In addition, our purpose was not to precisely quantify but rather to qualitatively identify differences between habitat complexes used by deer with respect to season and intensity of use. Nonparametric Wilcoxon rank sum tests were used to determine seasonal differences in the association of deer with habitat complexes. Cells with 0, 1, and 5 or more observations of deer/cell provided a contrast between habitat complexes with no apparent use, occasional use, and intensive use and were compared using both Kruskal-Wallis Chi-square approximations and Wilcoxon rank sum tests. A Chi-square test of independence was used to determine effects of permanent water on deer distribution. Delineation of the study area was determined primarily from distribution of marked deer, though actual boundaries were arbitrarily assigned using the drainage divide and roads. The three habitats generally were distributed in a regular pattern throughout the study area, minimizing biases attributable to location of study area boundaries (Porter and Church 1987).

RESULTS

Deer distribution (Fig. 1) was determined from 230 locations of 15 radio-collared females and 64 chance sightings among 28 neckbanded deer, of which 44 (69%) sightings were of adult females. Adult females were distributed largely in the Pasture and Lisk Creek drainages yearlong. All radio-collared females were yearlong residents on the study area. Annual home ranges of adult females based on 11-17 locations averaged 4.0 ± 0.5 km^2 ($\pm$ SE, range = 1.4-6.9 km^2). Home ranges from 6-9 locations in summer (mean = 1.3 ± 0.3 km^2, range = 0.1-3.4 km^2) were apparently smaller than those from 5-8 locations in winter (mean = 2.3 ± 0.3 km^2, range = 0.2-3.9 km^2).

Deer used riparian draws at levels exceeding availability ($P < 0.001$) throughout the year, although draws apparently received greater use by deer during summer than during winter (Table 1). Use of rangeland and cropland increased from summer to winter, but their use by deer during both seasons was less than expected on the basis of availability ($P < 0.001$). Use of rangeland was confined primarily to areas of bunchgrass prairie.

Habitat composition differed ($P < 0.05$) from summer to winter with respect to the relative abundance of the three habitat components in habitat complexes used by deer. Cells used by deer during summer contained less rangeland and more cropland and riparian draws than cells used during winter (Table 2), although fewer deer were observed in cropland during summer than winter (4% vs. 18%). The number of patches and the number of habitats in cells occupied during summer and winter were not significantly different (Table 2).

Only 80 (19%) of the 412 cells were occupied one or more times by marked deer. Unused cells contained more rangeland than those with documented use

Table 1. Use (%) of three habitats by radio-collared, adult female white-tailed deer in prairie-agricultural habitat, 1983-1984, using Chi-square goodness-of-fit tests and Bonferroni confidence intervals.

Habitat	% of Area	Annual (N = 230)[a]	Winter (N = 90)	Summer (N = 140)
Rangeland	50	5 ± 5 (−)[b]	7 ± 10 (−)	4 ± 6 (−)
Cropland	43	10 ± 7 (−)	18 ± 15 (−)	4 ± 6 (−)
Riparian draw	7	86 ± 9 (+)	76 ± 17 (+)	92 ± 9 (+)

[a]Total number of relocations of radio-collared deer.
[b]Percent of annual or seasonal observations ± 0.999 CI. A (+) indicates use exceeding availability ($P < 0.001$), and a (−) indicates use less than availability ($P < 0.001$).

Table 2. Comparison of habitat characteristics among grid cells that were occupied by all marked deer during summer and winter, 1983-1984.

Habitat characteristic	Season: Summer	Season: Winter	Probability[a]
Area in:			
Rangeland	136[b]	161	0.01
Cropland	156	135	0.03
Riparian draw	157	134	0.02
No. of:			
Patches	154	138	0.10
Habitats	153	139	0.09
No. grid cells	59	50	

[a]Probability level testing for differences between summer and winter using a Wilcoxon rank sum test.
[b]Mean Wilcoxon rank sum scores.

(Table 3), but only the difference between cells with no use and one observation was significant ($P < 0.05$). The relative amount of cropland did not differ ($P = 0.09$) between cells used by deer and those that were not used. However, cells with high use contained more riparian habitat ($P < 0.001$) than cells receiving occasional or no use.

The number of habitats and distinct patches was greater ($P < 0.001$) in cells with intense use than in those with only occasional or no use (Table 3). This suggested that deer selected areas that were more diverse. The presence of permanent water had no influence on deer distribution or habitat selection ($X^2 = 1.08$, $df = 1$, $P = 0.30$).

DISCUSSION

Our findings supported the close association between white-tailed deer and riparian habitat previously reported for the northern Great Plains. They also provide insight to the importance of other habitat components and factors that influence use of upland prairie habitats by deer. The grid cell analysis indicated that cropland and rangeland in association with riparian draws also are essential. Limited use of non-wooded habitats during daytime (Suring and Vohs 1979, Herriges 1986) may explain the preference for riparian draws and the less than expected use of cropland and rangeland habitats that we observed.

Our results illustrated the importance of habitat interspersion to white-tailed deer as reported by others (Wigley et al. 1980, Williamson and Hirth 1985). Areas of cropland and rangeland interspersed with riparian draws received intensive use by deer. This indicates that habitat diversity and the juxtaposition of habitat patches were "key" factors influencing use of specific sites by deer.

Table 3. Comparison of habitat characteristics among grid cells that were unoccupied (0), occupied only once (1), and occupied five or more times (5+), 1983-1984.

Habitat characteristic	Use intensity 0	1	5+	Probability[a]
Area in:				
Rangeland	201 A[b]	157 B	161 AB	0.03
Cropland	190 A	230 A	216 A	0.09
Riparian	191 A	183 A	274 B	0.002
No. of:				
Patches	191 A	180 A	284 B	0.001
Types	191 A	182 A	275 B	0.001
No. grid cells	333	34	22	

[a]Probability level testing for differences among groups using the Kruskal-Wallis Chi-square approximation.

[b]Mean Wilcoxon rank sum scores. Row values followed by different letters are significantly different ($P < 0.05$).

Our results also point out a potential weakness of use vs. availability analysis. Individual habitats can be important to local populations even though they are significantly avoided as inferred by simulations of Porter and Church (1987).

Diversity and habitat interspersion may also influence home range size. Wood (1987) reported a diurnal preference for cropland during fall-spring where fields comprised only 4% of the area; seasonal home ranges were smallest where cropland and riparian draws were closely interspersed. Although inclusion of nocturnal movements would likely increase home range size and proportionate use of croplands (Herriges 1986), the absence of nocturnal locations does not negate the importance of riparian draws or habitat diversity to whitetails on this area, or in nearby prairie and riverine environments (Wood 1987, Dusek and Mackie 1988).

Deer responded differently to habitat composition during summer and winter. They occupied habitat complexes with more cropland in summer, although observed use of cropland was greater in winter. This apparent contradiction could be explained by our observations that large patches of wooded cover used during summer were more closely associated with cropland. Patches of riparian habitat selected by adult females during summer may have provided optimal cover/forage complexes (Suring and Vohs 1979) as well as spatial isolation (Gavin et al. 1984).

Seasonal shifts within annual home ranges may have resulted from deer using sites that reduced effects of wind-chill during winter. Although deer heavily used riparian draws during winter, its use and occurrence in cells decreased.

Rangeland use and occurrence in cells increased during this season. Rough dissected topography was more likely to be associated with rangeland than cropland. For example, a portion of upper Redwater Creek that was used by one radio-collared female during winter included a rough dendritic drainage system interspersed with riparian cover but not with cropland. Wood (1987) reported use of riparian draws sheltered by rough terrain by white-tailed deer in response to severe winter weather. Many other studies have also documented the importance of shelter and/or cover for wintering white-tailed deer (e.g., Rongstad and Tester 1969).

Increased diurnal use of cropland during winter suggested that deer may travel from sheltered bedding sites to less sheltered areas to feed as similarily reported for mule deer (*O. hemionus*) in a prairie environment (Wood 1988). Studies in both river bottom and prairie habitats indicated that cereal grains, including wheat and barley, occurred in the diet primarily during fall and winter (Dusek 1984, Wood 1987). Less cropland in habitat complexes used by deer in winter may necessitate greater daily movement during that season. This may explain apparently larger winter than summer home ranges observed among adult female whitetails during this study. Deer that opt for a strategy of winter survival that involves increasing energy input through selective foraging, may require larger home ranges than those that utilize a strategy of energy conservation (Dusek 1987).

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Beaver Crop Depredation in Eastern South Dakota

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ABSTRACT — Cornfields along the Big Sioux River in eastern South Dakota were monitored in 1985 and 1986 for signs of depredation by beaver (*Castor canadensis*). Damage occurred in 31 of 49 (63%) fields. Damaged areas and related financial loss were small with an average loss of $8.56/field in 1985 and $3.15/field in 1986.

Historically, beaver populations in the northern plains have fluctuated along with the demand for fur. Beaver populations in South Dakota have increased dramatically in recent years, while at the same time, intensive agriculture has expanded into riparian habitat (Smith and Flake 1983). This has resulted in continued complaints about beaver damage from farmers and landowners (Miller 1985), causing beaver to change status from a valuable economic entity to a nuisance animal.

Chewing damage to planted trees and flooding of farmland due to damming of streams are problems commonly caused by beaver. Beaver crop depredation, especially in cornfields, occurs frequently where corn fields are located near streams and rivers. Our study objectives were to determine the extent of beaver depredation in cornfields adjacent to the Big Sioux River and to estimate related financial loss to farmers.

