GRAY SQUIRREL HABITAT AND NEST-TREE PREFERENCE[1]

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ABSTRACT

The mixed hardwoods, white oak/red oak/hickory, and chestnut oak forest types were most important for gray squirrels *(Sciurus carolinensis)* on an 8100 ha study area in West Virginia. The three most abundant tree species, chestnut oak *(Quercus prinus)*, white oak *(Q. alba)*, and northern red oak *(Q. rubra)*, in these forest types provided 75 percent of the nest dens and 54 percent of the leaf nests. Among 14 tree species used for nest-den trees, American chestnut *(Castanea dentata)* snags and sugar maple *(Acer saccharum)* were preferred. Hickories *(Carya* spp.), yellow-poplar *(Liriodendron tulipifera)*, and maples *(Acer* spp.) were preferred for leaf nests. Squirrels preferred trees 40+ cm dbh for nest dens. Intensive timber management would remove the mature and residual trees that provided most of the dens. Management for squirrels requires that a diversity of selected tree species be retained for dens and mast.

INTRODUCTION

Numerous investigations have been conducted on gray squirrel *(Sciurus carolinensis)* biology, harvest seasons, and bag limits, but little information is available on its use of habitat. Except for Uhlig's (1956) analysis of woodlot den trees in West Virginia, no comparisons have been made between the abundance of trees by species and their use by squirrels for nest dens. Therefore, this study was conducted to describe the availability and use by gray squirrels of some habitat features in oak/hickory forests of southeastern West Virginia. Information about these relationships is needed by forest landowners to meet the challenge of providing squirrel habitat in intensively managed hardwood forests.

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STUDY AREA

The study area was Middle Mountain in Greenbrier and Pocahontas Counties, West Virginia, on the Monongahela National Forest. The mountain is a ridge of 29 km long and 2.4 to 4.0 km wide. Elevations range from 620 m to 1,085 m. Its area is 9,500 ha, including nonforested private land along parts of the lower slopes. However, our observations were confined to about 8,100 ha of contiguous forest with a few open wildlife clearings.

The forest types are mostly xeric with some mesic hardwoods, white pine *(Pinus strobus)*, and eastern hemlock *(Tsuga canadensis)* in the hollows. At one time the American chestnut *(Castanea dentata)* was a dominant species and many blight-killed snags remain. The present vegetation is generally described as an oak/hickory/pine association (Strausbaugh and Core 1964).

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Most of the forest stands on Middle Mountain are of two age classes: mature, residual trees are mixed in the same stands with 20- to 40- or 40- to 60-year-old trees. The better forest stands average about 23 m^2 basal area per ha and stands considered to be marginally merchantable average 11.5 m^2 per ha. Residual trees account for about 30 percent of the basal area.

Site indices (Schnur 1937) for northern red oak (*Quercus rubra*) range from 80 or more in coves and stream bottoms to unknown but low on the driest ridges and southwest aspects; the site index for merchantable stands on the upper slopes averages 50.

METHODS

Den-tree counts, leaf-nest counts, and squirrel sightings were used to measure habitat use by gray squirrels. Observations were keyed to 2,533 permanent plot markers located at 80.5-m intervals on 57 parallel transects that crossed the main ridge at right angles and were 0.4 km apart.

Trees near the plot markers were sampled once after leaf fall by the point-center-quarter technique (Cottam and Curtis 1956). The sampling took 2 years to complete, 1968 through 1969. At each plot marker, the nearest living or dead tree 19 cm dbh or larger in each quadrant was measured. (Trees smaller than 19 cm dbh were considered too small to contain a den cavity.) The species, dbh, and distance from the centerpoint to the nearest edge of the tree were recorded, and each tree was carefully examined for dens with 7x50 binoculars. The height to each den entrance was estimated, and its location in the tree (butt, trunk, or limb) was recorded. Dens were classified as nest dens if they were suitable for litter rearing, had an entrance hole about 7.5 cm in diameter, were located so that the nest would remain dry, and showed some evidence of squirrel use. Escape dens were defined as any openings or hollows that would provide a squirrel a temporary hiding place. Den trees were also classed as dead or alive, hollow or snag, or a combination thereof.

