FACTORS INFLUENCING EASTERN WILD TURKEY NESTING SUCCESS IN THE OUACHITA MOUNTAINS, OKLAHOMA

By

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CHAPTER I

INTRODUCTION

This thesis is composed of 2 distinct manuscripts formatted for submission to a scientific journal. Each manuscript is complete as written and does not require any additional support material. Each chapter is formatted for the Journal of Wildlife Management. The order of arrangement for each manuscript is text, literature cited, tables, and figures.

CHAPTER II

VEGETATION CHARACTERISTICS AT EASTERN WILD TURKEY NEST SITES IN SOUTHEASTERN OKLAHOMA

Abstract: We fitted 130 eastern wild turkey (*Meleagris gallopavo silvestris*) (111 adult, 19 subadult) with radiotransmitters to determine nest site locations from January 1995 to August 1997. We characterized vegetation at 105 nests, adjacent, and non-use (random) sites to determine characteristics of successful versus unsuccessful nests. Nest sites selected by hens had more dense ($P < 0.001$) horizontal cover from 0.0-1.0 m height, and at 5 m from the nest horizontal cover was 42.6-94.0% higher than in adjacent and non-use plots ($P < 0.001$). The distance to 50% and 100% horizontal cover was significantly lower ($P < 0.001$) at the nest than in adjacent or non-use plots. Understory height was greater at the nest than non-use sites ($P < 0.001$). Percent ground cover of cryptogam ($P = 0.016$), litter ($P = 0.007$), rock ($P = 0.006$), and bare ground ($P = 0.027$) was less, at nests than in adjacent and non-use plots. Percent foliar cover of woody plants was greater at nests (17.3 ± 1.9 SE) than in adjacent (4.7 ± 0.4) and non-use (4.2 ± 0.4) plots ($P < 0.001$). Hens selected nest sites with a high density of small hardwood stems at and near the nest. Stem density was succeedingly greater in nested plots from 10-m down to 1-m radius plots. Successful nests were characterized by dense woody cover around the nest ($P = 0.031$). Successful nests had higher hardwood and total stem density in 1-m radius plots, in the 0.5-1.0 m height class and, in 10-m radius plots >2 m in height compared with unsuccessful nests. Lack of suitable nesting habitat appears to be a major factor

limiting nesting success. We recommend use of timber harvest to create openings (ESOs) that will be maintained with periodic fire of differing seasons and frequency. We also recommend openings that will be regenerated to a pine-hardwood mixture.

INTRODUCTION

Eastern wild turkey populations in southeastern U.S. have fluctuated greatly over the past decade. Results of winter flock and summer brood surveys conducted by the Oklahoma Department of Wildlife Conservation (ODWC) have shown a decline in the turkey population along with a decrease in the percentage of hens with poults. Seiss et al. (1990) stated that eastern wild turkey densities could be increased by improving nesting success.

Previous research in the Ozark Plateau and Ouachita Highlands of western Arkansas and eastern Oklahoma has suggested that insufficient nesting habitat may be related to low poult productivity thereby negatively influencing turkey populations (Wigley et al. 1985, Bidwell et al. 1989, Badyaev 1995, Badyaev et al. 1996). However, the landscape context of these studies, was considerably different than presently found in southeast Oklahoma. In the mid-1980s, considerable acreage of commercial pine (*Pinus* spp.) forests and U.S. Forest Service lands were undergoing extensive regeneration clearcutting. Since that time period, most of the regeneration areas have succeeded to mid-rotation pine stands and the U.S. Forest Service has limited the use of regeneration clearcutting (G. Bukenhofer, U.S. Forest Service, pers. comm.).

Therefore we determined that additional information was needed on nest site selection and movements because the landscape has changed considerably. Our purpose was to determine if nesting success and therefore population declines were related to a lack of suitable nesting habitat. Further, we hypothesized that nest success may be related to specific vegetation characteristics. Our primary objective was to characterize vegetation associated with eastern wild turkey nest site selection and to characterize habitat use by hens during pre-nesting and post-nesting seasons. Another objective was to determine if hens selected nesting habitat associated with roads, water, or edge.

STUDY AREA

Our study area included the Pushmataha Wildlife Management Area (PWMA) and surrounding properties. PWMA is owned and managed by the ODWC, located in Pushmataha County, Oklahoma, and encompasses 7,395 ha (Fig. 1). Private individuals and commercial timber corporations such as Georgia Pacific and Weyerhauser own much of the adjoining property. The study was expanded into these properties to include movement of the radio-transmittered hens. Our total study area encompassed approximately 29,800 ha and was in the Kiamichi Mountains in the Ridge and Valley Belt of the Ouachita Highland Province. The Kiamichi River borders the area along the northwestern side.

The Ouachita Mountains are composed of folded Mississippian and Pennsylvanian sandstones with north-facing slopes and shale valleys (Johnson et al. 1979). Cherty shales and resistant sandstones occur along prominent ridges. The resultant soils are thin and drought prone. Soils belong to the Carnsaw-Pirum-Clebit association with areas of rock outcrop, surrounded by Tuskahoma-Sherwood-Clebit association. The surface layer has a high percentage of rock on upland sites and varies in depth to 30 cm with a stony fine, sandy loam texture (Bain and Watterson 1979). A subhumid to humid climate prevails with hot summers and mild winters.

The PWMA lies within the oak-shortleaf pine (*Quercus* spp.-*Pinus echinata*) forest type. North slopes tend to be dominated by white oak (*Q. alba*), black oak (*Q. velutina*), mockernut hickory (*Carya tomentosa*), and shortleaf pine. Southern slopes tend to be dominated by black-jack oak (*Q. marilandica*), post oak (*Q. stellata*), and shortleaf pine. Other prevalent species include black hickory (*C. texana*) and eastern red cedar (*Juniperus virginiana*) (Masters 1991*b*).

The PWMA was initially established as a white-tailed deer (*Odocoileus virginianus*) refuge in 1954. From 1969-72, 71 elk (*Cervus elaphus*) were released on the PWMA (Masters 1991*a*). An aggressive timber management and prescribed burning program began in the early to mid-1970s to improve deer and elk habitat (Masters et al. 1993). The ODWC released eastern wild turkey on the study area in 1973 and 1975-76 (Masters 1991*a*).

METHODS

We located trap sites at food plots and other likely areas on the PWMA where we observed turkey or turkey sign and baited the sites with cracked corn. Trap sites were monitored daily to determine use by turkeys. When use of bait sites had been established, rocket nets or box nets were used to capture hens (Hawkins et al. 1968, Wunz 1987*b*). Trapping was initiated the first week of January and continued until 50 female turkeys were captured or until the start of nesting season.

Upon capture, we banded hens with numbered aluminum leg bands. We recorded age, weight, length of central tail feathers, length of wing, tarsus, spur, and beard if present (Bookout 1994). Each hen was classified as a juvenile or adult according to Pelham and Dickson (1992). Due to the low initial trapping success and sample size, 19 juvenile hens were radio-marked as well. We placed a radiotransmitter (Lotek Engineering, Inc., Newmarket, Ontario, Canada) on females using a backpack-style harness (Everett et al. 1978). All measurements and release took place at the trap site.

We used radiotelemetry to determine seasonal habitat use, movement patterns associated with nesting, and to locate nests for quantification of nesting habitat. Females (n = 130) were captured from January 1995 through March 1997. Hens that survived ≥14 days from capture were included in the study. Intensive monitoring occurred from the onset of nesting season until 2 weeks after the last nest hatched.

Hens were monitored daily to determine the onset of nesting. During the nesting season (April-July), we suspected nesting when a mortality signal was received during the day. If that occurred, we approached the suspected nest site and flagged a circle 25-50 m radius around the bird (Everett et al. 1980, Holbrook et al. 1987). We checked the bird >2 times/day to determine if the signal switched back to normal pulse suggesting a nesting hen. Nesting hens were monitored daily to ascertain nest departure and nesting dates. When a hen left the nest for >8 h nest fate was determined. A nest was categorized as successful if ≥1 egg hatched. We determined number of poults by egg fragments at the nest (Vangilder 1992). Nest success was calculated by dividing the number of successful nests by the number of known attempts. Predation or abandonment qualified as an unsuccessful nest. If suspected nesters remained in an area for >30 days on mortality, we located the bird and verified death or picked up the detached transmitter. No hens remained on their nest for >30 days.

Plot Layout

We began vegetation sampling <1 week after nest fate had been confirmed. We characterized vegetation in nest-centered plots, adjacent plots 40 m from the nest, and randomly located non-use sites. Adjacent plot location was determined by using a random bearing to position the first plot then locating the remaining 2 plots at 120° and 240° from the first. Non-use sites were located at a random bearing and random distance (<800 m) from the last adjacent plot measured. We measured 4 plots at the non-use site in a similar fashion as the nest and adjacent site (Badyaev 1994; Fig. 2).

Stand Characteristics

We measured stand characteristics at plot center and 4 perimeter points, established at right angles 5 m from plot center. At each point, we estimated overstory density using a spherical densiometer (Lemmon, 1957), conifer and hardwood basal area with a 10-factor prism (Avery 1964), percent slope with a clinometer (Suunto, Espoo, Finland), and slope position and aspect. Understory height measurements, with a maximum height of 0.5 m, also were taken at those points.

We used nested 1-, 2-, and 10-m fixed radius plots to estimate stem density with the nest as plot center. Nested plots were used to determine comparative scale of micro-nesting habitat selection. We categorized woody stems according to height and diameter at breast height (DBH). Height classes for stem densities were 0.0-0.5 m, 0.5-1.0 m, 1.0-2.0 m, and >2.0 m. Diameter classes were <25 cm, 25-45 cm, and >45 cm.

Percent Cover

We measured ground cover in 4 adjacent 1-m^2 plots (area = 16 m^2) using the center of the nest as a junction for the sampling frames. We categorized percent ground cover of cryptogam, forb, grass, litter, rock, bare ground, stem, and woody cover using a cover value gradient (after Daubenmire 1959). Relative horizontal cover was assessed using a density board (Nudds 1977), divided into 2 height classes (0-50 cm and 50-100 cm). By placing the board at each perimeter point and viewing from the nest center 46 cm above the ground (Seiss et al. 1990), we categorized percent cover into 1 of 7 classes (Schmutz et al. 1989). The board was then moved away from or toward the nest until 50% and 100% of the board was occluded for each height class. This distance was measured and recorded.

