170
51

Wild Turkey-Road Interactions on a Virginia National Forest.

by

Leigh Ann McDougal

Thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Fisheries and Wildlife Science

APPROVED:

Michael R. Vaughan, Chairman

Peter T. Bromley

Robert H. Giles, Jr.

David W. Smith

November 1990

Blacksburg, Virginia

Wild Turkey-Road Interactions on a Virginia National Forest.

by

Leigh Ann McDougal

Michael R. Vaughan, Chairman

Fisheries and Wildlife Science

(ABSTRACT)

I studied wild turkey *(Meleagris gallopavo)* movements and range use in response to roads and vehicular road use on the George Washington National Forest, Virginia. Radio-equipped wild turkeys used areas within 150 m of state roads less than expected and areas > 450 m from all roads greater than expected. Turkeys were observed to cross state roads only in locations where the roads were bordered by woods or fields less than 80 m wide. Seasonal habitat preferences, rather than vehicular road use levels, seemed to dictate turkey use of the area surrounding Forest Service roads. Revegetated Forest Service roads were preferred habitat in the spring and summer. Turkey mortality was not closely related to road type or road use levels.

Acknowledgements

I would like to thank the following persons and groups:

Members of my graduate committee; Drs. Mike Vaughan, Pete Bromley, Robert Giles, Jr. and Dave Smith, for their help, guidance, and patience during this project.

My technicians, Forest Service personnel, Deerfield residents and other volunteers who helped me with my field work, especially Louise Graham, Wayne Williams, Wiley Sale and Dave Gilbert.

All the students, technicians, and friends who helped me while I was a graduate student. Blair and Erica Jones for computer wizardry and horse-back riding; Martin O'Connell, for running numerous errands for me; Roy Smoger, for excellent room and board; the Gourmet Club, for sumptuous meals; and Close and Play, for musical entertainment.

This study was supported cooperatively by the U.S. Forest Service; Virginia Department of Game and Inland Fisheries; the U.S. Fish and Wildlife Service; the National Wild Turkey Federation; the Virginia Wild Turkey Federation; and the Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University.

Table of Contents

INTRODUCTION 1

LITERATURE REVIEW 3

Road disturbance 3

Turkeys and disturbance 7

Turkeys and roads 10

STUDY AREA 12

METHODS 15

Study period 15

Trapping and marking 15

Telemetry data collection and analysis 18

RESULTS AND DISCUSSION 25

Mortality 39

Nesting 47

Road use 49

Response to roads 49

SUMMARY 59

LITERATURE CITED 62

List of Tables

Table 1. Habitat categories near Deerfield, Virginia. 1985-1987. 21

Table 2. Length of roadtypes A, B, C, and D found within each turkey convex polygon homerange near Deerfield, Virginia, 1985-1987. 24

Table 3. Road-zone categories used for wild turkey use/availability analysis, Deerfield, Virginia. 28

Table 4. Habitat categories, with road-type E zones included, used for wild turkey use/availability analysis. 31

Table 5. Wild turkey trapping, tagging, and release data from 11 sites near Deerfield, Virginia, 1985-1987. 33

Table 6. Radio-equipped wild turkey mortality data near Deerfield, Virginia, September 1985- August 1987. 38

Table 7. Minimum convex polygon homeranges for turkeys that were followed at least 6 months near Deerfield, Virginia, 1985-1987. 40

Table 8. Monthly and annual survival rates of radio-marked female turkeys near Deerfield, Virginia, 1985-1987. 42

Table 9. Monthly and annual survival rates of radio-marked male turkeys near Deerfield, Virginia, 1985-1987. 43

Table 10. Number of nests and dead turkeys located within each road-zone near Deerfield, Virginia, 1985-1987. 46

Table 11. Nesting data for radio-equipped wild turkey hens near Deerfield, Virginia, 1986-1987. 48

Table 12. Road-zone use vs. road-zone availability for wild turkeys near Deerfield, Virginia, 1985-1987. 52

Table 13. Road-zone use vs. road-zone availability for male wild turkeys near Deerfield, Virginia, 1985-1987. 53

Table 14. Road-zone use vs. road-zone availability for female wild turkeys near Deerfield, Virginia, 1985-1987. 54

Table 15. Percentage of each habitat type found within each road-zone type near Deerfield, Virginia, 1985-1987. 56

List of Illustrations

Figure 1. Wild turkey study area location in Augusta, Bath, and Rockbridge counties, Virginia, 1985-1987. 13

Figure 2. Wild turkey study area location near Deerfield, Virginia, 1985-1987. 14

Figure 3. Four road types on the Deerfield, Virginia, study area, 1985-1987. 16

Figure 4. Habitats in the Deerfield, Virginia, study area, 1987. 22

Figure 5. Zones created around road types A, B, C and D in the Deerfield, Virginia, study area. 26

Figure 6. A section of the zones created around road types A, B, C and D in the Deerfield, Virginia, study area. 27

Figure 7. The composite convex polygon homerange of all radio-marked turkeys within the Deerfield, Virginia, study area. 29

Figure 8. Map of the habitat types in the Deerfield, Virginia, study area with 150m type E road-zones included. 30

Figure 9. Wild turkey trap sites and the number of turkeys caught at each site, 1985-1987, near Deerfield, Virginia. 32

Figure 10. Sample data set of radio-marked wild turkey locations, n = 1585, near Deerfield, Virginia, 1985-1987. 35

Figure 11. Convex polygon homeranges for wild turkeys followed at least 6 months near Deerfield, Virginia, 1985-1987. 41

Figure 12. Radio-equipped turkey nests and mortalities found in each road-zone category near Deerfield, Virginia, 1985-1987. 45

Figure 13. Average monthly road use for Forest Service roads open year around on the Deerfield, Virginia, study area, 1985-1987. 50

Figure 14. Average monthly road use for Forest Service roads open seasonally on the Deerfield, Virginia, study area, 1985-1987. 51

Figure 15. Seasonal habitat availability and use by wild turkeys within the Deerfield, Virginia, study area, 1985-1987. 60

INTRODUCTION

Roads are an integral part of forest management on most National Forests. On the George Washington National Forest (GWNF), Virginia, roads provide access for resource management and recreational uses. In 1986, the GWNF published its *Final Land and Resource Management Plan and Environmental Impact Statement*, hereafter the Plan, for the following 10 years (U.S. Department of Agriculture 1986). According to the Plan, the current road system was inadequate to manage the forest resources and 919 km of roads were planned for construction or reconstruction. Approximately 90 percent of the roads constructed would have been closed to public vehicle access after the associated resource activities were completed. Because of unresolved public appeals, the Plan was remanded to the GWNF in 1989 to be rewritten.

In 1986, 85 percent of the GWNF was already accessible, within 1.6 km, by a road (Goetz, pers. comm.). However, the impact of these roads and their use on wild animal populations in the GWNF was unknown. Review of the Plan revealed that the public thought the GWNF should know the effects of resource activities on wildlife species in order to make proper plans for use of the land without losing the wildlife resource. In response to public opinion, one of the research needs listed in the Plan was to determine the effects of roads and road management policies on wildlife species during all stages of their life cycles. The wild turkey was the first species chosen to be studied because of its importance as a Virginia game species and it was thought to be sensitive to environmental alterations and human disturbance.

Human disturbance has been recognized as an important factor affecting wild turkey populations (Folk and Marchinton 1980). In the past, the eastern wild turkey was considered a semi-wilderness species requiring a large, remote range with a minimum of human activity (Mosby and Handley 1943, Wheeler 1948, Latham 1956, Stoddard 1963, Bailey and Rinell 1968). More recent studies suggest that wild turkeys have greater tolerance to disturbance and restricted range than previously thought (Wunz 1971, Williams et al 1971, Folk and Marchinton 1980, Hayden 1980, Clark 1985, Wunz 1985).

Little is known about the affects of roads on turkey populations. Bailey and Rinell (1968) thought that areas in West Virginia with less than 2.5 km of open road per 1000 ha supported the best turkey populations. Several researchers have noted the lack of turkeys near highways (Michael 1978, Adams and Geis 1981). Wright and Speake (1975) reported that turkeys avoided areas of high human activity at Land Between the Lakes, Kentucky. Holbrook and Vaughan (1985) reported that radio-marked turkeys found dead in Virginia during the hunting season died closer to roads than turkeys found dead at other times of the year. They suggested that the extensive open road system (13.8 km/1000 ha) in their study area played an important role in the numbers of turkeys killed by hunters and the percentage of kills lost as cripples.

Forest roads can be beneficial to wild turkeys. In heavily forested areas, roads provide openings which turkeys may use for nesting, dusting, loafing or feeding (Mosby and Handley 1943). It is not unusual for wild turkey nests to be within 15m of little traveled roads (Mosby and Handley 1943, Williams 1981, Porter et al. 1983, Speake and Metzler 1985). Gobblers sometimes use roads as strutting areas in the spring (Holbrook and Lewis 1967) and some roads are important sources of grit. Logging roads planted to grasses and other wildlife food plants provide summer brood range and insect foods (Mosby and Handley 1943, Bailey and Rinell 1967).

Thus it appears that roads may affect wild turkey populations in some areas. This study was designed to determine the relationship between wild turkeys, roads and vehicular road use on an area of the GWNF. To do so we sought to:

1. Measure response of wild turkeys to road types throughout the year.
2. Determine how vehicular road use influences wild turkey area use.
3. Determine if turkey mortality is influenced by road type and road use levels.

LITERATURE REVIEW

Little is known about the effects of roads on wildlife populations. Early research on the subject was devoted primarily to mortality of animals along roadways (Haugan 1941, McClure 1951). In the last 2 decades, many other road-related wildlife topics have begun to be studied. Much of this work has involved highways (Van Der Zande 1980, Ferris 1979, Adams and Geis 1981, Leedy 1975).

Road disturbance

Animals may avoid the vicinity of a road when selecting nesting or feeding sites because of disturbances resulting from road use. Disturbances may include noise, dust, car exhaust fumes, headlight beams, increased salinity in the soil, vegetation and ditches, and visual stimuli (Mader 1984). DeLeonardis (1970), writing of the potential impacts of the Alaska pipeline/road development, thought that although the actual physical "take out" of habitat needed for the road was relatively insignificant, human activity might influence a much larger area. Researchers have begun to study which animals are disturbed by roads and how much habitat becomes unavailable to these animals because of the disturbance.

Elk *(Cervus elaphus)* have been the focus of much research on road influences. The elk is an important western game species and many states are concerned that the elk population is declining due to increased road construction. Declines in use of habitat adjacent to forest roads have been documented in studies of the elk on most of its range (Lyon 1983). Vehicular traffic on forest roads in Montana evoked an avoidance response by elk and use of potential habitat declined as road density increased (Lyon 1983). Elk avoided both county roads and interstate highways in Oregon (Adams and Geis 1981). In Washington, Perry and Overly (1976) concluded that more than 161 ha of habitat per km of road could be negatively affected. They also found that main roads had a larger sphere of influence than primitive roads. Witmer (1982), in Oregon, recorded a zone of elk aversion 245 m on each side of paved roads and 60 m on either side of non-paved roads. However, Burbridge and Neff (1975) believed that vehicles moving rapidly on highways in Arizona were less disturbing to elk than vehicles moving slowly, although less often, on primitive roads. Elk became much more wary when people were involved in out-of-vehicle activities (Ward 1975). They seemed to be more averse to timber harvest operations than to traffic on logging roads (Ward 1975). Rost and Bailey (1979) found that mule deer *(Odocoileus hemionus)* and elk in Colorado avoided roads, but so many other factors were involved that they could not pinpoint a reason for the avoidance. With current road densities in Arizona, the habitat value of almost every acre of elk habitat could be reduced (Davis 1982).

According to Bailey (1976), there is often a decline or extinction of the wilder varieties of forest game following the construction and public use of roads. The impact of increased traffic flow on species with a low tolerance for humans may be even more important than direct mortality or immediate removal of habitat (Michael 1978). Several researchers have reported that wolves *(Canis lupus)* generally do not occur in areas where road densities exceed 0.56 km/km^2 in parts of Wisconsin (Thiel 1985), Michigan, Ontario (Jensen et al. 1986), and Minnesota (Mech 1988). Roads themselves may not prevent wolves from inhabiting the area. The primary threat of high road densities comes from the accessibility they allow humans who deliberately, accidentaly or incidentaly kill wolves. Also, road densities may be associated with different types of land use, which may affect wolf security (Mech 1988). Van Dyke (1986) found that resident mountain lions *(Felis concolor)* in Arizona and Utah selected home areas relatively free of human disturbance with lower than average road densities.

McLellan and Shackleton (1988) reported that grizzly bears *(Ursus horribilis)* in Montana and British Columbia used the area within 100m of open roads less than expected, regardless of traffic levels, suggesting that a small amount of traffic could displace them. Most bear deaths in his study area were the result of people hunting from roads. McLellan and Shackleton (1989) found that grizzlies responded more strongly to moving vehicles and people on foot when they were in open habitat than when they were in cover. Cover was important in reducing responses of grizzly bears to terrestrial human activities.

Road avoidance by black bears *(Ursus americanus)* generally is observed in areas with hunting seasons and unrestricted vehicular road use (Hamilton 1978, Carr and Pelton 1984). Brown (1980) found that bears were more reluctant to venture within 0.5 km of roads with high traffic levels than to approach lightly traveled roads. Brody and Pelton (1989) found a negative relationship between the frequency black bears cross roads and traffic levels in western North Carolina. In areas where populations are protected and vehicular access is limited, black bears may be attracted to roads. Carr and Pelton (1984) found that road use among bears in Great Smokey Mountains National Park, North Carolina, seemed to be determined by the seasonally abundant food supplies found along roads. Similiarly, bears in White River National Wildlife Refuge (NWR), Arkansas (Smith 1985); Shenandoa National Park, Virginia (Garner 1986), and Great Dismal Swamp NWR, Virginia (Hellgren 1988); were attracted to roads because of prefered foods.

Researchers also have investigated how road disturbance affects habitat use by bird populations. Adams and Geis (1981) found that 9 species were positively influenced and 9 species were negatively influenced by roads in Virginia, North and South Carolina, Illinois, Oregon and California. No differences were detected in the distributions of the majority of bird species with respect to roads. Studies in Maine and Illinois found similiar results (Ferris 1979, Clark and Karr 1979). Van Der Zande (1980) found that density of blacktailed godwits *(Limosa limosa)* and lapwings *(Vanellus vanellus)* increased with distance from roads in Holland. He also thought that there was a definite threshold value of the road disturbance beyond which a bird will react by avoiding the road. He concluded that the busier the road, the farther away the birds will be located. Leclerq (1985) compared the influence of roads and road use on the behavior of capercaillie *(Tetrao urogallus)* and hazel grouse *(Tetrastes bonasia)* in the mountains of France. He found that grouse seemed to be little disturbed by road use because the thick habitat that they frequent serves as camouflage. On the other hand, capercaillies were drawn to roads because they are similiar to their preferred open habitat. Human road use caused capercailles to avoid roads, resulting in areas with many open roads having fewer capercailles than areas with few open roads because of the loss of habitat.

Little is known about the long-lasting ecological effects of road construction and traffic on animal mobility, increased isolation, and splitting of gene pools (Mader 1984). Most of the work done in these areas has involved small mammals, insects or large ungulates. Roadways have been shown to inhibit the movements of small forest mammals, carabid beetles, and butterflies (Oxley et al 1974, Mader 1984, Van Der Zande 1980). The following factors contribute to this barrier effect: (1) roads resemble rocky habitat and have a different microclimate than the surrounding habitat; (2) there is a broad band of emissions and disturbance surrounding roads and the right-of-way (ROW) is generally unstable because of cutting and spraying; (3) the plant and animal species that compose the ROW may differ considerably from those of more distant habitats and; (4) animals crossing roads are in danger of being killed or hurt (Mader 1984). Oxley et al. (1974) found that the most important factor inhibiting movements of forest mammals was road clearance (i.e., distance from forest to road edge). Divided highways with clearances of 90 m or more may be as effective barriers to dispersal of small forest mammals as bodies of fresh water which are twice as wide. If large gene pools are important to the survival of a population of animals, roadways may have harmful effects on these populations due to fragmentation of gene pools.

Roads interfere with the daily movement and seasonal migration of deer, elk, and antelope *(Antilocapra americana)* (Hancock 1963). This is especially true if fences are installed along the roads. Research is being done on caribou *(Rangifer tarandus)* response to roads and the oil pipeline in Alaska (Curatolo 1983, Alexander and Miller 1982). Dau and Cameron (1986) reported that the number of caribou maternal groups was positively correlated with distance from roads in their Alaska study area. Fewer caribou were located in the vicinity of a road after it was constructed than before construction. In Glacier National Park, mountain goats *(Oreamnus americanus)* have to cross a highway to reach a traditional mineral lick. Disturbances resulting from the highway include unsuccessful crossing attempts, separation of nannies from kids, alteration of crossing routes and crossing time to avoid people and traffic, and alteration in normal goat behavior. Traffic noise and the highway pavement are believed to be regarded as threats by the goats (Singer 1978).

Road right-of-ways have been the object of much research (Crabtree 1984, Egler 1957). The ROW along a road usually attracts species which were not present before the road was built, especially in forested areas (Clark and Karr 1979). The new species prefer edge or open habitats (Ferris 1979). When a highway is built, there is often a loss of forest bird and mammal populations within the ROW, but this area is eventually repopulated by species more suited to these habitats (Ferris 1979). In Maine, the actual area lost to a highway resulted in a 50% reduction in the bird population within that area (Ferris 1979).

In areas that are intensively farmed, ROWs can provide valuable wildlife habitat. Illinois developed a road-side habitat program to provide nesting cover for pheasants *(Phasianus colchicus)* (Joselyn and Tate 1972). Adams and Geis (1983) found more small mammal species in a ROW than in the adjacent habitat. They also found that small mammal density was greater in the ROW than in the adjacent areas. ROWs may also act as dispersal corridors that enable some species to penetrate areas that were previously inaccessible to them (Van Der Zande 1980, Getz et al. 1978). Pocket gophers *(Thomomys)* meadow voles *(Microtus pennsylvanicus)* and starlings *(Sturnus vulgaris)* have been found to occur along highways in areas that they did not inhabit before the highways were built (Huey 1941, Getz et al. 1978), Leedy 1975).

Turkeys and disturbance

Disturbance has long been recognized as an important factor affecting wild turkey populations (Folk and Marchinton 1980). In the past, the wild turkey has been considered a semi-wilderness species requiring a large remote range with a minimum of human activity. Wheeler (1948) concluded that persistent human intrusion and disturbance caused turkeys in Alabama to abandon an area and Stoddard (1963) reported that turkeys avoid areas where they frequently are disturbed by people. Mosby and Handley (1943) recommended 6,073 ha as the minimum size needed for a public hunting area but 2,024 ha may be sufficient for private hunting preserves. Latham (1956) also thought 6,073 ha minimal and 20,243 ha optimal for public hunting areas in Pennsylvania. Turkey populations in Pennsylvania were found to be inversely proportional to human abundance (Wunz 1971).

More recent studies suggest greater tolerance to disturbance and restricted range (Wunz 1971, Williams et al. 1971). Wunz (1971) suggested that turkeys could survive on forested units as small as 202.4 ha in Pennsylvania if hunting was restricted to gobblers in spring. Pennsylvania and New York both have turkey populations that live in woodlot, dairy farm regions (Hayden 1980, Wunz 1980). Healthy wild turkey populations also have been reported on lands managed intensively for pine (Kennamer et al. 1975, Holbrook 1985). Turkeys will tolerate normal farm operations and observations by researchers as long as the turkeys are not molested (Speake et al. 1969). In Kentucky, biologists drove within 20 m of flocks without greatly alarming them in an unhunted area. Turkeys that were hunted and endured the harassment of deer season were "wilder" than birds that were rarely disturbed. Different populations of turkeys react to disturbances differently (Wright and Speake 1975).

