

Wildlife Associations in Rocky Mountain Juniper in the Northern Great Plains, South Dakota

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ABSTRACT.--Rocky Mountain juniper is an important habitat component in the northern Great Plains. These woodlands provide vertical and horizontal vegetative structure that enhances wildlife use. Ecological approaches to managing habitats require understanding relationships between wildlife species and succession in plant communities. We determined bird, small mammals and large mammals habitat use in seral stages of Rocky Mountain juniper woodlands along the Missouri River in South Dakota. Fifty-three bird species occurred in these woodlands. Bird species diversity averaged 2.7 across 24 study sites and we tallied an average of 4.6 bird species during a 3day sample session at e&h site. Black-billed Magpies and Blue Jays were the only tree-nesting species whose abundance differed statistically among seral stages of juniper. Trends in the data suggested tree and shrub nesting guilds, total bird abundance, bird species diversity, and birds species richness increased in early and late seral stages. Snags and cavity-nesting species were rare in all seral stages. Northern Flickers were more abundant in late seral juniper; House Wrens were more abundant in intermediate seral juniper. Ground-nesting species declined from low seral to high seral stages. White-footed mice, deer mice, prairie voles, total small mammal abundance, and small mammal species richness were higher in the intermediate seral stage of juniper. Eastern cottontail abundance was greatest in late seral juniper. Trends in deer use suggested higher use of early and late seral stages of juniper woodlands. Patch size, juxtaposition of other woodlands, and animal home range size likely influenced wildlife abundance in seral stages of Rocky Mountain juniper.

INTRODUCTION

Rocky Mountain juniper (*Juniperus scopulorum*) woodlands exist in scattered stands in the Missouri River basin. This species is near the eastern limit of its range (Noble 1990). Juniper woodlands occur in highly eroded and rugged terrain. There is evidence of past harvest of larger trees for fence posts (Hansen et al. 1984). Larger trees occur in areas protected from fire or inaccessible to firewood cutting Rocky Mountain juniper does not sprout following fire or cutting (Noble 1990) and the areal

extent of juniper woodlands in the northern Great Plains has increased with suppression of fires (Wright et al. 1979).

Grassed and forbs of the mixed-grass prairie are common in juniper woodlands. Little-seed rice-grass (*oryzopsis micrantha*) is largely restricted to juniper woodlands in this region and it is often dominant in the understory (Hansen et al. 1984, Girard et al. 1989). Vegetative descriptions of "climax" stands of Rocky Mountain juniper in the northern Great Plains occur in Hansen et al. (1984) and Girard et al. (1989).

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Juniper woodlands are important habitat for wildlife because adjacent grassland habitats lack vegetation structure (Sieg 1991a). Greater vertical structure increases species richness and density of passerine birds (Willson 1974, Roth 1976, Rotenberry and Weins 1980). Juniper woodlands provide habitat necessary for existence of many bird species on the northern Great Plains (Sieg 1991a,b).

Juniper woodlands are also important for mammals. Some species of small mammals occur in greater abundance in juniper woodlands in the northern Great Plains (MacCracken et al. 1985a,b; Sieg 1988). Juniper woodlands are important habitats for mule deer (Severson and Carter 1978).

The relationships between wildlife and succession in Rocky Mountain juniper have not been examined for this region. The objective of our research was to use a coarse filter approach and examine wildlife abundance in relation to seral stages of Rocky Mountain juniper along the Missouri River in South Dakota.

STUDY AREA AND METHODS

We sampled 24 sites in 3 seral stages of Rocky Mountain juniper (N = 13, 5, and 6 in early, intermediate, and late seral stages, respectively) along the Missouri River from 1990 to 1992. A quantitative seral stage classification (Uresk 1990) was applied to Rocky Mountain Juniper woodlands to estimate seral stages (unpubl. data, Rocky Mountain Experiment Station, Rapid City, SD). The areal extent of juniper stands surrounding sample sites varied. The minimum size was large enough to encompass a 40 x 50 m plot for vegetation samples.

Of the sites we sampled, early seral juniper woodlands averaged 326 juniper seedling-saplings/ha (12.5 cm dbh) and 393 trees/ha (>2.5 cm dbh). Juniper seedling-saplings increased to 2087/ha with >1235 trees/ha in the intermediate seral stage. Seedling-sapling density declined to 526/ha in the late seral stage and tree density averaged 1418/ha. Tree density was similar between intermediate and late juniper, but average dbh increased from 7.5 cm to 12.7 cm and tree basal area nearly doubled in late seral juniper. Overstory canopy cover averaged 20% in early seral juniper, 50% in intermediate, and 54% in late seral juniper. Grass cover averaged 42%, 18% and 34% in early, intermediate, and late seral stages, respectively. Little-seed ricegrass averaged 19% cover in late seral juniper. Shrubs averaged 13%, 30%, and 4% cover in early to late seral juniper, respectively.

Birds

We estimated bird abundance at each site using the variable circular-plot technique (Reynolds et al. 1980). Bird counts were conducted between sunrise and 1100 hours for three consecutive days during each sample session. In 1990, we completed one sample session in late June. During 1991-92, we completed three sample sessions between May 15 and July 4. During a 5-minute sampling interval, we recorded the identity of all birds seen or heard, sex, estimated distance from the sample point, and presence in or out of the woodland. The sampling order of sites was changed daily to ensure that bird counts occurred throughout the morning. We did not count birds when wind speeds exceeded 10 km/hr or during rainy weather.