Statistical Analyses

We performed all statistical analyses on vegetation data using Statistical Analysis Software (SAS Institute 1989). We used analysis of variance for multiple univariate comparisons. Means were separated using the Least Significant Difference test (LSD). Data were analyzed as a split-split plot design. Year was the main unit treatment, month was the split-unit treatment, and use was the split-split unit treatment. We used an arcsine square root transformation where necessary to normalize data. Student's-t tests were used for unpaired and paired comparisons (SAS Institute 1989). We used SAS (PROC LOGISTIC) to determine which variables best explained successful versus unsuccessful nests (SAS Institute 1989). Our level of significance was $P < 0.05$.

RESULTS

Stand Characteristics

We found that hardwood, conifer, total basal area, and canopy cover differed little between nest, adjacent, or non-use sites (Table 1). Percent slope and aspect were not different between use types. However, understory height averaged 6.0 and 6.5 cm lower at adjacent and non-use sites respectively ($P < 0.001$). Significant year effects were noted in the amount of hardwood basal area, percent canopy cover, and percent slope. In years with dense canopy cover, hens may have selected sites with lower foliar cover and thus lower hardwood basal area.

Nest site selection based on stem density was evident at all scales of measurement (1-, 2-, and 10-m radius plots) around the nest (Table 2). Stem density was inversely proportional to the measurement scale; as plot radius from the nest decreased stem density increased. We found few stems in >25 cm DBH classes with no difference in density among use categories. Therefore, we combined all DBH classes for analysis and presentation (Table 2). Hens selected for greater hardwood and total density in the 0.5-1 m, 1-2 m and all heights combined height classes ($P < 0.05$) at all scales of measurement around the nest. In 10-m radius plots, hens also selected for dense hardwood stems and a high density of total stems in the 0-0.5 m height class ($P < 0.001$). No evidence of selection ($P > 0.05$) was found for stem density >2 m in any category (hardwood, conifer, or total stems).

Hardwood stems in the 0.0-0.5 m height class were composed of primarily blackberry (*Rubus* spp.), low blueberry (*Vaccinium vacillans*), and to a lesser extent poison ivy (*Rhus toxicodendron*), grape (*Vitis* spp.), fragrant sumac (*Rhus aromatica*), and post oak. In the greater height classes, additional tree and other shrub species predominated (e.g., *Q. marilandica*, *Vaccinium arboreum*, and *Ulmus alata*). The only conifers were shortleaf pine, loblolly pine (*P. taeda*) in ESOs (planted clearcuts), and eastern red cedar (*Juniperus virginanus*). Conifers were comparatively sparse in the understory and midstory across all use sites ($P > 0.05$).

Horizontal and Ground Cover

We found that nest sites selected by hens had more dense ($P < 0.001$) horizontal cover from 0.0-1.0 m height in the understory (Table 3). Horizontal cover 5 m from the nest was 42.6-94.0% higher at the nest than in adjacent and non-use plots ($P < 0.001$;Table 3). The distance to 50% and 100% horizontal cover was significantly lower ($P < 0.001$) at the nest than in adjacent or non-use plots. Average distance to 50% and 100% cover (maximum 15 m; 0.5-1 m height class; 100% cover) may give some indication as to the scale at which hen turkey selected nest sites on our study area (Table 3). The distance to 50% cover at nests was from 2.4-2.8 m less than adjacent or non-use sites in the 0.0-0.5 m height class and 3.9-4.5 m in the 0.5-1.0 height class ($P < 0.001$). Similarly, the distance to 100% cover at nests averaged from 3.8-4.8 m less than adjacent or non-use sites in the 0.0-0.5 m height class and 4.8-6.0 m less in the 0.05-1.0 m height class ($P < 0.001$; Table 3). We noted significant ($P < 0.05$) month effects on distance to 50% and 100% cover at the 0.5-1.0 m heights as a results of the onset of spring and foliar development of understory trees and shrubs (Table 3).

Percent ground cover of cryptogam ($P = 0.016$), litter ($P = 0.007$), rock, ($P = 0.006$) and bare ground ($P = 0.027$) was less, at nests than in adjacent and non-use plots (Table 4). Cryptogams were often associated with surface rock and covered a portion of exposed rock. Percent foliar cover of woody plants was greater at nests (17.3 ± 1.9 SE) than in adjacent (4.7 ± 0.4) and non-use (4.2 ± 0.4) plots ($P < 0.001$; Table 4). We found no significant ($P < 0.05$) month or year effects on herbaceous vegetation.

Nest Success

We found nesting success to be unrelated to stand characteristics such as hardwood, conifer and total basal area, canopy cover or slope, aspect, or understory height ($P > X > 0.05$). Nest success was not related to horizontal cover or stem density of conifers or hardwoods >25 cm DBH.

At the micro-habitat level, successful nests were characterized by dense woody cover around the nest ($P = 0.031$; Table 5). Nests with greater hardwood and total stem density in the 1-m radius plots at the 0.5-1.0 m height class were more successful ($P < 0.05$). Nests with greater hardwood and total stem density in the 10-m radius plots in the >2 m height class also had a higher probability of being successful ($P < 0.05$).

DISCUSSION

A key factor for improving wild turkey populations is increasing suitable habitat (Everett et al. 1985, Phalen et al. 1986, Sisson et al. 1991). When selecting potential nest sites, hens may use visual cues associated with vegetation structure. Vegetation density, percent cover, height, and composition may indicate suitable nest sites, or at least the best available nest sites. Badyaev (1995) found in an Arkansas study that hens selected for many of these attributes when selecting nest locations. Nesting hens prefer areas with rich herbaceous cover and structure that provides adequate cover at ground-level and above (Bidwell 1985, Day et al. 1991*a*, Hurst and Dickson 1992, Rumble and Hodoroff 1993. Badyaev 1995).

Our results clearly indicate that hens selected nest sites based on micro-habitat characteristics. Selection for specific nest site characteristics was apparent 15 m from the nest, but no selection for habitat structure or composition was evident at 40 m (location of adjacent plots). Badyaev (1995) reported that hens select nest patch size of about 40 m. Hens preferred sites with a greater understory height. Our nest sites had an understory height of 27.4 cm while Badyaev (1995) reported an understory height at the nest of 57.4 cm. Except for understory height, stand characteristics varied little when comparing the nest location versus adjacent and non-use (random) sites. Hens favored nest sites with a high density of hardwood stems > 0.5 m tall. Dense understory cover provided cover most suitable to nesting hens (Holbrook et al. 1987, Seiss et al. 1990). Dense cover and increased plant diversity reduced the number of nests found by predators (Bowman and Harris 1980.) Hens also selected nest sites with low amounts of rocky cover and a higher percentage of woody cover.

Currently, brood production is being limited by the lack of early successional habitats (Stewart 1999) and by high predation rates in this limited habitat type (Nicholson et al. 1999). Our data suggest that lack of suitable nesting habitat may be limiting (Stewart 1999). Nest sites in our study had especially dense cover in the 0.0-0.5 m class but less so at the 0.5-1.0 m height. Hens need sites with enough cover for protection from predators but not so dense that movement is impeded. Seiss et al. (1990) recommended the creation of edge in pine habitat.

MANAGEMENT IMPLICATIONS

The specificity of nest site selection suggests several management options. Because we found that early successional stages were preferred nest sites (Stewart 1999), additional forest openings are warranted to create potential nest sites. This can be accomplished economically through timber harvest (Masters et al. 1993).

Periodic fire is important for maintenance of and promotion of open herbaceous understory (Masters et al. 1993). However, too frequent dormant season fire can lead to homogenization of habitat structure (Sparks et al. 1998) and reduction of woody stem density to the detriment of hens searching for suitable nest sites with high woody stem density. Periodic shifts to growing season burns will create a mosaic in the burned area because of higher fuel moisture and fuel discontinuity as a result of patches of green vegetation and a high percentage of surface rock (Sparks et al. 1999). When woody encroachment into ESOs becomes a problem, periodic shifts back to frequent dormant season fire may help control woody vegetation (Masters et al. 1993).

The fact that no birds nested in the burned area in 1997 suggests that prescribed fire should be planned such that unburned areas suitable for nesting are left. However, the proportion of the spring male harvest that was taken in and around burned areas suggests that burned areas are attractive for breeding areas. The use of prescribed fire apparently has both short-term benefits for breeding behavior and short-term negative aspects for nesting hens. Do not burn or mow these areas during nesting season. Bottomland hardwood corridors should be protected as these provide preferred wintering habitat and travel corridors (Dalke et al. 1946, Smith et al. 1990, Stewart 1999).

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Table 1. Forest stand characteristics of eastern wild turkey nest, adjacent, and or non-use plots, in Pushmataha county, Oklahoma, 1995-97.

	Plot Location[a]								
	Nest		Adjacent		Non-use		*P*>F		
Parameter	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Use	Month	Year
Hardwood basal area	5.5	0.5	6.7	0.4	6.7	0.4	0.147	0.583	0.016
Conifer basal area	7.8	0.9	7.1	0.5	7.2	0.6	0.234	0.563	0.498
Total basal area	13.2	1.0	13.8	0.8	14.0	0.8	0.848	0.328	0.168
Canopy cover (%)	55.2	3.9	56.8	3.3	54.5	3.6	0.374	0.136	0.004
Percent slope (%)	4.7	0.6	3.9	0.3	3.8	0.4	0.989	0.187	<0.001
Aspect (°)	167.5	9.1	178.5	6.3	181.9	6.2	0.793	0.832	0.614
Understory height (cm)	27.4a	1.0	21.4b	0.7	20.9b	0.7	<0.001	0.557	0.587

[a] Within each row, means sharing the same letter are not different ($P > 0.05$).

Table 2. Stem density estimates (stems/ha) at turkey nests, adjacent, and random sites based on nested 1-, 2-, and 10-m radius plots, from Pushmataha County, Oklahoma spring and summer 1995-97.

Plot size, Height class (m) Category	Use Category[a] Nest $\bar{x}$	Nest SE	Adjacent $\bar{x}$	Adjacent SE	Non-use $\bar{x}$	Non-use SE	P>F Use	P>F Month	P>F Year
1-m radius									
0-0.5									
Hardwood	55,967	8,481	23,502	2,119	25,403	2,657	0.393	0.955	0.991
Conifer	278	140	1,669	502	719	153	0.483	0.488	0.425
Total	56,245	8,475	25,171	2,171	26,122	2,647	0.420	0.950	0.985
0.5-1.0									
Hardwood	14,432a	2,013	3,801b	529	3,394b	462	<0.001	0.015	0.960
Conifer	433	152	371	119	232	77	0.859	0.205	0.222
Total	14,865a	2,007	4,172b	533	3,626b	457	<0.001	0.029	0.952
1.0-2.0									
Hardwood	3,708a	612	1,370b	267	850b	146	0.004	0.086	0.098
Conifer	371	172	185	63	116	30	0.846	0.880	0.944
Total	4,079a	655	1,555b	278	966b	146	0.005	0.119	0.116
> 2.0									
Hardwood	1,885	371	783	111	610	84	0.603	0.941	0.670
Conifer	587	157	505	91	603	95	0.895	0.848	0.600
Total	2,472	426	1,288	146	1,213	127	0.730	0.998	0.507
All									
Total	77,661a	9,074	32,222b	2,531	31,926b	2,886	0.035	0.994	0.978

Table 2. Continued.

