HOME RANGE AND HABITAT USE OF THE EASTERN WILD TURKEY ON COMMERCIAL FORESTLAND IN SOUTHEASTERN OKLAHOMA

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Scope and Method of Study: One hundred and ten wild turkeys were captured and 52 were radio marked. Radio-telemetry locations from these birds were used to determine home range and habitat use. Habitat use was compared to habitat availability. Vegetation parameters were determined for 17 cover types and then compared to turkey use to determine preference or avoidance. The Habitat Evaluation Procedures (HEP) model was applied to the study area for additional assessment.

Findings and Conclusions: Seasonal home range for adult males was 225 ha in winter, 728 ha in spring, 1105 ha in summer, and 379 ha in fall. Seasonal home range for adult female turkeys was 225 ha in winter, 865 ha in spring, 780 ha in summer, and 459 ha in fall. Habitat use by adult females varied by season. Habitat types were not consistantly preferred or avoided. Pine settings were usually avoided during all seasons except summer. Cattle grazing probably influenced habitat use by turkeys in young pine settings. Adult female turkeys showed the strongest selection for mature timber stands during winter and spring. Habitat types in the annual home range of adult females were dominated by pine-hardwood and hardwood-pine. Fourteen turkeys nested and twelve turkey nests were found in 6 of the 19 cover types. The mean clutch size was 11.6 eggs. Eight of 14 nests were abandoned because of human disturbance, 4 were destroyed by predators, and 1 was destroyed by logging. One nest hatched successfully, and 4 poults were raised. No adult turkeys were killed while nesting. Fifty-six percent of the adult females nested. Seven percent renested. Nineteen percent of the radio marked turkeys were killed by predators including 3 by bobcat, 3 by great horned owl, and 3 by unidentified animals. The Habitat Evaluation Procedures (HEP) model identified summer food as a limiting factor for turkeys in all mature timber stands. Winter food and cover were limiting in 9 and 12 year old pine settings. Cover was limiting in 1, 3, and 6 year old pine settings regardless of food availability.

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CHAPTER I

INTRODUCTION

This thesis is comprised of 6 chapters formated for scientific journals. This chapter introduces the rest of thesis. The 5 remaining chapters are complete as written and do not need supporting material. The manuscripts, written in the Journal of Wildlife Management format are: Chapter II; 'Home range and habitat use of eastern wild turkey on commercial forestland in southeastern Oklahoma'; Chapter III, 'Nesting habitat and nest success of eastern wild turkey in southeastern Oklahoma'; Chapter IV, 'Mortality of adult wild turkeys in southeastern Oklahoma'; Chapter V, 'A comparison of cover types and vegetation characteristics in relation to wild turkey habitat on commercial forestland in southeastern Oklahoma'; and Chapter VI, 'Use of the habitat evaluation procedures as an index of habitat quality for the wild turkey in southeastern Oklahoma'.

CHAPTER II

HOME RANGE AND HABITAT USE OF THE EASTERN WILD TURKEY ON COMMERCIAL FORESTLAND IN SOUTHEASTERN OKLAHOMA

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ABSTRACT.-The purpose of this study was to determine habitat use of eastern wild turkeys and the relationship of habitat use to commercial forestry practices. One hundred and ten wild turkeys were captured, and 52 were radio marked during the 2 year study in southeastern Oklahoma. Home ranges of adult males and females were not significantly different. An average winter home range included mature timber stands (75%), pine settings (23%), and developed areas (2%). During spring, a typical home range included mature timber (71%), pine settings (29%), and pasture/ hay meadow, or developed areas (<1%). Summer home range included mature timber (73%), pine settings (27%), and pasture/hay meadow, or developed areas (<1%). Fall home range included mature timber stands (84%), pine settings (16%), but excluded pasture/hay meadow, or developed areas. Adult females showed the strongest selection for cover types during the winter and the least during the summer. Habitat selection could not always be explained by vegetation characteristics which were highly variable. Pine settings did not provide food and/or cover requirements

during most of the year. Intensive cattle grazing may have removed herbaceous vegetation from pine settings. Telemetry data suggested that stringers of timber left along draws and streams in pines settings did not attract turkeys in lieu of mature timber stands. As mature timber is replaced by pine monoculture, turkey populations may either decrease or shift to foods and cover that are available on pine settings.

Historical faunal records indicate that the eastern wild turkey (Meleagris gallopavo silvestris) originally occurred abundantly throughout most of Oklahoma (Nice 1931, Schorger 1966, Sutton 1967, Tomer 1974). Habitat losses and uncontrolled commercial hunting depleted Oklahoma populations so that by 1943 the bird had been essentially extirpated from the state (Duck and Fletcher 1945).

Wild turkey reintroductions were made by the Oklahoma Department of Wildlife Conservation after habitats had regenerated and game laws had been enacted. Early stocking attempts failed because of the use of pen-reared birds (Temple 1947, Thackston and Lowrey 1981). Later efforts, however, utilized live-trapped wild birds and proved successful.

Many studies of various eastern wild turkey populations have been conducted throughout the eastern United States (Bailey and Rinell 1967, Ellis and Lewis 1967, Raybourne 1968, Speake et al. 1969, Williams et al. 1969, Gardner 1972, Barwick et al. 1973, Davis 1973, Hillestad 1973, Hopkins 1973, Eichholtz and Marchinton 1975, Fleming and Webb 1975, Everett et al. 1978, Everett et al. 1980, Hopkins et al. 1980, Kennamer et al. 1980, Pack et al. 1980, Williams et al. 1980, Bailey et al. 1981, Hopkins 1981). Of these studies, none has evaluated the eastern wild turkey along the western boundary of its range. Oklahoma is on the western edge of the eastern wild turkey's distribution, so it is probable that habitat use parameters in southeastern Oklahoma differ from those in other states in the Southeast.

The wild turkey's range in Oklahoma includes forested areas in the southeastern part of the state. Much of this area is owned by the commercial forest industry. Intensive silvicultural activities including extensive road building, intensive pine monoculture, large clearcuts (> 41 hectares), and the associated loss or degradation of mixed mature pine hardwood forests, pose a threat to wild turkey populations (Markley 1967). Also, cattle grazing and hog foraging on pine settings and adjacent timber stands may adversely affect turkeys by destroying nesting habitat and food plants (National Wildlife Federation 1982).

STUDY AREA

The study area, bounded on the north and west by U.S. Highway 259, on the south by Carter Mountain, and on the east by the Mountain Fork River and Broken Bow reservoir, was on the Weyerhaeuser Company Mountain Fork Wildlife Management Area in McCurtain County, Oklahoma (Figure 1). The region is characterized by steep, rugged hills separated by valleys with rolling topography and clear streams with many spring fed tributaries. Approximate site indexes for pine on flat to rolling terrain were 60 and 38 for those on steeper slopes (James 1982). Annual rainfall averaged 115.3 cm (Weyerhaeuser Co., unpublished data). Elevations above mean sea level ranged from 183 to 381 m. Soil associations included Carnasaw-Sherwood and Goldston-Carnasaw-Sacul

(Reasoner 1974).

Duck and Fletcher (1945) described the vegetation in the study area as oak-pine forest. Dominant tree species on north slopes included white oak (*Quercus alba*), black oak (*Quercus velutina*), mockernut hickory (*Carya tomentosa*), and shortleaf pine (*Pinus echinata*). Pine settings in clearcuts were dominated by improved loblolly pine (*Pinus taeda*).

Approximately 15,708 ha of the 19,003 ha management area is owned and managed by the Weyerhaeuser Company; the balance is owned by private parties, the U.S. Army Corps of Engineers, and the Oklahoma Department of Wildlife Conservation.

Timber harvesting began in the region about 1907 by the Dierks Lumber and Coal Company. Under this company, merchantable pines were harvested, but hardwoods were left uncut. By the early 1930's, management had changed to selective harvest of pines larger than 30.5 cm d.b.h. (Little and Olmstead 1931). Herbicides were commonly used for hardwood control. The Weyerhaeuser Company bought most of the land in the Management Area in 1969. The first even-aged pine settings were planted in the area in 1972. Silvicultural practices used to establish settings usually included clearcutting, roller chopping, burning, contour ripping, and planting. Post-establishment practices have included prescribed burning and the use of various herbicides such as 2,4-DP, Silvex, and 2,4,5-T to control woody vegetation.

METHODS AND MATERIALS

Wild turkeys were captured by rocket projected nets (Dill 1969) during February, March, and November 1983 and January, February, and

March 1984. Trap sites were baited with chopped corn (Doster 1974), and handling procedures were similar to those described by Bailey et al. (1980). Sex was determined by breast feather coloration and shape (Godin 1960, Taber 1963). Age was was determined to be either juvenile or adult based on the contour of the row of greater secondary wing coverts (Leopold 1943, Williams 1961) and the shape and color barring of the outer tenth primary (Mosby and Handley 1943).

Solar and battery powered radio transmitters in the 164 MHZ range (Wildlife Materials, Inc.) were attached to turkeys by a backpack type harness. The harness was made of nylon covered rubber stretch tubing and secured with a square knot and heat shrinkable tubing (Schumacher et al. 1978). A yagi type hand-held antenna and portable receiver were used to locate radio marked-birds. A minimum of three compass bearings (Proud 1969) were taken for each triangulation (Cochran and Lord 1963) because of the rough terrain. Compass bearings were plotted on 1:24000 scale topographic maps (U.S. Geological Survey). Topographic maps were divided into a 2.6 ha^2 grid coordinate system. Turkeys were located during 3 activity periods per day (0600-1200, 1201-1600, and 1601-2000 hrs.) on at least 2 days per week.

Percent basal area (BA) of woody vegetation (Weyerhaeuser Co., unpublished data) was used to determine 5 basic cover types: pine $\geq$ 75% BA pine; pine-hardwood $\geq$ 50% but < 75% BA pine; hardwood-pine > 25% but < 50% BA pine; hardwood $\leq$ 25% BA pine; and pine settings approximately 1 to 12 years old. Cover types other than pine settings were further separated into north, south, and flat slopes.

Vegetation was classified by species into 5 horizontal zones depending on height and diameter at breast height (d.b.h.).

Classifications were: (1) trees (≥ 10.16 cm d.b.h. and > 1 m tall); (2) saplings and shrubs (< 10.16 cm d.b.h. and > 1 m tall); (3) saplings and shrubs (< 10.16 cm d.b.h. and ≤ 1 m tall); (4) woody vines; and (5) herbaceous vegetation. Woody and herbaceous species were grouped into preferred turkey food categories (Schemnitz 1956, Kennamer and Arner 1967, Blackburn et al. 1975, Holbrook 1975, Kennamer et al. 1980). Vegetation parameters were measured to relate stem density and potential food production to habitat use.

Home range and habitat use were calculated by a modified Telem software program similar to the one described by Koeln (1980). Habitat use and availability were compared using the Wilcoxon matched-pair signed-ranks test (Siegel 1956). Significant differences were set at $P < 0.05$. The standard t-test was used to compared home range size by sex and season.

Statistical analysis of vegetation characteristics was performed using the Stastistical Analysis System (SAS Institute, Inc. 1983). ANOVA and Duncan's Multiple Range Test (Kramer 1956) were used to test the significance of stem density, basal area, and d.b.h. differences among cover types, classes, and categories. Primary comparisons were made among north, south, and flat slopes of cover types within the same percent BA pine. Comparisons were also made among class 2, 3, 4, and 5 vegetation types among all cover types. Simple correlation was also used to test the relationships between stem density and BA.

RESULTS AND DISCUSSION

One hundred and ten wild turkeys were captured during 1983-84 and 52 were radio-marked (Table 1). There was no significant difference (P

> 0.05, t-test) between male and female home range by season (Table 2).

Winter Habitat Use

In winter, adult female turkeys preferred pine-hardwood stands that were south facing or flat, hardwood stands that were south facing, and hardwood-pine stands that were south facing (Table 3). In these preferred stands, class 1 stem density varied from 394 stems/ha to 864 stems/ha. Basal area varied from 14.6 m^2/ha to 27.4 m^2/ha and herbaceous stem density varied from 6.7 stems/m^2 to 43.8 stems/m^2 (Table 4). The density of class 3 stems on hardwood and hardwood-pine stands facing south was less ($P < 0.05$, Duncan's Multiple Range Test) than on corresponding north slopes. Adult females avoided pine stands facing north and south, hardwood stands that were on flat slopes, hardwood-pine stands facing north, and all age classes of pine settings (Table 3). Adult females did not prefer any north facing aspect cover type during the winter. It appeared reasonable to assume that habitat preferences were related to differences in vegetation. However, we did not find any consistent pattern of preference or avoidance of mature timber stands based on percent BA pine, size class stem density, or aspect. Little and Olmstead (1931) found substantial differences in vegetation characteristics from north to south aspects on Rich and Kiamichi Mountains north of our study area but also reported little difference on mountains similar to those in our study area.

Adult female turkeys preferred timber stands with open understory (Table 3). Wigley et al. (1985) attributed similar findings in the Ouachita Mountains of Arkansas to the selection of habitat for good visibility and easy movement. Mature timber stands with small permanent openings or vegetated roads also provide a good source of green herbaceous vegetation during the winter.

All age classes of pine settings, pasture/hay meadow, and developed areas were avoided by female turkeys during the winter. Possibly, these areas were avoided because they lacked hard or pine mast production, green herbaceous vegetation (> 50% ground cover), or because travel distances to escape cover were excessive. Pine settings (except 1 yr. old) had significantly greater herbaceous density ($P < 0.05$, Duncan's Multiple Range Test) than mature timber stands in June. However, younger pine settings ($\leq$ 4 yrs. old) were heavily grazed throughout the year, and forage and seed availability during the winter months appeared to be inadequate. Green forage was found to be inadequate based on the Habitat Evaluation Procedures (HEP) Model (Bidwell 1985). Unfortunately, seed availability was not measured. It is possible that older pine settings were avoided because the understory was too thick for the birds to penetrate and younger settings were avoided because of inadequate cover. Sweeney (1980) reported that many pine settings > 3 years old produced woody densities that impaired deer movements, and Gehrken (1975) reported that pine plantations $\leq$ 10 years old had understories too dense for turkey use. However, we did not find that woody densities in pine settings > 3 years old were significantly greater ($P > 0.05$) than those in mature timber stands. In our study area, cattle grazed intensively on pine settings all year and grazing may have opened up some of the woody vegetation.

Cover types in a typical winter home range included: 3% in pine, 38% in pine-hardwood, 12% in hardwood, and 23% in hardwood-pine (Table 5). Pine settings within the winter home range included: 2% in 11-13 year class, 9% in 8-10 year class, 1% in 5-7 year class, 9% in 2-4 year class, and 2% in the 1 year age class. Mean winter home range size was 225 ha and included mixed mature timber stands (75%), pine settings (23%), in developed areas (2%). Home range excluded pasture/hay meadow (Table 5).

Spring Habitat Use

Female turkeys preferred pine-hardwood stands on flat slopes during the spring season (Table 3). This cover type was the most abundant one found in the study area, but it was used significantly more ($P < 0.05$) than could be explained by its availability. Pine-hardwood stands on flat slopes had a basal area of 27.4 m^2/ha, class 1 stem density of 864 stems/ha (Table 4), and herbaceous stem density of 20.2 stems/m^2 (Table 6).

Adult females avoided pine stands on north, south, and flat slopes; hardwoods on south slopes; 6, 9, and 12 year old pine settings; pasture/hay meadow; and developed areas during the spring. One and 3 year old pine settings were used in proportion to their availability (Table 3). Wigley et al. (1985) reported that turkey hens usually avoided stands that had pole timber or smaller stems. This description could apply to pine settings in our study area, but was not applicable to mature timber stands.

Lack of green vegetation may explain avoidance of some stands during spring if small permanent openings or vegetated roads were not available. In Alabama, Kennamer et al. (1980) found that green vegetation was the main food item for all seasons. We observed turkeys using green herbaceous vegetation when it was available. Noticable change in dropping color and time spent in these areas verified the use of this food. Abundance of green forage has also been shown to be directly related to insect abundance because of the food and cover provided. In Virginia, Martin and McGinnes (1975) found 25 times more insects available in openings than under forest canopy. Another possible reason for avoidance is that pine settings provided no measurable hard mast production. Hard mast production is a very important food in early spring for turkeys (Kennamer et al. 1980).

A combination of green forage availability and insect availability probably influenced habitat use patterns during the spring. Other possible factors affecting turkey use were heavy human use and intense cattle grazing. Our study area was heavily used by turkey hunters during the spring and fall and by poachers throughout the year. Younger pine settings ($\leq$ 4 yrs. old) had good visability during spring, and heavy hunter use may have made the birds vulnerable. Pine settings were also heavily used by cattle (Nelson 1984) probably because of increased forage availability when compared to that in mature timber stands.

Cover types in a typical spring home range included: 5% in pine, 35% in pine-hardwood, 11% in hardwood, and 20% in hardwood-pine (Table 5). Pine settings by age class within the spring home range included: 4% in 11-13 year class, 5% in 8-10 year class, 1% in 5-7 year class, 14% in 2-4 year class, and 5% in the 1 year class. Mean spring home range size was 865 ha and included mature timber (71%), pine settings (29%), and pasture/hay meadow and developed areas ($<$ 1%). Kennamer et al. (1981) found that in Alabama, turkeys preferred mature timber stands in the greater than 21 year age class except during the spring, but we did not find this to be the case in our study area (Table 3).

Summer Habitat Use

During the summer, adult female turkeys preferred ($\underline{P} < 0.05$) hardwood-pine stands on flat slopes and avoided ($\underline{P} < 0.01$) 11-13 year old pine settings (Table 3). Only 1 of 12 mature timber stand cover types was used significantly more ($\underline{P} < 0.05$) than expected during the summer season. Also, only the very dense 12 year old pine settings were used significantly less ($\underline{P} < 0.01$) than their availability during the summer. We may therefore conclude that most habitat types were supplying only a minimum combination of habitat requisites. Hardwood-pine stands on flat slopes had a total woody stem density of 61,263.7 stems/ha, BA of 22.2 m^2/ha (Table 4), and herbaceous stem density of 20.0 stems/m^2 (Table 6). Eleven to 13 year old pine settings had a total woody stem density of 12,8971.9 stems/ha, BA of 20.0 m^2/ha (Table 4), and herbaceous stem density of 57.5 stems/m^2 (Table 6).

Cover types in a typical summer home range included 11% in pine, 32% in pine-hardwood, 7% in hardwood, and 23% in hardwood-pine (Table 5). Pine settings by age class within the spring home range included: 3% in 11-13 year class, 6% in 8-10 year class, 3% in 5-7 year class, 10% in 2-4 year class, and 5% in the 1 year old age class. Mean summer home range size was 780 ha and included mature timber stands (73%), pine settings (27%), and pasture/hay meadow or developments (< 1%).

Permanent openings are essential for high summer turkey populations because they supply food in the form of forage, insects, and soft mast for both adults and broods (Lewis 1964, Hillestad and Speake 1970, Hamrick and Davis 1972, Holbrook 1975, Dickson et al. 1978, Pack et al. 1980, Collins 1981, Frampton 1981). Some of the mature timber stands in our study area may have lacked sufficient numbers of these openings.

Healy (1979) reported that because of the relationship between site quality and ground vegetation, clearings were more important for turkeys on fair than on excellent sites. Most of our study area had low site indices.

When we applied the Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildl. Serv. 1980a) to our study area, summer food was found to be limiting in all mature timber stands but to be adequate in pine settings. Summer food may in fact have been a limiting factor in all cover types. In mature timber stands, herbaceous vegetation was in relatively short supply because of overstory canopy closure. In younger pine settings ($\leq$ 4 yrs. old), herbaceous vegetation may have been deficient because of intensive livestock grazing. Herbaceous vegetation was in short supply under the closed forest canopy in mature timber stands and was inversely correlated with basal area (r= -0.71666, P = 0.0012) as has been reported by Hurst et. al (1980) and Fenwood et al. (1984). However, our vegetation sampling design did not delineate small permanent openings or vegetated roads as a separate cover type and the HEP model did not address the fact that small permanent openings or vegetated roads were available for summer food production in mature timber stands. We also did not account for removal of green forage by cattle. Had we sampled forage availability throughout the growing season, we might have also found pine settings to be deficient in summer food.

In Alabama, Blackburn et al. (1975) found that intensity of grazing and the stage of vegetation succession directly affected the availability of seed heads to turkey poults in permanent openings. Gainey (1954) and Lindzey (1967) reported that nesting and brood rearing periods were the most important times for turkeys because of increased mortality. Intensive cattle grazing may directly affect food availability and cover for turkeys, particularly in young pine settings but may also affect food and cover availability for other herbivores (i.e., Sigmodon, Peromyscus). Decreased food and cover may result in reduced small mammal populations which may also result in increased predation on turkey broods.

Fall Habitat Use

Adult female turkeys used all mature timber stands and 2-4 year old pine settings in proportion to their availability. They avoided ($P < 0.01$) pasture/hay meadow, developed areas, and all other age class pine settings. Lack of use of pine settings other than the 2-4 year old class could have resulted from lack of herbaceous production. Warm season herbaceous vegetation was significantly more dense ($P < 0.05$, Duncan's Multiple Range Test) in 2-4 year age class pine settings than in 1 or 12 year old settings and in all mature timber stands. Kennamer et al. (1980) reported that green forage, including several grass species found in our study area, soft mast, and insects were important turkey foods during the fall in Alabama, and Dellinger (1973) reported that acorns (hard mast) were very important in the fall diet of turkeys in Missouri. Pine settings in our study area did not provide any measurable hard mast production potential, whereas mature timber stands had the potential to provided abundant fall foods.

Pine settings other than 2-4 year old, could have also been avoided because of limited seedhead production. Although herbaceous stem density in pine settings < 2 years old was similar to that of mature timber stands when sampled in June, the effect of heavy cattle grazing became evident as the growing season progressed. Seedheads of grasses and forbs were rarely observed during late summer or early fall.

Cover types in a typical fall home range included: 7% in pine, 41% in pine-hardwood, 16% in hardwood, and 20% in hardwood-pine. Pine settings by age class within the fall home range included: 0% in 11-13 year class, 3% in 8-10 year class, 1% in 5-7 year class, 10% in 2-4 year class, and 2% in the 1 year old age class (Table 5). Mean fall home range size was 459 ha and included mature timber stands (84%), pine settings (16%), and no use of pasture/hay meadow or developed areas.

CONCLUSION

Habitat use by adult female eastern wild turkeys usually varied with season in southeastern Oklahoma. Pine settings, pasture/hay meadows, and developed areas were usually avoided during all seasons except summer. Most mature pine stands were also avoided during winter and spring. These findings conflict somewhat with those reported by Wigley et al. (1985) in the Ouachita Mountains of Arkansas which showed that adult female turkeys preferred sawtimber stands with > 75% BA pine.

We did not detect a consistant preference or avoidance of cover types based on aspect. Adult female turkeys showed the strongest preference for cover types during the winter and the least selectivity during the summer. Selection of cover types could not always be traced to vegetation parameters. We suspect but cannot prove that cattle had some effect on habitat use by turkeys, particularly in pine settings.

Habitat types in the mean annual home range of adult females were dominated by pine-hardwood (36.48%) and hardwood-pine (21.57%) (Table 7). Both of these cover types were also the most common in the study area. Pine-hardwood with its 3 different aspect designations was preferred or used proportionally to its availability and was never avoided. Hardwood-pine was avoided only during the winter season on north slopes and the rest of the time was either preferred or used in proportion to its availability.

Management Implications

The management implications of our findings are two fold. First, adult turkey females avoided pine settings except during the summer. Avoidance suggests that settings do not meet the food and/or cover requirements during most of the year. Since turkeys avoided these settings,it also appears that stringers of timber left after cutting did not provide enough food or cover to attract turkeys.

Second, adult female turkeys used mature timber stands in proportion to their availability except during winter and spring and usually preferred mature timber stands with a mixture of mature pine and hardwood timber. Stand selection during winter and spring suggests that some mature timber stands provided better turkey habitat than others, but our vegetative analysis did not clearly identify the selection criteria.

As mixed hardwoods are replaced by pine monoculture, we may either see a decrease in the turkey population or a shift to other foods and cover types that are available but not preferred under present forest stand conditions. If the cover and/or food requirements are not met by pine settings, then we may see a population decline as mature timber stands are replaced. Pine stands or settings older (> 40 years old) than those found in our study area reportedly provided some life requisites for wild turkeys in Arkansas (Wigley et al. 1985). Since pine settings made up approximately 25% of the annual home range but were mostly avoided except during the summer, mature timber stands may already be in short supply and turkeys may have been forced into these pine settings as a result of fewer mature timber stands.

During the winter flock break up in March, two juvenile female turkeys emmigrated approximately 6.2 km from the northern part of the study area. Spring emmigration suggests population pressure which probably resulted from a combination of high turkey density and low available habitat. Year round grazing may have also decreased the use of pine settings by turkeys, but the data is not available to verify this hypothesis.

With the increase in the number and area of pine settings and the decrease of mature timber stands, pine settings will have to be managed to provide the maximum possible benefits to turkeys if they are to continue to be a part of commercial forests. Planned grazing systems, both in pine settings and mature timber stands, and maintenance of mature hardwood stands in sufficient quantity to supply hard mast, should be part of the overall forest management plan.

Therefore, we recommend that during future clearcutting operations, stringers of mature hard mast producing timber be left in widths that will be of use to wild turkeys. Several studies (e.g. Gehrken 1975) have suggested minimum widths of 60-100 m for turkey use. These recommendations could be used until additional research can establish minimum widths in this region. Also, studies should be implemented to clarify the relationship between grazing and turkey use and management techniques developed.

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Table 1. Wild turkey trapping and marking results on commercial forestland in southeastern Oklahoma.

Date	No. Captured	Age/Sex[a]	Radio Marked[b]
Feb 1983	5	AM	0
Mar 1983	7	JM	2
	1	JF	1
	10	AM	5
	5	AF	3
Nov 1983	4	AF	4
	9	JF	0
Jan 1984	24	AF	20
Feb 1984	3	AM	3
	17	AF	10
Mar 1984	12	AF	3
	3	JF	0
	4	AF	1
	2	JF	0
	2	AF	0
	1	JF	0
	1	AM	0
Totals	110		52

[a] AM = Adult Male, JM = Juvenile Male, AF = Adult Female, JF = Juvenile Female.

[b] Some radio transmittors were recovered and put out again.

Table 2. Comparison of home range (ha) by season and sex of wild adult turkeys on commercial forestland in southeastern Oklahoma.

Sex	Wi[a] $\overline{X}$ (SE)	Sp $\overline{X}$ (SE)	Su $\overline{X}$ (SE)	Fa $\overline{X}$ (SE)
Male	224.46* (98.09) n=3[b]	727.80* (351.50) n=4	1104.97* (823.45) n=4	378.99* (118.59) n=3
Female	225.00* (348.84) n=15	865.22* (378.24) n=20	780.88* (510.03) n=10	458.74* (353.98) n=8

[a] Winter = Dec-Feb; Spring = Mar-May; Summer = Jun-Aug; Fall = Sep-Nov.

[b] Number of birds located during the season.

* No significant difference ($P > 0.05$), students t-test.

Table 3. Comparison of habitat use by wild turkey hens[a] by season on commercial forestland in southeastern Oklahoma.