Mammals

We estimated small mammal abundance by trapping small mammals in Sherman live-traps. Two lines of 10 traps spaced at 5-m intervals, were established 10 m apart. Traps were baited with commercial bird seed mix and a mixture of peanut butter and rolled oats. We trapped small mammals four consecutive nights during the last week of July or first three weeks of August each year. Trapping periods of 3-5 days are adequate for estimating relative abundance of rodents (Johnston and Keller 1983). Each animal captured was toe-clipped for identification.

We estimated medium and large mammals use of juniper woodlands using scent pit surveys (Linart and Knowlton 1975, Conner et al. 1983, Drew et al. 1988). Vegetation and litter were cleared from four 1-m plots and the plot was covered with a fine layer of sifted soil. Two plots were located 25 m above and below the center of the sample site and two, 10 m on either side. A plaster disc soaked in fatty-acid scent (USDA, Animal Pesticide Health Inspection Service, Pocatello, ID) was placed in the center of each plot. We prepared plots during the day and identified tracks (Murie 1974) of animals in the sifted soil the next morning. Each plot was prepared again and tracks were recorded on the second day. Scent pellets were removed after each sample session. Three, two-day sample sessions were completed in June, September, and November 1990; four sample sessions (April, June, September, and November) were completed in 1991 and 1992.

Analyses

Detection and density estimates of most birds decline beyond 30 m (Emlen 1971, Verner and Ritter 1988). Only birds within 30 m of the count point and within the juniper woodland were included in our analyses. Although data are reported as density estimates within 30 m of the census point, they should not be construed as absolute estimates of density. It is impossible to assure that all birds within 30 m of the census point were counted (Verner 1985).

We summarized data to estimate abundance of birds and guilds (DeGraaf et al. 1991) as averages per site in a hierarchical manner. Data were aggregated to calculate averages across days within sample session, sample sessions within years, and years within sites. Some bird **species** occurred on fewer than five sites; these data were not presented. However, we included data from all birds within 30 m in calculations of guild abundance, species richness, and species diversity. Bird species diversity was calculated using the Shannon-Wiener formula from average abundance per site. Bird species richness is the number of species at each site per sample session.

Small mammal abundance is estimated as the average number of unique individuals per night at each site. Small mammal species richness is the number of species captured at each site. Medium and large mammals are the average number of visits each night for each site.

Our data did not meet homogeneity of variance and normality assumptions of parametric statistics. We used a multi-response permutation procedure (MRPP) (Mielke 1984) to test hypotheses of no differences of bird abundance, guild abundance, species diversity, and species richness among seral stages. MRPP **was also** used to make comparisons of small and large mammal abundance among seral stages.

We used a $\alpha = 0.20$ for tests of differences among seral stages. Our objectives were to provide managers with information regarding wildlife relationships to seral stages in juniper woodlands. Sample sites were selected along 320 km of the Missouri River without regard to size of woodlands or landscapes. Woodland area and juxtaposition of other vegetation types add variability to wildlife associations with seral stages. We did not select more stringent levels of statistical significance because Type II errors were as important as Type I errors.

RESULTS

Common and scientific names of birds and mammals and their occurrence are in Tables 1 and 2. We observed 53 bird species in juniper woodlands. Many species were rare or occurred on fewer than 5 sites. Bird species diversity averaged 2.7 for juniper woodlands regardless of seral stage; bird species richness averaged 4.6 per 3day sample session regardless of seral stage. Seven small mammal species were trapped and 11 other mammal species visited scent pits. Small mammal species richness averaged 2.2 per site.

Bird Responses To Seral Stages

Black-billed Magpies were more abundant ($P = 0.13$) in intermediate than early seral juniper (fig. 1). Despite a higher average abundance of magpies in late seral juniper did not differ from other seral stages. Blue Jays were more ($P = 0.03$) abundant in late seral juniper than the early or intermediate seral stages. Tree-nesting species tended to be more common in early and late seral stages than the intermediate seral stage. Northern Flickers were more ($P < 0.08$) abundant in late seral juniper (fig. 2) and intermediate seral juniper had more ($P = 0.01$) House Wrens than late or early seral stages of juniper. Abundance of cavity-nesting species showed trends toward increasing from early to late seral stages in juniper. No differences were apparent among birds in the shrub nesting guild (fig. 3). Common Yellowthroats and Rufous-sided Towhees showed trends toward higher abundance in later seral stages (fig. 4). Vesper Sparrows were more ($P = 0.03$) abundant in early seral juniper, while Field Sparrows, and lark sparrows showed trends toward greater abundance in early seral juniper.

Brown-headed Cowbirds were marginally more abundant ($P = 0.21$) in early seral juniper and declined in intermediate and late seral stages (fig. 5). Trends suggested total bird abundance and bird species richness reflected abundance of the tree nesting guild, but not significantly. Bird species diversity did not differ among seral stages ($P = 0.90$).

Table 1.-Common name, genus, species, and nesting guild of birds observed in juniper woodlands along the Missouri River, South Dakota, 1990-1992.