Leaf nests were counted annually from 1968 through 1970, after leaf fall (November) on plots 40.2 m wide and 160.9 m long. Leaf nest plots were contiguous along a transect and were centered on the transect line. As suggested by a pilot study of sample size requirements, 41 of the 54 transects were randomly sampled each year; they included 852 to 860 plots per year. For each tree with a leaf nest, species and dbh were recorded.

Squirrels were counted during the leaf-nest sampling and in April by researchers walking all transects at various times of the day. Observers recorded the number of the plot marker nearest the point where they first saw the squirrel. Approximately 100 man-days per year were spent measuring squirrel use along the transect lines.

Forest type was recorded for each plot during the den tree survey. We used forest types described by the USDA Forest Service (Unpublished handbook FSH 4813.1, 1957) and by the Society of American Foresters (1967), but some closely related standard types were combined:

Yellow pine: includes SAF types pitch pine and Virginia pine, and FS types pitch pine, Table Mountain pine, and Virginia pine.

Oak/pine: similar to SAF type white pine/chestnut oak; same as FS oak/pine.

Chestnut oak: SAF and FS types chestnut oak.

Red oak/scarlet oak: includes SAF types northern red oak and scarlet oak; FS type northern red oak.

White oak/red oak/hickory: SAF and FS types of the same names.

Mixed hardwoods: similar to SAF type yellow-poplar/white oak/northern red oak; FS type mixed hardwoods within the general type oak/hickory. Called cove hardwoods locally.

White pine: includes SAF and FS types white pine, white pine/hemlock, and hemlock.

The tree data for each forest type were analyzed with the formulas of Cottam and Curtis (1956) and computer programs similar to those of Ohmann and Ream (1971). An index of squirrel usage of each forest type was computed: (squirrels seen per year + leaf nests per year + nest dens) ÷ plots. Nest den and leaf nest usage indices were also computed: number of nest dens ÷ number of trees, and number of leaf nests per year ÷ number of trees. Chi-square goodness of fit tests were used to test randomness of (1) squirrel use and forest types, (2) nest dens and leaf nests among tree species, and (3) nest-den tree diameters among tree diameters of the same species. The t test was used to test for significance of differences in dbh, height of den entrance, den location, and tree class.

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RESULTS

From 1968 through 1970 we saw 127 gray squirrels and counted 182 nest dens in 144 trees, 1,761 escape dens in 1,163 trees, and 1,552 leaf nests in 1,511 trees. Although 50 percent of the den trees contained more than one den, only 5 percent contained both nest and escape dens.

The number of squirrels seen in each forest type was not a sufficient index of squirrel use because squirrel populations were low due to poor mast crops. Leaf nest and den nest counts were our best squirrel use indices.

Nest and Escape Dens

Live trees had 85 percent of the nest dens and 74 percent of the escape dens. Nest-den trees had significantly ($P < 0.001$) larger diameters than escape-den trees, and both kinds were larger than trees without dens (Table 1). Nest-den-entrance heights averaged 7.9 m; they were higher off the ground ($P < 0.001$) than escape-den entrances, which averaged 3.7 m. Eighty percent of the nest-den entrances were in tree trunks and 10 percent each in the tree butts and limbs. Nearly half of the escape-den entrances were in the butts of the trees, 45 percent were in tree trunks, and 8 percent were in limbs.

Table 1. Average diameters of trees with gray squirrel nest dens, escape dens, and no dens.

Trees with:	*Trees*	*Diameter*	
		Mean	*SE*
	No.	*Cm*	*Cm*
Nest den	144	47.7	1.27
Escape den	1,163	40.6	0.41
No den	8,824	28.7	0.10

Squirrel Preference for Forest Types

The red oak/scarlet oak forest type had the highest density of nest dens and was used by squirrels on Middle Mountain in proportion to its area (Table 2), but it occupied less than 2 percent of the study area and was not adequately sampled. The oak/pine, white pine, and yellow pine forest types were not preferred by squirrels. Therefore, these four forest types were considered unimportant to squirrels on Middle Mountain and were not analyzed further.

