WILDLIFE RESPONSE TO STAND STRUCTURE OF DECIDUOUS WOODLANDS

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Abstract: Deciduous woodlands provide important habitat for wildlife but comprise < 1% of the land area in the northern Great Plains. We sampled vegetation, birds, and mammals in 1983 and 1984 in 2 stand types of green ash *(Fraxinus pennsylvanica)* woodlands in northwestern South Dakota. Closed-canopy stands were multilayered communities with dense overstories of several age classes and sizes of trees and a variety of shrubs. Open-canopy stands lacked foliage layers and had sparse overstories of decadent trees. Fifteen birds and mammals occurred in significantly greater numbers ($P \leq 0.05$) in closed-canopy stands compared to open stands; numbers of 2 species were higher ($P \leq 0.05$) in open stands. Nearly 2x as many birds were observed in closed-canopy stands than were observed in open-canopy woodlands. The absence of tree reproduction in these riparian-like woodlands results in a loss of wildlife habitat and will eventually lead to the loss of this community.

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Deciduous woodlands comprise <1% of the northern Great Plains area (Bjugstad and Sorg 1984) but provide important habitat for wildlife and add to the species richness of the surrounding grasslands (Boldt et al. 1978). A major deciduous habitat in this region is green ash-chokecherry *(Prunus virginiana)* (Hansen 1985). Green ash-chokecherry stands are characteristically found in the upper reaches of grassland drainages and exist as narrow communities of varying length. When undisturbed these woodlands occur as multilayered communities with a tree canopy of green ash and a few box elder *(Acer negundo),* a dense shrub stratum of chokecherry and Saskatoon serviceberry (Ame-*Zanchier alnifolia),* and a ground layer dominated by long-beaked sedge *(Carex sprengelii),* Virginia wildrye *(Elymus virginicus)* and associated forbs (meadow rue *[Thalictrum venukosum]* and spikenard *[Smilacina stellata]).* Multilayered green ash woodlands will be referred to hereafter as closed-canopy stands.

Many green ash woodlands are declining (Boldt et al. 1978). The shrub layer is absent or nearly so with the exception of western snowberry *(Symphoricarpos occidentalis).* The ground cover is mostly Kentucky bluegrass *(Poa pratensis)* and forbs (dandelion *[Taraxacum officinale]* and yarrow *[Achillea millifolium])* (Hansen 1985) that are indicative of disturbance. Little or no reproduction of the tree or tall shrub layer is evident indicating that woodland communities may be converting to a low shrub, grass, and forb community. This stand type will be referred to as an open-canopy woodland. Heavy livestock grazing may be the major contributor to the decline of green ash

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woodlands (Severson and Boldt 1978). However, insect and disease damage and protection from fire are possible factors contributing to the decline of open-canopy woodlands (Severson and Boldt 1978).

Green ash woodlands are considered critical habitats for breeding birds in North Dakota (Gaines and Kohn 1982, Faanes 1984, Hopkins et al. 1986); throughout the Great Plains they provide habitat for birds, small mammals, mule deer *(Odocoileus hemionus),* and white-tailed deer *(O. virginianus)* (Severson and Carter 1978, Uresk 1982, Petersen 1984). We assessed the effect of woodland structure on the use of green ash communities by birds and mammals. The null hypothesis tested was that there is no difference in wildlife use or vegetative characteristics between open- and closed-canopy green ash woodlands.

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STUDY AREA AND METHODS

This study was conducted in the Slim Buttes of Harding County, northwestern South Dakota. Climate is semiarid and continental. Mean annual temperature at Camp Crook, South Dakota for 1896-1967 was 7 C (range = -34-40 C). January and July are the coldest and warmest month, respectively. Average annual precipitation is 35 cm (Spuhler et al. 1971). Elevation of the study sites range from 975 to 1,100 m above sea level. Plant communities of the Slim Buttes include mixed-grass prairie, ponderosa pine *(Pinus ponderosa)* stands, and green ash woodlands. Green ash woodlands occur in the bottom of grassland drainages.

