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Woodpecker Nesting Habitat in a Prairie River Woodland

J. Barry Parrish

WOODPECKER NESTING HABITAT IN A

PRAIRIE RIVER WOODLAND

BY

J. BARRY PARRISH

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head, Wildlife and
Fisheries Sciences

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Abstract

J. BARRY PARRISH

Differences in nest site selection of the common flicker (*Colaptes auratus*), yellow-bellied sapsucker (*Sphyrapicus varius*), downy woodpecker (*Picoides pubescens*), and red-headed woodpecker (*Melanerpes erythrocephalus*) were studied on the Big Sioux River riparian forest of eastern South Dakota during 1980 and 1981. Nest site preferences were compared using two-group stepwise discriminant analysis. Randomly selected potential nest trees showing no previous signs of cavity excavation were included as control groups. The yellow-bellied sapsucker-red-headed woodpecker function was the most efficient in separating groups because both species had specific nest site preferences. Sapsuckers nested only in live green ash (*Fraxinus pennsylvanica*), characteristically in park-like situations. Red-headed woodpeckers typically nested in American elm (*Ulmus americana*) snag stands with an open canopy and sparse woody understory. Functions involving common flickers or downy woodpeckers were relatively less effective at separating groups because they were more versatile in site selection. Common flickers utilized American elm in snag-dominated stands and green ash in more vigorous portions of the forest. Downy woodpeckers nested in green ash and peach-leaved willow (*Salix amygdaloides*) in vigorous stands and elm snags in areas with a mixture of live and dead trees, but avoided snag-dominated stands.

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INTRODUCTION

The spread of Dutch elm disease into South Dakota has decimated the Big Sioux River riparian forest. The die-off of American elms (*Ulmus americana*) has created a forest mosaic of dead elm stands, mixtures of dead elm and live trees, and areas dominated by live trees. The increase in snag (100% dead) numbers has been beneficial to the nesting woodpecker populations because these birds are dependent on trees with decayed heartwood for nest site excavation (Kilham 1973, Conner et al. 1976).

High densities of nesting woodpeckers along the Big Sioux River provided an opportunity to compare the selection of nest sites by red-headed woodpeckers (*Melanerpes erythrocephalus*), downy woodpeckers (*Picoides pubescens*), common flickers (*Colaptes auratus*), and yellow-bellied sapsuckers (*Sphyrapicus varius*) in a riparian ecosystem. Other nest habitat research involving these species has been conducted primarily in non-riparian areas (Dennis 1969, Erskine and McLaren 1972, Conner 1976, Conner and Adkisson 1976, Jackson 1976, Conner and Adkisson 1977). Stauffer and Best (1980) included these species, except the yellow-bellied sapsucker, in their study of nesting habitat by riparian nongame birds, but did not concentrate their efforts on woodpecker ecology.

The objectives of this study were to quantify certain microhabitat (nest tree) and macrohabitat (habitat immediately surrounding the nest tree) parameters compare the relative differences in nest site selection, and predict effects of current land-use practices on the four woodpecker species.

STUDY AREA

The study area is a 21.7 km portion of the Big Sioux River riparian forest located in Medary township, Brookings County, South Dakota (Fig. 1). Within the area the river is fed by Six Mile Creek, Lake Campbell Outlet, and numerous unnamed seasonal streams. Soil series represented are the Lamoure, Rauville, and Solomon, all of which are poorly drained (Westin et al. 1959:9).

The climate of Brookings County is continental with extreme seasonal temperature fluctuations. Mean temperatures range from -10.94 C in January to 22.56 C in late July. Precipitation occurs primarily during the growing season and averages 54.91 cm per year (Westin et al. 1959:4-6).

The dominant life form along the river is an elm-ash-cottonwood forest type (Choate and Spencer 1969). Principle tree species are American elm, green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), peach-leaved willow (*Salix amygdaloides*), cottonwood (*Populus deltoides*), hackberry (*Celtis occidentalis*), and chokecherry (*Prunus virginiana*). The woody understory consists of wolfberry (*Symphoricarpus occidentalis*), buckthorn (*Rhamnus catharticus*), sandbar willow (*Salix exigua*), tartarian honeysuckle (*Lonicera tartarica*), hawthorne (*Crataegus mollis*), and gooseberry (*Ribes missouriense*).