Holbrook and Lewis (1967) thought that recreational use of forests could cause wild turkey management problems because turkeys might abandon that part of their range where human activity was a disturbance. Wright and Speake (1975) in Alabama conducted one of the few studies that related human disturbance to turkey movements. This study took place at Land Between the Lakes, Kentucky. They found that each campground, foot trail or other special -use area of high human activity, removes a certain area around it from regular use by turkeys. Heavy foot trail use in the morning and evening coincided with maximum turkey usage of fields, so turkeys avoided the trails. Instrumented turkeys came no closer than 1.6 km to a campground. One gobbler used the interior of a campground in the winter, so mere presence of human-made facilities had little effect on turkey use. Turkeys were often harassed by motorcycles and hid in dense vegetation to elude them, but most did not leave their ranges. However, three hens and their poults abandoned their regular brood range after being disturbed by motorcycles at least twice a week. Wunz (1971) also found that turkeys used dense understories to escape disturbance.

Frequent and sustained disturbances, such as occurs during hunting season, have been reported to cause turkeys to enlarge their cruising radius or forsake portions of their home range (Latham 1956:39, Holbrook 1973). In Texas, Walker (1949:18) considered disturbance by hunters to be the most important factor in the drastic reduction of the Rio Grand turkey population. Mosby and Handley (1943:207) suggested that under normal conditions, a range of about 3,240 ha characterizes the requirements of the wild turkey in Virginia, but if they are disturbed continuously, the range may exceed this figure. Logan (1973) found a correlation between the pattern of movement to the winter area and poaching pressure on the winter area. Turkeys stayed on the winter area longer if poaching was negligible than when it occurred. In Virginia, heavy vehicular traffic was thought to be responsible for changes in size and shape of turkey home ranges during hunting season (Raybourne 1968). Other studies also have reported turkeys expanding or moving their ranges to avoid disturbance by hunters (Bowman et al. 1979, Hayden 1980, Wright and Speake 1975).

Recent studies have found that, rather than expanding their range when disturbed, turkeys may actually reduce their movements to avoid contact with humans. In Alabama, Everett et al. (1978) found no permanent movements out of established ranges that could be attributable to hunting pressure. Turkeys which were radio-tracked in Florida did not move away to escape hunters (Williams et al. 1978). Turkey movements were increased by encounters with hunters only when they were flushed several times during a brief interval. In many cases, hunter activity curtailed turkey movement and turkeys remained stationary in trees or in thick ground cover. Turkeys hiding in the underbrush could be approached within 6 m before they flushed. In Georgia, Folk and Marchinton (1980), found no evidence to indicate that even high numbers of deer hunters adversely affected movements or behavior of wild turkeys. They did find that when hunters were present, turkeys flew up to roost earlier and if flushed in the afternoon, they often remained in trees until the next day. Deer hunters had no effect on when turkeys flew down from roosts in the morning.

Turkey reactions to human disturbance are also influenced by the size and the character of the surrounding range (Williams et al. 1978). Hayden (1980) found that in Pennsylvania, turkeys living in open forests dispersed several kilometers to a new range because of hunting activity. However, in woodlot habitat, hunting had no effect on turkey movements. Folk and Marchinton (1980) stocked turkeys on a small, heavily-used penninsula and found that the turkeys hid in brushy habitat to avoid humans. If the surrounding habitat had been more hospitable, they might have moved to a better area when disturbed rather than hidden.

Turkeys and roads

Michael (1978) found that only 1% of all turkey sign along a West Virginia highway was within 160 m of the highway. Adams and Geis (1981) did not find any turkeys within 400 m of interstate highways and county roads. Latham (1956) reported that a few turkeys are killed annually in Pennsylvania and other states by fast moving vehicles on highways. Highways may also act as range barriers to turkeys. Eichholz and Marchinton (1975) never located any of 16 radio marked wild turkeys beyond a wooded area bordered by a 242.9 ha pasture and a highway in Georgia. According to Bailey and Rinell (1968) there is not a thriving turkey population where roads open to public vehicular travel exceed 6 km per 1000 ha. The best populations occur on areas with less than 2.5 km of open roads per 1000 ha. The George Washington National Forest staff tries to allow no more than 4 km of road per 1000 ha in featured turkey habitat. They also allow public vehicle access at no more than 3.2 km intervals (U.S. Department of Agriculture 1986).

Access due to a high density of roads and trails may increase the turkey harvest, illegal and legal, to dangerous levels (Bailey and Rinell 1968). Holbrook (1985) conducted a turkey study on commercial forest land in Virginia where there were 13.8 km of ungated roads per 1000 ha. He suspected that this extensive road system played an important role in the number of turkeys killed by hunters and the percentage of kill lost as cripples. Sixty-one percent of the radio-instrumented birds he studied died during fall and spring hunting seasons. Turkeys found dead during hunting season died closer to roads than turkeys found dead at other times of the year.

Poaching can be a significant contributor to turkey mortality. Wilson and Lewis (1955) thought that poaching was the greatest cause of death for turkeys in southwest Michigan. Mosby and Handley (1943) estimated that 10 percent of the turkey population in Virginia was killed annually by illegal hunting. Powell (1967) had a similiar estimate for illegal kill in parts of Alabama. However, Everett (1982), found that illegal kill was not an important limiting factor on game management areas in Alabama. Illegal losses were believed to be as high as 20 percent on Land Between the Lakes, Kentucky (Wright and Speake 1975).

Crippling loss is another important contributor to turkey mortality. Bailey and Rinell (1967) noted that the turkey is an extremely hardy bird and may recover from being shot. However, they estimated crippling loss to be as high as 20-30 percent of the harvest in West Virginia. Mosby and Handley (1943), estimated that 10 percent of the number bagged in Virginia may be lost to crippling. Everett (1982), also found a 10 percent crippling loss on the Alabama Wildlife Management Areas. A 20 percent crippling loss of gobblers was found by Everett et al. (1978). In the Virginia Piedmont, Holbrook (1985) concluded that as many as 4 turkeys may have been crippled per turkey carried out of the woods by a hunter.

Forest roads can be beneficial to wild turkeys. In heavily forested areas, roads provide openings which turkeys may use for nesting, dusting, loafing, or feeding (Mosby and Handley 1943). It is not unusual for wild turkey nests to be within 15 m of little traveled roads (Williams 1981, Mosby and Handley 1943). Gobblers sometimes use roads as strutting areas in the spring. Dirt roads may be utilized by turkeys in the spring and summer as dusting sites. Open stretches of road absorb heat and may be used as loafing areas on cold, sunny days (Leedy 1975). Turkeys also have been known to frequent roads in order to dry off after a rain (Holbrook, pers. comm.). Roads can provide an important source of grit, especially in the winter when snow is on the ground. The planting of old logging roads to grasses and other wildlife food plants is a desirable wild turkey management practice (Mosby and Handley 1943).

Turkeys, especially hens and poults, utilize these openings for feeding in the summer and fall. Roadside vegetation also is used for feeding.

STUDY AREA

The study area was located southwest of Deerfield in the Deerfield Ranger District of the George Washington National Forest (GWNF), Virginia. The actual study area boundary used for analysis was the composite homerange of all radio-marked turkeys. Portions of Bath, Augusta and Rockbridge counties were encompassed by the boundary (Fig. 1). The 15,727 ha study area included Walker Mountain, Sideling Hill, Little Mill Mountain, and Chestnut Ridge (Fig. 2). The study area is part of the Valley and Ridge physiographic province (Kozak 1970). The Deerfield Anticline underlies the area. Soils originating from Keefer and Oriskany sandstones are found on the mountaintops and Milboro shale and alluvium are found in the valleys.

Seventy percent of the study area was National Forest. The adjacent valley land was, with few exceptions, privately owned cattle farms and hunt club property. The study area was 66 percent hardwood forests, 16 percent mixed pine-hardwood forests, 10 percent fields, 5 percent regeneration areas and 3 percent pine forests. The dominant forest covertype was oak-hickory pole and sawtimber. This area was selected because it was thought to have a large turkey population, a representative sample of each road type and a variety of habitats.

Study area roads ranged from 2-lane blacktop roads to barely discernable woods roads. The roads were divided into 6 groups (Fig. 3): A) state blacktop roads (32.8 km); B) state gravel roads (26.5 km); C) Forest Service roads open all year (15.2 km); D) Forest Service roads open seasonally (22.6 km); E) Reseeded Forest Service roads (38.2 km); and F) woods roads and trails (unknown km). Type C roads were gravel roads designed for a low volume of traffic. Type D roads were gated normally but were opened seasonally for hunting or commercial resource

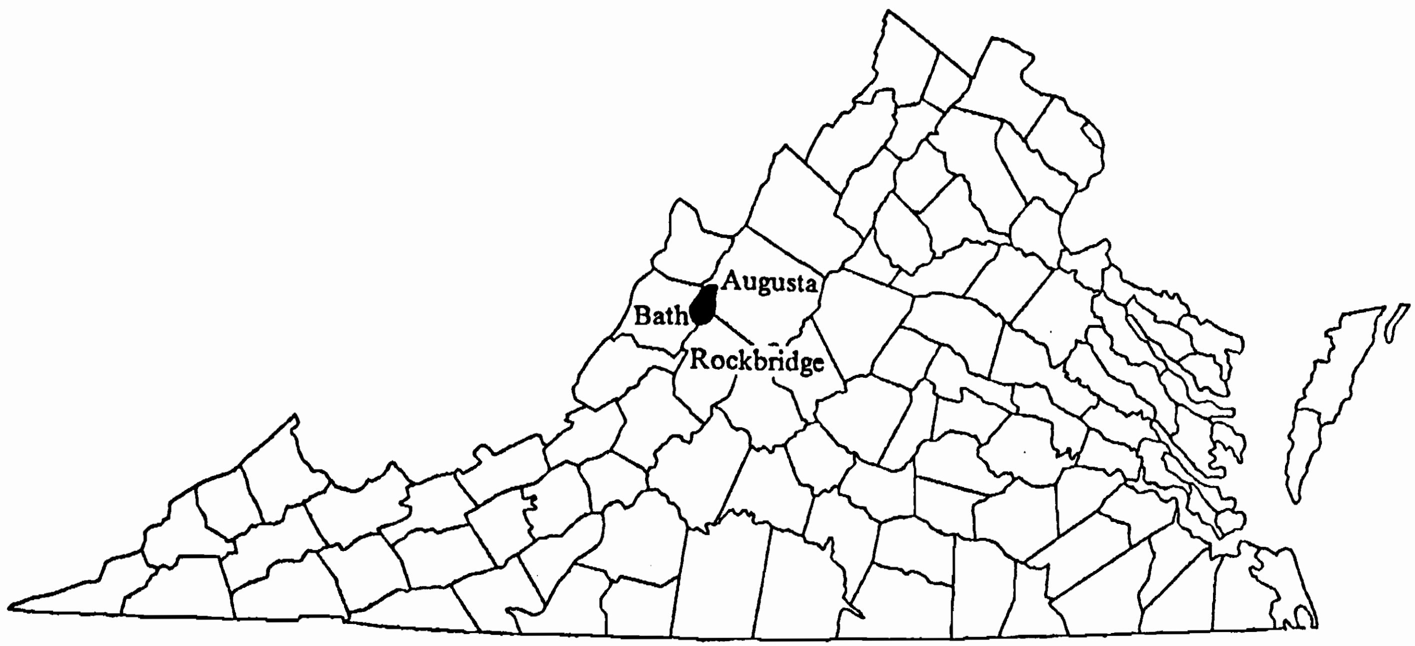

Figure 1. Wild turkey study area location in Augusta, Bath, and Rockbridge counties, Virginia, 1985-1987.

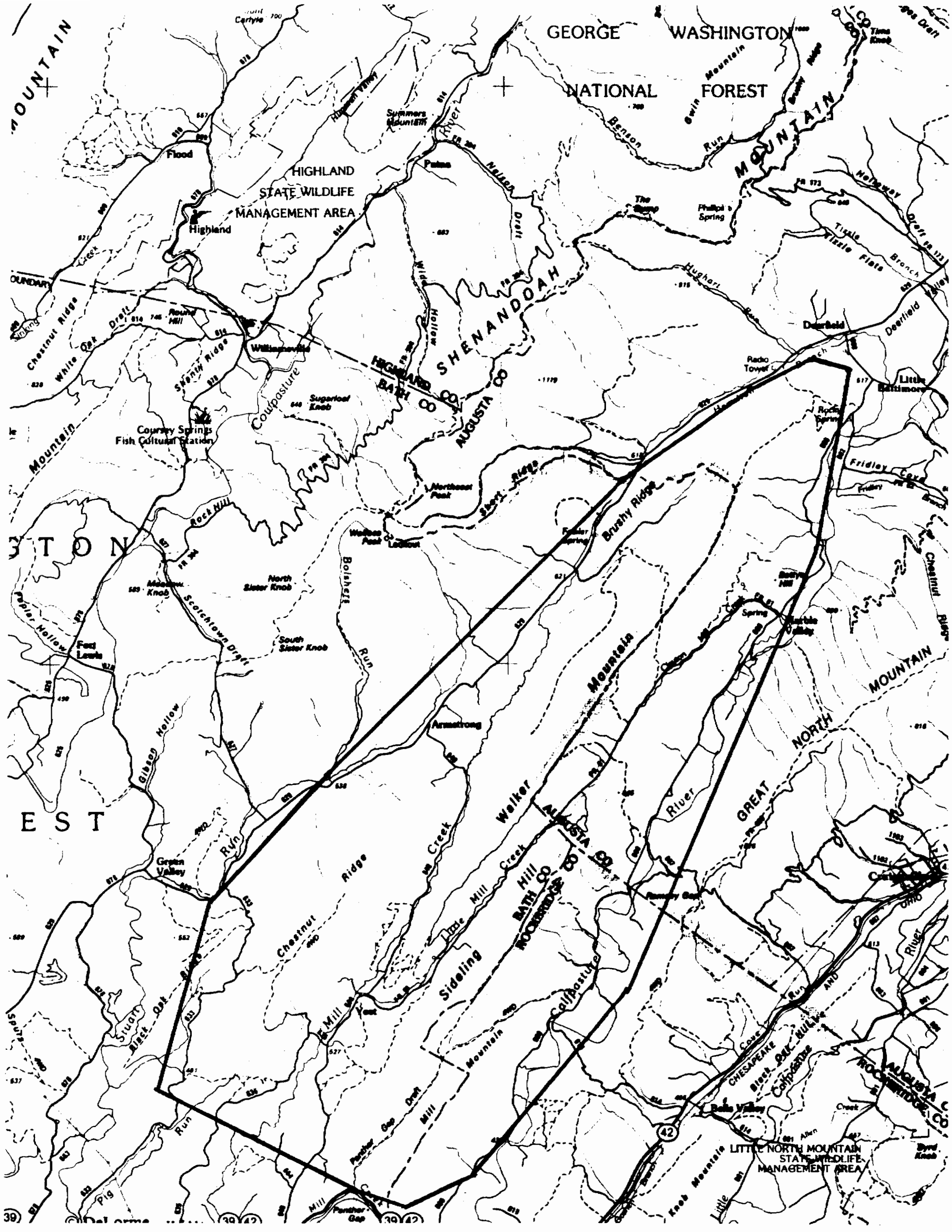

Figure 2. Wild turkey study area location near Deerfield, Virginia, 1985-1987.

activities. Type E roads typically were blocked by an earth mound to prevent vehicular use. Type F roads were rough trails used primarily by 4-wheel drive vehicles and hikers. Type F roads could not be accurately mapped because many were not visible on aerial photographs or topographic maps.

METHODS

Study period

The study extended from September 1985 through August 1987. Each year was divided into 4 seasons based on weather patterns and shifts in turkey movements and food habits: spring (March-May) included the breakup of winter groups, mating and nesting; summer (June-August) included the brood-rearing period; fall (September-November) included aggregation and gradual movement back to winter habitat; and winter (December-February) was characterized by consistent cold weather, turkeys in large unisex groups and reduced availability of food.

Trapping and marking

Wild turkeys were captured during 2 periods each year using either a cannon net or oral drugs. Early trapping was conducted during September and October before fall hunting seasons began and late trapping was conducted after fall hunting ended from January through March. Capture sites were located in areas away from open roads where turkeys or turkey sign had been sighted previously. Turkeys were lured to capture sites by scattering bait in

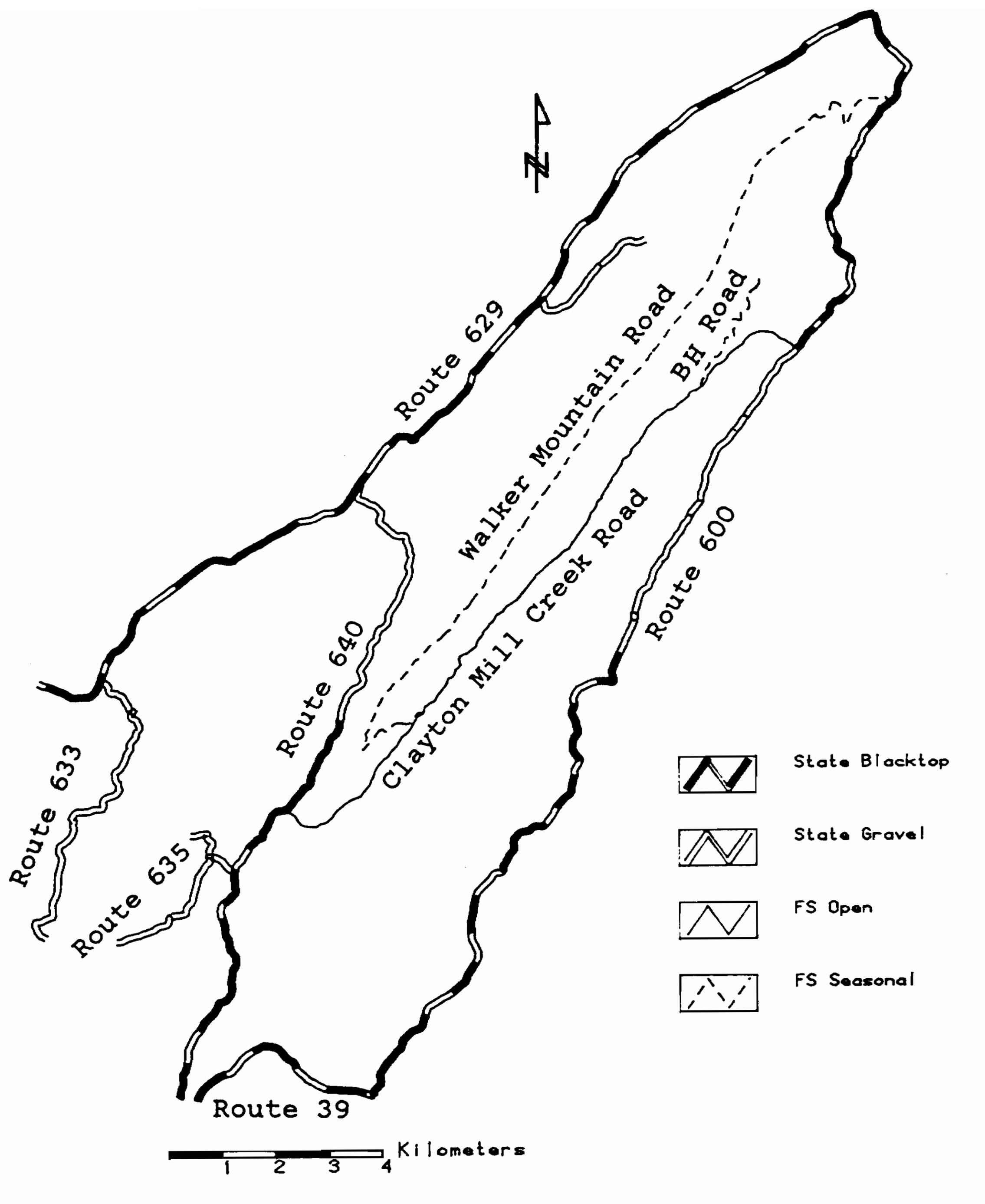

Figure 3. Four road types on the Deerfield, Virginia, study area, 1985-1987.

several lines radiating out from the trap site (Austin et al. 1975). Cracked corn was used as bait because it was not as likely to attract other animals as whole corn and it encouraged longer feeding than whole corn (Austin 1965). Whole corn was a preferred turkey food, but turkeys reportedly have choked on whole corn kernels which lodged in their tracheae after a cannon net was fired (Doster 1974). Blinds were built at each trap site using natural materials such as old chestnut *(Castanea dentata)* logs and pine branches. We attempted to catch turkeys after they had visited a bait site several times.