We established 8 800- x 60-m study sites in green ash woodlands in April 1983. We established a line the length of the draw closest to the north exposure and measured 30 m on each side to produce the 800- x 60-m band. We established 4 sites in stands that were subjectively rated as closed-canopy stands, and 4 in stands that were subjectively rated as open-canopy stands. Closed-canopy stands were generally restricted to steep north-facing slopes; open-stands were characteristic of gently sloping portions of the drainages. All sites were in pastures grazed by cattle.

We estimated plant canopy cover of the understory vegetation in 30 20- x 50-cm quadrats placed 1 m apart along a permanent 30-m transect. Five transects/site (100-m intervals) provided 150 quadrats/site. Percent canopy cover, bare ground, plant litter, and cover by individual plant species were estimated using 6 cover categories (Daubenrnire 1959). We sampled each transect in June and early August 1983 and 1984. Common and scientific names of plants followed Van Bruggen (1976).

We sampled overstory vegetation in 15 7- x 7-m macroplots established at 50-m intervals on alternate sides of each draw. Heights of all trees and shrubs in the plot >2 m were recorded by species. Percent canopy cover of overstory was sampled using a box prism with readings made at 100 points on each site. We recorded presence or absence of overstory and estimated percent cover from the number of positive hits.

We estimated relative small mammal densities for each study site by live trapping. Twenty live traps (H. B. Sherman Traps, Inc., Tallahassee, Fla.) (8 x 9 x 25 cm), spaced 10 m apart, were placed on each of 3 line transects on each site (60 traps/site). Each transect was 50 m apart with 2 on the north side and 1 on the south side of the study site. We trapped monthly from May to August in 1983 and 1984. We set traps for 5 consecutive nights following 1 night of prebaiting. Rolled oats mixed with peanut butter were used as bait. We identified captured mammals by species and marked them by toe clipping (Taber and Cowan 1971).

We sampled birds on 800-m belt transects following methods outlined by Emlen (1971, 1977). We sampled during favorable weather for 4 consecutive mornings monthly from May to October 1983 and 1984, beginning within 30 minutes of sunrise.

Sixteen I-m diameter track counting stations were placed every 50 m along the 800-m sect on each site. The tracking stations were located on established game trails on alternate sides of the draw to estimate use by intermediate and large-sized mammals. Track stations were cleared of all vegetation, debris, and rocks, and covered with approximately 1 cm of sifted soil. Each station was checked for 9 consecutive days/month and we recorded nurnbers of tracks by species. The stations were cleared of tracks each

day. Tracking stations were checked from June to September 1983 and May to October 1984.

Winter and spring deer use was estimated using an 800- x 2-m deer pellet transect on each site. The transect followed the bird transect. All deer pellets were cleared from the transect in September 1983 and pellets were counted in May 1984.

Data collected on animal species were treated as indices to assess use of the 2 stand types. Stand type differences for mammals, birds, and track counts were evaluated using repeated measures analysis of variance (ANOVA). The initial test was made using time as the repeated measure with months nested in years. If an interaction between stand type and year was detected, each year was analyzed separately using months as the repeated measure. If an interaction between stand type and month was detected during individual years, stand type differences were tested using a t-test on each month individually. Deer pellet groups were compared between stand types using a t-test for each sample session.

We compared understory plant canopy coverage between stand types using a 3-way ANOVA with the effects being stand type, year, and month. Homogeneity of variances was tested using the Bartlett's box F-test. Overstory tree and shrub species densities were calculated as numbers / ha; stand types were compared using a 1-way ANOVA by stand type. Percent canopy coverage of the overstory was compared by stand type using a l-way ANOVA. Trees >2 m tall measured in the macroplots were separated into 4 categories: 2-5, 6-8, 9-11, and > **11** m. Shrubs were separated into 2-3 m and >3 m categories. Density of trees or shrubs in each category was compared by stand type using a l-way ANOVA.