Common name	Genus/species	Guild ¹	Seral Stage ²		
			Early	Intermediate	Late
Killdeer	<i>Charadrius vociferus</i>	G	X		X
Turkey Vulture	<i>Cathartes aura</i>	T	X	X	
Prairie Falcon	<i>Falco mexicanus</i>	L	X		
Ring-necked Pheasant	<i>Phasianus colchicus</i>	G	X	X	X
Wild Turkey	<i>Meleagris gallopavo</i>	G	X		
Mourning Dove	<i>Zenaidura macroura</i>	T	X	X	X
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	S	X		
Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>	S	X		
Short-eared Owl	<i>Asio flammeus</i>	G	X		X
Common Nighthawk	<i>Chordeiles minor</i>	G	X	X	X
Northern Flicker	<i>Coleptes auratus</i>	C	X		X
Eastern Kingbird	<i>Tyrannus tyrannus</i>	T	X	X	X
Western Kingbird	<i>Tyrannus verticalis</i>	T	X		X
Great Crested Flycatcher	<i>Myiarchus crinitus</i>	C	X		X
Empidonax Flycatchers	<i>Empidonax species</i>	T	X		
Tree Swallow	<i>Tachycineta bicolor</i>	C	X		X
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	L	X	X	
Cliff Swallow	<i>Hirundo pyrrhonota</i>	L	X	X	X
Blue Jay	<i>Cyanocitta cristata</i>	T	X	X	X
Black-billed Magpie	<i>Pica pica</i>	T	X	X	X
Black-Capped Chickadee	<i>Parus atricapillus</i>	C	X	X	X
Whit-breasted Nuthatch	<i>Sitta carolinensis</i>	C	X		
House Wren	<i>Troglodytes aedon</i>	C	X	X	X
Wood Thrush	<i>Hylocichla mustelina</i>	S	X		X
American Robin	<i>Turdus migratorius</i>	T		X	
Loggerhead Shrike	<i>Lanius ludovicianus</i>	S	X	X	X
Gray Catbird	<i>Dumetella carolinensis</i>	S		X	
Brown Thrasher	<i>Toxostoma rufum</i>	S	X	X	X
Cedar Waxwing	<i>Bombycilla cedrorum</i>	T	X	X	X
Red-eyed Vireo	<i>Vireo olivaceus</i>	T	X		
Warbling Vireo	<i>Vireo gilvus</i>	T	X		
Yellow Warbler	<i>Dendroica petechia</i>	S	X		X
Common Yellowthroat	<i>Geothlypis trichas</i>	G	X	X	X
American Redstart	<i>Setophaga ruticilla</i>	T			X
Black-headed Grosbeak	<i>Pheucticus melanocephalus</i>	T	X		X
Blue Grosbeak	<i>Guiraca caerulea</i>	T	X		X
Indigo Bunting	<i>Passerina cyanea</i>	S	X		
Rufous-sided Towhee	<i>Pipilo erythrophthalmus</i>	G	X	X	X
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	G	X		
Vesper Sparrow	<i>Pooecetes gramineus</i>	G	X	X	X
Savannah Sparrow	<i>Passerculus sandwichensis</i>	G	X		X
Song Sparrow	<i>Melospiza melodia</i>	G	X		
Lark Sparrow	<i>Chondestes grammacus</i>	S	X	X	X
Field Sparrow	<i>Spizella pusilla</i>	G	X	X	X
Chipping Sparrow	<i>Spizella passerina</i>	G	X	X	X
Lark Bunting	<i>Calamospiza melancorys</i>	G	X		
Western Meadowlark	<i>Sturnella neglecta</i>	G	X	X	X
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	S	X	X	X
Brown-headed Cowbird	<i>Molothrus ater</i>	P	X	X	X
Common Grackle	<i>Quiscalus quiscula</i>	T	X	X	X
Northern Oriole	<i>Icterus galbula</i>	T	X		
House sparrow	<i>Passer domesticus</i>	C		X	
American Goldfinch	<i>Carduelis tristis</i>	T	X	X	X

¹Guild symbols - T = tree nesting; C = cavity nesting; S = shrub nesting; G = ground nesting; L = ledges, cliffs, and crevices; and P = nest parasite.
²X indicates present in seral stage.

Table 2.—Common and scientific names and occurrence by seral stage of small and large mammal species captured or visiting scent pits in juniper woodlands along the Missouri River, South Dakota, 1990-1992.

Common name	Genus/species	Seral Stage ¹		
		Early	Intermediate	Late
Thirteen-lined ground squirrel	<i>Spermophilus tridecemlineatus</i>	X		
Prairie vole	<i>Microtus ochrogaster</i>	X	X	X
Meadow vole	<i>Microtus pennsylvanicus</i>	X	X	X
House mouse	<i>Mus musculus</i>	X	X	X
Hispid pocket mouse	<i>Perognathys hispidus</i>	X		
White-footed mouse	<i>Peromyscus leucopus</i>	X	X	X
Deer mouse	<i>Peromyscus maniculatus</i>	X	X	X
Coyote	<i>Canis latrans</i>	X	X	X
Porcupine	<i>Erethizon dorsatum</i>	X		
Bobcat	<i>Lynx rufus</i>	X		
White-tailed jackrabbit	<i>Lepus townsendii</i>	X		
Striped skunk	<i>Mephitis mephitis</i>	X	X	X
Deer	<i>Odocoileus spp.</i>	X	X	X
Raccoon	<i>Procyon lotor</i>	X	X	X
Eastern cottontail	<i>Sylvilagus floridanus</i>	X	X	X
Badger	<i>Taxidea taxus</i>	X		X
Red fox	<i>Vulpes vulpes</i>	X		

¹X indicates present in seral stage.