STUDY AREA AND METHODS

This study was conducted in 1985 and 1986 along approximately 25 km of the Big Sioux River in Brookings and Medary counties. The Big Sioux River, which originates in Grant County, South Dakota, and flows in a southerly direction to the Missouri River at Sioux City, Iowa, is the primary drainage of the Coteau des Prairie. Livestock pastures as well as corn and small grain fields are present throughout the area, often in close proximity to the river channel.

Beaver lodge density during the study was 0.81 lodges per river km. The beaver population was unevenly distributed along the river with ungrazed areas holding higher concentrations of lodges (Dieter 1987).

All corn fields adjacent to the river in the study area were monitored throughout summer and fall of both years for beaver depredation. Due to record precipitation in eastern South Dakota in 1986 and subsequent spring floods, only 16 cornfields were planted near the river channel in 1986 compared to 33 in 1985. The following measurements were taken at each point where depredation occurred: (1) amount of beaver damage, (2) shortest distance from cornfield to water, and (3) longest distance beaver moved from water to cut corn. Financial loss was calculated using average corn yield in Brookings county and maximum price of corn ($2.10 per bushel) during the study.

RESULTS

Over the 2-year period, 31 of 49 (63%) cornfields were damaged by beaver (Table 1). Damage increased during the period of data collection in 29 of 31 (94%) fields. Statistical analysis using a t-test found that the mean perpendicular distance (9.7 m) from water of damaged fields was significantly less ($P \leq 0.05$) than for undamaged fields (27.2 m). Corn fields over 21 m from water were not damaged by beaver, indicating that food sources closer to the river were most likely to be damaged. Once beaver began using a cornfield, they moved as far as 40 m from water to cut corn, the mean distance being 23.8 m in damaged fields (Table 1).

Areas damaged within the cornfields were small and ranged from 0.001 to 0.07 ha (0.003 to 0.164 acres). Damaged area losses averaged 4.08 bushels or $8.56 per field in 1985 and 1.5 bushels or $3.15 per field in 1986 (Table 2).

Table 1. Cornfields and use by beaver along the Big Sioux River, South Dakota, in 1985 and 1986.

	1985	1986
Number of cornfields	33	16
Number of cornfields damaged by beaver	19	12
Mean distance from water to damaged fields	8.8 m	11.3 m
Mean distance from water to undamaged fields	31.8 m	20.0 m
Mean distance from water traveled by beaver	24.1 m	23.6 m

Table 2. Financial loss due to beaver depredation along the Big Sioux River, South Dakota, in 1985 and 1986.

	1985	1986
Mean area damaged	0.05 acres	0.016 acres
Range of damaged areas	0.003-0.164 acres (0.001-0.07 ha)	0.003-0.043 acres (0.001-0.02 ha)
Mean loss in bushels	4.08	1.50
Mean dollar loss per field at $2.10/bushel	$8.56	$3.15
Range of dollar losses	$0.50-$28.01	$0.57-$7.27

DISCUSSION

Beaver rely primarily on woody materials for food in winter, but herbaceous vegetation is often preferred during spring and summer (Chabreck 1958, Northcott 1971, Svendsen 1980, Roberts and Arner 1984). Beaver are opportunistic feeders and will utilize a variety of agricultural crops if available to them. Soybeans were found to be a major food item for beaver during summer and fall in Mississippi (Roberts and Arner 1984). Corn was an attractive food for beaver in this study and in another study in Montana (Swenson and Knapp 1980).

Study results indicated that the visual aspect of beaver damage to cornfields was apparent, but the farm financial loss was insignificant. Although damage was slight, several management options could be used to reduce or eliminate beaver depredation to corn fields. Since beavers tend to select cornfields in close proximity to water, planting fields a minimum of 40 m from water would likely prevent or reduce beaver depredation. Hog fencing erected on the river side of cornfields might deter beaver, but the cost of this practice may not be warranted unless the beaver population is very large, subsequently resulting in greater amounts of damage than in our study. These preventative measures should alleviate some problems of crop depredation and may be alternatives to nuisance beaver control which is costly to tax- or license-supported agencies.

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Characteristics of Bald Eagle Winter Roosts in Wyoming

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ABSTRACT – The Powder River Basin of Wyoming was surveyed by aircraft and ground searches for winter bald eagle roosts during 1984 and 1985. Twenty-three roosts were located, which contained from 1 to 24 eagles. Roosts were typically in forest with high densities of conifers and snags. These sites had larger and more open trees than the surrounding forest. Roost sites were associated with sheep ranches and individual eagles were observed near sheep ranches. Sheep and pronghorn antelope were a major prey found in eagle pellets along with lagomorphs, other small mammals and birds.

Concentrations of bald eagles (*Haliaeetus leucocephalus*) occur in northwestern Wyoming during winter, where they use communal roosts for sleeping at night and loafing during the day. Locations of roosts coincide in other regions with available food. In South Dakota, wintering bald eagles perch as close as possible to feeding areas (Steenhof et al. 1980) and in Oregon, California, and Nebraska, eagles roost in the closest site to feeding areas that have protected habitats (Keister and Anthony 1983, Lingle and Krapu 1986). Roosts also provide protection from severe weather. Thus, communal night roosts are used more often during days of winds greater than 17 km/hr (Steenhof et al. 1980) or during periods of inclement weather.

Previous work on forest characteristics of roosts showed that eagles selected the largest, most open structured conifers as roost sites (Keister and Anthony 1983). Eagles roosting along riparian areas of cottonwoods (*Populus deltoides*) selected the largest cottonwoods bordering the river (Steenhof et al. 1980). Few data were available on the characteristics of roosts in Wyoming (Platt 1976, Millsap 1986).

Our objectives were to: (1) locate roosts by using both aerial and ground surveys, (2) describe winter distribution relative to major food sources in north central Wyoming, (3) determine physiographic features of roosts, and (4) evaluate characteristics of forest stands used for roosts in the arid high plains.

STUDY AREA

The study area was located in northeastern Wyoming, from the city of Casper north to Sheridan and east to the South Dakota Border. The land was used mostly for livestock grazing with wintering pronghorn antelope (*Antilocapra americana*) common.

[1]Cooperators: Wyoming Game and Fish Department, University of Wyoming, and U.S. Fish and Wildlife Service.

Major vegetation communities in the area included scattered conifer forests with mixed shrubland and grasslands. Topography consisted of extensive plains with hills and low open mountains (Bailey 1980). Several rivers bordered by cottonwoods ran through the area.

METHODS

Aerial surveys of wintering bald eagles and their roosts were made November 1984-April 1985 in a 300 x 255 km^2 area. We located roosts during 100 hours of low-level (60-100 m) flying, mostly between 0800 and 1300 hr. A total of 220 hours was spent on ground searches for roosts. Searches were conducted in the study area where aircraft searches were inconclusive or not possible. Roosts located during aerial searches were also verified by the ground searches. Roosts were defined as areas where eagles were observed perched more than once, where white-wash was found on trees and fresh castings were on the ground, or where previous surveys had identified a roost. Potential roosts and eagles observed were marked on 30 x 60 min quadrangle maps.

The 23 identified roosts were compared to 92 random sites in the study area. For each roost, we randomly selected four points by compass degree within a 6-km radius and used the nearest valley that had a slope of at least 15% as the sampling point. Variables measured at both random and roost sites included: (1) length of ridge up to 1 km; (2) distance to the opposite ridge at the widest point, up to 1 km; (3) height of both ridges; (4) slope of both valley sides, classed between 15% and 50% (at 5% intervals); (5) aspect of both valley sides classified into 16° arcs; (6) orientation of the mouth of the valley; (7) center of the direction of view from midpoint of the roost or nonroost slope; (8) angle of view from the same point; and (9) distances in km to the nearest occupied dwelling, oil or gas well, improved or unimproved road, and riparian zone with cottonwoods. Comparisons between individual variables measured at roosts and at random sites were performed using a t-test for each variable between random and roost sites.

Characteristics of forest stands greater than 1 ha with roosts were estimated by randomly selecting a 0.04-ha plot for each 0.40 ha of stand and measuring all trees in these plots. All trees were measured in stands less than 1 ha. Tree DBH was measured and classified in increments of 7 cm. Tree height was measured using a Haga altimeter and classified in increments of 5 m. Structural classes of trees followed Keen (1943), in which a value of 1 was given to trees with heavy foliage and 5 to trees with no foliage. Differences between trees in the forest near roosts and roost trees, as well as differences between all roost trees, were determined using the nonparametric Wilcoxon paired-sample test (Zar 1984).

Forest stand characteristics of 16 roost sites were compared to nonroost sites selected from 7.5 min quadrangle maps. We selected nonroost sites with slope and aspects similar to those of roost sites. Differences between roost and nonroost sites were determined using the Wilcoxon paired-sample test (Zar 1984).

Food was determined by collecting eagle pellets beneath 14 roosts and recording percent occurrence of prey items. Comparisons were made between distances from eagles observed and random points to pronghorn winter habitat and sheep ranches. Random points were determined by overlaying a grid map with a randomly selected orientation and marking 1 point per 10 km^2. Chi square tests were used to see if distances between eagles and their food sources differed from random locations at the $P \leq 0.05$ level.

Maps (scale 1:500,000) of pronghorn winter ranges were provided by the Wyoming Game and Fish Department. Each average herd unit size was estimated using data collected by the Wyoming Game and Fish Department between years 1979 to 1983 and classified as high (>3000) or low (<3000 antelope). The Soil Conservation Service and the Agriculture Stabilization and Conservation Service (ASCS) provided data on sheep ranches larger than 2000 animals. These data were mapped on 30 x 60 min quadrangles. Ranches with more than 2000 sheep were selected because smaller flocks were fed and maintained close to ranch buildings in winter while larger herds ranged during winter without supplemental feeding. Weather data from the study site were provided by the National Atmospheric and Oceanic Administration and were collected at the Casper and Sheridan airports.