Cannon nets were set up in wildlife clearings that had been cleared of brush and mowed. Nets and cannons were disguised with leaves and grass. Blinds were located so that occupants could view the entire length of the net without disturbing turkeys that were visiting the trap site. Once turkeys began to frequent a bait site, cracked corn was placed only in a line about 1m in front of the net between the 2 outer cannons.

Oral drugs were used to capture turkeys in locations where cannon nets could not be utilized. Alpha-chloralose was chosen because it was the best drug available for turkey trapping (Williams 1966, Holbrook and Vaughan 1985). Alpha-chloralose laced bait capture sites were usually located in forested ravines with open understories to prevent narcotized turkeys from escaping easily (Holbrook and Vaughan 1985). The night before a trapping attempt, cracked corn was moistened with water and mixed at the rate of 2g alpha-chloralose per 0.25 l of bait (Williams 1966, Holbrook and Vaughan 1985). One batch (0.25 l each) of bait was mixed and placed in a plastic bag for each turkey thought to be using the bait site. Adults and juveniles were captured with the same drug dosage. The morning of a trapping attempt, alpha-chloralose laced bait was placed at the bait site in small piles (0.13 l each) about 1 meter apart.

One or 2 persons sat in blinds at the bait site until turkeys were either narcotized or the trapping attempt was abandoned. If a trapping attempt was abandoned, all alpha-chloralose laced bait was picked up before leaving the site. If the trapping attempt was successful, turkeys were caught by hand or with a long-handled fish dip net and placed in specially designed cardboard boxes (Williams et al. 1966, Austin et al. 1975). Narcotized turkeys were transported to a warm building and kept in their boxes until they fully recovered from the drug. Boxes were lined with newspaper to absorb droppings. Each turkey was removed from its box at 4-hour intervals to exercise its legs and give it water. Corn was surgically removed from the crop of any turkey that appeared to be overdosing on the drug (Williams 1966). Recovery time for each turkey was recorded. The nonparametric Wilcoxon Rank Sum (2-sample) and Kruskal Wallis tests were used to test for differences in recovery time between turkeys that had corn surgically removed and those that did not have corn removed.

Age (adult and juvenile) and weight were determined for all captured turkeys. Sex was determined for all adults and juveniles past their post juvenile molt. Each turkey was marked with Virginia Department of Game and Inland Fisheries (VDGIF) aluminum leg bands (National Band Co. size 24) and patagial wing tags (Allflex cattle or pig ear tags). Selected turkeys were equipped with 75g radio transmitters (Telonics, Inc., Mesa, Arizona), painted brown to blend with turkey plumage. Transmitters were attached to turkeys with nylon, overbraided backpack harnesses, fastened under the wings. Juveniles less than 2.25 kg were not equipped with transmitters. Motion-sensitive radio transmitters (Advanced Telemetry System, Isanti, Minnesota), designed to detect mortality, were placed on hens the second year of the study. Motion-sensitive radio transmitters had a delay-switch which changed signal speed if a hen did not move during a 3-hour period. All turkeys were released close to their capture site. Recaptured radio-equipped turkeys were examined for signs of transmitter or tag caused injuries.

Telemetry data collection and analysis

Turkeys were monitored with a hand-held 2-element yagi antenna and a portable receiver (Telonics, Inc., Mesa, Arizona). Radio-marked turkeys usually were located by triangulation (Cochran 1980) to avoid disturbing them. Radio locations were used only if azimuths were recorded within 15 minutes and were separated by at least 30 degrees. Because of the mountainous topography and limited road access in the study area, only 2 azimuths usually were taken to triangulate each location. Azimuths were taken from 279 permanent stations, most of which were located on roads. Program TELEM (Koeln 1980) triangulated azimuths and produced universal transverse mercator (UTM) coordinates for each turkey location.

To calculate telemetry error (Springer 1979, Lee et al. 1985) 12 transmitters were placed at known locations by 1 person and located by another. In addition, locations of 15 radio-equipped turkeys were used because telemetry could be checked against visual locations. The standard deviation of bearing error and the absolute error between radio-determined and actual locations were calculated. Distances from locations, radio-determined and actual, to the nearest road (type A, B, C or D) were calculated. A distance-to-road error was the absolute value after subtracting the radio-determined distance from the actual distance.

Each day (diurnal) was divided into 3 or 4, 4-hour periods depending on time of year and day length. One or 2 turkeys, or groups of turkeys systematically were choosen each day to be followed during 1 of the 4-hour periods. The turkeys were located every 2 hours (3 times) during the selected 4-hour period. First and last periods included roost locations. Turkeys that were not chosen to be followed during a 4-hour period on a particular day usually were located once that day. An attempt was made to locate each radio-marked turkey at least 5 times/week.

Radio-marked turkeys were located visually if they remained in one location for more than 2 days. Visual locations of live and dead radio-marked turkeys were plotted using the UTM grid system. Cause of death was determined if possible. Radio-marked turkeys shot legally during the hunting season usually were turned in at local check stations. Information was requested from hunters about kill location, date and time of day killed. A $25 reward was given for returned transmitters and a $10 reward was given for returned leg bands. Estimates of annual and monthly survival were calculated using program MICROMORT (Heisey and Fuller 1984). Turkeys dying from probable trap-related injuries were not included in the analysis. Survival was calculated by sex for the 2 years pooled.

Instrumented hens that were located in the same place for several consecutive days in the spring were presumed to be nesting. Nests were located by circling around the nesting hens at 25-50m and taking compass bearings at points around the circle. The nest and egg shells were visually located after the clutch had been hatched or abandoned (Everett et al. 1980). A nest was considered successful if any poults hatched. An attempt was made to count the number of poults in each hen's brood, when 3 weeks old, to calculate brood survival.

Data sets were formed by combining all radio-marked turkey locations within the study area except those suspected of dying from trap related injuries. Data sets were sorted by season, sex or time of day. To minimize dependence between observations, only one location per turkey per day was randomly chosen to be included in each data set. If turkeys were traveling in groups, only one location per group was used. A computer program was written (A.B. Jones, III, unpub.) to create random point data sets within the study area to compare to turkey location data sets.

A study area cover map was constructed using U.S. Geological Survey (USGS) topographic maps (scale 1:24,000), U.S. Forest Service maps and stand information, and VDGIF aerial 35 mm slide photographs. The USGS topographic maps were enlarged (scale 1:12,000) and printed as 1 map on transparent mylar. U.S. Forest Service map information was transferred to the mylar map using a Kargl reflecting projector. The aerial slides then were projected through the mylar map at the proper scale and features were traced onto the mylar. Infrared and natural color slides were taken during leaf-off periods to facilitate mapping roads. Five broad habitats were delineated on the cover map (Table 1, Fig. 4).

The mylar cover map then was digitized and transferred to a Geographic Information System (PC ARC/INFO, Redlands, Ca) to create individual computerized maps of habitat, roads and streams. Homerange and turkey location maps were created by transferring UTM coodinates from TELEM to PC ARC/INFO. Each map was associated with a table containing information about that particular map. For example, each turkey location was associated with a time, date, and turkey number. PC ARC/INFO allowed subsetting and overlaying of individual maps to form new maps.

Table 1. Habitat categories near Deerfield, Virginia, 1985-1987.

Category	Area (ha)	Percent Total Area	Description
Hardwood	8541	65.7	Predominately upland oak (*Quercus* sp.) and hickory (*Carya* sp.). Also cove hardwoods; yellow poplar (*Liriodendron tulipifera*) and maple (*Acer* sp.)
Pine	409	3.1	Dominated by *Pinus* sp.; Virginia (*P. virginiana*), pitch (*P. rigida*), shortleaf (*P. echinada*), Table mountain (*P. pungens*) and eastern white (*P. strobus*) pines. Also eastern hemlock (*Tsuga canadensis*).
Mixed pine-hardwood	2063	15.8	Mixed pine-hardwood stands.
Regeneration	708	5.5	Hardwood stands, 0-33 years old.
Fields	1287	9.9	Agricultural fields, predominately pasture land.

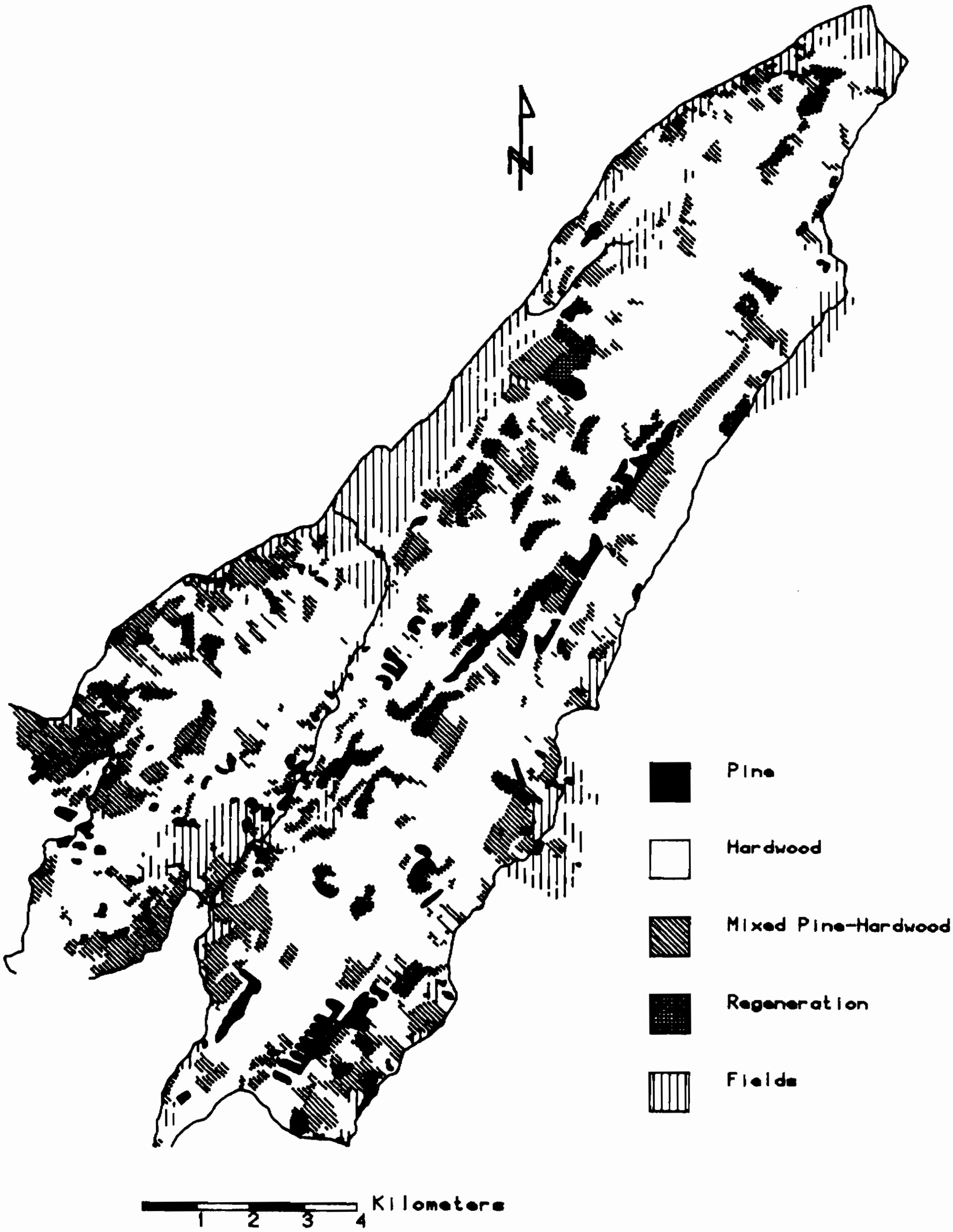

Figure 4. Habitats in the Deerfield, Virginia, study area, 1987.

Program TELEM (Koeln 1980) calculated home ranges using the 100% minimum convex polygon method (Mohr 1947). All locations obtained per turkey were used in determining home ranges. Annual home ranges were calculated for turkeys with at least 15 locations in each season (n=9). Total home ranges were calculated for turkeys with greater than 6 months of telemetry data (n=10), but not enough data to calculate annual home ranges. A composite home range was calculated using locations from all radio-marked turkeys.

Individual home ranges and the composite home range of all turkeys were overlayed on the road map to obtain the length (m) of road types A, B, C and D within each home range (Table 2). The percentages of each road type found within an individual home range were obtained by dividing the length of each road type by the combined lengths of road types A, B, C and D within the home range. The Wilcoxon Rank Sum (2-sample) and Kruskal Wallis tests were used to test for differences in road type percentages between the individual home ranges and the composite home range.

A computer program was written (A.B. Jones, III, unpub.) to calculate distances from a given point to the nearest road of type A, B, C or D. The nonparametric Wilcoxon Rank Sum test (2-sample) and Kruskal Wallis test were used to test for distance-from-road differences between random points and radio-marked turkey locations. Nest and dead turkey location distances also were compared to random point distances. Distances from carcass to roads for harvested radio-marked turkeys were compared to distances to roads for radio-marked turkeys that died from other causes.

Using the buffer command of PC ARC/INFO, three 150m zones were created around each type A, B, C and D road in the study area (Fig. 5 and 6, Table 3). Fourteen zones were created including zone intersections and areas greater than 450m from any road. The composite home range of all radio-marked turkeys was used as the study area boundary (Fig. 7). Radio-marked turkey location maps were overlayed on the road-zone map to obtain the percentage of radio-marked turkey locations in each zone and the effective study area. The chi-square goodness-of-fit test was used to compare the percentage of turkey locations in each zone with the percentage expected, testing the hypothesis that turkeys use the zones in

Table 2. Length (m) of roadtypes A, B, C, and D found within each turkey total convex polygon homerange near Deerfield, Virginia, 1985-1987.

Turkey	Roadtype A	Roadtype B	Roadtype C	Roadtype D	Total Length
140	2779	0	0	0	2779
320	3834	0	1535	0	5369
101	1769	4075	354	0	6198
930	0	1003	2798	2434	6235
120	1629	4412	499	0	6540
490	2824	0	3794	515	7133
143	1842	0	958	4544	7344
910	3054	3244	398	3052	9748
458	0	3504	124	6985	10613
030	0	3427	6411	1514	11352
360	1861	3739	898	4878	11376
160	2186	0	1798	8789	12773
050	944	79	7458	6336	14817
530	3051	5479	3958	3321	15809
510	6392	4105	5392	2434	18323
200	2379	6281	6196	6080	20936
260	5166	3891	7031	4881	20969
849	57	0	8668	12283	21008
060	1694	0	8879	13237	23810
Comp	32842	26458	15237	22613	97150

Comp = Composite convex polygon homerange of all radio-marked turkeys.

A = state blacktop, B = state gravel, C = Forest Service open all year,

and D = Forest Service open seasonally.

proportion to availability. Bonfererroni z-statistics were used to determine if the zones were used more or less ($p<0.05$) than available (Neu et al. 1974). Zone use was analyzed by sex and season. The road-zone map was overlayed on the habitat map to obtain the percentage of each habitat within each zone.

A 150 m zone was created around all type E (reseeded) roads in the study area. These zones were overlayed on the habitat map to create a new map (Fig. 8, Table 4). Turkey location maps were overlayed on the new map to obtain the percentage of turkey locations in each habitat. Chi-square analysis and Bonferroni z-statistics were used to determine if the habitats were used more or less ($p<0.05$) than available (Neu et al. 1974). Habitat use was analyzed by sex and season. Nest locations also were overlayed on the habitat map.

Road-traffic counters were placed on road types C and D. Pressure sensitive cords were buried in each road to avoid vandalism and count data were recorded weekly. Average traffic counts for road types A and B were obtained from the Virginia Department of Transportation. Distances from turkeys to roadtype C were tested for correlation with road use.

RESULTS AND DISCUSSION

Sixty-four wild turkeys were trapped at 11 trap sites during 15 trapping attempts (Fig. 9, Table 5). Twenty-eight turkeys were trapped at 5 trap sites the first year of the study and 49, including 5 recaptures, were trapped at 8 trap sites the second year. Sites were baited throughout the study area but most (64%) of the successful trap sites were located on the SE sides of Walker Mountain and Sideling Hill. Although successful trap sites were not located randomly in the study area, spring dispersal resulted in the redistribution of radio-marked turkeys over most of the area (Fig. 10).

Four turkeys were captured using a cannon net while the rest were caught with alpha-chloralose laced cracked corn. Lack of large clearings in the study area limited the use

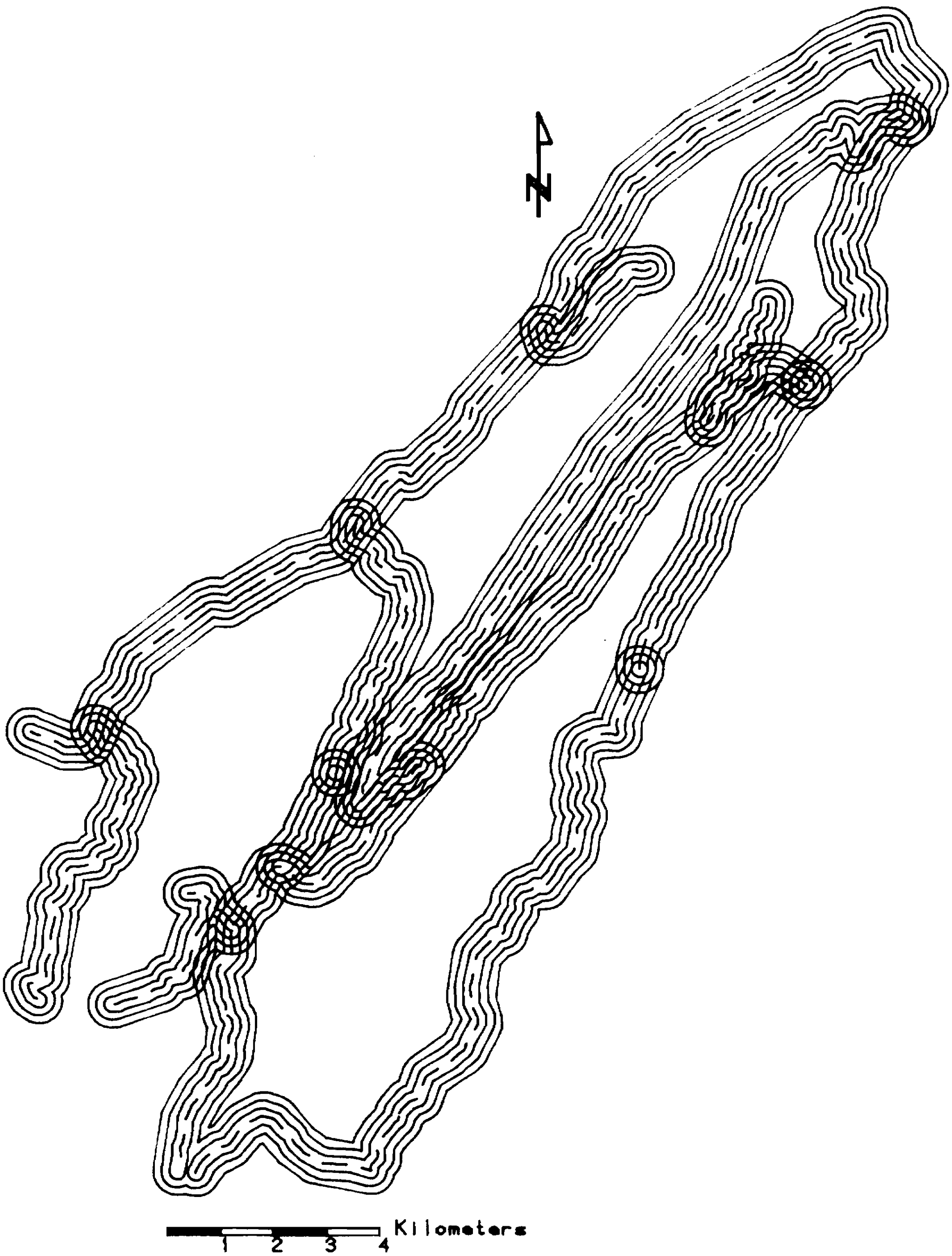

Figure 5. Zones created around road types A, B, C and D in the Deerfield, Virginia, study area.

