WILD TURKEY RESPONSES TO INTENSIVE PINE MANAGEMENT IN VIRGINIA'S CENTRAL PIEDMONT

by

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(ABSTRACT)

Wild turkey mortality rates, habitat use patterns, and recruitment were investigated on intensively managed pine forest of the Central Piedmont. Thirty-two adults and poults were captured with adult dosages of alpha-chloralose. Poults were easily sedated and usually recovered 1 day sooner than adults.

The annual mortality rate for marked turkeys was 85%; September-February mortality was 65% (N=17), and March-August mortality was 57% (N=21). Turkeys that died during hunting seasons were recovered significantly ($p < 0.05$) closer to roads than those that died out of hunting seasons. High mortality during the hunting seasons and the association of hunting season mortality with roads suggests a crippling loss to legal harvest ratio as high as 4:1.

Use of young pine plantations, hardwood leave strips, large stands of mixed hardwoods, mature pine stands, and

fields was not significantly different ($p > 0.1$) from availability. Turkeys were associated with edges while on their winter and prenesting ranges. Nests were located in a variety of stand types, near edges, and in heavier cover than generally available. Nesting success was 48%. Post critical period brood survival was 90%. These data indicate that wild turkeys can adapt to the early stages of forest conversion for intensive pine management.

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GENERAL INTRODUCTION

Responses of established turkey (*Meleagris gallopavo*) populations to conversion of mature, upland hardwood forests to loblolly pine (*Pinus taeda*) plantations is unknown. Participants in the symposium *Habitat Requirements and Habitat Management for the Wild Turkey in the Southeast* (Bromley and Carlton 1981) expressed concern for the future of turkeys on converted forests and concluded that more information was needed on the relationship between intensive forest management and wild turkey productivity.

Johansen (1981) and Victor (1981) examined the impact of forest conversion on turkeys in Virginia's Central Piedmont. Johansen (1981) measured invertebrate biomass available to poults in mature hardwood stands and in various aged pine plantations. Victor (1981) measured feeding rates of human-imprinted poults. Both studies indicated that young pine stands produce sufficient food for turkey poults. This research examined wild turkey habitat preferences, nest site selection, nesting success, and brood survival in and around new pine plantations. The results are presented in three papers. The first discusses the use of alpha-chloralose for

capturing adult and juvenile wild turkeys. The second reports mortality rates, including losses due to crippling by hunters, and the associated influence of roads. The final paper discusses wild turkey recruitment and habitat use on intensively managed, domesticated forest (Stone 1975) lands.

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TRAPPING ADULT AND JUVENILE WILD TURKEYS WITH ALPHA-CHLORALOSE

Oral anesthetics provide an effective alternative to rocket and cannon nets for capturing wild turkeys (*Meleagris gallopavo*), particularly where suitable netting sites are scarce. Although turkey trappers have used methoxymol, tribromoethanol, and alpha-chloralose (Bailey 1976; Bailey and Doepker 1977; Evans et al. 1975; Williams 1966, 1967; Williams et al. 1966), numerous drawbacks limit selection and use of these drugs.

Methoxymol is distasteful to turkeys (Williams 1966) and not readily available (Bailey 1976). Tribromoethanol is expensive, difficult to obtain, and unstable in light and air (Evans et al. 1975, Bailey 1976). Trichloroethanol, a less expensive relative of tribromoethanol, produced variable levels of narcosis in North Carolina turkeys and often proved lethal (Bailey 1976, Bailey and Doepker 1977).

Alpha-chloralose has been criticized because it has 2-4 hours induction time and 1-4 days recovery time (Williams 1966). The time lag from onset of feeding to full narcosis increases the probability that drugged turkeys will be frightened or wander from trap sites. Lengthy recovery

periods allow more time for trap-related mortalities through leg paralysis or other trauma due to handling.

However, alpha-chloralose is tasteless to turkeys, stable in light and air, and does not result in unacceptable mortality rates (Williams 1966, Williams et al. 1966). It also is affordable, easily obtained, and effective. Notable successes have been reported in Florida (Williams et al. 1973) with the capture of over 1600 turkeys and in Alabama (Speake et al. 1969; Barwick and Speake 1973; Speake, pers. comm.) with the capture of numerous turkeys for radio telemetry studies.

We used alpha-chloralose to trap adult and juvenile turkeys on industrial forests in the Central Piedmont of Virginia. Earlier trappers (Williams et al. 1973, Speake, pers. comm.) used reduced dosage rates when capturing young turkeys with oral drugs. This paper presents induction and recovery times for adult and juvenile wild turkeys captured with adult doses of alpha-chloralose. Methods for protecting and securing lightly narcotized turkeys are also discussed.

Study Area and Methods

During 1982 and 1983, trapping was conducted in Buckingham County, Virginia approximately 20 km north of Appomattox on properties owned and managed by Westvaco. Terrain was rugged relative to most areas of the Piedmont. Elevation varied from 150 to 425 m, and steep slopes in excess of 45° were common.

Trapping began in late August and ended when hard mast became readily available to turkeys in October. A second trapping season began with the close of deer (*Odocoileus virginianus*) season in early January and ended with the spring green-up in early April. We established bait sites where turkeys frequently fed. Because well-distributed openings were not available, we placed bait piles in upland hardwood stands with open understories. Sites were prebaited with coarse, cracked, yellow corn until turkeys visited them with some regularity (Williams 1966, Williams et al. 1966).

Two-to-eight hours before a trapping attempt, cracked corn was moistened with water and mixed at the rate of 2 g alpha-chloralose (Sigma Chemical Company, St. Louis, Missouri) per 0.25 l of bait (Williams 1966). Treated corn was transported to the trap site in plastic bags.

Bait was presented in the same manner throughout prebaiting and trapping. However, when poults were using trap sites, whole kernels and large pieces of cracked corn were removed from the bait prior to treatment with alpha-chloralose. This procedure decreased the drug-to-surface area ratio and lessened toxicity of treated corn.

Two 0.13 l piles of laced corn were set for each turkey thought to be using the site. Blinds constructed of downed trees, branches, and other debris were located within 40 m of the bait site. Turkeys were allowed to consume as much corn as they desired. Trappers remained in blinds until at least 2 hours after the onset of feeding, unless a narcotized turkey wandered near open water. Heavily sedated birds were captured by hand. A long-handled dip net was used to secure birds that maintained their footing.

Toxic bait was removed surgically (Williams 1966) from the crop of heavily narcotized poults. Incisions through the skin were sutured in the field; incised crops closed themselves and did not require sutures (Williams, pers. comm.). No other precautions were taken against overdose.

Captured turkeys were placed in cardboard turkey boxes (National Wild Turkey Federation and Westvaco) and transported to a holding facility for protection from severe weather. The following day, they were instrumented with

radio transmitters, marked with patagial tags (Knowlton et al. 1964, Wallace et al. 1980) and aluminum leg bands, and placed in clean turkey boxes. A small amount of water was given to any turkey that would freely take it (Williams 1966). Turkeys still in heavy narcosis at this time were handled frequently to elicit increased muscular activity.

Time of capture and recovery was recorded for each turkey. Records were kept on capture success and trapping-related mortalities. Turkeys were released in open areas as near as possible to the trap site. Success of releases of instrumented birds was verified with radio telemetry.

Results and Discussion

We captured 55 different turkeys in 10 successful trapping attempts. Twenty adults and sub-adults were captured in the winter; 10 adults and 26 poults were captured in September. One adult hen was captured in both September and the following March. Three adults (5%) died from physical injuries associated with trapping and handling. There were no poult moralities or mortalities resulting from overdoses.