RESULTS AND DISCUSSION

We located 23 roosts in our study, and the eagle numbers in the roosts ranged from 1 to 24. Five of the physiographic measurements differed significantly between roosts and random sites. Roosts were found on steeper slopes than nonroost sites (43.5 vs 37.4%, $P < 0.0005$). Valley slopes opposite roosts were steeper (45.1%) than nonroost sites (32.6%, $P < 0.0005$). Roosts had a smaller degree of view (15.2°) than nonroosts (103°, $P < 0.05$). Aspect of roosts differed from nonroost sites (33° vs 30°, $P < 0.005$), and aspects of slopes opposite roosts also differed (233° vs 349°, $P < 0.05$). These results showed the importance of ridges in protecting roost sites since they were located in areas likely to be more protected from high winds. Protection from wind also appeared to influence roost sites in Utah and Oregon (Swisher 1964, Keister and Anthony 1983). No opposing valley slopes were found in 15% of the nonroost sites while all roosts had opposing slopes.

Most trees used for roosting were ponderosa pines (*Pinus ponderosa*). Two other species of tree, Douglas fir (*Pseudotsuga menzeisii*) and limber pine (*Pinus flexilis*), were also used.

Roost trees were generally the largest tree in terms of DBH and height in the stand. Roost stands also had larger and taller trees than nonroost sites. Average tree structure of 3.10 for roost trees reflected an open tree with only moderate foliage (5 would indicate a tree with no foliage) (Table 1). No differences were found in tree structure between roost stands and nonroost stands. However, tree density was greater in roost stands. Snags were much more common in roost stands than nonroost sites.

Analysis of 574 castings found under roosts indicated sheep and pronghorn antelope were dominant food items in 28%. Two species of lagomorphs (*Lepus townsendii* and *Sylvilagus nuttallii*) were found in 38% of castings. Other species included domestic cattle, domestic cat (*Felus catus*), mule deer (*Odocoileus hemionus*), prairie dog (*Cynomys spp.*), and American robin (*Turdus migratorius*), as well as several unidentified birds and rodents.

Roosts were observed in higher proportions than expected near large sheep ranches (Table 2). Thirty-five percent were less than 1 km from sheep ranch boundaries, with 60% of the adult and 57% of the immature eagles being seen within this distance from a ranch. Fewer adult and immature bald eagles were observed near pronghorn winter ranges than sheep ranches (Table 2).

Food availability was an important factor influencing the locations of communal roosts (Steenhof et al. 1980, Keister and Anthony 1983). Sheep and other ungulates, most often taken as carrion, were major food sources in our study areas. The high frequency of sheep remains in bald eagle castings (Jenkins et al. 1980) supported our data showing that eagles were associated with sheep ranches.

In summary, roost trees were typically among the oldest in a forest stand (Keister and Anthony 1983). Eagles selected the largest, most open structured trees for roosting. Most roosts were located on slopes with a northeasterly aspect and with relatively high densities of large conifers and the presence of snags. Thus, maintenance of winter bald eagle roosts in eastern Wyoming consists of protecting older stands of trees found in small fragments away from human disturbance (Stalmaster and Newman 1978).

Table 1. Mean values of roost sites, roost trees, and nonroost trees at roost and nonroost sites in north central Wyoming.

	Tree DBH (CM)	Tree Height (M)	Tree Structure	Percent Snags	Percent trees infected by beetle	Density Trees
Roost Stands (n = 23)	30.50**	11.50**	2.24**	15.14**	2.06**	72.97**
Roost Tree (n = 23)	33.00*	15.50*	3.10*			
Nonroost Sites (n = 92)	27.50	10.00	2.82	4.65	2.29	49.36

*Significant difference between roost tree and trees in forest at $P \leq 0.95$.
**Significant difference between roost site and non-roost site at $P \leq 0.05$.

Table 2. Percent of eagle roosts (measured to center), observed eagles, and random points less than 1, 1 to 5, and more than 5 km from boundaries of pronghorn winter ranges and sheep ranches.

	Pronghorn Population < 3.000			Pronghorn Population > 3,000			Sheep > 2,000		
	< 1 km	1-5 km	> 5 km	< 1 km	1-5 km	> 5 km	< 1 km	1-5 km	> 5 km
Bald Eagle Roost Site n = 23	4	8	88*	4	18	78*	35	8	57*
Bald Eagle (observed adults) n = 268	10	13	77*	10	10	80*	60	11	29*
Bald Eagle (observed immatures) n = 111	12	9	79*	7	24	69*	57	21	22*
Random (n = 92)	17	15	68	14	11	75	19	7	74

*Distance differed from random at $P \leq 0.05$.

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Acute Aspergillosis in Mallards at Oahe Seep Near Pierre, South Dakota

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ABSTRACT — Aspergillosis was diagnosed as the cause of death of 158 mallards (Anas platyrhynchos) in January and February 1985 and 11 mallards in December 1985 near Pierre, SD. Isolation of *Aspergillus fumigatus* from carcass tissues confirmed the diagnosis. The sex ratio of mallards dead from aspergillosis in January and February 1985 was significantly different from the sex ratio in the local population at that time. The source of the fungus was not determined, but severe weather caused physiologically stressed mallards to feed on corn stored in open piles on the ground, a likely source of the *Aspergillus* fungus.

Aspergillosis is an infectious but noncontagious fungal disease of birds caused chiefly by *Aspergillus fumigatus* (Chute 1965). The respiratory tract is usually involved, but lesions can also appear in the liver or on the intestinal surface (Chute 1965, O'Meara and Witter 1971). In chronic infections, yellow plaques, nodules, or grossly visible fungal mats might be seen in the air sacs or lungs. Birds often become emaciated over a considerable period before death. In acute infections, birds die quickly with hemorrhagic lungs filled with yellow nodules of various sizes. Acute aspergillosis has occurred in mallards (*Anas platyrhynchos*) in Colorado (Neff 1955, Adrian et al. 1978) and California (Herman 1943) and was associated with moldy ensilage and rice hulls. A wide array of bird species, both captive and wild, are known to succumb to this disease (Torrey et al. 1934, Quortrup and Schillinger 1941, Ainsworth and Rewell 1949, McDougle and Vaught 1968, Wobeser 1981).

The causative fungus and its potentially infective spores are found almost worldwide, the Antarctic being the exception (O'Meara and Witter 1971). Infection is caused by inhaling the spores. The number of spores inhaled, the physiological condition, and age of the bird combine to determine the initiation and severity of clinical disease. Newly hatched domestic chicks, aged 2-5 days, are highly susceptible; resistance increases as the birds get older. In older juvenile and adult birds, aspergillosis is more likely to develop in individuals experiencing marked physiological stress (Friend and Trainer 1969, O'Meara and Witter 1971).

Modern changes in agricultural practices allow mallards to winter farther north than traditional wintering areas (Jorde et al. 1983), and large reservoirs provide

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areas of open water for these birds. But northern climates can be harsh and can impose severe physiological stress on the birds. Wet, heavy snows or winter thaws might cause waste grain to mold with *A. fumigatus* and thus present a source of infection for birds feeding on the moldy grain. The 1975 outbreak in Colorado killed at least 387 mallards and was preceded by a heavy, wet snow (Adrian et al. 1978). We document the occurrence of acute aspergillosis in mallards wintering in central South Dakota.

STUDY AREA AND METHODS

Lake Oahe, 1500 km^2, was artificially constructed by erecting a 75-meter-high dam completed in 1962 in the Missouri River. Seep water is collected inside the dam and drains throughout the winter, keeping small areas (less than 1 ha) of water open for use by waterfowl when all other still water areas are frozen. Routine searches for sick and dead waterfowl are conducted annually in the area by the South Dakota Division of Wildlife. Personnel on foot with retrieving dogs searched for carcasses along the shorelines and interface between open water and ice of the Oahe seep eight times during the winter of 1984-85 and twice during the winter of 1985-86. Cursory checks were conducted periodically to monitor for the presence of carcasses or sick birds.

Birds found dead were necropsied on site or sent to the U.S. Fish and Wildlife Service's National Wildlife Health Research Center (NWHRC) in Madison, WI, for necropsy and laboratory evaluation. Thirteen carcasses were necropsied at NWHRC, the other 187 were necropsied at the die-off area. A provisional diagnosis of aspergillosis was based on the presence of multiple small white nodular lesions and hemorrhage throughout the lungs, fungal plaques with typical myceloid forms of fungus in air sacs, or enlarged bronchi with plugs of caseous exudate. Growth of the fungus on Sabouraud's agar and subsequent identification of *Aspergillus fumigatus* by morphological characteristics (Beneke 1980) confirmed the diagnosis. Twenty-two livers of carcasses necropsied were analyzed for lead levels by atomic absorption spectrophotometry as described by Locke et al. (1982).

An observer from the South Dakota Division of Wildlife determined the sex ratios of local duck populations using a spotting scope. Monthly summaries of local climatological data for Pierre, SD, were used to obtain temperature, precipitation, and snow depth on the ground (National Climatic Data Center, Asheville, NC).