Due to current land-use practices and the impact of Dutch elm disease, the gallery forest along the Big Sioux River has taken on a patchwork appearance. There are few sections of the river that have not been affected by either farming or grazing. The forest in the unaffected areas is more than 20 m wide and has a woody understory with saplings

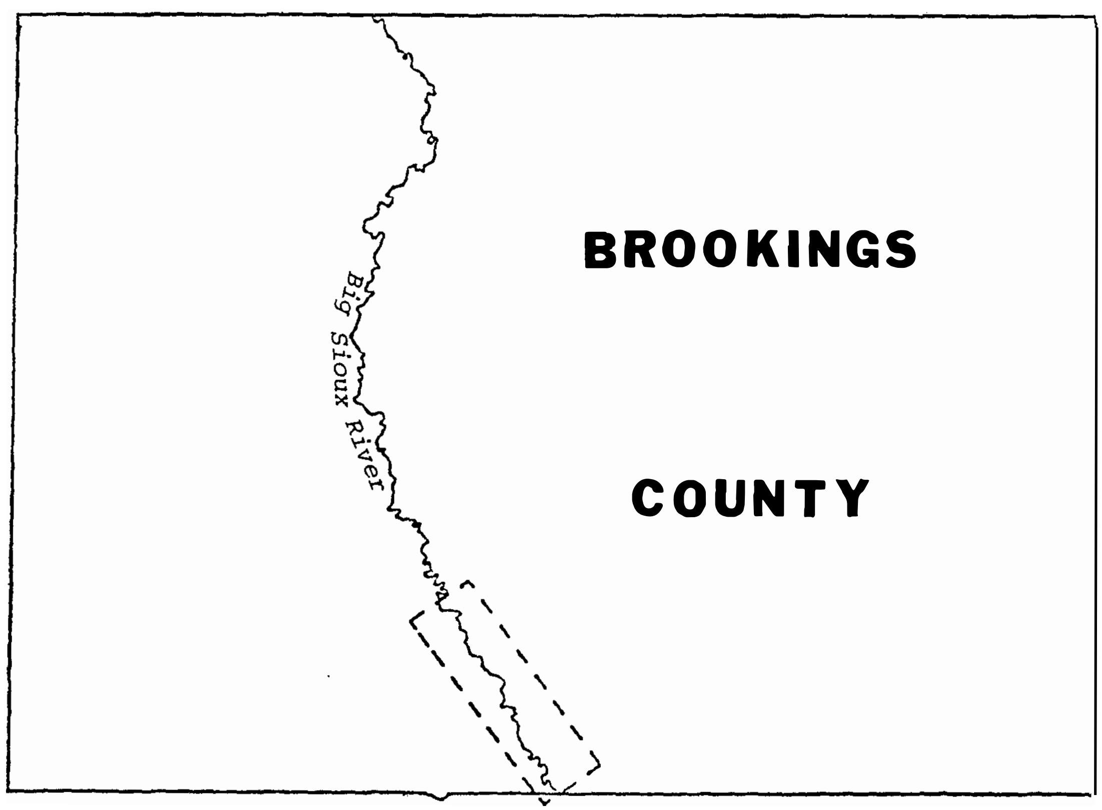

Fig. 1. The Big Sioux River study area (enclosed by dashed lines) located in Brookings County in eastern South Dakota.

of the dominant trees present. In contrast, disturbed areas are park-like with a sparse shrub understory composed primarily of wolfberry. Many of the areas that once consisted of nearly pure elm are now snag stands with little regeneration; still other sections have no trees boarding the river.

METHODS

The entire study area was systematically searched for active woodpecker nest cavities during the 1980 and 1981 nesting seasons. Active nests were either those that were nearly completed and had an individual excavating, or completed cavities where a woodpecker was seen entering. Thirty randomly chosen American elm and green ash were used as controls to compare with trees having active nest cavities. These control trees had decayed limbs large enough for woodpecker nest cavities, but showed no signs of previous excavation.

Each nest tree and control tree was considered to be the center of a 0.04 ha circular plot, similar to that used by James and Shugart (1970) during bird censusing. Micro- and macrohabitat (Conner and Adkisson 1977) parameters measured within each plot are listed in Table 1. Many of these variables have been used successfully in earlier woodpecker nest habitat research (Conner and Adkisson 1976, Conner and Adkisson 1977). In addition, live and dead basal area was measured for an indication of tree stand vigor. Canopy cover and canopy depth gave a relative measure of canopy closure and amount of foliage, respectively. Tree regeneration and woody ground cover estimates were derived from sapling and shrub densities. Nest tree species and nest cavity position within the tree also were included in the analyses. Many of the woodpecker cavities were located in dead elms and because of climbing hazards, diameter at the nest cavity was approximated using the mean diameter of three accessible limbs that appeared to be the same size as the limb in question.