Only trace amounts of alpha-chloralose dropped off the bait when the mixture dried. Williams (1966) in Florida kept cracked corn damp so the powder would not flake off,

and Evans et al. (1975) in Louisiana presoaked wheat for 2-4 hours so the drug would adhere to the bait longer. The small loss of drug that we observed presented no problems in trapping.

Unlike adults, which had slow induction times and frequently wandered from bait sites, poults were sedated quickly and seldom moved from the bait piles. Poults recovered from narcosis faster than adults ($P < 0.005$). Average recovery time was 1.1 (±0.2 SD) days for poults (N=26) and 2.1 (±0.3) days for adults (N=30). Williams et al. (1973) found that poults fed reduced dosage rates of tribromethanol had more rapid recoveries than adults captured on full dosage rates. However, adult hens that fed on reduced rates of tribromoethanol usually were narcotized insufficiently to be captured.

Surgically removing toxic bait from poults (N=4) had no apparent effect on recovery time; removing larger pieces of corn may have effected the potency of alpha-chloralose on poults. Poults that were treated surgically after capture appeared to select large pieces of corn. This selectivity was not tested, and its importance is unknown. Reducing the drug-to-surface area ratio of bait did not alter the effects of alpha-chloralose on adult turkeys. In September, we captured 10 of 11 adult turkeys that fed on treated bait set

specifically for poults. During the winter when cracked corn was unaltered, we captured 19 of 21 adults and sub-adults that visited trap sites.

All poults that fed on treated bait were captured. Nineteen percent (6) of the adults that fed on treated bait were sedated insufficiently to be caught easily; three escaped. One adult gobbler captured in September was narcotized insufficiently to be picked up on the afternoon of the trapping attempt, but was recovered 24 hours later, less than 75 m from where he was last seen. On one other occasion, 9 hens and 1 young gobbler came to a bait site, fed a short while, then wandered over 100 m from the site. Darkness prevented our picking up 2 of the turkeys; however, the following morning both were captured. Williams (1966) caught an adult gobbler a few feet from the bait site after leaving the bird overnight. He avoided late afternoon trapping attempts to prevent the possibility of losing slightly narcotized turkeys to nightfall (Williams et al. 1966). Other than vulnerability to predation, turkeys drugged with alpha-chloralose experience thermoregulation difficulties and could die of exposure during inclement weather (Williams et al. 1966).

We used steep terrain to our advantage in catching turkeys that wandered from bait sites. Slightly narcotized

turkeys often started up slopes, but usually wandered back to drainage bottoms. Partially sedated turkeys that stayed on mid or upper slopes were approached best from the downhill side. Because sedated turkeys had difficulty walking up hills, we selected bait sites on mid and low slopes when possible.

Williams (1966) noted that drugged turkeys easily drown. Turkeys showed no sign of avoiding water after being drugged, and drowning caused 1 mortality. One adult gobbler was rescued while crouching in 15 cm of water. On several other occasions, turkeys collapsed next to water or in dry creek beds. These experiences are contrary to observations in Louisiana (Evans et al. 1975) where turkeys avoided water after ingesting tribromoethanol. The effect of steep terrain may have overridden any tendency by drugged turkeys to avoid water. When trapping circumstances dictated that bait sites be located near creeks, blinds were located between the bait and the water so rescues could be made.

Summary

Adult turkeys and September poults were captured successfully with the same dosage rate, 2 g of alpha-chloralose per 0.25 l of cracked corn. Poults recovered 1 day sooner than adults. Rapid narcosis and quick recoveries

made poults ideally suited for capture with alpha-chloralose. Removing treated corn from the crop of poults did not affect recovery time or survival.

Steep terrain served as a drift fence when narcotized birds wandered from bait sites. These turkeys frequently collapsed in or near water. Blinds were positioned near creeks, permitting trappers to prevent turkeys from drowning. The slow action of alpha-chloralose resulted in lightly dosed turkeys becoming immobilized overnight and easily captured the following day.

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INFLUENCE OF ROADS ON TURKEY MORTALITY

Wildlife biologists typically agree that overharvest through unregulated hunting significantly contributed to the disappearance of wild turkeys (Meleagris gallopavo) from much of their original range (Markley 1967, Williams et al. 1978, Williams 1981). However, opinions differ on the effects of regulated sport hunting on turkey survival. Estimates of fall harvest rates, annual turnover rates, illegal kills, and hunter crippling losses vary widely. Differences between states in hunting regulations reflect these inconsistencies.

Generally, one-third of the population is a permissable either sex harvest rate and annual turnover rate due to all causes may total two-thirds of the fall population (Hewitt 1967, Sanderson and Shultz 1973, Halls 1975, Sweeney 1980, U.S. Department of Agriculture 1980). Band returns from turkey populations nationwide indicate that approximately 20% are harvested annually under substantial hunting pressure (Bailey and Rinell 1967, DeGraff and Austin 1975, Lewis and Kelly 1973, Powell 1965). In Florida 86% of a radio-marked population was harvested annually during a

3-year period when either sex harvest was legal (Williams et al. 1978). Loss to illegal hunting in Virginia was estimated at 10% (Mosby 1943), but probably varied by region (Powell 1967). Estimates of crippling losses which were based on hunter surveys ranged between 10% and 80% above the estimated or reported harvest and from 1% to 15% of the fall population (Markley 1967, Bailey and Rinell 1967).

Little information exists on the impact of extensive road systems on hunting pressure and wild turkey mortality. While roads per se do not adversely affect turkeys, increased hunter access may be detrimental to turkey populations (Bailey et al. 1981). Bailey and Rinnell (1968) concluded that in West Virginia thriving turkey populations did not exist where roads open to the public exceeded 6 km per 1000 ha. At Land Between The Lakes, Kentucky, vehicular traffic disturbed turkeys and may have caused home range shifts (Wright and Speake 1975). The Forest Service considers road impact important enough to recommend closing roads unneeded for ongoing forestry practices when road concentrations exceed one per 3.2 km interval (U.S. Dep. Agric. 1980).

We here report turnover rates in a turkey population in relation to an extensive road system.

Study Area and Methods

The study was conducted on 2 units of intensively managed, industrial forest land located in the Central Piedmont about 20 km north of Appomattox, Virginia. The 2212 ha and 3674 ha units were less than 10 km apart and had similar terrain and habitats. Approximately 70% of the former tract and 50% of the latter have been converted to loblolly pine (*Pinus taeda*) from mixed upland hardwoods since 1974 and 1978, respectively. Interconnecting hardwood leave strips which account for 75% of the unconverted forest were retained between plantations and along drainages and steep slopes. These areas had 13.8 km of ungated roads per 1000 ha.

The fall hunting season for turkeys (Nov-Dec) was either sex and overlapped with deer (*Odocoileus virginianus*) season. Spring gobblers were hunted for 4 weeks in April and May. Both areas were opened to public hunting on a permit basis.

During 1982 and 1983, we captured 55 wild turkeys with alpha-chloralose (Williams 1966, Williams et al. 1966) and equipped 9 adult and sub-adult gobblers, 15 adult and sub-adult hens, and 8 September poults with 75 g radio transmitters (Telonics, Inc.). Transmitters were placed between the shoulders and attached with a nylon overbraided

backpack harness that fastened on the ventral side of adult turkeys above the keel. Poult harnesses were loosely looped across the back and under the wings without crossing the ventral side of the bird. This procedure placed the transmitter between the wing butts and allowed for growth of the breast and skeleton. Transmitters were painted brown to match turkeys' cryptic coloration. In additon, all turkeys were marked with a 4.5 x 5.8 cm patagial tag (Allflex cattle ear tag) (Wallace et al. 1980), on the right patagium and an aluminum leg band. All marks bore a request for return and leg bands offered a $10 reward.