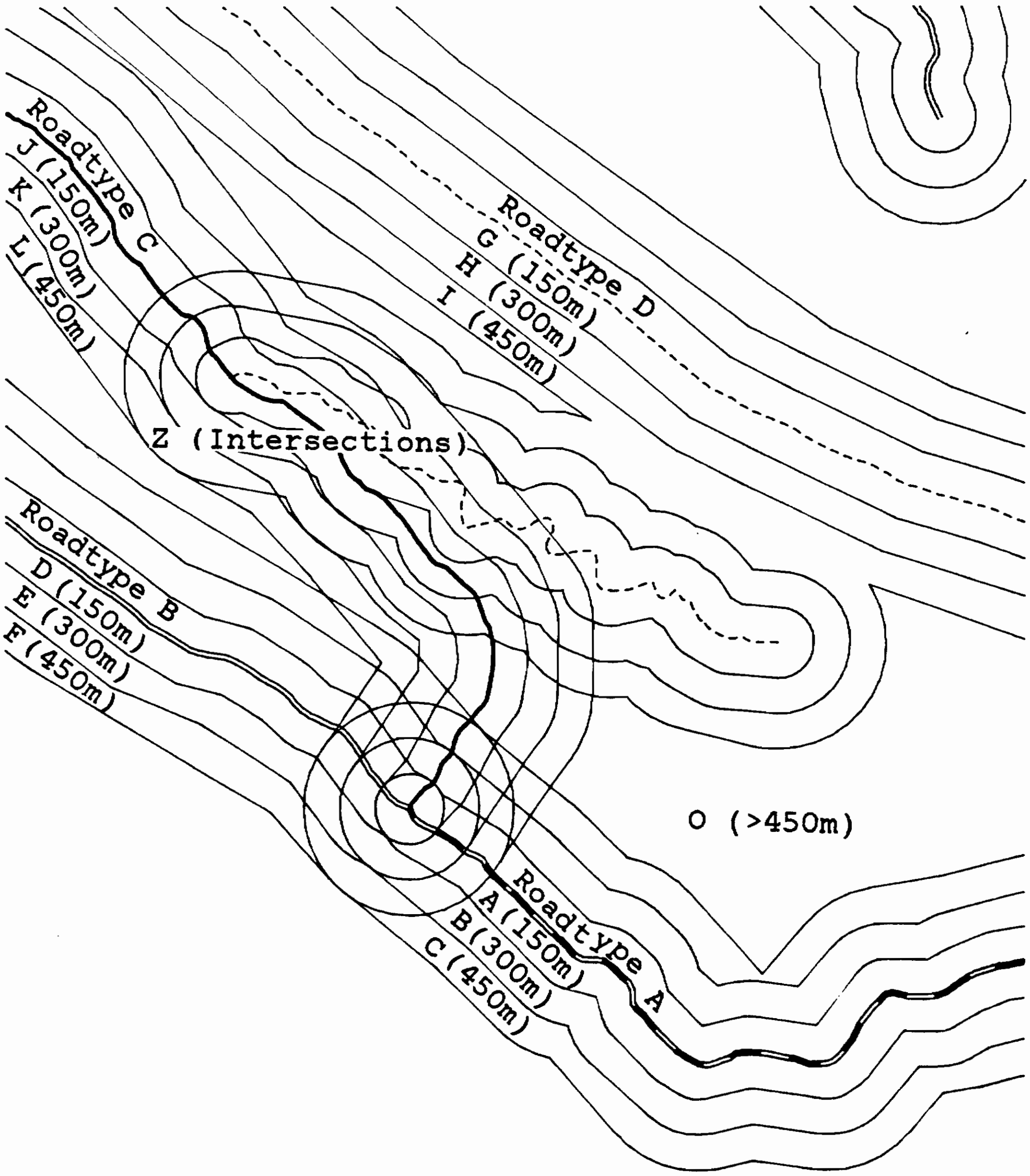

Figure 6. **A section of the zones created around road types A, B, C and D in the Deerfield, Virginia, study area.**

Table 3. Road-zone categories used in wild turkey use/availability analysis, Deerfield, Virginia.

Category	Area (ha)	Percent Total Area	Roadtype location (m)	Zone (m)
A	809	6.5	State Blacktop	0-150
B	814	6.5	State Blacktop	150-300
C	837	6.7	State Blacktop	300-450
D	674	5.4	State Gravel	0-150
E	639	5.0	State Gravel	150-300
F	608	4.9	State Gravel	300-450
G	309	2.5	FS[a] Seasonal	0-150
H	286	2.3	FS Seasonal	150-300
I	273	2.2	FS Seasonal	300-450
J	539	4.3	FS Open	0-150
K	487	3.9	FS Open	150-300
L	454	3.7	FS Open	300-450
Z	1066	8.6	Zone intersections	
O	4639	37.0	> 450m from any road	

[a]Forest Service

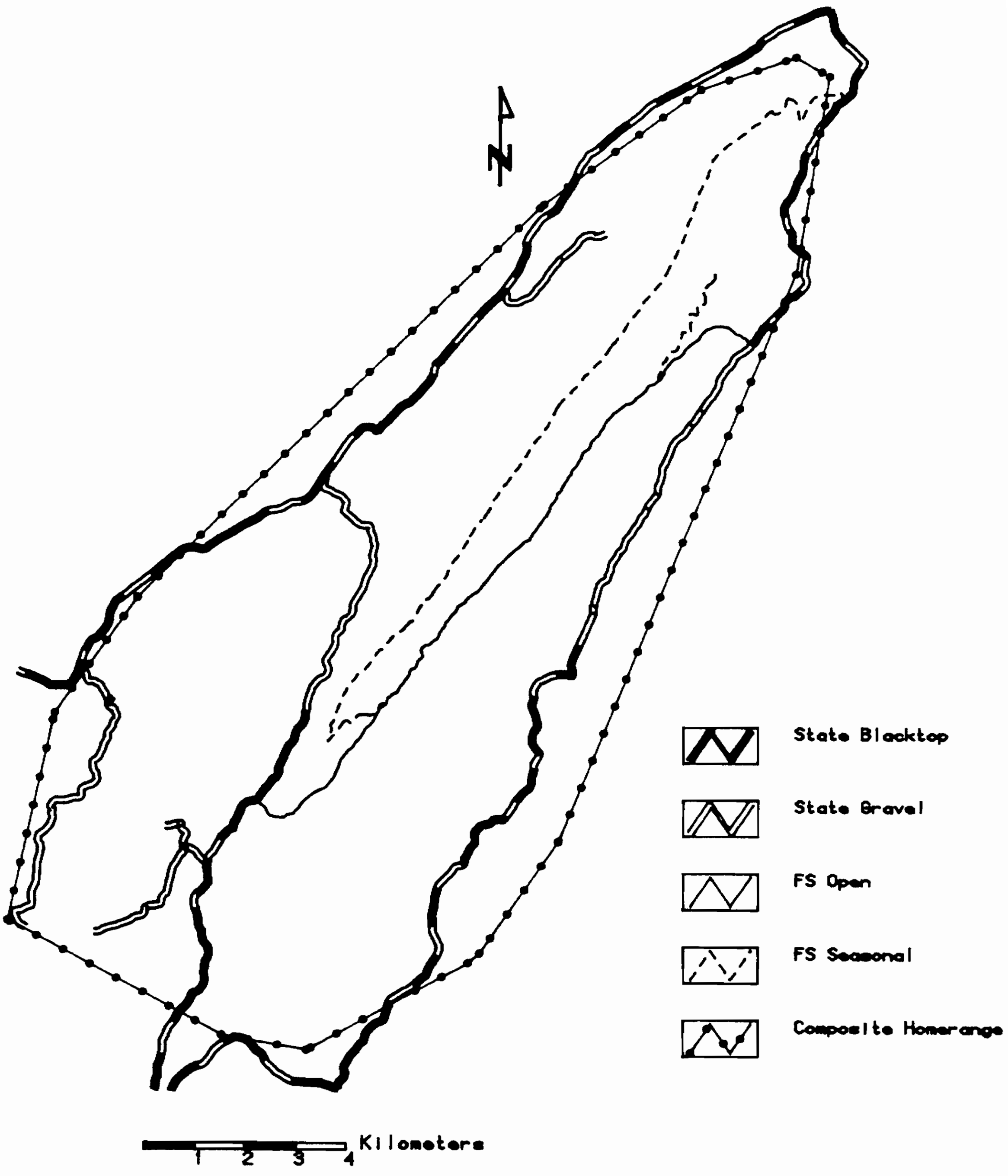

Figure 7. The composite convex polygon homerange of all radio-marked turkeys within the Deerfield, Virginia, study area.

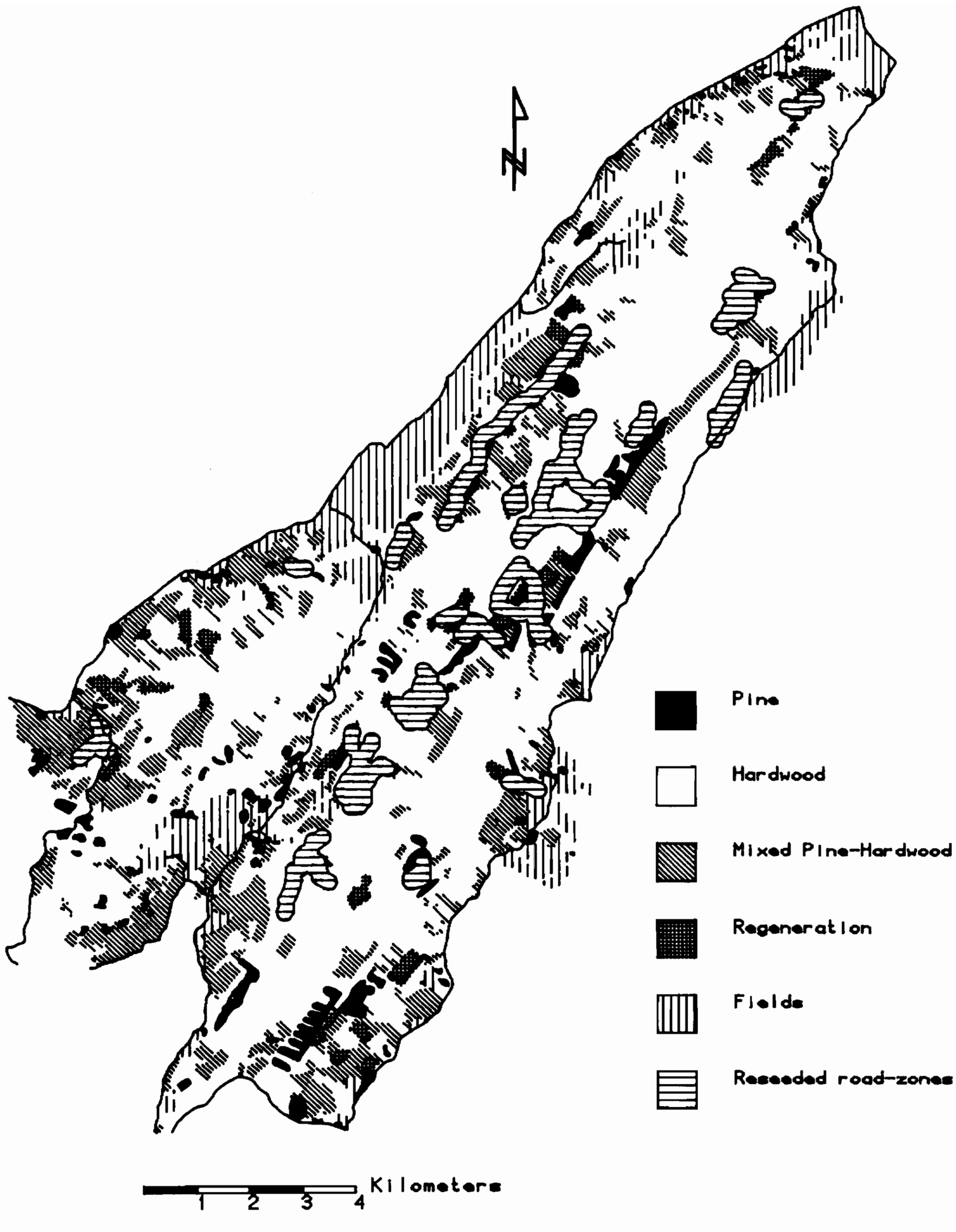

Figure 8. Map of the habitat types in the Deerfield, Virginia, study area with 150m type E road-zones included.

Table 4. Habitat categories, with road-type E zones included, used in wild turkey use/availability analysis, Deerfield, Virginia.

Category	Area (ha)	Percent Total Area	Description
Hardwood	7965	61.0	Predominately upland oak (*Quercus* sp.) and hickory (*Carya* sp.). Also cove hardwoods; yellow poplar (*Liriodendron tulipifera*) and maple (*Acer* sp.)
Pine	376	2.9	Dominated by *Pinus* sp.; Virginia (*P. virginiana*), pitch (*P. rigida*), shortleaf (*P. echinada*), table mountain (*P. pungens*) and eastern white (*P. strobus*) pines. Also Eastern hemlock (*Tsuga canadensis*).
Pine-hardwood	1958	15.0	Mixed pine-hardwood stands.
Regeneration	313	2.4	Hardwood stands, 0-33 years old.
Fields	1269	9.8	Agricultural fields, predominately pasture land.
Type E road-zone	1132	8.7	150m zones around type E roads.

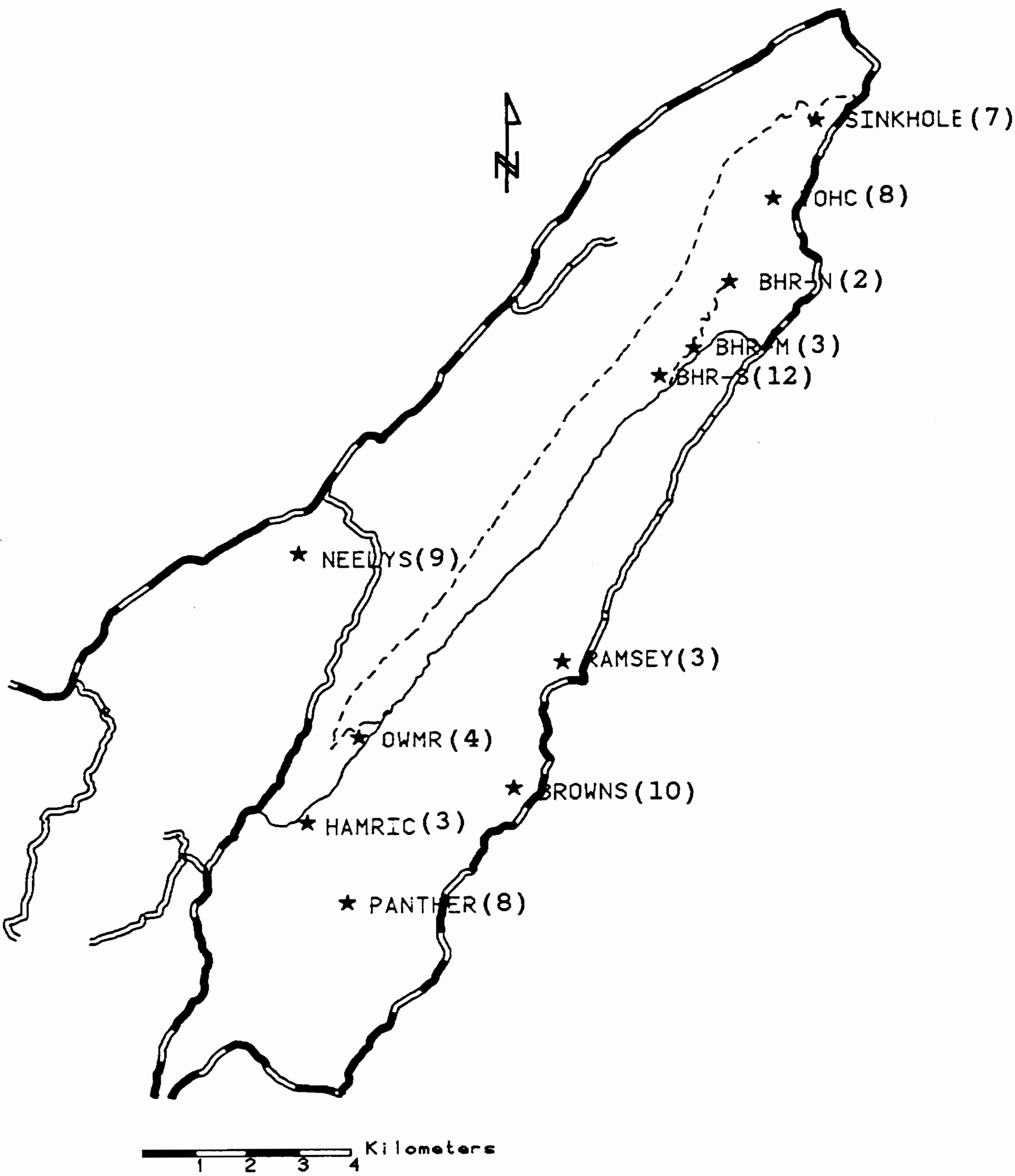

Figure 9. Wild turkey trap sites and the number of turkeys caught at each site, 1985-1987, near Deerfield, Virginia.

Table 5. Wild turkey capture, tagging, and release data from 11 sites (shown in Fig. 9) near Deerfield, Virginia, 1985-1987.

Capture date (time)	Site	Capture number	Sex	Age	Weight (kg)	Band number	Transmitter frequency	Release date
10/10/85 (0900)	Panther	1	M	A	7.7	1473	150.490	10/13
		2	M	A	8.6	1476	150.140	10/12
		3	M	A	8.6	1475	150.320	10/12
		4	M	A	7.7	1476	-	10/12
10/25/85 (1230)	Ramsey	5	M	A	7.7	1477	150.010	10/28
		6	M	A	8.6	1478	150.030	10/26
		7	M	A	7.2	1479	150.950	10/27
2/01/86 (0800)	BHR-S	8	F	J	3.8	1500	150.160	2/04
		9	F	A	4.5	1499	150.930	2/03
		10	F	A	4.3	1498	150.240	2/05
		11	F	A	4.0	1497	150.510	2/03
		12	F	J	3.6	1496	150.458	2/03
		13	F	J	4.3	1495	150.200	2/03
		14[A]	F	A	-	-	-	-
		15[A]	F	J	-	-	-	-
		16[A]	F	J	-	-	-	-
		17[A]	F	J	-	-	-	-
		18[C]	F	A	-	-	-	-
		19[C]	M	A	-	-	-	-
3/22/86 (0800)	YOHC	20	M	J	5.0	1461	150.101	3/23
		21	M	J	5.9	1490	150.390	3/23
		22	M	J	5.9	1491	150.558	3/23
		23	M	J	5.0	1492	150.060	3/24
		24	M	J	5.0	1494	150.849	3/24
		25	M	J	6.1	1493	150.120	3/25
3/22/86 (0830)	Hamric	26	F	A	3.6	1462	150.360	3/24
		27	F	J	4.1	1463	150.260	3/25
3/26/86 (1530)	Hamric	28	M	J	6.3	1464	150.530	3/28
9/06/86 (1030)	OWMR	29[B]	-	J	2.3	1481	-	9/06
		30[B]	-	J	2.3	1482	-	9/06
		31[B]	F	J	2.3	1483	150.910	9/06
		32[B]	F	J	2.7	1484	150.030	9/06
9/09/86 (1130)	Panther	33[*]	M	A	7.2	1475	150.320	9/12
		34[*]	M	A	7.2	1474	-	9/12
		35[*]	M	A	6.8	1473	150.490	9/12
		36	M	A	7.7	1485	151.050	9/11

Table 5. (continued).