Table 1. Independent variables used in discriminant function analysis of woodpecker nest sites.

Variables	Units of Measurement
Microhabitat	
Vigor	Percent of tree alive
Diameter at breast height	Nearest 0.5 cm
Diameter at nest cavity	Nearest 1.0 cm
Height of tree	Nearest 0.5 m
Height of nest cavity	Nearest 0.5 m
Distance to clearing	Distance to edge of forest in meters
Elm nest site[a]	Nest occurring in elm
Ash nest site[a]	Nest occurring in ash
Willow nest site[a]	Nest occuring in willow
Trunk[a]	Position of cavity in tree
Limb[a]	Position of cavity in tree
Macrohabitat	
Tree density	Trees (dbh > 7 cm) per ha
Total basal area	Square meters
Live basal area	Square meters
Dead basal area	Square meters
Canopy cover	Percent canopy cover on plot
Canopy depth	Maximum minus minimum canopy height
Shrub density	Shrubs (dbh < 7 cm) per ha
Sapling density	Saplings (dbh < 7 cm) per ha

[a]Dummy variable.

This process also was used on nest cavities that could be measured directly. In the latter case, no approximation differed by more than 2 cm from the measured diameter. Canopy depth was obtained by subtracting measurements of minimum canopy height from maximum canopy height. James and Shugart (1970), Conner and Adkisson (1976), and Conner and Adkisson (1977) discussed techniques for measuring the remaining parameters.

Stepwise discriminant analysis (Cooley and Lohnes 1971:243-261) was used to evaluate the relative importance of the independent variables. Similar use of this technique for waterfowl was described by Mack and Flake (1980). Other studies (Anderson and Shugart 1974, Conner and Adkisson 1976, Conner and Adkisson 1977) have employed multivariate techniques in analyzing woodpecker nesting habitat. In this analysis, groups (woodpecker nest sites and randomly chosen control trees) were discrete dependent variables and most independent variables were continuous. Where independent variables were discrete they were treated as dummy variables (Klecka 1975). Stepwise discriminant analysis began by selecting the best single discriminating variable. A second best discriminating variable was then selected, which improves the discriminatory power in combination with the first. Subsequent variables were similarly included until little additional discrimination was added to the function. At each step previously selected variables may have been removed if they were found to reduce the discriminatory power of the function (Klecka 1975).

Analyses were run on two groups (woodpecker nest sites and control trees) at a time, with plots for each woodpecker species compared individually with the other three species (e.g. downy woodpecker plots were analyzed versus red-headed woodpecker plots, then versus common flicker plots, and finally versus yellow-bellied sapsucker plots). In addition, nest sites of all the individuals of a particular woodpecker species, nesting in the same tree species, were grouped and analyzed with the appropriate sample of random non-nesting plots (e.g. downy woodpecker nest plots in green ash were grouped and analyzed versus random green ash plots).

Results of the discriminant function must be interpreted as the optimal set of variables, due to interactions among variables (Klecka 1975). The discriminant function coefficients represent the relative contribution of that variable to the function and the sign denotes whether this contribution is positive or negative. Group centroids represent the most typical location of a case for that particular group in the discriminant function space. Distances between group centroids in the two-group comparisons indicate the relative effectiveness of the included variables to discriminate the groups. Classification of cases was based on prior probabilities which were equal to the proportion of cases in each group. Wilks' lambda gave an inverse measure of the discriminatory power of the variables which had not yet been removed by the function. A one-way analysis of variance was used to calculate F ratios to test for equality of group means on included variables (Klecka 1975). These within-group means were consulted to determine associations of groups with independent variables.

RESULTS AND DISCUSSION

There were 147 woodpecker nests found on the Big Sioux River study area during 1980 and 1981. Red-headed woodpecker nests were the most abundant (n = 61; 40.9%), followed by downy woodpeckers (n = 46; 32.2%), common flickers (n = 28; 18.8%), and yellow-bellied sapsuckers (n = 12; 8.1%). The number of nests located for each species does not accurately reflect the abundance of nesting woodpecker species on the study area because I searched exclusively for red-headed woodpecker nests prior to 13 June 1980. Common flickers were probably more abundant than the data suggest (Emmerich 1978).