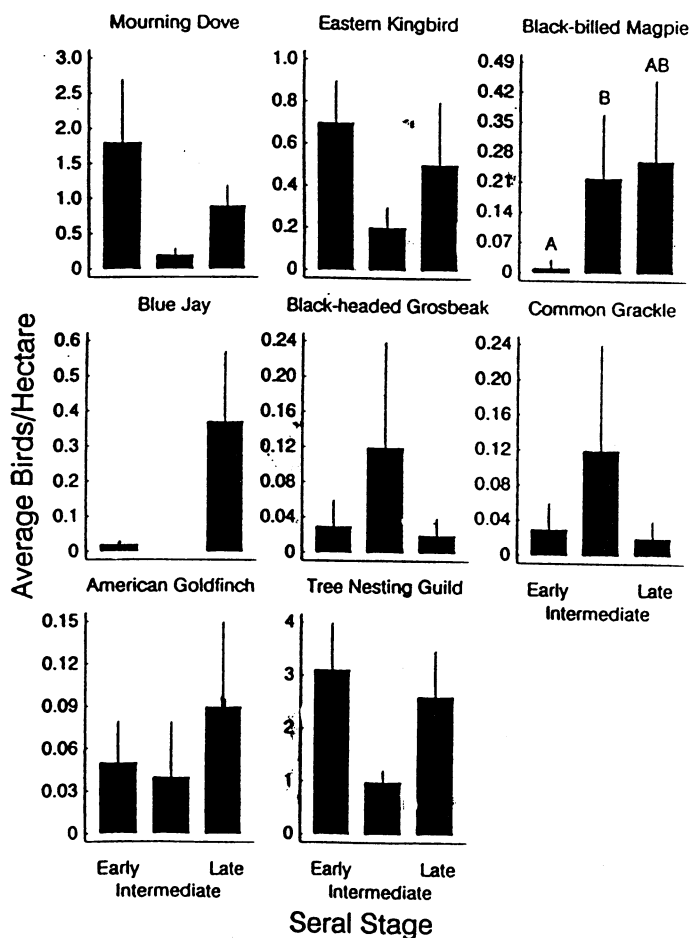


Figure 1.—Average abundance (birds/ha) of tree-nesting species among seral stages of Rocky Mountain juniper along the Missouri River, South Dakota 1990-92. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$, MRPP test.

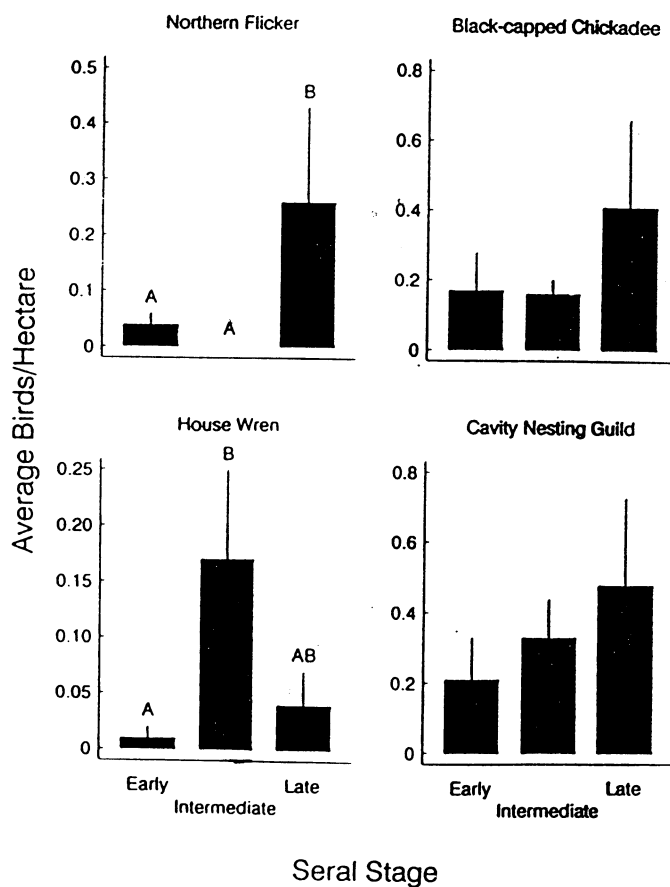


Figure 2.—Average abundance (birds/ha) of cavity-nesting species among seral stages of Rocky Mountain juniper along the Missouri River, South Dakota 1990-92. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$, MRPP test.