Table 2. Summary of gray squirrels seen, leaf nests, and nest dens by forest type.

Forest type	*Plots*		*Squirrels seen*		*Leaf nests*		*Nest dens*		*Usage index*
	No.	*%*	*No./100 ha*	*%*	*No./ha*	*%*	*No./ha*	*%*	
Mixed hardwoods	228	9.0	5.78	17.3	1.90	19.6	2.89	12.1	.464[a]
White oak/red oak/hickory	1,181	46.6	3.63	56.3	1.16	62.0	1.85	40.2	.382[a]
Red oak/scarlet oak	45	1.8	0.00	0.0	0.44	0.9	8.67	0.7	.318
Chestnut oak	375	14.8	1.78	8.8	0.57	9.7	4.52	31.2	.291
Oak/pine	581	22.9	2.30	17.6	0.25	6.6	0.69	7.4	.095[b]
White pine	46	1.8	0.00	0.0	0.25	0.5	2.37	2.0	.065[b]
Yellow pine	77	3.0	0.00	0.0	0.22	0.8	0.00	0.0	.039[b]

[a] Proportion of squirrel use significantly greater than proportion of forest type.
[b] Proportion of squirrel use significantly less than proportion of forest type ($P < 0.05$).

Squirrels preferred the mixed hardwoods and white oak/red oak/hickory forest types; the chestnut oak type, which occupied about 15 percent of the sudy area, was used in proportion to its area (Table 2). These three types occupied about 70 percent of the study area, accounted for 84 percent of the nest dens and 92 percent of the leaf nests, and had above-average indices of use by squirrels (Table 2).

Tree Species with Nest Dens

In the 3 most important forest types, 35 species of trees were recorded and nest dens were found in 14 species of trees that ranged from 20 to 94 cm dbh (Table 3). Nearly all of our nest-den samples were too small for us to compare diameter classes within or among species, or distinguish preferences for species from those for diameter. The exception was that American chestnut snags and sugar maples *(Acer saccharum)* with a dbh of 40 cm and more were used significantly ($P < 0.05$) more than all other species and had proportionally more nest dens than any other species-diameter class. These two species of trees had 10 percent of the total number of nest dens.

Table 3. Species distribution of trees (19+ cm dbh) with and without nest dens in the mixed hardwoods (MH), white oak/red oak/hickory (WO/RO/H), and chestnut oak (CO) forest types.

Species	*MH*	*WO/RO/H*	*CO*	*Combined*
	%	%	%	%
Species with nest dens:				
Quercus prinus	12.0	20.9	70.0	30.1
Quercus alba	4.9	21.4	3.7	15.5
Quercus rubra	20.7	16.6	7.3	15.2
Carya spp., 4 species	8.9	10.9	3.7	9.1
Quercus coccinea	1.4	9.7	2.9	7.2
Quercus velutina	1.2	4.1	1.5	3.2
Robinia pseudoacacia	6.5	1.8	0.7	2.1
Castanea dentata	1.6	2.3	1.1	1.3
Acer saccharum	4.7	0.9	—	1.2
Magnolia acuminata	5.9	0.6	—	1.2
Acer rubrum	2.9	1.0	0.2	1.1
Species without nest dens:				
Pinus rigida	1.6	4.5	3.7	4.0
Pinus strobus	1.5	1.5	1.1	1.4
Nyssa sylvatica	1.5	1.0	0.9	1.0
Liriodendron tulipifera	6.8	0.2	0.2	1.0
Pinus pungens	—	0.8	2.2	1.0
Tilia americana	5.2	0.3	0.1	0.9
Pinus virginiana	—	1.5	1.1	0.8
Tsuga canadensis	2.0	0.4	0.1	0.6
Betula lenta	3.6	0.3	—	0.6
Fagus grandifolia	3.5	0.2	—	0.6
Fraxinus americana	1.4	0.2	—	0.3
Prunus serotina	0.3	0.2	—	0.2
Ostrya virginiana	0.3	0.1	—	0.1
Juglans cinerea	0.2	0.1	—	0.1
Platanus occidentalis	0.5	—	—	0.1
Amelanchier arborea	0.2	tr[a]	—	tr
Populus tremuloides	—	tr	—	tr
Betula alleghaniensis	0.2	—	—	tr
Cornus florida	—	tr	—	tr
Sassafras albidum	0.2	—	—	tr
Carpinus carolinana	—	tr	—	tr
Trees sampled	912	4,670	1,499	7,081