Capture date (time)	Site	Capture number	Sex	Age	Weight (kg)	Band number	Transmitter frequency	Release date
9/19/86 (0800)	Browns	37	F	A	4.1	1486	150.950	9/22
		38	M	J	3.2	1468	150.340	9/21
		39	-	J	1.8	1469	-	-
		40	-	J	1.8	1470	-	-
		41	-	J	1.8	1471	-	-
		42	-	J	1.8	1465	-	-
		43	-	J	1.8	1472	-	-
		44	-	J	1.8	1488	-	-
		45	-	J	1.8	1489	-	-
		46[A]	-	JI	-	-	-	-
9/19/86 (0730)	Sinkhole	47	M	A	7.4	1467	150.240	9/23
		48	M	A	7.2	1487	150.390	9/23
1/21/87 (1130)	BHR-N	49	F	J	3.6	1601	151.217	1/23
		50	F	A	3.6	1602	151.143	1/23
1/21/87 (0730)	YOHC	51	F	A	3.6	1603	151.055	1/23
		52	M	A	6.1	1604	150.340	2/12
3/11/87 (0900)	BHR-M	53	M	A	7.7	1611	150.558	3/18
		54*	M	A	5.0	1494	150.849	3/15
		55	M	A	7.2	1612	150.140	3/14
3/13/87 (0830)	Neelys	56*	F	A	3.8	1496	150.458	3/16
		57	F	J	4.1	1613	151.312	3/16
		58	M	J	5.2	1615	150.950	3/16
		59	F	J	4.1	1616	151.056	3/16
		60	F	A	3.8	1618	151.276	3/16
		61	F	J	3.6	1617	-	3/16
		62	F	J	3.6	1619	-	3/16
		63	F	J	3.8	1620	-	3/16
		64	F	J	4.3	1621	-	3/16
3/18/87 (1630)	Sinkhole	65[A]	M	A	7.4	1605	-	-
		66[A]	M	A	7.0	1606	-	-
		67	M	J	5.2	1607	150.010	3/20
		68	F	J	3.6	1608	-	3/21
		69	M	J	5.6	1609	150.240	3/22

[A]Died from drug overdose
[B]captured with cannon netting
[C]killed by predators while sedated
*Recaptured

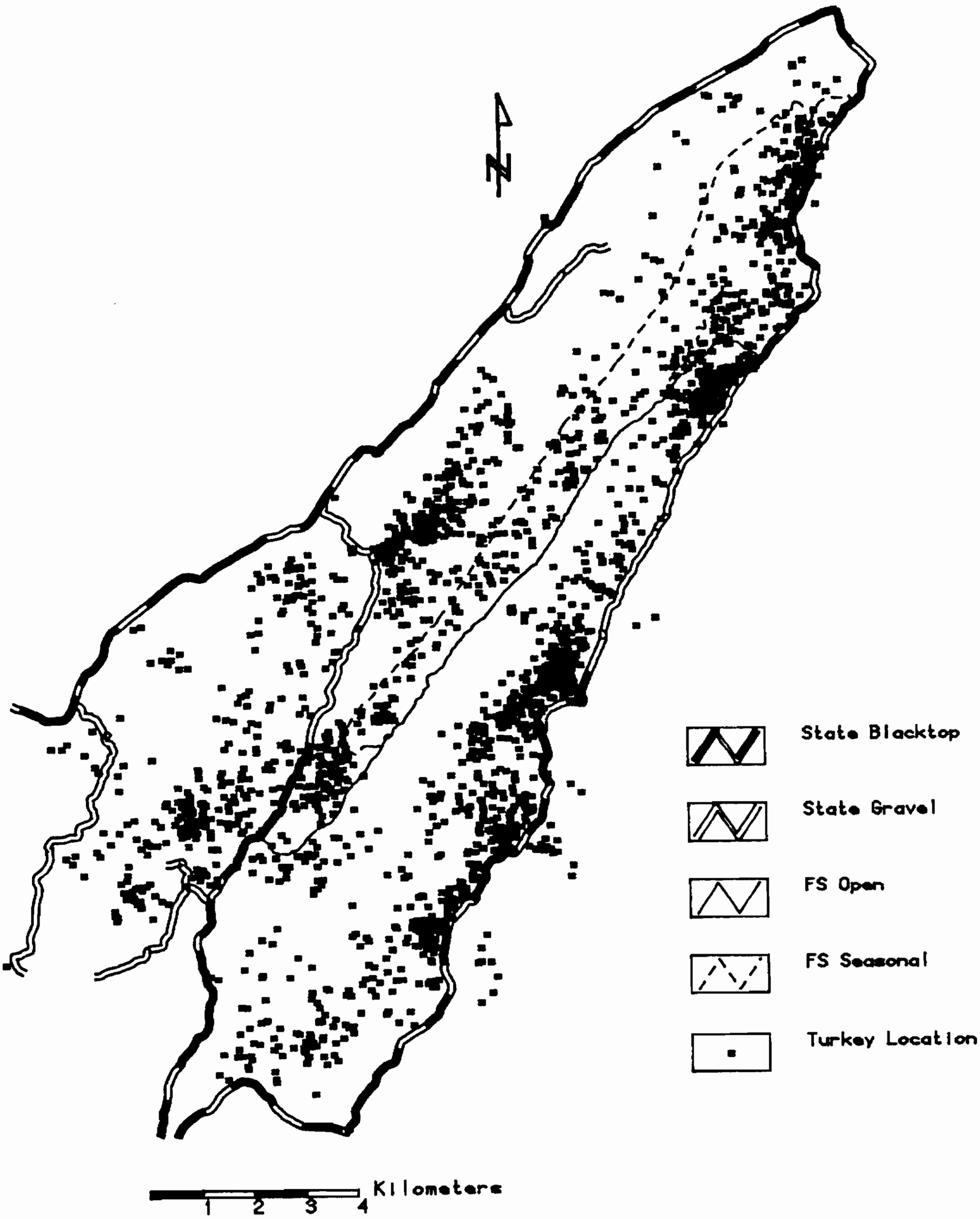

Figure 10. Sample data set of radio-marked wild turkey locations, n=1585, near Deerfield, Virginia, 1985-1987.

of a cannon net. Turkeys were difficult to capture in the fall of 1985 due, apparently, to an excellent acorn crop (VDGIF-1985 oak mast ratings) and inexperienced trapping personnel. Turkeys were more easily trapped in the winter of 1985 - 1986 when preferred native foods were less plentiful.

Seven turkeys (10.4 percent) died from drug overdoses. Williams (1966) and Morgan (1989) reported similiar overdose rates when using alpha-chloralose. Alpha-chloralose laced corn was not removed surgically from any crops during the first 3 trapping attempts. The first 2 groups captured were adult gobblers caught in the fall when food was abundant, and they failed to eat enough corn to become fully sedated. One gobbler escaped and could not be captured with a fish dip net. The next group, primarily hens, was trapped in the winter and 4 hens overdosed (Table 5). Corn was not surgically removed from their crops because of inexperience in detecting signs of overdose. During subsequent trapping attempts, corn was surgically removed from any turkey that appeared to be overdosing.

Turkeys that had corn surgically removed from their crops ($n=9$) recovered faster than those that did not have corn removed ($n=45$; 1.5 days vs 2.4 days; $p<0.05$). Only 1 of 7 turkeys that overdosed had corn surgically removed from its crop. Corn removed from 2 adult gobbler crops was measured. One had consumed 0.50 liters, twice the normal dosage, and the other had eaten 0.34 liters. One adult gobbler developed leg paralysis while narcotized. He was kept in captivity for a month until he recovered full use of his legs and then was released.

Forty turkeys were equipped with transmitters over a 2-year period. The maximum number of radio-equipped turkeys on the study area at one time was 20. All ($n=4$) of the recaptured radio-equipped turkeys appeared to have no injuries related to the transmitters or tags. Six hens were equipped with motion-sensitive transmitters, in 1987, but the 3-hour delay-switch was too short to be a dependable indicator of mortality because the transmitters' radio-signals occasionally changed speed when hens were roosting or incubating nests. One hen was flushed off her nest by research personnel after her transmitter had been on mortality mode for 3 days.

Seven turkeys lost their transmitters 21 - 315 days after they were equipped (Table 6). Five of the transmitters were retrieved with backpack harnesses still intact, but the fate of the turkeys remained undetermined. Since the harnesses were fastened only under the wings and not across the breast, the turkeys might have removed the harnesses by accidentally catching them on obstructions, such as branches. A gobbler, kept in captivity for a month while recovering from capture-induced leg paralysis, was able to remove his harness when it was caught on something. Poaching, which has been reported as a significant source of mortality in other areas (Fleming and Speake 1976, Everett et al. 1978, Holbrook 1985, Kurzejeski et al. 1987) was another possible explanation. Proof of poaching was not found, but human and dog tracks were in the snow near one of the retrieved harnesses.

We recorded 4,100 turkey locations during the study. Trapping efforts and poor weather conditions limited the amount of location data collected during the winter. Locations of radio-equipped turkeys frequenting bait sites were not used in any analysis. The error arc deviation of bearing error calculated from the practice transmitters was 7.5 degrees at a mean distance of 710m. The mean absolute error between radio-determined and actual locations was 170m. The absolute errors ranged from 5m to 466m. The mean distance-to-road error was 96m. The distance-to-road error was always less than or equal to the corresponding absolute error.

The composite home range for all radio-equipped turkeys within the study area was 15,727 ha. Annual home ranges ranged from 1,130 ha to 3,426 ha with a mean of 2,100 ha (Table 7, Fig. 11). Annual home range sizes were similiar to those found in other mountainous study sites. Wigley et al. (1986) reported home ranges between 856 and 7,775 ha in the Quachita Mountains. Home ranges in Alabama's mountains averaged between 1,439 and 3,514 ha (Everett et al. 1979, Speake and Metzler 1985). Annual home ranges in coastal plain and Piedmont habitats were smaller ranging from 65 to 553 ha (Brown 1980).

Home range size is considered a function of habitat quality because turkeys on less productive ranges are believed to move farther to meet their needs than those on better habitat with good interspersion of forested habitats and openings (Mosby and Handley 1943,

Table 6. Radio-equipped wild turkey mortality data near Deerfield, Virginia, September 1985 - August 1987.

Turkey number	Trap date	Days followed	Fate
490	10/10/85	690	survived
140	10/10/85	184	shot 04/12/86
320	10/10/85	356	trans[D], then recaptured. survived.
010	10/25/85	171	shot 04/14/86
030	10/25/85	187	trans[D], shot 11/29/86
950	10/25/85	20	dead[B] 11/14/86
160	02/01/86	298	shot 11/25/86
930	02/01/86	184	trans[D]
240	02/01/86	75	dead[C] 04/16/86, maybe nesting
510	02/01/86	303	shot 11/30/86
458	02/01/86	577	survived
200	02/01/86	292	shot 11/19/86
101	03/22/86	287	dead[C] 01/07/87
390	03/22/86	17	dead[B] 04/08/86
558	03/22/86	124	dead[C] 07/28/86
060	03/22/86	310	dead[C] 01/30/87
849	03/22/86	371	dead[C] 04/01/87
120	03/22/86	230	shot 11/10/86
360	03/22/86	266	shot 12/16/86
260	03/22/86	315	trans[D]
530	03/26/86	243	shot 11/24/86
910	09/06/86	236	trans[D]
031	09/06/86	112	shot 12/27/86
050	09/09/86	355	survived
951	09/19/86	31	dead[C] 10/20/86
340	09/19/86	82	dead[C] 12/10/86
241	09/19/86	64	shot 11/22/86
391	09/19/86	60	shot 11/18/86
217	01/21/87	219	survived[A]
143	01/21/87	220	survived
055	01/21/87	21	trans[D]
341	01/21/87	41	leg problems[B], dead 03/03/87
559	03/11/87	37	shot 04/17/87
141	03/11/87	173	survived
312	03/13/87	76	survived[A]
952	03/13/87	137	dead 07/28/87[C]
056	03/13/87	168	survived
276	03/13/87	171	survived
011	03/18/87	171	survived[A]
242	03/18/87	46	trans[D]

[A]left study area permanently
[B]probably trap related
[C]died from unknown causes
[D]turkey lost transmitter

Bailey and Rinell 1968, Speake et al. 1975, Everett et al. 1979). Everett et al. (1979) found that coastal-plain turkeys, restocked in the mountains, increased home ranges to equal those of resident birds. Public lands are often the highest, steepest, and driest landscapes leaving only a portion of the original habitats available to turkeys. The gently sloping sites are most often developed for other uses (Healy 1981). My study area contained 10 percent fields but most of them were located on private land on the edges of the study area so there was not a good interspersion of forested habitats and openings.

Mortality

Survival data were obtained from 38 of 40 different turkeys released with transmitters during the 2 years of the study. Turkeys that left the study area in 1987 were assumed to have survived. The overall annual survival rate was 37 percent. Females had an annual survival rate of 35 percent while males had a 39 percent survival rate. Females had a 48 percent harvest mortality rate and a 17 percent mortality rate due to unknown causes (Table 8). Males had a 24 percent harvest mortality rate and a 37 percent mortality rate due to unknown causes (Table 9). All known shot turkeys were killed during turkey hunting seasons. Of 8 turkeys shot during fall hunting season, 37.5 percent were shot during the first week of deer rifle season, 25.0 percent were shot during the second week of deer rifle season and 37.5 percent were shot during other seasons.

The overall survival rate was within the 6 to 40 percent range reported by others (Mosby 1967, Williams et al.1978, Holbrook and Vaughan 1985). Mosby (1967) calculated that a Virginia wild turkey population could remain stable with a 60.4 percent total annual mortality rate and a 33.3 percent harvest mortality rate. Markley's (1967) survey of allowable harvest indicated that 40-60 percent of a population could be removed in high-quality Florida habitat while only 40 percent could be removed in less productive habitat in Pennsylvania. The 48 percent female harvest mortality rate in my study area exceeds the maximum 30 percent

Table 7. Convex polygon homeranges for turkeys followed at least 6 months near Deerfield, Virginia 1985-1987.

Turkey Number	Area (ha)	Age	Sex	Seasons Included
030	1485	A	M	All
050	2384	A	M	All
140	1369	A	M	Fa,Wi,Sp
320	2346	A	M	All
490	2542	A	M	All
143	979	A	F	Sp,Su
360	1530	A	F	Sp,Su,Fa
458	2051	A	F	All
510	2469	A	F	Sp,Su,Fa
930	381	A	F	Sp,Su
060	1130	J	M	All
101	1130	J	M	All
120	2235	J	M	Sp,Su,Fa
530	2694	J	M	Sp,Su,Fa
849	2409	J	M	All
910	1564	J	M	Fa,Wi,Sp
160	1369	J	F	Sp,Su,Fa
200	2281	J	F	Sp,Su,Fa
260	3426	J	F	All

Sp= Spring (March-May), Su= Summer (June-August), Fa= Fall (september- November), Wi= Winter (December-February), All= All seasons (Annual homerange).

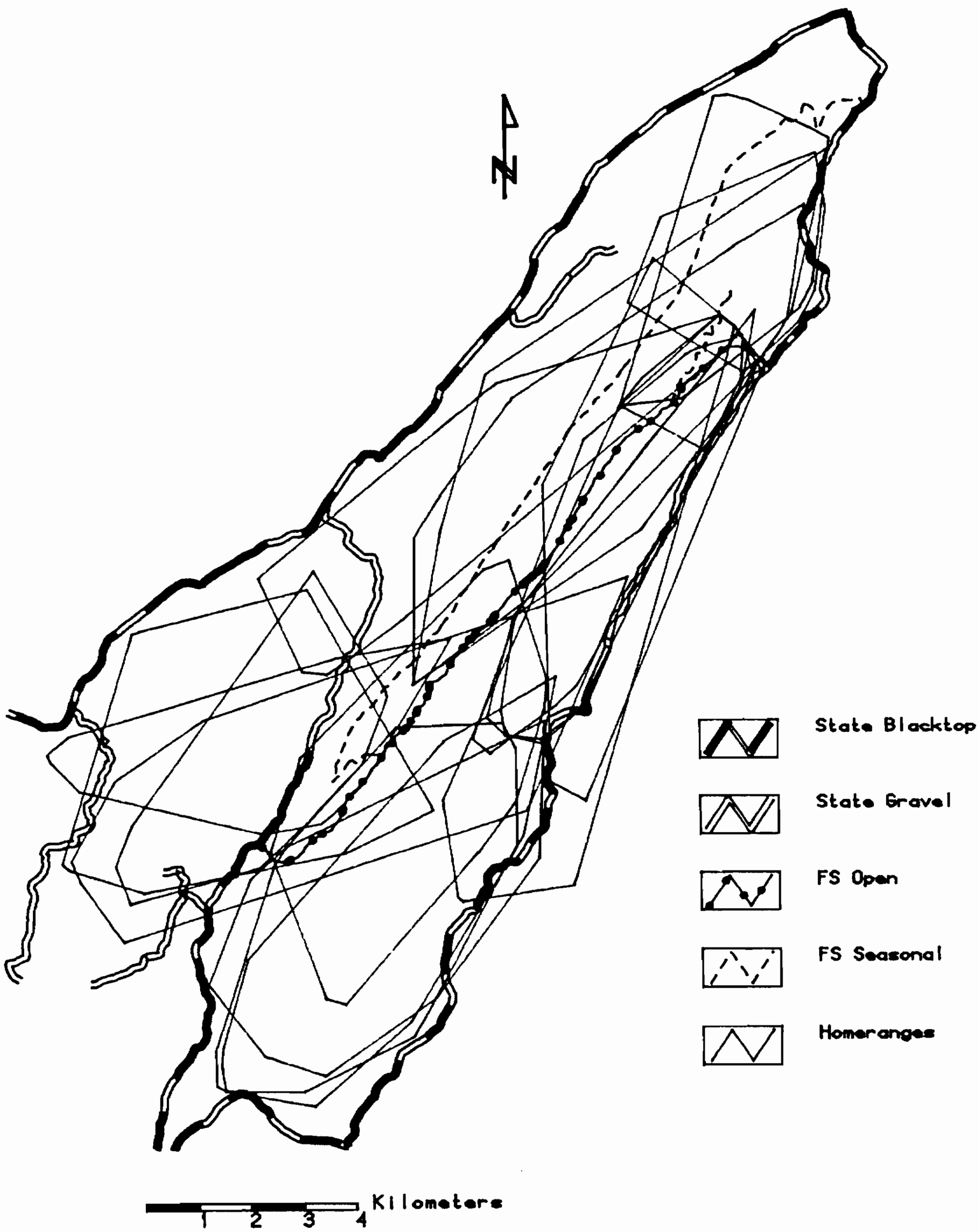

Figure 11. Convex polygon homeranges for wild turkeys followed at least 6 months near Deerfield, Virginia, 1985-1987.

Table 8. Monthly and annual survival rates of radio-marked female turkeys near Deerfield, Virginia, 1985-1987.

Month	Radio Days	Mortality % Shot	Mortality % Other	% Monthly Survival	
January	87	0	0	100.0	
February	300	0	0	100.0	
March	395	0	0	100.0	
April	436	0	6.4	94.0	Gobbler
May	403	0	0	100.0	season
June	330	0	0	100.0	
July	341	0	0	100.0	
August	313	0	0	100.0	
September	239	0	0	100.0	
October	268	0	11.0	89.0	Fall
November	224	33.0	0	67.0	hunting
December	136	37.0	0	63.0	seasons
Annual	3472	48.1	16.9	35.0	

Table 9. Monthly and annual survival rates of radio-marked male turkeys near Deerfield, Virginia, 1985-1987.