Plot size, Height class (m) Category	Use Category[a]								
	Nest		Adjacent		Non-use		P>F		
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Use	Month	Year
2-m radius									
0.0-0.5									
Hardwood	36,273	4,811	20,153	1,528	19,888	1,825	0.347	0.840	0.640
Conifer	541	237	1,264	306	747	199	0.618	0.714	0.992
Total	36,814	4,804	21,418	1,572	20,635	1,866	0.364	0.841	0.638
0.5-1.0									
Hardwood	10,755a	1,631	3,344b	345	3,281b	389	<0.001	<0.001	0.678
Conifer	348	112	355	87	216	45	0.764	0.351	0.223
Total	11,102a	1,628	3,699b	358	3,497b	386	<0.001	0.001	0.688
1.0-2.0									
Hardwood	2,681a	448	1,398b	205	945b	139	0.001	0.094	0.188
Conifer	185	91	232	69	162	35	0.900	0.604	0.675
Total	2,866a	470	1,630b	220	1,107b	144	0.003	0.140	0.243
> 2.0									
Hardwood	765	121	783	80	593	50	0.227	0.806	0.798
Conifer	340	62	515	71	475	62	0.161	0.953	0.383
Total	1,105	155	1,298	116	1,068	83	0.080	0.952	0.491
All									
Total	51,888b	5,484	28,090b	1,910	26,308b	2,032	0.011	0.872	0.601

Table 2. Continued.

Plot size, Height class (m) Category	Use Category[a] Nest $\bar{x}$	Nest SE	Adjacent $\bar{x}$	Adjacent SE	Non-use $\bar{x}$	Non-use SE	P>F Use	P>F Month	P>F Year
10-m radius									
0.0-0.5									
Hardwood	15,468a	1,462	11,944b	850	11,977b	1,138	0.033	0.719	0.202
Conifer	422	144	547	91	590	172	0.926	0.472	0.925
Total	15,890a	1,465	12,491b	858	12,567b	1,176	0.043	0.736	0.211
0.5 – 1.0									
Hardwood	5,687a	1,238	2,859b	215	2,502b	239	<0.001	<0.001	0.291
Conifer	233	58	263	52	175	25	0.612	0.585	0.400
Total	5,920a	1,236	3,122b	224	2,677b	238	<0.001	<0.001	0.276
1.0 – 2.0									
Hardwood	2,381a	659	1,274b	137	1,001b	125	<0.001	<0.001	0.004
Conifer	163	39	161	33	148	24	0.964	0.840	0.586
Total	2,544a	661	1,434b	147	1,150b	131	<0.001	<0.001	0.006
> 2.0									
Hardwood	733	63	813	54	740	42	0.283	0.460	0.481
Conifer	422	49	463	49	440	41	0.719	0.433	0.187
Total	1,155	89	1,277	83	1,180	69	0.260	0.286	0.212
All									
Total	25,510a	2,493	18,324b	1053	17,573b	1,306	<0.001	0.114	0.102

[a] Within each row, means sharing the same letter are not different ($P > 0.05$).

Table 3. Horizontal cover at eastern wild turkey nests, adjacent and non-use sites in Pushmataha county, Oklahoma, 1995-97.

	Nest		Adjacent		Non-use		*P*>F		
Parameter, height	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Use	Month	Year
Horizontal cover (%)									
at 5 m from nest									
0.0-0.5 m	69.6a	2.5	49.7b	1.9	48.8b	2.0	<0.001	0.301	0.388
0.5-1.0 m	51.4a	2.7	28.6b	1.7	26.5b	1.5	<0.001	0.041	0.346
Dist. (m) to 50% cover									
0.0-0.5 m	4.0b	0.3	6.4a	0.3	6.8a	0.3	<0.001	0.607	0.065
0.5-1.0 m	7.6b	0.5	11.5a	0.4	12.1a	0.3	<0.001	0.015	0.158
Dist. (m) to 100% cover									
0.0-0.5 m	9.9b	0.6	13.7a	0.5	14.7a	0.5	<0.001	0.082	0.631
0.5-1.0 m	15.0b	0.7	19.8a	0.5	21.0a	0.6	<0.001	0.016	0.514

Table 4. Understory characteristics (% cover) of eastern wild turkey nest sites, adjacent and random plots, Pushmataha county, Oklahoma, 1995-97.

	Use Category								
	Nest		Adjacent		Non-use		$P>F$		
Cover class	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	Use	Month	Year
Cryptogam	1.5b[a]	0.3	2.5a	0.3	2.7a	0.4	0.016	0.941	0.602
Forb	5.3	0.7	7.5	0.8	7.6	1.0	0.738	0.602	0.112
Grass	22.2	2.3	15.7	1.5	15.5	1.3	0.111	0.265	0.430
Litter	46.7b	2.7	57.6a	2.0	58.2a	2.1	0.007	0.263	0.770
Rock	1.4b	0.4	4.3a	0.6	3.7a	0.4	0.006	0.190	0.229
Bare Ground	1.9b	0.5	5.0a	0.8	5.1a	0.8	0.027	0.006	0.354
Stem	1.0	0.2	0.7	0.1	0.6	0.1	0.982	0.340	0.182
Vine	9.5	1.7	3.3	0.6	3.3	0.5	0.462	0.560	0.921
Woody	17.3a	1.9	4.7b	0.4	4.2b	0.4	0.0005	0.256	0.255

[a] Within each row, means sharing the same letter are not different ($P > 0.05$).

Table 5. Ground cover (%) characteristics of successful (n = 40) versus unsuccessful (n = 79) eastern wild turkey nest sites on the PWMA and vicinity in 1995-1997.

	Successful		Unsuccessful		
Cover class	$\bar{x}$	SE	$\bar{x}$	SE	$P > \chi^2$
Cryptogam	0.9	0.2	1.6	0.3	0.304
Forb	4.0	1.9	5.7	0.7	0.628
Grass	17.5	4.6	23.6	2.7	0.300
Litter	43.2	6.3	47.7	3.1	0.787
Rock	2.2	1.6	1.2	0.2	0.274
Soil	1.0	0.5	2.1	0.7	0.301
Stem	1.4	0.6	0.9	0.3	0.299
Vine	13.8	4.5	8.3	1.7	0.101
Woody	25.8	4.6	14.9	1.9	0.031

[a] Next success predicted using PROC LOGISTIC ($P > 0.05$).

Figure 1. Study area in Pushmataha County, Oklahoma.

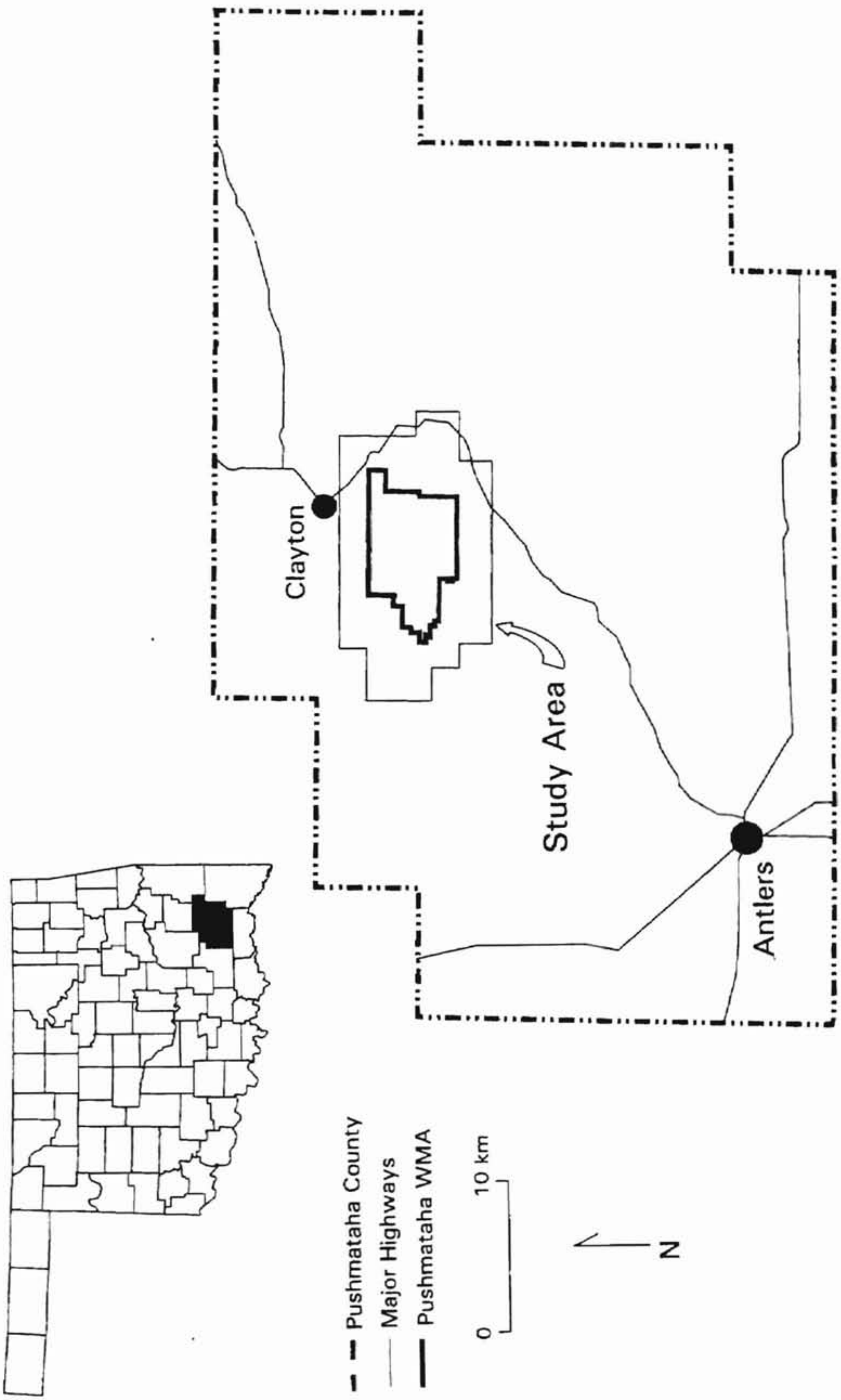
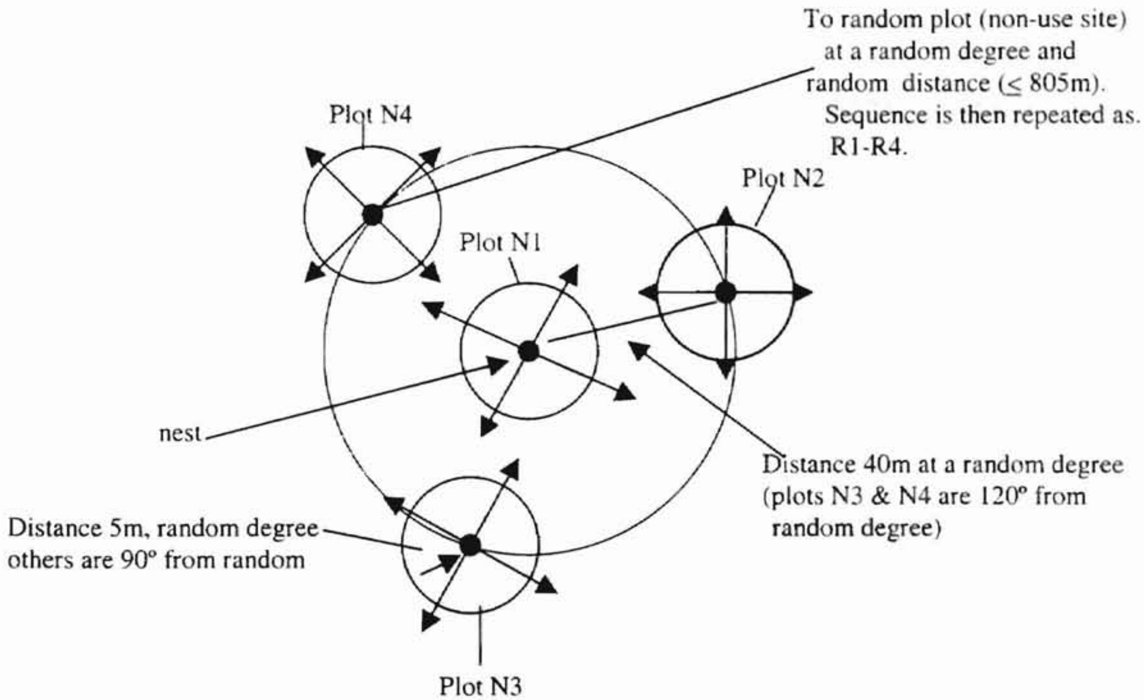