RESULTS

Two hundred dead mallards were picked up during carcass searches in January and February 1985 on Oahe seep. Most (91%) were found during the latter part of January. Aspergillosis was diagnosed in 79% (158) of the 200 ducks necropsied; 74% (93 of 125) males and 87% (65 of 75) of the females. Three of 12 mallards aged at necropsy were immatures, the other nine were adults. Eighteen mallard carcasses were also recovered in December 1985; 11 of these died from aspergillosis. Body condition was poor in 86% (145 of 169) of birds dead of aspergillosis (these birds had little, if any, fat present and there was some degree of breast muscle atrophy), 8% (13) had normal muscle development, and 6% (11) were intermediate. During January and February 1985, there was disproportionate aspergillosis mortality between sexes. Females accounted for a larger percentage of aspergillosis deaths, and males accounted for less than expected based on the sex ratio in the live population (Table 1). Eight mallards found in January and February 1985 were lead poisoning victims. Five of the eight livers of lead poisoned birds were analyzed and found to contain lead concentrations of 37 ppm to 61 ppm (wet weight). Seventeen livers of 15 mallards that died of aspergillosis and of two gunshot birds had liver lead concentrations ranging from 0.4 ppm to one that was 2.4 ppm (wet weight). Average liver lead

Table 1. Sex ratio of 158 mallards found dead from aspergillosis in January and February 1985, and sex ratio in the live population in January 1985 at the Lake Oahe seep near Pierre, SD.

Sex	% of aspergillosis deaths	% in live population[a]
Male	59[b]	77
Female	41[b]	23

[a]Sex ration of live population based on 16 counts of a total of 1106 mallards at Oahe Dam in January 1985.
[b]Significantly different from live population (x^2 = 24.04, 1 d.f.; P $\leq$ 0.01).

concentrations of these 17 carcasses was 0.74 ppm (wet weight). The other causes of death were gunshot, trauma, or the cause of death was not determined.

Gross lesions observed in aspergillosis cases included multiple 1-mm nodular lesions throughout the lungs, often with hemorrhages; other lesions observed included enlarged and congested livers, enlarged bronchi with plugs of caseous exudate within the lumen, and fungal plaques within air sacs. *Aspergillus fumigatus* was recovered consistently from lung tissues; *Mucor*, another genus of fungi, was also occasionally recovered from the lungs. No evidence of any bacterial or viral disease was present in any of the carcasses examined. No identifiable grains or other potential sources of fungus were found in gizzard contents.

A severe snowstorm occurred on 15 January 1985, with 30 cm of snow and cold temperatures, following which hundreds of mallards were seen feeding at an uncovered pile of moldy corn. Most of the deaths occurred within eight days after this storm. After 23 January, 10 more mallards were found dead from aspergillosis. Similar environmental conditions occurred the following winter. On 1 December 1985, a severe storm dropped 62 cm of snow on the ground. Thirteen days later 10 mallards were found dead of aspergillosis and one more was found on 23 December, following a heavy snowfall on 19 December.

DISCUSSION

Lesions observed in mallards indicated that acute aspergillosis was occurring, yet most mallards that died were in poor condition and thus were possibly more susceptible to disease. The disproportionately higher mortality in females might have been due to differences in body condition between the sexes, because physiological stress increases susceptibility to aspergillosis (Friend and Trainer 1969). The source of the fungus causing mortality was not determined. However, the moldy corn was the most likely source.

Based on the information reported here and in previous studies, we recommend against allowing waterfowl to feed on moldy grain. Some preventive measures to discourage this type of food source should be undertaken to reduce mortality from aspergillosis.

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Bats and Birds Stuck on Burdock

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ABSTRACT — A review of the literature reveals several cases of bats and birds becoming stuck on the burs of common burdock (*Arctium minus*). The most frequently reported species is the golden-crowned kinglet (*Regulus satrapa*), while the largest has been the solitary vireo (*Vireo solitarius*).

The recent note by Zimmer and Kantrud (1987) on the finding of a dead ruby-crowned kinglet (*Regulus calendula*) on a burdock in North Dakota, in which they note their inability to find more than one previous publication on this subject, stimulated me to place the results of an earlier compiled review on record. As many of the incidents known to me were published in regional journals or books, I doubt that my review is complete. However, because a note on birds published by Taylor and Cameron (1985) after I had finished my initial review contained only one case that I had not found earlier, and because a note on bats by Verts (1988) published after this review was submitted contained no earlier cases unknown by me, I believe that my review is representative of the information available.

Humphrey and Cope (1976) considered accidents in general to be the single most important non-human cause of mortality to bats and listed entrapment on burdock among the accidents responsible. Several other general works on bats include burdock among hazards to these mammals (Barbour and Davis 1969, Gillette and Kimbrough 1970, Banfield 1974, Fenton 1983), while Terres (1980) lists the prickly burs of burdock among deathtraps to small birds. The incidents summarized in Table 1 suggest that small birds and bats are caught fairly frequently on burdock, though probably not sufficiently often to serve as an important mortality factor at a population level. The suggestion by Terres (1980) that small birds become entangled while extracting seeds can explain entrapment of finches and chickadees, but does not explain incidents involving bats and insectivorous birds. The entrapment of some of the latter has coincided with the presence of large numbers of insect larvae on the plants (Needham 1909). In addition to the attempts by the birds to procure food, Herzberg and Juhola (1986) suggest that gusty winds may contribute to entrapment. Such winds have been known to contribute to the deaths of some seabirds (McNicholl and Hogan 1979 and references therein), by blowing the birds against cliffs while landing, and might well cause birds foraging in burdock plants to lose their balance.

Both birds (Brown 1970, Terres 1980) and bats (Gillette and Kimbrough 1970) have become trapped by various other plants in addition to burdock. Naturalists alert to such hazards can help document both the species of plants responsible and the frequency with which various bird or bat species become trapped and the circumstances involved.

Comments and suggestions by Douglas H. Johnson and Ann Marie Wyckoff on an earlier draft helped improve this review.

Table 1. Reported incidents of bats and birds stuck on burdock.

Species	Number	Location	Condition	Source
Ruby-throated hummingbird (*Archilochus colubris*)**	2	Lake George, NY	skeleton + live bird	Fisher 1876*
	1?**	Sault Ste. Marie, Ont.	not stated	Taylor and Cameron 1985
Black-capped chickadee (*Parus atricapillus*)	1	Sault Ste. Marie, Ont.	long dead, most of carcass eaten by ants	Preece 1923
	1	?	found dead, apparently, killed while attempting to extract seeds	Archibald *fide* Brown 1970*
Red-breasted nuthatch (*Sitta canadensis*)	1	Plum Is., MA	flew after being released	Little 1925
Golden-crowned kinglet (*Regulus satrapa*)	1	Rochester, NY	mummified	Bowdish 1906*
	"scores"	Lake Forest, IL	1 released, rest found dead	Needham 1909*
	1	Plum Is., MA	almost dead; died shortly after removal	Little 1925
	2	Waterloo, Ont.	m. and f. found dead	Humphreys 1975*
	1	Oshawa, Ont.	?	D. Brunton *in* Taylor and Cameron 1985
	1	Toronto, Ont.	found dead	Herzberg and Juhola 1986
	1	near Bowmanville, Ont.	dessicated f.	J. Jennings *in* Tozer and Richards 1974*
Ruby-crowned kinglet (*Regulus calendula*)	1	Jamestown, ND	carcass, m.	Zimmer and Kantrud 1987
Solitary vireo (*Vireo solitarius*)	1	Ottawa, Ont.	recently dead	Taylor and Cameron 1985
Yellow-rumped warbler (*Dendroica coronata*)	1	Lake George, NY	fastened to plant	Fisher 1876*

Table 1 continued.

Common yellow-throat (*Geothlypis trichas*)	1	Tranquility, NJ	released alive	Brown 1970*
Pine siskin (*Carduelis pinus*)	1	East Pachoque, NY	?	O. L. Austin, Jr., *in* Brown 1970*
American goldfinch (*Carduelis tristis*)	1	Lake George, NY	flew off minus a few feathers	Fisher 1876*
	1	Belmont County, OH	mummified	Bowdish 1906*
	?-plural used	Ontario	?	D. A. Mac-Lulich *in* Humphreys 1975
	1	New Paltz, NY	imm. m., flew on release	R. Larsen *in* Wright 1984*
Bat (sp.)	1	Plum Is., MA	found dead	Little 1925
Little brown bat (*Myotis lucifugus*)***	"at least a dozen"	Rock Is., Arsenal, IL	mummified	Lyon 1925
	2	Lebanon, OR	mummified	W. Thacka-berry *in* Verts 1988
Red bat (*Lasiurus borealis*)	1	Alexandria, VA	recently dead	Johnson 1933

*also cited by Taylor and Cameron (1985)

**The record in Tyler (1940) cited by Taylor and Cameron (1985) actually involved a thistle, not burdock. The hummingbird specimen cited by them as originating at Sault Ste. Marie in 1923 may be a mistaken reference to the chickadee found there by Preece (1923). Ruby-throated hummingbird has also been reported stuck on a blue bur or stickseed (*Lappula schinata*) in Manitoba (Mossop 1959).

***Identification "probable"

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Effects of Grazing on Western Snowberry Communities in North Dakota

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ABSTRACT — Eleven communities dominated by western snowberry (*Symphoricarpos occidentalis*) were compared in 1982 and again in 1986 at the Central Grasslands Research Station in south central North Dakota to examine the impact of cattle grazing under four grazing treatments. Young stems provided 55% of stem composition in 1982 and 59% in 1986. Shrub cover decreased ($P < 0.05$) on season-long, twice-over rotation, and control treatments. Shrub production averaged across the grazed treatments increased from 142 g/m^2 in 1982 to 195 g/m^2 in 1986. Total herbaceous production on treatments averaged 218 g/m^2 in 1982 and 222 g/m^2 in 1986. Graminoid species comprised 76% of the herbaceous production; Kentucky bluegrass (*Poa pratensis*) accounted for 68% of the graminoid production. Five years of grazing by cattle under various management strategies, stocking rates, and densities did not consistently alter the structure or composition of western snowberry communities.