Cover Type[b]	Availability (%)	Use[c]			
		Wi[d] [619][e] n=15[f]	Sp [678] n=20	Su [544] n=9	Fa [411] n=8
Pine North[g]	0.6	(-)**	(-)**	(0)	(0)
Pine South	1.0	(-)**	(-)**	(0)	(0)
Pine Flat	3.3	(0)	(-)	(0)	(0)
Pine-Hardwood North	2.9	(0)	(0)	(0)	(0)
Pine-Hardwood South	7.7	(+)**	(0)	(0)	(0)
Pine-Hardwood Flat	22.6	(+)*	(+)**	(0)	(0)
Hardwood North	3.6	(0)	(0)	(0)	(0)
Hardwood South	2.5	(+)**	(-)*	(0)	(0)
Hardwood Flat	4.2	(-)**	(0)	(0)	(0)
Hardwood-Pine North	5.7	(-)**	(0)	(0)	(0)
Hardwood-Pine South	2.9	(+)	(0)	(0)	(0)
Hardwood-Pine Flat	8.6	(0)	(0)	(+)	(0)
Pine Setting (12)[h]	4.3	(-)**	(-)**	(-)**	(-)**
Pine Setting (9)	7.2	(-)**	(-)**	(0)	(-)**
Pine Setting (6)	4.9	(-)**	(-)**	(0)	(-)**
Pine Setting (3)	11.1	(-)**	(0)	(0)	(0)
Pine Setting (1)	3.3	(-)*	(0)	(0)	(-)**
Pasture/Hay Meadow[i]	2.2	(-)**	(-)**	(0)	(-)**
Other[j]	1.4	(-)**	(-)**	(0)	(-)**

[a] Comparison between habitat use and availability was not made for male turkeys because of the small sample size.

[b] Pine $\geq$ 75% BA pine, Pine-Hardwood $\geq$ 50 & < 75% BA pine, Hardwood-Pine > 25 $\overline{\&}$ < 50% BA pine, Hardwood $\leq$ 25% BA pine.

[c] Significant selection ($P < 0.05$) (+), ($P < 0.02$) (+)*, ($P < 0.01$) (+)**; avoidance ($P < 0.05$) (-), ($P < 0.02$) (-)*, ($P < 0.01$) (-)**; or neutrality (0) based on the Wilcoxon matched pairs signed-ranks test.

[d] Winter = Dec-Feb; Spring = Mar-May; Summer = Jun-Aug; Fall = Sep-Nov.

[e] Number of radio locations.

[f] Number of birds located during the season.

[g] North slope > 10%, south slope > 10%, and flat slope $\leq$ 10%.

[h] Age class $\pm$ 1 year.

[i] Tame pasture = fescue with mixed annual and perennial warm season grasses.

[j] Other = residential or commercial development.

Table 4. Density (stems/ha) and basal area (m^2/ha) of woody vegetation by class and cover type in mature timber stands and pine settings on commercial forestland in southeastern Oklahoma

Cover Type	Class 1[a]	Class 2	Class 3	Class 4	Total	Basal Area
Pine North[b]	800.7	3542.6	2141.6	15982.6	22467.5	24.7
Pine South	790.2	3379.7	2193.6	197.4	6560.8	27.2
Pine Flat	562.1	3592.1	4991.8	28935.4	38081.4	19.7
Pine-Hardwood North	1097.2	1871.8	5501.2	3498.2	11968.4	31.1
Pine-Hardwood South	814.2	1876.1	4399.6	755.3	7845.2	25.3
Pine-Hardwood Flat	864.4	3747.1	5213.2	5357.2	15181.8	27.4
Hardwood North	779.3	3023.9	27650.9	4253.8	35707.9	19.2
Hardwood South	390.2	3160.6	3347.5	1409.7	8308.1	14.6
Hardwood Flat	733.7	2410.6	11571.4	41332.4	56048.0	21.8
Hardwood-Pine North	860.7	2354.9	13676.2	1612.0	18503.8	18.7
Hardwood-Pine South	586.7	2899.0	3899.5	1238.6	8623.8	20.0
Hardwood-Pine Flat	671.1	4438.5	9293.7	46860.4	61263.7	22.2
Pine Setting (12)	1502.0	7592.8	4674.9	115202.2	128971.9	20.0
Pine Setting (9)	460.1	5018.4	3141.6	50442.0	59062.0	11.5
Pine Setting (6)	-	5341.6	5158.1	8539.8	19039.4	< 2.3
Pine Setting (3)	-	643.4	6828.7	3263.9	10736.0	< 2.3
Pine Setting (1)	-	-	1107.3	-	1107.3	< 2.3

[a] Class 1 = woody stems $\geq$ 10.16 cm d.b.h. and > 1 m tall.
Class 2 = woody stems $\leq$ 10.16 cm d.b.h. and > 1 m tall.
Class 3 = woody stems < 10.16 cm d.b.h. and $\leq$ 1 m tall.
Class 4 = woody vines.

[b] North = north aspect slope > 10%, South = south aspect slope > 10%, Flat = slope $\leq$ 10%.

[c] Age class $\pm$ 1 year.

Table 5. Percent use of habitat types by season within the home range of turkey hens on commercial forestland in southeastern Oklahoma.

Cover Type[a]	Use (%)			
	Wi[b]	Sp	Su	Fa
	$\overline{X}$	$\overline{X}$	$\overline{X}$	$\overline{X}$
Pine North[c]	0.65	1.36	3.82	2.45
Pine South	0.83	1.15	4.87	2.95
Pine Flat	1.64	2.32	2.07	1.24
Pine-Hardwood North	2.07	2.47	1.91	3.63
Pine-Hardwood South	12.66	9.50	9.29	13.61
Pine-Hardwood Flat	22.74	22.82	21.15	24.00
Hardwood North	2.02	5.23	3.17	11.05
Hardwood South	6.29	2.33	1.32	2.59
Hardwood Flat	3.76	2.98	2.17	2.41
Hardwood-Pine North	3.76	4.29	7.64	5.51
Hardwood-Pine South	6.78	4.60	3.28	5.04
Hardwood-Pine Flat	12.07	11.39	12.38	9.49
Pine Setting (12)[d]	1.62	4.18	2.96	0.00
Pine Setting (9)	8.52	5.30	5.60	2.58
Pine Setting (6)	1.35	1.13	3.47	1.49
Pine Setting (3)	9.34	13.57	9.77	10.29
Pine Setting (1)	1.77	5.03	5.03	1.58
Pasture/Hay Meadow	0.00	0.17	0.06	0.00
Other[e]	1.88	0.18	0.04	0.00

[a] Pine $\geq$ 75% BA pine, Pine-Hardwood $\geq$ 50 & < 75% BA pine, Hardwood-Pine > 25 & < 50% BA pine, Hardwood $\leq$ 25% BA pine.

[b] Winter = Dec-Feb, Spring = Mar-May, Summer = Jun-Aug, Fall = Sep-Nov.

[c] North Slope > 10%, South slope > 10%, Flat Slope $\leq$ 10%.

[d] Age class $\pm$ 1 year.

[e] Other = Commercial or residential development.

Table 6. Mean density and percent ground cover of herbaceous vegetation in mature timber stands and pine settings on commercial forestland in southeastern Oklahoma.

Cover Type	Ground Cover (%)	Density (stems/m^2)
Pine North[a]	13.55	38.90
Pine South	11.80	33.15
Pine Flat	28.30	73.10
Pine-Hardwood North	2.65	6.30
Pine-Hardwood South	24.25	29.50
Pine-Hardwood Flat	12.30	20.15
Hardwood North	10.30	20.20
Hardwood South	20.80	43.75
Hardwood Flat	22.90	29.45
Hardwood-Pine North	4.60	6.90
Hardwood-Pine South	8.00	6.65
Hardwood-Pine Flat	12.00	20.00
Pine Setting (12)[b]	26.30	57.50
Pine Setting (9)	32.00	77.20
Pine Setting (6)	39.95	102.22
Pine Setting (3)	35.45	110.80
Pine Setting (1)	17.50	38.50

[a] North = north aspect slope $>$ 10 %.
South = south aspect slope $>$ 10%.
Flat = flat aspect $\leq$ 10%.

[b] Age class $\pm$ 1 year.

Table 7. Percent cover type in the mean annual home range of adult female turkeys on commercial forestland in southeastern Oklahoma.

Cover Type[a]	Home Range (%) Including Aspect	Home Range (%) Excluding Aspect
Pine North[b]	2.07	
Pine South	2.45	6.35
Pine Flat	1.83	
Pine-Hardwood North	2.53	
Pine-Hardwood South	11.27	36.48
Pine-Hardwood Flat	22.68	
Hardwood North	5.37	
Hardwood South	3.14	11.34
Hardwood Flat	2.83	
Hardwood-Pine North	5.30	
Hardwood-Pine South	4.94	21.57
Hardwood-Pine Flat	11.33	
Pine Setting (12)[c]	2.19	2.19
Pine Setting (9)	5.52	5.52
Pine Setting (6)	1.86	1.86
Pine Setting (3)	10.74	10.74
Pine Setting (1)	3.35	3.35
Pasture/Hay Meadow	0.06	0.06
Other (developments)	0.54	0.54

[a] Pine $\geq$ 75% BA pine, Pine-Hardwood $\geq$ 50 & < 75% BA pine, Hardwood-Pine > 25 & < 50% Ba pine, Hardwood $\leq$ 25% BA pine.

[b] North Slope > 10%, South Slope > 10%, Flat $\leq$ 10%.

[c] Age class $\pm$ 1 year.

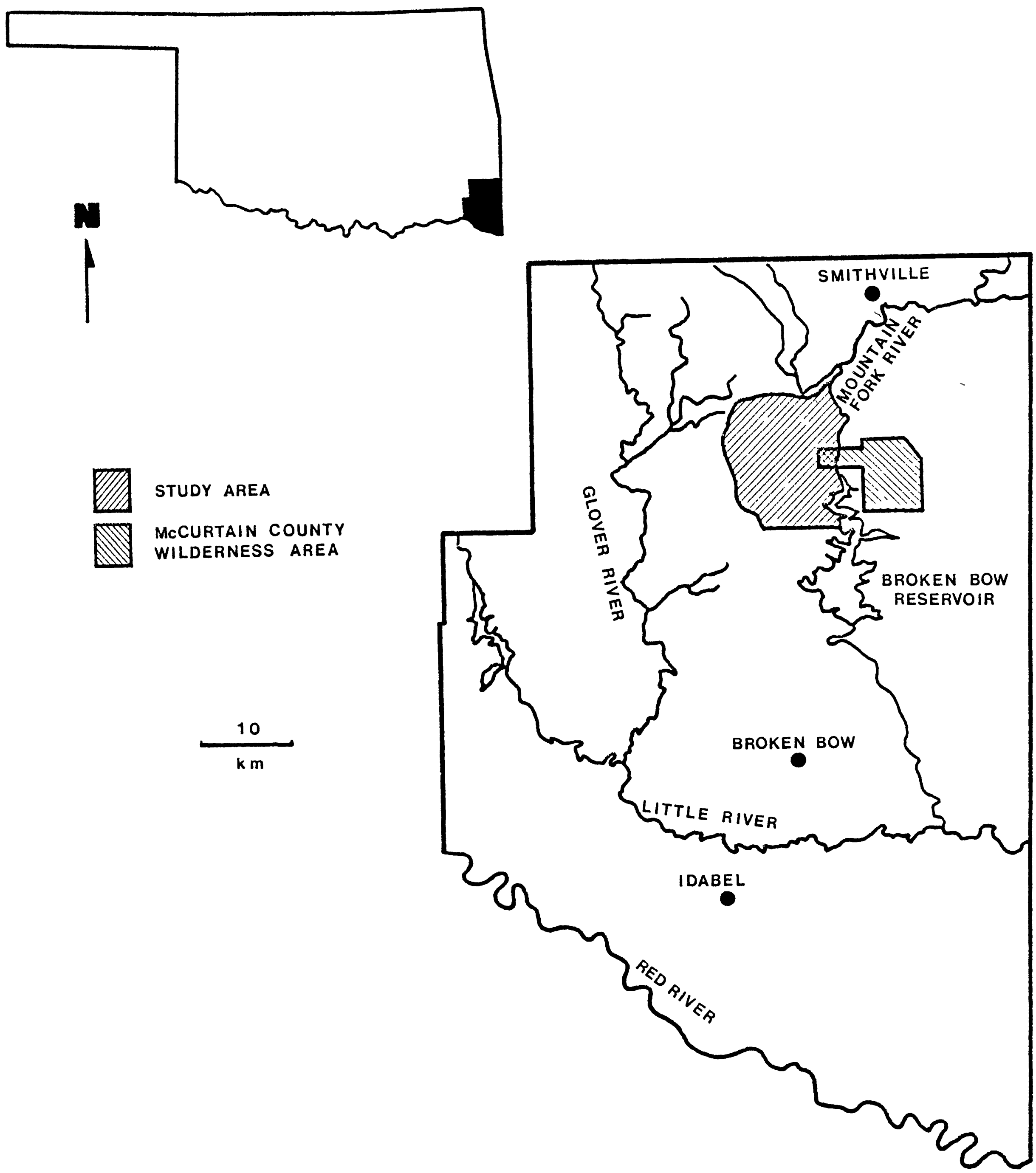

Figure 1. Study area in McCurtain County, Oklahoma

CHAPTER III

NESTING HABITAT AND NEST SUCCESS OF THE EASTERN WILD TURKEY IN SOUTHEASTERN OKLAHOMA

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Abstract.-This study describes nesting habitat and nesting success of eastern wild turkeys in southeastern Oklahoma. Fourteen of 25 (56%) turkeys nested and 12 nests were found in 6 of the 19 cover types. One nest was successful. One of 14 (7%) turkeys renested. Nest site characteristics were highly variable.

Little is known about nesting habitat or productivity of the eastern wild turkey (*Meleagris galloparo silvestris*) in southeastern Oklahoma. This area is intensively utilized for timber harvest. Extensive clearcutting and road building by industrial foresters have reduced the amount of mature hardwood-pine forests and possibly altered eastern wild turkey nesting habitat. Continuous cattle grazing and hog (*Sus scrofa*) foraging on clearcuts, pine settings, and mixed mature timber stands may also have adversely affected turkey populations in the area (National Wildlife Federation 1982).

Nesting and brood rearing requirements generally limit turkey populations because of high mortality during these periods (Gainey 1954, Lindzey 1967, Shaffer and Gwynn 1967, Speake 1980). Ligon (1946), Weston (1952), Stoddard (1963), Kirsch (1969), and Baker (1978) reported that heavy grazing had a negative affect on turkey nest success. Baker (1978) reported that nest success was higher under rotational grazing systems than in areas that were continuously grazed. Gainey (1954) and Lindzey (1967) have suggested that because of the tendency for populations to be limited during these periods, most research efforts should be directed toward factors that affect poult production.

The purpose of this paper is to describe preferred nesting habitat and nest success of a radio marked wild turkey population. We report vegetation and topographic parameters around nests, number of eggs layed, number of poults hatched, fate of nests, and probable predators.

We gratefully acknowledge the assistance of J. M. Gray, L. G. Talent, J. H. Shaw, and F. S. Schitoskey. Field assistance provided by S. Conrady and E. Stewart was greatly appreciated. Special thanks go to R. Thackston and G. Woods of the Oklahoma Department of Wildlife Conservation and D. Moore and J. Buneau of the Weyerhaeuser Company. W. D. Warde assisted with statistical analyses.

STUDY AREA

The study area was located on the Weyerhaeuser Company Mountain Fork Wildlife Management Area in McCurtain County, Oklahoma. The study area is bounded on the north and west by U.S. Highway 259, on the south by Carter Mountain, and on the east by the Mountain Fork River and Broken Bow Reservoir. The region is characterized by steep rugged hills separated by valleys with rolling topography and clear streams with many spring fed tributaries. Duck and Fletcher (1945) described the vegetation in the area as oak-pine forest.

METHODS

Sixty-eight wild turkey hens were captured in 1983 and 1984 with rocket projected nets and 41 were equipped with radio packages as part of a broader study of home range and habitat use (Bidwell 1985). Thereafter radio marked hens were monitored regularly to determine nest site selection. Once nests were located, they were monitored from a distance until the third week of incubation when the hen was flushed and nest characteristics measured.

Parameters measured at each nest included the number of eggs; land slope aspect; distance, width, and type of the nearest road; and vegetation characteristics. The point centered quarter method (Cottom and Curtis 1956) was used to sample the woody stems and vines at each nest. A diameter tape was used to measure stems $\geq$ 10.16 cm at 1.37 m above ground. A 10 factor wedge prism was used to measure basal area (BA). A 1 m^2 quadrat and meter stick were used to measure number and percent cover of herbaceous stems. Vegetation was grouped into 5 classifications: (class 1) woody stems $\geq$ 10.16 cm d.b.h. (diameter breast height) and > 1 m tall, (class 2) woody stems < 10.16 cm d.b.h and > 1 m tall, (class 3) woody stems < 10.16 cm d.b.h. and $\leq$ 1 m tall, (class 4) woody vines, and (class 5) herbaceous stems.

Simple correlations were performed using the Statistical Analysis System (SAS Institute, Inc. 1982).

RESULTS AND DISCUSSION

Nesting Habitat

Fourteen turkeys nested and 12 nests (11 adults, 1 juvenile) were located and evaluated for physical and vegetative characteristics. These nests occurred in 6 of the 19 cover types on the study area (Table 1). Seventy-nine percent (11/14) of the nests occurred in mature stands of hardwood-pine and pine-hardwood, which made up 50.5% of the study area. Three nests were found in 7-9 year old pine settings (2 adults, 1 juvenile). Nest site characteristics were highly variable (Table 1).

Pinus echinata accounted for 47.7% of class 1 woody stems around nests and was found around 75% (9/12) of the nests. *Carya tomentosa*, *Nyssa sylvatica*, and *Cornus florida* accounted for > 50% of class 2 woody stem density around nests and were found around 83% (10/12) of the nests. *Vaccinium vacillans* made up 50% of class 3 woody stem density and was observed around 66.7% (8/12) of the nests. Seven species of woody vines (class 4) were found around nests and each species accounted for < 23% of the total vine density around nests (Table 2).

Forest litter was the substrate of 42% (5/12) of the nest sites where no herbaceous stems occurred within 1 m^2 of these nest. On nest sites with herbaceous stems, there was an inverse relationship between d.b.h. and herbaceous vegetation (r = -0.60158, P = 0.0502) and basal area and herbaceous vegetation (r = -0.63018, P = 0.0281). Negative correlations probably resulted from a combination of canopy closure, moisture availability, and alleopathic relationships. Both herbaceous stem density (r = -0.50437, P = 0.0945) and ground cover (r = -0.60118, P = 0.0969) were inversely related to class 3 woody stem density at nest sites.

Most nests were found next to a tree or stump. The distance from nests to stumps or woody stems (class 1) was correlated to the density of woody vines (r = 0.74823, P = 0.0081) and total woody stem density (r = 0.73212, P = 0.0104). Hens are known to select nest sites in dense cover. There was also positive relationship between class 3 woody stem density and the distances of the nests to roads (r = 0.63089, P = 0.0278). There was no significant relationship (P > 0.05) found between the number of eggs and slope, aspect, width of road, class 1 density, or class 2 density for nest sites.

The relationship of nest site selection to habitat characteristics has been partially documented. Hillestad (1973), Speake et al. (1975), and Everett (1982) reported that utility rights-of-way and other openings were important nesting habitat. Hon et al. (1978) reported that hens preferred to nest near game trails and firebreaks. In our study area, vines were usually found close to the ground only along roads, trails, or openings. Vines at ground level may provide good nesting cover, but they were not a main cover component around any of the nests that we found. Bowman (1982) found 31% (4/13) of his nests in permanent openings, and Davis (1976) reported poor nesting habitat in areas without openings. However, none of the turkeys that we monitored nested in permanent openings (Table 1).

Nest sites characteristically had sparse ground cover provided by herbaceous plants and small woody stems. Overhanging limbs and brush piles were also found at nest sites. The proximity of some nests to roads may have resulted from increased ground cover due to the edge effect provided by increased sunlight penetration or to accessibility to the nest sites provided by roads. Although only distances from nests to roads were measured, three nests located in pine settings and one in mature timber had cattle trails or firebreaks closer than roads. These open areas could have also provided access or escape routes.

Nest Success

Fourteen of 25 (56%) turkey hens in the sample population nested in 1983 and 1984. Williams et al. (1972), Hon et al. (1978) and Bowman (1982) reported nesting rates of 64%, 69%, and 78%. The mean clutch size was 11.6 eggs, as compared to 9.6 in a Florida study (Williams et al. 1972), 10.1 in a Georgia study (Hon et al. 1978), and 10.8 in an Alabama study (Everette et al. 1980). Most nest losses (61%, 8/13) were due to abandonment caused by human disturbance. Unidentified predators destroyed 4 of 13 nests (31%), and 1 (8%) was destroyed by logging. One nest hatched successfully and 4 poults were raised.

Nests that were destroyed by predators did not contain egg shell fragments or other signs of disturbance. For this reason, snakes were suspected of taking eggs from nests, although none were observed at nest sites. Beasom (1974) reported snakes as the most important nest predator in Texas, and Blakey (1937) reported the black snake (*Elaphe* sp.), timber rattlesnake (*Crotalus* sp.), and opossum (*Didelphis virginiana*) as egg predators in the Missouri Ozark Range. Hon et al. (1978) and Everett et al. (1980) reported nest predation rates of 26% and 19% respectively. Ligon (1946), Weston (1952), and Kirsch (1969) reported increased nest loss and predation when cover was depleted by overgrazing. Gainey (1954) and Speake (1980) reported that the nesting season was a critical time for predation on nesting hens although none of our radio marked hens were killed while nesting. Cattle grazed along roads in early successional (1-10 yrs) pine settings (Nelson 1984), but grazing was not noted around nest sites.

Although some new logging roads were built and clearcutting occurred during the study period, only one nest was directly destroyed by commercial forestry operations. This nest was destroyed when a tree was dropped onto it during a logging operation. This bird then renested, incubated for 21 days, and subsequently abandoned the nest for unknown reasons. Only 7.1% (1/14) of the hens in our study renested. This value is substantially lower than the 29.4% reported by Williams et al. (1972) and 22.0% reported by Everett et al. (1980). Also, Williams et al. (1980) reported high compensatory renesting in Florida. Low initial and second nesting rates may reflect low productivity that may have resulted from low habitat quality or high populations. Another possibility is suggested by Williams et al. (1972) who reported that handling turkeys during March and early April may delay nesting.

Turkey populations in southeastern Oklahoma have been considered stable and high (Thackston and Lowrey 1981). It is possible that with high populations we would see a low initial nesting rate because of density-dependent factors such as reduced reproduction and low juvenile hen reproduction (Hopkins 1973). It is also possible that clearcuts, road building, cattle grazing, and herbicide use have modified some habitat components that affect nesting in the study area. Also, 1983 was a poor mast production year, and poor mast production could have affected nesting rates because of poor nutrition. Further nesting studies are needed because of the complexity of cover types and land management practices that continue in southeastern Oklahoma.

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Table 1. Turkey nest location and physical description on commercial forestland in southeastern Oklahoma.

Bird no.	Cover type[b]	No. of eggs	Slope (%)	Aspect (°)	Dist. to Rd. (m)	Road type	Road width (m)
5[a]	PHN	11	25	340	10.25	Logging (old)	3.38
5	PHF	14	6	27	7.30	Logging (new)	5.54
44	HPF	8	35	100	60.00	County	5.15
28	RHS	14	27	202	35.34	Logging	4.40
46	HPF	15	8	323	103.00	County	4.50
39[c]	PS77 (7 yr.)	13	43	115	160.93	Logging	4.00
52	HPF	10	10	195	131.00	Logging	3.55
37	PS75 (9 yr.)	11	12	288	16.68	Logging (old)	2.64
31	PHN	11	32	358	33.20	Logging (old)	2.30
34	HPF	11	5	94	49.05	Logging (old)	2.25

Table 1. Continued.

Bird no.	Cover type[b]	No. of eggs	Slope (%)	Aspect (°)	Dist. to Rd. (m)	Road type	Road width (m)
35	PHF	13	14	222	20.80	Logging	5.52
49	PS75 (9 yr.)	8	21	355	60.96	Logging	3.00
30[c,d]	PHF	-	-	-	-	Logging	4.64
61[d]	PHS	-	-	-	-	Logging	4.85
$\overline{x}$		11.63	19.36		61.66		4.03
S_d		2.38	13.07		49.68		1.17
Range		8-15	5-43		7.30-160.93		2.25-5.54

[a] 1983 nest.

[b] PHN = Pine-Hardwood North Aspect.
PHF = Pine-Hardwood Flat Aspect.
HPF = Hardwood-Pine Flat Aspect.
PHS = Pine-Hardwood South Aspect.
PHN = Pine-Hardwood North Aspect.
PS = Pine Setting Age Class.

[c] Juvenile.

[d] Nest site was not found.

Table 2. Mean abundance of plant species associated with turkey nests on commercial forestland in southeastern Oklahoma.

Species	Relative density (%)	Absolute density (stems/ha)	Frequency	Relative frequency
Class 1[a] (603.42 stems/ha)				
Pinus echinata	47.73	288.01	81.82	45.00
Cornus florida	2.27	13.70	9.09	5.00
Quercus alba	11.36	68.55	27.27	15.00
Carya tomentosa	13.64	82.31	27.27	15.00
Pinus taeda	18.18	109.70	18.18	10.00
Quercus stellata	2.27	13.70	9.09	5.00
Quercus falcata	4.55	27.46	9.09	5.00
Class 2[b] (3704.84 stems/ha)				
Cornus florida	16.67	617.60	41.67	14.71
Amelanchier arborea	2.08	77.06	8.33	2.94
Nyssa sylvatica	20.83	771.72	41.67	14.71
Carya tomentosa	16.67	617.60	58.33	20.59

Table 2. Continued.

Species	Relative density (%)	Absolute density (stems/ha)	Frequency	Relative frequency
Class 2 (cont'd)				
Viburnum prunifolium	8.33	308.61	16.67	5.88
Quercus marilandica	2.08	77.06	8.33	2.95
Quercus stellata	4.17	154.49	16.67	5.88
Ulmus alata	10.42	386.04	25.00	8.82
Quercus alba	4.17	154.49	16.67	5.88
Pinus taeda	6.25	231.55	16.67	5.88
Crataegus sp.	2.08	77.06	8.33	2.94
Pinus echinata	2.08	77.06	8.33	2.94
Vaccinium arboreum	2.08	77.06	8.33	2.94
Quercus rubra	2.08	77.06	8.33	2.94

Table 2. Continued.

Species	Relative density (%)	Absolute density (stems/ha)	Frequency	Relative frequency
Class 3[c] (26421.39 stems/ha)				
Vaccinium vacillians	56.25	14862.03	66.67	33.33
Nyssa sylvatica	4.17	1101.77	16.67	8.33
Cornus florida	8.33	2200.90	25.00	12.50
Fraxinus sp.	2.08	549.56	8.33	4.17
Viburnum prunifolium	8.33	2200.90	25.00	12.50
Quercus alba	2.08	549.56	8.33	4.17
Ulmus alata	8.33	2200.90	25.00	12.50
Quercus falcata	2.08	549.56	8.33	4.17
Rhus copallina	4.17	1101.77	8.33	4.17
Carya tomentosa	2.08	549.56	8.33	4.17
Querus marilandica	2.08	549.56	8.33	4.17

Table 2. Continued.

Species	Relative density (%)	Absolute density (stems/ha)	Frequency	Relative frequency
Class 4[d] (1742.46 stems/ha)				
Parthenocissus quinquefolia	8.33	145.15	25.00	11.54
Rubus sp.	14.58	254.05	25.00	11.54
Rhus radicans	18.75	326.71	41.67	19.23
Smilax rotandifolia	10.42	181.56	33.33	15.38
Vitis sp.	22.92	399.37	41.67	19.23
Lonicera simpervierns	2.08	36.24	8.33	3.85
Smilax bona-nox	22.92	399.37	41.67	19.23

[a] Class 1 = trees $\geq$ 10.16 cm d.b.h. and > 1 m tall.