[a] tr = less than 0.1 percent.

Three other species, regardless of diameter, were more important numerically than American chestnut and sugar maple. Seventy percent of all the trees were white oak *(Quercus alba)*, chestnut oak *(Q. prinus)*, or northern red oak and they had 75 percent of the nest dens. White oaks had more nest dens in the white oak/red oak/hickory type than expected ($P < 0.05$), along with American chestnut and sugar maple. Otherwise, these three oaks and the remaining nine species were used as nest-den trees about in proportion to their occurrence, except for scarlet oak *(Q. coccinea)* and black oak *(Q. velutina)*. Scarlet oak had fewer dens than expected in one type and in the three types combined; black oak had more dens than expected in one type (Table 4).

Table 4. Nest-den usage index (and number of trees sampled) by species in three forest types.

Tree species	*White oak/red oak/hickory*		*Mixed hardwoods*		*Chestnut oak*		*Combined forest types*	
Castanea dentata	.067[a]	(60)	.067	(15)	.176[a]	(17)	.087[a]	(92)
Acer saccharum	.093[a]	(43)	.023	(43)	—	(0)	.058[a]	(86)
Quercus alba	.025[a]	(998)	.089	(45)	.018	(55)	.027	(1098)
Magnolia acuminata	.000	(28)	.037	(54)	—	(0)	.024	(82)
Quercus prinus	.015	(974)	.028	(109)	.025	(1050)	.021	(2133)
Quercus rubra	.012	(777)	.021	(189)	.046	(109)	.017	(1075)
Robinia pseudoacacia	.024	(83)	.000	(59)	.000	(10)	.013	(152)
Acer rubrum	.021	(48)	.000	(26)	.000	(3)	.013	(77)
Carya spp., 4 species	.008	(507)	.037	(81)	.018	(56)	.012	(644)
Quercus velutina	.000	(184)	.000	(11)	.111[a]	(18)	.009	(213)
Quercus coccinea	.004[b]	(454)	.000	(13)	.023	(44)	.006[b]	(511)

[a] Proportion of trees used for nest dens significantly greater than the proportion of trees in forest types.
[b] Proportion of trees used for nest dens significantly less than the proportion of trees in forest types ($P < 0.05$).

Among 14 species in all 3 forest types, 36 cm dbh was the threshold diameter above which the relative frequencies of trees with nest dens exceeded the relative frequencies of all trees (Fig. 1). There were significantly ($P < 0.05$) more nest dens in trees 40 cm dbh and larger.

Tree Species with Leaf Nests

Twenty-six of 35 tree species had leaf nests, and 54 percent of the leaf nests were found in the 3 most abundant species: Chestnut oak, white oak, and northern red oak. In the chestnut oak type, squirrels preferred to build leaf nests in white oak ($P < 0.05$), however white oak and chestnut oak were less preferred in the forest types where these species were the most abundant. Otherwise, these oaks had about as many leaf-nests as would be expected by chance, or fewer (Table 5).

Hickories *(Carya* spp.) were clearly the most consistently preferred trees for leaf-nest building. Yellow-poplar *(Liriodendron tulipifera)* and red *(A. rubrum)* and sugar maples also had more leaf nests than expected ($P < 0.05$) in at least one forest type and in all three types combined (Table 5).

Among the remaining 19 species of trees, there were few statistically significant preferences and none of practical value (Table 5).