Average tree density on the study area was 327.6 trees/ha. Estimates of the relative abundance of tree species and snags are presented in Table 2 (Unpubl. data, R. L. Smith and L. D. Flake, Department of Wildlife and Fisheries Sciences, South Dakota State University, Brookings). Nearly 88.0% of the forest consisted of green ash, American elm, and box elder. A disproportionate percentage (79.9%) of the snags on the study area were American elm. The percentages of nests in snags were 95% for red-headed woodpeckers, 71% for common flickers, and 63% for downy woodpeckers. Besides elm, the only other tree species utilized by woodpeckers were green ash and peach-leaved willow, comprising 2.8% and 0.9% of the snags, respectively (Table 3). Box elder snags were the second most common (Table 2), however no woodpecker cavities were found in this species.

Table 2. Forest composition and snag abundance on the Big Sioux River study area.

Species	Average Density (Trees/ha)	Relative density (%)	Average snag density (Snags/ha)	Relative density (%)
Green ash (*Fraxinus pennsylvanica*)	152.76	46.63	1.63	2.84
American elm (*Ulmus americana*)	73.21	22.35	45.85	79.86
Peach-leaved willow (*Salix amygdaloides*)	17.94	5.48	0.52	0.91
Box elder (*Acer negundo*)	61.06	18.64	7.75	13.50
Hawthorne (*Crataegus mollis*)	6.70	2.05	——[a]	——
Cottonwood (*Populus deltoides*)	0.71	0.22	——[a]	——
Hackberry (*Celtis occidentalis*)	6.39	1.95	1.41	2.46
Chokecherry (*Prunus virginiana*)	8.84	2.70	——[a]	——
TOTAL	327.61		57.41	

[a] Snags of this species were not encountered during sampling.

Table 3. Tree species utilized as nest sites by woodpeckers on the Big Sioux River study area.

Tree species	Number of nests			
	Red-headed woodpecker	Downy woodpecker	Common flicker	Yellow-bellied sapsucker
American elm (*Ulmus americana*)	57	24	17	0
Green ash (*Fraxinus pennsylvanica*)	3	15	11	12
Peach-leaved willow (*Salix amygdaloides*)	1	7	0	0
TOTAL	61	46	28	12

Woodpecker Nest Site Comparisons

Red-headed and downy woodpecker nest sites were separated by a combination of micro- and macrohabitat factors (Table 4). Included variables explained approximately 40% of the variance in nest sites between the two species. The completed function correctly classified 90% of the red-headed woodpecker and 80% of the downy woodpecker nest sites. Based on within-group means, red-headed woodpeckers tended to select American elms as nest sites more often and excavate cavities in larger limbs than downy woodpeckers. Downy woodpeckers preferred nest trees in areas with relatively more canopy cover and greater sapling and shrub densities. The discriminating variables, excluding diameter at the nest cavity, suggest that red-headed woodpecker nests were primarily located in non-regenerating stands dominated by elm snags.

Although half of the downy woodpecker nests were in elm snags (Table 3), these sites tended to be surrounded by a mixture of live and dead trees and had a woody understory layer. Preferred downy woodpecker foraging sites during the summer are living trees (Jackson 1970), especially smaller branches (Kiesel 1972) and understory vegetation (Anderson and Shugart 1974). In fact, Shugart et al. (1974) found that sustained brush clearance in a forest decreased the amount of downy woodpecker habitat. On the Big Sioux River study area the majority of smaller limbs had fallen off many elm snags leaving areas of the forest composed essentially of trunks and larger primary or secondary branches. These snag stands also had a

Table 4. Major independent variables discriminating between woodpecker species' nest sites as indicated by stepwise forward discriminant analyses.