Western snowberry plays a role in the composition and structure of several woody vegetation types in the Little Missouri Badlands (Nelson 1961, Mastel 1983) and contributes significantly to shrub cover of the mixed-grass prairie (Pessin et al. 1986, Kirby and Ransom-Nelson 1987). Western snowberry communities are also important in wildlife and livestock production. These communities are attractive early-season nest sites for many upland nesting ducks (Leitch 1951, Duebbert et al. 1986), sharp-tailed grouse (*Tympanuchus phasianellus*) (Grosz and Kirby 1986), and numerous non-game upland nesting birds (Messmer 1985). Western snowberry is seasonally an important component of deer (*Odocoileus* spp.) and pronghorn antelope (*Antilocapra americana*) diets (Dirschl 1963, Allen 1968, Mitchell and Smoliak 1971, Dusek 1975), while cattle make limited use of western snowberry as browse (Dusek 1975, Pessin et al. 1986). Additionally, western snowberry communities protect wild and domestic animals from harsh weather.

Lura (1985) estimated that western snowberry communities covered about 33% of the pastureland at the Central Grasslands Research Station (CGRS) in south central North Dakota. Kirby and Ransom-Nelson (1987) reported that herbaceous production in western snowberry communities was about 200 g/m^2

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compared to 350 g/m^2 from similar silty range sites dominated by herbaceous species. From these data, reduction of these communities would appear desirable for livestock production. However, knowledge of the response of western snowberry communities to grazing by cattle under various management systems is essential prior to recommending management strategies for reducing snowberry. We examined the effects of cattle grazing under various management systems on western snowberry communities at the CGRS.

STUDY AREA AND METHODS

Study Area

The study was conducted on the CGRS, approximately 65 km southwest of Jamestown, ND, within the Missouri Coteau. The Coteau, of glacial origin, is characterized by "hummocky," irregular, rocky plains, and many potholes and sloughs. Vegetation is typical of the mixed-grass prairie (Whitman and Wali 1975). Important graminoid species include western wheatgrass (*Agropyron smithii*), Kentucky bluegrass, blue grama (*Bouteloua gracilis*), needle-and-thread (*Stipa comata*), Junegrass (*Koeleria pyramidata*), and threadleaf sedge (*Carex filifolia*). Some important forbs include white sage (*Artemisia ludoviciana*), fringed sage (*A. frigida*), silver-leaf scurf pea (*Psoralea argophylla*), red false globemallow (*Sphaeralcea coccinea*), and goldenrods (*Solidago* spp.). Western snowberry is the dominant low shrub on mesic sites originally supporting a variety of mid and tall graminoid species. Nomenclature follows the Great Plains Flora Association (1986).

The area has a continental climate with cold winters and warm summers. January is the coldest month with an average temperature of − 14°C and July is the warmest with an average temperature of 20°C. Mean annual precipitation for a 35-year period (1951-1986) was 45 cm, with 80% falling between April and September. Between 1982 and 1986, annual precipitation averaged 54 cm.

Grazing Treatments

Control (idle) sites were selected in sections 24 and 36 as these were last grazed in 1979. Section 25 was equally divided in 1982 and managed under short duration and season-long grazing treatments. The short duration system consisted of eight equal-sized pastures and had been grazed by one herd at a heavier (45%) than the recommended (1.8 AUM/ha) stocking rate (U.S. Soil Conservation Service 1984) since 1983 (Table 1). The system had a 5-day grazing period followed by a 35-day rest period. Livestock in the season-long treatment were free to select and graze any area within the 130-ha pasture. During 1985 and 1986, section 31 was grazed as two replicates of a twice-over rotation grazing system. Each replicate was subdivided into four equal-sized pastures and grazed by one herd at a heavier (45%) than recommended stocking rate. Each pasture was grazed for 20 days and then rested for 60 days. In 1983 and 1984 each replication of the twice-over system had three pastures totaling 100 ha.

Table 1. Grazing seasons, cow-calf pairs stocked, and stocking rate (AUM/ha) for grazed treatments, Central Grasslands Research Station, North Dakota.

Year	Date	Short duration		Season-long		Twice-over rotation	
		Pairs	Rate	Pairs	Rate	Pairs	Rate
1982	June 15-Nov. 2	45	1.6	30	1.1	0	—
1983	June 2-Nov. 8	60	2.4	40	1.6	40	2.2
1984	June 5-Nov. 5	65	2.6	45	1.8	45	2.4
1985	May 28-Nov. 4	65	2.7	45	1.8	60	2.4
1986	May 23-Oct. 31	65	2.7	45	1.8	65	2.7

Site Establishment

In 1981 and 1982, 12 western snowberry sites were arbitrarily selected for analysis based on the following criteria: (1) vigor, (2) coverage, and (3) density (at least one site per 65 ha on the station). Selection of sites was part of an initial inventory of the range plant communities of the CGRS to aid in establishing stocking rates and to provide synecological information on the most prevalent shrub community. Analyses were conducted on 11 sites in 1986. Three sites were included from each of short duration and twice-over rotation grazing systems, as well as from a control. Only two sites could be relocated in 1986 in the season-long grazed pasture. Between sampling periods, pastures were being examined for upland ground-nesting birds using a chain drag method. The transect markers for the unlocated site were removed or destroyed during these operations.

At each site, all vegetation analyses were conducted along permanently marked transects that radiated from the center of the community to the north, south, east, and west. Nine sites contained 25-m transects, while two contained 10-m transects.

Vegetation along several transects (about 10%) experienced damage due to Junebug larvae (*Phyllophaga anxia*) infestations in 1986. Transects affected by the infestations were omitted from the 1982 data and not sampled in 1986.

Vegetation Sampling

Stem density was determined by counting the number of individuals per age class located within 25 x 50 cm quadrats along each of the four permanent transects, at 10 m and 20 m on 25-m transects and at 5 m and 10 m on 10-m transects. The four age classes followed Dasmann (1951): seedling or new sucker (plus resprout), young, mature, and decadent.

A western snowberry seedling, sucker, or resprout was a small succulent, unbranched twig. A young plant was a second-year stem with primary branching originating only from the main stem. A mature stem had attained greater stature and was characterized by complex branching and a rounded crown, consisting of 50% or more living material. A decadent stem was a mature stem that appeared to be dying, containing greater than 50% of the stems and canopy as dead material.

The line intercept method (Canfield 1941) was used to determine cover of the shrub layer. Total interception by western snowberry and its two associated shrub species, prairie wild rose (*Rosa arkansana*) and leadplant (*Amorpha canescens*), was measured along the four transects at each site. The line was placed 2 m to the left of each permanent transect, parallel to it in a north, south, east, and west direction to eliminate trampling along permanent transects.

Five plants per line per age class were clipped at ground level at each site to determine shrub standing crop. This compares to systematically collected samples from sites in 1982 (Kirby and Ransom-Nelson 1987). The current season's twig and leaf growth were removed. Dry weight production of leaves and twigs was determined after drying at 65°C.

Herbaceous standing crop was estimated by placing two 25 x 50 cm quadrats 2 m (1982) and 3 m (1986) to the right of each permanent baseline. The quadrats were placed at the 7.5 m and 12.5 m marks on the 25-m transects and at the 5 m and 10 m marks on the 10-m transects. All vegetation within the quadrat, with the exception of western snowberry, was clipped at ground level. The clippings were bagged, labeled accordingly, oven dried at 65°C for three days, and weighed to the nearest 0.1 g.

Statistical analyses were performed using the Statistical Analysis System (SAS 1985). A one-way analysis of variance, with sites as replicates, was used to determine changes in western snowberry communities between years under various grazing treatments. Comparisons between grazing treatments were omitted as treatments were not replicated. Duncan's multiple range test was used to separate the means (Steel and Torrie 1980). Significance levels were determined at $P \leq 0.05$.

RESULTS AND DISCUSSION

Density

Average density of western snowberry stems remained unchanged after five years of grazing by cattle (Table 2). An average of 56 stems/m^2 was estimated in 1982 and 1986. In addition, no change in stem density occurred for any age class between the sample periods.

Mature stem density was highest on the control, whereas densities of the remaining age classes were highest on the short duration grazing system each sampling period (Table 2). Total densities of all age classes of western snowberry were highest both sampling periods on the short duration grazing treatment, followed by control, twice-over rotation, and season-long treatments. However, these differences were a result of the initial selection of study sites and not the grazing treatments as site selection was made in 1982 the same year the grazing treatments were implemented on the CGRS.

Table 2. Western snowberry age class densities (No./m²) following five years of cattle grazing under selected treatments, Central Grasslands Research Station, North Dakota.[1]

Age Class	Year	Short duration	Season-long	Twice-over rotation	Idle	Average
Sucker-	1982	30 ± 6.3	6 ± 2.7	22 ± 4.8	24 ± 4.5	21
Resprout	1986	38 ± 7.5	22 ± 4.8	22 ± 3.2	21 ± 3.7	26
Young	1982	13 ± 4.2	8 ± 2.4	10 ± 3.2	10 ± 2.3	10
	1986	11 ± 2.0	5 ± 1.6	6 ± 1.4	5 ± 1.4	7
Mature	1982	19 ± 4.2	18 ± 4.8	15 ± 2.6	22 ± 3.8	18
	1986	21 ± 4.1	12 ± 3.3	15 ± 3.2	25 ± 3.2	18
Decadent	1982	11 ± 2.8	5 ± 2.5	5 ± 1.3	6 ± 1.6	7
	1986	9 ± 2.1	3 ± 1.8	5 ± 1.8	4 ± 1.4	5
Total	1982	73 ± 8.3	37 ± 6.4	52 ± 7.7	62 ± 6.7	56
	1986	79 ± 12.3	42 ± 6.2	48 ± 6.9	55 ± 6.2	56

[1]Means ± SE between years for each age class and treatment were not different ($P > 0.05$).