RESULTS

Vegetation

Understory total plant canopy coverage (P = 0.67), litter (P = 0.16), and bare ground (P = 0.99) were similar between stand types for all sample sessions combined (Jun and Aug 1983-84), indicating stand type has little effect on these parameters. Shrub canopy coverage (woody plants <2 m tall) was higher (P = 0.002) in closed-canopy stands, averaging 55% compared to 39% in open-canopy stands for all sessions combined. Grass canopy coverage was higher (P = 0.004) in open stands than in closed stands, averaging 53 and 35% respectively. Forb coverage was similar between stand types (P = 0.24), averaging 27% in closed stands, and 22% in open stands.

Table 1. Overstory tree and shrub densities, by height category in green ash woodlands, South Dakota, 1983.

Vegetation Ht (m)	Closed-canopy			Open-canopy		
	n	$\bar{x}$	SE	*n*	$\bar{x}$	SE
Shrub						
2-3	2,707	677	184	313	78	44*[a]
>3	529	132	26	13	3	3*
Tree						
2-5	1,252	313	36	217	54	19*
6-8	1,442	360	43	585	146	20*
9-11	1,048	261	31	501	125	14*
>11	190	48	23	81	20	9

[a] Closed vs. open-canopy is significantly different ($P \leq 0.05$).

Tree densities were greater (P < 0.001) in closed stands than in open stands in all height categories measured with the exception of the trees > 11 m tall, which were similar but quite variable (P = 0.30) in both stand types (Table 1). Densities of shrubs in both height categories were greater (P < 0.02) in closed-canopy stands than in open-canopy stands (Table 1). Percent canopy coverage of the tree overstory was greater ($P <$ 0.001) in closed-canopy stands (62%) than in open-canopy stands (30%).

Mammals

Voles *(Microtus* spp.) and deer mice *(Peromyscus maniculatus)* were the most common small mammals captured in both stand types. Other species captured were white-footed mice *(Peromyscus leucopus),* bushy-tailed woodrats *(Neotoma cinerea),* house mice *(Mus musculus),* plains pocket mice *(Perognathus flavescens),* and hispid pocket mice *(P. hispidus).* Voles were captured in similar numbers (P = 0.86) in open- and closed-canopy woodlands with 675 and 644 unique captures, respectively. Prairie vole *(M. ochrogaster)* and meadow vole *(M. pennsylvanicus)* were present on the study area but were not differentiated. Deer mice (*n* = 350) (P = 0.01), white-footed mice (*n* = 21) (P = 0.01) and bushy-tailed woodrats (*n* = 15) (P = 0.05) were captured in significantly higher numbers in closed-canopy stands compared to open-canopy stands ($n =$ 147, 2, and 1, respectively). No small mammal species were found in significantly higher numbers ($P \leq 0.05$) in open stands than in closed stands.

The most common mammals whose presence was detected by track stations in open- and closed-canopy woodlands were white-tailed and mule deer. Tracks of other species of mammals included cottontail *(Sylvilagus* spp.), white-tailed jackrabbits *(Lepus townsendii),* porcupines (*Erethixon dorsatum),* striped skunks *(Mephitis mephitis),* raccoons *(Procyon lotor),* coyotes *(Canis latrans),* red foxes *(Vulpes vulpes),* bobcats *(Felis refus),* and weasels *(Mustela* spp.). Deer (n = 581) and cottontail (n = 41) tracks were found in significantly (P = 0.03 and 0.01, respectively) greater numbers in closed-canopy stands compared to open-canopy stands (n = 369 and 7, respectively). There were no animal species found in significantly ($P \leq 0.05$) greater numbers in open stands than in closed stands for both years combined; however, when years were analyzed separately, white-tailed jackrabbit tracks were found in significantly (P = 0.03) greater numbers in open stands (n = 11) than in closed stands (n = zero) during 1983.

Track counts indicated that deer numbers peaked and were higher (P = 0.04) in closed stands (n = 246) than in open stands (n = 128) in June. Numbers of deer tracks declined from July to September in open (n = 138, 77, and 26, respectively) and closed (n = 145, 98, and 92, respectively) green ash woodlands.