[b] Class 2 = saplings and shrubs < 10.16 cm d.b.h. and > 1 m tall.

[c] Class 3 = saplings and shrubs < 10.16 cm d.b.h. and $\leq$ 1 m tall.

[d] Woody vines.

CHAPTER IV

MORTALITY OF ADULT WILD TURKEYS IN SOUTHEASTERN OKLAHOMA

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ABSTRACT.-This study describes predation on eastern wild turkeys in southeastern Oklahoma. Nine of 47 (19%) turkeys were killed by predators including 3 by bobcat, 3 by great horned owl, and 3 by unidentified animals. All predation on adult females occurred during February and March, before nesting season.

Eastern wild turkey (*Meleagris gallopavo silvestris*) populations may be regulated by density-dependent factors such as reduced reproduction, zero juvenile hen reproduction, and emigration of juveniles during spring (Hopkins 1973). The effects of various avian and mammalian predators are not thought to limit wild turkey populations in most areas but may be significant during nesting and early brood rearing season (Korschgen 1973, Speake 1980). Little is known about the effects of predation on turkey populations in areas of intensive cattle grazing and extensive commercial forestry practices.

The purpose of this study was to determine the predation rate, identify predators, and determine the level and causes of non-predatory losses of turkeys on commercial forestland in southeastern Oklahoma.

We gratefully acknowledge the assistance of F. S. Schitoskey, L. G. Talent, J. H. Shaw, J. M. Gray, K. Peters, and H. L. Murray. Field assistance provided by S. Conrady and E. Stewart was greatly appreciated. Special thanks go to R. Thackston and G. Woods of the Oklahoma Department of Wildlife Conservation and D. Moore of the Weyerhaeuser Company. W. D. Warde assisted with statistical analyses.

STUDY AREA

The study area, bounded on the north and west by U.S. Highway 259, on the south by Carter Mountain, and on the east by the Mountain Fork River and Broken Bow Reservoir, was on the Weyerhaeuser Company Mountain Fork Wildlife Management Area in McCurtain County, Oklahoma. The region is characterized by steep rugged hills separated by valleys with rolling topography, clear streams, and many spring fed tributaries. Duck and Fletcher (1945) described the vegetation in the region as oak-pine forest.

METHODS

Adult turkey mortality and loss were calculated from a sample of 47 radio instrumented birds that were monitored from March 1983 through August 1984. Turkeys were captured with rocket-projected nets, instrumented, and released at the capture site. Both solar and battery powered transmitters were used. Battery powered transmitters included mortality switches which activated after the bird had remained motionless for about 2 hours.

Instrumented birds were located 3 days/week and 3 activity periods per day (i.e., 0800-1200, 1201-1600, 1601-2100). When the mortality mode (faster than normal pulse rate) of a radio transmitter was detected, the bird was located as quickly as possible and examined for sign of predation.

RESULTS AND DISCUSSION

Nine of 47 (19.2%) radio-equipped turkeys were killed by predators; including 3 by bobcat (*Felis rufus*), 3 by great horned owl (*Bubo virginianus*), and 3 by unidentified animals (Table 1). Turkeys killed by bobcats typically had a partially eaten breast and neck and the entire carcass was covered with forest litter. Great horned owls, however, severed the head from the turkey, left plucked and sheared feathers laying around the carcass, and removed tissue neatly from the bones.

All predation on adult female turkeys occurred during February and March prior to nesting (Table 2). Fleming and Speake (1976) also reported that overwinter losses prior to nesting were much greater than losses during nesting season, but Shaffer and Gwynn (1967), Beasom (1974), and Speake (1980) reported that predation on hens with poults and nesting hens may limit turkey populations.

In other areas, several predators are occasionally known to kill turkeys. Glazener (1967) listed coyotes (*Canis latrans*), bobcats, and raccoons (*Procyon lotor*) as predators of adult male turkeys (*M. g. intermedia*) and eagles as predators of adult females in Texas. He also stated that great horned owls attacked poults. Wild turkey remains were found in bobcats stomachs by Rolley (1983) in southeastern Oklahoma. Speake (1980) reported that bobcats, golden eagles (Aquila chrysaetos), gray foxes (Urocyon cinereoargenteus), and dogs (Canis familiaris) were predators of turkeys in Alabama.

Currently, in southeastern Oklahoma, mature hardwood-pine forests are being replaced with even-aged pine monocultures. There are no studies with which to compare our predation rate of 19.1%, but it is possible that the conversion from hardwood to pine, the subsequent decrease of hard and soft mast production, and low site indexes, may be forcing turkeys to move over large areas to obtain life requisites. A result of all these factors could be increased susceptibility to predation. Markley (1967) stated that turkeys traveling into unfavorable territory may be more subject to predation than those in familiar habitat and concluded that "predation can be of concern when residual native or transplanted populations are low, when nesting or escape cover is inadequate, when food shortages or water scarcity force birds into unfavorable range, when only low numbers of other prey (buffer) species occur, and when birds are exposed to severe weather conditions such as flooding or prolonged periods of deep snow and severe cold."

Another factor that may indirectly affect predation on turkeys is grazing and foraging by cattle and feral hogs (Sus scrofa) in early to mid successional pine plantations. Overgrazing by domestic livestock has previously been shown to cause a reduction of food and cover and result in increased predation of turkeys (Walker 1949, Weston 1952, Glazener 1963). In addition, grazing may also reduce populations of buffer species. Cattle and free ranging hogs are known to compete with wild turkeys for food (Mosbey and Handley 1943, Schemnitz 1956). If grazing made small rodents more vulnerable to predation, the decreased densities of buffer species (e.g., Sigmodon, Neotoma, Peromyscus, Reithrodontomys) in an area may have resulted in more bobcat predation on winter turkey flocks. Rolley (1983) reported that bobcats spent much of their time in pine plantations, presumably due to the higher availability of small rodents in these habitat types than in mature forests. If this hypothesis is true, the trend toward even-aged pine monocultures and elimination of mature hardwoods may increase the vulnerability of wild turkeys to predation.

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Table 1. Predation rate of wild turkeys on commercial forestland in southeastern Oklahoma from March 1983 through August 1984.

		Predator Species				
Age/sex[a]	N	Bobcat	Great Horned Owl	Unidentified	Total	Rate (%)
AF	38	2	3	3	8	(21.05)
AM	7	1	0	0	1	(14.29)
JF	1	0	0	0	0	(0.0)
JM	1	0	0	0	0	(0.0)
Total	47	3(6.38)	3(6.38)	3(6.38)	9	(19.15)

[a] AF = adult female; AM = adult male; JF = juvenile female; JM = juvenile male

Table 2. Total loss by all causes for instrumented wild turkeys on commercial forest land in southeastern Oklahoma.

Month/Year	No. of Birds[a] in Sample	Bird No.	Cause of Loss	Age/Sex[b]
Mar 83	11	4	Unknown	AF
		1	Great horned owl	AF
		3	Lost transmitter	JF
		7	Capture stress	JM
		6	Capture stress	AM
		8	Unknown	AM
		9	Unknown	AM
Apr 83	4		None	
May 83	4		None	
Jun 83	4	2	Unknown	JM
		11	Unknown	AM
Jul 83	2		None	
Aug 83	2	5	Lost transmitter	AF
Sep 83	1		None	
Oct 83	1	10	Bobcat	AM
Nov 83	4		None	
Dec 83	4		None	
Jan 84	24	23	Transmitter failure	AF
Feb 84	27	21	Bobcat	AF
		24	Great horned owl	AF
		25	Bobcat	AF
		22	Unidentified predator	AF

Table 2. Continued.

Month/Year	No. of Birds[a] in Sample	Bird No.	Cause of Loss	Age/Sex[b]
		40	Transmitter failure	AF
		18	Transmitter failure	AF
Mar 84	27	48	Unidentified predator	AF
		37	Lost transmitter	AF
		51	Great horned owl	AF
		36	Unidentified predator	AF
		27	Lost transmitter	AF
		41	Transmitter failure	AF
		32	Lost transmitter	AF
Apr 84	27		None	
May 84	27	28	Transmitter failure	AF
		55	Transmitter failure	AF
		61	Unknown	AF
Jun 84	24	47	Unknown	AF
		30	Transmitter failure	JF
Jul 84	22	17	Transmitter failure	AF
		49	Transmitter failure	AF
		20	Transmitter failure	AF
		52	Transmitter failure	AF
Aug 84	18	33	Lost transmitter	AF

[a] Includes new radio marked birds less loss and transmitters put out more than once.

[b] AF = adult female, AM = adult male, JF = juvenile female, JM = juvenile male.

CHAPTER V

A COMPARISON OF COVER TYPES AND VEGETATION CHARACTERISTICS IN RELATION TO WILD TURKEY HABITAT ON COMMERCIAL FORESTLAND IN SOUTHEASTERN OKLAHOMA

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ABSTRACT.-This study describes the relationship of cover types and vegetation characteristics on commercial forestland in southeastern Oklahoma. Twelve year old pine settings were the most dense cover type in the study area. Basal area and woody stem density ($\geq$ 10.16 cm d.b.h.) were positively correlated and did not differ among cover types by slope or aspect in mature timber stands. The mean d.b.h. of trees in pine stands on flat slopes was greater than that in all other cover types. Woody shrub ($\leq$ 1 m tall) density was greater on hardwood-pine stands on north slopes than those on hardwood-pine stands on south and flat slopes. Woody shrub density was greater on 3, 6, and 9 year old pine settings than on 1 year old settings. Pine settings had no measurable hard mast production potential. Soft mast producing tree ($\geq$ 10.16 cm d.b.h.) density was greater on hardwood stands on north slopes than in all other cover types except pine-hardwood stands on north slopes. Soft mast producing trees were also more dense in pine-hardwood

stands on north slopes than on corresponding stands on south or flat slopes. Density of soft mast producing shrubs ($\leq$ 1 m tall) was greater in hardwood stands on north slopes than on hardwood stands on flat slopes. The basal area of other hardwoods was greater in hardwood stands on north and flat slopes than on hardwood stands on south slopes and in all other cover types. Pine settings of all age classes (except 1 year old) had greater herbaceous stem density than did mature timber stands. Herbaceous stem density was inversely correlated with basal area in all cover types. The stem density of Panicum sp. was greater in 6, 9, and 12 year old pine settings than in all other cover types. The stem density of Lespedeza sp. was greater in 6, 9, and 12 year old pine settings than in all other cover types except 1 year old pine settings and pine-hardwood stands on south slopes. There were no consistant differences in stem density classifications among stands on north, south, and flat slopes for delineated cover types.

Silvicultural practices have a direct effect on native vegetation and as a result influence habitat use by animals such as the eastern wild turkey (Meleagris gallopavo silvestris). Previous turkey studies have often used cover or stand data provided by the forest industry or government management agencies to describe vegetation characteristics. Very little information was found that described vegetation strata within general cover types that might be related to wild turkey use. We have attempted to describe turkey habitat and potential food production in terms of density and species composition for use in conjunction with turkey use and movement patterns in southeastern Oklahoma.

This vegetation study was part of a general home range and habitat use study of the eastern wild turkey described in detail by Bidwell (1985).

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STUDY AREA

This study was conducted on the Weyerhaeuser Company Mountain Fork Wildlife Management Area in McCurtain County, Oklahoma. The study area was bounded on the north and west by U.S. Highway 259, on the south by Carter Mountain, and on the east by the the Mountain Fork River and Broken Bow Reservoir. The region is characterized by steep rugged hills separated by valleys with rolling topography and clear streams with many spring fed tributaries. Elevations above mean sea level ranged from 183 to 381 m. Soil associations included Carnasaw-Sherwood and Goldston-Carnasaw-Sacul (Reasoner 1974). Approximate site indexes were 60 for pine on flat to rolling terrain and 38 for steeper slopes (James 1982). Annual rainfall averaged 115.3 cm (Weyerhaeuser Co., unpublished data).

Duck and Fletcher (1945) described the vegetation in the area as oak-pine forest. Dominant tree species on north slopes included white oak (Quercus alba), black oak (Quercus velutina), mockernut hickory (Carya tomentosa), and shortleaf pine (Pinus echinata). South slopes were dominated by post oak (Quercus stellata), blackjack oak (Quercus marilandica), and shortleaf pine (Pinus echinata).

Approximately 15,708 ha of the 19,003 ha management area was owned and managed by the Weyerhaeuser Company and the balance was owned and managed by private parties, the U.S. Army Corps of Engineers, and the Oklahoma Department of Wildlife Conservation.

Timber harvesting began in the region about 1907 by the Dierks Lumber and Coal Company. Merchantable pines were harvested and hardwoods were left uncut during this period. By the early 1930's, management had changed to selective harvest of pines larger than 30.5 cm d.b.h. (Little and Olmstead 1931), and herbicides were commonly used for hardwood control. The Weyerhaeuser Company bought most of the land in the study area in 1969, and the first pine setting in the study area was planted in 1972 (Weyerhaeuser Co., unpublished data). Silvicultural practices used to establish pine settings usually included clearcutting, roller chopping, burning, contour ripping, planting, and application of herbicides for hardwood control.

METHODS

Vegetation was sampled during June 1984. Timber stand maps and pine setting records (Weyerhaeuser Co., unpublished data) were used to construct a cover map on aerial photos. U.S. Geological Survey (1:24,000) topographic maps were overlaid with aerial photos to determine north and south slopes. Percent basal area (BA) of woody vegetation (Weyerhaeuser Co., unpublished data) was used to determine 5 basic cover types: pine $\geq$ 75% BA pine, pine-hardwood $\geq$ 50% but < 75% BA pine, hardwood-pine > 25% but < 50% BA pine, hardwood $\leq$ 25% BA pine, and pine settings approximately 1 to 12 years old (Table 1 and 2).

Woody species were grouped into families and categorized as either hard mast, soft mast, pine mast, or other hardwood mast (Appendix 1). Herbaceous species were also grouped by family and categorized as Panicum sp., Digitaria sp., other legumes, Oxalis sp., Cyperus sp., other grasses, other forbs, Lespedeza sp., and other sedges or grasslike plants.

Cover types other than pine settings, pasture/hay meadow, and development areas were further separated into north, south, and flat slopes (≤ 10%) and were classified as mixtures of mature or climax pine and hardwood.

To sample vegetation, transects were run diagonally across slopes to include lower, middle, and ridge except where the cover type ran horizontally across the slope. A species area curve and standard error of the mean were used to determine sample size (Mueller-Dombois and Ellenberg 1974).

Vegetation was classified by species into 5 horizontal zones depending on height and diameter at breast height (d.b.h.). Classifications were: (1) trees (≥ 10.16 cm d.b.h. and > 1 m tall); (2) saplings and shrubs (< 10.16 cm d.b.h. and > 1 m tall); (3) saplings and shrubs (< 10.16 cm d.b.h. and ≤ 1 m tall); (4) woody vines; and (5) herbs. Woody species within each size class were grouped into preferred turkey food categories according to their ability to produce mast. Herbs were also grouped into preferred food categories (Appendices 1 and 2). Mast production was estimated from vegetation parameters.

The point centered quarter method was used to sample all woody stems (Cottom and Curtis 1956, Mueller-Dombois and Ellenberg 1974). A diameter tape was used to measure d.b.h. for stems $\geq$ 10.16 cm. A 10 factor wedge prism was used to measure BA and a 1 m^2 quadrat was used to sample herbs. Absolute density, relative density, frequency, and relative frequency were calculated for each woody species, category, classification, and cover type. Absolute density and frequency were calculated for each herbaceous species, category, and habitat type.

Statistical analyses were performed using the Statistical Analysis System (SAS Institute, Inc. 1983). ANOVA and Duncan's Multiple Range Test (Kramer 1956) were used to test the significance of stem density, BA, and d.b.h. differences within and between cover types and categories. Primary comparisons were made among cover types on north, south, and flat slopes within the same percent BA pine. We also compared class 2, 3, 4, and 5 vegetation types among all cover types. Simple correlation was used to test the relationships between stem density classifications and BA.

Multiplicative error was suspected in the density estimates (larger estimated densities had larger errors than smaller estimated densities); therefore, a logarithmic transformation of the densities was made (Snedecor and Cochran 1971). When no stems were observed within 30 m of the point in any quarter for any of the 10 points on the transect, the density ($\hat{P}$) was considered zero. Conversions of zero values to log ($\hat{P}$) yield the equation $-\infty(\ln \hat{P} = -\infty)$. Therefore, where zero values occurred we added a value of one stem at 30 m in one quadrant to the observation. This procedure gave the formula

$$\hat{P} = \frac{1}{\bar{d}^2} \; \Gamma \frac{^2[3/2 - \ln (39/40)]}{(1 - 39/40)^2} = - 11.053$$

This value was used for zero observations (Warde and Petranka 1981).

RESULTS AND DISCUSSION

Vegetation in the study area was highly variable. Historical land use practices including land clearing for agriculture, logging, grazing, and fire were probably responsible for this variability. Little and Olmstead (1931) reported that historically the mesophytic *Quercus alba* climax forest association occurred primarily on north facing slopes in the Rich and Kiamichi Mountains and to a lesser extent on north slopes similar to those within the study area. Plant diversity and density appear to have changed dramatically since the area was settled in the 1800's. Historical timber stand data from the 1950's and 1960's showed that the mean d.b.h. of pine (*Pinus* sp.) was 20.66 cm in mature pine and hardwood stands. This low d.b.h. was probably the result of a hardwood control program that started during that period (Barnes and Melchiors 1982). High grading and other silviculture activities may have also contributed to the increase in d.b.h. since the 1950's. Based on the historical reports, d.b.h. and species diversity were higher than what we found (Little and Olmstead 1931). Therefore, timber stands in the study area may not be mature or climax. A combination of wild fires, prescribed fires, herbicide applications, and silvicultural activities are probably responsible for these conditions.

Several studies (Ralston 1964, Carmean 1975, Carmean 1977) have found that the position of a timber stand relative to the slope may be the single most useful factor in evaluating the growth potential of forest trees. North facing slopes normally receive less sunlight, have cooler temperatures, and are more moist than south facing slopes (Spurr and Barnes 1980). An increase in density, BA, and d.b.h. of woody species was expected on north slopes over south slopes because of these characteristics (Little and Olmstead 1931). However, this trend did not always occur in the study area, probably because of the relatively short slopes.

Studies of oak site quality in the Appalachian Mountains found that relative position between ridge top and cove, aspect, and degree of slope were all closely related to site quality, topography, and resultant microclimate (Trimble and Weitzman 1956, Doolittle 1958, Carmean 1977). In our study, species composition, density, and mast and forage production potential differed significantly by aspect among cover types of the same BA criteria (Table 3). We also found significant differences between timber stands of different BA criteria.

Total Stem Density, Basal Area, and Diameter at Breast Height of Woody Stems

Basal area and class 1 stem density were positively correlated with one another (r = 0.82632, P = 0.0001). This correlation demonstrated that BA was as good an estimate of the potential mast producing trees as calculating stem density by the point centered quarter method. Twelve year old pine settings had significantly greater class 1 density ($P <$ 0.05, Duncan's Multiple Range Test) than all other cover types. Seventeen percent of the statistical comparisons of class 1 stems found north aspects to be significantly more dense than ($P < 0.05$) south. Class 1 vegetation was not found in 1, 3, or 6 year old pine settings because of the successional stage.

Differences in total density, BA, and d.b.h. were expected when we compared north, south, and flat slopes in mature timber stands because Little and Olmstead (1931) had found different hardwood associations on north slopes than on south, particularly on mountain slopes that had longer slopes and greater height than those found in the study area. The mean d.b.h. of pine in the study area was 20.8 cm which was 4.2 cm larger than reported for the same area in 1950 (Barnes and Melchiors 1982). However, no significant difference ($\underline{P} > 0.05$) was found in total class 1 density or BA among cover types by slope or aspect in mature timber stands. Significant differences ($\underline{P} < 0.05$, Duncan's Multiple Range Test) were found in d.b.h. among cover types. Pine stands on flat slopes had significantly greater d.b.h. than did those on corresponding north or south slopes and all other cover types. This difference was probably related to better site conditions because of better soils on more level slopes. Both north and south pine stands did not meet Weyerhaeuser's percent BA pine criteria which may have been responsible for some of the observed differences (Table 1). Also, pine stands on flat slopes had been thinned and had the hardwood controlled. Otherwise, there were no significant differences ($\underline{P} > 0.05$) in the d.b.h. of class 1 stems within cover types by slope or aspect.

Total class 2 stem density was significantly less ($\underline{P} < 0.05$, Duncan's Multiple Range Test) in 1 and 3 year old pine settings than in all other setting age classes. Class 2 stems were not found in 1 year old pine settings because of the previous silvicultural activities. There was no significant difference ($\underline{P} > 0.05$) within cover types of the same percent BA pine. D.b.h. was not recorded for this class.

Total class 3 density was significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) on north aspects of hardwood and hardwood-pine stands than on their respective corresponding south slopes. Only 2% BA pine was found over the defined cover type limit which again may have accounted for some of the observed differences (Table 1). Other cover types were not significantly different ($P > 0.05$) by slope or aspect. Three, 6 and 12 year old settings were significantly more dense ($P <$ 0.05, Duncan's Multiple Range Test) than 1 year old settings in this class.

Total woody vine density (class 4) was not significantly different ($P > 0.05$) between any given BA pine classification by slope or aspect. Woody vines were not found in 1 year old pine settings because of previous silvicultural practices.

Hard Mast Production Potential

Hard mast producing species were dominated by *Quercus alba* and *Quecrus velutina* on north slopes, by *Quercus stellata*, *Quercus alba* and *Quercus marilandica* on south slopes, and by *Quercus alba* and *Quercus stellata* on slopes $\leq$ 10% (Appendices 1, 3, and 5). Pine stands on north slopes had significantly greater hard mast producing stem density ($P <$ 0.05, Duncan's Multiple Range Test) than did corresponding stands on south or flat slopes. However, pine stands on north slopes had 17% less BA pine than defined by the Weyerhaeuser Company's stand maps (Table 1) which may account for some of the significant differences seen between the two slopes. Similiarly, hardwood-pine stands on north slopes were significantly more dense and had greater BA (Table 5) of hard mast producing stems than did corresponding stands on flat slopes ($P < 0.05$, Duncan's Multiple Range Test).

The BA of potential hard mast producing stems was greater in hardwood-pine stands on south slopes and pine in stands on north and south slopes than on corresponding flat slopes. However, hardwood-pine stands on flat slopes had 15% more BA pine than defined for this cover type which may account for some of the significant differences between these stands (Table 1). Pine stands on flat slopes, in which hardwood stems had been controlled, had significantly less ($\underline{P} < 0.05$, Duncan's Multiple Range Test) hard mast production potential than all other mature cover types. Hard mast production potential was not found in pine settings. There were no significant differences ($\underline{P} > 0.05$) in d.b.h. among mature timber stands with the same or different percent BA pine.

Soft Mast Production Potential

Class 1 soft mast species were dominated by *Nyssa sylvatica* and *Cornus florida* (Appendices 1, 3, and 5). Potential soft mast producing stem density and BA (Table 6) were significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) in hardwood stands on north slopes than in hardwood stands on south slopes although the south aspects had 2% more BA pine than defined which may account for some of the significant differences (Table 1). Stem density in hardwood stands on north slopes was also significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) than on corresponding flat slopes and all other cover types except pine-hardwood stands on north slopes. Pine-hardwood stands on north slopes were significantly more dense ($\underline{P} < 0.05$, Duncan's Multiple Range Test) than those on corresponding flat slopes and had a greater BA of soft mast producing stems than those on corresponding south slopes.

The d.b.h. of soft mast producers was significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) on all south slope cover types than on corresponding north or flat slopes. Timber stand densities are usually thought to be less on south slopes because of moisture stress. Moisture limitations may have been overcome because of spacing on south slopes. No class 1 soft mast production potential was found in pine settings.

Other measured soft mast production potential was provided by class 2, 3, and 4 woody stems (Appendix 3). Class 2 was dominated by *Cornus florida*, *Vaccinium arboreum*, and *Viburnum prunifolium*. Class 3 was dominated by *Vaccinium arboreum*, *Viburnum prunifolium*, *Vaccinium stamineum*, and *Vaccinium vacillans*. Woody vine soft mast production was dominated by *Rubus* sp., *Smilax bona-nox*, *Vitis* sp., and *Parthenocissus quinquefolia*.

There were no significant differences ($P > 0.05$) in the density of soft mast producers in Class 2 by percent BA pine or aspect. Class 2 stems in 9 and 12 year old pine settings had significantly greater densities ($P < 0.05$, Duncan's Multiple Range Test) than in 3 year old pine settings. There was no class 2 soft mast production potential in 1 or 6 year old pine settings. There was no explanation for the lack of soft mast production potential in 6 year old pine settings. Class 3 soft mast producing stems were significantly more dense ($P < 0.05$, Duncan's Multiple Range Test) in hardwood stands on north slopes than in hardwood stands on flat slopes. Otherwise, there was no significant difference ($P > 0.05$) in class 3 vegetation between north and south slopes of the same or different percent BA pine cover types. Class 3 stem density in 12 year old pine settings was significantly greater ($P < 0.05$, Duncan's Multiple Range Test) than it was in 6 year old settings.

Soft mast producing woody vine density was significantly less ($P < 0.05$, Duncan's Multiple Range Test) in 1 year old pine settings than in all other age class pine settings. Pine stands on north slopes had a significantly greater density in this category (_P_ < 0.05, Duncan's Multiple Range Test) than did pine stands on south slopes. However, results in terms of potential soft mast production of woody vines may have been misleading because all age classes of vines were included in the sample.

Pine Mast Production Potential

Pine mast production potential was predominantly provided by _Pinus echinata_ in mature cover types and by _Pinus taeda_ in pine settings (Appendices 1, 3, and 5). Class 1 pine density and BA (Table 7) in 9 and 12 year old pine settings were significantly greater (_P_ < 0.05, Duncan's Multiple Range Test) than in 1, 3, and 6 year old settings. No class 1 stems were found in settings of this age. Otherwise, stem density, BA, and d.b.h. of pine mast producers were not significantly different (_P_ > 0.05) among cover types. A timber survey in 1965 found a mean density of 247 pine stems/ha (Anon. 1968). This value is lower than the value found in this study (Appendix 3).

Other Hardwood Production Potential

The other mast producing species category was dominated by _Carya tomentosa_ (Appendices 3 and 5). Pine stands on north slopes had significantly greater stem density (_P_ < 0.05, Duncan's Multiple Range Test) in this category than did pine stands on flat slopes. Otherwise, there were no significant differences (_P_ > 0.05) in density or d.b.h. among cover types.

The BA of other hardwoods category was significantly greater (_P_ <

0.05, Duncan's Multiple Range Test) in hardwood stands on north and flat slopes than in hardwood stands on south slopes and all other cover types (Table 8). Also, the BA of other hardwoods in pine stands on north slopes was significantly greater ($P < 0.05$, Duncan's Multiple Range Test) than in pine stands on flat slopes. Otherwise, there were no significant differences ($P > 0.05$) among cover types of the same percent BA pine or in pine settings.

Herbaceous Stem and Seedhead Production Potential

Herbaceous stem density was inversely correlated with BA ($r = -0.71666$, $P = 0.0012$) which agreed with reports by Hurst et al. (1980) and Fendwood et al. (1984). Total herbaceous ground cover (%) in 3 year old pine settings was significantly greater ($P < 0.05$, Duncan's Multiple Range Test) than in 1 year old pine settings. Herbaceous stem density was significantly greater ($P < 0.05$, Duncan's Multiple Range Test) in 3 and 6 year old pine settings than in 1 and 12 year old settings. In general, all pine settings except 1 year old had significantly greater total herbaceous stem density ($P < 0.05$, Duncan's Multiple Range Test) than all other mature timber stand cover types.