Seventeen turkeys were radio-tracked between September 1982 and February 1983, and 21 were radio tracked between March and August 1983. Radio-marked turkeys were located by triangulation (Cochran 1980). The transmitters were not designed to detect mortality, thus we used variation in signal strength (Cochran 1980) as an indication that marked turkeys were alive. When no variation in signal strength was detected or when an individual turkey was located in the same place on consecutive days, we used portable tracking equipment to locate that individual visually and determine its status. When a dead bird was found, distance from the carcass to the closest road was measured.

Summer poult mortalities were not considered in our calculation of annual mortality. Kolmogorov-Smirnov and Kuiper goodness-of-fit tests were used to test data normality. We tested with a student's t-test the null hypothesis that distances from carcasses to roads would not be different for turkeys found dead during hunting season and those that died outside of the hunting season.

Results

Fourteen of 23 (61%) instrumented turkeys died during the 12 weeks of fall and spring turkey seasons (Fig. 1). Two of 17 (12%) instrumented turkeys were harvested in the fall. One of 17 (6%) died prior to the fall hunting season, and 8 (47%) died of unknown causes during the fall hunting season. Thus, 65% (90% CI 45-85%) of the turkeys instrumented in fall died prior to 1 March.

Four of 7 instrumented gobblers died of unknown causes during the spring gobbler season, but none were successfully taken by spring turkey hunters. An unknown predator killed 1 hen prior to nesting season. Remaining spring-summer losses were hen mortalities during the nesting and brood rearing seasons. Four of 12 hens died of suspected predation during the nesting season. Two hens that successfully hatched broods were killed by predators during

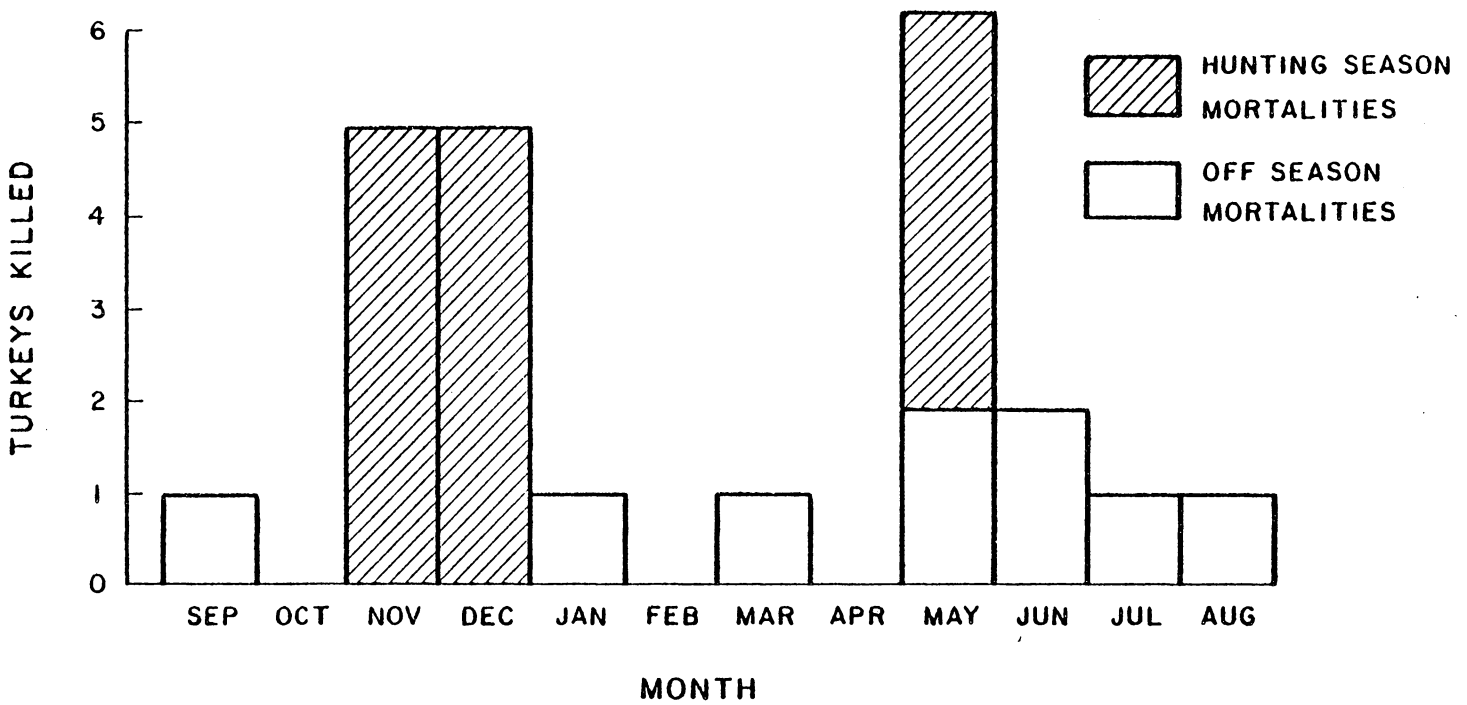

Fig. 1. Monthly mortality of radio-marked turkeys in the Central Piedmont of Virginia, 1982-83.

the summer. One was killed one week after the loss of her brood. In summary, 57% (90% CI 38-76%) of the marked sample alive in March died before 1 September. Thus, the annual mortality rate was 85%.

Turkeys found dead during the hunting season died closer to roads ($0.025 < p < 0.05$; $t=1.99$) ($\bar{X}=84.6$ m, N=10) than turkeys found dead at other times of the year ($\bar{X}=180$ m, N=8). The difference in distance to roads for the 2 groups was 95.4 m (90% CI=11.7 m - 179.1 m) (Fig. 2, Table 1). When compared to a sample of random points (N=23, $\bar{X}=232$ m), in-season mortalities were closer to roads ($P<0.01$), but out-of-season mortalities were not ($P>0.1$).

Discussion

Some investigators have suggested that differential mortality rates may occur between game birds marked with tags, bands, collars, or transmitters and the general population (Gilmer et al. 1974, Greenwood and Sargeant 1973, Boag 1972). We do not believe that differential mortality was a problem in our study. In West Virginia, Nenno and Healy (1979) observed radio-marked, human-imprinted turkeys and concluded that after a couple of days, radios had little effect on turkey behavior, including walking, running, flying and roosting. In our study, transmitters and