Deer pellet groups were significantly (P = 0.01) greater in closed-canopy stands than in open-canopy stands, indicating deer used closed-canopy stands in the winter and early spring to a greater extent than the open stands. More deer pellet groups (n = 52) were found in closed-canopy stands compared to open-canopy stands (n = 14).

Birds

We observed 82 species of birds. Significantly (P = 0.002) more birds were found in closed-canopy stands compared to open-canopy stands. Rufous-sided towhee *(Pipilo erythrophthalmus)* and field sparrow *(Spixella pusilla)* were the most abundant species in both stand types. The next most commonly observed birds in closed stands were black-capped chickadee *(Parus atricapillus),* American robin *(Turdus migratorius),* empidonax flycatcher *(Empidonax* spp.), and American goldfinch *(Carduelis tristis).* In open stands, the next most abundant species were mountain bluebirds *(Sialia currucoides),* sharp-tailed grouse *(Tympanuchus phasianellus),* and western meadowlarks *(Sturnella neglecta).* Bird species found in significantly ($P \leq 0.05$) higher numbers in closed-canopy stands compared to open-canopy stands with years combined included rufous-sided towhees, black-capped chickadees, field sparrows, American goldfinches, great horned owls *(Bubo virginianus),* dark-eyed juncos *(Junco hyemalis),* empidonax flycatchers, orange-crowned warblers *(Vermivora celata),* Wilson's warblers *(Wilsonia pusilla),* and Swainson's thrushes *(Catharus ustulatus)* (Table 2). Of these species, dark-eyed juncos, empidonax flycatchers, Wilson's warblers, and Swainson's thrushes were observed in green ash woodlands only during migration; the remainder were also observed during the breeding season. During the 1984 fall migration, American robins were present in greater (P = 0.05) numbers in closed-canopy stands compared to open-canopy stands. The only species of birds observed in greater (P = 0.03) numbers in open-canopy stands compared to closed-canopy stands was the western meadowlark.

DISCUSSION

Closed-canopy stands with their different size and age classes of trees and shrubs show signs of perpetuating themselves. Open stands consisted of a low shrub layer of western snowberry and a sparse tree overstory of mature green ash trees with intermediate layers absent. Open stands showed little sign of reproduction of the tree and tall shrub component and appeared to be converting to grass-forb communities. Boldt et al. (1978) reported lack of regeneration and replacement of woodlands by grass-forb stands as a major problem.

Topography appeared to have an important influence on stand structure in these woodlands. The steep slopes of closed stands discouraged livestock use although the stands were located in the same pastures and exposed to similar grazing pressure as open stands. Cattle use decreased as slope increased in southwestern Montana (Mueggler 1965). Also steeper, north-facing slopes receive less sunlight and are cooler and more moist than other more exposed areas (Richardson and Wollenhaupt 1983). The combination of reduced cattle grazing and increased moisture likely provided more suitable growing conditions for plants in closed stands than open stands.

Deer mice, white-footed mice, and bushy-tailed woodrats preferred closed- to open-can-

Table 2. Birds observed/site in green ash woodlands of the Slim Buttes, South Dakota in 1983-84 combined, that were significantly different between closed and open canopys ($P \leq 0.05$).

Species	Closed-canopy			Open-canopy		
	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Great horned owl	19	5	1	2	1	1
Western meadowlark	4	1	1	104	26	7
Rufous-sided towhee	813	203	15	333	83	14
Black-capped chickadee	532	133	18	106	27	5
Field sparrow	687	172	30	315	79	6
Dark-eyed junco	81	20	4	16	4	1
Empidonax flycatchers	101	25	5	20	5	1
American goldfinch	187	47	2	61	15	3
Orange-crowned warbler	35	9	2	7	2	1
Swainson's thrush	34	9	3	1	1	1
Wilson's warbler	28	7	3	4	1	1

opy woodlands. Higher deer mouse densities in closed-canopy stands were attributed to lower grass densities on these sites, compared to open-canopy stands. Other authors (Hansen and Warnock 1978, Geier and Best 1980) reported negative correlations of deer mouse captures with grass cover. White-footed mice prefer woodlands and brushy areas (Jones et al. 1983) and may be attracted to the more extensive tree and shrub layer that is found in closed-canopy woodlands. Higher shrub densities in closed-canopy stands provided potential den sites and food for bushy-tailed woodrats. Woodrats select den sites in a variety of locations usually with rocks and shrubs; leaves of shrubs provide the greatest amount of food (Lechleitner 1969).