DISCUSSION

Generally we found 0.5 to 2 leaf nests and 2 to 4 nest dens per ha. The nest den density was considered sufficient to support a huntable squirrel population (Nixon 1968, Uhlig 1956). We recognize that some dens were probably incorrectly classified, but we believe our den tree sampling methods gave us the best estimate of the number of nest and escape dens that is possible without inspecting each cavity.

Regardless of species, squirrels preferred live trees 40 cm dbh and larger for nest dens. Many of these nest-den trees were probably residual trees, ones that were not cut during past commercial timber harvests. However, today timber harvesting or thinning on Middle Mountain without regard to squirrel habitat would remove the mature and residual trees.

We considered the mixed hardwoods, white oak/red oak/hickory, and chestnut oak forest types important for squirrels on Middle Mountain. However the red oak/scarlet oak and oak/pine types should not be ignored in other areas where they contain good mast-producing and den-forming trees.

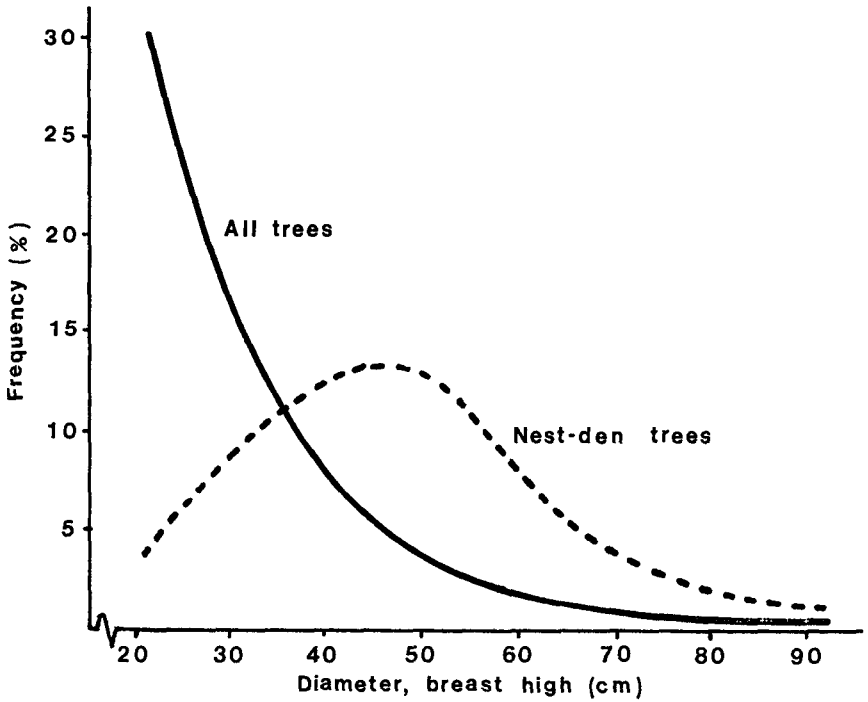

Figure 1. Distribution of diameters of nest-den trees compared to that of all trees of the 14 species in which nest dens were found. Only trees 19.0 cm dbh and larger found in the mixed hardwoods, white oak/red oak/hickory, and chestnut oak forest types are included.

Table 5. Leaf-nest usage index (and number of trees sampled) by species in three forest types.