Kirby and Ransom-Nelson (1987) reported in 1982 that 60% of the same western snowberry communities exhibited a youthful age structure suggesting an increase in dominance of these communities. However, their data were inconclusive because mortality rates of individual stems were not determined. Since their study, proper grazing use has been maintained on each of the grazing treatments. Annual forage use has ranged from 41% to 67% on the treatments (Kirby et al. 1986). Under this degree of use, the communities have mainained a similar age structure between study periods.

Canopy Cover

Shrub cover in grazed western snowberry communities decreased ($P < 0.05$) between sampling periods with the exception of the short duration treatment (Fig. 1). In 1982, mean shrub canopy cover was 40% in grazed treatments and declined to 32% by 1986. Leadplant and prairie wild rose together contributed less than 1% to the total canopy cover both years of sampling.

Western snowberry communities in the control had the greatest canopy cover in 1982. Although not grazed by domestic livestock, cover of shrubs decreased from 59% to 46% between 1982 and 1986. Other than variability introduced by observers' sampling error, no other explanation for this decrease in canopy cover is readily available.

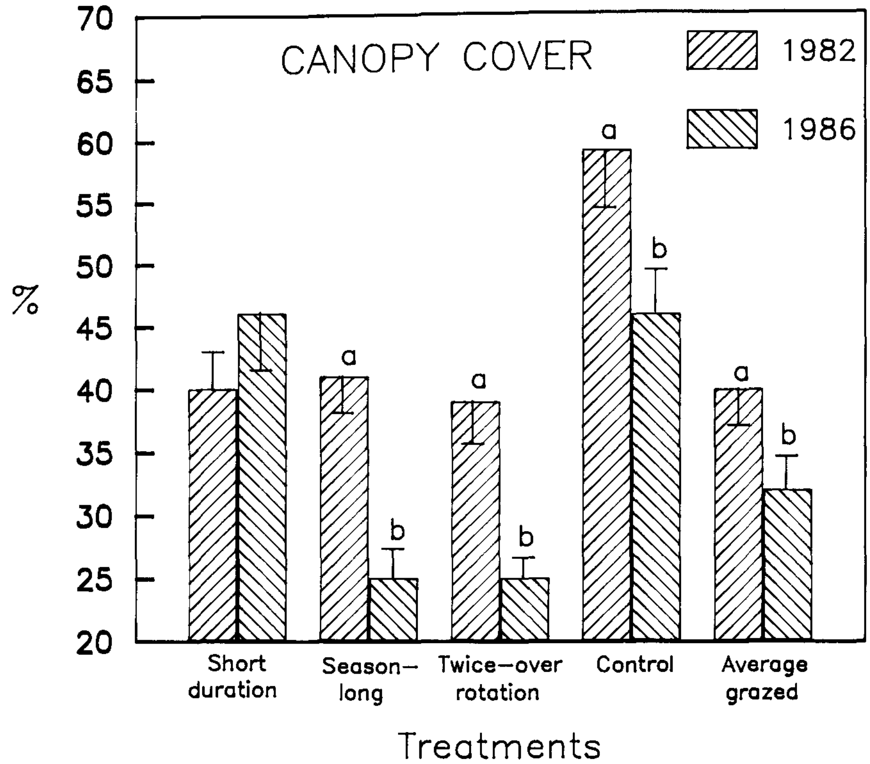

Figure 1. Changes in canopy cover (%) of western snowberry communities following five years of grazing by cattle, Central Grasslands Research Station, North Dakota. Means ± SE between years within treatments followed by a different letter differ ($P<0.05$).

Shrub Standing Crop

Shrub standing crop and composition was dominated by western snowberry both years of vegetative sampling (Fig. 2). In 1982, western snowberry contributed 97% of the total shrub standing crop (Kirby and Ransom-Nelson 1987). Prairie wild rose and leadplant together comprised less than 3% of shrub standing crop and were encountered in substantial amounts (greater than 100 kg/ha) on only one site.

Western snowberry standing crop increased ($P<0.05$) by nearly 100 g/m^2 from 170 g/m^2 in 1982 to 262 g/m^2 in 1986 in the short duration treatment (Fig. 2). Mean grazed shrub standing crop increased from 142 g/m^2 in 1982 to 195 g/m^2 in 1986. Shrub standing crop increased from 215 g/m^2 in 1982 to 223 g/m^2 in 1986 on control sites. Favorable moisture conditions between 1982 and 1986 may account for increased standing crop in all treatments.

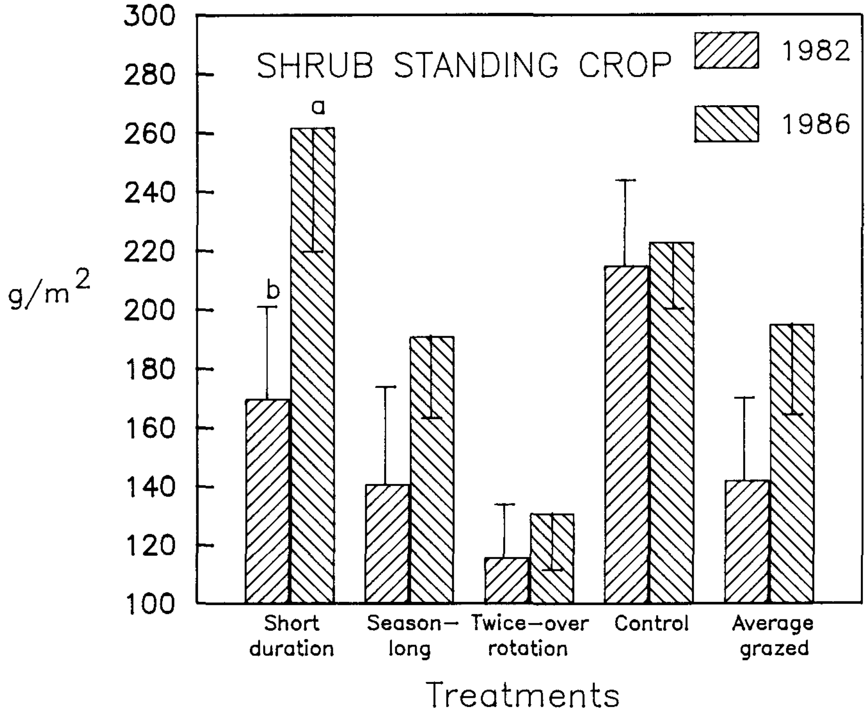

Figure 2. Changes in shrub standing crop (g/m^2) of western snowberry communities following five years of grazing by cattle, Central Grasslands Research Station, North Dakota. Means ± SE between years within treatments followed by a different letter differ ($P<0.05$).

Herbaceous Standing Crop

Total herbaceous standing crop averaged 218 g/m^2 and 222 g/m^2 in 1982 and 1986, respectively (Table 3). Increases were noted on season-long and short duration grazing treatments, while that on the twice-over rotation treatment and control decreased. The control had the least herbaceous standing crop, 191 g/m^2 and 180 g/m^2 in 1982 and 1986, respectively, which coincided with an increase in shrub canopy cover.

Graminoid species contributed the majority of herbaceous standing crop on treatments, averaging 164 g/m^2 in 1982 and 176 g/m^2 in 1986 (Table 3). Kentucky bluegrass accounted for the majority of graminoid standing crop, averaging 98 g/m^2 in 1982 and 133 g/m^2 in 1986. Sedges, other graminoids, and forbs also contributed to herbaceous standing crop both sampling periods.

Few changes in herbaceous standing crop occurred between sampling periods on the grazing treatments (Table 3). No change ($P>0.05$) was determined in

Table 3. Herbaceous standing crop (g/m^2) from western snowberry communities following five years of cattle grazing, Central Grasslands Research Station, North Dakota.[1]

Category	Year	Short duration	Season-long	Twice-over rotation	Idle	Average
Poa	1982	99 ± 10.8	109[a] ± 21.3	71 ± 11.8	113 ± 15.1	98
pratensis	1986	135 ± 14.0	197[b] ± 20.9	84 ± 8.5	116 ± 13.1	133
Carex	1982	27 ± 7.9	13 ± 4.0	32 ± 7.6	15 ± 4.9	22
spp.	1986	13 ± 6.4	4 ± 1.7	28 ± 4.2	5 ± 1.5	13
Other	1982	34 ± 8.8	49 ± 12.8	73 ± 12.1	20 ± 6.2	44
graminoids	1986	19 ± 3.5	22 ± 6.6	51 ± 7.1	30 ± 12.8	31
Total	1982	260 ± 13.3	171[a] ± 17.1	176 ± 14.9	148 ± 12.6	164
graminoids	1986	167 ± 14.2	223[b] ± 19.5	163 ± 8.5	151 ± 14.4	177
Forbs	1982	62 ± 9.5	48 ± 11.2	62 ± 11.4	43 ± 7.5	54
	1986	91 ± 23.9	53 ± 15.1	34 ± 6.4	29 ± 8.4	52
Total	1982	222 ± 17.6	219 ± 22.1	238 ± 20.1	191 ± 13.3	218
herbaceous	1986	258 ± 29	276 ± 24	197 ± 10.2	180 ± 15.6	229

[1]Means ± SE between years for each age class and treatment followed by a different letter differ ($P < 0.05$).

total herbaceous, forb, other graminoid and sedge standing crop for each grazing treatment between sampling periods. Only Kentucky bluegrass and total graminoid standing crop on the season-long treatment increased ($P < 0.05$) between 1982 and 1986. No decrease ($P > 0.05$) in herbaceous standing crop for any species or group occurred on treatments between years of sampling.