Pine stands on flat slopes had significantly greater ($P < 0.05$, Duncan's Multiple Range Test) total and *Panicum* sp. stem density than pine stands on south slopes. This difference probably occurred because pine stands on flat slopes were the only mature stands that we sampled which had been thinned of mid story-pine and all commercial hardwoods. This opening effect probably accounted for the increase in herbaceous stem density.

The percent ground cover of the *Panicum* sp. category was significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) in 6, 9, and 12 year old pine settings than in 3 year old settings and all other mature cover types except pine flat and pine-hardwood south. Also, Panicum sp. density was significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) in 6, 9, and 12 year old pine settings than in all other cover types.

In the forb category Oxalis sp., density and ground cover in 3 year old pine settings were significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) than on new site preps (1 year old settings), older settings, and all mature cover types. The reason for these differences was probably related to successional stage.

Grasses other than those already categorized were significantly more dense ($\underline{P} < 0.05$, Duncan's Multiple Range Test) in 12 year old pine settings and hardwood stands on flat slopes than in 1 year old settings and hardwood stands on north slopes respectively. There were no significant differences ($\underline{P} > 0.05$) among cover types by slope or aspect in percent ground cover of other grasses.

The density of the Lespedeza sp. category in 6, 9, and 12 year old pine settings was significantly greater ($\underline{P} < 0.05$, Duncan's Multiple Range Test) than in all other cover types except 1 year old settings and pine-hardwood south. Twelve year old settings had pine (Pinus taeda) canopies that were beginning to close in which BA was previously shown to be negatively correlated with herbaceous stems. Also, pine settings had greater densities of Lespedeza sp. than did mature cover types. Some lespedezas are known to respond positively to soil disturbance and fire which may account for their prominance in pine settings. Otherwise, there were no significant differences ($\underline{P} > 0.05$) among cover types with respect to density or ground cover of lespedezas.

Paspalum sp. and Digitaria sp. categories were not found in the study area in sufficient quantity to measure by our methods. Although other categories such as other legumes, Cyperus sp., other forbs, other sedges or grasslike plants, and ferns were found, they were not significantly different ($P > 0.05$) among cover types.

With the exception of 1 year old pine settings, herbaceous stems were more dense in pine settings than in mature timber stands. Herbaceous production tended to peak in pine settings from 3 to 6 years old.

CONCLUSION

Spurr and Barnes (1980) reported that species diversity increases following fire until crown closure occurs, but thereafter declines. When fire was used during initial site preparation, we found a similar trend in pine settings (Appendices 3 and 4) in the study area. Spurr and Barnes also reported that clear cutting to make openings with a diameter at least twice the height of the stand, would favor the invasion of pioneer species, particularly if mineral soil was exposed. Site preparation such as occurs in new pine settings should produce similar openings as those described by Spurr and Barnes. Some mature timber stands and older pine settings were burned periodically to decrease competition from understory plants, release nutrients, and decrease the fuel loads. These prescribed burns may have benefited some herbaceous and woody understory plants such as the lespedezas but usually harmed woody species such as Vaccinium vacillans (Little and Olmstead 1931). Variation in site preparation burns such as air temperature, wind speed, fuel load, and moisture conditions may have caused the occurrence of different plant species in different timber stands.

Allelopathy may have also affected vegetation composition and structure, particularly in pine settings. Species of Celtis and Quercus have been shown to inhibit herbaceous plants (Lodhi and Rice 1971, Lodhi 1976, 1978). Also, various grasses have long been known to retard the growth of many tree seedlings, particularly hardwoods (Spurr and Barnes 1980).

Rice (1974) reported that allelopathy was a major factor in succession of infertile old fields, which would be similar to clearcuts and subsequent pine settings. He stated that early successional stages favored plants with low nitrogen requirements and later stages favored plants with higher nitrogen requirements. Fenwood et al. (1984) reported the possibility of a similar situation when they measured crude protein and compared sites of different quality.

We did not detect an overall trend of significance ($P > 0.05$) between north, south, and flat slopes with the same BA criteria in all cover types. Also, when vegetation was divided into food categories, significance trends from north to south aspects were also variable and not consistent. Therefore, we can not assume that north slopes had greater mast production potential than flat or south slopes or vice versa. It would seem reasonable to expect significant differences in vegetation between north and south aspects based on data from the Rich and Kiamichi Mountains, but consistent differences did not occur. High variation within and among timber stand cover types complicated interpretation of the results. Further research is needed in the area of hard and soft mast production, herbaceous seedhead production, and seasonal availability of these foods. Also, the impact of high-intensity long-duration cattle grazing on vegetation characteristics in the Ouachita's needs to be assessed.

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Table 1. Differences in Weyerhaeuser defined cover types by percent BA pine (excluding pine settings) versus sample values of percent BA pine on commercial forestland in southeastern Oklahoma.

Cover Type	Weyerhaeuser Co. Value	Sample Value
Pine North[a]	≥ 75	58*
Pine South	≥ 75	73*
Pine Flat	≥ 75	97
Pine Hardwood North	≥ 50 & < 75	57
Pine Hardwood South	≥ 50 & < 75	61
Pine Hardwood Flat	≥ 50 & < 75	68
Hardwood Pine North	> 25 & < 50	27
Hardwood Pine South	> 25 & < 50	43
Hardwood Pine Flat	> 25 & < 50	65*
Hardwood North	≤ 25	23
Hardwood South	≤ 25	27*
Hardwood Flat	≤ 25	24

[a] North slope > 10%, south slope > 10%, flat slope $\leq$ 10%.

* Did not conform to Weyerhaeuser Co. criteria.

Table 2. Area and percent of cover types present in Weyerhaeuser Company's Mountain Fork Wildlife Management Area and adjacent holdings in southeastern Oklahoma.

Cover Type	Hectares	Percent of Study Area
Pine North	116.64	0.64
Pine South	176.26	0.97
Pine Flat	596.16	3.27
Pine-Hardwood North	536.54	2.94
Pine-Hardwood South	1407.46	7.72
Pine-Hardwood Flat	4118.69	22.60
Hardwood North	660.96	3.63
Hardwood South	461.38	2.53
Hardwood Flat	759.46	4.17
Hardwood-Pine North	1041.98	5.72
Hardwood-Pine South	536.54	2.94
Hardwood-Pine Flat	1565.57	8.59
Pine Setting 1972 (12 year old)	777.60	4.27
Pine Setting 1975 (9 year old)	1303.78	7.15
Pine Setting 1978 (6 year old)	899.42	4.94
Pine Setting 1981 (3 year old)	2013.98	11.05
Pine Setting 1973 (1 year old)	596.16	3.27
Tame Pasture/Hay Meadow	401.76	2.20
Other (developments)	256.61	1.40
Total	20526.98	100.00

Table 3. Significance levels of vegetation classification by category in Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Class	Unit	Category	N	*F* Value	d.f.	*P* Value
1	Density[a]	Total stems	680	375.27	16,17	0.0001
1	Density	Hard mast	680	148.83	16,17	0.0001
1	Density	Soft mast	680	2.76	16,17	0.0226
1	Density	Pine mast	680	21.47	16,17	0.0001
1	Density	Other	680	5.90	16,17	0.0004
1	d.b.h.	Total stems	1168	18.57	16,17	0.0001
1	d.b.h.	Hard mast	321	6.25	13,14	0.0008
1	d.b.h.	Soft mast	43	220.39	12,7	0.0001
1	d.b.h.	Pine mast	602	8.50	16,17	0.0001
1	d.b.h.	Other	202	7.81	13,14	0.0002
2	Density	Total stems	680	82.84	16,17	0.0001
2	Density	Soft mast	680	9.68	16,17	0.0001
3	Density	Total stems	680	5.23	16,17	0.0008
3	Density	Soft mast	680	2.44	16,17	0.0388
4	Density	Total stems	680	8.49	16,17	0.0001
4	Density	Soft mast	680	16.11	16,17	0.0001
5	Density	Total stems	340	15.58	16,17	0.0001
5	Ground cover[b]	Total %	340	3.17	16,17	0.0118
5	Density	*Panicum* sp.	340	33.63	16,17	0.0001
5	Ground cover	*Panicum* sp.	340	6.03	16,17	0.0003

Table 3. Continued.

Class	Unit	Category	N	*F* Value	d.f.	*P* Value
5	Density	Other legumes	340	1.62	16,17	0.1675*
5	Ground cover	Other legumes	340	1.43	16,17	0.2339*
5	Density	*Oxalis* sp.	340	2446.12	16,17	0.0001
5	Ground cover	*Oxalis* sp.	340	172.63	16,17	0.0001
5	Density	*Cyperus* sp.	340	1.00	16,17	0.4980*
5	Ground cover	*Cyperus* sp.	340	-	16,17	-
5	Density	Other grasses	340	3.56	16,17	0.0065
5	Ground cover	Other grasses	340	1.61	16,17	0.1692*
5	Density	Other forbs	340	2.18	16,17	0.0604*
5	Ground cover	Other forbs	340	2.18	16,17	0.0610*
5	Density	*Lespedeza* sp.	340	5.43	16,17	0.0006
5	Ground cover	*Lespedeza* sp.	340	2.08	16,17	0.0724*
5	Density	Other[c]	340	0.93	16,17	0.5518*
5	Ground cover	Other[c]	340	1.48	16,17	0.2158*
5	Density	*Pteridium* sp.	340	4.55	16,17	0.0017
5	Ground cover	*Pteridium* sp.	340	4.27	16,17	0.0025
1,2	BA	Total	340	11.86	16,17	0.0001
1,2	BA	Hard mast	340	7.69	16,17	0.0001
1,2	BA	Soft mast	340	3.03	16,17	0.0147

Table 3. Continued.

Class	Unit	Category	N	*F* Value	d.f.	*P* Value
1,2	BA	Pine mast	340	4.77	16,17	0.0013
1,2	BA	Other	340	15.29	16,17	0.0001

[a] Stems/ha.

[b] Percent cover.

[c] Other sedges or grasslike plants.

* Not significant at the 0.05 level.

Table 4. Comparison of cover types by total basal area (m^2/ha) in Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Cover Type	N	Mean
Pine-Hardwood North Aspect	20	31.11 A*
Pine-Hardwood Flat	20	27.43 AB
Pine South Aspect	20	27.20 AB
Pine-Hardwood South Aspect	20	25.25 AB
Pine North Aspect	20	24.68 AB
Hardwood-Pine Flat	20	22.15 ABC
Hardwood Flat	20	21.81 ABC
Hardwood-Pine South Aspect	20	19.97 BCD
Pine Setting 1972 (12 yr. old)	20	19.97 BCD
Pine Flat	20	19.74 BCD
Hardwood North Aspect	20	19.23 BCD
Hardwood-Pine North Aspect	20	18.71 BCD
Hardwood South Aspect	20	14.58 DC
Pine Setting 1975 (9 yr. old)	20	11.48 D
Pine Setting 1978 (6 yr. old)	20	< 2.30 E
Pine Setting 1981 (3 yr. old)	20	< 2.30 E
Pine Setting 1983 (1 yr. old)	20	< 2.30 E

* Means with the same letter are not significantly different ($P > 0.05$).

Table 5. Comparison of cover types by basal area (m^2/ha) of hard mast producing stems in Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Cover Type	N	Mean
Pine-Hardwood North Aspect	20	9.41 A*
Hardwood-Pine North Aspect	20	9.30 A
Hardwood-Pine South Aspect	20	8.74 AB
Hardwood South Aspect	20	7.12 ABC
Pine-Hardwood South Aspect	20	6.77 ABC
Pine-Hardwood Flat	20	6.43 ABC
Pine North Aspect	20	5.97 ABC
Hardwood Flat	20	5.85 ABC
Hardwood North Aspect	20	5.57 ABC
Pine South Aspect	20	4.94 ABC
Hardwood-Pine Flat	20	3.68 DC
Pine Setting 1972 (12 yr. old)	20	0.92 D
Pine Flat	20	0.34 D
Pine Setting 1975 (9 yr. old)	20	0.23 D
Pine Setting 1978 (6 yr. old)	20	< 2.30 D
Pine Setting 1981 (3 yr. old)	20	< 2.30 D
Pine Setting 1983 (1 yr. old)	20	< 2.30 D

* Means with the same letter are not significantly different ($\underline{P} > 0.05$).

Table 6. Comparison of cover types by basal area (m^2/ha) of soft mast producing stems in Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Cover Type	N	Mean
Hardwood North Aspect	20	2.76 A*
Pine-Hardwood North Aspect	20	1.95 AB
Pine North Aspect	20	0.80 BC
Pine-Hardwood Flat	20	0.69 BC
Hardwood-Pine Flat	20	0.57 BC
Hardwood South Aspect	20	0.57 BC
Hardwood-Pine North Aspect	20	0.57 BC
Hardwood-Pine South Aspect	20	0.46 C
Pine-Hardwood South Aspect	20	0.34 C
Pine Setting 1972 (12 yr. old)	20	0.23 C
Pine South Aspect	20	0.23 C
Hardwood Flat	20	0.23 C
Pine Flat	20	< 2.30 C
Pine Setting 1975 (9 yr. old)	20	< 2.30 C
Pine Setting 1978 (6 yr. old)	20	< 2.30 C
Pine Setting 1981 (3 yr. old)	20	< 2.30 C
Pine Setting 1983 (1 yr. old)	20	< 2.30 C

* Means with the same letter are not significantly different ($\underline{P} > 0.05$).

Table 7. Comparison of cover types by basal area (m^2/ha) of pine mast producing stems on Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Cover Type	N	Mean
Pine South Aspect	20	19.74 A*
Pine Flat	20	19.17 A
Pine Hardwood Flat	20	18.71 A
Pine Setting 1972 (12 yr. old)	20	18.48 A
Pine-Hardwood North Aspect	20	17.56 A
Pine-Hardwood South Aspect	20	15.50 AB
Pine-Hardwood Flat	20	14.35 ABC
Pine North Aspect	20	14.23 ABC
Pine Setting 1975 (9 yr. old)	20	11.25 ABCD
Hardwood Pine South Aspect	20	8.49 ABCD
Hardwood Flat	20	5.28 BCD
Hardwood Pine North Aspect	20	5.17 BCD
Hardwood North Aspect	20	4.48 BCD
Hardwood South Aspect	20	3.90 CD
Pine Setting 1978 (6 yr. old)	20	< 2.30 D
Pine Setting 1981 (3 yr. old)	20	< 2.30 D
Pine Setting 1983 (1 yr. old)	20	< 2.30 D

* Means with the same letter are not significantly different ($\underline{P} > 0.05$).

Table 8. Comparison of cover types by basal area (m^2/ha) of other hardwood stems on Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Cover Type	N	Mean
Hardwood Flat	20	10.67 A*
Hardwood North Aspect	20	6.43 B
Hardwood Pine Flat	20	3.90 C
Hardwood Pine North Aspect	20	3.67 C
Pine North Aspect	20	3.44 C
Hardwood South Aspect	20	2.98 C
Hardwood-Pine South Aspect	20	2.87 C
Pine-Hardwood South Aspect	20	2.72 C
Pine South Aspect	20	2.30 CD
Pine-Hardwood North Aspect	20	2.18 CD
Pine-Hardwood Flat	20	1.49 D
Pine Setting 1972 (12 yr. old)	20	0.34 D
Pine Flat	20	0.23 D
Pine Setting 1975 (9 yr. old)	20	< 2.30 D
Pine Setting 1978 (6 yr. old)	20	< 2.30 D
Pine Setting 1981 (3 yr. old)	20	< 2.30 D
Pine Setting 1983 (1 yr. old)	20	< 2.30 D

* Means with the same letter are not significantly different ($\underline{P} > 0.05$).

Appendix 1. Woody species plant names by family found on the Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Family	Genus/Species	Common Name	Food Category[a]
Pinaceae	Pinus echinata Mill.	Shortleaf Pine	5
	Pinus taeda L.	Loblolly Pine	5
	Juniperus virginiana	Eastern Red Cedar	6
Fagaceae	Quercus alba L.	White Oak	3
	Quercus stellata Wang.	Post Oak	3
	Quercus marilandica Muenchh.	Blackjack Oak	3
	Quercus velutina Lam.	Black Oak	3
	Quercus falcata Michx.	Southern Red Oak	3
	Quercus nigra L.	Water Oak	3
	Quercus rubra L.	Northern Red Oak	3
Juglandaceae	Carya tomentosa (Poir.) Nutt.	Mockernut Hickory	6
	Carya cordiformis (Wang.) K. Koch	Bitternut Hickory	6
Betulaceae	Ostrya virginiana (Mill.) K. Koch	Eastern Hophornbeam	6
Ericaceae	Vaccinium stamineum L.	Common Deerberry	4
	Vaccinium vacillans Torr.	Lowbush Blueberry	4
	Vaccinium arboreum Marsh.	Farkleberry	4
	*Rhododendron sp.	Azalea	6
	*Rhododendron sp.	Azalea	6
Ulmaceae	Ulmus alata Michx.	Winged Elm	6
	Celtis sp.	Hackberry	3
Cornaceae	Cornus florida L.	Flowering Dogwood	4
	*Cornus racemosa Lam.	Gray Dogwood	6
Anacardiaceae	Rhus copallina L.	Flameleaf Sumac	3
	Rhus radicans L.	Poison Ivy	6
	Rhus aromatica Ait.	Fragrant Sumac	6
Rosaceae	Crataegus sp.	Hawthorn	4
	Amelanchier arborea (Michx. f.) Fern.	Downy Serviceberry	6
	Prunus serotina Ehrh.	Black Cherry	4
	Prunus mexicana S. Wats	Mexican Plum	4
	Rosa carolina L.	Carolina Rose	6
	Rubus sp.	Blackberry	4
Nyssaceae	Nyssa sylvatica Marsh.	Blackgum	4
Caprifoliaceae	Viburnum prunifolium L.	Rusty Blackhaw	4
	Viburnum rafinesquianum Schultes	Missouri Viburnum	4
	Lonicera simpervirens L.	Trumpet Honeysuckle	6
	Symphoricarpos orbiculatus Moench	Coralberry	6
Guttiferae	Hypericum spathulatum (Spach) Steud.	St. Johnswort	6

Appendix 1. Continued.

Family	Genus/Species	Common Name	Food Category[a]
Lauraceae	Sassafras albidum (Nutt.) Nees	Sassafras	4
Vitaceae	Vitis sp.	Grape	4
	Parthenocissus quinquefolia (L.) Planch.	Virginia Creeper	4
Liliacea	Smilax rotundifolia L.	Common Greenbrier	4
	Smilax bona-nox L.	Saw Greenbrier	4
Ebenaceae	Diospyros virginiana L.	Common Persimmon	4
Moraceae	Morus rubra L.	Mulberry	4
Aceraceae	Acer rubrum	Red Maple	6
Oleaceae	Chionanthus virginicus	Fringe Tree	6
	Fraxinus pennsylvanica Marsh.	Green Ash	6
Rhamnaceae	Berchemia scandens (Hill.) K. Koch	Alabama Supplejack	6
	*Rhamnus caroliniana Walt.	Carolina Buckthorn	4
	Ceanothus herbaceus Raf.	Ceanothus	6
Aquifoliaceae	Ilex opaca Ait.	American Holly	6
Hamamelidaceae	Liquidambar styraciflua L.	Sweetgum	6
Leguminosae	Robina pseudo-acacia L.	Black Locust	6
	Cercis canadensis L.	Eastern Redbud	6
Celastraceae	Euonymus americana L.	Brook Euonymus	4
Verbenaceae	Callicarpa americana L.	American Beautyberry	4
Sapotaceae	Bumelia lanuginosa (Michx.) Pers.	Chittamwood	4
Saxifragaceae	Ribes sp.	Currant	4
Compositae	*Baccharis halimifolia L.	Eastern Baccharis	6

*Not found in sample plots.

[a] 3 = hard mast, 4 = soft mast, 5 = pine mast, 6 = other.

Appendix 2. Herbaceous species plant names by family found on the Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Family	Genus/Species	Common Name	Food Category[a]
Polypodiaceae	Pteridium acquilinum (L.) Kuhn	Western Bracken Fern	11
Gramineae	Uniola sessilflora Poiret	Stalkless Spranglegrass	7
	Andropogon sp.	Bluestem	7
	Andropogon scoparius Michx.	Little Bluestem	7
	Digitaria sp.	Crabgrass	3
	Panicum sp.	Panicum, Witchgrass	2
	*Sphenopholis sp.	Wedgescale	7
	Festuca paradoxa Desv.	Cluster Fescue	7
	Elymus sp.	Wildrye	7
	Andropogon virginicus L.	Broomsedge Bluestem	7
	*Cynodon dactylon (L.) Pers.	Bermudagrass	7
	Sporobolus sp.	Dropseed	7
	Danthonia spikata (L.) Beauv.	Poverty Danthonia	7
Cyperaceae	Carex sp.	Sedge	10
	Scirpus sp.	Bulrush	10
	Cyperus sp.	Flatsedge	6
Commelinaceae	Tradescanthia ohiensis Raf.	Ohio Spiderwort	8
	*Tradescanthia occidentalis (Britt.) Smyth	Prairie Spiderwort	8
Juncaceae	Juncus sp.	Rush	10
Liliaceae	Allium canadense	Canada Garlic	8
	*Nothoscordum bivalve (L.) Britton	Yellow Falsegarlic	8
	*Trillium viride Bech	Green Trillium	8
	*Smilacina racemosa Desf.	False Solomonseal, Solomonplume	8
Dioscoreaceae	*Dioscorea quarternata (Walt.) Gemel.	Yam	8
	*Polygonatum canaliculatum (Muhl.) Pursh	Solomonseal	8
Iridaceae	*Sisyrinchium campestre Bicknell	Prairie Blueeye Grass	8
	*Iris virginica	Southern Blue Flag	8
Polygonaceae	Eriogonum longifolium Nutt.	Longleaf Wild Buckwheat	8
	*Rumex sp.	Dock	8
Chenopodiaceae	Chenopodium sp.	Goosefoot	8
Phytolaccaceae	Phytolacca americana L.	Polk Weed	8

Appendix 2. Continued.

Family	Genus/Species	Common Name	Food Category[a]
Portulacaceae	*Claytonia virginica L.	Springbeauty	8
Caryophyllaceae	Silence virginica L.	Firepink	8
Rununculaceae	Rununculus sp.	Buttercup	8
	Anemonella thalictroides (L.) Spach	Anemonella	8
	Delphinium sp.	Larkspur	8
Berberidaceae	Podophyllum peltatum L.	Common Mayapple	8
Cruciferae	*Arabis laevigata (Muhl.) Poir.	Smooth Rockcress	8
	Streptanthus maculatus Nutt.	Clasping Twistflower	8
	*Cardamine parviflora L.	Bittercress	8
	Lepidium virginicum L.	Virginia Pepperweed	8
	*Dentaria laciniata Muhl.	Cutleaf Toothwort	8
	*Capsella bursa-pastoris (L.) Medic	Common Shepherdspurse	8
Rosaceae	Gillenia stipulata (Muhl.) Trel.	Gillenia	8
	Potentilla simplex	Spreading Cinquefoil	8
	Potentilla recta	Sulfur Cinquefoil	8
	*Potentilla arguta Pursh.	Clammy Cinquefoil	8
Oxalidaceae	Geranium carolinianum L.	Carolina Cranesbill	8
Leguminosae	Baptisia leucantha T. & G.	Atlantic Wildindigo	4
	Stylosanthes biflora (L.) BSP	Sidebeak Penciflower	4
	Lespedeza procumbens Michx.	Trailing Lespedeza	9
	Clitoria meriana L.	Pigeonwings	4
	Rhynchosia latifolia Nutt.	Broadleaf Snoutbean	4
	Psoralea simplex (Nutt.) T. & G.	Scurfpea	4
	Lespedeza sp.	Lespedeza	4
	Vicia carolina Walt.	Carolina Vetch	4
	Tephrosia virginiana (L.) Pers.	Virginia Tephrosia	4
	*Desmodium nudiflorum (L.) DC	Barestem Tickclover	4
	Desmodium sp.	Tickclover	4
	Astragalus sp.	Loco, Milkvetch	4
	Crotalaria sagittalis L.	Arrow Crotalaria	4
	*Trifolium pratense L.	Red Clover	4
	Trifolium dubium Sibth.	Hop Clover	4
	Lespedeza striata (Thunb.) H. & A.	Common Lespedeza	9
	Cassia fasciculata Michx.	Showy Partridge Pea	4
	Lespedeza cuneata (Dument) G. Don	Sericea Lespedeza	9
	*Baptisia nuttalliana Small	Nuttall Wildindigo	4
Polygalaceae	Polygala sp.	Milkwort	8

Appendix 2. Continued.

Family	Genus/Species	Common Name	Food Category[a]
Euphorbiaceae	Crotonopsis elliptica Willd.	Crotonopsis	8
	Euphorbia obtusata Pursh	Roughpod Euphorbia	8
	Euphorbia corollata	Flowering Spurge	8
	Euphorbia sp.	Euphorbia	8
Violaceae	Viola sagittata Ait.	Arrowleaf Violet	8
	Viola pedata L.	Birdsfoot Violet	8
	*Viola rafinesquii Greene	Johnny-Jump-Up	8
	*Viola langloisii Greene	Bayou Violet	8
Passifloraceae	Passiflora lutea L.	Yellow Passionflower	8
Umbelliferae	Sanicula canadensis L.	Canada Sanicle	8
Gentianaceae	*Swertia caroliniensis (Walter) Ktze.	Columbo	8
Loganiaceae	*Spigelia marilandica L.	Indian Pink	8
Apocynaceae	*Apocynum androesaemifolium L.	Spreading Dogbane	8
Asclepiadaceae	Asclepias sp.	Milkweed	8
	*Asclepias variegata L.	White Milkweed	8
	*Asclepias amplexicaule J. E. Sm.	Bluntleaf Milkweed	8
	*Matelea baldwynianus (Sweet) Woodson	Climbing Milkweed, Angle-pod	8
Polemoniaceae	Phlox glaberrima L.	Smooth Phlox	8
	Phlox divaricata L.	Blue Phlox	8
Hydrophyllaceae	Phacelia strictiflora (Engelm. & Gray) Gray	Prairie Phacelia	8
Boraginaceae	*Cynoglossum virginianum L.	Blue Houndstongue	8
	Cynoglossum amabile Stapf & Drummond	Houndstongue	8
Verbenaceae	*Verbena canadensis (L.) Britt.	Rose Verbena	8
Labiatae	*Monarda russeliana Nutt.	Russell Beebalm	8
	Monarda virgata Raf.	Beebalm	8
	Monarda sp.	Beebalm	8
	Cunila origanoides (L.) Britt.	Maryland Stonemint	8
	Prunella vulgaris (Bart.) Fern.	Selfheal	8
	Scutellaria sp.	Skullcap	8
	Pycnanthemum tenuifolium Schrad.	Mountainmint	8
	Salvia lyrata Benth.	Lyre-leaved Sage	8
	Lamium amplexicaule L.	Henbit Deadnettle	8

Appendix 2. Continued.