Group	No. of cases	% Correctly classified[a]	Group centroid[b]	Major discr. variable[c] and Wilks' lambda ( )[d]	Standardized discr. function coeff.	Within-group means		Significance between means (P)
						Downy	Red-headed	
Downy				Elm nest site (0.7731)	0.6918	0.52	0.93	< 0.01
Woodpecker	46	80.4	- 1.1164	Diam. at nest (0.7023)	0.6792	17.95	25.90	< 0.01
vs.				Canopy cover (0.6591)	- 0.3582	44.35	20.41	< 0.01
Red-headed				Sapling density (0.6272)	- 0.3323	92.93	26.93	0.18
Woodpecker	61	90.2	0.8419	Shrub density (0.5986)	- 0.3021	42.93	23.76	< 0.05
						Downy	Flicker	
Downy				Diam. at nest (0.6635)	0.9730	17.95	28.35	< 0.01
Woodpecker	46	86.7	- 0.8764	Willow nest site (0.5670)	- 0.5772	0.15	0.00	< 0.05
vs.				Canopy depth (0.5390)	- 0.6331	3.90	2.58	< 0.01
Common								
Flicker	61	78.6	1.4399					
						Red-headed	Flicker	
Red-headed				Green ash nest site (0.8079)	0.6892	0.05	0.39	< 0.01
Woodpecker	61	90.2	- 0.4734	Nest in trunk (0.7686)	0.4549	0.21	0.54	< 0.01
vs.				Tree density (0.7491)	0.1202	204.51	260.71	0.07
Common								
Flicker	28	60.7	1.0313					
						Downy	Sapsucker	
Downy				Nest tree vigor (0.6666)	0.9422	25.45	82.50	< 0.01
Woodpecker	46	95.7	- 0.6298	Willow nest site (0.5929)	- 0.5186	0.15	0.00	0.15
vs.				Diam. at nest (0.5076)	0.5215	17.95	24.65	< 0.01
Yellow-bellied								
Sapsucker	12	91.7	2.4142					
						Sapsucker	Red-headed	
Yellow-bellied				Green ash nest site (0.2393)	0.7229	1.00	0.05	< 0.01
Sapsucker	12	100.0	1.7708	Nest tree vigor (0.2057)	0.4779	82.50	4.02	< 0.01
vs.				Nest in trunk (0.1988)	0.1769	0.67	0.21	< 0.01
Red-headed								
Woodpecker	61	96.7	- 0.9385					

Table 4. Continued

Group	No. of cases	% Correctly classified[a]	Group centroid[b]	Major discr. variable[c] and Wilks' lambda ( )[d]	Standardized discr. function coeff.	Within-group means: Sapsucker	Within-group means: Flicker	Significance between means (P)
Yellow-bellied Sapsucker	12	83.3	1.7191	Nest tree vigor (0.6293)	0.9804	82.50	24.82	< 0.01
vs.				Diam. at nest (0.5813)	- 0.3073	24.65	28.35	0.18
				Height of nest tree (0.5455)	- 0.5508	9.68	11.03	0.27
Common Flicker	28	89.3	- 0.7368					

[a]Based on prior probabilities which were equal to the proportion of cases in each group.

[b]Centroid in reduced space of the discriminant score.

[c]Major independent discriminating variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

[d]Inverse measure of the discriminatory power of the variables which had not yet been removed by the function.

sparse woody understory. Downy woodpecker nests were probably not located in these snag stands because of a limited number of preferred summer foraging sites.

The red-headed woodpecker association with dead elm stands probably relates to the minimal canopy cover and lack of woody understory characteristic of these areas. This open aspect provides a favorable environment for hawking insects and ground foraging, both of which are important modes of feeding during the summer (Williams 1975, Jackson 1976). Perching sites with unobstructed views were numerous and there was little woody understory vegetation to inhibit ground feeding. Other studies also have found red-headed woodpecker preference for open areas, usually near an edge (Reller 1972, Conner 1976, Jackson 1976, Conner and Adkisson 1977). My findings concur with Bock et al. (1971) who noted that red-headed woodpeckers did not necessarily nest near the forest edge, but wherever open areas occurred. Red-headed woodpeckers did not nest in the more closed stands probably because few of their activites occur in these areas (Hardin and Evans 1978).

Diameter at the nest cavity was an important discriminating variable in the downy woodpecker comparisons with red-headed woodpeckers, common flickers, and yellow-bellied sapsuckers (Table 4). In each case, downy woodpeckers selected limbs significantly ($P < 0.01$) smaller than the other woodpecker species. These relations were expected because the smaller body size of downy woodpeckers allows them to nest in relatively smaller limbs (Conner et al. 1975, Conner and Adkisson 1977, Thomas et al. 1979).

Peach-leaved willow nest sites, diameter at nest cavity, and canopy depth were important variables in the downy woodpecker-common flicker analysis (Table 4). Forty-six percent of the variance in nest site selection was accounted for by the three variables. Over 86% of the downy woodpecker and more than 78% of the common flicker nest sites were correctly classified by the discriminant function. Although relatively few downy woodpecker nest cavities were located in peach-leaved willow (Table 3) the importance of this variable was a result of common flickers not nesting in this tree species. Significantly ($P < 0.01$) different group means indicate downy woodpecker macrohabitats were associated with more foliage, probably because this arboreal foraging species exploits greater arthropod populations found in vigorous trees (Travis 1977). Common flickers, on the other hand, forage primarily on the ground (Conner et al. 1975, Hardin and Evans 1978, Cruz and Johnson 1979), hence open ground is more important than amount of foliage. In Massachusetts and Virginia, common flickers were found to prefer either edge conditions or clear-cuts (Dennis 1969, Conner et al. 1975, Conner and Adkisson 1976). Although the present data did not indicate similar relationships, any point within the narrow gallery forest was relatively close to adjacent agricultural fields. Many times common flickers were observed crossing the forest to feed in these fields. In addition, there was much open ground within the forest created by heavy grazing pressure.