Clayton
Study Area
Antlers
Pushmataha County
Major Highways
Pushmataha WMA
0
10 km
N

Figure 2. Sampling design for vegetation measurements on nest (N1), adjacent (N2-N4), and non-use plots (R1-R4), 1995-97.


To random plot (non-use site) at a random degree and random distance (≤ 805m). Sequence is then repeated as. R1-R4.
Plot N4
Plot N2
Plot N1
nest
Distance 40m at a random degree (plots N3 & N4 are 120° from random degree)
Distance 5m, random degree others are 90° from random
Plot N3

CHAPTER III

MACRO-HABITAT CHARACTERISTICS AND USE ASSOCIATED WITH EASTERN WILD TURKEY NEST SITE SELECTION

Abstract: Macro-habitat characteristics of eastern wild turkey (*Meleagris gallopavo silvestris*) nest sites were studied to determine factors limiting productivity. Determining macro-habitat selection for nest sites could provide a useful tool for management decisions on a large scale. Hens preferred habitats with a high diversity and close juxtaposition to edges or other habitat types. Although hens selected nesting sites closer to roads than random points in our study area ($P = 0.001$), nest success was unrelated to distance from roads, edge, or former trap site. Hens that nested closer to water had a tendency to be more successful ($P = 0.078$). Nest success was influenced by the habitat type chosen for nesting (Fisher's Exact Test; $P = 0.004$). Hardwood-pine stands, pine-hardwood stands, and early successional openings (ESOs), accounted for 70.6% of the nesting attempts. Only 12.5% of the hens that nested in ESOs were successful versus 58.8% of those attempting nests in hardwood-pine stands. ESOs had the lowest nesting success rate for any habitat type selected for nesting. Hens most often selected pine-hardwood habitat for nesting over other habitat types. No nesting attempts were made in pasture, bottomland hardwood/stream corridor, or pine plantation cover types. Home range size for 1 January to 1 August locations was 1,369.7 ha ± 918.3 SE. Pre-nesting home ranges were 1,718.5 ha ± 1,293.5. Post-nesting home ranges were 1,177.2 ha ± 1,405.8. Home range size did not vary within individual years or season when we tested

for a season main effect ($P > 0.05$). We found that food plots were the most preferred habitat type in terms of proportional use on the area during our sampling period. Food plots made up only 0.2% of the total study area and were preferred significantly ($P < 0.05$) greater than the next ranked cover type, ESOs, across all seasons. Bottomland/stream corridor habitats were the third highest in preference. The least preferred habitat type was hardwood-pine stands, which proportionally comprised the greatest amounts of a given cover type on our study area (26.7-28.5%).

INTRODUCTION

Relatively few studies have been conducted on nesting requirements of wild turkey in Ouachita Mountains of Oklahoma and Arkansas. Bidwell (1985) conducted studies on commercial timber land in southeastern Oklahoma. Hens select hardwood and hardwood-mixed stands with an open canopy and herbaceous understory (Bidwell 1985). Wild turkey hens exhibited avoidance or no preference for 0-13-year-old pine (*Pinus taeda*) plantation, meadows, and developed areas (Bidwell et al. 1989). Comparable results were found in Arkansas. Adult hens preferred >40-year-old natural pine stands throughout the year. The hens avoided pine plantations in fall and winter, while showing no avoidance or no preference in spring and summer (Wigley et al. 1985).

However, the landscape has changed considerably in the southeastern Oklahoma since those studies. In the mid-1980s, considerable acreage of commercial pine forests and U.S. Forest Service lands were undergoing extensive regeneration clearcutting. Since that time period, most of the regeneration areas have succeeded to mid-rotation pine stands and the U.S. Forest Service has limited the use of regeneration clearcutting (G. Bukenhofer, U.S. Forest Service, pers. comm.).

Additional information was needed on nest site selection and movements because the landscape context has changed considerably. Our purpose was to determine if nesting success, and therefore population declines were related to a lack of suitable nesting habitat. Our primary objective was to determine habitat type associated with eastern wild turkey nest site selection and to characterize habitat use by hens during pre-nesting and post-nesting seasons. We also sought to determine if nest site selection was based on proximity to roads, water, or edge.

STUDY AREA

Our research area included the Pushmataha Wildlife Management Area (PWMA) and surrounding properties. PWMA is state owned, located in Pushmataha County, Oklahoma, and encompasses 7,395 ha. Private individuals and corporations such as Georgia Pacific and Weyerhauser own adjoining property. The Kiamichi Mountains in the Ridge and Valley Belt of the Ouachita Highland Province surround the study area. The Kiamichi River borders the area along the northwestern side.

The Ouachita Mountains are composed of folded Mississippian and Pennsylvanian sandstones with north-facing slopes and shale valleys (Johnson et al. 1979). Cherty shales and resistant sandstones occur along prominent ridges. Soils are thin and drought prone with areas of rock outcroppings. The surface layer varies in depth to 30 cm with a stony fine, sandy loam texture (Bain and Watterson 1979). A subhumid to humid climate prevails with hot summers and mild winters.

The PWMA lies within the oak-shortleaf pine (*Quercus* spp.-*P. echinata*) forest type. North-facing slopes tend to be dominated by white oak (*Q. alba*), black oak (*Q. velutina*), mockernut hickory (*Carya tomentosa*), and shortleaf pine. South-facing slopes tend to be dominated by black-jack oak (*Q. marilandica*), post oak (*Q. stellata*), and shortleaf pine. Other prevalent species include black hickory (*C. texana*) and eastern red cedar (*Juniperus virginiana*) (Masters 1991*b*).

The PWMA was initially established as a white-tailed deer (*Odocoileus virginianus*) refuge in 1954. Seventy-one elk (*Cervus elaphus*) were released on the PWMA from 1969-72 (Masters 1991*a*). ODWC released eastern wild turkey on the study area in 1973 and 1975-76 (Masters 1991*a*). Management practices within the PWMA include timber harvest, mowing, planting food plots, and prescribed fire.

METHODS

We located trap sites at food plots and other likely areas across the PWMA where turkey or turkey sign was seen. We baited the sites with cracked corn. Trap sites were monitored daily to determine use by turkeys. Optimally, capture should have been distributed across the area, but due to low population density we trapped where possible. When use of bait sites had been established, rocket nets or box nets were used to capture hens (Hawkins et al. 1968, Wunz 1987*b*). Trapping was initiated the first week of January and continued until 50 female turkeys were captured or until the start of nesting season.

Upon capture, we banded hens (preferably adults) with numbered aluminum leg bands. After weight, measurements (length of tail feather, wing, tarsus, spur and beard if any), and age (Bookout 1994) of the bird were recorded, we placed a radio transmitter (Lotek Engineering, Inc., Newmarket, Ontario, Canada) on females with a backpack-style harness (Everett et al. 1978). All measurements and release took place at the trap site within the PWMA.

Telemetry

Battery-powered transmitters weighed $\leq$ 90g and operated in the 150-151 MHz range with mortality and activity switches. The models in the 150 MHz range operated on a long (8-10 h delay) mortality switch, with a minimum life of 35 months; the 151 MHz range operated on a short (2-3 h delay) mortality switch and a minimum life of 17 months. Lotek Engineering Inc. model SRX-400 scanning receivers (Lotek Engineering, Inc., Newmarket, Ontario, Canada) along with a hand-held 3-element Yagi antenna were used to locate signals. The receivers had a maximum line of sight detection of 24 km.