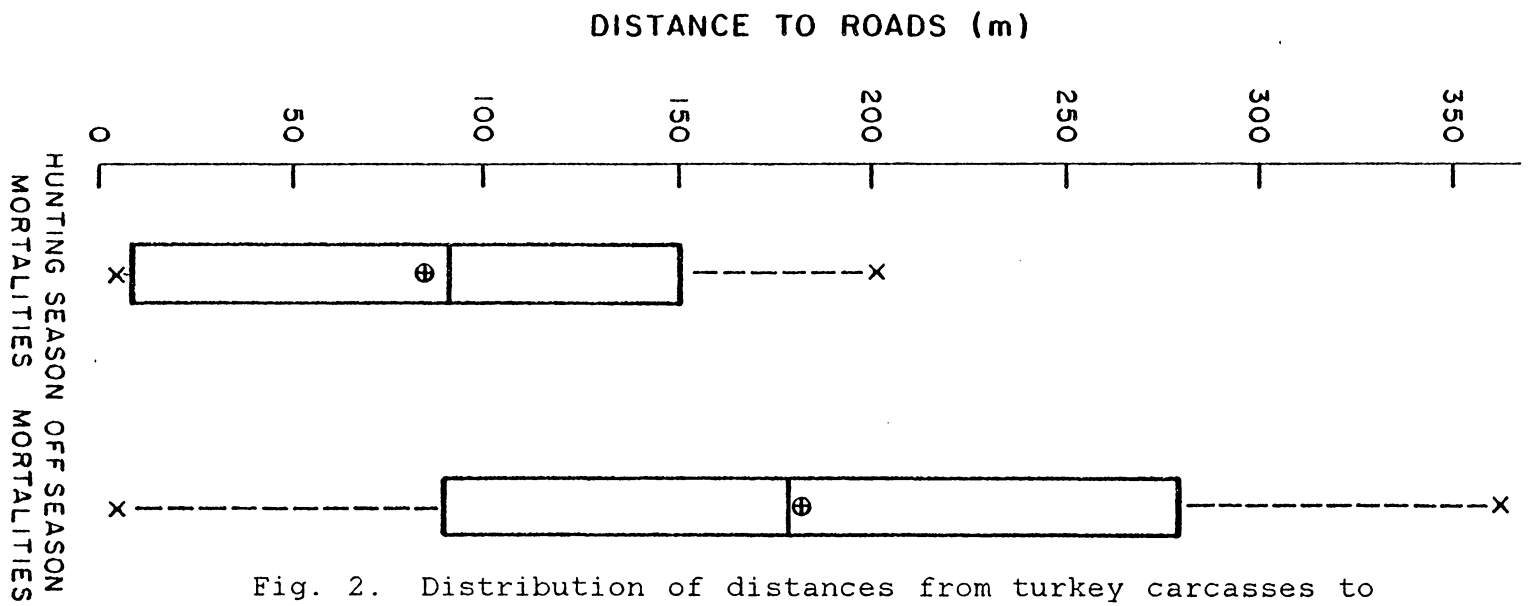

Fig. 2. Distribution of distances from turkey carcasses to the nearest road for hunting season mortalities and off season mortalities near Appomattox, Virginia, 1982-83. Inner horizontal bars represent medians, + represents means, and X's represent extreme data points. N=10 hunting season mortalities and M=8 off-season mortalities.

Table 1. Distance turkey carcasses were found from the nearest road for birds which died in and out of the hunting seasons, Appomattox, Virginia, 1982-83.

	Bird ID	Distance (m)	Sex	Age
Hunting Season Mortalities	G03	150	F	J
	003	80	F	J
	006	4	F	J
	Y03	50	F	A
	B06	150	F	A
	G06	4	M	J
	G02	8	M	A
	Y02	200	M	A
	B09	100	M	A
	011	100	M	A
Out of Season Mortality	B03	200	F	J
	G10	60	F	J
	B10	5	F	J
	010	150	F	A
	009	300	F	A
	G12	250	F	A
	Y09	115	F	A
	W02	360	F	A

patagial tags were only visible at close range and for 8 turkeys that were recovered, caused no abnormal feather wear or other injuries. Only 2 of 234 wild turkeys in Florida showed signs of injuries from transmitter packages (Williams et al. 1978). Transmitters and harnesses did not appear to place poults at a disadvantage. We monitored 1 hen that carried a transmitter for a year after being instrumented as a poult. Fleming (1975) successfully placed 65 g transmitters on poults weighing as little as 1.25 kg.

Adult and juvenile mortality rates were not the highest recorded. In Florida, Williams et al. (1978) reported a 94% harvest in 1 season of heavy hunting pressure. In our study, the prehunting season fall population estimates based on flock counts were similar in 1982 and 1983, despite the high turnover rate. The surviving birds plus their recruitment only accounted for 50% of the 1983 fall population. Thus, approximately 50% of the 1983 fall population appeared to be composed of immigrants. Some immigration was confirmed by movements of instrumented hens from large hardwood areas off the edge of the study area to leave strips and plantations on the area during shifts from winter to prenesting ranges (Holbrook, unpubl. data).

Kolmogorov-Smirnov and Kuiper goodness-of-fit tests strongly indicated that distances from turkey carcasses to roads both in and out of the hunting season had normal distributions ($p > 0.15$). Box plots (Figure 2) further supported normality because of the proximity of means and medians and the lack of outliers for both distributions. Therefore, parametric procedures were appropriate. The data and box plots (Table 1, Figure 1) indicated that nonseason mortalities occurred randomly, while hunting season mortalities were nearer to roads.

Peaks in turkey mortality were coincident with hunting seasons. In addition, the proximity of hunting season mortalities to roads implies that these losses were hunting-related. Exact causes of death were rarely known because carcasses were most often too mutilated or decayed for accurate necropsy. Most likely improper ammunition, such as buckshot, and long-range shooting of "easy" roadside turkeys resulted in a high crippling loss and turnover rate. Road access (13.8 km/1000 ha) as complete as that on our study area appeared to play an important role in number of turkeys killed by hunters and percent of the kill lost as cripples. Based on telemetry data, 4 turkeys may have been crippled per turkey carried out of the woods by a hunter.

It is probable that some of the hunting season mortalities resulted from natural causes and some of the off-season mortalities resulted from poaching. Both possibilities would tend to reduce differences in proximity to roads for the 2 groups.

Summary

Thirty-two wild turkeys were captured with alpha-chloralose and instrumented with radio transmitters. Seventeen were radio-tracked between September 1982 and February 1983, and 21 were radio-tracked between March and August 1983. The annual mortality rate of marked turkeys was 85%; September-February mortality was 65% (N=11), and March-August mortality was 57% (N=12). Ninety-one percent (N=10) of the fall-winter mortalities occurred during a hunting season. Turkeys that died during a hunting season were recovered significantly ($p < 0.05$) closer to roads than those that died outside of the hunting season. A high mortality rate during the hunting seasons and the association of these turkey carcasses with roads suggested that hunter crippling losses may have been as high as 4 birds for every one recovered by a hunter. Extensive road systems (13.8 km/1000 ha) open to public travel seemed to contribute to excessive turnover rates and crippling losses.

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WILD TURKEY HABITAT PREFERENCES AND RECRUITMENT ON INTENSIVELY MANAGED PIEDMONT FORESTS

Abstract.

We investigated wild turkey (*Meleagris gallopavo*) habitat use and recruitment in mixed habits of loblolly pine (*Pinus taeda*) plantations (0-5 years old), hardwood leave strips (60-70 years old), large stands of mixed upland hardwoods (60-70 years old), natural pine stands (30-50 years old), and fields. Seasonal use of these habitats was not different ($p > 0.1$) from their availability. During winter and the prenesting period, turkeys were associated with edges. Turkeys nested in a variety of stand types, near edges, and in heavier cover than was generally available within a stand. Nesting success was 48 percent. Survival for poults after reaching 3 weeks of age was 90 percent.

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Habitat requirements for wild turkeys in the southeast are well documented (Mosby and Handley 1943, The Southeastern Section of The Wildlife Society 1959, Hewitt 1967, Sanderson and Shultz 1973, Halls 1975, Sweeney 1980,

Bromley and Carlton 1981). It is generally accepted that "good turkey habitat contains mature stands of mixed hardwoods, groups of sawtimber sized conifers, relatively open understories, scattered clearings, well distributed water, reasonable freedom from disturbance, and adequate area" (Section 401.11, U.S. Dep. Agric. 1980). Southern industrial forests typically do not provide turkeys with saw timber-sized conifers or an abundance of mature hardwoods. The response of wild turkey populations to forest conversion and intensive pine management is poorly understood.