Tree species	*White oak/red oak/hickory*		*Mixed hardwoods*		*Chestnut oak*		*Combined forest types*	
Carya spp., 4 species	.204[a]	(378)	.338[a]	(60)	.200[a]	(35)	.223[a]	(473)
Liriodendron tulipifera	.787[a]	(8)	.086	(43)	.150	(2)	.194[a]	(53)
Acer spp., 2 species	.190[a]	(72)	.086	(43)	1.000[a]	(2)	.165[a]	(117)
Betula spp., 2 species	.213	(8)	.062	(21)	—	(0)	.138	(29)
Quercus velutina	.100	(123)	.500[a]	(6)	.164	(14)	.124	(143)
Quercus rubra	.116	(558)	.112	(134)	.122[b]	(82)	.116	(774)
Tsuga canadensis	.070	(10)	.100	(13)	—	(0)	.100	(23)
Nyssa sylvatica	.100	(33)	.009	(8)	.000	(7)	.089	(48)
Quercus coccinea	.086	(357)	.300	(10)	.061	(33)	.089	(400)
Tilia americana	.100	(10)	.084	(32)	.000	(1)	.086	(43)
Magnolia acuminata	.095	(21)	.079	(38)	—	(0)	.085	(59)
Quercus alba	.074[b]	(727)	.261	(28)	.134[a]	(32)	.083	(787)
Quercus prinus	.099	(735)	.160	(73)	.023[b]	(743)	.065[b]	(1551)
Fraxinus americana	.100	(7)	.025	(12)	—	(0)	.053	(19)
Pinus virginiana	.048	(42)	—	(0)	—	(0)	.048	(42)
Robinia pseudoacacia	.078	(55)	.006[b]	(47)	.037	(8)	.045	(110)
Pinus strobus	.041	(56)	.000	(8)	.054	(13)	.039	(77)
Fagus grandifolia	.000	(7)	.041	(17)	—	(0)	.029	(24)
Pinus pungens	.011	(26)	.000	(24)	—	(0)	.006	(50)
Castanea dentata	.000	(45)	.037	(8)	.000	(8)	.005[b]	(61)
Pinus rigida	.006[b]	(123)	.000	(10)	.000	(37)	.004[b]	(170)

[a] Proportion of trees used for leaf nests significantly greater than the proportion of trees in forest type.
[b] Proportion of trees used for leaf nests significantly less than the proportion of trees in forest type ($P < 0.05$).

In the three forest types that were used most by squirrels, we found nest dens in one-third to one-half of the tree species. Collectively these species were preferred for nest dens, but there was not much preference among them—except for American chestnut snags and sugar maple. Only 7 percent of the nest dens were in chestnut snags, but since they are highly preferred for nest dens they should be retained as long as possible.

The fact that we found leaf nests more consistently in hickories than in trees of any other species substantiates the well-known value of hickory mast for squirrels: it is a first-choice (Nixon et al. 1968:297), high energy (Smith and Follmer 1972:84, 86) food that contributed to improved winter survival of adults and spring-born young in Ohio (Nixon et al. 1975:23). Leaf nests were also frequently located in yellow-poplars, whose seeds are an important fall food for gray squirrels (Nixon et al. 1968).

MANAGEMENT RECOMMENDATIONS

On Middle Mountain the white oak/red oak/hickory and mixed hardwood types contained a good mixture of species for squirrels. However, where present, American beech *(Fagus grandifolia)* should be favored. The basal area of beech should be increased to the recommended 0.7 to 1.4 m^2/ha for mast (Nixon et al. 1968).

The chestnut oak type was about 70 percent chestnut oak. There forest management should be aimed at increasing species diversity. Other oaks, red maple, and blackgum *(Nyssa sylvatica)* should be favored for dens, and hickories and oaks (scarlet, northern red, and black) for a greater variety of mast. The recommended basal area for fruiting hickories is 2.2 to 3.4 m^2/ha (Nixon et al. 1975); for maples it is 0.2 m^2/ha. In addition, a variety of other species are needed for a dependable year-round mast supply (Nixon et al. 1968).

If these stands were under intensive timber management, many of the largest trees would be removed—in either even-aged or uneven-aged silviculture. With either management system, where squirrels are important the cutting should maintain diversity among tree species—at least among the 14 species in which we found nest dens. These include species such as the oaks, which form dens slowly, and red maple, which probably forms dens faster than oaks because it is more susceptible to

decay (Shigo and Larson 1969:12). A few other species present in the study area, such as American beech and blackgum should also be retained because they are prone to form dens (Baumgartner 1940). Species diversity is also needed to maintain a stable year-round food supply. But mast production places more value on retaining hickories and yellow-poplar than does den management.

Management for dens and for mast both require long rotations—at least 100 years in stands like the ones we studied. Longer rotations are justified where squirrels are sufficiently important to compensate for reduced timber yields.