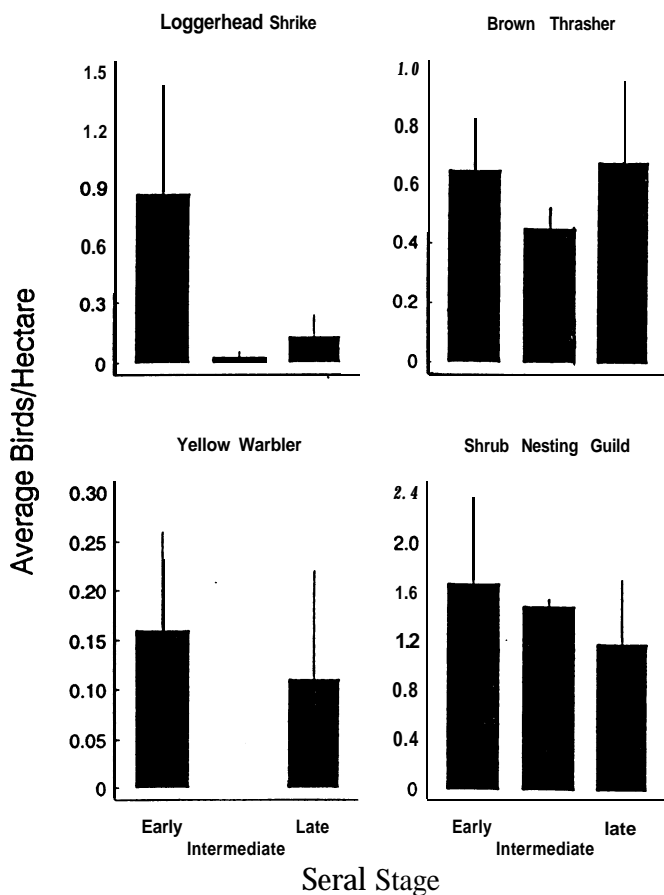


Figure P.-Average abundance (birds/ha) of shrub-nesting species among seral stages of Rocky Mountain juniper along the Missouri River, South Dakota 1990-92. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$ MRPP test.

Mammal Responses To Seral Stages

White-footed mice were more ($P < 0.12$) abundant in intermediate and late seral stages of juniper than the early seral stage (fig 6). Deer mice were the most common small mammal and abundance in intermediate seral juniper was greater ($P < 0.09$) than early or late seral juniper. Meadow voles were more ($P < 0.06$) abundant in early than intermediate or late seral stages. Prairie voles were more ($P = 0.01$) abundant in intermediate than early seral juniper; abundance in late seral juniper did not differ from the previous. Intermediate seral juniper woodlands had more ($P < 0.03$) small mammals and greater ($P < 0.11$) species richness than early or late seral stages. Hispid pocket mice occurred in low abundance in early seral juniper

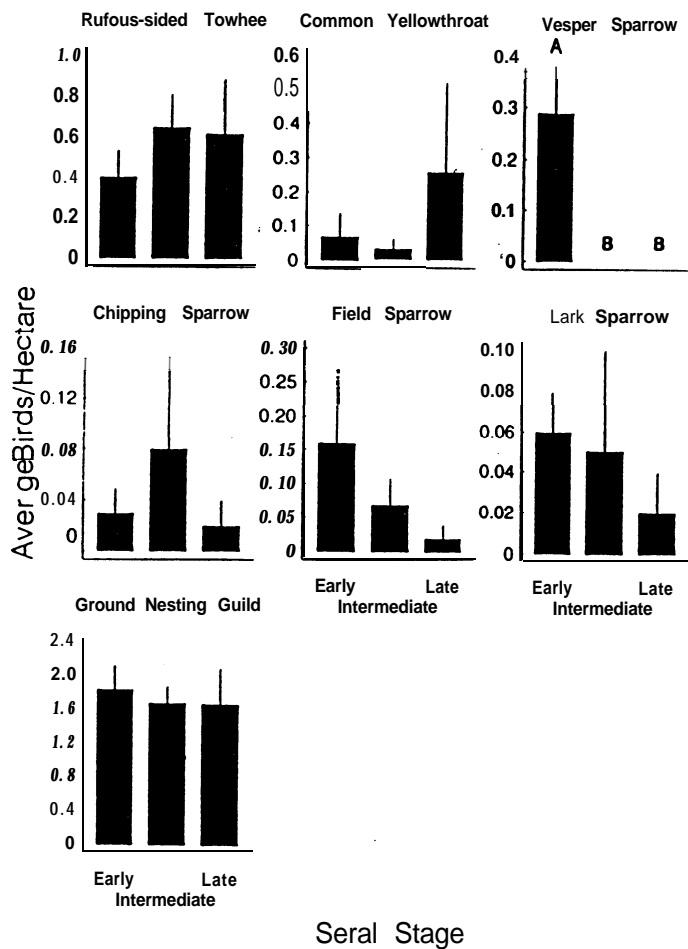


Figure Q.-Average abundance (birds/ha) of ground-nesting species among seral stages of Rocky Mountain juniper along the Missouri River, South Dakota 1990-92. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$, MRPP test

sites, but no differences were apparent among seral stages.

Visitations by coyote, raccoon, striped skunk, and badger did not differ among seral stages (fig. 7). Trends suggest the latter three may have used late seral juniper woodlands more than other seral stages. No trends were evident in deer use among seral stages of juniper. Cottontail abundance increased ($P = 0.04$) as succession progressed from early to late seral stages.