Whether wild turkeys can adapt to intensive pine management is questionable (Stoddard 1963, Markley 1967, Staffer and Gwynn 1967, Bailey 1980). The notions that turkeys prefer open, mature woods (Bailey and Rinell 1967) and require large timberlands with little human disturbance (Shaw 1959) are not consistent with intensive pine management. However, recent investigations indicate that turkeys may be more adaptable than previously thought. Kennamer et al. (1980) in Alabama found that Coastal Plain turkeys made limited use of young pine plantations, and in Virginia's Piedmont where intensive pine management is widespread (Sheffield 1976), harvest statistics indicate that turkey populations are not declining and may have increased (Virginia Commission of Game and Inland Fisheries 1982).

We investigated the effects of forest conversion on wild turkey recruitment and habitat preferences. In particular, we evaluated the practice of retaining interconnecting hardwood "leave strips" between pine plantations. Our objectives were to evaluate seasonal habitat preferences, nest site selection, nesting success, and brood survival for turkeys on converted forests of the Central Piedmont.

This research was supported by the Virginia Commission of Game and Inland Fisheries, National Wild Turkey Federation, Westvaco, U.S. Fish and Wildlife Service, and the Department of Fisheries and Wildlife Sciences, VPI. E. Jones and B. Jones provided assistance with computer programs. W. Pirie of the Statistical Consulting Services, VPI, helped with statistical analysis.

STUDY AREA

The study area consisted of 2212 ha and 3674 ha tracts of intensively managed forest land in the Central Piedmont about 20 km north of Appomattox, Virginia. Seventy percent of the former was converted to pine beginning in 1974, and 50 percent of the latter was converted beginning in 1978. Plantations ranged from 4 ha to 52 ha in size. Interconnecting hardwood leave strips from 20 m to 200 m wide were retained between pine plantations along the

drainages and steep slopes. Each tract contained 0- to 5-year-old loblolly pine (Pinus taeda) plantations, 60- to 70-year-old hardwood leave strips and large hardwood stands, 40- to 50-year-old pine stands, and fields. Adjacent properties consisted of large (≥100 ha) hardwood stands, blocks of mature pines, and scattered fields. Turkey densities were 1 per 40 ha on the larger unit and 1 per 80 ha on the smaller unit (Holbrook, unpubl. data).

METHODS

We captured 55 wild turkeys with alpha-chloralose (Williams 1966, Williams et al. 1966) and equipped 32 with 75 g radio transmitters (Telonics, Inc.). Each captured turkey was marked with a patagial tag (Allflex cattle ear tag) (Wallace et al. 1980, Knowlton et al. 1964) and an aluminum leg band before release at the capture site.

We monitored turkeys with a hand-held, 2-element yagi antenna and a portable receiver. Preliminary fixes were taken to allow the observer to move close to a turkey prior to taking 2 recorded fixes for triangulation. Locations were discarded later if the angle formed by intersecting fixes was less than 45° (Springer 1979) or if the fixes were taken more than 15 minutes apart. Consecutive locations for an individual turkey were separated by at least 1.5 hours.

Turkey locations were plotted by program TELEM on digitized type maps of the study area (Koeln 1980). TELEM also calculated home ranges by the convex polygon method (Mohr 1947) and located geometric centers of activity.

Habitat availability was estimated using the distance from the geometric center to the outer most location of a seasonal home range as the radius of a circle of availability (Fig. 1). Habitats within this circle were ranked by area, and habitat use was ranked by percentage of locations falling in each stand type. Locations that fell on edges were divided equally between the stand types involved. Importance of edge was evaluated by comparing distances from turkey locations to edge with distances from random points to edge (Marcum and Loftsgaarden 1980). Edges were defined as road within any one stand type as well as the boundary between 2 stand types. The junction between pine and hardwood types was the most common edge.

Nests were located by circling instrumented nesting hens at 25 to 50 m, marking points along the circle, and recording the compass bearing from the points to the hen. After a clutch was hatched or abandoned, the nest was found by searching near the intersection of the bearings.

Habitat parameters measured at the nest site and at randomly selected points within the same stand included

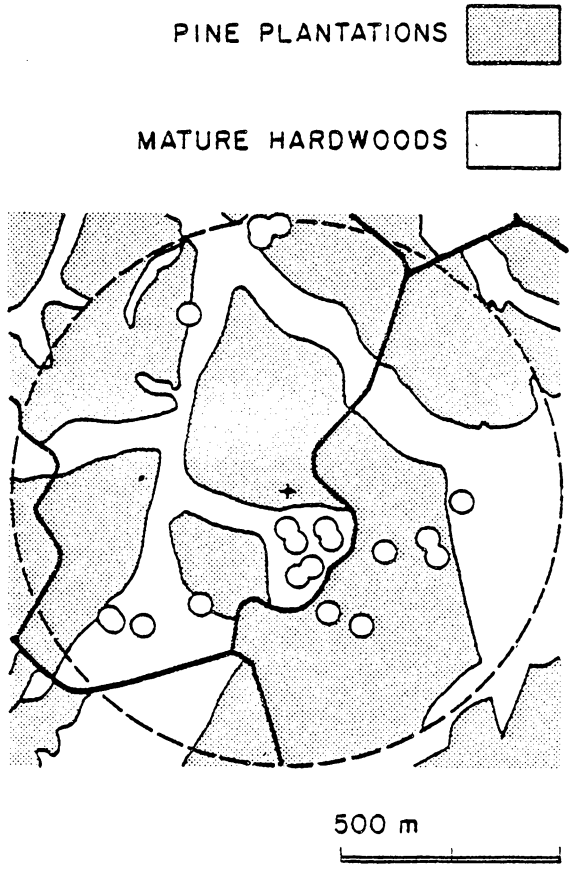

Fig. 1. Circle of seasonal habitat availability with the radius equal to the distance from the geometric center of the home range to the most distant perimeter point. Open circles represent turkey locations. Heavy lines represent roads.

canopy height, canopy depth (distance from top of canopy to midstory), percent slope, aspect, canopy density (Lemmon 1956), horizontal cover density (0-2 m height), ground cover, number of stems (within a 0.004 ha circle), distances to nearest horizontal and vertical cover, and distances to water and travel corridors.

Nests were considered successful if any poults hatched. Nesting success and brood survival for poults 3 weeks old or older were calculated as described by Mayfield (1975). This method calculates nest and poult mortality rates by dividing the total number of losses by the total number of nest or poult-days (one nest or one poult for one day; Mayfield 1975).

STATISTICAL ANALYSIS

Habitat use was compared to availability with an F statistic (Johnson 1980). We used a Wilcoxon Rank Sum to test the null hypothesis of no difference between winter and prenesting home ranges or between winter and summer home ranges in the percent use of any particular stand type. Kolmogorov-Smirnov and Kuiper goodness-of-fit tests were used to test normality of nest site selection data. We used Wilcoxon Signed Rank to test the null hypothesis of no difference in cover around nests and around random points.

RESULTS

Habitat Use

Fall dispersals (distance from capture sites to geometric centers of winter ranges) (N=15) averaged 3.2 ± 2.9 (SD) km, spring dispersals (distance from geometric center of winter ranges to that of summer or prenesting ranges) (N=8) for gobblers and nonnesting hens averaged 2.9 ± 2.6 km, and 1.9 ± 1.6 km for prenesting hens (N=10). Winter (January to April) home ranges (N=9) were 175 ± 142 ha, summer (June to September) home ranges (N=8) were 280 ± 248 ha, and prenesting (hen flock break-up to hatching or nest abandonment) ranges were 102 ± 99 ha.