The optimum combination of variables separating nests of red-headed woodpeckers from common flickers were green ash nest sites, cavities in tree trunks, and tree density (Table 4). The small amount of variance (25%) described by the equation and closeness of group centroids suggests that this was the least efficient of the woodpecker comparisons. The function correctly classified 90% of the red-headed woodpecker sites, but only about 60% of the common flicker nests. Within-group means for green ash nest sites and tree density suggest that flickers were not as dependent on dead elm stands as red-headed woodpeckers. Flicker nests not located in elm snags were characteristically in overgrazed park-like stands or regenerating stands. Red-headed woodpeckers may have avoided nesting in these areas because the higher tree densities and mixtures of live and dead trees obstruct insect hawking. Common flickers selected tree trunks for nest sites more often than red-headed woodpeckers (0.54 vs. 0.21) probably due to their larger body size. Red-headed woodpeckers, being smaller, were able to use relatively smaller limbs (Conner and Adkisson 1977).

Microhabitat characteristics separated yellow-bellied sapsucker nest sites from those of the other three species (Table 4). Distances between group centroids and Wilks' lambda values indicate these three yellow-bellied sapsucker analyses to be the most efficient of the study. In each case nest tree vigor was an important discriminating variable. Significant ($P < 0.01$) differences between within-group means suggest sapsucker preference for vigorous trees. These relationships resulted from sapsuckers nesting only in live green ash, whereas common flickers, red-headed woodpeckers, and downy woodpeckers all used snags to some degree. Other studies have found yellow-bellied sapsuckers to prefer live aspens (*Populus* spp.) having visible fungal conks and a straight bole with a large enough diameter for cavity excavation (Lawrence 1967, Shigo and Kilham 1968, Kilham 1971). Green ash utilized as nest sites by sapsuckers on the Big Sioux River study area possessed these attributes. Peach-leaved willow nest sites were important discriminators in the yellow-bellied sapsucker comparison with downy woodpeckers because no sapsucker nests were found in willow trees (Table 3). Results yielded by the yellow-bellied sapsucker-red-headed woodpecker function suggest live green ash nest sites as the most important factor discriminating between the two species (Table 4). As expected, within-group means infer that sapsuckers utilized these sites more than red-headed woodpeckers. Although a few red-headed woodpecker nests were in green ash (Table 3), they preferred elm-dominated stands. This difference in nest site location agrees with previous studies that have shown red-headed woodpeckers to prefer open areas (Bock et al. 1971, Reller 1972, Conner 1976, Jackson 1976, Conner and Adkisson 1977) and sapsuckers more vigorous stands (Lawrence 1967). In addition to nest tree vigor, diameter at the nest cavity and height of the nest tree were included in the sapsucker-flicker equation (Table 4). On the average, flickers selected larger diameter limbs (28.35 vs. 24.65) and taller trees (11.03 vs. 9.68) for location of the nest cavity. Taller trees apparently were chosen as nest sites by flickers because they generally have greater trunk and limb diameters, which are necessary for larger woodpecker species (Conner et al. 1975, Thomas et al. 1979).

To summarize the woodpecker nest site analyses, yellow-bellied sapsucker comparisons were the most efficient (Table 4) because they nested only in live green ash. Red-headed woodpeckers preferred sites in American elm snags with a relatively open canopy and sparse woody understory. Common flickers were fairly versatile, utilizing snag stands and more vigorous portions of the forest. Downy woodpeckers also were versatile in nest site selection; however, they preferred vigorous stands with a woody understory and avoided snag-dominated areas.