Month	Radio Days	Mortality % Shot	Mortality % Other	% Monthly Survival	
January	286	0	20.0	80.0	
February	252	0	0	100.0	
March	404	0	0	100.0	
April	636	13.0	4.0	83.0	Gobbler
May	468	0	0	100.0	season
June	450	0	0	100.0	
July	459	0	13.0	87.0	
August	403	0	0	100.0	
September	294	0	0	100.0	
October	453	0	0	100.0	Fall
November	497	25.0	5.0	70.0	hunting
December	351	0	8.0	92.0	seasons
Annual	4953	24.0	37.0	39.0	

recommended by Williams (1981) to maintain a viable population. Only 1 hen died during nesting and spring gobbler seasons. Other studies have reported their highest hen mortalities during this time of year (Everett et al. 1980, Speake 1980, Kimmel and Kurzejeski 1985, Speake and Metzler 1985, Vander Haegen et al. 1988).

Seventeen percent of turkeys shot were within 150m of either a type A, B, C or D road and 25 percent were shot in an intersection zone. Forty-two percent were shot greater than 450m from a road. All turkeys ($n=7$) that died of unknown causes died > 150m from a road (Fig. 12, Table 10). Distances from roads to random points and distances from roads to locations of dead turkeys were similiar ($p > 0.05$). Distances from carcass to road for shot turkeys and turkeys dying of other causes were similiar ($p > 0.05$).

Eighty-seven percent of male turkeys and 100 percent of female turkeys that were found dead of unknown causes died in months containing open hunting seasons. One recaptured gobbler had lead shot holes in his transmitter and he was in bad physical condition. One wing appeared to have been shot, he was infested with lice and weighed only 5 kg. Although he was almost 2 years old, he still had button spurs. He was equipped with a new transmitter but died 21 days later.

Crippling loss is thought to be an important contributor to turkey mortality. Bailey and Rinell (1968) noted that the turkey is an extremely hardy bird and may recover from being shot. However, many studies have estimated crippling losses to be 10-30 percent (Bailey and Rinell 1968, Everett et al. 1978, Holbrook and Vaughan 1985). Most researchers have concluded that losses of adult gobblers to predators are rare (Shaffer and Gwynn 1967, Everett et al. 1980, Speake 1980). I suspect that some of the deaths attributed to unknown causes in my study were actually crippling losses since 5 of the 6 gobblers that died of unknown causes were adults and 3 of the deaths occurred in months with open hunting seasons. The carcasses were not found near roads (within 150m), but the capacity of turkeys for escaping after being shot is well known (Williams 1981:70).

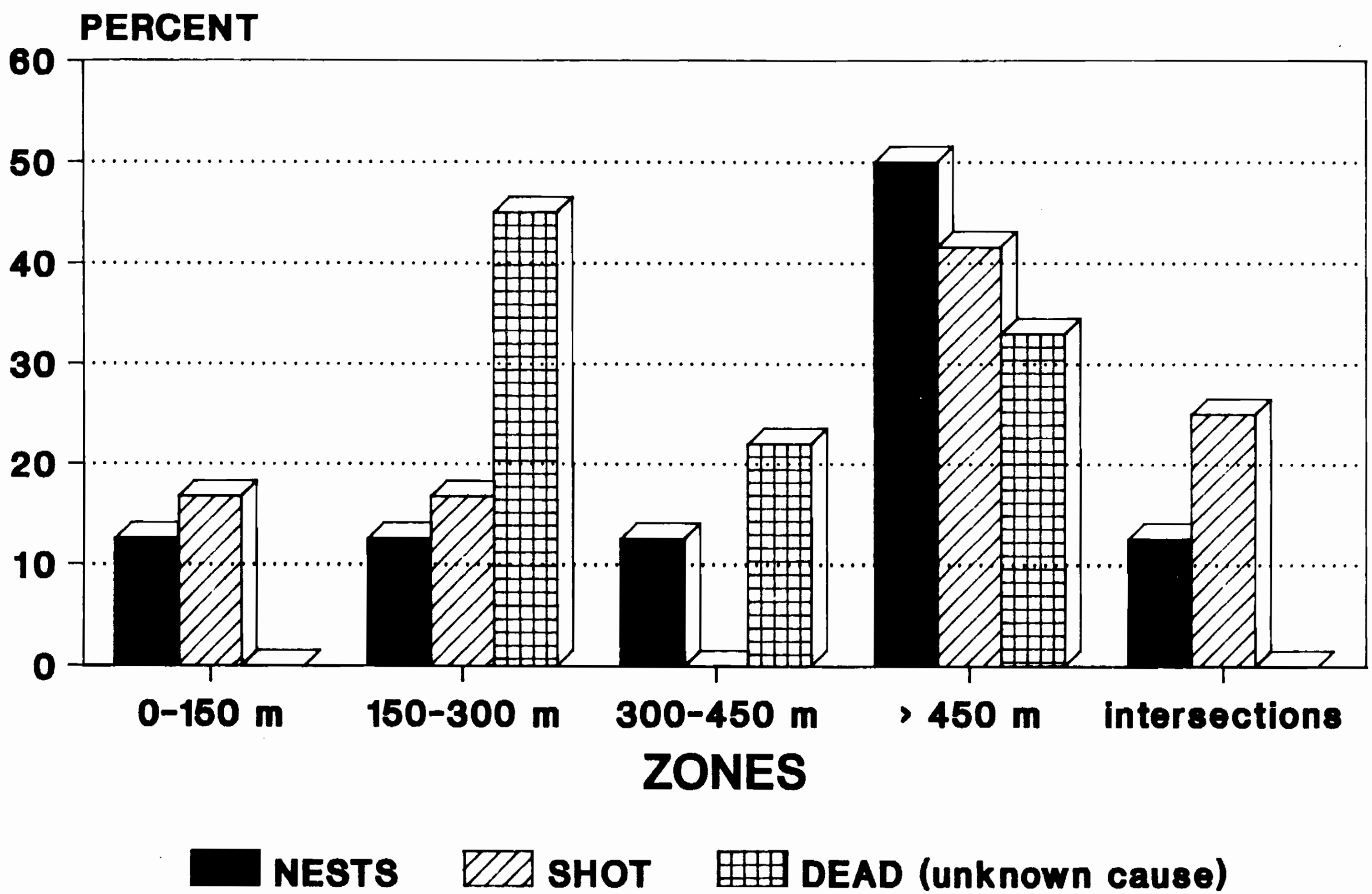

Figure 12. Radio-equipped turkey nests and mortalities found in each road-zone category near Deerfield, Virginia, 1985-1987.

Table 10. Number of nests and dead turkeys located within each road-zone near Deerfield, Virginia, September 1985- August 1987.

Road Type	Zone (m)	Nest	Shot	Dead[A]
A	0-150	0	0	0
A	150-300	0	2	0
A	300-450	0	0	1
B	0-150	1	0	0
B	150-300	0	0	0
B	300-450	1	0	0
C	0-150	0	2	0
C	150-300	1	0	1
C	300-450	0	0	1
D	0-150	0	0	0
D	150-300	0	0	3
D	300-450	0	0	0
-	intersections	1	3	0
-	> 450	4	5	3
Total (N)		8	12	9

[A]died from unknown causes.

Nesting

Hens followed most of the typical nesting patterns reported by others. They often travelled long distances to nest sites although suitable nesting habitat was available in their winter ranges (Healy 1981, Williams 1981). Hens moved an average of 2.6 km from capture sites to nest sites (Table 11). The maximum and minimum distances traveled from capture sites to nests were 4.8 km and 0.9 km respectively. Seventy-five percent ($n=8$) of the radio-marked hens successfully nested in 1986. Only 1 hen ($n=6$) successfully nested in 1987. One nest was found destroyed by predators in 1987 and the rest of the hens failed to remain in one area long enough to indicate nesting. Nesting activity in 1987 occurred at least 1 week later than in 1986.

Most nests were located in areas with dense, low vegetation and were usually placed next to a tree or other vertical object (Bailey and Rinell 1967, Hayden 1980, Healy 1981, Lazarus and Porter 1985). Mountain laurel *(Kalmia latmi)* and huckleberry *(Vaccinium* sp.) were typical understory species near nests. Several nests were located in areas with large rocks and boulders with little understory vegetation. One hen nested in a young (3-year old) hardwood regeneration area. The only radio-equipped hen followed through 2 nesting seasons nested in the same general area (within 900m) both years. The average clutch size in my study was similiar to the 10 and 11 eggs per nest reported by others (Williams et al. 1971, Hon et al. 1978, Everett et al. 1980, Speake and Metzler 1985). Each successful hen hatched an average of 9 eggs (Table 11). Three hens left 1 or 2 unhatched eggs in their nests.

Openings and road-edges were not utilized as nest sites as much as other studies have reported (Speake et al. 1975, Speake and Metzler 1985). Fifty percent of nests were located greater than 450m from a road and only thirteen percent were within 150m of a type A, B, C, or D road (Table 10, Fig. 12). The nest located closest to a road was destroyed by a predator. Twenty-two percent of nests were within 150m of a type E (reseeded) road. Distances from nests ($n=8$) to roads (type A,B,C or D) and random points were similiar ($P>0.05$). Proximity to woods roads and trails (type F) was not analyzed.

Table 11. Nesting data for radio-equipped wild turkey hens, Deerfield, Va. 1986-1987.

Hen number	Starting date[A] egg laying	Starting date[B] incubation	Date hatched	Eggs layed	Eggs hatched	Distance (m) from road	Distance (m) from trapsite
510	4-11-86	4-25-86	5-23-86	9	9	558	95445
200	4-12-86	4-26-86	5-24-86	10	9	192	948
930	4-13-86	4-27-86	5-25-86	?	?	303	1050
360	4-17-86	5-1-86	5-29-86	11	8	260	1220
260	4-23-86	5-7-86	6-4-86	9	9	1353	3680
458	4-26-86	5-10-86	6-9-86	12	11	666	2985
458	5-6-87	5-20-87	6-17-87	?	?	845	3635
276	?	?	predated	?	?	62	1200

[A]Estimated using a 14 day laying period.

[B]Estimated using a 28 day incubation period.

Road use

The Virginia Department of Transportation (VDT) counted traffic on type A and B roads once (24 hrs) each year, usually in the spring. Traffic on type A and B roads averaged 115 and 63 cars per day respectively. A short segment of type A road (state route 39) on the southern border of the study area averaged 1670 cars per day. Traffic on the only type-C road in the study area ranged from 2 - 123 cars per day (Fig. 13). Traffic on type-D roads ranged from 0 - 60 cars per day (Fig. 14). Type-D roads were open to the general public only during fall hunting seasons (late September - December). Loggers and Forest Service employees were the main type D road users during the remainder of the year. Traffic was heaviest on both type-C and type-D roads during the 2 weeks of deer rifle season in November. Traffic in November on type-C and type-D roads was 9-fold and 18-fold the January through September average, respectively. Spring gobbler season in April and May was related to a slight increase in traffic levels on the type C road. Type-F roads were not considered in any analysis because they could not be accurately mapped.

Response to roads

Distances from turkeys and random points to the nearest road (type A,B C or D) were not different ($p > 0.05$), but turkeys used the area within 150m of roadtypes A and B less than expected ($p < 0.05$) annually (Tables 12, 13 and 14). The percent of road type B found within individual home ranges and the composite home range was similiar ($p > 0.05$), however, individual home ranges had less of road type A ($p < 0.05$) than the composite home range. Turkeys were observed to cross roadtypes A and B only in locations where the road was bordered by woods or fields less than 80m wide.

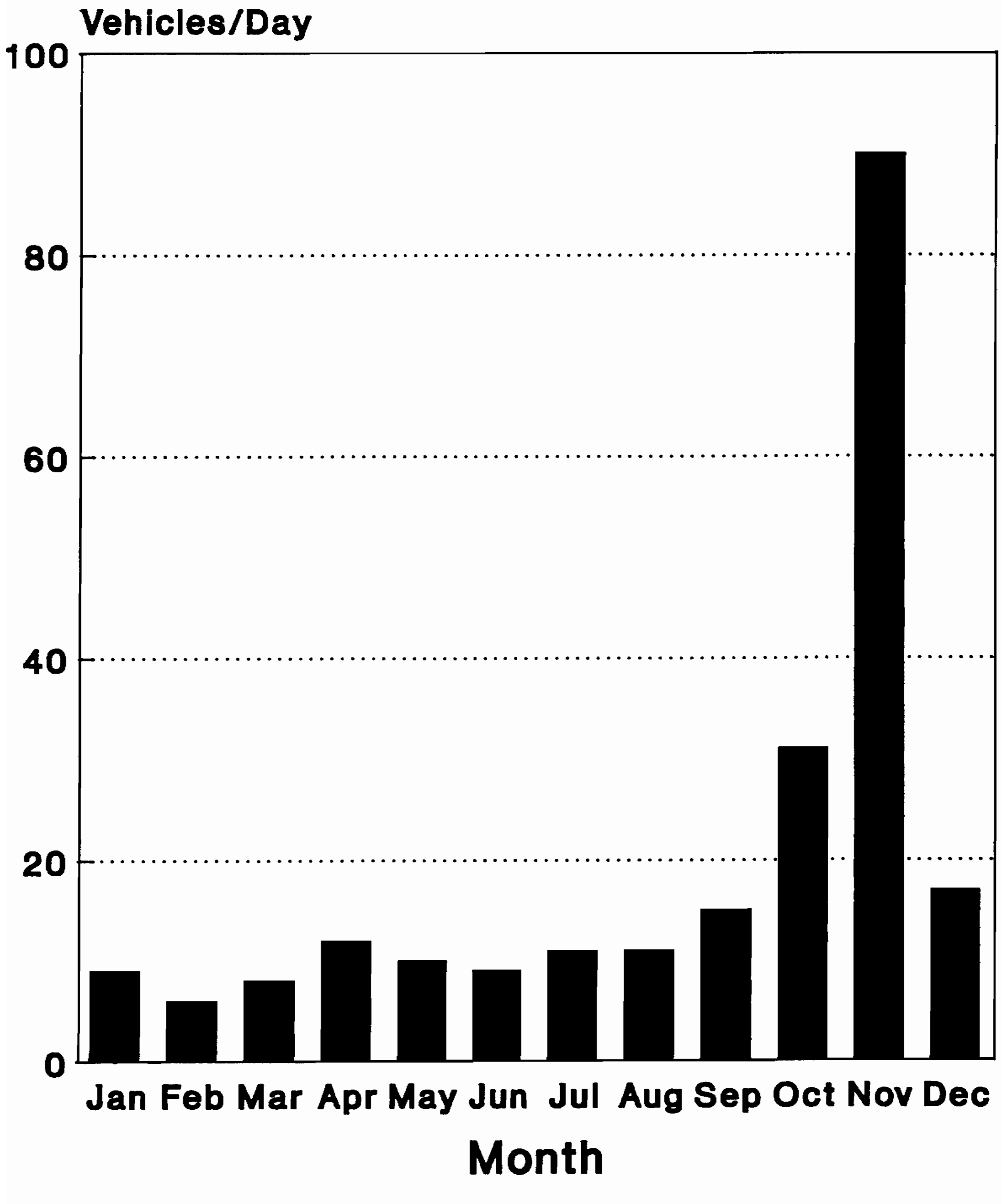

Figure 13. Average monthly road use for Forest Service roads open year around on the Deerfield, Virginia, study area, 1985-1987.

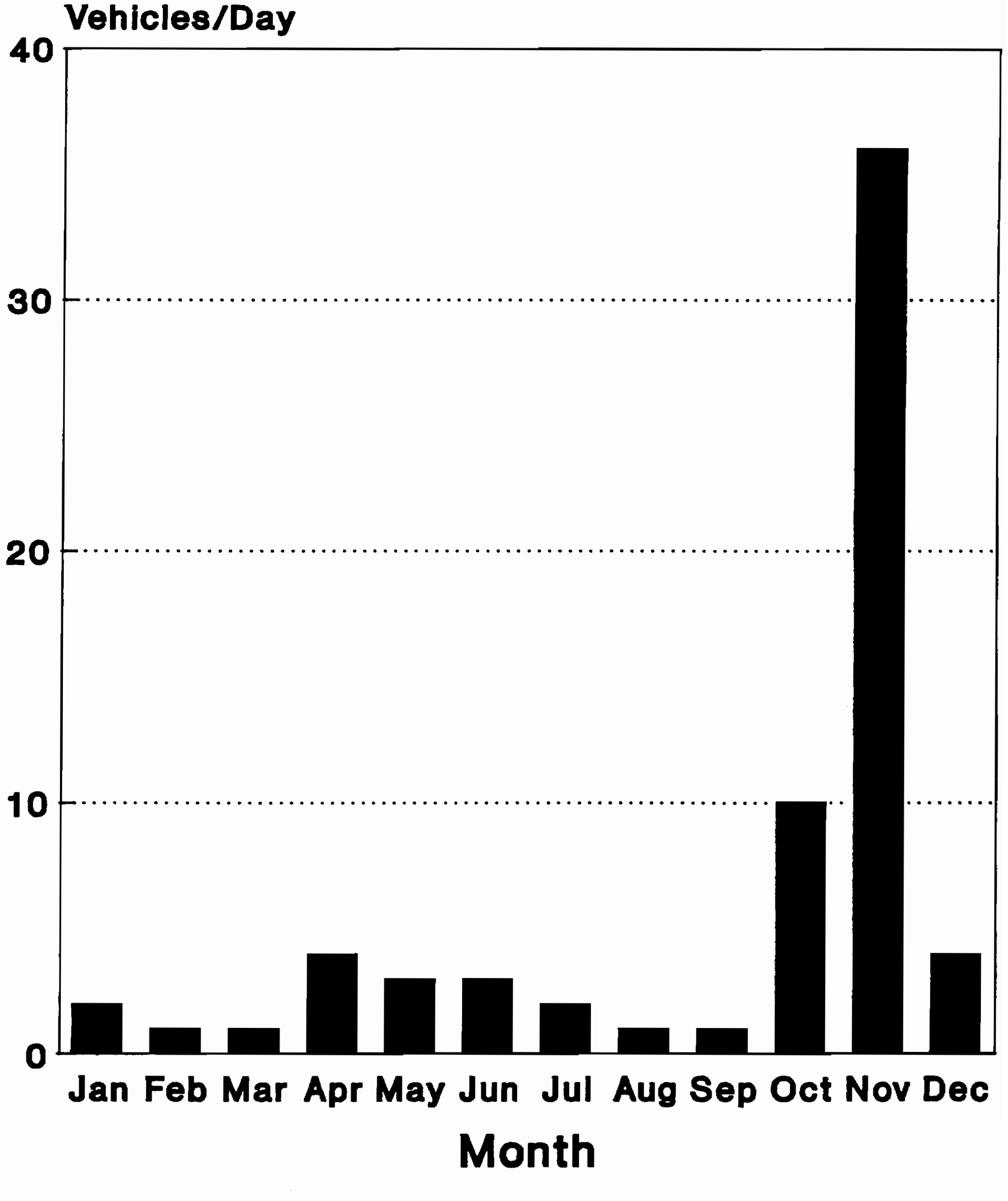

Figure 14. Average monthly road use for Forest Service roads open seasonally on the Deerfield, Virginia, study area, 1985-1987.

Table 12. Road-zone use vs. road-zone availability for wild turkeys near Deerfield, Virginia 1985-1987.