DISCUSSION

We expect juniper woodlands to expand in distribution with a trend toward late seral stages because of fire suppression. Grazing has little

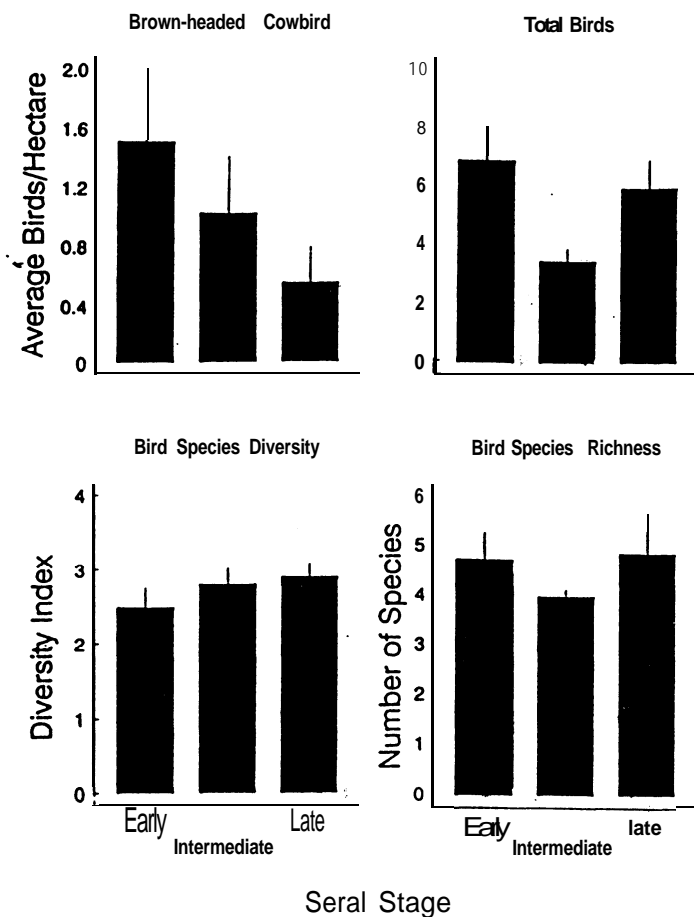


Figure 5.—Average abundance (birds/ha) of Brown-headed Cowbirds, total birds, bird species diversity, and bird species richness among seral stages of Rocky Mountain Juniper along the Missouri River, South Dakota 1990-92. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$, MRPP test.

direct impact on juniper (Severson and Boldt 1978), but excessive grazing encourages expansion of this woodland (Wright et al. 1979). Rocky Mountain juniper woodlands are “edge” or “island” habitats in the prairie. Wildlife populations were influenced by seral stage as well as stand size (Johns 1993), dispersion, and juxtaposition of other woodlands on the landscape.

Birds

Members of nesting guilds share some resource requirements, but may differ in other critical resource needs or ability to adjust to alterations of resources (Verner 1984). Managing one or a few indicator species within a guild may not represent all other guild members (DeGraaf and Chadwick 1984, Block et al. 1987).

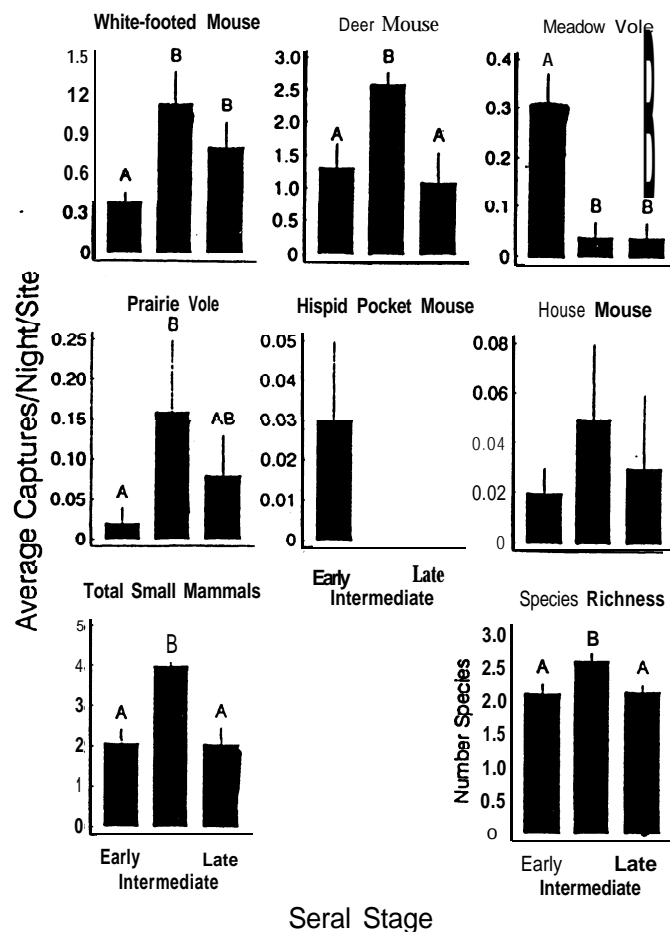


Figure 6.—Average unique individuals per night of small mammals among seral stages of Rocky Mountain juniper along the Missouri River, South Dakota, 1990-1992. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$, MRPP test.