Woodpecker Nest Site Comparisons With Randomly Selected Trees

The functions produced in the downy woodpecker nest site analyses with randomly selected green ash and American elm accounted for only about 32% of the variance and correctly classified approximately 60% of the nest sites (Table 5). Significant ($P < 0.01$ and $P < 0.05$) differences in group means indicate downy woodpeckers chose less vigorous green ash for cavity excavation in areas with greater than average live basal area. Selection of dying trees for cavity excavation indicates the need of downy woodpeckers to excavate in decayed limbs (Kilham 1973, Conner et al. 1976). Although green ash normally occurred in stands mixed with snags, downy woodpeckers chose relatively vigorous areas for nest sites. This selection was probably due to their preference for feeding on live substrate (Lawrence 1967, Jackson 1970, Williams 1975). Distance to clearing and tree density were the best discriminating variables in the downy woodpecker-American elm function. The significantly ($P < 0.01$) different within-group means depict downy woodpecker nest

Table 5. Major independent variables discriminating between woodpecker nest sites and randomly selected non-nesting sites as indicated by stepwise forward discriminant analysis.

Group	No. of cases	% Correctly classified[a]	Group centroid[b]	Major discr. variable[c] and Wilks' lambda ( )[d]	Standardized discr. function coeff.	Within-group means		Significance between means (P)
						Downy	Elm	
Downy Woodpecker	46	62.5	0.7774	Dist. to clearing (0.8321)	0.7123	89.75	45.63	< 0.01
vs.				Tree density (0.7305)	0.7209	270.83	175.00	< 0.01
American Elm	30	83.3	- 0.6219					
						Downy	Ash	
Downy Woodpecker	46	60.0	- 1.1600	Nest tree vigor (0.8277)	0.8282	50.33	76.00	< 0.01
vs.				Live basal area (0.6627)	- 0.7251	0.89	0.64	< 0.05
Green Ash	30	93.3	0.5800					
						Flicker	Elm	
Common Flicker	28	88.2	1.4177	Dead basal area (0.7057)	1.7928	1.14	0.51	< 0.01
vs.				Diam. breast height (0.6666)	0.2912	63.52	46.76	< 0.01
				Nest tree vigor (0.6356)	- 0.4464	0.00	8.83	0.17
American Elm	30	90.0	- 0.8034					
						Flicker	Ash	
Common Flicker	28	72.7	- 1.7559	Dist. to clearing (0.8824)	- 0.5427	74.00	38.35	< 0.05
vs.				Live basal area (0.8047)	- 1.2563	0.88	0.64	< 0.05
				Height of nest tree (0.6688)	0.6072	10.88	11.87	0.30
Green Ash	30	96.7	0.6438					
						Red-headed	Elm	
Red-headed Woodpecker	61	53.3	0.4824	Dead basal area (0.8711)	- 0.1285	0.92	0.51	< 0.01
vs.				Diam. breast height (0.8140)	0.3906	59.31	46.76	< 0.01
				Nest tree vigor (0.7861)	- 0.4223	1.67	8.33	0.08
American Elm	30	91.2	- 0.9166					

Table 5. Continued

Group	No. of cases	% Correctly classified[a]	Group centroid[b]	Major discr. variable[c] and Wilks' lambda ( )[d]	Standardized discr. function coeff.	Within-group means		Significance between means (P)
						Sapsucker	Ash	
Yellow-bellied sapsucker	12	75.0	- 1.6902	Live basal area (0.8079)	- 1.3269	0.96	0.64	< 0.01
				Canopy cover (0.5777)	1.1393	49.17	52.67	0.62
vs.				Height of nest tree (0.5184)	0.5299	9.68	11.87	< 0.01
Green Ash	30	96.7	0.6761					

[a]Based on prior probabilities which were equal to the proportion of cases in each group.

[b]Centroid in reduced space of the discriminant score.

[c]Major independent discriminating variables are listed in the order of their ability to discriminate between groups. The ability of each variable is dependent on the ability of the variables listed prior to it.

[d]Inverse measure of the discriminatory power of the variables which had not yet been removed by the function.

sites in areas of the forest away from clearings. Because they are primarily an arboreal foraging species (Jackson 1970, Kiesel 1972, Anderson and Shugart 1974), sites within the forest offer more potential feeding sites than edge conditions.

Common flicker comparisons with randomly selected American elm and green ash indicated selection of different habitats. The flicker-elm function included dead basal area, diameter at breast height, and nest tree vigor, while the flicker-ash equation was composed of distance to clearing, live basal area, and height of the nest tree. These functions accounted for about one-third of the variance. The completed equations correctly classified 88% of the American elm and 72% of the green ash nest sites. Differences between within-group means denote flicker preference for large elm snags located in snag-dominated stands. In contrast, flicker nests in green ash were away from the forest edge (74.00 vs. 38.33 m), in areas of greater than average live basal area (0.87 vs. 0.63 cm^2), and located in shorter than average green ash (10.88 vs. 11.87 m). Nesting in vigorous stands was probably of no special benefit to this ground foraging species; however, due to the narrow aspect of the forest, flickers were never far from feeding sites in the open agricultural fields.