Family	Genus/Species	Common Name	Food Category[a]
Scrophulariaceae	*Verbascum thapus* L.	Flannel Mullein	8
	**Verbascum blattaria*	Moth Mullein	8
	**Linaria canadensis* (L.) Dumont	Oldfield Toadflax	8
	**Penstemon digitalis* Nutt.	Smooth Penstemon	8
	**Pedicularis canadensis* L.	Early Lousewort	8
Acanthaceae	*Ruellia pedunculata* Torr.	Stalked Ruellia	8
Rubiaceae	*Galium arkansnum* Gray	Arkansas Bedstraw	8
	Hedyotis sp.	-	8
	**Hedyotis crassifolia* Raf.	Bluets	8
	**Hedyotis purpurea* (L.) T. & G.	Mountain Houstonia	8
	**Hedyotis nigracans* (Lam.) Fosb.	-	8
Valerianaceae	**Valerianella* sp.	Cornsalad	8
Lobeliaceae	**Lobelia cardinalis* L.	Cardinal Flower	8
	**Lobelia appendiculata* A. DC.	Earflower Lobelia	8
	Lobelia spikata Lam.	Palespike Lobelia	8
Campanulaceae	*Specularia perfoliata* (L.) A. DC.	Venus Lookingglass	8
	Physalis sp.	Groundcherry	8
	Solanum sp.	Nightshade	8
Compositae	*Aster patens* Ait.	Skydrop Aster	8
	Aster sp.	Aster	8
	Lactuca sp.	Lettuce	8
	Solidago sp.	Goldenrod	8
	Helianthus hirsutus Raf.	Roughleaf Sunflower	8
	Helianthus angustifolius L.	Swamp Sunflower	8
	Antennaria plantaginifolia (L.) Richards	Pussytoes	8
	Verbesina helianthoides Michx.	Gravelweed Crownbreard	8
	Hieracium gronovii L.	Hawkweed	8
	Coreopsis grandiflora Hogg	Bigflower Coreopsis	8
	Erigeron philadelphicus L.	Philadelphia Fleabane	8
	Cirsium texanum Buckley	Thistle	8
	**Krigia dandelion* (L.) Nutt.	Tuber Dandelion	8
	Eupatorium rugosum Houtt.	White Snakeroot	8
	Rudbeckia sp.	Coneflower	8
	Echinacea sanguinea Nuttall	Echinacea	8
	Ambrosia artemisiifolia L.	Common Ragweed	8
	Silphium sp.	Rosinweed	8
	Senecio sp.	Groundsel	8
	Erechtites hieracifolia (L.) Raf.	Fireweed	8
	**Hymenopappus scabiosaeus* L'Her.	Woolywhite	8

Appendix 2. Continued.

Family	Genus/Species	Common Name	Food Category
	Pyrrhopappus scabosus DC.	Tuber False Dandelion	8
	Conyza sp.	Marestail	8

*Collected other than during sampling procedure.

[a] 2 = *Panicum* sp., 3 = *Digitaria* sp., 4 = other legumes, 6 = *Cyperus* sp., 7 = grasses, 8 = other forbes, 9 = *Lespedeza* sp., 10 = other sedges or rushes, 11 = ferns.

Appendix 3. Frequency and density of woody vegetation by cover type, classification, and species on the Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Pine North Aspect				
Class 1 (800.70 stems/ha)				
Quercus velutina	2.50	20.02	10.00	4.25
Carya tomentosa	18.75	150.13	50.00	21.28
Quercus stellata	23.75	190.16	60.00	25.53
Quercus alba	13.75	110.10	35.00	13.83
Pinus echinata	35.00	280.24	60.00	25.53
Cornus florida	1.25	10.01	5.00	1.98
Nyssa sylvatica	1.25	10.01	5.00	1.98
Carya cordiformis	3.75	30.03	10.00	4.26
Class 2 (3542.56 stems/ha)				
Quercus stellata	8.75	309.97	30.00	13.33
Cornus florida	8.75	309.97	20.00	8.89
Pinus echinata	46.25	1638.43	65.00	28.89
Quercus alba	7.50	265.69	25.00	11.11
Carya tomentosa	15.00	531.38	40.00	17.78
Ulmus alata	1.25	44.28	5.00	2.22
Quercus velutina	2.50	88.56	10.00	4.44
Prunus mexicana	2.50	88.56	10.00	4.44
Vaccinium arboreum	3.75	132.85	15.00	6.67
Vaccinium stamineum	3.75	132.85	5.00	2.22
Class 3 (2141.61 stems/ha)				
Diospyros virginiana	3.75	80.31	5.00	1.64
Carya tomentosa	25.00	535.40	65.00	21.31
Quercus marilandica	12.50	267.70	35.00	11.48
Quercus stellata	10.00	214.16	30.00	9.84
Nyssa sylvatica	5.00	107.08	15.00	4.92
Quercus velutina	5.00	107.08	20.00	6.56
Cornus florida	12.50	267.70	45.00	14.75
Ulmus alata	2.50	53.54	10.00	3.28
Vaccinium arboreum	2.50	53.54	10.00	3.28
Prunus mexicana	5.00	107.08	15.00	4.92
Juniperus virginiana	3.75	80.31	15.00	4.92
Symphoricarpous orbiculatus	2.50	53.54	10.00	3.28
Viburnum prunifolium	3.75	80.31	15.00	4.92
Robina pseudoacacia	3.75	80.31	5.00	1.64
Quercus alba	1.25	26.77	5.00	1.64
Vaccinium stamineum	1.25	26.77	5.00	1.64

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 4 (15982.59 stems/ha)				
Rubus sp.	21.25	3396.30	40.00	22.86
Parthenocissus quinquefolia	15.00	2397.39	25.00	14.29
Smilax bona-nox	53.75	8590.64	75.00	42.86
Vitis sp.	6.25	998.91	20.00	11.43
Rhus radicans	2.50	399.56	10.00	5.71
Smilax rotundifolia	1.25	199.78	5.00	2.86
Pine South Aspect				
Class 1 (790.15 stems/ha)				
Pinus echinata	66.25	523.47	100.00	48.78
Quercus stellata	12.50	98.77	45.00	21.95
Quercus marilandica	11.25	0.01	30.00	14.65
Carya tomentosa	7.50	59.26	20.00	9.76
Quercus alba	1.25	9.88	5.00	2.44
Nyssa sylvatica	1.25	9.88	5.00	2.44
Class 2 (3379.71 stems/ha)				
Pinus echinata	51.25	1732.10	70.00	33.33
Carya tomentosa	16.25	549.20	45.00	21.43
Quercus stellata	13.75	464.71	30.00	14.29
Viburnum prunifolium	1.25	42.25	5.00	2.38
Quercus marilandica	3.75	126.74	15.00	7.14
Ulmus alata	2.50	84.49	10.00	4.76
Quercus velutina	1.25	42.25	5.00	2.38
Quercus alba	1.25	42.25	5.00	2.38
Cornus florida	1.25	42.25	5.00	2.38
Vaccinium arboreum	3.75	126.74	10.00	4.76
Nyssa sylvatica	1.25	42.25	5.00	2.38
Diospyros virginiana	2.50	84.49	5.00	2.38
Class 3 (2193.58 stems/ha)				
Quercus marilandica	10.00	219.36	25.00	9.43
Quercus stellata	33.75	740.33	75.00	28.30
Prunus serotina	2.50	54.84	5.00	1.89
Vaccinium arboreum	3.75	82.26	15.00	5.66
Pinus echinata	5.00	109.68	15.00	5.66
Crataegus sp.	1.25	27.42	5.00	1.89
Carya tomentosa	22.50	493.56	60.00	22.64

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 4 (197.39 stems/ha)				
Smilax bona-nox	26.25	51.82	60.00	27.27
Parthenocissus quinquefolia	6.25	12.34	25.00	11.36
Rubus sp.	21.25	41.25	45.00	20.45
Rhus radicans	43.75	86.36	80.00	36.36
Vitis sp.	2.50	4.93	10.00	4.55
Pine Flat				
Class 1 (562.07 stems/ha)				
Pinus echinata	100.00	562.07	100.00	100.00
Class 2 (3592.09 stems/ha)				
Ouercus velutina	3.75	134.70	10.00	3.39
Pinus echinata	16.25	583.72	45.00	15.25
Morus rubra	1.25	44.90	5.00	1.69
Quercus falcata	2.50	89.80	5.00	1.69
Quercus stellata	12.50	449.01	40.00	13.56
Viburnum prunifolium	2.50	89.80	10.00	3.39
Ulmus alata	7.50	269.41	25.00	8.47
Carya tomentosa	20.00	718.42	55.00	18.64
Quercus marilandica	6.25	224.51	15.00	5.08
Querus alba	5.00	179.60	20.00	6.78
Rhus copallina	3.75	134.70	5.00	1.69
Cornus florida	10.00	359.21	25.00	8.47
Nyssa sylvatica	5.00	179.60	20.00	6.78
Vaccinium arboreum	1.25	44.90	5.00	1.69
Acer rubrum	2.50	89.80	10.00	3.39
Class 3 (4991.80 stmes/ha)				
Diospyros virginiana	2.50	124.79	5.00	1.89
Pinus echinata	5.00	249.59	5.00	1.89
Quercus stellata	5.00	249.59	10.00	3.77
Ulmus alata	2.50	124.79	10.00	3.77
Rhus copallina	5.00	249.59	10.00	3.77
Carya tomentosa	12.50	639.97	40.00	15.09
Quercus marilandica	12.50	639.97	30.00	11.32
Cornus florida	13.75	686.37	30.00	11.32
Crataegus sp.	5.00	249.59	20.00	7.55
Morus rubra	1.25	62.40	5.00	1.89
Prunus serotina	3.75	187.19	15.00	5.66
Ceanothus herbaceous	2.50	124.79	5.00	1.89

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Vaccinium stamineum	1.25	62.40	5.00	1.89
Quercus alba	1.25	62.40	5.00	1.89
Vaccinium vacillans	16.25	811.17	30.00	11.32
Ilex opaca	1.25	62.40	5.00	1.89
Acer rubrum	1.25	62.40	5.00	1.89
Quercus velutina	1.25	62.40	5.00	1.89
Quercus nigra	1.25	62.40	5.00	1.89
Fraxinus pennsylvanica	1.25	62.40	5.00	1.89
Nyssa sylvatica	3.75	187.19	15.00	5.66
Class 4 (28935.44 stems/ha)				
Vitis sp.	16.25	4702.01	25.00	16.13
Rhus radicans	66.25	19169.73	90.00	58.06
Smilax bona-nox	11.25	3255.24	25.00	16.13
Simlax rotundifolia	1.25	361.69	5.00	3.23
Parthenocissus quinquefolia	2.50	723.39	5.00	3.23
Rubus sp.	2.50	723.39	5.00	3.23
Pine-Hardwood North Aspect				
Class 1 (1097.17 stems/ha)				
Pinus echinata	47.50	521.16	75.00	36.59
Quercus alba	32.50	356.58	60.00	29.27
Carya tomentosa	8.75	96.00	30.00	14.63
Quercus velutina	1.25	13.71	5.00	2.44
Cornus florida	2.50	27.43	10.00	4.78
Quercus rubra	1.25	13.71	5.00	2.44
Acer rubrum	1.25	13.71	5.00	2.44
Nyssa sylvatica	5.00	54.86	15.00	7.32
Class 2 (1871.80 stmes/ha)				
Cornus florida	28.75	538.14	65.00	29.55
Carya tomentosa	13.75	257.37	35.00	15.91
Fraxinus pennsylvanica	1.25	23.40	5.00	2.27
Pinus echinata	2.50	46.79	10.00	4.55
Vaccinium stamineum	2.50	46.79	5.00	2.27
Nyssa sylvatica	12.50	233.97	20.00	9.09
Quercus alba	28.75	538.14	50.00	22.73
Ilex opaca	3.75	70.19	5.00	2.27
Sassafras albidum	1.25	23.40	5.00	2.27
Ulmus alata	2.50	46.79	10.00	4.55
Quercus velutina	1.25	23.40	5.00	2.27
Quercus stellata	1.25	23.40	5.00	2.27

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 3 (5501.22 stems/ha)				
Quercus alba	11.25	618.89	25.00	12.20
Quercus velutina	5.00	275.06	15.00	7.32
Prunus serotina	3.75	206.30	10.00	4.88
Vaccinium vacillans	37.50	2062.96	50.00	24.39
Nyssa sylvatica	8.75	481.36	25.00	12.20
Cornus florida	26.25	1444.07	50.00	24.39
Carya tomentosa	6.25	343.83	25.00	12.20
Viburnum rafinesquianum	1.25	68.77	5.00	2.44
Class 4 (3498.17 stems/ha)				
Parthenocissum quinquefolia	27.50	961.99	50.00	23.26
Rhus radicans	38.75	1355.54	75.00	34.88
Smilax bona-nox	18.75	655.91	50.00	23.26
Rubus sp.	1.25	43.73	5.00	2.33
Vitis sp.	12.50	437.27	30.00	13.55
Lonicera simperviern s	1.25	43.73	5.00	2.33
Pine-Hardwood South Aspect				
Class 1 (814.23 stems/ha)				
Pinus echinata	47.50	386.76	85.00	38.64
Carya tomentosa	11.25	91.60	30.00	13.64
Quercus stellata	18.75	152.67	40.00	18.18
Quercus alba	8.75	71.25	20.00	9.09
Nyssa sylvatica	1.25	10.18	5.00	2.27
Quercus velutina	2.50	20.36	10.00	4.55
Ulmus alata	5.00	40.71	15.00	6.82
Quercus falcata	1.25	10.18	5.00	2.27
Quercus marilandica	3.75	30.53	10.00	4.55
Class 2 (1876.05 stems/ha)				
Ulmus alata	21.25	398.66	50.00	17.79
Vaccinium arboreum	12.50	234.51	35.00	12.46
Pinus echinata	10.00	187.61	35.00	12.46
Rhus copallina	2.50	46.90	5.00	1.78
Quercus stellata	12.50	234.51	35.00	12.46
Prunus mexicana	1.25	23.45	5.00	1.78
Quercus alaba	5.00	93.80	10.00	3.56
Caryo tomentosa	21.25	398.66	50.00	17.79
Viburnum prunifolium	1.25	23.45	5.00	1.78
Quercus velutina	1.25	23.45	5.00	1.78

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Cornus florida	1.25	23.45	5.00	1.78
Crataegus sp.	2.50	46.90	5.00	1.78
Symphoricarpous orbiculatus	2.50	46.90	5.00	1.78
Hypericum spathulatum	1.25	23.45	5.00	1.78
Quercus marilandica	1.25	23.45	5.00	1.78
Juniperus virginiana	1.25	23.45	5.00	1.78
Diospyros virginiana	1.25	23.45	5.00	1.78
Class 3 (4399.60 stems/ha)				
Vaccinium vacillans	20.00	879.92	30.00	12.00
Carya tomentosa	11.25	494.96	35.00	14.00
Quercus stellata	12.50	549.95	35.00	14.00
Ulmus alata	32.50	1429.87	60.00	24.00
Prunus mexicana	1.25	55.00	5.00	2.00
Cornus florida	1.25	55.00	5.00	2.00
Quercus falcata	1.25	55.00	5.00	2.00
Nyssa sylvatica	1.25	55.00	5.00	2.00
Querus velutina	5.00	219.98	15.00	6.00
Viburnum prunifolium	5.00	219.98	20.00	8.00
Vaccinium arboreum	6.25	274.98	25.00	10.00
Prunus serotina	1.25	55.00	5.00	2.00
Quercus nigra	1.25	55.00	5.00	2.00
Class 4 (755.31 stems/ha)				
Smilax bona-nox	21.25	160.50	55.00	24.77
Rhus radicans	22.50	169.94	50.00	22.52
Vitis sp.	26.25	198.27	55.00	24.77
Parthenocissus quinquefolia	6.25	47.21	10.00	4.51
Rosa sp.	2.50	18.18	10.00	4.51
Rubus sp.	21.25	160.50	40.00	18.02
Pine-Hardwood Flat				
Class 1 (864.35 stems/ha)				
Quercus alba	16.25	140.45	45.00	23.08
Pinus echinata	66.25	572.63	95.00	48.72
Carya tomentosa	8.75	75.63	30.00	15.38
Quercus marilandica	2.50	21.61	5.00	2.56
Quercus velutina	1.25	10.80	5.00	2.56
Quercus stellata	5.00	43.22	15.00	7.69

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 2 (3747.10 stems/ha)				
Carya tomentosa	18.75	702.58	60.00	20.34
Quercus stellata	17.50	655.74	45.00	15.25
Pinus echinata	17.50	655.74	40.00	13.56
Quercus alba	13.75	515.23	45.00	15.25
Vaccinium arboreum	12.50	468.39	35.00	11.68
Rhus copallina	2.50	93.68	5.00	1.69
Quercus velutina	1.25	46.84	5.00	1.69
Cornus florida	10.00	374.71	40.00	13.56
Vaccinium stamineum	2.50	93.68	5.00	1.69
Ulmus alata	1.25	46.84	5.00	1.69
Carya cordiformis	1.25	46.84	5.00	1.69
Quercus falcata	1.25	46.84	5.00	1.69
Class 3 (5213.15 stems/ha)				
Nysaa sylvatica	2.50	130.33	10.00	4.08
Carya tomentosa	3.75	195.49	15.00	6.12
Vaccinium arboreum	3.75	195.49	15.00	6.12
Cornus florida	8.75	456.15	35.00	14.29
Quercus alba	5.00	260.66	15.00	6.12
Viburnum prunifolium	3.75	195.49	10.00	4.08
Ulmus alata	6.25	325.95	15.00	6.12
Vaccinium vacillians	30.00	1563.95	35.00	14.29
Quercus stellata	21.25	1107.80	40.00	16.33
Quercus marilandica	1.25	65.16	5.00	2.04
Hypericum spathulatum	1.25	65.16	5.00	2.04
Sassafras albidum	1.25	65.16	5.00	2.04
Quercus velutina	7.50	390.99	25.00	10.20
Vaccinium stamineum	1.25	65.16	5.00	2.04
Crataegus sp.	1.25	65.16	5.00	2.04
Quercus falcata	1.25	65.16	5.00	2.04
Class 4 (5357.22 stems/ha)				
Vitis sp.	35.00	1875.03	65.00	36.11
Rhus radicans	42.50	2276.82	70.00	38.89
Smilax bona-nox	11.25	602.69	20.00	11.11
Parthenocissus quinquefolia	10.00	535.72	20.00	11.11
Rubus sp.	1.25	66.97	5.00	2.78

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Hardwood North Aspect				
Class 1 (779.30 stems/ha)				
Quercus velutina	12.50	97.41	40.00	14.29
Pinus echinata	22.50	175.34	65.00	23.21
Quercus alba	17.50	136.38	45.00	16.07
Amelanchier arborea	3.75	29.22	10.00	3.57
Carya tomentosa	27.50	214.31	60.00	21.43
Acer rubrum	5.00	38.97	20.00	7.14
Prunus serotina	8.75	68.19	30.00	10.71
Nyssa sylvatica	1.25	9.74	5.00	1.79
Ostrya virginiana	1.25	9.74	5.00	1.79
Class 2 (3023.94 stems/ha)				
Quercus alba	7.50	226.80	25.00	9.43
Carya tomentosa	22.50	680.39	65.00	24.53
Cornus florida	21.75	642.59	55.00	20.75
Amelanchier arborea	3.75	113.40	10.00	3.77
Prunus sp.	2.50	75.60	10.00	3.77
Nyssa sylvatica	12.50	377.99	25.00	9.43
Acer rubrum	2.50	75.60	5.00	1.89
Prunus serotina	2.50	75.60	10.00	3.77
Ostrya virginiana	21.25	642.59	45.00	16.98
Quercus veluntina	2.50	75.60	10.00	3.77
Viburnum prunifolium	1.25	37.80	5.00	1.89
Class 3 (27650.90 stems/ha)				
Quercus velutina	13.75	3802.00	45.00	20.00
Vaccinium vacillians	52.50	14516.72	75.00	33.33
Quercus alba	5.00	1382.55	20.00	8.89
Carya tomentosa	8.75	2419.45	20.00	8.89
Prunus serotina	3.75	1036.91	10.00	4.44
Nyssa sylvatica	1.25	345.64	5.00	2.22
Ostrya virginiana	8.75	2419.45	25.00	11.11
Cornus florida	3.75	1036.91	15.00	6.67
Ulmus alata	1.25	345.64	5.00	2.22
Viburnum prunifolium	1.25	345.64	5.00	2.22

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 4 (4253.77 stems/ha)				
Rhus radicans	61.25	2605.43	80.00	45.71
Vitis sp.	21.25	903.93	45.00	25.71
Rubus sp.	2.50	106.34	10.00	5.71
Dioscorea quaternata	11.25	478.55	25.00	14.29
Parthenocissus quinquefolia	2.50	106.34	10.00	5.71
Smilax bona-nox	1.25	53.17	5.00	2.86
Hardwood South Aspect				
Class 1 (394.22 stems/ha)				
Quercus alba	15.00	59.13	11.25	18.00
Quercus stellata	27.50	106.44	16.25	26.00
Carya tomentosa	26.25	103.48	16.25	26.00
Quercus marilandica	7.50	29.57	7.50	12.00
Pinus echinata	20.00	78.85	8.75	14.00
Quercus velutina	2.50	9.86	1.25	2.00
Cornus florida	1.25	4.93	1.25	2.00
Class 2 (3160.60 stems/ha)				
Vaccinium arboreum	11.25	355.57	25.00	8.33
Pinus echinata	27.50	869.17	70.00	23.33
Quercus stellata	3.75	118.52	15.00	5.00
Sassafras albidum	2.50	79.02	10.00	3.33
Cornus florida	3.75	118.52	10.00	3.33
Nyssa sylvatica	1.25	39.51	5.00	1.67
Ulmus alata	8.75	276.55	30.00	10.00
Diospyros virginiana	1.25	39.51	5.00	1.67
Quercus velutina	5.00	158.03	20.00	6.67
Acer rubrum	1.25	39.51	5.00	1.67
Ceanothus herbaceous	2.50	79.02	10.00	3.33
Prunus serotina	1.25	39.51	5.00	1.67
Carya tomentosa	15.00	474.09	45.00	15.00
Prunas mexicana	2.50	79.02	10.00	3.33
Quercus alba	3.75	118.52	10.00	3.33
Viburnum prunifolium	6.25	197.54	15.00	5.00
Quercus marilandica	1.25	39.51	5.00	1.67
Juniperus virginiana	1.25	39.51	5.00	1.67

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 3 (3347.53 stems/ha)				
Nyssa sylvatica	3.75	125.53	10.00	3.70
Quercus marilandica	1.25	41.84	5.00	1.85
Vaccinium arboreum	25.00	836.88	45.00	16.67
Pinus echinata	1.25	41.84	5.00	1.85
Quercus velutina	8.75	292.91	25.00	9.26
Cornus florida	2.50	83.69	5.00	1.85
Ceanothus herbaceous	5.00	0.15	20.00	7.41
Ulmus alata	10.00	0.28	25.00	9.26
Quercus alba	1.25	41.84	5.00	1.85
Viburnum prunifolium	3.75	125.53	10.00	3.70
Bumelia languinosa	3.75	125.53	5.00	1.85
Vaccinium stamineum	2.50	83.69	10.00	3.70
Rhus aromatica	2.50	83.69	5.00	1.85
Quercus stellata	10.00	0.28	35.00	12.96
Carya tomentosa	13.75	460.28	40.00	14.81
Callicarpa americana	2.50	83.69	10.00	3.70
Rhus copallina	2.50	83.69	10.00	3.70
Class 4 (1409.73 stems/ha)				
Rhus radicans	13.75	193.84	35.00	14.89
Vitis sp.	32.50	458.16	75.00	31.91
Berchemia scandens	1.25	17.62	5.00	2.13
Rubus sp.	32.50	458.16	65.00	27.66
Parthenocissus quinquefolia	5.00	70.49	15.00	6.38
Simlax bona-nox	8.75	123.35	25.00	10.64
Rosa carolina	2.50	35.24	10.00	4.26
Lonicera simpervierns	3.75	52.86	5.00	2.13
Hardwood Flat				
Class 1 (733.68 stems/ha)				
Carya cordiformis	6.25	45.90	20.00	7.10
Ulmus alata	13.75	100.90	35.00	12.50
Quercus stellata	16.25	119.20	45.00	16.10
Fraxinus pennsylvanica	22.50	165.10	55.00	19.60
Juniperus virginiana	1.25	9.20	5.00	1.80
Celtis sp.	1.25	9.20	5.00	1.80
Pinus echinata	16.25	119.20	40.00	14.30
Liquidambar styraciflua	6.25	45.90	20.00	7.10
Nyssa sylvatica	1.25	9.20	5.00	1.80
Quercus alba	3.75	27.50	15.00	5.40
Carya tomentosa	2.50	18.30	10.00	3.60
Acer rubrum	3.75	27.50	10.00	3.60
Quercus falcata	3.75	25.70	10.00	3.60

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 2 (2410.60 stems/ha)				
Ulmus alata	28.75	693.05	55.00	19.30
Crataegus sp.	6.25	150.66	25.00	8.77
Carya cordiformis	3.75	90.36	15.00	5.26
Cercis canadensis	13.75	331.46	35.00	12.28
Fraxinus pennsylvanica	5.00	120.53	15.00	5.26
Celtis sp.	1.25	30.13	5.00	1.75
Symphoricarpous orbiculatus	1.25	30.13	5.00	1.75
Viburnum prunifolium	1.25	30.13	5.00	1.75
Pinus echinata	6.25	150.66	15.00	5.26
Prunus mexicana	1.25	30.13	5.00	1.75
Vaccinium arboreum	1.25	30.13	5.00	1.75
Quercus falcata	5.00	120.53	20.00	7.02
Quercus stellata	3.75	90.38	10.00	3.51
Rosa carolina	1.25	30.13	5.00	1.75
Euonymus americana	1.25	30.13	5.00	1.75
Viccinium stamineum	1.25	30.13	5.00	1.75
Nyssa sylvatica	3.75	90.38	10.00	3.51
Hypericum spathulatum	2.50	60.26	5.00	1.75
Liquidambar styraciflua	1.25	30.13	5.00	1.75
Cornus florida	3.75	90.38	15.00	5.26
Quercus nigra	1.25	30.13	5.00	1.75
Carya tomentosa	2.50	60.26	5.00	1.75
Acer rubrum	2.50	60.26	10.00	3.51
Class 3 (11571.36 stems/ha)				
Vaccinium stamineum	2.50	289.28	5.00	1.82
Vaccinium vacillans	1.25	144.64	5.00	1.82
Quercus stellata	8.75	1012.49	20.00	7.27
Symphorcarpous orbiculatus	12.50	1446.42	20.00	7.27
Ulmus alata	16.25	1880.35	45.00	16.36
Ceris canadensis	6.25	723.21	20.00	7.27
Crataegus sp.	2.50	289.28	10.00	3.64
Querus nigra	13.75	1591.06	35.00	12.73
Quercus falcata	3.75	433.93	10.00	3.64
Cornus florida	5.00	578.57	20.00	7.27
Carya cordiformis	3.75	433.93	10.00	3.64
Prunus mexicana	1.25	144.64	5.00	1.82
Fraxinus pennsylvancia	6.25	723.21	20.00	7.27
Nyssa sylvatica	6.25	723.21	10.00	3.64
Carya tomentosa	1.25	144.64	5.00	1.82
Quercus velutina	3.75	433.93	15.00	5.45
Hypericum spathulatum	1.25	144.64	5.00	1.82
Acer rubrum	3.75	433.93	15.00	5.45