CONCLUSIONS

Following five years of grazing or exclusion of grazing by cattle, no significant changes had occurred in phytosociological or standing crop characteristics of western snowberry communities within a mixed-grass prairie. Moderately stocked (1.8 AUM/ha) season-long grazing did not alter density, age class structure, brush cover or standing crop, or herbaceous standing crop of these communities. In addition, rotational grazing at an increased stocking rate of 45% and greater stock densities (animals/ha) of 580 and 1160%, when compared to season-long grazing, resulted in no more community change than was evident under moderately stocked season-long grazing or grazing exclusion. These data suggest that the western snowberry communities examined are relatively stable under the present environmental and biological conditions.

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Book Reviews

Prairie Nat. 20(3):170-171. 1988.

BADGERLAND BIRDS

Wisconsin Birds. A Seasonal and Geographical Guide. Stanley A. Temple and John R. Cary. 1987. University of Wisconsin Press, Madison. 364 pages. $27.50 (cloth), $9.95 (paper).

A passion shared by most birders is to list things. I keep lists of the birds I have seen in Central America, in each state I have visited, in my lifetime, and during each year no matter where I have been. At times, some birders sit back and reflect on their collective lists and wonder why we ever kept them. Others try to put those lists to some practical or scientific use.

I was in the audience at the 1982 annual convention of the Wisconsin Society for Ornithology when Stanley Temple announced his plans to collect and collate weekly checklists of bird observations from birders across the state. Temple's objective was to develop a technique for determining the relative frequency and seasonal distribution of birds in Wisconsin. "From birders' checklists?", I thought. Being an ornithologist, I naturally assumed that a more elaborate and "scientific" technique was needed. With publication of this book, I am happy to admit I was wrong.

During 1982-1986, the authors received 22,829 weekly bird checklists from 431 birders in 43 regions (mostly counties) of Wisconsin. The result of their efforts is information on 265 regularly occurring birds. As the first sentence of the Introduction states, "What are the chances of finding a particular species of bird in Wisconsin?" By calculating the mean percentage of participants in the project who reported a species at least once each year during the project, the authors give you that information.

The book is arranged simply, with 25 introductory pages explaining how the project was established and how the data were analyzed. Guidance is given on how to interpret the range maps and the data on seasonal abundance patterns. A section called "A Cautionary Note" reminds us that birds, like all else in nature, do not necessarily follow the patterns that books say they should follow.

The title of the book may lead you to believe this is a state bird book, which it is not. The bulk of the book is made up of range maps and relative frequency graphs for each species considered. We are also provided with information on the seasonal abundance of each bird species. The value of these data is immense. The serious ornithologist is given a clear indication of where and when a species of interest is most easily studied. Biogeographers can compare relative abundances of, say, American woodcock in Wisconsin with similar information from New England. Birders interested in adding the great gray owl to their list need only turn to page 143 to learn that they are most likely to find their target species in Taylor County during late March.

A list of 98 "rare species" (rare for Wisconsin) is presented at the conclusion of the species accounts. Primarily these data are for irregularly occurring birds that could not be assigned frequency values. The data presented include species name, counties of occurrence, and the months it was observed. The Appendix contains information on how the data were collected and managed, presumably with an eye toward other states assuming similar projects.

I experienced one disappointment in reviewing this book. There is absolutely no information about the habitats occupied by each species. So, when you arrive in Taylor County looking for the great gray owl you will still need another reference or two to help pin down where in the region the bird might be found.

I believe that Temple and Cary are to be commended for their development of an apparently valuable technique for quantifying relative abundance of birds over a large geographic area. My only hope is that other states or provinces with sizable populations of birders will take on a similar project, perhaps ancillary to the many atlasing projects currently underway. — *Craig A. Faanes, U.S. Fish and Wildlife Service, 2604 St. Patrick Avenue, Grand Island, NE 68803.*

Prairie Nat. 20(3):171-172. 1988.

A PRIMER FOR WILDLIFE MODELING

Building Models for Conservation and Wildlife Management. A. M. Starfield and A. L. Bleloch. 1986. Macmillan Publishing Company, New York. 253 pages. $34.95 (cloth).

Gone are the days when a wildlife biologist needed only binoculars, hip boots, and notebook to learn about wild animals. Tools of today include computers, radio-telemetry, and satellite imagery. And models. These abstractions of nature were used in the pencil-and-paper era, too, but they have taken on a greater role with the advent of computers, especially affordable and accessible microcomputers, and with the greater mathematical sophistication of biologists. This book is an attempt to show how to build and use models, even when the problems are ill-defined, relations are poorly understood, and data are lacking. It succeeds admirably.

Each chapter but the first begins with a brief description of a management problem involving wildlife, in particular, African ungulates or carnivores. A model is constructed to address the problem and is modified in light of available information. Lessons from the model are clearly stated. Notable is the inclusion not only of modeling successes, but of failures, or, as they are more aptly called, false starts. Too many treatments of modeling dwell on the successes, so when a practitioner finds that a modeling effort fails to achieve the anticipated results, disappointment and disillusion follow, with modeling and the modeler both losing credibility. Starfield and Bleloch indicate that false starts are the rule rather than the exception, but they can be turned around to become useful.

Chapter 1 is introductory. Here the authors define objectives of modeling, mention that the value of a model depends on how well it suits its purpose and not on its realism, and discuss resolution of models and how time enters into modeling.

The next four chapters take the reader through the development of several models. The book is agreeable, both because it is fairly easy reading and because the authors make many statements that I agree with, but could not express as well. I have found that modeling compels individuals with differing opinions to state them clearly, and to defend them. Similarly, Starfield and Bleloch observed that modeling a declining wildebeest population forced managers to move from holding varied and vague explanations of the decline to establishing a mechanism by which it might have happened. They note correctly that validation of models is impossible, but find useful the iterative process of using a model, modifying it in response to the results, and slowly gaining confidence in it. Perhaps the most valuable statement in the book is in Chapter 2, where they mention that the purpose of modeling is not to mimic nature, but to enable one to think usefully about a problem.

For that reason, the authors, like myself, are not sanguine about the utility of ecosystem models, which attempt to capture all relevant processes of major ecosystems. They state that every detail added to a model comes at a price — the loss of our intellectual grip on the model.

Most of the book is devoted to simulation models, complex enough to require a computer to process. Chapter 6, on the other hand, deals with analytic models, which, at least in principle, can be solved mathematically. The cost of mathematical tractability is the loss of detail and specificity; results are general in nature, rather than applicable to a certain place or time. Nonetheless, analytic models with their simplicity offer a clear and direct link between the assumptions made and the results obtained, a connection often clouded in simulation models by a maze of computer code.

Chapter 7 briefly covers harvest strategies. Again one of the immediate benefits of quantifying harvest goals is to force managers to state explicitly what they are. Chapter 8 includes an introduction to rule-enhanced modeling, which permits direct interaction between a model and its user in the form of questions and answers. This leads logically to Chapter 9, a brief but effective introduction to modern decision-making tools, including expert systems. Expert systems, one of the latest buzzwords in computer technology, attempt to encapsulate the knowledge base of one or more experts on a subject into a computer data base. A client desiring the views of the expert(s) can consult instead the expert system and obtain equally good advice. Again, the authors note that possibly the greatest value of an expert system is the stimulation achieved by building the system.

The book is marred by some typographical errors or misspellings (principle for principal on page 20, analagous for analogous twice on page 127, paramters on page 199).

As a statistician, I noted some conceptual problems. On page 31 and elsewhere the authors state conclusions about simulated animal populations as if they were the real animals. The authors clearly understand the difference, but they should not let the readers lose sight of it. On page 201 the authors state that statisticians tend to reject "bad" data points, those that do not fit the trend of the rest of the data. They point out that the errant observations might provide clues to unsuspected variables playing a role. This too is one of the first possibilities a competent statistician would inquire about. A statistician would, however, suggest that hypotheses raised by this process be tested with subsequent experimentation or observation, and not simply accepted as fact.

But these points are minor. The book is a fine one, worth reading by beginning or experienced modelers alike, and by those biologists and conservationists who have heard about modeling, but are not clear as to what it's all about. — *Douglas H. Johnson, U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Jamestown, ND 58402.*

Notes

Prairie Nat. 20(3):173. 1988.

BREEDING SEASON OF THE NORTHERN GRASSHOPPER MOUSE IN KANSAS—In captivity, the northern grasshopper mouse (*Onychomys leucogaster*) breeds throughout the year, with a peak from late spring to early autumn (Egoscue, 1960, J. Mammal. 41:99-110). In the wild, reproduction "is limited to the warmer months" (Jones et al., 1983, Mammals of the Northern Great Plains, University of Nebraska Press, Lincoln). In Kansas, the species reportedly breeds "mostly from spring to early fall (April to September)" (Bee et al., 1981, Public Educ. Ser. Univ. Kans. Mus. Nat. Hist. 7:1-300).

Discovery in the Texas Cooperative Wildlife Collections of three northern grasshopper mice that had been pregnant when collected in the first week of April of 1978 in Morton County, Kansas, suggested that the period of reproduction for this species in Kansas sometimes might begin as early as March. This prompted a review of label data for females of this species in the Museum of the High Plains.