The loss of squirrel habitat by timber harvesting or thinning can be tempered by leaving the more vigorous nest-den trees in small clumps or islands. The regenerated even-aged stand or the remaining thinned trees should be managed to favor a mixture of mast-producing and den-forming species.

These recommendations consider the mature trees that are important for mast and nest dens in the existing stands, and also consider the need for mast-producing and den-forming species in future forest stands. These recommendations depend on each other, like links in a chain, to provide continuing squirrel habitat.

The key to gray squirrel habitat management is to provide a diversity among species selected as either present or potential den sites or mast producers. Species such as sugar maple, white oak, and yellow-poplar will be represented in the stand for their timber value. Hickories will also be favored on the better sites because of their increasing market value (Southern Lumberman 1975). Species with low timber values, such as red maple, blackgum, and cucumber tree *(Magnolia acuminata)* are a problem. But leaving about two of these trees that are important for dens or mast per hectare, in addition to the high-timber-value den and mast species, will provide the species diversity needed for squirrel habitat at small cost to timber production.

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WOODCOCK SINGING GROUNDS AND DIURNAL HABITAT IN NORTH CENTRAL OKLAHOMA

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ABSTRACT

The use of tall grass prairie singing sites and associated diurnal habitat by American woodcock was analyzed on the Oklahoma State University Ecology Preserve near Stillwater, Payne County, Oklahoma. The effect on woodcock use of breeding display habitat via artificially creating singing sites by mowing was observed in conjunction with an extensive study of display behavior. Woodcock preferred sparsely vegetated singing sites, regardless of their floral composition, aspect, shape, size, area, perimeter, soil texture, and pH. Preferred singing sites were well drained, had moderate slopes and were close to water or diurnal cover. Distances between singing grounds ranged from 150 to 300m. The mowing of plots proved successful in setting back succession and creating new display sites. The essential components of diurnal habitat were moderately dense overstory and understory, adequate ground cover, and moist loamy soil. Overgrazing appeared to be incompatible with good diurnal woodcock cover.

INTRODUCTION

The American woodcock, *Philohela minor* (Gmelin), has traditionally been considered a rare transient in Oklahoma by authorities such as Nice (1931), Force (1929), and Fletcher and Temple (1942), Baumgartner and Howell (1948) and Sutton (1968). On 27 February 1970, Barclay discovered a small population of woodcock displaying on eroded tallgrass prairie sites 14.5km west of Stillwater, Oklahoma, on the Oklahoma State University Ecology Preserve. Woodcock display behavior had not been recorded in Oklahoma prior to the present study. The presence of the local population, far from traditional breeding and wintering grounds (Sheldon 1967), thus led to investigation of breeding behavior and habitat use each spring through 1975. This paper documents only that portion of the study which evaluated woodcock habitat on the Ecology Preserve.

Displays on the study area were observed as early as 26 December in 1971, under unseasonably warm temperatures. However, subsequent displays were not encountered again that winter until 12 February, 1972. Other than the above exception, display initiation dates ranged from 26 January (1971) to 12 February (1972). The earliest date of termination of courtship activity was 11 March (1974) and the latest was 8 April (1970). Display season length ranged from 38 days (1974) to 59 days (1973). On 7 April, 1973, a woodcock hen with a 10 day old chick was observed on the area. The chick was captured and banded as the only confirmed nesting record for the Preserve.

Mendall and Aldous (1943) had remarked that no woodcock breeding records were available for Oklahoma in the 25 years prior to 1943. However, as Leopold (1933) noted, valuable insights relative to biological tolerance and habitat requirements of a species can be obtained on the periphery of its range. Thus, the presence of breeding woodcock on the western fringe of its range afforded a unique research opportunity in terms of woodcock population ecology and management.

The objectives of that portion of the study reported here were to: (1) analyze the characteristics of woodcock singing grounds and diurnal habitat on the Oklahoma State University Ecology Preserve; and (2) observe the response of a small woodcock breeding population to manipulation of habitat by artificially creating singing sites by mowing.

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