Direct linkage between habitat associations of rare species and occurrence in seral stages be made. However, barring better data, our data provide managers with starting points in their habitat assessments.

Juniper woodlands add vegetation density and structure to the northern Great Plains. Bird community patterns are associated with vegetation structural diversity (Roth 1976, Rotenberry and Wiens 1980, Sabo and Holmes 1983). Bird occurrence and abundance in juniper woodlands is greater than in prairie grasslands (Sieg 1991a) and varies with seral stages. Most **vegetation structure was** provided by the tree canopy and there were more tree nesting birds than birds in other nesting guilds in juniper woodland. Ground-nesting species that use trees for perches or feeding also benefited from juniper woodlands.

Vegetative conditions in intermediate seral juniper are too dense for ground nesting birds, and not yet favorable for the tree-nesting species. High numbers of juniper saplings and trees result in a dense, uniform stand of small trees in the intermediate seral stage. Late seral juniper stands have fewer saplings, taller trees, greater canopy volume, and horizontal patchiness. This structural diversity in vegetation increases abundance and richness (Willson 1974, Holmes et al. 1979, Anderson et al. 1983).

Cavity-nesting species were uncommon! in juniper woodlands because cavities, and snags were rare. Northern Flickers was the only woodpeckers in any seral stage of juniper. Black-capped Chickadees were the most abundant cavity-nesting species in our study and another in western South Dakota (Sieg 1991a). No snags >38 cm dbh occurred in the sites we sampled and snags 13- 38 cm

dbh occurred only in early (0.4/ha) and late seral juniper (0.8/ha). Suitable snags for cavity nesters were usually species other than juniper. Cavity nesting birds were uncommon in southwest pinon-juniper woodlands if pine trees (*P. monophyla* and *P. edulis*) were absent (Balda and Masters 1980). Other cavity-nesting species, such as House Wrens, probably* nested in nearby green ash or cottonwood trees.

The Loggerhead Shrike is being considered for listing under the Endangered Species Act and is considered threatened or endangered in several states (Finch 1992, Smith and Kruse 1992). Loggerhead Shrikes prefer open habitats with scattered perch sites (Finch 1992) typical of the early seral stages of juniper on the northern Great Plains.

Vesper Sparrows, Field Sparrows, and Lark Sparrows are ground-nesting birds associated with scattered shrub or woodlands. Abundance of these species declined (some not significantly from early to late seral stages. Reduced ground cover for nesting from early to late seral stages- may have been a factor affecting use of juniper woodlands by these species. Common Yellowthroats and rufous sided Towhees are associated with tall shrubs or small trees that may account for the insignificant increase in late seral juniper. Many of the birds in the ground nesting guild using juniper woodlands are prairie species and do not require woodlands.

Brown-headed Cowbirds have been implicated in the decline of song birds in the United States and are obligate nest parasites (Brittingham and Temple 1983). Cowbird abundance was correlated with abundance of both tree ($r = 0.6$, $P < 0.01$) and ground ($r = 0.4$, $P = 0.03$) nesting birds in this study. Cowbirds prefer open scattered woodlands (DeGraaf et al. 1991) and may have found nests easier in the open canopy early seral stages of juniper.

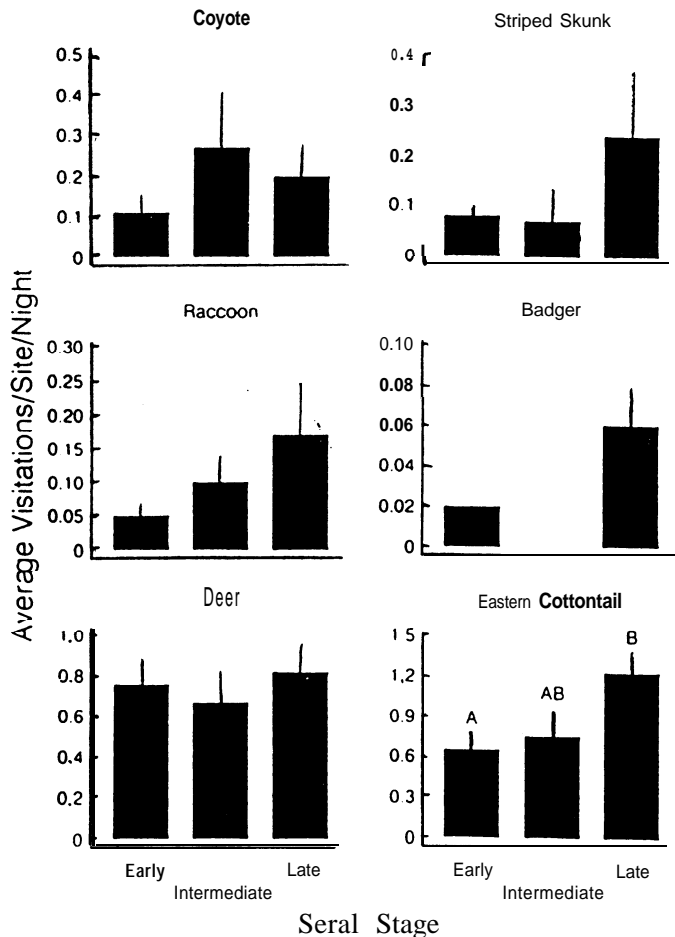


Figure 7.—Average visitations per session to scent pits by intermediate and large mammals among seral stages of Rocky Mountain juniper along the Missouri River in South Dakota, 1990-1992. Standard errors are indicated by vertical lines. Letters above abundance bars indicate significant differences among seral stages $\alpha \leq 0.20$, MRPP test.