We established 198 telemetry stations at road intersections and dispersed throughout the study area to obtain radio locations on transmittered hens. A handheld Global Positioning System (GPS) receiver, the GeoExplorer, and a ProXR (Trimble Navigation, Sunnyvale, California, USA) unit were used to collect universal transverse mercator (UTM) coordinates for telemetry triangulation stations, trap sites, and nest locations. Base station data for post-processing was obtained from the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas, Fayetteville. The ProXR provided real-time GPS with differential correction coming from a Coast Guard beacon (299.0 frequency) at Sallisaw, Oklahoma.

We attempted to locate each hen $\geq$ 1 time per day prior to nesting season (January-March), all locations were based on $\geq$ 3 triangulation bearings. During the nesting season, an attempt was made to locate each bird 3 times daily. Rough terrain and hen dispersal limited our ability to accomplish this. Therefore, each bird was located as many times as possible. Radio fixes were obtained on an alternating pattern between days to assess habitat use throughout the day. We continued monitoring hens until 2 weeks after the last hen departed from a nest, or until 1 August whichever was latest.

Hens were monitored daily to determine the onset of nesting. During the nesting season (April-July), we suspected nesting when we received a mortality signal during the day. At that time, we approached the suspected nest site and flagged a circle 25-50 m around the bird (Everett et al. 1980, Holbrook et al. 1987). We checked the bird ≥ 2 times/day to determine if the signal switched back at any time to normal pulse indicating a nesting hen. Nesting hens were monitored daily to ascertain departure from the nest. When a hen left the nest for > 8 h nest fate was determined. A nest was categorized successful if ≥ 1 egg hatched. We determined successful nests and number of poults by egg fragments at the nest (Vangilder 1992). Predation or abandonment qualified as an unsuccessful nest. If suspected nesters remained in an area for >30 days, we walked in and verified death or picked up the detached slipped transmitter. No hens remained on their nest for > 30 days.

Geographical Information Systems

Black-and-white aerial photos for winter 1990 were obtained from the U. S. Department of Agriculture Aerial Photography Field Office, Salt Lake City, Utah. Photographs were 60.96 x 60.96 enlargements with a representative fraction (RF) of 1:7,920. We also used 1996 color infrared photographs obtained from Georgia Pacific, a commercial timber company.

Clear mylar sheets placed over each 60.96 x 60.96 photo allowed us to trace habitat types from the aerials. Use of winter aerial photos assisted in differentiating hardwoods from pine because of leaf loss. Features identified included: all visible roads, water, and vegetation cover. We obtained additional information from Georgia Pacific 1996 aerial photos and harvest strategies, GPS collected data, satellite thematic map (TM) scenes, Topologically Integrated Geographic Encoding and Referencing (TIGER) files, Digital Line Graphs (DLG) files at 1:250,000 scale, and Digital Elevation Models (DEM) at 1:100,000 scale.

Completed mylar sheets were digitized using a digital scanner and hand digitizing. Scanned images were edited, rectified, and converted to vector files using Line Trace Plus version 2.2 (U.S. Forest Service and Soil Conservation Service, 1991) within the UNIX environment. Arc/INFO and PC ArcView (ESRI, Redlands, California, USA) were used to create maps concerning spatial analysis. Supervised photo interpretation was used to label each habitat type. Habitat polygons were classified according to the U.S. Forest Service Silvicultural Examination and Prescription Book (1981).

We classified habitat polygons into 9 distinct cover types and water. We defined the bottomland/stream corridor cover type as areas in the flood plain of perennial streams with the canopy dominated by >70% of the basal area in hardwoods. The hardwood cover type was on upland sites and was composed of >70% of the basal area in hardwoods. The hardwood cover type also was composed of >70% of the dominant or co-dominant trees in hardwoods. Hardwood-pine cover types were mixed with approximately 60% hardwood and 40% pine in the canopy and pine-hardwood cover types were 60% pine and 40% hardwoods. Pine cover types were forested with >70% mature pine in the canopy. The pine plantation cover type was defined as planted pine stands from crown closure (~6 years old) to early mid-rotation.

Early successional openings were areas where timber had been harvested. They were dominated by herbaceous ground cover (annual and perennial grasses and forbs) and shrub to sapling size woody plants. On PWMA, numerous ESOs had been previously harvested and maintained in an early sere, using prescribed fire on a 3-5-year rotation. Masters et al. (1993) provided a description of how these areas were created and managed as a wildlife management technique. Early regeneration clearcuts up to sapling size or prior to crown closure also were considered as ESOs on private lands surrounding PWMA.

Pasture cover types were mostly introduced grasses, primarily bermuda grass and fescue in various stages of reversion to native grasses, and native grasses maintained as hay meadows. Food plots were defined as small (generally <5 ha) cultivated areas (all on PWMA) planted to a mixture of cool season grasses, cereal grains and legumes. Food plots were cultivated or mown every several years.

We categorized roads based on width, surfacing, and amount of travel. Blacktop road accounted for all highways and hard surface roads distinguishable on TIGER maps. The average width of blacktop roads was 6.2 m. All other maintained roads within TIGER files were classified as secondary roads with an average width of 3.9 m. Within PWMA, Pine Tree Circle was the main partially graveled thoroughfare, with an average width of 2.5 m. Remaining PWMA roads were gravel and dirt and received little travel and maintenance. The average width of these roads was 2.0 m. All widths accounted for right-of-ways and borrow ditches.

We accounted for rivers, perennial streams, ponds, and lakes. We retrieved water and road information from TIGER files and verified with topographical maps, aerial photos, TM scenes, and field observations. Information on water sources and road locations were updated with GPS where possible.

Analysis

We divided the telemetry data into pre- and post-nesting seasons. We also analyzed all locations for the total time period. Nesting was defined as the time period of egg laying and actual incubation on the nest. We defined pre-nesting home range as the area a female used from either time of capture or 1 January (for surviving birds) until nest initiation. Post-nesting home range was defined as the area of use from the breakup of her first nest until 1 August. During warm days of January and February individual birds broke up from the flock and disperse large distances (>3 km), then flocked back up when the weather turned cold. These large movements prevented us from determining a time period of <1 week to define spring breakup. For birds that did not make nesting attempts, we used the median spring breakup date for comparison with nesting birds.

A SAS (SAS Institute, Inc. 1989) program was written to analyze locations with >3 bearings. Permutations and combinations of the data allowed for calculations of every possible combination of radio-fixes within 30 min, and 3 bearings when >3 bearings were taken. Data was then processed with a modification of the SAS program TRIANG (White and Garrott 1990) to determine location UTM coordinates and ellipse error. In order for a location to be used, the error ellipse had to be < 4 ha. The location with the smallest ellipse was used when >1 combination of bearings within 30 min were output by the permutation program. We included individual locations occurring on the same day if they were > 30 min apart. Only hens with telemetry data >1 month were used for calculation of home ranges.

We used adaptive kernel estimates within KERNELHR (Seaman and Powell 1996) to calculate home ranges. Many studies have used the minimum convex polygon method for calculation of home ranges (Harris et al. 1990). We chose an adaptive kernel estimator because the minimum convex polygon method often includes large areas that may not be used by the individual (White and Garrott 1990). Kernel methods of home range estimation generally are smaller than minimum convex polygon methods (Lawson and Rogers 1997).

Kernel estimators provide a density estimate that can be analyzed quantitatively (Seaman and Powell 1996). Grid size was automatically selected versus a set grid size because preliminary analysis indicated that all birds did not use habitats across the study area in the same manner. Grid size has less impact on kernel based estimators versus other methods of estimating home range size (White and Garrott 1990). We used least squares cross validation procedure to minimize mean integrated square error because it makes no assumptions about distribution of the data (Seaman and Powell 1996).

We used analysis of variance to test for differences in home range size (SAS Institute 1989). We tested for main effects of year and season. We also tested for interaction of bird X year because we had individuals that survived for >1 year. We used bird X year as the error term in a random effects model. Variables that best explained successful versus unsuccessful nests was determined using logistic regression. We used Fisher's exact test to determine if a particular cover type had a greater number of successful nests. Our level of significance was $P < 0.05$.

To assess habitat use versus availability, we used the program PREFER v5.1 (Johnson 1980). We used this program because chi-square analysis of locations and habitat use assumes that the bird is accurately located in a specific habitat type. With an error ellipse of 4 ha and signal bounce associated with mountainous terrain, we could not be sure that all habitat types associated with a location were entirely accurate. In this case, a more conservative analysis approach such as offered by Johnson (1980) is warranted (White and Garrott 1990). PREFER performs analysis on ranks and calculates an F-statistic for testing the hypothesis of equal preference of habitat types. Waller-Duncan comparisons are made based on the critical value of *W* to each level of use and availability of a given habitat type with every other habitat type (Johnson 1980, Waller and Duncan 1969). We included habitat locations for each day spent at the nest in this analysis so that other habitat types would not be weighted disproportionately over the time period that we monitored birds.

RESULTS

Cover Types

The area individual cover types changed over the 3 years of this study because of logging activity. In 1995, the area was 88.8% forested (Table 1). This forested area was composed of 4.6% bottomland hardwoods or stream corridors, 6.5% native pine, 20.6% pine-hardwood, 28.5% hardwood-pine, 14.6% hardwood, and 6.5% pine plantation. Unforested areas comprised 0.2% food plots (on the WMA only), 6.8% pasture and hay meadows (mainly private land along the river), 4.3% ESOs, including forest openings, clear cuts, and 0.6% water including lakes, ponds, rivers and streams (Table 1). Clearcuts during this study increased ESOs by 49.6%. Additional clearcuts through the 1996 field season led to another increase in ESOs by 36.7% by May 1997. Little change was noted between years in the area of other habitat cover types.

Home Range

We took 1,320 bearings in 1995, 3,481 in 1996, and 4,766 in 1997 for a total of 9,567 bearings and over 3,000 triangulation locations. Of those, we were able to use 2,444 locations in calculation of home ranges because of large error ellipse size. Four birds were not included in home range analysis because they moved outside of our study area. One bird moved ~55 km south of the study area and established a new center of movement at that location. Further records were not kept because of logistic constraints.

Home range size for 1 January to 1 August locations was 1,369.7 ha ± 918.3 SE (Table 2). Pre-nesting home ranges were 1,718.5 ha ± 1,293.5. Post-nesting home ranges were 1,177.2 ha ± 1,405.8. Home range size did not vary within individual years or season when we tested for a seasonal main effect ($P > 0.05$). Home range size varied somewhat ($P = 0.083$) from year to year with the most notable difference found in 1995 (Table 2). Pre-nesting home ranges in 1995 were considerably less than post-nesting home ranges, in other years the reverse was true. This may have been the result of low sample size for pre-nesting home ranges ($n = 3$) and limited pre-nesting telemetry locations. We were limited in the number of pre-nesting observations on birds because trap success was poor at the beginning of the 1995 trapping period.