The earliest evidence of breeding in Kansas was two grasshopper mice noted as pregnant when trapped on 15 March 1985 in Finney County. One of these females contained three fetuses with crown-rump lengths of 15 mm, whereas the other contained five fetuses with crown-rump lengths of 7 mm. Given a gestation period of "about four weeks" (Jones et al., 1983), these females became pregnant in early March. The only other evidence of breeding in March was a female that contained six fetuses with crown-rump lengths of 24 mm when it was trapped on 28 March 1964 in Haskell County.

Many adult females collected from April through August in various years were pregnant. The incidence of pregnancy decreased during September, but five adult females collected on 29-30 September 1984 in Finney County included four that were pregnant (two with five fetuses, one with six, and one with eight). The latest pregnancy in autumn was an individual containing six fetuses measuring 5 mm when it was captured in Ellsworth County on 17 October 1965.

These data document that the breeding season of the northern grasshopper mouse in Kansas extends from March into October. However, the fact that the species may breed throughout the year in captivity suggests that the period of reproductive activity in the wild varies from year to year depending on weather, population size, food availability, or other factors. — *LTC Richard M. Pitts, 420th Engineer Brigade, 511 Carson, Bryan, TX 77843; Jerry R. Choate, Museum of the High Plains, Fort Hays State University, Hays, KS 67601;* and *Michael J. Smolen, Department of Wildlife and Fisheries Sciences, Texas A & M University, College Station, TX 77843.*

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ARMADILLO IN NORTHEASTERN COLORADO—The nine-banded armadillo, *Dasypus novemcinctus*, is a Neotropical species that ranges from South America to the south-central and southeastern United States (Hall, 1981, The mammals of North America, John Wiley and Sons, New York). Its distribution has expanded northward on the central Great Plains during historic time, reaching Kansas before 1942 (Cockrum, 1952, Univ. Kans. Publ. Mus. Nat. Hist. 7:1-303) and Nebraska by 1972 (Choate and Fleharty, 1975, Occas. Papers Mus. Tex. Tech Univ. 37:1-80).

The first armadillo recorded in Colorado was a subadult female that was captured alive in 1963 in the Cimarron River Valley 32 km south of Walsh in Baca County, the southeasternmost county in the state (Hahn, 1966, Southwest. Nat. 11:303). Based on this armadillo and the occasional occurrence of the species in Kansas, Armstrong (1972, Monogr. Mus. Nat. Hist. Univ. Kans. 3:1-415) predicted (p. 313) that "at least intermittent populations are, or soon will be, established in southeastern Colorado, particularly along the Cimarron River and its affluents." Meaney et al. (1987, Southwest. Nat. 32:507-508) subsequently reported on a male armadillo that was found dead in 1986 near the Arkansas River 13 km east of Lamar in Prowers County. This locality was 109 km north and 29 km west of the locality of record in Baca County but still in southeastern Colorado.

On 2 July 1987, one of us (Pinkham) found a road-killed armadillo in northeastern Colorado 2.5 km south and 9 km west of Hale (T5S, R44W, NW ¼ Sec. 25), Yuma County. This locality is near the South Fork of the Republican River (just upstream from Bonny Reservoir) and approximately 180 km north of the previous northernmost locality of record in Colorado for the species. The surrounding area consisted of an alfalfa field and an old farmstead just south of the boundary of the Bonny Reservoir State Recreation Area. The armadillo was preserved as a skin and skull and deposited in the Museum of the High Plains (MHP 24,898).

All three nine-banded armadillos known thus far from Colorado were found in association with riparian corridors. The locality of record near the South Fork of the Republican River in Yuma County is 90 km southwest (upstream) from a previous locality of record for the species near Benkelman in Dundy County, Nebraska (Choate and Fleharty 1975). The locality of record near the Arkansas River in Prowers County likewise is upstream from a previous locality of record for the species in Ford County, Kansas (Choate and Fleharty 1975). Finally, the locality of record near the Cimarron River in Baca County is upstream from a previous locality of record for the species in Stevens County, Kansas (Cockrum 1952). As noted by Humphrey (1974, Bioscience 24:457-462), nine-banded armadillos in semiarid regions are most numerous in riparian habitats and frequently use river valleys as dispersal conduits. Accordingly, it seems probable that all three records for the species in Colorado are the result of dispersal upstream (westward) rather than dispersal overland (northward). We have no reason to suspect human intervention in dispersal of the nine-banded armadillo into Colorado or elsewhere on the central Great Plains. —*Jerry R. Choate and Justin B. Pinkham, Museum of the High Plains, Fort Hays State University, Hays, KS 67601.*

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TWO DEER MICE CAPTURED SIMULTANEOUSLY IN A MUSEUM SPECIAL SNAP TRAP—Social traveling by nocturnal small mammals has been inferred from captures of pairs of animals in single capture live traps (e.g., Blaustein and Rothstein, 1978, Am. Midl. Nat. 100:376-383; Spencer et al., 1982, Am. Midl. Nat. 107:384-385; Novak, 1983, J. Mammal. 64:710-713). The validity of these inferences is questioned because of the variability in the triggering mechanism and springing weight required to close live traps (Bergstrom, 1986, Can. J. Zool. 64:1407-1411; Bergstrom and Sauer, 1986, Am. Midl. Nat. 115:201-203). Manipulating springing weights of live traps, Bergstrom and Sauer (1986) found that significantly fewer deer mice (*Peromyscus maniculatus*) were captured in insensitive (springing weight greater than 25 g) than sensitive traps (springing weight less than 25 g). Furthermore, Bergstrom (1986), using unmanipulated Sherman live traps, found that multiple captures of deer mice occurred in traps that were significantly less sensitive than traps which captured single individuals. These authors suggest that multiple captures are not necessarily due to simultaneous entry of two mice into a live trap (social traveling), only that the weight of two mice is required to spring the trap. The second mouse could, therefore, arrive and enter the trap asynchronously to the first mouse. Although social traveling has been inferred from trapping data for *Peromyscus*, it has been directly observed in two other species of nocturnal small mammals, white-toothed shrew (*Crocidura*; Zippelius, 1972, Z. Tierpsychol., 30:305-320) and hispid cotton rat (*Sigmodon hispidus*; Kaufman and Kaufman, 1987, Prairie Nat. 19:128).

During a study of the annual reproductive cycle of the deer mouse in north central Kansas, we captured 1613 deer mice in 24,840 trap nights of combined effort in three habitat types: (1) limestone outcrops in grazed native mixed-grass prairie, (2) cultivated fields in the fallow cycle, and (3) cultivated fields in the wheat cycle. On one occasion, we simultaneously captured two deer mice in a Museum Special snap trap. This double capture occurred on a limestone outcrop in Russell County, Kansas (NE ¼, Sec. 21, T11S R11W) on 17 April 1983. Both deer mice were reproductively inactive females (nonpregnant, nonlactating, and no placental scars). Standard body measurements (total length, tail length, foot length, and ear length in mm) and body weights were 142-57-18.5-14.5 and 16.2 g and 126-50-18.0-14.0 and 12.5 g for K1979 and K1980, respectively.

Due to the fact that little bait was placed on snap traps and that the peanut butter still remained on the treadle at the time of capture, it is unlikely that one of the individuals was sitting and feeding without triggering the trap as the second individual arrived. In addition, the probability of a random event in which both individuals would arrive from the same direction and at the same angle to the trap is very low. Therefore, our double capture of deer mice in a snap trap is much more indicative of social traveling than are multiple captures in live traps (Bergstrom, 1986; Bergstrom and Sauer, 1986). This capture of two deer mice eating peanut butter from the same treadle also provides an unequivocal observation of food sharing by two adult female deer mice. We do not suggest that our one double capture in over 1600 capture events represents the frequency of social traveling or, for that matter, food sharing. Rather, snap traps should underestimate social traveling since both mice must be close to each other and properly aligned for both to be caught when the trap is set off.

Support for the study of annual reproductive cycles in deer mice was provided by the Kansas Agricultural Experiment Station, Project No. R231. This is contribution No. 88-453-J, Division of Biology, Kansas Agricultural Experiment Station, Kansas State University, Manhattan. — *Glennis A. Kaufman and Donald W. Kaufman, Division of Biology, Kansas State University, Manhattan, KS 66506.*

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INFORMATION FOR CONTRIBUTORS

Correspondence: Manuscripts and correspondence should be sent directly to the Editor, P.O. Box 8238 University Station, Grand Forks, ND 58202-8238. Telephone: (701) 777-2199. Book Reviews and books for review should be sent to Book Review Editor, Douglas H. Johnson, Northern Prairie Wildlife Research Center, P.O. Box 2096, Jamestown, ND 58402-2096.

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Manuscript Preparation: Authors should follow a clear, concise style. The Council of Biology Editors (CBE) Style Manual, 5th ed., is a good reference; however, consult recent issues of *The Prairie Naturalist* for the preferred style of Literature Cited. Manuscripts should be typewritten on 8½ x 11 inch paper, double spaced throughout, with one-inch margins. The original and two photocopies are required for review purposes. Please allow about six weeks for review. For further information, see Vol. 20, No. 1, p. 64. Style Rules have also been prepared and may be obtained by writing the Editor.

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THE COVER AND ITS ARTIST

The Indian bat (*Myotis sodalis*), an endangered species, occurs mainly in the eastern states, but reaches as far west as Oklahoma. The illustration, done by Karen A. Smith while she worked for the U.S. Fish and Wildlife Service in Minneapolis, was completed as part of a series on endangered species of the Great Lakes region. Karen currently manages Lostwood National Wildlife Refuge in North Dakota.