The most discriminating set of variables in the red-headed woodpecker-American elm function included dead basal area, diameter at breast height, nest tree vigor, and shrub density (Table 5). Only about 21% of the variance was explained by these variables. A little more than half of the red-headed woodpecker nest sites were correctly classified by the equation. The typical red-headed woodpecker nest site had more dead basal area (0.92 vs. 0.51 cm^2), a larger diameter at breast height (59.31 vs. 46.76 cm), and was located in elms of less vigor (1.67 vs. 8.33%) than randomly chosen trees. These relations reiterate a preference for nesting in large dead elms in snag-dominated stands.

The yellow-bellied sapsucker-green ash function was the most effective (distance between group centroids equals 2.6663) comparison between woodpecker nest sites and randomly selected trees (Table 5). The combination of live basal area, canopy cover, and height of the nest tree accounted for 48% of the variance. Seventy-five percent of the sapsucker nest sites were correctly classified by the discriminant function. There was a significant ($P < 0.01$) difference in the mean live basal area associated with sapsucker nest sites (0.96 m^2) and randomly selected green ash (0.64 m^2). Sapsuckers, like downy woodpeckers, probably nested in vigorous stands because they feed primarily in live trees (Lawrence 1967, Williams 1975). Although the within-group means were not significantly ($P < 0.05$) different, canopy cover was the second most important (standardized discriminant coefficient equals 1.1393) variable in the overall equation. Sapsuckers selected nest sites with relatively less canopy cover than randomly chosen green ash (49.17 vs 52.67). This association was probably due to 11 of the 12 nest sites being located in open, park-like situations. This species forages primarily in denser parts of the forest (Lawrence 1967) and although sapsucker nest sites in the present study were in open forest situations, regenerating stands were never far away.

Sapsuckers nested in significantly ($P < 0.01$) shorter than average green ash (9.68 vs. 11.87); however, reasons for this relationship were not clear.

In summary, analyses involving randomly selected trees were less effective than comparisons between woodpecker species' nest sites. Downy woodpecker nests in American elm were within the forest, away from edge conditions. Their nest sites in green ash tended to be located in vigorous stands. Common flickers utilizing American elm selected snag-dominated stands, while those in green ash were characteristically in vigorous areas. Red-headed woodpeckers showed a preference for large dead elms in snag-dominated stands. Yellow-bellied sapsuckers nested primarily in vigorous park-like stands.

CONCLUSIONS

The riparian forest of the Big Sioux River is presently in a state of transition. Dutch elm disease has decimated the American elms and intensive grazing pressure has greatly reduced the forest's regenerative powers. At the present time this forest is a very heterogenous unit.

Some stands were dominated by dead elms and had very little shrub understory. These open areas appeared to offer prime nesting habitat for both red-headed woodpeckers and common flickers. Most elm snags were physically suitable for these woodpecker species. In addition, there was minimal obstruction to hinder red-headed woodpeckers while hawking insects and ample open ground for both species to ground forage. Flickers also were found to use live green ash in park-like stands created by heavy grazing and vigorous regenerating stands. Downy woodpeckers may be limited not by potential nest sites but by proper nesting habitat. They apparently do not utilize dead elm stands for nesting, but instead prefer more vigorous parts of the forest. Of the species studied, yellow-bellied sapsuckers were the least versatile, nesting only in live green ash. These findings indicate that even though a large number of potential nest sites were available in an area of highly interspersed habitat types, woodpeckers selected sites based on certain measurable parameters.

If present trends continue, heavily grazed dead elm stands will revert to pasturelands as the snags fall. The park-like sections will also disappear due to a lack of regeneration, leaving only patches of riparian woodland. As the forest opens up, downy woodpecker and yellow-bellied sapsucker populations will probably be affected first because of their dependence on vigorous regenerating stands. Red-headed woodpecker and common flicker populations initially may benefit from the present trend, but will decline as suitable nest sites vanish. In addition, secondary cavity nesting species, such as wood ducks (Aix sponsa), house wrens (Troglodytes aedon), tree swallows (Iroprocne bicolor), American kestrels (Falco sparverius), and screech owls (Otus asio) will also decline. Thus if there is to be a riparian forest with associated cavity nesting species along the Big Sioux River in the future, proper land management permitting normal tree regeneration must be implemented.

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