To the Graduate Council:

I am submitting herewith a thesis written by Lowell Wayne Brown entitled "An Evaluation of Food Plots as a Management Tool for Wildlife on Farms and Forest Lands in East Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Ecology.

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AN EVALUATION OF FOOD PLOTS AS A MANAGEMENT TOOL FOR WILDLIFE ON FARMS AND FOREST LANDS IN EAST TENNESSEE

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

Lowell Wayne Brown

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ABSTRACT

The effects of food plots on wildlife populations were studied on two types of research areas in East Tennessee: pine plantations and farm lands. Wildlife food plants used on the pine plantation included soybeans, kobe lespedeza, Korean lespedeza, white dutch clover, red clover, bicolor lespedeza, and autumn olive. Soybeans, browntop millet, and German millet were used in food plots on the farm land. The average yearly cost per acre of area treated was $1.73 on the pine plantation and $1.12 on the farm.

Wildlife population surveys on the pine plantation revealed a 550 percent increase in bobwhite quail densities. The increase in quail numbers was attributed primarily to the presence of food plots (the only habitat manipulation not common to all study areas). Populations of mourning doves, songbirds, cottontail rabbits, and small mammals appeared to be related to the stage of vegetative succession rather than the presence of food plots. This conclusion was based on the fact that population characteristics of these species on the experimental area did not vary greatly from those on Control 2.

Food plots were believed responsible for a relatively high quail population on the farm land. Bobwhite densities were substantially higher on the treated area than on the control area during both years surveyed. Mourning doves, cottontails, and songbirds did not appear to be influenced to any great extent by food plots. Populations of house mice and white-footed mice were substantially higher within food plots when compared to surrounding areas.

As determined by examination of crop contents, soybeans were the most important winter food source of bobwhites on both farm land and pine plantations when this seed was available. Lespedezas were also a major food source on pine plantations. Bicolor lespedeza and clover were not important constituents of the quail diet during winter. Millets appeared to be important as a food source only in the late summer and early fall months. Forestiera spp. was also an important food source for quail on farm lands.

Cost-return analysis for bobwhite quail on pine plantations was $3.45 per bird. The same type analysis on farm lands revealed a cost of $12.46 per bird.

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CHAPTER I

INTRODUCTION

The importance of food and cover plantings for game species on private land has been noted by many biologists (Burger and Linduska, 1967; Madson, 1962; Musser, 1963; Schumacher, 1969; Sheffer, 1962). In the Southeast, the bobwhite quail (Colinus virginianus) is a very important small game species and has received major emphasis during this type management research. However, few studies of food and cover manipulation as a management practice for bobwhites have been undertaken in Tennessee. At a time when increasing demands are being placed on decreasing game habitat, information concerning the management implications of food plots on bobwhite populations seems vital for more intensive management efforts.

The rising concern for conservation of all natural resources has emphasized the importance of managing for both game and nongame species. Nongame species are valuable as members of ecosystems, for scientific purposes, and for human enjoyment, and must be conserved. In the past, wildlife management programs conducted by state agencies have been financed largely by revenues collected from license holders and have been oriented toward the interests of this group. A lack of funds has prevented many states from initiating adequate management programs for nongame species even though these comprise most wildlife (International Association of Game, Fish and Conservation Commissioners, ND).

Numerous studies have been conducted on the changes in bird and mammal populations following dramatic alterations of the forest and farm habitat. These investigations have demonstrated a diversity of responses to such practices as clear-cutting and intensified farming.

Lovejoy (1971) found that small mammal populations did not increase following clear-cutting, whereas Turkowski and Reynolds (1970) and Tevis (1956) observed significant increases in Arizona and California, respectively, after the forest had been cut. Decoste (1959), Gillespie (1960), and Radvanzi (1970) all observed an increase in small mammals corresponding with the development of successional stages. The quantitative and qualitative changes in the mammal community complex is of considerable significance to the natural or artificial re-establishment of vegetation on areas which have undergone removal of the original forest community, yet knowledge of these changes is incomplete.