Pre-nesting home ranges were considerably larger in 1997. This was possibly the result of extensive downed timber from an ice storm and high winds across the study area during winter 1996-97. Post-nesting home ranges were influenced by the number of hens with surviving poults in preceding years. Only 1 hen had a brood (1 poult) in 1995; 3 had broods in 1996 with broods surviving at least to 4 weeks; and 6 hens had broods in 1997 surviving from 2-6 weeks (Table 3).

Total home ranges varied the least from year to year. Total home range size included only those hens that survived ≥4 months. When all home ranges were combined across years, we found that pre-nesting home range was significantly higher ($P = 0.05$) than total home range or post-nesting home range (Table 2). We tested for bird X year interaction and found that birds surviving from 1 year to the next had a significant ($P = 0.001$) year interaction. Some birds had larger seasonal home ranges in 1 year and smaller home ranges the next. On the other hand, other individuals had the opposite size seasonal home ranges.

Pre-nesting and total home range size had little ($P > 0.05$) influence on ultimate nesting status (Table 4). We had only 15 hens that did not attempt to nest out of 90 birds for which we had sufficient home range data in all years. Again, post-nesting home range size was strongly influenced by the number of hens with broods. Those hens with broods had lower home range size. Post-nesting home ranges had lower sample sizes because of high predation rates on hens.

Macro-Habitat Nest Site Selection

Hens selected nest sites closer to roads than random points ($P < 0.001$; Table 5). We found a tendency for hens to nest in close association with an edge ($P = 0.069$). The average distance from the nest to the original trap site tended to be less than to random sites ($P = 0.096$). Nest success tended ($P = 0.078$) to be higher for nests located further from permanent water. Nest success was unrelated to given nest proximity to either a road, edge, corresponding trap site, or distance between nesting attempts ($P > 0.05$; Table 6).

We determined habitat cover types for 119 nesting attempts (Table 7, Figs. 1, 2, and 3). Hens made 34 attempts in hardwood-pine stands, 26 attempts in pine-hardwood stands, and 24 attempts in ESOs (Table 7). The remaining 35 attempts were spread across hardwood stands, pine stands, and food plots, respectively. None of our hens attempted to nest in either bottomland/stream corridor, pine plantation, or pasture cover types. One possible exception was a hen that limited her movements for several days along the Kiamichi River but subsequent flooding prevented attempts to determine if the bird was attempting to nest.

Habitat Use

We found that food plots were the most preferred habitat type in terms of proportional use on the area for the period from capture until 1 August (Tables 8 and 9). Food plots made up only 0.2% of the total study area and were preferred significantly ($P < 0.05$) greater than the next ranked cover type, ESOs, across all seasons (Tables 8 and 9). Bottomland/stream corridor habitats were the third highest in preference. The least 2 preferred habitat types were mature pine stands and hardwood-pine stands. The hardwood-pine stands, proportionally comprised the greatest amount of a given cover type on our study area (26.7-28.5%) but were not used in proportion to their abundance (Table 8 and 9). Relative rankings of habitat preference during the pre-nesting period for hens were similar (Table 10).

DISCUSSION

Although we used different methods to calculate home range size, relative comparisons can be made considering that minimum convex polygon estimates are higher than kernel estimates by about one-third. When comparing our total home range

(January–July) to annual home ranges in the Ouachitas of Arkansas, our values were apparently lower. Our pre-nesting home ranges were somewhat higher than pre-nesting ranges of Badyaev and Faust (1996). But our home range size was lower than the spring home range size found by Wigley et al. (1985). These studies were conducted in commercial pine forest (Wigley et al. 1985, Badyaev et al. 1996*a*). Bidwell et al. (1989) also worked in commercial forest with a large proportion of pine plantations in southeastern Oklahoma but reported smaller spring home ranges than our study. Spring home ranges tend to have the greatest range in size among individual birds than at other times of the year (Badyaev et al. 1996*a*). Our largest home range reported was actually during post-nesting season. However, the inclusion of 4 birds that moved well out of our study area during the pre-nesting period would have increased the home range size during that period. Although not represented in this data, we had 1 hen move ~ 55 km from the trap site to begin nesting. One of these hens moved ~ 11 km within a 24 hr period to an area where she later nested.

Different land-management practices within an area can result in home range changes (Wigley et al. 1985). Wigley et al. (1985) stated that even-aged management may reduce the quality of wild turkey habitat. Because the PWMA is managed as a wildlife area, we could expect a mosaic of habitat types and more diversity compared with commercial pine forests. Limited suitable nesting habitat may cause larger movements (Badyaev 1994). Suitable habitat types may be closer on wildlife managed areas, but patch size or proximity to other habitat types could be limiting. We found a higher nesting rate with higher nesting success over other studies of nesting hens in the region (Bidwell et al. 1989, Badyaev et al. 1995). Wigley et al. (1985) did not observe any nesting attempts in their study. Therefore, differences in habitat use and home range size could be attributed to different patch size, landscape configuration and land use patterns, which dictate the distance traveled necessary to meet the nutritional requirements for successful reproduction by hens.

Wigley et al. (1985) reported that adult hens avoided stands with moderate to high hardwood basal area. Hens preferred older, large stands with a high basal area of pine. Hens in our study tended to avoid mature pine and hardwood-pine stands in proportion to their availability. Wigley et al. (1985) found that wild turkey selected young pine plantations but increased home range size because of limited access to these habitat types. Wild turkey hens have shown avoidance or no preference for 0-13-year-old pine plantations, meadows, and developed areas (Bidwell et al. 1989). In an Arkansas study, adult hens preferred >40-year-old natural pine stands throughout the year (Wigley et al. 1985). Hens avoided pine plantations in fall and winter, while showing no avoidance or no preference in spring and summer (Wigley et al. 1985). Our results show that hens preferred early successional stages of growth, similar to young clearcuts. However, these habitat types were widely dispersed on our study area with the exception of cuts on Georgia Pacific property and have a small patch size. In this context, wild turkey hens may need to move larger distances for adequate food resources (Wigley et al. 1985, Badyaev et al. 1996*a*).

Forest management practices from fall 1995 to spring 1996 altered vegetation cover types and landscape structure within our study area. Most hens used approximately the same wintering grounds throughout the study but because of the shift in habitat composition, we believe the proportion of preferred nesting habitat was altered. In particular extensive clearcutting began in 1995 on a 700 ha area just south of the PWMA. Hens responded by increased nest initiation in this area. This 700 ha had only 1 hen using the area, she made 2 unsuccessful nesting attempts in 1995. In 1996 and 1997, respectively, 6 and 11 hens made several attempts within this area. In 1997, a shift was noted in nest location in response to a wildfire of approximately 2,720 ha (Jack Waymire, ODWC, pers. comm.). Only 1 hen nested in this area in 1997, while in 1995 and 1996, 5 and 7 hens, respectively, nested in this area.

Food plots and ESOs were used in greater proportion to their availability and ranked significantly higher than most all other habitats. The food plots on PWMA were mostly perennial food plots with some native vegetation. These habitats are early successional stages and potentially provide essential brood-rearing habitat. Early seral stages provide an abundance of herbaceous plants and insects, which are essential in the first 2-4 weeks in a poults life (Hurst and Stringer 1975).

Early successional openings in particular were selected for nesting habitat while food plots were avoided as nest locations. However, nest predation was proportionally higher in ESOs than in other habitat types (L. Nicholson, pers. comm.). At present, ESOs appear to act as a population sink rather than source because of predation. Throughout the course of the study we flushed numerous untransmittered hens while monitoring transmittered nesting hens or characterizing nesting habitat around a nest location. Evidence from a study of predator use of various habitats on PWMA does not indicate predator selectivity for ESOs or other habitat types for that matter (L. Nicholson, pers. comm.). Therefore, the creation of ESOs does not necessarily predispose a site to high predator use. Predation may be a problem in these habitats because of the relatively high abundance of nesting hens per unit area found in a habitat of limited extent.

Bidwell et al. (1989) found that early successional pine plantations were avoided in winter and neutral in preference in other seasons, in contrast to our findings. However, their study context was in a landscape dominated by commercial forest and clearcuts that were heavily grazed (ESOs). Grazing pressure and disturbance from large numbers of livestock may have degraded potential nesting and brood rearing habitat. We noted proportionally higher use and nesting attempts on ungrazed or low intensity grazed clearcuts and on harvested settings maintained in early succession by periodic prescribed fire. The major difference was the high proportion of intensively grazed ESOs in Bidwell et al.'s (1989) study versus no grazing pressure on a small number of ESOs in our study. This suggests that grazing management that emphasizes lower stocking rates on commercial lands may benefit nesting hens.

Selection by hens for ESOs in proportion to availability suggests that timber management through regeneration clearcutting or creation of ESOs maintained with fire may be appropriate land management strategies. However, at this stage we do not know the optimum proportion of ESOs in the landscape to sustain maximum productivity. Apparently, the 6.0% of ESOs found on our study area provided too little suitable nesting habitat and predisposed birds to predation, while the 19.3% found on Bidwell et al.'s (1989) study area may be too much. With lower grazing pressure, the proportion of ESOs in his study may have been suitable.

Bottomland/stream corridor habitats were used in proportion to availability. These habitats were primarily associated with upland perennial streams rather than classical bottomland habitats. Many of the birds in our study used areas along the Kiamichi River early in winter, then progressively moved into uplands in mid- to late winter. The bottomland/stream corridor habitats in uplands were characterized by a narrow floodplain associated with a perennial or ephemeral stream in the upper reaches, and a dramatic habitat change outside or upslope from the floodplain. Apparently these areas were used as travel corridors from wintering areas to nesting locations as spring approached (Smith et al. 1990). Our results corroborate the findings of Smith et al. (1990) who also noted this movement pattern in pine-dominated landscapes (commercial timberlands). Movements to bottomland hardwood habitats also were reported by Dalke et al. (1946). Our results also suggest they are important in a mixed pine-hardwood context.

Badyaev et al. (1996*b*) hypothesized that pre-nesting birds exhibit movement patterns that essentially sample habitats for nest suitability. In his comparison of non-nesters with nesters, they found that unsuccessful nesters had a smaller pre-nesting home range and further hypothesized that hens what sampled larger areas had a higher probability of nest success because wider movements were correlated with more suitable nest-site selection. We found no difference in non-nesters and nesting birds pre-nesting home range size and further that pre-nesting home range size was unrelated to nesting success.