Use was not different ($p > 0.1$) from availability for any stand type during the winter ($F=1.62$), prenesting ($F=1.18$) or summer ($F=1.54$) seasons (Table 1). Intensity of leave strip use did not vary by stand width ($p > 0.1$) (Table 2) for winter ($F=0.62$), prenesting ($F=1.51$), or summer ($F=1.02$) seasons. Percent use of large hardwood stands, hardwood leave strips, and pine plantations did not change from the winter to prenesting ranges ($p > 0.1$) or from winter to summer ranges of gobblers and nonnesting hens ($p > 0.4$). Winter locations for all turkeys ($\bar{X}=93.6\pm106.2$ m) and prenesting locations for hens ($\bar{X}=75.2\pm162.8$ m) were closer ($p <0.005$) to edges than random locations ($\bar{X}=246.2\pm295.9$ m), while summer locations of adult turkeys were not ($p > 0.1$).

Table 1. Mean values of seasonal stand type use and availability in 1983 on intensively managed pine forests of Virginia's Central Piedmont. Values are percentages with standard deviations in parentheses. Tests were performed with use and availability data for individual turkeys (prenesting) and flocks (winter and summer).

Seasonal use and availability	N	Large hardwoods	Hardwood leave strips	Pine plantations	Fields	Mature Pines
Use-Winter	9	58.3(43.2)	20(25.1)	17.8(22.2)	1.8(3.7)	2.9(6.7)
Available-Winter	9	46.3(32.8)	24.4(23.2)	20.6(18.9)	7.9(10.8)	0.7(0.9)
Use-Prenesting	10	51.8(44.1)	17.4(21.7)	28.3(28.6)	2.5(5.7)	0 (0)
Available-Prenesting	10	44.5(32.5)	20.7(16.6)	26.7(24.3)	7.1(8.5)	1.3(2.1)
Use-Summer	8	61.6(29.1)	18.4(23.2)	6.9(7.4)	7(10.4)	6.1(8.4)
Available-Summer	8	50.5(26.7)	16.4(15.4)	19.5(21.9)	9(14.0)	3.4(5.6)

Table 2. Mean values of seasonal hardwood width class use and availability in 1983 on intensively managed pine forests of Virginia's Central Piedmont. Values are percentages with standard deviations in parentheses. Tests were performed with use and availability data for individual turkeys (prenesting) and flocks (winter and summer).

Seasonal use and availability	N	0 - 40	40 - 80	80 - 160	160 - 320	>320
Use-Winter	9	0(0)	6.3(11.5)	14.1(20.7)	14.1(21.6)	65.4(43.1)
Available-Winter	9	1.8(2.0)	6.6(7.2)	15.7(21.6)	15.6(13.0)	60.3(38.3)
Use-Prenesting	10	7.4(13.2)	24.6(29.6)	8.4(12.8)	0.7(2.2)	58.9(47.3)
Available-Prenesting	10	3.5(4.7)	11.7(13.7)	14(16.0)	5.7(10.1)	65.1(35.2)
Use-Summer	8	1.1(2.1)	4.3(7.4)	9.4(18.0)	8.5(12.4)	77.1(26.0)
Available-Summer	8	1.9(2.7)	5.9(8.3)	11.6(15.9)	8.8(12.1)	71.9(26.2)

Mean width of hardwood stands in meters.

During the early brood rearing period, hens with poults (N=4) moved along hardwood leave strips and the edges of large hardwood stands and pine plantations. Young broods used both pines and hardwood types. However, within 3 weeks of the hatch, all hens still with broods (N=3) shifted ranges. One hen died 4 weeks after the hatch and a second dropped her transmitter shortly after shifting ranges. The remaining hen established a summer brood range along a road (Fig. 2). During winter, she averaged 506±214 m (N=20) from a road, but only 69±77 m (N=38) during summer.

Nest Site Selection

Nesting occurred in loblolly pine plantations (N=1), large hardwood stands (N=3), hardwood leave strips (N=3), and thinned pine stands (N=3). Nests were closer ($p < 0.025$) to edges than random locations. Canopy density, canopy depth, canopy height, distance to travel corridors, distance to open water, and stem counts at nest sites and at randomly selected sites were not different ($0.3 < p < 0.5$). Understory cover was heavier around nests than generally available in the stand (Table 3).

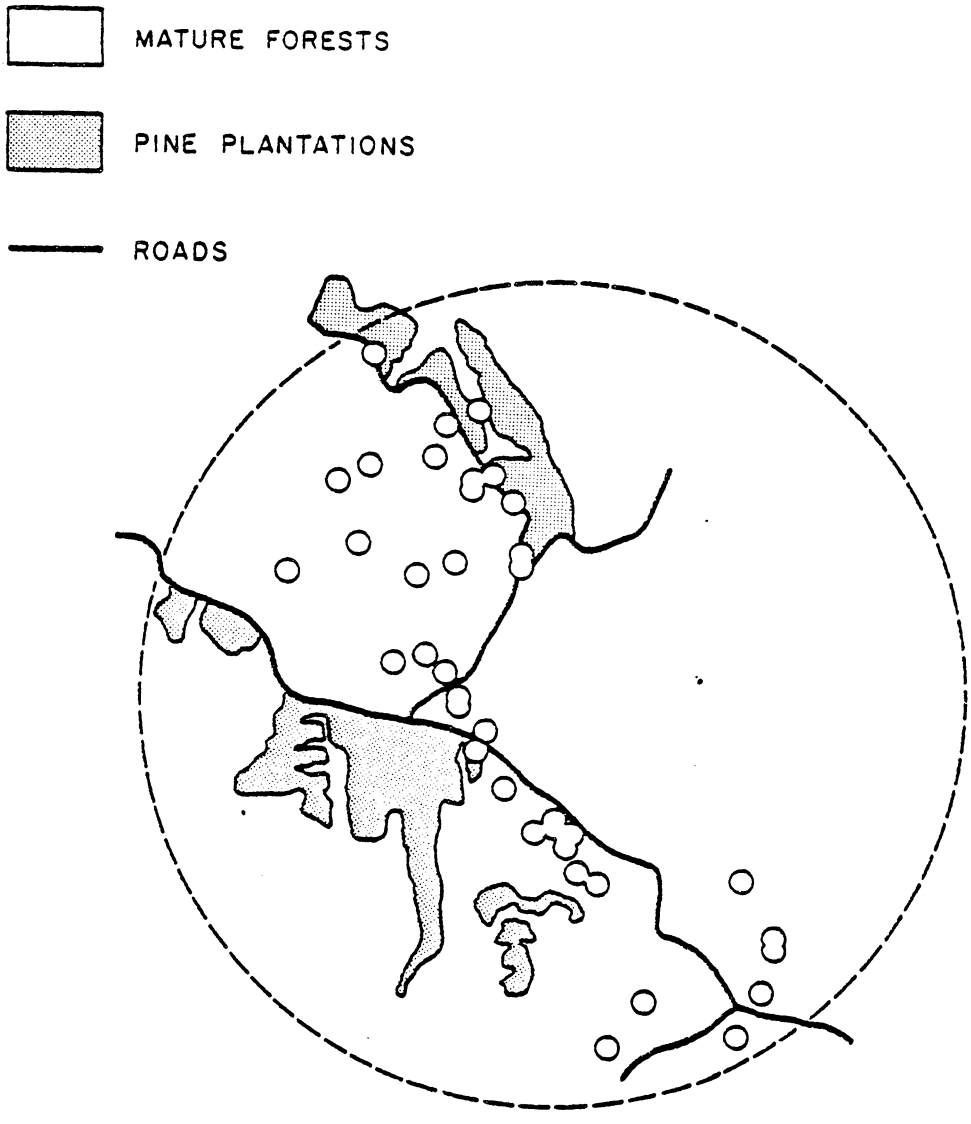

Fig. 2. Locations of hen and brood activities along a road on intensively managed forests of Central Virginia, summer 1983. The average distance from locations to the road was 69 m.