Mammals

Species richness of small mammals in Rocky Mountain juniper was low, but low species richness may not be uncommon in northern Great Plains. Other reports show only 6-9 species of small mammals MacCracken et al. 1985b, Hodorff et al. 1988, Sieg 1988). Abundance and species richness of small mammals contrasted data for birds; the intermediate seral stage supported more small mammals. Reduced variability and stronger associations of small mammal to seral stages of juniper than birds resulted from their resident status and small home ranges.

Deer mice are widespread generalist rodents in North America (Baker 1968). In southeastern Montana woodlands, deer mice were positively correlated with understory vegetative cover (MacCracken et al. 1985b). Intermediate seral juniper woodlands in our study had more shrub cover, less grass cover, and greater patchiness in the understory early or late seral woodlands.

White-footed mice are usually associated with riparian habitats in the Great Plains (Anderson and Jones 1971, Hodorff et al. 1988). Rocky Mountain juniper woodlands are not riparian ecosystems. Similar to deer mice, white-footed mice were more abundant in the intermediate seral stage Ribble and Samson (1987) suggested these two species partition macrohabitats but use similar microhabitats. We found them using similar macrohabitats in juniper woodlands.

Meadow voles are associated with high vegetative cover (Huntly and Inouye 1987) and shrublands (Snyder and Best 1988). They usually occur in moist meadows, but inhabit upland areas if sufficient vegetation is present (Jones et al. 1983, Sieg 1988). Early seral juniper, where meadow voles were more abundant, had greater understory and grass cover than other seral stages of juniper.

Upland habitats with herbaceous cover appear to meet habitat needs of prairie voles (Moulton et al. 1981). Prairie voles partition habitats with meadow voles where their distribution overlaps to prevent competition (Jones et al. 1983) and in the juniper woodlands we studied, meadow voles and prairie voles exhibited opposite trends in abundance among seral stages.

Hispid pocket mice are associated with upland habitats, bare ground (Jones et al. 1983), shortgrass prairie (Moulton et al. 1981), or early seral grasslands (McMill and Kaufman 1994). They select habitats with loamy soils, for burrows (Jones et al. 1983). Suitable habitat conditions for Hispid pocket mice occurred only in early seral stages of Rocky Mountain juniper. Hispid pocket mice also used woodland habitats on the Konza Prairie, Kansas (McMillan and Kaufman 1994). House mice also were uncommon, but occurred in all seral stages of Rocky Mountain juniper.

Cottontail abundance increased with habitat changes from early to late seral conditions in juniper. Cottontails are usually associated with shrub habitats in the Great Plains (Morgan and Gates 1983, Rumble 1989). Cottontails in Oklahoma preferred eastern red cedar (*J. virginiana*) habitats (Lochmiller et al. 1991). Cottontails prefer escape cover and a clear view (Morgan and Gates 1983). Late seral juniper with low, dense branches and

open understory provided this habitat better than other seral stages. Juniper, however, is not a preferred food of cottontails (Lochmiller et al. 1991) and they probably fed on other vegetation.

Big game animals are attracted to forests in the northern Great Plains for thermal and hiding cover and browse (Martinka 1968, Wood et al. 1989). Late seral juniper provided vegetative cover overhead and horizontally. Juniper woodlands of Badlands National Park (probably late seral stages) were used extensively by mule deer (Severson and Carter 1978) and were important for mule deer fawns in late summer (Steigers 1981). Most deer in juniper woodlands were mule deer.

Raccoons are uncommon in dry upland forests and grasslands (Pritzell 1977, Jones et al. 1983). Badgers do not depend on prairie woodlands; they are inhabitants of grasslands and forest edges (Jones et al. 1983). Coyotes inhabit a variety of habitats. Coyote diets reflect prey abundance (Andelt et al. 1987, MacCracken and Hansen 1987, Reiche 1991) and the hunt where prey species concentrate (Reichel 1991). We presume coyotes used juniper woodlands for hunting because of the increased abundance of cottontails and other prey.

CONCLUSIONS

Early and late seral stages of Rocky Mountain juniper provided habitat for birds in all nesting guilds. House Wrens were the only bird that occurred in greater abundance in the intermediate seral stage of juniper. Intermediate seral juniper is a dense uniform stand of trees and lacks the vertical and horizontal structure for most bird species. Some ground-nesting species in early seral juniper are prairie species and do not depend on these habitats. Most small mammals were more abundant in the intermediate seral juniper, but meadow voles and Hispid pocket mice appeared to prefer early seral juniper woodlands. Late seral juniper provided the best habitat for cottontails. Several species of intermediate or large mammals also used Rocky Mountain juniper, but were not associated with any seral stages. These species have large home ranges that encompassed several woodland sites or types. Once objectives for wildlife species are developed, techniques that maintain or alter seral stages of juniper woodlands to meet management objectives can be done. Ensuring sustained biological diversity in Rocky Mountain juniper woodlands will require all seral stages across the landscape.

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