		All Year		Fall		Summer		Spring	
Road-zone Type (m)	% Available	% Used	Pref[A]	% Used	Pref	% Used	Pref	% Used	Pref
A (0-150)	6.5	3.0	-	4.0	0	2.0	-	2.4	-
A (150-300)	6.5	7.0	0	9.5	0	5.0	0	5.7	0
A (300-450)	6.7	9.6	+	12.9	+	10.0	+	5.0	0
B (0-150)	5.4	1.7	-	0.5	-	6.0	0	3.1	0
B (150-300)	5.0	4.0	0	2.0	-	4.0	0	7.3	0
B (300-450)	4.9	4.0	0	4.0	0	2.6	-	8.1	0
C (0-150)	4.3	3.7	0	5.7	0	2.7	0	2.9	0
C (150-300)	3.9	2.0	-	1.7	-	2.4	0	2.9	0
C (300-450)	3.7	2.0	-	0.5	-	1.8	-	3.6	0
D (0-150)	2.5	0.8	-	0.0	0	0.8	-	1.6	0
D (150-300)	2.3	2.0	0	0.5	-	3.0	0	3.1	0
D (300-450)	2.2	1.5	0	1.0	0	2.0	0	1.3	0
> 450	37.0	47.0	+	48.0	+	52.0	+	39.0	0
inters.	8.6	11.0	+	9.0	0	9.6	0	13.0	+
N locations		2185		402		882		616	
χ^2		270		98		163		73	

[A] + = used more than available; - = used less than available; 0 = use proportional to availability ($p<0.05$).

Table 13. Road-zone use vs. road-zone availability for male wild turkeys near Deerfield, Virginia, 1985-1987.

Road Type	Zone (m)	% Available	All Year % Used	All Year Pref[A]	Spring % Used	Spring Pref	Summer % Used	Summer Pref
A	0-150	6.5	3.7	-	3.0	-	1.8	-
A	150-300	6.5	7.8	0	5.6	0	3.7	0
A	300-450	6.7	11.0	+	6.6	0	14.4	+
B	0-150	5.4	1.1	-	2.8	0	1.2	0
B	150-300	5.0	3.1	0	6.6	0	2.1	0
B	300-450	4.9	4.1	0	8.3	0	2.8	0
C	0-150	4.3	2.9	0	3.8	0	3.7	0
C	150-300	3.9	1.7	-	2.8	0	1.5	-
C	300-450	3.7	2.2	-	3.5	0	2.8	0
D	0-150	2.5	0.9	-	2.1	0	0.9	0
D	150-300	2.3	3.1	0	3.8	0	5.5	0
D	300-450	2.2	1.7	0	1.4	0	4.0	0
-	> 450	37.0	49.7	+	38.0	0	51.0	+
-	inters.	8.6	7.0	0	12.0	+	4.6	-
N locations			1145		288		326	
χ^2			195		30		116	

[A] + = used more than available, - = used less than available, 0 = use proportional to availability ($p<0.05$)

Table 14. Road-zone use vs. road-zone availability for female wild turkeys near Deerfield, Virginia, 1985-1987.

			All Year		Spring		Summer	
Road Type	Zone (m)	% Available	% Used	Pref[A]	% Used	Pref	% Used	Pref
A	0-150	6.5	1.9	-	1.0	-	2.1	-
A	150-300	6.5	6.4	0	3.6	0	7.0	0
A	300-450	6.7	6.2	0	3.9	0	8.0	0
B	0-150	5.4	2.6	-	4.7	0	2.3	0
B	150-300	5.0	5.6	0	9.0	0	4.6	0
B	300-450	4.9	4.8	0	7.5	0	2.8	0
C	0-150	4.3	4.3	0	2.5	0	1.8	-
C	150-300	3.9	2.6	-	2.9	0	1.8	0
C	300-450	3.7	1.4	-	2.9	-	0.9	-
D	0-150	2.5	0.7	-	1.1	0	0.9	0
D	150-300	2.3	1.3	0	1.4	0	0.9	0
D	300-450	2.2	1.1	-	1.1	0	1.6	0
-	> 450	37.0	47.0	+	45.0	0	29.0	0
-	inters.	8.6	14.0	+	13.0	0	13.0	0
N locations			960		279		434	
χ^2			135		67		81	

[A] + = used more than available, - = used less than available, 0 = use proportional to availability ($p < 0.05$).

Avoidance of the area within 150m of road types A and B may have been caused by the synergistic interaction of road use and surrounding habitat. The 150m zone around type A and type B roads contained 55 percent and 35 percent fields, respectively (Table 15). Eichholz and Marchinton (1975) found that constructed topographic features such as improved pastures, roads and large agricultural clearings acted as barriers to turkeys. Turkeys in their study area never crossed a 243 ha pasture bordered by a highway. Raybourne (1968) reported that turkeys crossed clearcut areas not greater than 137-183m wide but did not penetrate beyond 46-69m if clearcuts were greater than 274m in width. Williams et al. found that palmetto prairies restricted turkey movements (Williams et al. 1974). Oxley et al. (1974) found road clearance (the distance from forest to road edge) to be the most important factor inhibiting movements of forest mammals across roads.

Turkeys have a highly developed sense of hearing (Maiorana and Schleidt 1972) but seem to rely more on sight than hearing to detect danger. According to Williams (1981:60), sound alone causes no genuine fear, and turkeys can become accustomed to routine sounds in their environment, even those associated with people, such as automobiles and chainsaws. Manci et al. (1988) found that sonic booms failed to break-up brood groups and turkeys returned to normal activity 30 seconds after a sonic boom.

Turkeys may cross type A and B roads in wooded areas and small fields because they can not see approaching traffic. The sound of traffic may not be enough to cause flight without the added stimulus of seeing the vehicles. A turkey in a wide field can see approaching vehicles from a farther distance and may be disturbed before reaching the road to cross it.

Van Der Zande et al. (1980) found that there was a definite threshhold value of a stimulus beyond which a bird will react by avoidance. Madsen (1985) reported that geese would feed undisturbed in fields only at greater than 200-300m from a road. This distance increased with greater traffic levels. The area 300-450m away from road type A was used more than expected ($p<0.05$) annually. Use of the area 300-450m away from road type B was not different from expected ($p<0.05$). This zone contained 26-28 percent fields. Turkeys located in fields in these zones were observed for reactions to passing vehicles. The sound of an approaching

Table 15. Percentage of each habitat type found within each road-zone type near Deerfield, Virginia, 1985-1987.

Road-Zone Type (m)	Habitat Type				
	% Pine	% Pine-Hw	% Fields	% Hardwood	% Regeneration
A (0-150)	3	19	55	23	0
A (150-300)	3	22	41	34	.2
A (300-450)	3	26	28	43	.5
B (0-150)	3	18	35	42	2
B (150-300)	2	17	29	50	2
B (300-450)	2	15	26	56	1
C (0-150)	6	8	2	65	20
C (150-300)	6	6	2	63	24
C (300-450)	9	9	2	67	13
D (0-150)	2	.7	.6	83	14
D (150-300)	1	3	.1	86	10
D (300-450)	2	8	.2	84	6
> 450	3	16	8	69	4

Hw= Hardwood

vehicle usually would cause a turkey to raise its head, but only large trucks occasionally would cause flight. Turkeys may have become used to seeing traffic at a distance on type A or B roads since most vehicles rarely slowed or stopped. Burbridge and Neff (1975) found that vehicles moving rapidly on roads were less disturbing to elk than vehicles moving slowly, although less often, on rougher roads. Wright and Speake (1975) observed that turkeys at Land Between the Lakes would feed in large fields with a tractor 500m away. Apparently the avoidance threshhold in large fields near type A or B roads lies between 0 - 300m from the road.

Pastures along type A and B roads were generally bordered by woven-wire fences. Turkeys are easily confused by fences that they cannot walk through (Williams 1981:71). One unmarked hen in my study area almost was captured by hand after she crossed a type B road and ran into a woven-wire fence. Turkeys may remember areas with fences and choose alternative sites, such as unfenced woods, at which to cross roads.

Sufficient traffic may cause turkeys to avoid crossing a road. Radio-marked turkeys in the study never crossed a section of heavily used type A road (70 vehicles/hour) even though it was bordered primarily by woods on each side. Vehicles may have passed frequently enough to discourage any turkey attempting to cross the road in this area. Local residents reported seeing turkeys occasionally flying across wide fields and busy roads such as interstates.

Turkeys used the area 150-450m away from road type C less than expected ($p<0.05$) annually (Table 12). Distances from turkeys to road type C were not correlated with road use. The percent of road type C found within individual home ranges and the composite home range was similiar ($p>0.05$). Since turkeys avoided the 150 - 450m zone rather than the 0 - 150m zone, the results probably reflect habitat use rather than road or road-use effects.

The type C road was bordered on the east by the northwest side of Sideling Hill which was primarily hardwood habitat with dense ericaceous understories or regeneration cuts. Turkeys seldom were located in this type of habitat except during nesting season or when the huckleberries were ripe. Healy (1981) observed that turkeys use brush understories for escape cover, for nesting, and for feeding when food is abundant in them. Hardwood forest with open understories generally is considered preferred fall and winter habitat (Bailey and Rinell 1968, Bailey 1976, Eichholz and Marchinton 1976). Turkeys located on the opposite side of Sideling Hill generally had oblong shaped home ranges, the long axes of which ran parallel with the topography. Turkeys moved linearly along the southeast slopes in the fall and winter rather than crossed over to the northwest slopes of Sideling Hill.

Females used the area within 150m of type C roads less than expected ($p < 0.05$) in the summer (Table 14). Road use, which ranged from 0 - 11 vehicles/24 hours during the summer, likely did not cause the hens to avoid the road. Another possible explanation is that good brood habitat generally was unavailable near the type C road except sections at either end of the road which were included in the intersection zone. Hens may have used the 150m zone less than expected in the summer because better brood range was available elsewhere.

Turkeys used the area within 150m of road type D less than expected ($p < 0.05$) annually and in the summer (Table 12). Females used the 300-450m zone around type D roads less than expected ($p < 0.05$) annually (Table 14). Two type D roads were included in the study area (Fig. 3); Walker Mountain road (18.7 km) followed a ridgetop and Bettys Hill road (3.9 km) was located on a southeast midslope. Speake and Metzler (1985) found that mountaintops in Alabama were non-utilized as brood range due to little herbaceous cover and few openings. Walker Mountain had few openings, most of which were located on either end of the mountain and included in the intersection zone category rather than the road type D zones. Bettys Hill road area was utilized by turkeys in the winter and early spring, but winter location data were not plentiful enough to analyze. Three successful trapsites were located near the road during the winter. Annual data sets contained primarily spring, summer and fall locations.

The area greater than 450m from any type A, B, C, or D road was used more than expected annually, in the fall and in the spring ($p < 0.05$). The intersections zone was used more than expected annually and in the spring ($p < 0.05$). Males used the intersection zone less than expected in the summer ($p > 0.05$). Intersection zones occurred primarily in areas where two road types met. Engineers design road intersections in areas with low slopes which typically have good timber site indexes (Trimble and Weitzman 1956, U.S. Department of Agriculture

1987). Turkeys may have used intersection zones because the habitat was better than that available on much of the study area. Turkeys were seen on roads more in the spring and early summer than at any other time of year analyzed.

The area within 150m of type E (reseeded) roads was used more than expected in the summer and spring and less than expected in the fall (Fig. 15). Other turkey studies have shown the importance of roads seeded to grasses and legumes (Ellis and Lewis 1967, Bailey and Rinell 1968, Hillestad and Speake 1971, Blackburne et al 1975, Speake et al 1975, Hayden 1980). They provide an important source of food in the spring when other food sources have been depleted. Hens require a high-protein, high calcium diet for egg-laying (Scott 1973, Healy 1981) and green forage and invertebrates are important in meeting these needs (Korschgen 1973, Krapu and Swanson 1975). Insects are more abundant in fields and other clearings than in the forest (Wheeler 1948, Stoddard 1963, Martin and McGinnes 1975).

SUMMARY

Turkeys response to road types seemed to depend on: 1) amount of vehicular road use; 2) surrounding habitat; and 3) season. Surrounding habitat and season became more important in determining turkey use of an area as traffic levels decreased. Radio-equipped turkeys never crossed a busy (1670 vehicles/24 hours) state blacktop road, but turkeys crossed state roads with less traffic (63-115 vehicles/24 hours) in locations where the roads were bordered by woods or fields less than 80m wide. State roads bordered by wide fields acted as impediments to turkey movement.

Distance from turkeys to open Forest Service roads was not negatively correlated with vehicular road use, although traffic levels may not have varied enough to test adequately for correlation. Correlation efforts were further confounded because peak road use occurred during hunting season when turkeys could have been disturbed by hunters in the woods.

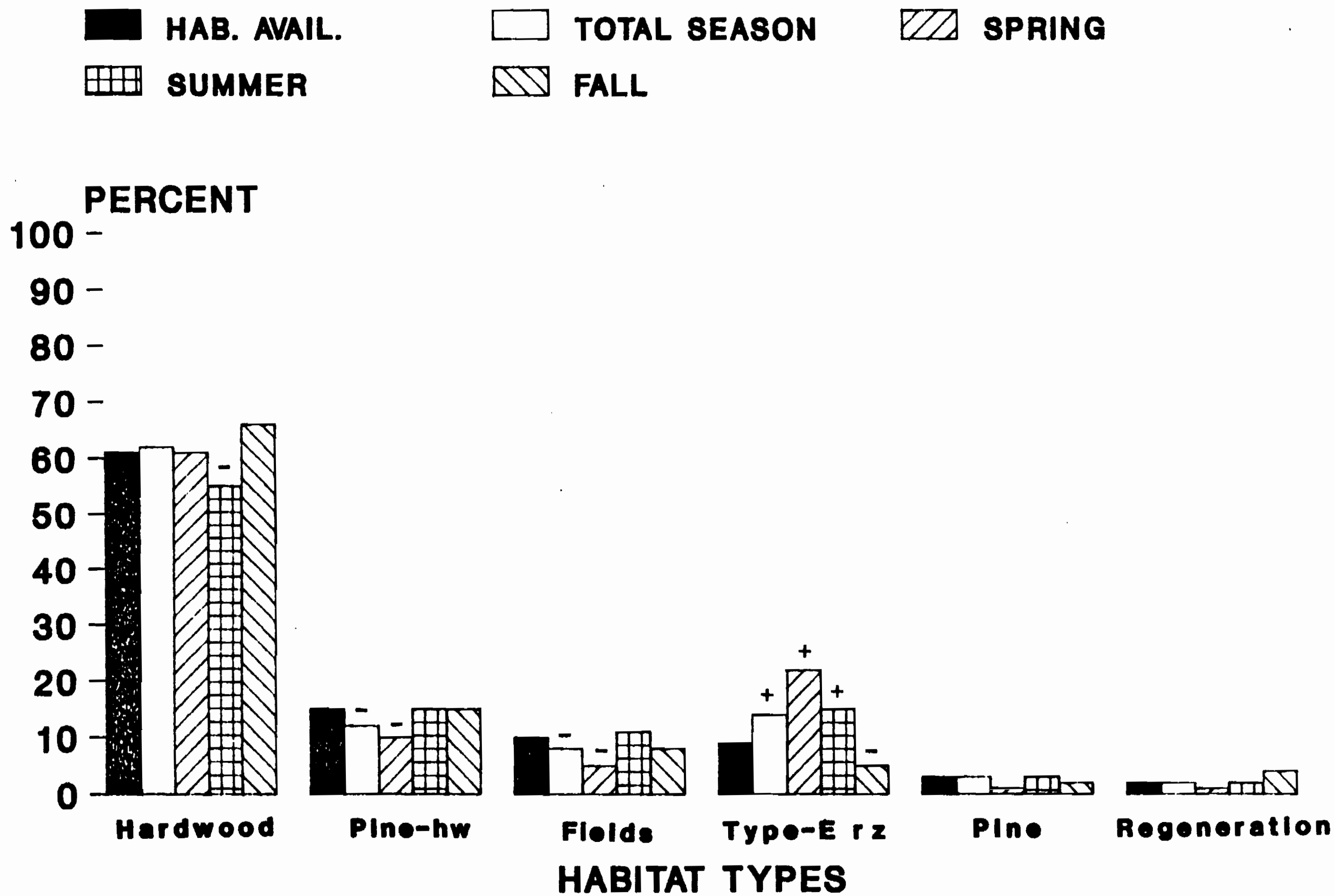

Figure 15. Seasonal habitat availability and use by wild turkeys within the Deerfield, Virginia, study area, 1985-1987.

Seasonal habitat preferences seemed to be responsible for turkey use of areas near Forest Service roads. Lack of preferred brood habitat near Forest Service roads may have caused hens to use the near-road zone less than expected in the summer. Traffic levels were relatively low (0-11 vehicles/24 hours) and yet hen use also was low. Areas greater than 450m from any road were preferred throughout most of the year.

Turkey mortality did not seem to be closely related to road type or road use levels. The majority of radio-marked turkeys did not die or were not shot close to roads. Turkeys shot in the spring were farther from open roads than those shot in the fall when more roads were open to public use. Poaching of radio-equipped turkeys along open roads did not seem to be a significant source of mortality in the study area. The fall hen harvest on the study area was greater than the maximum harvest generally recommended to sustain a viable population. Since 62 percent of the turkeys harvested during fall hunting seasons were shot during the 2-week deer rifle season, removing turkey hunting from the deer season might reduce the hen harvest.

The closed, revegetated roads in the study area were preferred turkey habitat during the spring and summer. The practice of revegetating logging roads after the timber is harvested should be continued on the GWNF. Seed mixtures beneficial to turkeys and other wildlife should be used wherever possible. Roads that presently are gated but never open to the public, also could be revegetated until they need to be used again.

The GWNF is fragmented by private landholdings; steep, mountainous areas typically belong to the Forest Service while the valley land is privately owned. Many state maintained roads are located in valleys and Forest Service land may border the roads in only a few locations. Since state roads surrounded by wide fields may restrict turkey movements, the Forest Service should strive to maintain sections of mature forest near state roads to avoid eliminating wildlife travel corridors.

This study was conducted on a small area with a small sample size of each road type. Future studies of wildlife responses to roads and road use should be conducted on a larger area with a greater variety of roads and road use.

LITERATURE CITED

Adams, L.W. and A.D. Geis. 1981. Effects of highways on wildlife. Federal Highway Administration Rep. FHWA-RD-81-067. 149 pp.

_____, and A.D. Geis. 1983. Effects of roads on small mammals. J. Appl. Ecol. 20:403-415.

Alexander, V. and M.C. Miller. 1982. Pipeline haul-road investigations north of the Brooks Range. Inst. Mar. Sci., Univ. Alaska. 105 pp.

Austin, D.H. 1965. Trapping turkeys in Florida with the cannon net. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 19:16-22

_____, T.E. Peoples, and L.E. Williams, Jr. 1975. Procedures for capturing and handling live wild turkeys. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 26:226-236.

Bailey, R.W. 1976. The wild turkey's management and future in North Carolina. N.C. Wildl. Resour. Comm. Div. Game. 21 pp.

_____ and K.T. Rinell. 1968. History and management of the wild turkey in West Virginia. W.Va. Dep. Nat. Resour. Div. Game and Fish Bull. 6. 59 pp.

Blackburn, W.E., J.P. Kirk, and J.E. Kennamer. 1975. Availability and utilization of summer foods by eastern wild turkey broods in Lee County, Alabama. Proc. Natl. Wild Turkey Symp. 3:86-95.

Bowman, J.A, C.E. Hill and R.Q. Burleson. 1979. Seasonal movements of restocked wild turkeys in North Carolina. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 33:212-223.

Brody, A.J. and M.R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildl. Soc. Bull. 17:5-10.

Brown, E.K. 1980. Home range and movements of wild turkeys - a review. Proc. Natl. Wild Turkey Symp. 4:251-261.

Brown, W.S. 1980. Black bear movements and activities in Pocahontas and Randolph counties, West Virginia. M.S. Thesis, W.Va. Univ., Morgantown.

Burbridge, W.R. and D.J. Neff. 1975. Cocomino National Forest-Arizona game and fish department cooperative roads-wildlife study. Pages 44-57 in Proc. Elk-Logging-Roads Symp. Univ. of Idaho, Moscow.