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 4 (41332.39 stems/ha)				
Rhus radicans	42.25	17462.94	65.00	39.40
Smilax bona-nox	40.00	16532.96	60.00	36.36
Berchemia scandens	6.25	2583.27	10.00	6.06
Parthenocissus quinquefolia	10.00	4133.24	20.00	12.12
Rubus sp.	2.50	1033.31	10.00	6.06
Hardwood-Pine North Aspect				
Class 1 (860.68 stems/ha)				
Quercus alba	17.50	150.62	45.00	18.37
Carya cordiformis	13.75	118.34	35.00	14.29
Quercus velutina	31.25	268.96	75.00	30.61
Pinus echinata	31.25	268.96	70.00	28.57
Prunus serotina	1.25	10.76	5.00	2.04
Quercus stellata	1.25	10.76	5.00	2.04
Carya tomentosa	1.25	10.76	5.00	2.04
Quercus marilandica	2.50	21.52	5.00	2.04
Class 2 (2354.89 stems/ha)				
Quercus velutina	13.75	323.80	40.00	15.09
Viburnum prunifolium	3.75	88.31	10.00	3.77
Prunus serotina	2.50	58.87	5.00	1.89
Cornus florida	16.25	382.67	45.00	16.98
Pinus echinata	6.25	147.18	20.00	7.55
Quercus alba	10.00	235.49	35.00	13.21
Carya cordiformis	38.75	912.52	80.00	30.19
Chionanthus virginicus	2.50	58.87	5.00	1.89
Vaccinium stamineum	1.25	29.44	5.00	1.89
Carya tomentosa	2.50	58.87	10.00	3.77
Vaccinium arboreum	1.25	29.44	5.00	1.89
Sassafras albidum	1.25	29.44	5.00	1.89
Class 3 (13676.22 stems/ha)				
Vaccinium vacillans	27.50	3760.96	35.00	14.58
Carya cordiformis	8.75	1196.67	35.00	14.58
Quercus velutina	20.00	2735.25	35.00	14.58
Sassafras albidum	3.55	512.86	10.00	4.17
Vaccinium stamineum	6.25	854.76	20.00	8.33
Quercus alba	6.25	854.76	20.00	8.33
Cornus florida	10.00	1367.62	30.00	12.50
Diospyros virginiana	1.25	170.95	5.00	2.08
Chionanthus virginicus	1.25	170.95	5.00	2.08

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Morus rubra	1.25	170.95	5.00	2.08
Viburnum prunifolium	3.75	512.86	10.00	4.17
Quercus stellata	1.25	170.95	5.00	2.08
Quercus marilandica	2.50	341.91	10.00	4.17
Prunus serotina	1.25	170.95	5.00	2.08
Amelanchier arborea	3.75	512.86	5.00	2.08
Vaccinium arboreum	1.25	170.95	5.00	2.08
Class 4 (1611.97 stems/ha)				
Rhus radicans	10.00	161.20	20.00	11.11
Parthenocissus quinquefolia	42.50	685.09	70.00	38.89
Vitis sp.	43.75	705.24	75.00	41.67
Rubus sp.	3.75	60.45	15.00	8.33
Hardwood-Pine South Aspect				
Class 1 (586.70 stems/ha)				
Pinus echinata	30.00	176.01	75.00	30.00
Quercus marilandica	26.25	154.01	55.00	22.00
Carya tomentosa	20.00	117.34	40.00	16.00
Ulmus alata	1.25	7.33	5.00	2.00
Quercus stellata	7.50	44.00	20.00	8.00
Fraxinus pennsylvanica	1.25	7.33	5.00	2.00
Quercus veluntina	6.25	36.67	20.00	8.00
Quercus alba	3.75	22.00	15.00	6.00
Cornus florida	1.25	7.33	5.00	2.00
Nyssa sylvatica	1.25	7.33	5.00	2.00
Prunus serotina	1.25	7.33	5.00	2.00
Class 2 (2899.00 stems/ha)				
Pinus echinata	37.50	1087.13	60.00	27.91
Carya tomentosa	8.75	253.66	20.00	9.30
Vaccinium arboreum	18.75	543.56	45.00	20.93
Ulmus alata	6.25	181.19	15.00	6.98
Nyssa sylvatica	2.50	72.48	5.00	2.32
Cornus florida	8.75	253.66	20.00	9.30
Quercus alba	1.25	36.24	5.00	2.32
Rhus copallina	2.50	72.48	5.00	2.32
Quercus stellata	3.75	108.71	15.00	6.98
Juniperus virginiana	1.25	36.24	5.00	2.32
Fraxinus pennsylvanica	1.25	36.24	5.00	2.32
Quercus velutina	1.25	36.24	5.00	2.32
Vaccinium stamineum	5.00	144.95	5.00	2.32
Viburnum prunifolium	1.25	36.24	5.00	2.32

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 3 (3899.54 stems/ha)				
Carya tomentosa	18.75	732.16	60.00	20.00
Quercus stellata	8.75	341.21	35.00	11.67
Vaccinium vacillans	8.75	341.21	15.00	5.00
Vaccinium arboreum	7.50	292.47	30.00	10.00
Quercus velutina	6.25	243.72	20.00	6.67
Querus falcata	1.25	48.74	5.00	1.67
Quercus marilandica	7.50	292.47	20.00	6.67
Cornus florida	6.25	243.72	20.00	6.67
Pinus echinata	1.25	48.74	5.00	1.67
Ceanothus herbaceous	1.25	48.74	5.00	1.67
Ulmus alata	6.25	243.72	15.00	5.00
Nyssa sylvatica	2.50	97.49	10.00	3.33
Quercus alba	3.75	146.23	15.00	5.00
Prunus serotina	1.25	48.74	5.00	1.67
Rhus copallina	1.25	48.74	5.00	1.67
Vaccinium stamineum	7.50	292.47	10.00	3.33
Hypericum sp.	2.50	97.49	5.00	1.67
Viburnum prunifolium	3.75	146.23	5.00	1.67
Prunus mexicana	1.25	48.74	5.00	1.67
Fraxinus pennsylvanica	2.50	97.49	10.00	3.33
Class 4 (1238.60 stems/ha)				
Smilax bona-nox	21.25	263.20	50.00	22.73
Vitis sp.	27.50	340.62	60.00	27.27
Parthenocissus quinquefolia	6.25	77.41	20.00	9.09
Rhus radicans	31.25	387.06	65.00	29.55
Rubus sp.	13.75	170.31	25.00	11.36
Hardwood-Pine Flat				
Class 1 (671.14 stems/ha)				
Pinus echinata	55.00	369.13	80.00	36.36
Nyssa sylvatica	2.50	16.78	10.00	4.54
Ulmus alata	3.75	25.17	10.00	4.54
Quercus stellata	11.25	75.50	40.00	18.18
Carya tomentosa	10.00	67.11	35.00	15.91
Carya cordiformis	5.00	33.56	10.00	4.54
Prunus mexicana	1.25	8.39	5.00	2.27
Quercus falcata	2.50	16.79	10.00	4.54
Quercus velutina	8.75	58.72	20.00	9.09

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 2 (4438.52 stems/ha)				
Ulmus alata	8.75	388.37	20.00	7.69
Vaccinium arboreum	7.50	332.89	30.00	11.54
Carya tomentosa	25.00	1109.63	50.00	19.23
Cornus florida	27.50	1220.59	60.00	23.08
Carya cordiformis	11.25	499.33	35.00	13.46
Prunus mexicana	1.25	55.48	5.00	1.92
Quercus stellata	10.00	443.85	30.00	11.54
Crataegus sp.	1.25	55.48	5.00	1.92
Quercus velutina	1.25	55.48	5.00	1.92
Fraxinus pennsylvanica	1.25	55.48	5.00	1.92
Pinus echinata	3.75	166.45	10.00	3.85
Chionanthus virginicus	1.25	55.48	5.00	1.92
Class 3 (9293.68 stems/ha)				
Morus rubra	2.50	232.34	5.00	1.96
Carya cordiformis	11.25	1045.54	25.00	9.80
Ulmus alata	15.00	1394.05	45.00	17.65
Quercus stellata	16.25	1510.22	40.00	15.69
Carya tomentosa	6.25	580.86	25.00	9.80
Fraxinus pennsylvanica	3.75	348.51	5.00	1.96
Cornus florida	20.00	1858.74	45.00	17.65
Viburnum prunifolium	1.25	116.17	5.00	1.96
Diospyros virginiana	1.25	116.17	5.00	1.96
Quercus velutina	6.25	580.86	20.00	7.84
Vaccinium vacillans	8.75	813.20	15.00	5.88
Vaccinium arboreum	2.50	232.34	5.00	1.96
Acer rubrum	1.25	116.17	5.00	1.96
Class 4 (46860.36 stems/ha)				
Rhus radicans	55.00	25773.20	85.00	47.22
Parthenocissus quinquefolia	27.50	12886.60	60.00	33.33
Smilax bona-nox	11.25	5271.79	25.00	13.89
Vitis sp.	6.25	2928.77	10.00	5.56
Pine Setting 1972 (12 yr. old)				
Class 1 (1502.02 stems/ha)				
Pinus taeda	100.00	1502.02	100.00	100.00

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 2 (7592.77 stems/ha)				
Pinus taeda	5.00	379.64	10.00	3.13
Cornus florida	13.75	1044.01	35.00	10.94
Ulmus alata	10.00	759.00	35.00	10.94
Quercus stellata	2.50	189.82	10.00	3.13
Fraxinus pennsylvanica	3.75	284.73	15.00	4.69
Nyssa sylvatica	6.25	474.55	20.00	6.25
Rhus copallina	13.75	1044.01	35.00	10.94
Quercus velutina	2.50	189.82	10.00	3.13
Carya tomentosa	13.75	1044.01	35.00	10.94
Crataegus sp.	5.00	379.64	20.00	6.25
Pinus echinata	2.50	189.82	10.00	3.13
Quercus falcata	5.00	379.64	20.00	6.25
Quercus alba	3.75	284.73	15.00	4.69
Chionanthus virginicus	5.00	379.64	20.00	6.25
Prunus mexicana	2.50	189.82	10.00	3.13
Diospyrous virginiana	1.25	94.91	5.00	1.56
Celtis sp.	1.25	94.91	5.00	1.56
Acer rubrum	1.25	94.91	5.00	1.56
Viburnum prunifolium	1.25	94.91	5.00	1.56
Class 3 (4674.87 stems/ha)				
Vaccinium vacillans	6.25	292.18	10.00	3.51
Rhus copallina	10.00	467.49	40.00	14.04
Ceanothus herbaceous	5.00	233.74	15.00	5.26
Vaccinium arboreum	12.50	584.36	30.00	10.53
Nyssa sylvatica	2.50	116.87	10.00	3.51
Crataegus sp.	7.50	350.62	15.00	5.26
Ulmus alata	6.25	292.18	20.00	7.02
Carya tomentosa	16.25	759.67	45.00	15.79
Quercus stellata	2.50	116.87	10.00	3.51
Quercus alba	5.00	233.74	10.00	3.51
Cornus florida	10.00	467.49	25.00	8.77
Prunus serotina	1.25	58.44	5.00	1.75
Viburnum prunifolium	1.25	58.44	5.00	1.75
Quercus velutina	3.75	175.31	10.00	3.51
Quercus falcata	1.25	58.44	5.00	1.75
Acer rubrum	1.25	58.44	5.00	1.75
Chionanthus virginicus	5.00	233.74	15.00	5.26
Morus rubra	1.25	58.44	5.00	1.75
Quercus marilandica	1.25	58.44	5.00	1.75

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 4 (115202.21 stems/ha)				
Rubus sp.	27.50	31680.61	50.00	34.38
Rhus radicans	35.00	40320.77	50.00	31.25
Smilax bona-nox	31.25	36000.69	45.00	28.13
Vitis sp.	6.25	7200.14	10.00	6.25
Pine Setting 1975 (9 year old)				
Class 1 (460.08 stems/ha)				
Pinus taeda	100.00	460.06	100.00	100.00
Class 2 (5018.35 stems/ha)				
Rhus copallina	27.50	1380.05	55.00	20.75
Diospyrous virginiana	1.25	62.73	5.00	1.89
Carya tomentosa	17.50	878.21	40.00	15.09
Quercus velutina	2.50	125.46	10.00	3.77
Quercus stellata	15.00	752.75	40.00	15.09
Vaccinium arboreum	3.75	188.19	10.00	3.77
Pinus taeda	7.50	376.38	25.00	9.43
Callicarpa americana	6.25	313.65	15.00	5.66
Pinus echinata	2.50	125.46	10.00	3.77
Prunus mexicana	1.25	62.73	5.00	1.89
Ulmus alata	8.75	439.11	25.00	9.43
Cratagus sp.	3.75	188.19	15.00	5.66
Quercus marilandica	2.50	125.46	10.00	3.77
Class 3 (3141.59 stems/ha)				
Viburnum prunifolium	6.25	196.35	15.00	5.26
Acer rubrum	1.25	39.27	5.00	1.75
Callicarpa americana	3.75	117.81	15.00	5.26
Vaccinium stamineum	1.25	39.27	5.00	1.75
Ceanothus herbaceous	15.00	471.28	30.00	10.53
Rhus copallina	18.75	589.05	50.00	17.54
Carya tomentosa	17.50	549.78	45.00	15.79
Hypericum sp.	1.25	39.27	5.00	1.75
Quercus marilandica	2.50	78.54	5.00	1.75
Symphoricarpos orbiculatus	1.25	39.27	5.00	1.75
Prunus mexicana	5.00	157.08	20.00	7.02
Quercus alba	2.50	78.54	10.00	3.51
Quercus stellata	6.25	196.35	20.00	7.02
Crataegus sp.	6.25	196.35	20.00	7.02
Diospyros virginiana	1.25	39.27	5.00	1.75
Bumelia languinosa	1.25	39.27	5.00	1.75
Ulmus alata	6.25	196.25	15.00	5.26
Vaccinium arboreum	2.50	78.54	10.00	3.51

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Class 4 (50441.97 stems/ha)				
Smilax bona-nox	45.00	22698.89	55.00	36.67
Rubus sp.	42.50	21437.84	70.00	46.67
Rhus radicans	6.25	3152.62	15.00	10.00
Vitis sp.	2.50	1261.05	5.00	3.33
Rosa carolina	3.75	1891.57	5.00	3.33
Pine Setting 1978 (6 year old)				
Class 1 - None found				
Class 2 (5341.57 stems/ha)				
Rhus copallina	51.25	2737.56	90.00	40.91
Quercus stellata	15.00	801.24	30.00	13.64
Ulmus alata	13.75	734.47	35.00	15.91
Pinus taeda	3.75	200.31	10.00	4.55
Carya tomentosa	8.75	467.39	25.00	11.36
Crataegus sp.	2.50	133.54	10.00	4.55
Carya cordiformis	1.25	66.77	5.00	2.27
Celtis sp.	1.25	66.77	5.00	2.27
Quercus velutina	2.50	133.54	10.00	4.55
Class 3 (5158.10 stems/ha)				
Quercus stellata	15.00	773.71	40.00	17.02
Crataegus sp.	11.25	580.29	35.00	14.89
Rhus copallina	53.75	2772.48	95.00	40.43
Carya tomentosa	5.00	257.90	15.00	6.38
Symphoricarpos orbiculatus	2.50	128.95	10.00	4.25
Diospyros virginiana	1.25	64.48	5.00	2.13
Ulmus alata	7.50	386.86	20.00	8.51
Sassafras albidum	1.25	64.48	5.00	2.13
Class 4 (8539.75 stems/ha)				
Rubus sp.	55.00	4696.86	80.00	50.00
Parthenocissus quinquefolia	6.25	533.73	20.00	12.50
Rosa carolina	2.50	213.49	5.00	3.13
Smilax bona-nox	31.25	2668.67	50.00	31.24
Vitis sp.	5.00	426.99	5.00	3.13

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Pine Setting 1981 (3 year old)				
Class 1 - None found				
Class 2 (643.36 stems/ha)				
Pinus taeda	50.00	321.68	85.00	34.69
Ulmus alata	5.00	32.17	10.00	4.08
Carya tomentosa	6.25	40.21	20.00	8.16
Rhus copallina	17.50	112.59	50.00	20.41
Quercus stellata	10.00	64.34	35.00	14.29
Quercus alba	5.00	32.17	20.00	8.16
Quercus marilandica	1.25	8.04	5.00	2.04
Bumelia languinosa	1.25	8.04	5.00	2.04
Diospyros virginiana	1.25	8.04	5.00	2.04
Quercus velutina	1.25	8.04	5.00	2.04
Pinus echinata	1.25	8.04	5.00	2.04
Class 3 (6828.72 stems/ha)				
Crataegus sp.	2.50	170.72	10.00	4.26
Pinus taeda	15.00	1024.31	35.00	14.89
Quercus velutina	7.50	512.15	20.00	8.51
Ulmus alata	5.00	341.44	10.00	4.26
Vaccinium stamineum	1.25	85.36	5.00	2.16
Quercus stellata	6.25	426.80	25.00	10.64
Carya tomentosa	6.25	426.80	20.00	8.51
Quercus falcata	1.25	85.36	5.00	2.13
Rhus copallina	46.25	3158.28	75.00	31.91
Prunus mexicana	1.25	85.36	5.00	2.13
Vaccinium arboreum	3.75	256.08	10.00	4.26
Nyssa sylvatica	1.25	85.36	5.00	2.13
Quercus marilandica	1.25	85.36	5.00	2.13
Quercus alba	1.25	85.36	5.00	2.13
Class 4 (3263.91 stems/ha)				
Smilax bona-nox	26.25	856.78	40.00	22.86
Rubus sp.	56.25	1835.95	90.00	51.43
Rhus radicans	7.50	244.79	15.00	8.57
Vitis sp.	7.50	244.79	20.00	11.43
Rosa carolina	2.50	81.60	10.00	5.71

Appendix 3. Continued.

Species	Relative Density (%)	Absolute Density (stems/ha)	Frequency (%)	Relative Frequency (%)
Pine Setting 1983 (1 year old)				
Class 1 - None found				
Class 2 - None found				
Class 3 (1107.29 stems/ha)				
Carya cordiformis	13.75	152.25	35.00	13.73
Quercus velutina	6.25	69.21	20.00	7.84
Carya tomentosa	31.25	346.03	70.00	27.45
Quercus stellata	12.50	138.41	35.00	13.73
Quercus alba	7.50	83.05	20.00	7.84
Quercus marilandica	2.50	27.68	5.00	1.96
Pinus taeda	17.50	193.78	40.00	15.69
Vaccinium vacillans	2.50	27.68	10.00	3.92
Viburnum prunifolium	1.25	13.84	5.00	1.96
Diospyros virginiana	1.25	13.84	5.00	1.96
Ulmus alata	3.75	41.52	10.00	3.92
Class 4 - None found				

Appendix 4. Density and percent ground cover of herbaceous vegetation by cover type and species on the Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklahoma.

Cover Type	Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Pine North Aspect		13.55	38.90
	Andropogon sp.	2.05	15.40
	Aster patens	0.35	0.45
	Solidago sp.	0.60	0.85
	Stylosanthes biflora	0.05	0.05
	Panicum sp.	0.55	1.10
	Aster sp.	0.25	0.35
	Lespedeza procumbens	0.15	0.20
	Monarda sp.	5.10	12.55
	Helianthus hirsutus	0.45	0.55
	Qxalis violaceae	0.05	0.05
	Clitoria meriana	0.35	0.35
	Tadescanthia ohiensis	0.05	0.05
	Uniola sessilflora	0.15	0.40
	Baptisia lucantha	0.30	0.10
	Antennaria plantaginifolia	1.25	2.55
	Specularia perfoliata	0.05	0.10
	Physalis sp.	0.05	0.05
	Cunila origanoides	0.25	0.45
	Carex sp.	0.15	0.30
	Galium arkansanum	0.30	0.95
	Viola sagitatta	0.10	0.15
	Pteridium acquilinum	0.25	0.55
	Scutellaria sp.	0.25	0.95
	Elymus sp.	0.05	0.05
	Danthonia spikata	0.10	0.20
	Rhynchosia latifolia	0.25	0.10
	Psorlea simplex	0.05	0.05
Pine South Aspect		11.80	33.15
	Aster sp.	0.80	1.20
	Andropogon sp.	4.30	12.85
	Carex sp.	0.85	9.45
	Unk. Forb	0.05	0.05
	Clitoria meriana	0.45	0.60
	Lespedeza procumbens	0.10	0.05
	Solidago sp.	0.50	1.00
	Uniola sessilflora	0.55	0.25
	Panicum sp.	0.25	0.30
	Danthonia spikata	0.15	0.50
	Helianthus hirsutus	0.50	0.55

Appendix 4. Continued.

Cover Type Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Monarda sp.	1.15	2.70
Lactuca sp.	0.05	0.05
Physalis sp.	0.20	0.35
Scutellaria sp.	0.35	0.85
Crotonopsis elliptica	0.05	0.15
Antennaria plantaginifolia	0.05	0.10
Hieracum gronovii	0.50	1.00
Aster patens	0.30	0.35
Psorlea simplex	0.05	0.05
Coreopsis grandiflora	0.15	0.15
Lespedeza sp.	0.05	0.05
Euphorbia obtusata	0.15	0.30
Vicia carolina	0.05	0.05
Tephrosia virginiana	0.10	0.10
Streptanthus maculatus	0.05	0.05
Pteridium acquilinum	0.05	0.05
Pine Flat	28.30	73.10
Panicum sp.	1.40	7.00
Uniola sessilflora	7.10	19.45
Helianthus hirsutus	0.15	1.35
Monarda sp.	0.25	0.30
Tradescanthis ohiensis	0.05	0.20
Oxalis stricta	0.05	0.30
Unk. Grass	1.70	2.75
Scirpus sp.	0.55	1.65
Andropogon scoparius	4.25	7.60
Solidago sp.	0.05	0.15
Hedyotis sp.	0.05	0.20
Antennaria plantaginifolia	4.05	12.60
Unk. Legume	0.40	0.65
Unk. Forb	1.20	2.25
Eriogonum longifolium	0.15	0.15
Podophyllum peltatum	0.05	0.05
Tephrosia virginiana	0.05	0.05
Psoralea simplex	0.20	0.40
Pteridium acquilinum	0.05	0.05
Lamium amplexicaule	0.05	0.05
Lactuca sp.	0.25	0.30
Oxalis violaceae	0.05	0.05
Coreopsis grandiflora	0.10	0.10
Andropogon sp.	4.00	13.00
Aster patens	0.20	0.80
Erigeron philadelphicus	0.05	0.10
Lespedeza procumbens	0.60	1.30
Desmodium sp.	0.15	0.20
Lespedeza sp.	0.10	0.05

Appendix 4. Continued.

Cover Type Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Pine-Hardwood North Aspect	2.65	6.30
Solidago sp.	0.25	0.30
Carex sp.	0.35	2.10
Monarda sp.	0.95	1.90
Andropogon sp.	0.20	1.05
Lespedeza procumbens	0.05	0.10
Aster patens	0.10	0.15
Antennaria plantaginifolia	0.10	0.20
Unk. Forb	0.05	0.05
Anemonella thalictroides	0.25	0.20
Panicum sp.	0.05	0.05
Astragalus sp.	0.10	0.05
Cunila origanoides	0.05	0.05
Aster sp.	0.15	0.10
Pine-Hardwood South Aspect	24.25	29.50
Oxalis violaceae	0.10	0.10
Solidago sp.	0.55	0.40
Lespedeza procumbens	1.05	2.05
Rhynchosia latifolia	0.85	0.55
Unk. Forb	0.70	0.90
Aster patens	0.85	0.70
Andropogon sp.	3.80	7.25
Panicum sp.	1.60	1.65
Aster sp.	1.75	1.40
Psorlea simplex	0.90	1.50
Antennaria plantaginifolia	2.70	3.55
Monarda sp.	1.65	2.75
Lespedeza sp.	0.25	0.30
Phlox glaberrima	0.05	0.05
Carex sp.	0.30	1.50
Helianthus hirsutus	0.70	0.65
Galium arkansanum	0.50	0.60
Uniola sessilflora	1.45	1.10
Unk. Grass	1.00	0.50
Baptisia leucantha	1.50	0.50
Erigeron philadelphicus	1.00	1.00
Tradescanthia occidentalis	1.00	0.50

Appendix 4. Continued.

Cover Type	Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Pine-Hardwood Flat		12.30	20.15
	Unk. Forb	0.20	0.25
	Andropogon sp.	0.55	3.35
	Cyperus sp.	0.10	0.05
	Psorlea simplex	0.15	0.10
	Lactuca sp.	0.05	0.05
	Monarda sp.	2.05	2.30
	Antennaria plantaginifolia	3.10	5.85
	Scirpus sp.	0.20	0.35
	Unk. Legume	0.35	0.40
	Solidago sp.	0.35	0.25
	Desmodium sp.	0.65	0.40
	Uniola sessilflora	0.30	0.65
	Aster sp.	0.60	0.50
	Panicum sp.	0.10	0.20
	Festuca panadoxa	0.25	2.05
	Crotalaria sagittalis	0.60	0.60
	Juncus sp.	0.15	0.80
	Tradescanthia ohiensis	0.10	0.10
	Physalis sp.	0.20	0.30
	Carex sp.	0.10	0.15
	Baptisia leucantha	0.25	0.05
	Aster patens	0.25	0.35
	Viola sagittata	0.25	0.40
	Helianthus hirsutus	0.15	0.20
	Sanicula canadensis	0.10	0.05
	Lilaceae	0.05	0.05
	Oxalis violacea	0.05	0.05
	Cirsium texanum	0.05	0.05
	Lespedeza procumbens	0.85	0.15
	Chenopodium sp.	0.05	0.05
	Hieracium gronovii	0.05	0.05
Hardwood North Aspect		10.30	20.20
	Antennaria plantaginifolia	0.60	1.00
	Monarda sp.	1.25	2.60
	Anemonella thalictroides	2.05	6.65
	Desmodium sp.	0.40	0.20
	Solidago sp.	0.65	0.70
	Helianthus hirsutus	0.40	0.35
	Aster sp.	0.85	3.45
	Unk. Legume	0.30	0.40
	Gillenia stipulata	0.85	0.50
	Panicum sp.	0.45	0.95
	Unk. Forb	1.25	1.15
	Unk. Grass	0.15	0.55

Appendix 4. Continued.

Cover Type Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Galium arkansanum	0.05	0.05
Pteridium acquilinum	0.15	0.15
Heydotis sp.	0.05	0.05
Clitoria meriana	0.50	1.10
Viola sagitatta	0.10	0.10
Vicia carolina	0.25	0.25
Hardwood South Aspect	20.80	43.75
Hypericum spathulatum	0.05	0.05
Andropogon sp.	10.05	19.20
Panicum sp.	1.25	8.20
Aster sp.	0.75	0.75
Aster patens	0.75	1.20
Heydotis nigracans	0.15	0.25
Euphorbia corrulata	0.30	0.45
Antennaria plantaginifolia	0.75	1.45
Unk. Forb	0.40	0.35
Solidago sp.	0.90	0.95
Hieracum gronovii	0.35	0.75
Monarda sp.	0.70	1.30
Helianthus hirsutus	1.15	1.20
Streptanthus maculatus	0.05	0.05
Scutellaria sp.	1.20	2.65
Lespedeza procumbens	0.30	0.95
Rynchosia latifolia	0.35	0.35
Euphorbia obtusata	0.40	1.50
Unk. Grass	0.30	0.60
Ruellia pedunculata	0.05	0.05
Viola pedata	0.05	1.00
Desmodium sp.	0.10	0.25
Euphorbia sp.	0.10	0.20
Pteridium acquilinum	0.10	0.05
Lactuca sp.	0.05	0.05
Tradescantha ohiensis	0.05	0.05
Eupatorium rugosium	0.10	0.05
Hardwood Flat	22.90	29.45
Uniola sessilflora	13.60	15.65
Antennaria plantaginifolia	0.20	0.30
Unk. Forb	1.60	2.75
Festuca paradoxa	0.40	0.25
Panicum sp.	0.65	1.25
Unk. Legume	0.50	0.50
Monarda sp.	0.50	0.15
Scirpus sp.	0.70	1.10
Unk. Grass	1.55	2.65

Appendix 4. Continued.