The desert cottontail (S. *audubonii)* and eastern cottontail (S. *floridans)* occur in the Slim Buttes; both species are abundant in thickets and brushy vegetation where suitable cover is provided (Andersen and Jones 1971). The dense shrub cover of closed-canopy stands likely provided more habitat for cottontails than open woodlands that lacked shrub cover. The white-tailed jackrabbit is the only species of jackrabbit that occurs in northwestern South Dakota (Andersen and Jones 1971) and is associated with open plains.

The combination of cover and more food may explain the high deer use of closed- rather than open-canopy stands. Mule deer use chokecherry habitat extensively as fawning sites and for early fawn rearing activities, and shrubs for hiding and shade (Steigers 1981). Closed-canopy stands in the Slim Buttes fulfilled these habitat requirements to a greater extent than did open-canopy stands. Swenson et al. (1983) found that green ash woodlands were important to mule deer and white-tailed deer in southeastern Montana during the winter months because they provided protection from inclement weather and contained abundant browse. The proportion of woody plants in diets of white-tailed deer in the Black Hills of South Dakota increased throughout the winter months (Uresk and Dietz 1980).

The arboreal activities of birds enabled them to take full advantage of dense multilayered closed-canopy stands. Physical structure of the habitat is an important dimension for birds because it provides courtship and display stations, nesting sites, protection from predators, shelter from physiological stress, and additional substrates for food (Wiens and Rotenberry 1981). Closed-canopy stands in the Slim Buttes had greater densities of trees and shrubs than open-canopy stands in nearly all size classes. This resulted in a more structurally diverse habitat in closed- compared to open-canopy stands and contributed to higher bird numbers in closed-canopy stands.

There were 10 bird species found in significantly higher numbers in closed-canopy stands compared to open-canopy stands. Rufous-sided towhees, field sparrows, and American goldfinches were associated with high shrub densities in green ash woodlands in North Dakota (Faanes 1983). Shrub density was greater in closed-canopy stands compared to open-canopy stands in the Slim Buttes, which could explain these species' affinity for closed-canopy woodlands. Black-capped chickadees inhabited the middle sapling layer in deciduous woodlands in Pennsylvania (Casey and Hein 1983). This layer was more extensive in closed-canopy stands than in open-canopy stands, which may explain the large numbers of black-capped chickadees in Slim

Buttes closed-canopy stands. The great horned owl is a characteristic inhabitant of groves or thickets of trees (Stewart 1975). In the Slim Buttes, they selected the more dense vegetation of closed-canopy stands (at least during the day). Empidonax flycatchers, dark-eyed juncos, orange-crowned warblers, and Wilson's warblers are characteristic of dense deciduous woodlands (Johnsgard 1979), which likely explains their preference for closed stands during migration through the Slim Buttes. The Swainson's thrush is characteristic of dense moist coniferous forests (Johnsgard 1979); during migration closed-canopy woodlands met their habitat needs better than open stands. American robins flock in the fall and congregate in areas of high berry production (Bent 1949). Large flocks of robins observed in closed-canopy stands were attributed to the higher frequency of berry-producing plants such as chokecherry and serviceberry when compared to open stands. The western meadowlark is primarily a grassland species and uses green ash mainly for perches. Therefore green ash woodlands in any condition would not be critical to its survival.

Further research on how to rejuvenate open-canopy stands is a prerequisite to maintaining these stands and the resulting populations of the wildlife species that are dependent on them. The multiple layers of closed-canopy stands provide habitat for a variety of wildlife, which open stands fail to match. Seedling and sapling growth that was occurring in closed-canopy stands will ensure the perpetuation of this valuable habitat type on the northern Great Plains.

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