Both clear-cutting of forest land and intensification of agriculture on farm land induce major changes in communities of breeding birds. Warback (1958) and Dambach (1940) reported declines in breeding bird populations on farm land as agricultural practices intensified. McClure and Othman (1965) noted that clear-cutting of forest land causes many species of birds to leave the area. Hooper (1967), however, noted that clear-cutting may eventually provide more niches for breeding birds than uncut forest stands. But he and others (Odum, 1964; Kilgore, 1971) emphasized the importance to breeding

birds of development of a shrub layer. Gillespie (1960) as well as Johnston and Odum (1956) found young pine forests to be undesirable for most breeding birds.

Few studies have attempted to quantify the cost and benefits of specific management practices. Burger and Linduska (1967) and Ellis, Edwards, and Thomas (1969) evaluated cost of food and cover plantings for quail. With respect to non-game wildlife, Hooper (1967) reported that food patches were of primary value only to migrating slate-colored juncos (Junco hyemalis); however, additional literature relating a management practice to nongame species of wildlife is sparse.

Agriculture and forest management practices in the Southeast have changed drastically during the past several decades. Small farms are changing to large field, highly automated and mechanized farming operations. Beef cattle operations are also becoming increasingly important in this region. These advanced agriculture methods are eliminating much wildlife cover by the removal of fence rows, corners, and woody coverts (Eubanks, 1972). There is also an increase in the practice of clear-cutting and disking forest areas as a preparatory measure for planting pine trees. The fact that most of these lands are privately owned, coupled with a decrease in wildlife habitat and an increase in demands for consumptive and nonconsumptive uses of wildlife, dictates the need for wildlife management research on these type areas.

This study is the initial phase of a long-term research project designed to collect much-needed data on the cost of providing food

and cover plots for wildlife, and to determine the effectiveness of these plots for managing both game and nongame species of wildlife. Specific objectives are (1) to determine the impact of food plots on populations of bobwhite quail, mourning doves (Zenaida macroura), ruffed grouse (Bonasa umbellus), and cottontail rabbits (Sylvilagus floridanus), and on community complexes of small mammals and breeding songbirds in areas of intensified agriculture and in young pine plantations, and (2) to evaluate the economic feasibility and management practicality of food plots on private lands.

CHAPTER II

DESCRIPTION OF STUDY AREA

Forest Lands

Location and Physiography

The portion of this study concerned with wildlife management on forest lands was conducted on two pine plantations located in Rhea County, Tennessee. The Stinging Fork study area is approximately 8 kilometers (5 miles) west of Spring City, Tennessee and the Bumbee Creek area is located 4.8 kilometers (3 miles) southwest of the Stinging Fork area.

The study areas are located on the Appalachian Plateau province (Cumberland Plateau) in Rhea County. The section is characterized by relatively smooth areas dissected with deep, narrow V-shaped valleys (Hasty, 1948). The elevation of the Appalachian Plateau is between 426.8 meters (1,400 ft.) and 609.8 meters (2,000 ft.). Most of the streams in this portion of the county drain into the Tennessee River.

The Stinging Fork study area (Figure 1) is approximately 213 hectares (526 acres) in size and generally composed of gently rolling hills. A large ditch, which empties into Stinging Fork Creek on the area's southern boundary, separates the pine plantation into two segments. The southern segment is composed of approximately 89 hectares (220 acres) and the northern segment is composed of approximately 123.9 hectares (306 acres). Second-growth hardwood forest surrounds the study area.