Roads and associated habitats can provide the necessary cover needed for nesting and brood-rearing hens. Other research has shown that wild turkey hens often nest near edges (Hon et al. 1978, Seiss et al. 1990). Edges increase understory density through increased lighting (Holbrook et al. 1987). We found that distance to edge was closer for successful nests (47.1 m) but not significantly different from unsuccessful nests (61.3 m).

Seiss et al (1990) reported distances of 7.8 m for successful nests and 12.1 m for unsuccessful.

Roads provide travel lanes and a variety of cover that hens seem to prefer. Moore (1995) found that hens nested near low use roads greater than their availability with most nests within 40 m. Badyaev (1995) reported nest distances to roads of 31.5 m versus 112.2 m to random points compared to our 138.9 m to roads and 440.0 m to random points. Badyaev (1995) stated that successful nests were farther from the road than depredated nests but renesters did nest closer than the first attempts. Seiss et al. (1990) reported that successful nests were closer to roads.

MANAGEMENT IMPLICATIONS

The results of this study suggest several management options based on selection of nest locations with specific structural characteristics, habitat selection and nest site selection following major events on the land. Female turkey clearly selected nesting areas in early successional stages but these are limited over the study area. Shifts in movements during the 1996 nesting season to recent clearcuts further emphasize the need for creation of early succession habitats. Creating or enlarging forest openings that provide adequate brood rearing habitat in close proximity to preferred nesting sites may be the best long-term solution to improve populations (Everett et al. 1985, Lazarus and Porter 1985). Creation of additional ESOs is warranted to provide greater availability of a preferred nesting habitat. Additional ESOs may spread nesting activity such that a number of birds are not using the same ESO. Therefore brood survival may be enhanced by less likelihood of multiple nest predation in a given ESO.

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Table 1. Year to year changes in area (ha) of habitat cover types in Pushmataha county, Oklahoma, 1995-97.

Habitat type	1995	1996	1997	% Change
	Year			
Bottomland/stream corridor	1,377.1	1,377.1	1,377.1	0.0
Early successional openings	1,282.1	1,917.4	2,621.5	104.5
Food plots	61.0	61.0	60.3	-1.1
Hardwood	4,363.1	4,379.0	4,385.2	0.5
Hardwood-pine	8,501.6	8,281.2	7,955.1	-6.4
Pasture	2,034.8	2,033.0	2,033.0	-0.1
Pine	3,965.3	3,896.6	3,649.2	-8.0
Pine-hardwood	6,135.1	5,774.8	5,638.7	-8.1
Pine plantation	1,928.6	1,928.6	1,928.6	0.0
Water	172.0	172.0	172.0	0.0

Table 2. Home range size (ha) of eastern wild turkey hens in Pushmataha County, Oklahoma, 1995-97.

	Year							
	1995		1996		1997		All years	
Season	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Pre-nesting	1,301.7	503.1	1,479.0	1,053.0	1,849.7	1,412.2	1,718.5a	1,293.5
Post-nesting	2,334.1	2,498.6	903.4	527.8	678.8	481.0	1,177.2b	1,405.8
Total	1,307.6	1,082.7	1,144.9	720.5	1,573.2	975.7	1,369.7b	918.3

[a] Within each column, means sharing the same letter are not different ($P > 0.05$).

Table 3. Home range size (ha) of eastern wild turkey hens with broods at 2 weeks, 4 weeks and ≥6 weeks post hatch in Pushmataha County, Oklahoma, 1995-97.

	Year							
	1995		1996		1997		All years	
Time	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
2 weeks	.	.	478.5	.	351.9	338.3	370.0	312.5
4 weeks	259.8	.	505.1	115.3	424.6	318.9	433.1	244.8
≥6 weeks	.	.	.	.	426.3	130.7	426.3	130.7

Table 4. Seasonal home range size (ha) of eastern wild turkey hens by nesting status in Pushmataha County, Oklahoma, 1995-97.

	Year[a]							
	1995		1996		1997		All years	
Season, status	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Pre-nesting								
Nester	1,301.8	503.1	1,357.3	877.9	1,924.3	1,469.9	1,740.4	1,316.6
Non-nester	.	.	1,844.3	1,531.8	1,485.9	1,103.3	1,623.8	1,235.0
Post-nesting								
Nester	2,559.9	2,571.0	943.7	539.8	490.3	216.6	1,211.9a	1,493.6
Non-nester	527.7	.	580.3	361.8	1,526.9	424.7	948.4b	597.6
All								
Nester	1,372.6	1,104.1	1,045.5	457.1	1,536.8	972.6	1,341.7	877.3
Non-nester	527.7	.	1,526.1	1,329.5	1,972.7	1,124.4	1,560.3	1,199.5

[a] Within each column, means sharing the same letter are not different ($P > 0.05$).

Table 5. Eastern wild turkey nest and random point distances (m) to nearest road, source of permanent water, nearest edge, and to respective trap site in Pushmataha County, Oklahoma, 1995-97.

	Nest		Random		
Distance feature	$\bar{x}$	SE	$\bar{x}$	SE	$P>T$
Roads	138.9	20.6	440.0	39.9	<0.001
Water	321.1	253.4	368.6	299.0	0.277
Trap site	2,963.4	212.5	4,414.0	791.9	0.096
Edge	57.6	8.1	79.7	8.8	0.069

Table 6. Eastern wild turkey nest success relative to distances (m) to nearest road, source of permanent water, nearest edge, and to respective trap site in Pushmataha County, Oklahoma, 1995-97.

	Successful		Unsuccessful		
Distance feature	$\bar{x}$	SE	$\bar{x}$	SE	$P>X^2$
Roads	140.4	32.6	138.4	25.5	0.966
Water	236.3	44.7	350.7	34.1	0.078
Trap site	2,830.8	297.7	3,018.1	275.5	0.687
Edge	47.1	12.2	61.3	10.1	0.450

Table 7. Eastern wild turkey nest success based on habitat type selection in Pushmataha county, Oklahoma, 1995-97.

Habitat type	1995		1996		1997		Total	
	S[a]	U[b]	S	U	S	U	S	U
Bottomland/stream corridor	0	0	0	0	0	0	0	0
Hardwood	1	7	4	0	1	4	6	11
Hardwood-pine	3	4	1	5	2	5	6	14
Pine-hardwood	0	3	5	3	3	12	8	18
Pine	1	1	0	8	2	4	3	13
Pine plantation	0	0	0	0	0	0	0	0
Early successional openings	0	1	0	9	3	11	3	21
Pasture	0	0	0	0	0	0	0	0
Food plots	0	0	0	0	0	2	0	2

Year (spans 1995–1997)

[a] Successful.

[b] Unsuccessful.

Table 8. Year to year proportions (%) of habitat cover types in Pushmataha county, Oklahoma, 1995-97.

	Year		
Habitat type	1995	1996	1997
Bottomland/stream corridor	4.6	4.6	4.6
Hardwood	14.6	14.7	14.7
Hardwood-pine	28.5	27.8	26.7
Pine-hardwood	20.6	19.4	18.9
Pine	13.3	13.1	12.2
Pine plantation	6.5	6.5	6.5
Early successional openings	4.3	6.4	8.8
Food plots	0.2	0.2	0.2
Pasture	6.8	6.8	6.8
Water	0.6	0.6	0.6

Table 9. Relative rankings of eastern wild turkey hen habitat use from January 1-August 1, based on use versus availability of habitat types in Pushmataha county, Oklahoma, 1995-97.

	Year			
Habitat type	1995	1996	1997	All
Bottomland/stream corridor	3ab	3b	2b	3b
Hardwood	4bc	4c	5d	5c
Hardwood-pine	9e	9e	9f	9f
Pine-hardwood	5cde	5c	7de	6d
Pine	8de	7d	8e	8e
Pine plantation	6cde	6c	4c	4c
Early successional openings	2ab	2a	3b	2b
Food plots	1a	1a	1a	1a
Pasture	7de	8d	6d	7d

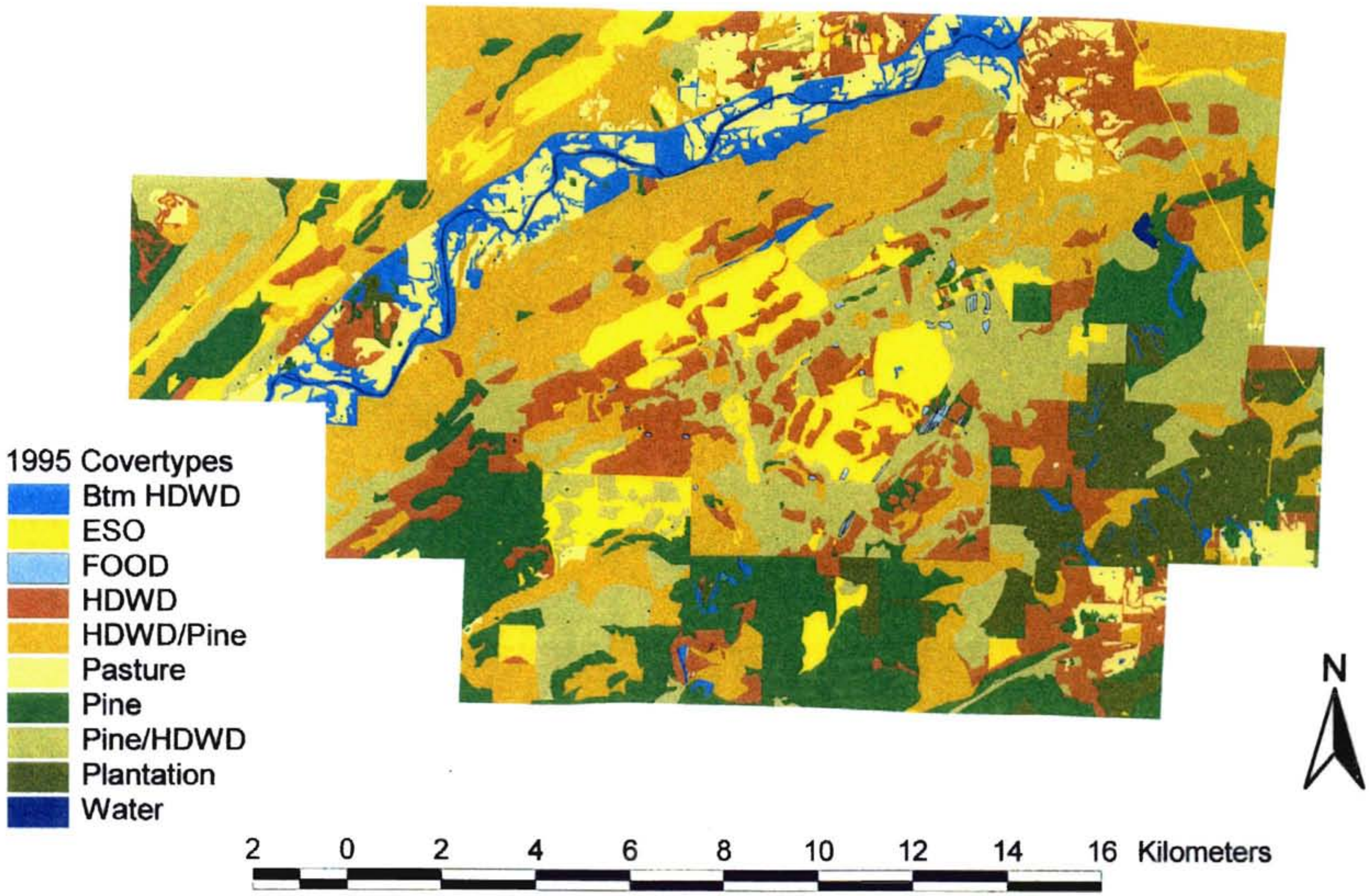
[a] Within each column, means sharing the same letter are not different ($P > 0.05$).