Carr, P.C., and M.R. Pelton. 1984. Proximity of adult female black bears to limited access roads. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 38:70-77.

Clark, L.G. 1985. Adjustment by transplanted wild turkeys to an Ohio farmland area. Proc. Natl. Wild Turkey Symp. 5:33-48.

Clark, W.D. and J.R. Karr. 1979. Effects of highways on red-winged blackbird and horned lark populations. Wilson Bull. 91:143-145.

Cochran, W.W. 1980. Wildlife telemetry. Pages 507-520 in S.D. Schemnitz, ed. Wildlife Management Techniques Manual, 4th ed. The Wildlife Society, Washington, D.C. 686 pp.

Curatolo, J. 1983. Caribou response to pipeline/road complex in the Kuparuk Oilfield, AK. Proc. Alaska Sci. Conf. 34:10.

Dau, J.R. and R.D. Cameron. 1986. Effects of a road system on caribou distribution during calving. Rangifer, special issue 1:95-101.

Davis, J.W. 1982. Population, second homes, roads and other developments and their effects on wildlife. Page 25- in Proc. of the workshop: the effects of land manage. practices on fish and wildl. in southwestern conifer forest.

DeLeornardis, S. 1970. The industrialization of the north and its effects on wildlife resources. Pages 46-49 in 34th Fed. Prov. Wildl. Conf. Yellowknife, Northwest Territories.

Doster, G.L. 1974. Aspirated corn kernels cause death of cannon netted wild turkeys. J. Wildl. Manage. 38:578.

Egler. R.E. 1957. Rights of ways and wildlife habitat: a progress report. Trans. N. Am. Wildl. Conf. 22:133-142.

Eichholz, N.F. and R.L. Marchinton. 1975. Dispersal and adjustment to habitat of restocked wild turkeys in Georgia. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 29:373-378.

Ellis, J.E. and J.B. Lewis. 1967. Mobility and annual range of wild turkeys in Missouri. J. Wildl. Manage. 31:568-581.

Everett, D.D, D.W. Speake, W.K. Maddox, D.R. Hillestad and D.N. Nelson. 1978. Impact of managed public hunting on wild turkeys in Alabama. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 32:116-125.

_____, D.W. Speake and W.K. Maddox. 1979. Wild turkey ranges in Alabama mountain habitat. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 33:233-238.

_____, D.W. Speake and W.K. Maddox. 1980. Natality and mortality of a Northern Alabama wild turkey population. Proc. Natl. Wild Turkey Symp. 4:117-126.

_____, D.W. Speake, W.K. Maddox, D.R. Hillestad and D.N. Nelson. 1978. Impact of managed public hunting on wild turkeys in Alabama. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 32: 116-125.

Everett, D.D, Jr. 1982. Factors limiting populations of wild turkeys on state wildlife management areas in North Alabama. Ph.D. dissertation, Auburn Univ., Al. 124 pp.

Ferris, C.R. 1979. Effects of interstate 95 on breeding birds in Northern Maine. J. Wildl. Manage. 43:421-427.

Fleming, J.W. and D.W. Speake. 1976. Losses of the eastern wild turkey from a stable Alabama population. Proc. Ann. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 30:377-385.

Folk, R.H, III. and R.L. Marchinton. 1980. Effects of intensive deer hunting on behavior of wild turkeys. J. Wildl. Manage. 44:922-927.

Garner, N.P. 1986. Seasonal movements, habitat selections, and food habits of black bears *(Ursus americanus)* in Shenandoah National Park, Virginia. M.S. Thesis, Virginia Polytech. Inst. and State Univ., Blacksburg. 104 pp.

Getz, L.L., F.R. Cole and D.L. Gates. 1978. Interstate roadsides as dispersal routes for *Microtus pennsylvanicus*. J. Mammal. 59:208-212.

Hamilton, R.J., and R.L. Marchinton. 1980. Denning and related activities of black bears in the coastal plain of North Carolina. Int. Conf. Bear Res. and Manage. 4:121-126.

Hancock, N.V. 1963. Impact of interstate highways upon the wildlife resource. Proc. Annu. Conf. Western Assoc. Game and Fish Comm. 43:183-187.

Haugan, A.O. 1944. Highway mortality of wildlife in Southern Michigan. J. Mammal. 25:141-146.

Hayden, A.H. 1980. Dispersal and movements of wild turkeys in Northern Pennsylvania. Trans. Northeast Sect. Wild. Soc. 37:258-265.

Healy, W.M. 1981. Habitat requirements of wild turkeys in the southeastern mountains. Pages 24-34 in P.T. Bromley and R.L. Carlton, eds. Proc. Symp. Habitat Requirements and Habitat Management for the Wild Turkey in the Southeast. Richmond, Va. 180 pp.

Hellgren, E.C. and M.R. Vaughan. 1988. Seasonal food habits of black bears in Great Dismal Swamp, Virginia-North Carolina. Proc. Southeast. Assoc. Fish and Wildl. Agencies. 42:295-305.

Heisey, D.M., and T.K. Fuller. 1985. Evaluation of survival and cause- specific mortality rates using telemetry data. J. Wildl. Manage. 49:668-674

Hillestad, H.O. and D.W. Speake. 1970. Activities of wild turkey hens and poults as influenced by habitat. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildlife Agencies. 24:244-251.

Hilmon, J.B. and H.L. Holbrook. 1981. Wild turkey management on southern national forests. Pages 55-58 in P.T. Bromley and R.L. Carlton, eds. Proc. Symp. Habitat Requirements and Habitat Management for the Wild Turkey in the Southeast. Richmond, Va. 180 pp.

Holbrook. H.L. 1973. Management of wild turkey habitat in southern forest types. Pages 245-252 in G.C. Sanderson and H.C. Schultz, eds. Wild turkey management: current problems and programs. Univ. Missouri Press, Columbia.

_____, and J.C. Lewis. 1967. Management of the eastern turkey in the southern Appalachian and Cumberland Plateau Region. Pages 343-370 in O.H. Hewitt, ed. The wild turkey and its management, The Wildlife Society, Washington, D.C., 589 pp.

Holbrook, H.T., and M.R. Vaughan. 1985. Capturing adult and juvenile wild turkeys with adult dosages of alpha-chloralose. Wildl. Soc. Bull. 13:160-163.

_____, and M.R. Vaughan. 1985. Influence of roads on turkey mortality. J. Wildl. Manage. 49:611-614.

Hon, T., D.P. Belcher, B. Mullis and J.R. Monroe. 1978. Nesting, brood range and reproductive success of an insular turkey population. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 32:137-149.

Huey, L.M. 1941. Mammalian invasion via the highway. J. Mammal. 22:383-385.

Jensen, W.F., T.K. Fuller, and W.L. Robinson. 1986. Wolf *(Canis lupus)* distribution on the Ontario-Michigan border near Sault Ste. Marie. Can. Field-Nat. 100:363-366.

Joselyn, G.B., and G.I. Tate. 1972. Practical aspects of managing roadside cover for nesting pheasants. J. Wildl. Manage. 36:1-11.

Kennamer J.E., J.R. Gwaltney, K.R. Sims and A. Hosey, Jr. 1981. Effects of forest management on wild turkeys in the coastal plain regions. Pages 131-136 in P.T Bromley and R.L. Carlton, eds. Proc. Symp. Habitat Requirements and Habitat Manage. for the Wild Turkey in the Southeast. Richmond, Va. 180 pp.

Kimmel, V.L. and E.W. Kurzejeski. 1985. Illegal hen kill - a major turkey mortality factor. Proc. Natl. Wild Turkey Symp. 5:55-65.

Koeln, G.T. 1980. A computer technique for analyzing radio-telemetry data. Proc. Natl. Wild Turkey Symp. 4:262-271.

Korschgen, L.J. 1967. Feeding habits and foods. Pages 137-198 in O.H. Hewitt, ed. The Wild Turkey and its Management. The Wildlife Society, Washington, D.C. 589 pp.

Kozak, S.J. 1970. Report of investigations 21. Geology of the Elliot Knob, Deerfield, Craigsville and Augusta Springs Quadrangles, Virginia. Va. Div. Mineral Resources. 23 pp.

Krapu, G.L. and G.A. Swanson. 1975. Some nutritional aspects of reproduction in prairie nesting pintails. J. Wildl. Manage. 39:156-162.

Kurzejeski, E.W., L.D. Vangilder and J.B. Lewis. 1987. Survival of wild turkey hens in North Missouri. J. Wildl. Manage. 51:188-193.

Latham, R.M. 1956. Complete book of the wild turkey. Stackpole Company. Harrisburg, Pa. 265 pp.

Lazarus, J.E. and W.F. Porter. 1985. Nest habitat selection by wild turkeys in Minnesota. Proc. Natl. Wild Turkey Symp. 5:67-81.

Leclerq, B. 1985. Influence des routes et voies de penetrations humaines sur les comportements de grand tetras et de gelinottes dans le Haut-Jura francais. Pages 197-203 in J.M. Bernard, M. Lansiart, C. Kempf, and M. Tille, eds. Routes et Faune Sauvage, Actes du colloque. CIFFEN, Colmar, France. 406 pp.

Lee, J.E., G.C. White, R.A. Garrott, R.M. Bartmann, and A.W. Alldredge. 1985. Accessing accuracy of a radiotelemetry system for estimating animal locations. J. Wildl. Manage. 49:658-663.

Leedy, D.L. 1975. Highway-wildlife relationships volume 1. A state-of-the-art-report. Fed. Highway Admin. Rep. FHWA-RD-76-4. 184 pp.

Logan, T.H. 1973. Seasonal Behavior of Rio Grande wild turkeys in Western Oklahoma. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 27:74-91.

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. J. For. 81:592-595.

Mader, H.J. 1984. Animal habitat isolation by roads and agricultural fields. Biol. Conserv. 29:81-96.

Madsen, J. 1985. Impact of disturbance on field utilization of pink-footed geese in West Jutland, Denmark. Biol. Conserv. 33:53-63.

Maiorana, V.A. and W.M. Schleidt. 1972. The auditory sensitivity of the turkey. J. Aud. Res. 12:203-207.

Manci, K.M., D.N. Gladwin, R. Villella, M.G. Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. U.S. Fish and Wildl. Serv. National Ecology Research Center, Ft. Collins, Co. NERC-88/29. 88 pp.

Markley, M.H. 1967. Limiting factors. Pages 199-243 in O.H. Hewitt, ed. The wild turkey and its management, The Wildlife Society, Washington, D.C. 589 pp.

Martin, D.D. and B.S. McGinnes. 1975. Insect availability and use by turkeys in forest clearings. Proc. Natl. Wild Turkey Symp. 3:70-75.

McClure, H.E. 1951. An analysis of animal victims on Nebraska highways. J. Wildl. Manage. 15:410-420.

McLellan, B.N. and D.M. Shackleton. 1988. Grizzly bears and resource-extraction industries: effects of roads on behavior, habitat use and demography. J. Appl. Eco. 25:451-460.

_____, and D.M. Shackleton. 1989. Immediate reactions of grizzly bears to human activities. Wildl. Soc. Bull. 17:269-274.

Mech, L.D., S.H. Fritts, G.L. Radde and W.J. Paul. 1988. Wolf distribution and road density in Minnesota. Wildl. Soc. Bull. 16:85-87.

Michael, E.D. 1978. Effects of highway construction on game animals. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 32:48-52.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.

Morgan, J.T. 1989. Overwinter survival of wild turkeys on central Virginia's industrial forests. M.S. Thesis, VPI and SU, Blacksburg, Va. 85 pp.

Mosby, H.S. 1967. Population dynamics. Pages 113-136 in O.H. Hewitt, ed. The wild turkey and its management. The Wildlife Society, Washington, DC. 589 pp.

_____, and C.O. Handley. 1943. The wild turkey in Virginia: its status, life history and management. Va. Comm. Game and Inland Fish. Richmond, Va. 281 pp.

Neu, C.W., C.R. Byers, and J.M. Peek. 1974. A technique for analysis of utilization-availability data. J. Wildl. Manage. 38:541-545.

Oxley, D.J., M.B. Fenton, and G.R. Carmody. 1974. The effects of roads on populations of small mammals. J. Appl. Ecol. 11:51-59.

Perry, C. and R. Overly. 1975. Impacts of roads on big game distribution in portions of the Blue Mountains of Washington. Pages 62-68 in Proc. Elk-Logging-Roads Symp. Univ. Idaho.

Porter, W.F. 1980. An evaluation of wild turkey brood habitat in southeastern Minnesota. Proc. Natl. Wild Turkey Symp. 4:203-212.

Powell, J.A. 1965. The Florida wild turkey. Tech. Bull. 8. Fla. Game and Fresh Water Fish Comm., Tallahassee. 28 pp.

Raybourne, J.W. 1968. Telemetry of turkey movements. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 22:47-54.

Rost, G.R. and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. J. Wildl. Manage. 43:634-641.

SAS Institute Inc. 1982. SAS user's guide: statistics, 1982 edition. SAS Institute Inc., Cary, N.C. 923 pp.

Scott, M.L. 1973. Nutrition and reproduction-direct effects and predictive functions. Pages 46-59 in D.S. Farner, ed., Breeding biology of birds. National Academy of Sciences, Washington, D.C. 515 pp.

Shaffer, C.H. and J.W. Gwynn. 1967. Management of the eastern turkey in oak-pine forests of Virginia and the Southeast. Pages 303-342 in O.H. Hewitt, ed. The wild turkey and its management. The Wildlife Society, Washington, D.C. 589 pp.

Singer, F.J. 1978. Behavior of mountain goats in relation to U.S. highway 2, Glacier National Park, Montana. J. Wildl. Manage. 42:591-597.

Smith, T.R. 1985. Ecology of black bears in a bottomland hardwood forest in Arkansas. Ph.D. Thesis, Univ. Tennessee, Knoxville. 209 pp.

Speake, D.W. 1980. Predation of wild turkeys in Alabama. Proc. Natl. Wild Turkey Symp. 4:86-101.

Speake, D.W., L.H. Barwick, H.O. Hillestad and W. Stickney. 1969. Some characteristics of an expanding turkey population. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Comm. 23:46-58.

_____, T.E. Lynch, W.J. Fleming, G.A. Wright and W.J. Hamrick. 1975. Habitat use and seasonal movements of wild turkeys in the southeast. Proc. Natl. Wild Turkey Symp. 3:122-130.

_____, and R. Metzler. 1985. Wild turkey population ecology on the Appalachian Plateau region of northeastern Alabama. Alabama project # W-44-6. Final Report.

Springer, J.T. 1979. Some sources of bias and sampling error in radio triangulation. J. Wildl. Manage. 43:926-935.

Steffen, D.E., G.A. Hurst, W.E. Smith and W.J. Hamrick. 1988. Hunter response to road closures for walk-in turkey hunting. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 42:382-387.

Stoddard, H.L, Sr. 1963. Maintenance and increase of the eastern wild turkey on private lands of the coastal plain of the deep southeast. Tall Timbers Research Station Bull. 3. Tallahassee, Fla.

Thiel, R.P. 1985. The relationship between road densities and wolf habitat suitability in Wisconsin. Am. Midl. Nat. 113:404-407.

Trimble, G.R., JR., and S. Weitzman. 1956. Site index studies of upland oaks in the northern Appalachians. For. Sci. 1:162-173.

U.S. Department of Agriculture. 1986. Final environmental impact statement and proposed land and resource management plan for the George Washington National Forest. U.S. Dept. Agric., For. Serv., Southern Region.

_____. 1987. Road preconstruction handbook. U.S. Dept. Agric., For. Serv. Pages 2.32-2.33.

Vander Haegen, W.M., W.E. Dodge, M.W. Sayre. 1988. Factors affecting productivity in a northern wild turkey population. J. Wildl. Manage. 52:127-133.

Van Der Zande, A.N., W.J. Terkeurs and W.J. Van Der Weijden. 1980. The impact of roads on the densities of four bird species in an open field habitat-evidence of a long-distance effect. Biol. Conserv. 18:299-321.

Van Dyke, F.G., R.H. Brocke, H.G. Shaw, B.B. Ackerman, T.P. Hemker and F.G. Lindzey. 1986. Reactions of mountain lions to logging and human activity. J. Wildl. Manage. 50:95-102.

Walker, E.A. 1949. Factors influencing wild turkey populations in the central mineral region of Texas. Texas P-R Report, Series V. 28 pp.

Ward, A.L. 1975. Elk behavior in relation to timber harvest operations and traffic on the Medicine Bow Range in South-Central Wyoming. Pages 32-43 in Proc. Elk-Logging-Roads Symp. Univ. Idaho.

Wheeler, R.J, Jr. 1948. The wild turkey in Alabama. Alabama Dep. Conserv. Bull. 12. 92 pp.

Williams, L.E., Jr. 1966. Capturing wild turkeys with alpha-chloralose. J. Wildl. Manage. 30:50-56.

_____. 1981. The book of the wild turkey. Winchester Press, Tulsa, Oklahoma. 181 pp.

_____, D.H. Austin, and J. Peoples. 1966. Progress in capturing turkeys with drugs applied to baits. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 20:219-226.

_____, D.H. Austin, and J. Peoples. 1974. Movement of wild turkey hens in relation to their nests. Proc. Annu. Conf. Southeast. Fish and Wildl. Agencies. 28:602-622.

_____, D.H. Austin, and J. Peoples. 1978. Turkey harvest patterns on a heavily hunted area. Proc. Annu. Conf. Southeastern Fish and Wildl. Agencies. 32:303-308.

_____, D.H. Austin, J. Peoples, and R.W. Phillips. 1971. Laying data and nesting behavior of wild turkeys. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 25:90-106.

_____, D.H. Austin, J. Peoples, and R.W. Phillips. 1973. Capturing turkeys with oral drugs. Pages 219-227 in G.C. Sanderson and H.C. Schultz, eds. Wild turkey management. Missouri Chapter of the Wildlife Society, Columbia, Mo. 355 pp.

_____, D.H. Austin, N.F. Eichholz, T.E. Peoples, and R.W. Phillips. 1968. A study of nesting turkeys in southern Florida. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 22:16-30.

Wigley, T.B., J.M. Sweeney, M.E. Garner and M.A. Melchoiors. 1986. Wild turkey home ranges in the Ouachita Mountains. J. Wildl. Manage. 50:540-544.

Wilson, H.J. and J. Lewis. 1959. Establishment and spread of the wild turkey in southeastern Michigan. J. Wild. Manage. 23:210-215.

Witmer, G.W. 1982. Roosevelt elk habitat use in the Oregon coast range. Ph.D. Thesis. Oregon State Univ., Corvallis. 111 pp.

Wright, G.A. and D.W. Speake. 1975. Compatibility of the eastern wild turkey with recreational activities at Land Between the Lakes, Kentucky. Proc. Annu. Conf. Southeast. Assoc. Game and Fish Comm. 29:578-584.

Wunz, G.A. 1971. Tolerances of wild turkeys to human disturbance and limited range. Trans. Northeast Sect. of the Wildl. Soc. 28:159-165.

_____, 1985. Wild turkey establishment and survival in small range units of farmland and suburban environments. Proc. Natl. Wild Turkey Symp. 5:49-53.

Vita

Leigh Ann McDougal was born on October 25, 1958 near Philadelphia, Pennsylvania. She graduated from York High School, Yorktown, Virginia in 1976. She attended Virginia Polytechnic Institute and State University and received a bachelor of Science degree in Forestry and Wildlife in June 1982. As an undergraduate, she worked as a co-op student with the U.S. Fish and Wildlife Service in Gainesville, Florida. She entered Virginia Polytechnic Institute and State University as a graduate student in the Department of Fisheries and Wildlife Sciences in January, 1985. She worked as a co-op student-wildlife biologist trainee with the U.S. Forest Service on the Homochitto National Forest in Mississippi from January, 1988 to June, 1988. She accepted a zone wildlife biologist position on the George Washington National Forest in Covington, Virginia, in August, 1989.

Leigh A. McDougal