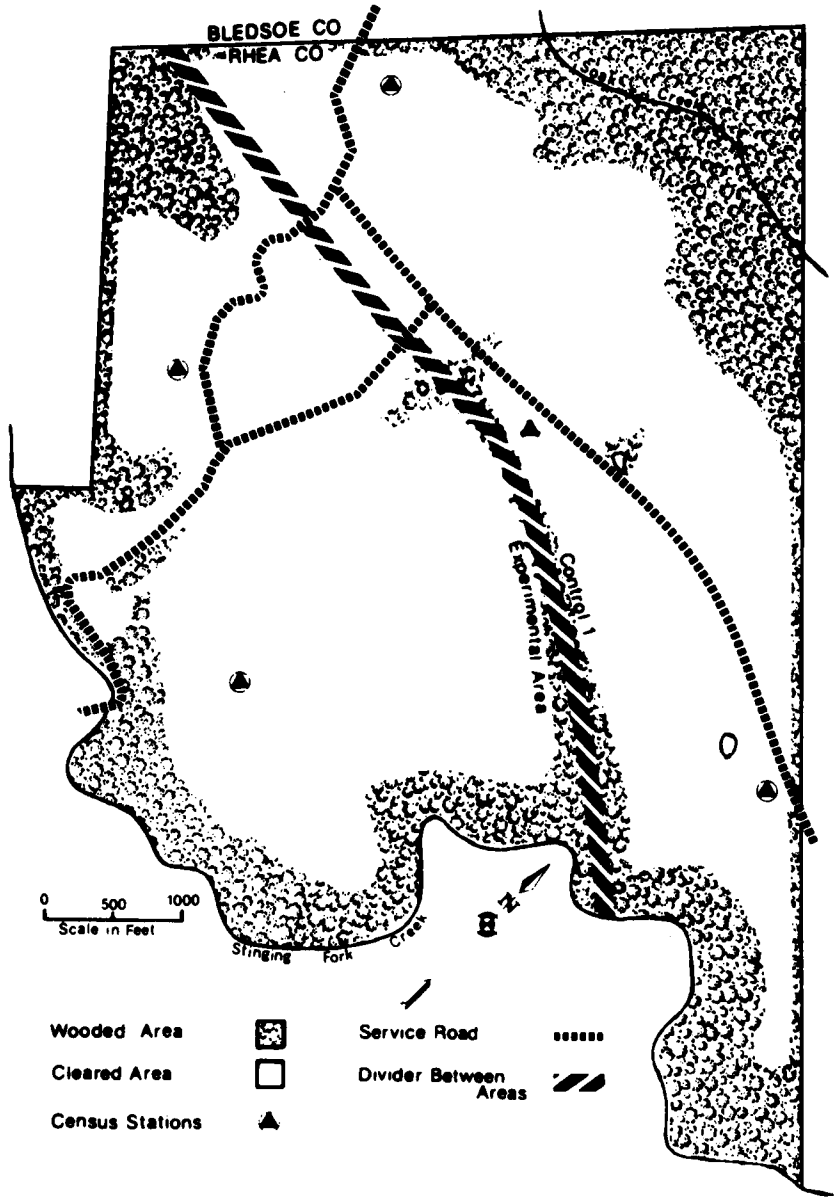

Figure 1. Map of the 526 acre Stinging Fork Creek study area including the 220 acre experimental area and the adjacent 306 acre control area.

The topography of the Bumbee Creek area (Figure 2) is similar to the Stinging Fork study area. It is composed of rolling hills bordered by second-growth hardwood forest on the west, north, and northeast. On the east and south lies a young loblolly pine (Pinus taeda) stand. A pine progeny test area is located in the southwest corner. Bumbee Creek flows along the northeast border and a dirt service road runs the length of the east, south, and west boundaries. This area contains 123.9 hectares (306 acres).

Geology and Soils

The rocks of the plateau are level-bedded and mostly sandstones of the Pennsylvanian series of the Carboniferous system (Hasty, 1948). The soil of the Stinging Fork study area is composed of approximately 70 to 75 percent Muskingum stony, fine sandy loam, hilly phase. The soil has a hilly rather than steep relief with a slope range from 9 to 30 percent. The soils have a low water-holding capacity, unprotected areas are subject to erosion, and are low in phosphorus. Hartsell's fine sandy loam, rolling phase is the next most prevalent soil, occupying roughly 14 to 17 percent of the area. This soil has a more rolling relief than the Muskingum soil with a slope range from 5 to 9 percent. These soils are found primarily on ridge tops where internal drainage is good. The remaining area is composed of Muskingum stony fine sandy loam, rolling phase, Jefferson stony fine sandy loam, eroded sloping phase, and Philco fine sandy loam which is recent alluvium found in bottom lands or drains.