Table 3. Significant nest site selection parameters in 1983 for turkeys on intensively managed forests in the Virginia Piedmont.

Variable	Mean difference between nests and random points	P-value	90% two-sided CI on paired differences
Distance to nearest vertical cover	-2.98	<0.01	(-4.22, -1.74)
Distance to nearest horizontal cover	-0.17	<0.01	(-0.27, -0.06)
Cover profile 0-0.2 m strata	11.89	<0.10	(-2.48, 26.25)
Cover profile 0.2-0.4 m strata	22.93	<0.01	(14.48, 31.37)
Cover profile 0.6-0.8 m strata	11.39	<0.01	(5.29, 17.49)
Cover profile 1.4-1.6 m strata	13.74	<0.05	(0.25, 13.49)
Volumetric estimate of cover 0-1 m	14.61	<0.01	(6.9, 22.31)
Volumetric estimate of cover 1-2 m	6.56	<0.05	(-0.14, 13.26)
Ground coverage	17.18	<0.01	(5.7, 28.66)

Distances are in meters, and cover is expressed as percent of a density board or a 2 m^3 space around the nest filled with vegetation. Negative values indicate that nests were closer to cover than were random points; positive values indicate that vegetation was heavier around the nest than around random points.

Based on a Wilcoxon signed rank test for paired design.

Bounds on the paired differences that include zero result from using one-sided tests and two-sided confidence intervals for bounds on the paired differences.

Nesting Success and Brood Survival

Probability of a successful nest (Mayfield 1975) (N=163 nest-days) was 48% (95% CI 39-57%). Two of 4 broods were lost within 3 weeks of the hatch. After the first 3 weeks, the probability of a poult surviving to September was 90% (95% CI 87-92%).

DISCUSSION

Study area boundaries rarely represent true habitat availability for free ranging animals, so availability was defined around the seasonal centers of activity for individual flocks or birds. A circle around the geometric center was our best method of defining the available area. The nonparametric ranking for testing use versus availability best accounts for arbitrariness in delineating habitats available to animals (Johnson 1980).

Most turkeys used habitats in proportion to availability. Some showed preferences, but no 2 turkeys showed the same preferences. Individual variation in home range sizes and dispersal distances and use of habitats in proportion to their availability suggest that the wild turkey is highly adaptable. However, the way industrial forests and surrounding lands are managed may impact turkey use of intensively managed tracts.

Relative amounts of pine and hardwoods, plantation age classes, and degree of interspersion between pines and hardwoods may limit the capability of intensively managed forest land to support turkeys. Plantations on the smaller unit of the study area averaged 4 years older than those of the larger unit. The smaller tract also had 20% more plantations, 50% fewer hardwood stands on surrounding properties, and 50% fewer turkeys. In Alabama, Kennamer et al. (1980) found that use of 0.5-12 year-old plantations was less than availability, while natural pine stands (>21 years old) were used in excess of availability. Lower use of these older plantations may reflect a reluctance by turkeys to enter exceedingly thick vegetation, since dense understory is not suitable turkey habitat (Holbrook and Lewis 1967, Bailey and Rinell 1967).

Gehrken (1975) believed that turkey populations can exist on intensively managed pine forests if quality habitat is maintained in corridors, permitting turkeys to travel over large areas. Adult turkeys on our study area readily traveled in leave strips and pine plantations. Extensive use of both stand types demonstrated that at the mix available on our study area, both are suitable habitats.

Proximity of winter and prenesting ranges to edge suggests that a high level of interspersion is important.

The value of edge in the winter is unknown but may reflect a reduced energy expenditure of living near a variety of resources instead of moving long distances to meet daily needs. However, mobility of turkeys reduces the importance of juxtaposition of different resources. The association of prenesting ranges with edges is likely related to the assocation of nests with edges. Edge provides a variety of resources for the less mobile incubating hens. Incubating hens in Alabama typically restricted their movements to within 100 m of the nest (Hillestad and Speake 1970). Edges may also provide desirable nesting cover because understory density is increased through increased lighting and/or the addition of logging slash.

Turkey hens appeared to select nesting cover by understory characteristics. Cover below the 2 m level was denser around nest sites than randomly selected sites with differences greater at the 0-1 m level than at the 1-2 m level. A Theil (Hollander and Wolfe 1973) regression between stem counts and cover showed a nonsignificant ($0.15 < p < 0.20$) negative relationship with stem counts, decreasing (slope = -0.22) as total vegetation cover increased. There was a positive relationship ($p < 0.04$) between stem counts and cover at random points with stem counts increasing (Slope = 0.1) as total cover increased.

Thus, hens selected nest sites where they were concealed but not impeded in moving off of the clutch. With one exception, hens had multiple avenues of escape from their nests.

Differences between nests and random points in habitat parameters other than understory cover were not significant. In Georgia, Hon et al. (1978) found turkey nests near game trails, fire breaks, or other travel lanes. In xeric areas, water appears to influence nest placement (Cook 1972). Abundance of small creeks and travel lanes may have negated their importance in Piedmont Virginia.

Nesting success was calculated by the Mayfield (1975) method rather than by dividing the number of successful nests by the number of known nesting attempts because the former is not influenced by losses of undiscovered nests. Nests were lost from predation by egg predators, predation on the nesting hen, and unknown reasons. The sample size was insufficient to test differences in nesting success for different stand types. However, edges between pine plantations and hardwoods may have been the most productive nesting areas. All three hens that nested in hardwood leave strips were successful. The 48% nesting success was similar to earlier Virginia data where 47.5% of the nests investigated were successful (Mosby and Handley 1943).

Counts of individual poults were not possible during the first 3 weeks because of difficulties in tallying young poults in some habitats, thus onlly losses of entire broods were recorded. Poult mortality followed the pattern observed in previous studies (Glidden and Austin 1975, Everett et al. 1980) with most mortalities occurring in the first 3 weeks. The summer poult mortality rate of 10% was similar to the morality rate suffered by adults (Holbrook, unpubl. data).

MANAGEMENT IMPLICATIONS

The finding that wild turkeys used pine plantations, leave strips, and adjacent hardwood areas in proportion to their availability underlines the adaptability of the bird and has implications for turkey habitat management on intensively managed pine forests. Contentions that conversion of mixed hardwoods to loblolly pine stands would eliminate wild turkey habitat are not supported by our research. However, the management practices on our study area are not typical of most Piedmont commercial forest lands. On southern pine forests that are being managed with turkey habitat as an additional objective, management practices should include retaining hardwood leave strips between pine plantations. Although habitats were used in

proportion to availability, interconnecting leave strips insure a high level of interspersion between pine and hardwood stand types. The abundance of edge encourages use by turkeys during the winter and prenesting seasons and provides quality nesting and early brood rearing habitat.

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APPENDIX TABLES

Table 1. Recovery times for turkeys captured with 2 g alpha-chloralose per 0.25 l of cracked corn.