Cover Type	Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
	Gillenia stipulata	0.25	1.05
	Desmodium sp.	0.25	0.20
	Sanicula canadensis	0.50	0.95
	Hieracium gronovii	0.10	0.10
	Prunella vulgaris	0.10	0.10
	Pycnanthum tenuifolium	0.35	0.40
	Allium sp.	0.15	0.65
	Salvia lyrata	0.05	0.05
	Carex sp.	0.15	0.30
	Trifolium dubium	0.50	0.55
	Rudbeckia sp.	0.10	0.05
	Oxalis violacea	0.25	0.10
	Tradescanthia ohiensis	0.35	0.30
	Oxalis stricta	0.05	0.05
Hardwood Pine North Aspect		4.60	6.90
	Viola sagitatta	0.10	0.20
	Andropogon sp.	0.25	0.15
	Panicum sp.	0.35	0.90
	Monarda sp.	0.70	1.75
	Lespedeza sp.	0.40	0.70
	Galium arkansanum	0.55	0.85
	Unk. Forb	0.25	0.30
	Solidago sp.	0.15	0.30
	Desmodium sp.	0.50	0.30
	Unk. Grass	0.10	0.30
	Antennaria plantaginifolia	0.25	0.35
	Aster patens	0.05	0.05
	Baptisia leucantha	0.50	0.25
	Vicia carolina	0.20	0.05
	Anemonella thalictroides	0.15	0.25
	Rynchosia latifolia	0.05	0.15
Hardwood Pine South Aspect		8.00	6.65
	Unk. Forb	1.20	1.05
	Viola sagitatta	0.05	0.05
	Andropogon sp.	2.20	1.40
	Rynchosia latifolia	0.50	0.20
	Aster sp.	0.15	0.25
	Panicum sp.	0.20	0.30
	Unk. Legume	0.80	1.30
	Unk. Grass	0.15	0.05
	Antennaria plantaginifolia	0.45	0.45
	Helianthus angustifolia	0.05	0.10
	Aster patens	0.10	0.05
	Tephrosia virginiana	0.50	0.20
	Hieracium gronovii	0.30	0.15

Appendix 4. Continued.

Cover Type Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Helianthus hirsutus	0.90	0.80
Galium arkansanum	0.10	0.05
Vicia carolina	0.20	0.10
Phlox glaberrima	0.10	0.10
Monarda sp.	0.05	0.05
Hardwood Pine Flat	12.00	20.00
Helianthus hirsutus	0.20	0.40
Monarda sp.	0.45	1.00
Uniola sessilflora	6.75	12.10
Unk. Legume	0.10	0.10
Baptisia leucantha	0.15	0.10
Solidago sp.	0.75	0.90
Unk. Forb	1.15	1.65
Unk. Grass	0.35	1.65
Andropogon sp.	0.25	0.20
Potentillia simplex	0.05	0.05
Crotalaria sagittalis	0.25	0.35
Lespedeza sp.	0.10	0.10
Panicum sp.	0.35	0.65
Viola sagitatta	0.10	0.10
Aster patens	0.05	0.10
Antennaria plantaginifolia	0.10	0.15
Oxalis violacea	0.05	0.05
Salvia lyrata	0.05	0.05
Gillenia stipulata	0.05	0.05
Galium arkansanum	0.10	0.10
Podophyllum peltatum	0.60	0.15
Pine Setting 1972 - 12 yr. old	26.30	57.50
Panicum sp.	5.75	14.15
Aster sp.	0.70	0.75
Lespedeza procumbens	4.50	8.90
Eriogonum longifolium	0.30	0.95
Coreopsis grandiflora	0.05	0.05
Uniola sessilflora	3.50	9.25
Lespedeza sp.	0.25	0.55
Sanicula canadensis	0.20	0.20
Solidago sp.	0.15	0.15
Potentilla recta	0.05	0.10
Crotonopsis elliptica	0.05	0.05
Monarda sp.	0.25	0.45
Physalis sp.	0.05	0.05
Phlox glaberrima	0.15	0.15
Andropogon sp.	2.30	6.15
Desmodium nudiflorum	1.35	1.35
Verbesina helianthoides	0.50	0.70

Appendix 4. Continued.

Cover Type	Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
	Unk. Forb	0.45	0.80
	Carex sp.	0.15	0.50
	Viola sagitatta	0.05	0.05
	Clitoria meriana	0.15	0.30
	Passiflora lutea	0.05	0.05
	Pteridium acquilinum	0.20	0.20
	Tradescanthia ohiensis	0.05	0.05
	Helianthus hirsutus	0.20	0.50
	Oxalis stricta	0.05	0.10
	Lespedeza striata	0.10	0.55
	Stylosanthes biflora	0.25	0.70
	Danthonia spikata	3.05	7.05
	Tephrosia virginiana	0.05	0.10
	Unk. Grass	0.45	0.90
	Viola pedata	0.05	0.05
	Psorlea simplex	0.15	0.35
	Aster patens	0.10	0.10
	Echinacea sanguinea	0.25	0.20
	Antennaria plantaginifolia	0.20	0.70
	Baptisia leucantha	0.30	0.05
	Galium arkansanum	0.05	0.25
Pine Setting 1975 - 9 yr. old		32.00	77.20
	Physalis sp.	0.05	0.15
	Lespedeza procumbens	12.40	24.75
	Crotonopsis elliptica	0.05	0.05
	Panicum sp.	7.05	19.20
	Oxalis stricta	0.20	0.40
	Salvia lyrata	0.50	1.05
	Aster sp.	0.25	0.35
	Uniola sessilflora	0.55	0.85
	Unk. Forb	1.00	1.25
	Cynoglossum amabilie	0.25	0.25
	Carex sp.	0.60	1.45
	Oxalis violacea	0.05	0.05
	Andropogon sp.	4.50	16.05
	Monarda sp.	2.75	6.00
	Lespedeza sp.	0.15	0.25
	Coreopsis grandiflora	0.05	0.05
	Solidago sp.	0.05	0.05
	Prunella vulgaris	0.05	0.05
	Lespedeza stricta	0.05	0.15
	Danthonia spikata	0.50	3.50
	Eupatorium rugosium	0.10	0.05
	Psorlea simplex	0.20	0.30
	Clitoria meriana	0.25	0.35

Appendix 4. Continued.

Cover Type	Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
	Ruellia pedunculata	0.05	0.05
	Solanum sp.	0.10	0.15
	Helianthus hirsutus	0.05	0.10
	Tephrosia virginiana	0.15	0.25
	Cunilla origanoides	0.05	0.05
Pine Setting 1978 - 6 yr. old		39.95	102.00
	Erigeron philadelphicus	0.30	0.60
	Ambrosia artemisiifolia	0.05	0.05
	Monarda sp.	1.45	3.45
	Unk. Grass	1.55	2.40
	Panicum sp.	9.45	23.80
	Trifolium dubium	0.90	4.15
	Salvia lyrata	0.35	0.55
	Carex sp.	1.95	5.20
	Prunella vulgaris	1.30	2.90
	Andropogon sp.	3.95	17.40
	Oxalis stricta	0.25	0.30
	Specularia perfoliata	0.50	0.80
	Galium arkansanum	0.05	0.20
	Physalis sp.	0.50	1.15
	Lespedeza procumbens	4.30	9.75
	Stylosanthes biflora	0.30	3.10
	Aster patens	0.05	0.05
	Phlox glaberrima	0.10	0.15
	Solidago sp.	1.85	4.05
	Viola sagitatta	0.10	0.10
	Aster sp.	1.45	2.85
	Lactuca sp.	0.25	0.35
	Cassia fasciculata	0.15	0.40
	Clitoria meriana	0.30	0.60
	Scutellaria sp.	0.10	0.10
	Danthonia spikata	1.35	4.65
	Euphorbia obtusata	0.05	0.05
	Antennaria plantaginifolia	0.05	0.10
	Coreopsis grandiflora	0.05	0.05
	Echinacea sanguinea	1.20	1.90
	Helianthus hirsutus	1.10	2.95
	Uniola sessilflora	0.10	0.05
	Passiflora lutea	0.20	0.60
	Pycnanthum tenuifolium	3.05	4.85
	Elymus sp.	0.20	0.35
	Senecio sp.	0.10	0.10

Appendix 4. Continued.

Cover Type	Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
	Desmodium sp.	0.05	0.10
	Unk. Forb	0.05	0.05
	Asclepias sp.	0.05	0.05
	Erechtites hieracifolia	0.10	0.10
	Lespedeza striata	0.50	1.25
	Psorlea simplex	0.20	0.30
	Pyrrhopappus sp.	0.05	0.05
Pine Setting 1981 - 3 yr. old		35.45	110.80
	Aster sp.	0.35	1.00
	Elymus sp.	0.05	0.15
	Desmodium nudiflorum	0.10	0.20
	Uniola sessilflora	0.05	0.50
	Helianthus hirsutus	0.65	1.35
	Panicum sp.	15.20	55.40
	Cassia fasciculata	0.70	1.95
	Pteridium acquilinum	0.25	0.35
	Solidago sp.	0.90	1.90
	Ruellia pedunculata	0.05	0.05
	Specularia perfoliata	0.10	0.10
	Oxalis stricta	0.30	0.65
	Lespedeza procumbens	1.25	2.85
	Lespedeza sp.	0.55	1.10
	Psorlea simplex	0.15	0.20
	Physalis sp.	0.25	0.60
	Hypericum spathulatum	0.10	1.55
	Rudbeckia sp.	0.50	1.20
	Monarda sp.	1.35	3.30
	Strepthanus maculatus	0.05	0.20
	Phlox glaberrima	0.05	0.05
	Pteridium acquilinum	0.85	1.10
	Trifolium dubium	0.30	0.70
	Clitoria meriana	0.45	0.80
	Andropogon sp.	1.60	11.20
	Lespedeza cuneata	0.10	0.10
	Lespedeza striata	1.45	4.25
	Eupatorium rugosium	3.40	8.50
	Lobelia spikata	0.15	0.20
	Crotonopsis elliptica	0.30	0.65
	Cynodon dactylon	0.05	0.50
	Eriogonum longifolium	0.20	0.25
	Pyrrhopappus scaposus	0.40	0.85
	Unk. Grass	0.05	0.50
	Carex sp.	0.60	1.45
	Danthonia spikata	0.20	0.45

Appendix 4. Continued.

Cover Type · Species	$\bar{x}$ % Ground Cover	$\bar{x}$ Density (stems/m^2)
Lactuca sp.	0.25	0.20
Unk. Forb	0.55	1.35
Antennaria plantaginifolia	0.15	0.20
Galium arkansanum	0.20	0.80
Rynchosia latifolia	0.10	0.10
Stylosanthes biflora	0.05	0.05
Polygala sp.	0.20	0.60
Crotalaria sagittalis	0.05	0.05
Verbascum thapus	0.10	0.05
Digitaria sp.	0.05	0.10
Lepidium virginicum	0.05	0.05
Euphorbia corrulata	0.25	0.40
Cynoglossum amabile	0.25	0.45
Echinacea sanguinea	0.15	0.25
Pine Setting 1983 - 1 yr. old	17.50	38.50
Monarda sp.	0.45	0.80
Conyza sp.	9.25	15.95
Panicum sp.	1.50	5.45
Erechites hieracifolia	2.45	3.20
Erigonum longifolium	0.05	0.05
Crotonopsis elliptica	0.75	1.60
Verbesena helianthoides	0.05	0.05
Carex sp.	0.30	5.25
Cunila origanoides	0.10	0.20
Antennaria plantaginifolia	0.45	1.50
Lespedeza sp.	0.40	2.40
Eupatorium rugosium	0.30	0.25
Tradescanthia ohiensis	0.05	0.05
Oxalis stricta	0.30	0.40
Specularia perfoliata	0.05	0.10
Galium arkansanum	0.10	0.65
Streptanthus maculatus	0.05	0.05
Prunella vulgaris	0.10	0.20
Phytolacca americana	0.50	0.15
Verbascum thapus	0.15	0.05
Physalis sp.	0.05	0.10
Coreopsis grandiflora	0.10	0.05

Appendix 5. Relative dominance of woody species by basal area on the Weyerhaeuser Company's Mountain Fork Wildlife Management Area in southeastern Oklkahoma.

Cover Type Species	$\bar{x}$ Basal Area (m^2/ha)	Relative Dominance (%)
Pine North Aspect ($\bar{x}$ Ba = 24.68 m^2/ha)		
Pinus echinata	14.23	57.7
Quercus stellata	4.25	17.2
Carya tomentosa	3.10	12.6
Nyssa sylvatica	0.46	1.8
Quercus rubra	0.12	0.5
Carya cordiformis	0.34	1.4
Quercus alba	1.38	5.6
Quercus velutina	0.34	1.4
Cornus florida	0.23	0.9
Prunus mexicana	0.23	0.9
Pine South Aspect ($\bar{x}$ BA = 27.20 m^2/ha)		
Pinus echinata	19.74	72.6
Quercus alba	9.18	1.7
Quercus marilandica	3.31	5.5
Quercus stellata	4.27	11.0
Nyssa sylvatica	4.59	0.8
Carya tomentosa	4.13	7.6
Ulmus alata	2.30	0.8
Pine Flat ($\bar{x}$ BA = 19.74 m^2/ha)		
Pinus echinata	19.17	97.0
Quercus alba	0.23	1.2
Carya tomentosa	0.12	0.6
Quercus stellata	0.12	0.6
Acer rubrum	0.12	0.6

Appendix 5. Continued.

Cover Type	Species	$\bar{x}$ Basal Area (m^2/ha)	Relative Dominance (%)
Pine-Hardwood North Aspect ($\bar{x}$ BA = 31.11 m^2/ha)			
	Carya tomentosa	3.74	4.8
	Quercus alba	9.44	28.8
	Pinus echinata	18.48	56.5
	Cornus florida	4.59	2.2
	Quercus velutina	2.30	1.5
	Acer rubrum	2.30	0.7
	Fraxinus pennsylvanica	2.30	0.4
	Nyssa sylvatica	6.31	4.1
	Quercus rubra	2.30	0.4
	Ilex opaca	4.59	0.7
Pine-Hardwood South Aspect ($\bar{x}$ BA = 25.25 m^2/ha)			
	Pinus echinata	15.50	61.4
	Quercus stellata	4.25	16.8
	Quercus velutina	0.46	1.8
	Carya tomentosa	1.72	6.8
	Quercus marilandica	0.23	0.9
	Ulmus alata	0.69	2.7
	Viburnum prunifolium	0.12	0.5
	Rhus copallina	0.23	0.9
	Quercus alba	1.49	5.9
	Nyssa sylvatica	0.12	0.5
	Quercus falcata	0.34	1.4
	Vaccinium arboreum	0.12	0.5
Pine-Hardwood Flat ($\bar{x}$ BA = 27.43 m^2/ha)			
	Pinus echinata	18.71	68.2
	Quercus stellata	2.51	9.2
	Quercus alba	3.44	12.6
	Cornus florida	0.34	1.3
	Carya tomentosa	1.38	5.0
	Vaccinium arboreum	0.23	0.8
	Carya cordiformis	0.12	0.4
	Quercus falcata	0.12	0.4
	Quercus marilandica	0.34	1.3
	Viburnum prunifolium	0.12	0.4
	Quercus velutina	0.12	0.4

Appendix 5. Continued.

Cover Type	Species	$\bar{x}$ Basal Area (m^2/ha)	Relative Dominance (%)
Hardwood-Pine North Aspect ($\bar{x}$ BA = 18.71 m2)			
	Carya cordiformis	3.67	19.6
	Quercus stellata	0.34	1.8
	Pinus echinata	5.17	27.6
	Quercus velutina	5.39	28.8
	Quercus alba	3.10	16.6
	Cornus florida	0.34	1.8
	Quercus marilandica	0.46	2.5
	Prunus serotina	0.12	0.6
	Sassafras albidum	0.12	0.6
Hardwood-Pine South Aspect ($\bar{x}$ BA = 19.97 m^2/ha)			
	Quercus marilandica	4.13	20.7
	Pinus echinata	8.49	42.5
	Quercus stellata	1.26	6.3
	Quercus velutina	1.49	7.5
	Carya tomentosa	2.64	13.2
	Cornus florida	0.34	1.7
	Quercus alba	1.38	6.9
	Nyssa sylvatica	0.12	0.6
	Ulmus alata	0.12	0.6
Hardwood-Pine Flat ($\bar{x}$ BA = 22.15 m^2/ha)			
	Ulmus alata	0.69	3.1
	Pinus echinata	14.35	64.8
	Carya tomentosa	2.18	9.8
	Carya cordiformis	0.80	3.6
	Quercus stellata	2.30	10.4
	Quercus velutina	0.69	3.1
	Prunus mexicana	0.23	1.0
	Quercus falcata	0.57	2.6
	Cornus florida	0.23	1.0
	Nyssa sylvatica	0.12	5.2

Appendix 5. Continued.

Cover Type	Species	$\bar{x}$ Basal Area (m^2/ha)	Relative Dominance (%)
Pine Setting 1972 - 12 yr. old ($\bar{x}$ BA = 19.97 m^2/ha)			
	Pinus taeda	18.48	92.5
	Quercus stellata	0.12	0.5
	Carya tomentosa	0.23	1.2
	Cornus florida	0.23	1.2
	Quercus falcata	0.46	2.3
	Quercus alba	0.23	1.2
	Fraxinus pennsylvanica	0.12	0.5
	Quercus velutina	0.12	0.5
Pine Setting 1975 - 9 yr. old ($\bar{x}$ BA = 11.48 m^2/ha)			
	Pinus taeda	11.25	98.0
	Quercus falcata	0.12	1.0
	Quercus velutina	0.12	1.0
Pine Setting 1978 - 6 yr. old ($\bar{x}$ BA $<$ 2.30 m^2/ha)			
Pine Setting 1981 - 3 yr. old ($\bar{x}$ BA $<$ 2.30 m^2/ha)			
Pine Setting 1983 - 1 yr. old ($\bar{x}$ BA $<$ 2.30 m^2/ha)			

Appendix 5. Continued.

Cover Type	Species	$\bar{x}$ Basal Area (m^2/ha)	Relative Dominance (%)
Hardwood North Aspect ($\bar{x}$ BA = 19.63 m^2/ha)			
	Pinus echinata	4.48	23.4
	Quercus alba	4.13	21.6
	Ulmus alata	0.80	4.2
	Carya tomentosa	4.25	22.2
	Amelanchier arborea	0.69	3.6
	Quercus velutina	1.38	7.2
	Acer rubrum	0.46	2.4
	Nyssa sylvatica	1.26	6.6
	Prunus serotina	0.92	4.8
	Cornus florida	0.57	3.0
Hardwood South Aspect ($\bar{x}$ BA = 14.58 m^2/ha)			
	Pinus echinata	3.90	26.9
	Carya tomentosa	2.76	18.9
	Quercus marilandica	0.92	6.3
	Quercus stellata	3.55	24.4
	Quercus velutina	0.57	3.9
	Viburnum prunifolium	0.23	1.6
	Quercus alba	2.07	14.2
	Cornus florida	0.34	2.4
	Ulmus alata	0.23	1.6
Hardwood Flat ($\bar{x}$ BA = 21.81 m^2/ha)			
	Fraxinus pennsylvanica	4.36	20.0
	Ulmus alata	1.49	6.8
	Carya cordiformis	2.30	10.5
	Liquidambar styraciflua	1.49	6.8
	Quercus stellata	4.25	19.5
	Pinus echinata	5.28	24.2
	Nyssa sylvatica	0.12	0.5
	Quercus alba	0.34	1.6
	Carya tomentosa	0.12	0.5
	Acer rubrum	0.46	2.1
	Quercus velutina	0.12	0.5
	Quercus falcata	0.69	3.2
	Cercis canadensis	0.23	1.1
	Quercus nigra	0.12	0.5
	Celtis sp.	0.12	0.5
	Juniperus virginiana	0.12	0.5
	Crataegus sp.	0.12	0.5
	Prunus serotina	0.12	0.5

CHAPTER VI

USE OF THE HABITAT EVALUATION PROCEDURES AS AN INDEX OF HABITAT QUALITY FOR THE WILD TURKEY IN SOUTHEASTERN OKLAHOMA

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ABSTRACT.-This study describes the use of the Habitat Evaluation Procedures (HEP) for eastern wild turkey in southeastern Oklahoma. Summer food was limiting in all mature timber stands. Winter food was limiting in 9 and 12 year old pine settings. Both summer and winter foods were limiting in pine stands on flat slopes. Cover was limiting in all ages of pine settings.

The Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1980a) have been used in several eco-regions for evaluating wildlife habitat (Schamberger and Farmer 1978). These procedures provide a standardized method for documenting the quality and quantity of wildlife habitat and are currently used by various natural resource agencies to monitor the impact of land use changes on targeted wildlife species. We propose that HEP could also be used by the forest products industry to evaluate the impacts of commercial forestry practices and livestock grazing on eastern wild turkey (*Meleagris gallopavo* salvestris) habitat.

There seems to be a void of minimum standards for preservation of wild turkey habitat. Therefore, the purpose of this study was to determine and describe the quality and quantity of turkey habitat and identify possible limiting factors by applying HEP. This study was part of a larger study of turkey home range and habitat use (Bidwell 1985).

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STUDY AREA

The study area, bounded on the north and west by U.S. Highway 259, on the south by Carter Mountain, and on the east by the Mountain Fork River and Broken Bow Reservoir, was on the Weyerhaeuser Company Mountain Fork Wildlife Management Area in McCurtain County, Oklahoma. The region is characterized by steep rugged hills separated by valleys with rolling topography and clear streams with many spring fed tributaries. Duck and Fletcher (1945) described the vegetation in the region as oak-pine forest.

METHODS

The procedures for development of the Habitat Suitability Index (H.S.I.) models for turkey were obtained from a handbook formulated for eco-region 2320 (U.S. Fish and Wildlife Service 1980). Basic procedures were outlined in part 102 of the Ecological Services Manual (U.S. Fish and Wildlife Service 1980a). Habitat quality and quantity were based on two primary variables: the H.S.I. and the total area of available habitat (U.S. Fish and Wildlife Service 1980a). The H.S.I. was defined by the formula (U.S. Fish and Wildife Service 1980b):

$$\text{H.S.I.} = \frac{\text{Study Area Habitat Conditions}}{\text{Optimum Habitat Conditions}}$$

HEP are based on the assumption that habitat for a particular wildlife species can be described by an H.S.I. (U.S. Fish and Wildlife Service 1980a).

Cover types were determined from 1:24000 Weyerhaeuser Co. stand maps, setting maps, and aerial photos. The number of hectares per cover type was determined by an Altek digitizer. Vegetation sampling procedures and cover type characteristics were described in detail by Bidwell (1985). Cover types are defined in Appendix 1. Life requisite definitions and mathematical functions are shown in Appendix 2 and habitat variables in Appendix 3.

A Suitability Index (S.I.) was determined from suitability curves (Figure 1) for each life requisite in each cover type and entered into an equation to derive a H.S.I. value for each cover type. The lowest value of the life requisites for each cover type was then used as the H.S.I. for that particular cover type. The H.S.I. value was then multiplied by the area of that cover type to obtain the available Habitat Units (H.U.) for the study area. The mean H.S.I. for the study area was then derived by dividing the total number of H.U.'s by the area of available habitat.

It was assumed that the H.S.I. was a linear index that had a direct relationship with carrying capacity and had no change in magnitude through its range of 0.0 to 1.0 (U.S. Fish and Wildlife Service 1980b).

A major limitation of this model was that optimal percent life requisites were based on literature reviews of data taken throughout the eastern wild turkey's range. These data may not be representative of the situation in southeastern Oklahoma. The model also did not adequately address the vegetative characteristics of pine settings, particularly for the cover value. It was assumed that herbaceous vegetation that fell within the prescribed parameters would provide adequate insects, green forage, seeds, nesting cover, and brood rearing habitat. Other assumptions made were that roost trees were not limiting if forest cover was adequate and that surface water was present and adequately distributed (U.S. Fish and Wildlife Service 1980).

RESULTS AND DISCUSSION

The mean H.S.I. for available habitat was 0.47. Pine-hardwood stands on flat slopes and pine stands on north slopes were the most and least abundant cover types respectively (Table 1). Limiting factors for 18 cover types included summer food -67% (12/18), winter food -5% (1/18), and cover -28% (5/18) (Table 2 and 3).

Summer Food

Summer foods are provided primarily by insects, green forages, grass, forb seeds, and fruits (U.S. Fish and Wildlife Service 1980). Summer food was limiting in all mature forest cover types (Table 1). In mature timber stands, herbaceous stem density was inversely related to overstory density ($\underline{r}$ = -0.49871, $\underline{P}$ = 0.0416) and basal area (BA) ($\underline{r}$ = -0.71666, $\underline{P}$ = 0.0012). These factors are also correlated to the low S.I. values for summer food. Halls and Schuster (1965), Blair (1969), Wiggers et al. (1978), Wolters (1979), Fenwood et al. (1984) reported that understory production declined rapidly as the overstory canopy closed.

Summer food was the limiting factor in mature forest cover types but not in pine settings. The model did not assess the impact of long-duration, high-intensity grazing by cattle or herbicide applications on pine settings nor did it provide a way to weight individual pine settings based on their shape and adjacent cover types to determine a relative shape index value. This information would have allowed us to estimate the potential use of pine settings based on the above criteria and other S.I. variables.

Turkeys were generally observed using the edges of pine settings. Intensive grazing along roads and edges of pine settings in these areas may have decreased forage, seed, and soft mast availability but no data were available.

Blackburn et al. (1975) reported that the intensity of grazing and the stage of vegetation succession directly affected herbaceous seedhead production. Cattle and hogs moved freely throughout most of the study area, and cattle tended to concentrate along roads in pine settings. Also, cattle tended to remove less vegetation in the center regions of pine settings that did not include roads and used mature timber stands infrequently (Nelson 1984).

The S.I. values for herbaceous vegetation (V_1, V_2) and fruit producing shrubs (V_4) did not reflect the presence or absence of seed or fruit production, only the potential. Also, vegetation measurements were made in June during the peak growing season and just before the dry season, and heavy grazing pressure (forage removal) was more evident during late summer (August, September) than during the sampling period. Therefore, the HEP may have overestimated the summer food value of pine settings.

Winter Food Value

Winter food was limiting in pine stands on flat slopes, tame pastures/hay meadows, and 1972-1975 (12 to 9 year old) pine settings (Table 2). Winter foods were primarily provided by mast, fruit, or green forage (U.S. Fish and Wildlife Service 1980). Pine (*Pinus* sp.) and acorn (*Quercus* sp.) mast, green herbaceous leaves, grapes (*Vitis* sp.), green briar fruits (*Smilax* sp.), and dogwood (*Cornus* sp.) berries were reported as important turkey foods by Schemnitz (1956), Kennamer and Arner (1967), Blackburn et al. (1975), Holbrook (1975), and Kennamer et al. (1980). Where roads or small permanent openings with abundant green forage were present in the study area, only pasture/hayland cover types were deficient in winter food by model determination.

The percent of herbaceous vegetation remaining green during the winter months (V_6) was significantly different (F = 277.43, d.f. = 3,8, P = 0.0001) between pine settings, pasture/hay meadow, roads and small permanent openings, and mature timber stands. Sign (tracks/scats) and visual observations during late winter and early spring indicated that turkeys often used old vegetated roads and small openings. These roads and openings were the only areas that had > 50% herbaceous vegetation remaining green during the winter months (Figure 2). The S.I. values (V_6) were not optimal for herbaceous vegetation remaining green during the winter except where roads or small permanent openings were present (Table 2). Kennamer et al. (1980) also found green vegetation to be an important food item in Alabama. Further, Healy (1979) reported that openings were more important on fair than on excellent sites because of the relationship between site quality and ground vegetation. In our study area, site indices were generally low.