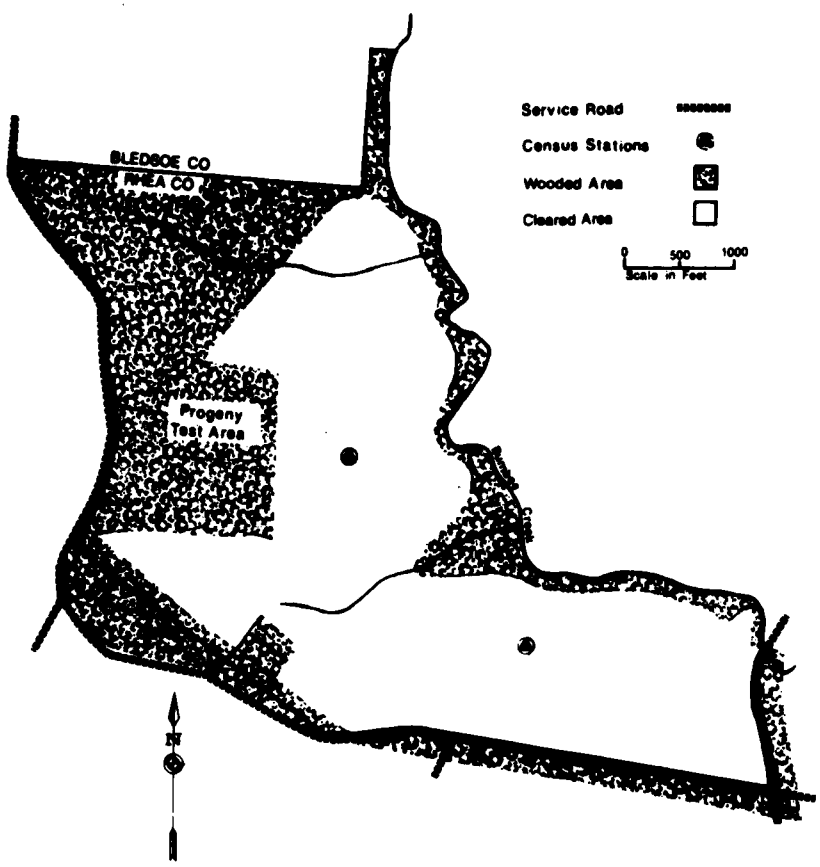

Figure 2. Map of the 306 acre Bumbee Creek control area.

Hartsell's fine sandy loam, rolling phase comprises 48 to 50 percent of the Bumbee Creek study area (Hasty, 1948). Approximately 38 to 40 percent of the soils are Muskingum stony fine sandy loam, hilly phase. Muskingum stony fine sandy loam, rolling phase and Hartsell's fine sandy loam are found on the remaining land of this study area.

Climate

The climate of Rhea County is temperate and continental, having moderate winters with short cold periods and warm summers (Hasty, 1948). Temperature extremes of 108° F to -20° F have been recorded but these are rare. There is a difference of 33.4° F between the mean summer and winter temperatures on the plateau section of the county. The growing season is long enough for most field crops with an average of 179 frost free days. The average precipitation on the Cumberland Plateau portion is 137.6 centimeters (54.2 inches) and snowfall averages 30.7 centimeters (12.1 inches). Generally, precipitation is highest in the winter and spring months and lowest in the fall. Climatological data gathered at the Crossville Office of the U. S. Weather Bureau are presented in Table I.

Vegetation

Rhea County lies within the mixed mesophytic forest region of the Appalachian Forest (Smith, 1962). Second-growth oak (*Quercus*), hickory (*Carya*), dogwood (*Cornus florida*), and shortleaf pine (*Pinus echinata*) predominate in the forest cover (Hasty, 1948; TVA, 1941).