Sample	Poult recovery time (days)	Adult recovery time (days)
1	1.2	1.3
2	1.2	2.6
3	1.0	1.9
4	1.0	2.6
5	1.0	2.6
6	1.0	2.0
7	1.1	2.0
8	1.0	2.1
9	1.1	2.1
10	1.0	2.6
11	1.0	2.3
12	1.0	2.3
13	1.0	2.0
14	1.0	2.0
15	1.0	1.9
16	1.0	2.1
17	1.0	2.5
18	0.9	2.5
19	0.9	2.5
20	1.0	1.9
21	1.0	1.9

Table 1. continued.

Sample	Poult recovery time (days)	Adult recovery time (days)
22	1.0	1.9
23	1.3	1.9
24	1.5	1.9
25	1.5	2.0
26	1.5	2.0
27		2.0
28	—	2.0
	x=1.08	x=2.12

Table 2. Stand type percent use [a] and availability [b] for wild turkeys on intensively managed pine forests in the Virginia Piedmont, winter 1983.

Flock	Large hardwood stands	Hardwood leave strips	Pine Plantations	Fields	Mature Pines
a					
505	69	2	0	27	2
402,212	79	0	0	21	0
210-309	76	9	8	5	1
202	3	56	41	0	0
102	11	51	38	0	0
501,209,109	36	25	36	1	2
502	7	50	42	0	1
101	53	27	20	0	0
111	83	0	0	17	0
b					
505	88	0	0	6	6
402,212	100	0	0	0	0
210-309	72	11	17	0	0
202	0	67	33	0	0
102	0	43	57	0	0
501,209,109	67	6	7	0	20
502	8	46	46	0	0
101	100	0	0	0	0
111	90	0	0	10	0

Table 3. Stand type percent use [a] and availability [b] for wild turkeys on intensively managed pine forests in the Virginia Piedmont, prenesting range 1983.

Hen	Large hardwood stands	Hardwood leave strips	Pine Plantations	Fields	Mature Pines
a					
211	4	40	56	0	0
509	20	34	46	0	0
212	79	0	0	16	5
402	83	0	0	17	0
510	0	37	63	0	0
309	55	13	23	8	1
110	71	16	13	0	0
511	13	41	46	0	0
210	73	0	0	22	5
410	47	23	20	8	2
b					
211	0	35	65	0	0
509	0	62	38	0	0
212	83	0	0	17	0
402	92	0	0	8	0
510	0	37	63	0	0
309	87	0	13	0	0
110	67	17	16	0	0
511	6	23	71	0	0
210	100	0	0	0	0
410	83	0	17	0	0

Table 4. Stand type percent use[a] and availability[b] for wild turkeys on intensively managed pine forests in the Virginia Piedmont, summer 1983.

Flock	Large hardwood stands	Hardwood leave strips	Pine Plantations	Fields	Mature Pines
a					
111	61	0	4	13	22
505	47	29	0	14	10
211	84	4	12	0	0
410	72	0	0	28	0
511	0	69	17	0	14
409	95	5	0	0	0
209	59	24	17	0	0
501	75	16	5	1	3
b					
111	75	0	3	6	16
505	58	2	0	31	9
211	69	17	13	1	0
410	58	0	0	32	0
511	4	41	54	0	1
409	77	14	9	0	0
209	45	27	27	1	0
501	18	30	50	1	1

Table 5. Hardwood stands width class percent use [a] and availability [b] for wild turkeys on intensively managed pine forests in the Virginia Piedmont, winter 1983.

Flock	0-40 m	40-80 m	80-160 m	160-320 m	>320 m
a					
505	0	0	0	0	100
402,212	0	0	0	0	100
210-309	0	0	14	11	75
202	0	7	40	53	0
102	0	17	17	49	17
501-109	0	0	0	14	86
502	0	33	56	0	11
101	0	0	0	0	100
111	0	0	0	0	100
b					
505	1	1	4	13	81
402,212	0	2	0	0	48
210-309	1	2	3	4	90
202	3	19	36	37	5
102	3	14	44	22	17
501-109	6	3	3	15	73
502	2	15	52	19	12
101	0	2	0	30	68
111	0	1	0	0	99

Table 6. Hardwood stands width class percent use [a] and availability [b] for wild turkeys on intensively managed pine forests in the Virginia Piedmont, prenesting range 1983.

Hen	0-40 m	40-80 m	80-160 m	160-320 m	>320 m
a					
211	14	72	7	7	0
509	10	45	35	0	10
212	0	9	0	0	91
402	0	0	0	0	100
510	8	75	17	0	0
309	0	0	0	0	100
110	0	20	0	0	80
511	42	25	25	0	8
210	0	0	0	0	100
410	0	0	0	0	100
b					
211	7	9	53	22	9
509	5	24	12	0	59
212	0	2	8	0	90
402	0	3	0	0	97
510	14	45	13	26	2
309	1	8	12	0	79
110	1	8	4	9	78
511	7	15	29	0	49
210	0	0	0	0	100
410	0	3	9	0	88

Table 7. Hardwood stands width class percent use [a] and availability [b] for wild turkeys on intensively managed pine forests in the Virginia Piedmont, summer 1983.

Flock	0-40 m	40-80 m	80-160 m	160-320 m	>320 m
a					
111	0	0	0	0	100
505	4	0	48	19	29
211	5	0	0	0	95
410	0	0	0	0	100
511	0	21	26	0	56
409	0	5	0	0	95
209	0	8	0	31	61
501	0	0	1	18	81
b					
111	0	1	0	0	99
505	2	0	10	25	63
211	1	1	4	6	88
410	0	1	0	0	99
511	7	24	47	0	22
409	0	2	13	0	85
209	0	7	0	30	63
501	5	11	19	9	56

Table 8. Mean values for habitat parameters measured at the nest site and at random points around each nest for 10 turkey hens in Piedmont Virginia, 1983.

Variable	Nest site mean[1]	Random point mean[1]
Ground coverage	60.5	43.1
Distance to vertical cover	0.5	3.3
Distance to horizontal cover	0.3	0.4
Distance to travel lane	27.0	27.3
Slope	16.4	18.5
Canopy height	18.1	18.1
Canopy depth	5.8	6.0
Canopy density	59.5	59.5
Volumetric estimate of cover 0-1 m	30.5	15.9
Volumetric estimate of cover 1-2 m	9.2	3.0
Cover profile 0-0.2 m	46.1	35.7
Cover profile 0.2-0.4 m	41.9	19.2
Cover profile 0.6-0.8 m	18.1	6.6
Cover profile 1.0-1.2 m	6.3	3.2
Cover profile 1.4-1.6 m	7.6	2.2
Cover profile 1.8-2.0 m	4.7	2.4
Total stem count (<7.6 cm)	69.8	57.6
Total stem count (7.6-15.2 cm)	3.3	2.4

[1] Distances are in meters, slope is expressed as a percent, and cover is expressed as percent of a density board or a 2 m^3 space around the nest filled with vegetation.

Table 9. Correlation data for stem counts and vegetational volume at nest sites and random points on Piedmont industrial forests, 1983.

Random Points		Nest Sites	
Stem counts	Vegetational volume	Stem counts	Vegetational volume
18.00	11.67	96	48.75
45.80	11.98	42	23.33
57.80	19.50	35	47.50
69.90	29.10	16	47.50
62.00	13.10	110	20.00
81.70	18.11	76	35.00
35.42	8.75	41	4.00
101.00	16.16	106	22.00
59.34	16.21	92	23.75
45.16	14.88	84	32.50

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