The S.I. values for crown cover of fruit producing shrubs (V_4) increased from north to south to flat slopes in pine and pine-hardwood cover types and decreased in hardwood and hardwood-pine cover types (Table 2). Light penetration, moisture gradients, allelopathic relationships, and historical silvicultural practices may have all affected the presence of fruit producing shrubs. Timber stand cover types were highly variable in percent crown cover of fruit producing shrubs. Total vegetation density had no significant affect ($\underline{P} > 0.05$) on the density of fruit producing shrubs in mature forest cover types.

The S.I. values for percent canopy closure of nut or seed producing trees (V_5) was ≥ 0.90 for 92% (11/12) of the mixed forest cover types. Pine stands on north slopes were the only mixed forest cover type where percent canopy closure was lower than 92% (Table 2). The lack of hardwood interspersion probably accounted for the lower value of nut or seed producing trees in pine stands on north slopes. Pine settings were devoid of mast producing trees.

Winter food values were low on pine settings primarily because of the lack of cover and size of woody stems. Both hard and soft mast producing trees and shrubs were observed as saplings in pine settings and have the potential to improve the habitat for turkeys in the future. However, if extensive hardwood control continues or pine settings are not eventually thinned in favor of some hardwood stands, mast production potential may not be realized.

Winter food value for tame pasture/hay meadow was lower than optimum because of the size of pastures and distances (V_3) from pastures to forest cover types. Also, tame pastures were present mainly in the west central part of the study area around farmsteads and increased human activity which may have discouraged turkey use in these areas. Billingsley and Arner (1970) found high use of forest openings in Missssissippi and reported fescue as an important turkey food. In our study area, mixed forest cover types have been increasingly converted to even aged pine settings. This trend is sure to continue. As the canopies of these pines close and intensive cattle grazing continues, fescue pastures, small permanent openings, and old roads may become even more important winter feeding areas for turkeys.

Cover Value

Cover is related to the size of forest stands and their composition in terms of the percentage of evergreen and deciduous trees (U.S. Fish and Wildlife Service 1980). Mosby and Handley (1943) reported that small areas of pine interspersed with hardwoods provided the turkey with roosting sites in the conifers and feeding areas in the hardwoods. However, pure pine stands with closed canopies had little use. Mosby (1959) also reported that blocks smaller than 200 ha tended to lose their turkey populations. The U.S. Forest Service (1971) reported that good escape cover consisted of dense pole or sapling stands or extensive woodlands where turkeys would not be disturbed. Lewis (1958) described good turkey habitat in Missouri as 70% timber and 30% openings. Also, Dellinger (1973) described ideal turkey habitat in Missouri as having 10 to 20% in oaks and the rest of the unit interspersed in age classes:

40% sawtimber, 30% poles, 20% saplings, and 10% in reproduction. Kennamer et al. (1981) reported that turkeys in Alabama preferred mature timber stands in the > 21 year age class except during the spring. He suggested the following land use patterns for turkeys: 55% clear cut, 19% mixed pine-hardwood, 3% subject to hardwood removal, 6% in permanent openings, and 2% (timber loading areas) planted in clovers (Trifolium sp.), small grains, and chufa (Cyperus esculentus). Collins (1981) reported that the optimal basal area for mast producing trees as 11.5 m^2/ha.

The S.I. values for the size of continuous forest stand (V_9) were assumed to be adequate ($\geq$ 80 ha) because of the stand sizes present in the study area. Therefore, V_9 was assigned a value of 1.0 for all elgible cover types (Table 2).

The S.I. values were $\geq$ 0.94 for percent canopy closure of evergreen trees (V_{10}) in 83% (10/12) of the mixed forest cover types (Table 2). Pine and hardwood-pine stands on flat slopes were deficient in percent canopy closure because of the relatively high percentage of pine overstory and the previous hardwood harvest. Pine settings also had low values in relation to canopy closure because of previous silvicultural practices.

The S.I. values for preference or avoidance of basal area (BA) (V_{11}) was $\geq$ 0.86 for 92% (11/12) of the mature mixed forest cover types. Preference was set at 20-24 m^2/ha BA and avoidance was set at < 11 m^2/ha BA (Wigley et al. 1985). The xeric hardwood stands on south slopes were of low value (0.39). The S.I. values of BA pine settings were low except for those in the 1972 age class which was 0.95 (Table 2). However, turkeys did not prefer such young high density stands (Kennamer et al. 1981). It is important to note that BA measurements did not reflect the actual size of individual trees, only the area (m^2) of coverage per hectare. BA could have been represented by small trees at high stocking rates or by large trees at low stocking rates. However, because of the positive correlation between basal area and class 1 stem density, these two parameters gave us a good estimate of timber stand characteristics. For example, the density of vines and saplings in 1972 pine settings had the highest density of any cover type (127,469.9 stems/ha), and this high density may have discouraged turkey use. The BA of this cover type also suggested avoidance when applied to the model.

CONCLUSION

Summer food was a limiting factor for wild turkeys in all mature timber stands (Table 1) but adequate at the time of sampling in pine settings. As a result of limited summer food, mature timber stands were rated low for nesting and brood rearing habitat (Reproductive Value). It is possible that summer food was also limiting in pine settings, but we did not directly measure seed production or insect availability and cannot therefore evaluate this hypothesis. We measured herbaceous vegetation and values for this variable were used as an indirect measure to estimate seed production and insect availability in the model. However, samples were not taken throughout the year as cattle progressively removed forage, so we cannot estimate the effect of grazing on seed production, forage availability, or insect availability. Winter food was limiting in 9 and 12 year old pine settings that did not contain roads or openings with abundant ($\geq$ 50% ground cover) cool season forage. Both summer and winter foods were limiting in pine stands on flat slopes.

Cover was limiting in 9 and 12 year old pine settings even if abundant cool season forage was available in openings or on roads. Cover was also limiting in 1, 3, and 6 year old pine settings regardless of the availability of winter or summer foods. Pine settings that are adjacent to mature timber stands and properly managed may provide an important boost in summer food availability for turkeys. Such settings, if properly managed, may become more important in providing life requisites for turkeys and other wildlife species as more land is removed from hardwood production. Proper management would require the adoption of planned grazing systems with leasee cooperation. Therefore, we recommend the adoption of U.S.D.A. (Forest Service or Soil Conservation Service) woodland grazing guidelines and close monitoring of grazing leases.

Habitat Evaluation Procedures allowed us to quantify various habitat characteristics and relate them to the turkey's life requisites. The disadvantages of the use of HEP were that the model required more information concerning pine settings than was available and would require redefining the optimum for the Ouachita Mountain region of Oklahoma and Arkansas. HEP adjusted specifically for this area would allow managers to access the effects of future silvicultural practices, agricultural impacts, and habitat improvement practices. In addition, use of the model would allow the forest industry to identify limiting factors for turkeys and develop management practices that would benefit this species.

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Table 1. Summary of habitat suitability index values by cover type on commercial forestland in southeastern Oklahoma.

Cover type	Summer food	Winter food[a]	Winter food[b]	Cover
PN	0.45[c,d]	0.47	1.00	1.00
PS	0.52[c,d]	0.71	1.00	1.00
PF	0.77[c,d]	0.77[c]	1.00	0.86
PHN	0.18[c,d]	0.75	1.00	0.98
PHS	0.81[c,d]	0.85	1.00	1.00
PHF	0.64[c,d]	0.86	1.00	0.98
HN	0.73[c,d]	1.00	1.00	0.98
HS	0.63[c,d]	0.65	1.00	0.73
HF	0.62[c,d]	0.67	1.00	0.99
HPN	0.48[c,d]	0.94	1.00	0.95
HPS	0.58[c,d]	0.87	1.00	1.00
HPF	0.62[c,d]	0.84	1.00	0.86
PS 72	0.89	0.47[c]	1.00	0.58[d]
PS 75	0.82	0.19[c]	1.00	0.27[d]
PS 78	0.84	0.27	0.27	0.00[c,d]
PS 81	0.76	0.19	0.19	0.00[c,d]
PS 83	0.49	0.09	0.09	0.00[c,d]
P/H	0.50[c,d]	0.50[c]	0.50[d]	*

[a] Does not have roads or small permanent openings with abundant green forage ($\geq$ 50%).

[b] Has roads or small permanent openings with abundant green forage ($\geq$ 50%).

[c] Life requisite limiting factor with winter food[a].

[d] Life requisite limiting factor with winter food[b].

* Does not apply because of model definitions.

Table 2. Summary of suitability index values for each cover type on commercial forestland in southeastern Oklahoma.

Cover type	V_1	V_2	V_3	V_4	V_5	V_6^a	V_6^b	V_9	V_{10}	V_{11}
PN	0.20	1.00	*	0.00	0.70	0.01	1.00	1.00	1.00	1.00
PS	0.20	1.00	*	0.20	0.95	0.01	1.00	1.00	1.00	1.00
PF	0.45	1.00	*	0.30	1.00	0.01	1.00	1.00	0.68	0.94
PHN	0.01	1.00	*	0.23	1.00	0.01	1.00	1.00	0.95	1.00
PHS	0.40	1.00	*	0.55	1.00	0.00	1.00	1.00	1.00	1.00
PHF	0.20	1.00	*	0.56	1.00	0.01	1.00	1.00	0.94	1.00
HN	0.16	1.00	*	1.00	1.00	0.01	1.00	1.00	1.00	0.93
HS	0.34	0.98	*	0.14	0.90	0.01	1.00	1.00	1.00	0.39
HF	0.38	1.00	*	0.00	1.00	0.01	1.00	1.00	0.98	1.00
HPN	0.05	1.00	*	0.79	1.00	0.01	1.00	1.00	1.00	0.86
HPS	0.15	1.00	*	0.56	1.00	0.06	1.00	1.00	1.00	1.00
HPF	0.20	1.00	*	0.50	1.00	0.01	1.00	1.00	0.63	1.00
PS 72	0.45	1.00	*	0.65	0.20	0.18	1.00	1.00	0.20	0.95
PS 75	0.53	1.00	*	0.27	0.00	0.15	1.00	1.00	0.45	0.05
PS 78	0.65	1.00	*	0.10	0.00	0.35	0.35	1.00	0.00	0.00
PS 81	0.58	1.00	*	0.00	0.00	0.26	0.26	1.00	0.00	0.00
PS 83	0.27	0.90	*	0.00	0.00	0.14	0.14	1.00	0.00	0.00
P/H	1.00	1.00	0.50	*	*	1.00	1.00	*	*	*

[a] Habitat without roads or small permanent openings with abundant green vegetation ($\geq$ 50%).

[b] Habitat with roads or small permanent openings with abundant green vegetation ($\geq$ 50%).

* Does not apply because of model definitions.

Table 3. Available habitat units for each cover type on commercial forestland in southeastern Oklahoma.

Cover type[a]	Hectares	H.S.I.[b]	Available Habitat Units (ha)
Pine North[c]	116.64	0.45	52.49
Pine South	176.26	0.52	91.66
Pine Flat	596.16	0.77	459.04
Pine-Hardwood North	536.54	0.18	96.58
Pine-Hardwood South	1407.46	0.81	1140.04
Pine-Hardwood Flat	4118.69	0.64	2635.96
Hardwood North	660.96	0.73	482.50
Hardwood South	461.38	0.63	290.67
Hardwood Flat	759.46	0.62	470.87
Hardwood-Pine North	1041.98	0.48	500.15
Hardwood-Pine South	536.54	0.58	311.19
Hardwood-Pine Flat	1565.57	0.62	970.65
Pine Setting (12)[d]	777.60	0.58	451.01
Pine Setting (9)	1303.78	0.27	352.02
Pine Setting (6)	899.42	0.00	0.00
Pine Setting (3)	2013.28	0.00	0.00
Pine Setting (1)	595.95	0.00	0.00
Pasture/Hay Meadow	484.78	0.50	200.88
Other[e]	256.61	0.00	0.00
Total	20526.28		

[a] Cover Type = Pine $\geq$ 75% BA pine, Pine-Hardwood $\geq$ 50% & <75% BA pine,

Hardwood-Pine > 25% & < 50% BA pine, Hardwood $\leq$ 25% BA pine.

[b] Habitat Suitability Index.

[c] North Aspect > 10% slope, South Aspect > 10% slope, Flat $\leq$ 10% slope.

[d] ( ) Setting age in years.

[e] Commercial or residential development.

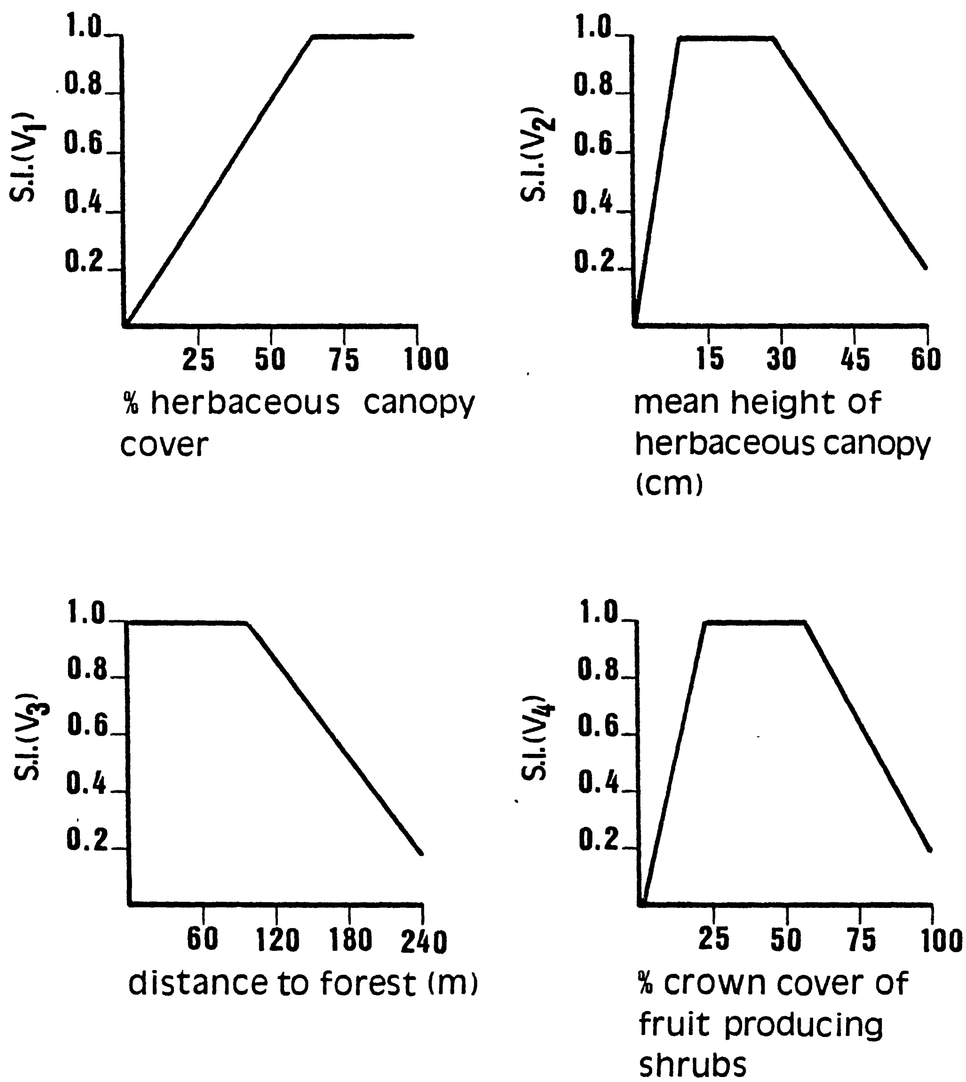

Figure 1. Habitat suitability curves

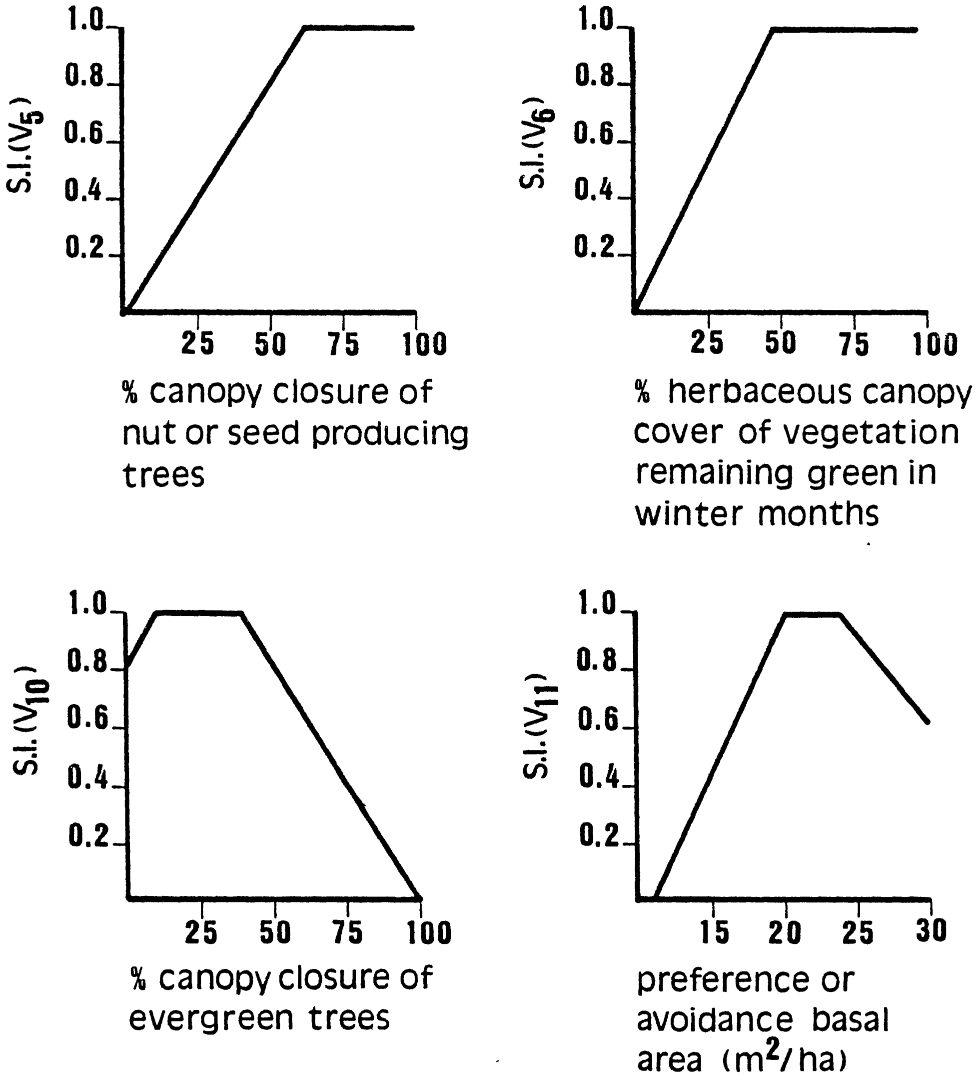

Figure 1. (Continued)

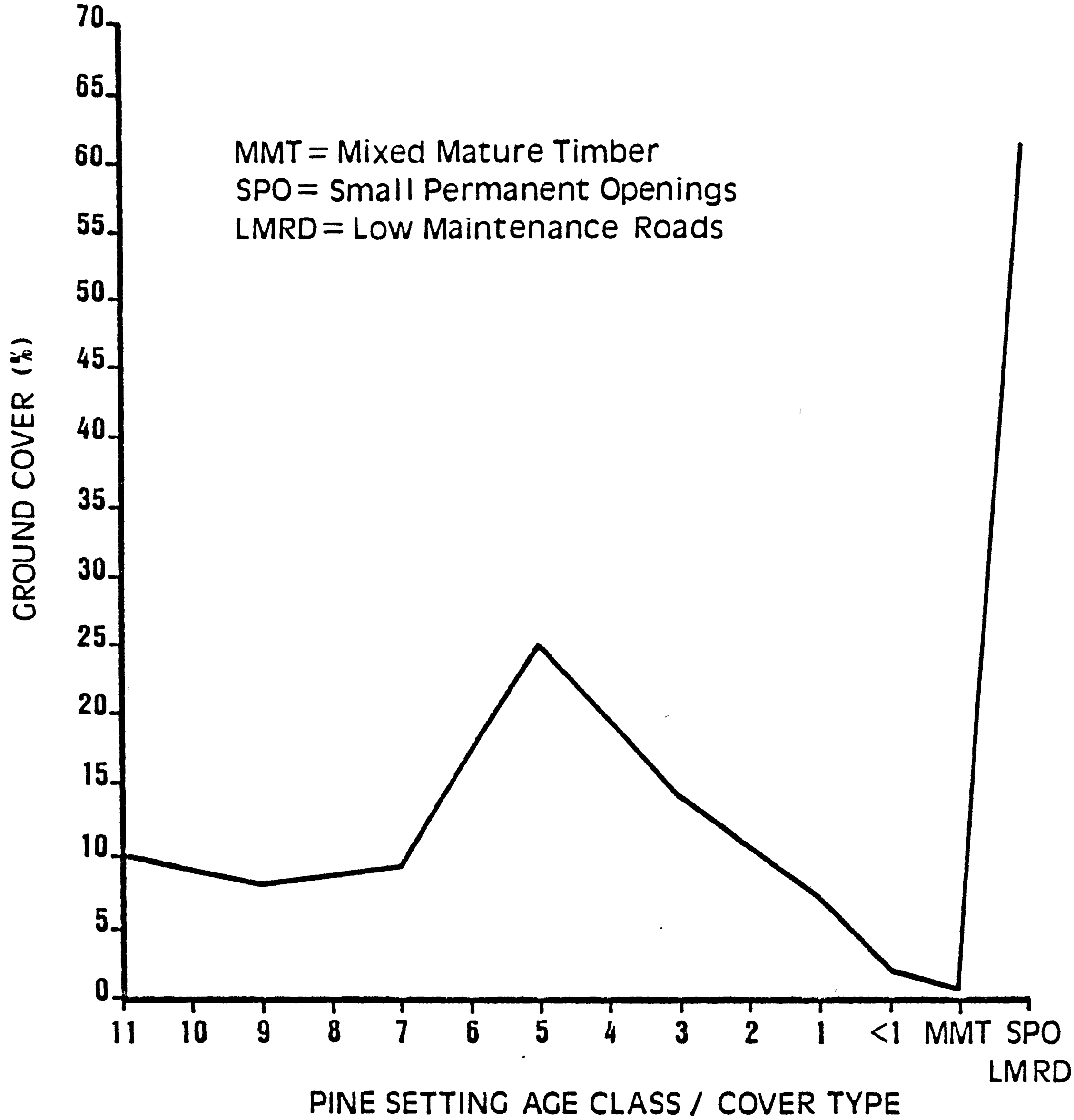

Figure 2. Percent of herbaceous vegetation remaining green during the winter months

Appendix 1. Definition of cover types by slope and aspect on commercial forestland in southeastern Oklahoma.

Symbol	Cover type[a] and slope[b]
PN	Pine north slope
PS	Pine south slope
PF	Pine flat slope
PHN	Pine-hardwood north slope
PHS	Pine-hardwood south slope
PHF	Pine-hardwood flat slope
HN	Hardwood north slope
HS	Hardwood south slope
HF	Hardwood flat slope
HPN	Hardwood-pine north slope
HPS	Hardwood-pine south slope
HPF	Hardwood-pine flat slope
PS 72	Pine setting planted 1972[c]
PS 75	Pine setting planted 1975[c]
PS 78	Pine setting planted 1978[c]
PS 81	Pine setting planted 1981[c]
PS 83	Pine setting planted 1983[c]
P/H	Pasture/Hay Meadow
Other	Developments (residential/commercial)

[a] Pine = $\geq$ 75% BA pine; pine-hardwood = $\geq$ 50% hardwood but $<$ 75% BA pine; hardwood-pine = $>$ 25% but $<$ 50% BA pine; hardwood = $\leq$ 25% BA pine.

[b] Flat $\leq$ 10%; north and south $>$ 10%.

[c] Plus or minus one year.

Appendix 2. Life requisite definitions and mathematical functions (U.S. Fish and Wildlife Service 1980).

Life requisite	Optimal % Est.	Mathematical function	Definition
Summer Food	40	$(V_1 \times V_2)^{1/2} + \frac{V_4}{3}$	Summer food value in evergreen and decidious forests is a function of V_1, V_2, and V_4. V_1 and V_2 are interactive, and compensations exist between them; therefore, they are combined in a geometric mean. The combined effect of V_1 and V_2 has the potential to provide optimal summer food, whereas it is assumed that fruit alone has only the potential to provide one-third of optimal summer food. If the function exceeds 1.0, the life requisite value will be 1.0.
		$(V_1 \times V_2)^{1/2} \times V_3$	Summer food value in pasture/hayland is a function of V_1, V_2, and V_3. V_1 and V_2 are interactive and are combined in a geometric mean. If either V_1 or V_2 equals 0, the life requisite will equal 0. The value of $(V_1 \times V_2)^{1/2}$ is multiplied by V_3 because it is assumed that the value of food will be lowered directly by the distance to cover. If the function exceeds 1.0, the life requisite value will be 1.0.

Appendix 2. Continued.

Life requisite	Optimal % Est.	Mathematical function	Definition
Winter food	60	$\frac{V_4 + 2V_5 + 2V_6}{3}$	Winter food value in evergreen and deciduous forests is a function of V_4, V_5, and V_6. It is assumed that either mast (V_5) or green forage (V_6) have the potential to provide two-thirds of optimal winter food alone, and that fruit (V_4) alone has the potential to provide one-third of optimal winter food. The life requisite value will equal zero only if all variables are equal to 0. If the function exceeds 1.0, the life requisite value will be 1.0.
		$V_3 \times V_6$	Winter food value in pasture/hay meadow is a function of V_3 and V_6. The value of green forage (V_6) is multiplied by V_3 because it is assumed that the value of food will be lowered directly by the distance to cover.
Water value	Present within home range	none	Water is required within the home range; however, it is assumed that water will not be limiting in this region.

Appendix 2. Continued.

Life requisite	Optimal % Est.	Mathematical function	Definition
Cover value	50	$(V_9 \times V_{10} \times V_{11})^{1/3}$	Cover value in evergreen and deciduous forests is a function of V_9, V_{10}, and V_{11}*. These variables are interactive and compensations exist between them. If the value of variable is 0, the life requisite will be 0.
Reproductive value	-	-	Reproductive value is comprised of both nesting habitat and brood rearing habitat. It is assumed that nesting habitat will be met by food and cover requirements. It is assumed that brood-rearing habitat is provided by the criteria for summer food.

* Function modified by adding V_{11}.

Appendix 3. Definition of habitat variables for HEP Model. (U.S. Fish and Wildlife Service 1980).

V_1	Percent herbaceaus canopy cover.
V_2	Average height of herbaceous canopy.
V_3	Distance to forest or shrub cover type, or travel lane of shrubs or trees connected to forest or shrub cover type.
V_4	Percent crown cover of fruit producing shrubs.
V_5	Percent canopy closure of nut or seed producing trees.
V_6	Percent herbaceous canopy cover of vegetation remaining green in winter months.
V_9	Size of continuous forest stand.
V_{10}	Percent canopy closure of evergreen trees.
V_{11}*	Basal area of woody trees, shrubs, and saplings.

* Added variable based on preference or avoidance of BA range.

VITA 5

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