Table 10. Relative rankings of pre-nesting eastern wild turkey hen habitat use based on use versus availability of habitat types in Pushmataha county, Oklahoma, 1995-97.

	Year			
Habitat type	1995	1996	1997	All
Bottomland/stream corridor	3b	3b	3b	3b
Hardwood	6c	6c	6c	7d
Hardwood-pine	9d	9e	9e	9f
Pine-hardwood	4c	7d	7d	5d
Pine	8c	8d	8d	8e
Pine plantation	5c	4c	4c	4c
Early successional openings	2ab	2ab	2ab	2b
Food plots	1a	1a	1a	1a
Pasture	7c	5c	5c	6d

[a] Within each column, means sharing the same letter are not different ($P > 0.05$).

Figure 1. 1995 cover type map for eastern wild turkey study in Pushmataha county, Oklahoma.



study in Pushmataha County.

Figure 2. 1996 cover type map for eastern wild turkey study in Pushmataha County, Oklahoma.

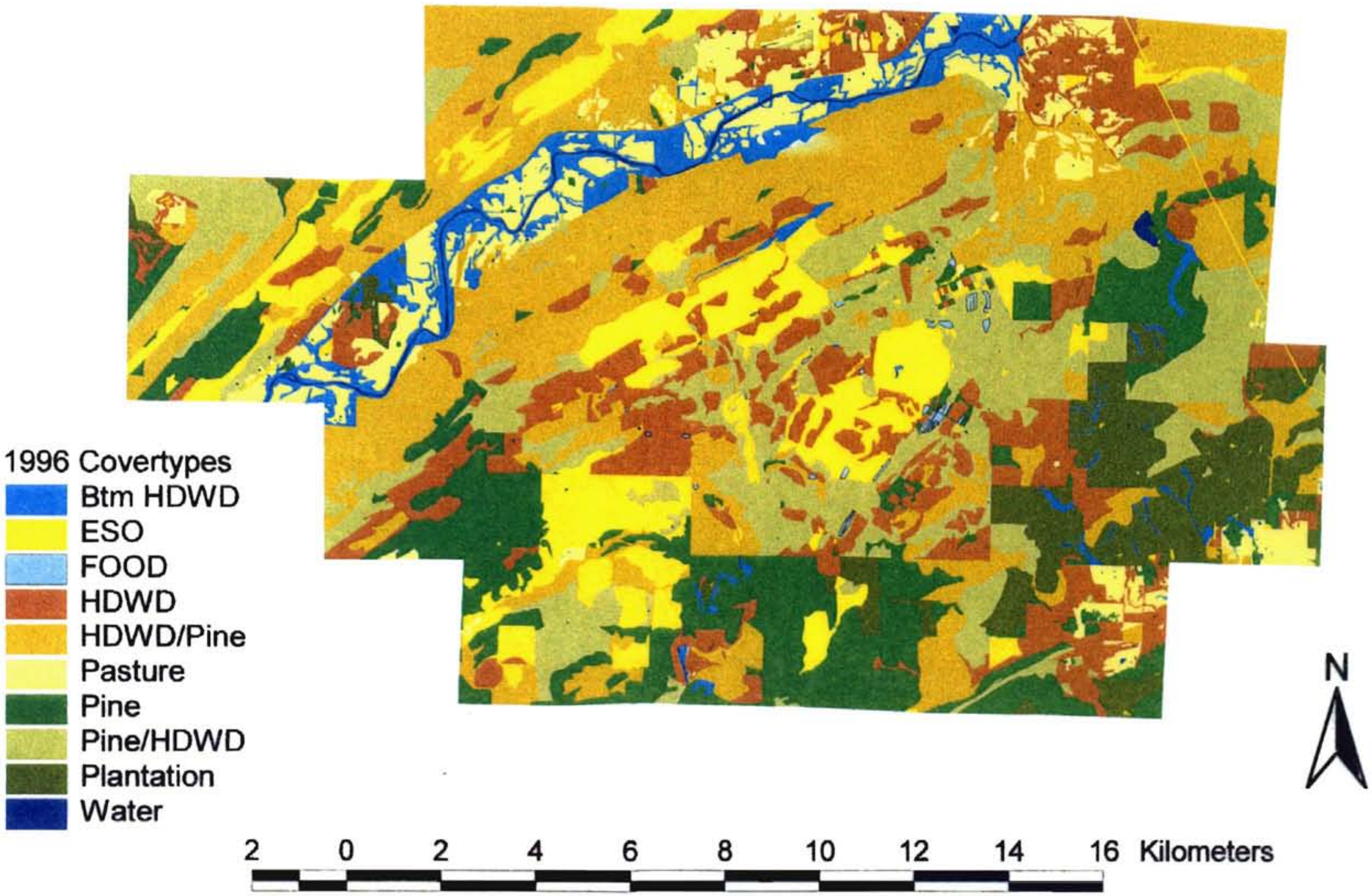
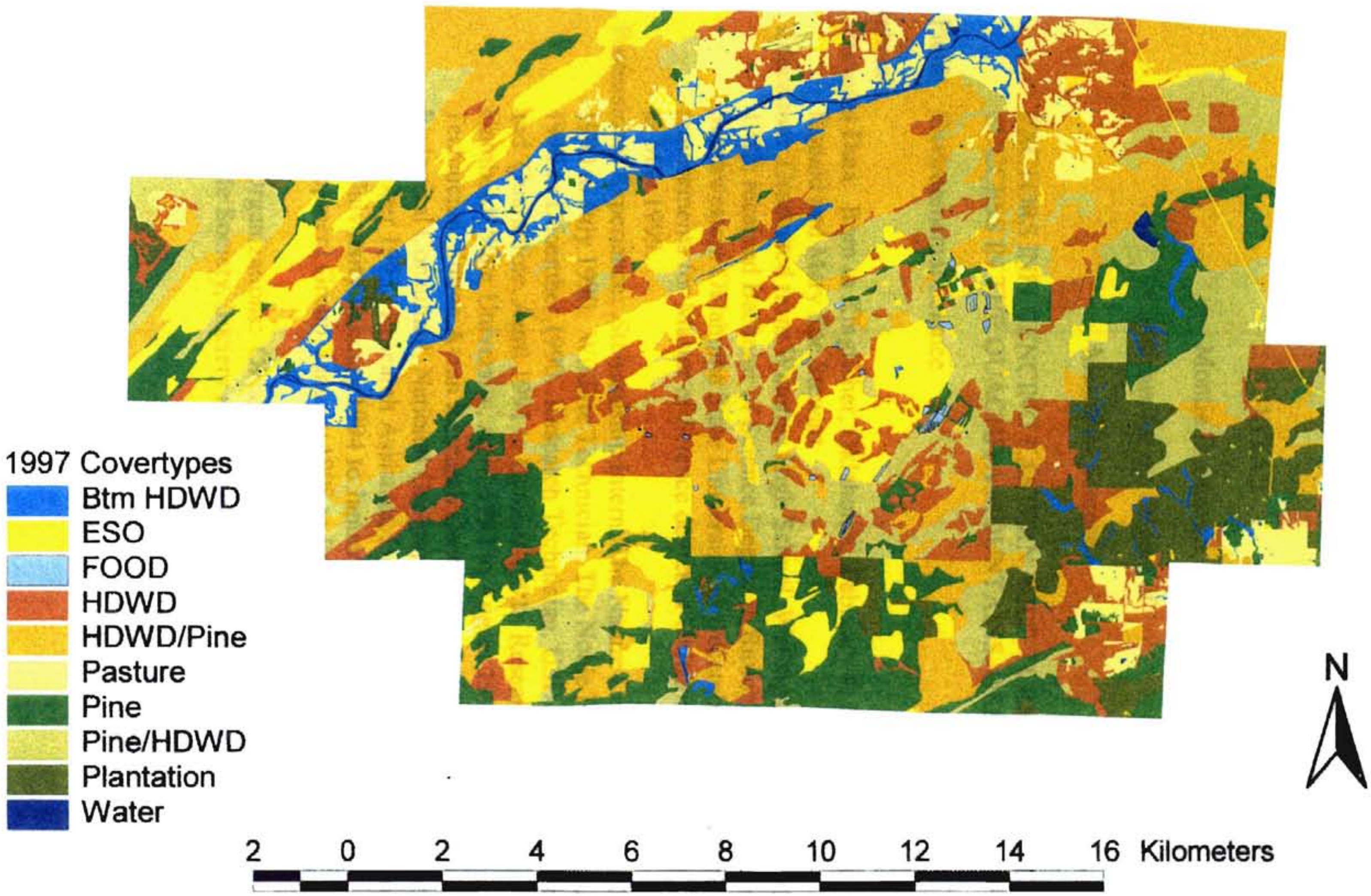

1996 Covertypes
Btm HDWD
ESO
FOOD
HDWD
HDWD/Pine
Pasture
Pine
Pine/HDWD
Plantation
Water
N
2 0 2 4 6 8 10 12 14 16 Kilometers

Figure 3. 1997 cover type map for eastern wild turkey study in Pushmataha County, Oklahoma


1997 Covertypes
Btm HDWD
ESO
FOOD
HDWD
HDWD/Pine
Pasture
Pine
Pine/HDWD
Plantation
Water
N
2 0 2 4 6 8 10 12 14 16 Kilometers

VITAE

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