TABLE I

TEMPERATURE AND PRECIPITATION DATA FROM CROSSVILLE, TENNESSEE

Month	Average Monthly Temperature in °F[b]					Total Monthly Precipitation in Inches[a]				
	1931 to 1960	1972	Deviation[b] from mean	1973	Deviation from mean	1931 to 1960	1972	Deviation from mean	1973	Deviation from mean
January	36.9	36.3	-0.6	32.6	-4.3	5.83	8.68	+2.85	4.21	-1.62
February	38.2	34.1	-4.1	33.7	-4.5	5.62	5.15	-0.47	4.05	-1.57
March	44.8	43.8	-1.0	50.7	+5.9	5.45	5.75	+0.30	11.18	+5.73
April	55.1	55.0	-0.1	51.3	-3.8	4.37	5.76	+1.39	5.37	+1.00
May	63.6	60.7	-2.9	57.8	-5.8	3.90	3.25	-0.65	14.99	+11.09
June	70.7	65.5	-5.2	70.0	-0.7	4.03	4.51	+0.48	8.99	+4.96
July	73.8	70.6	-3.2	72.4	-1.4	4.66	5.55	+0.89	5.75	+1.09
August	73.0	70.3	-2.7	70.6	-2.4	4.40	1.78	-2.62	1.51	-2.89
September	68.1	67.8	-0.3	68.7	+0.6	3.40	5.00	+1.60	3.41	+0.01
October	57.0	51.7	-5.3	58.8	+1.8	2.83	6.38	+3.55	1.86	-0.97
November	45.2	42.8	-2.4	47.8	+2.6	4.03	5.22	+1.19	8.35	+4.32
December	43.0	40.4	-2.6	35.7	-7.3	5.48	9.53	+4.05	6.19	+0.71
Annual	55.3	53.3	-2.0	54.2	-1.1	54.00	66.56	+12.56	75.86	+21.86

[a]Source: U. S. Weather Bureau, Climatological Data, Tennessee, U. S. Dept. Commerce. Annual Summary, 1972 - 1973. Vols. 77, 78.

[b]Deviation from mean - determined by subtracting monthly data for years 1972 and 1973 from the average data collected during the years 1931 to 1960.

The Stinging Fork Creek and Bumbee Creek areas are owned by Hiwassee Land Company (a division of Bowaters Southern Paper Corporation) and are managed primarily as pine plantations for the production of pulpwood. Prior to the fall of 1971, the vegetation of both areas was second-growth hardwoods. At this time the areas were cleared with a procedure of shearing, windrowing, and disking as a preparatory measure for planting pine. Both areas were planted with loblolly pine during the spring of 1972. In addition, the 89 hectare segment of the Stinging Fork area was planted with various wildlife food plant species. These species included soybeans (Glycine max var. Lee, Hood, and Dare), Korean lespedeza (Lespedeza stipulacea), kobe lespedeza (L. striata), white Dutch clover (Trifolium repens), red clover (T. pratense), Autumn olive (Elaeagnus umbellata), and bicolor lespedeza (L. bicolor).

During the summer of 1972, only a sparse vegetative cover invaded either the Stinging Fork or Bumbee Creek areas. However, the Bumbee Creek area obviously had a more advanced vegetative cover than did the Stinging Fork area. The vegetation primarily included common ragweed (Ambrosia artemisiifolia), blackberry (Rubus spp.), pine weed (Hypericum gentianoides), panic grass (Panicum spp.), partridge pea (Cassia fasciculata), and various hardwood sprouts.

The naturally occurring vegetation on both study areas was studied during the summer of 1973 (Taylor and Brown, 1973). Quadrats were examined for number of species and number of individuals. The average height, basal area, and ground cover of the vegetation were also estimated. On the Stinging Fork area Panicum dichotomum composed

45.8 percent of all species of plants present. Fescue grass (Festuca spp.) (9.4%), Potentilla simplex (5.5%), sedge (Carex spp.) (4.0%), Lespedeza spp. (3.5%), pine weed (3.2%), and blue stem grasses (Andropogon spp.) (3.1%) followed the panic grass in percent of total plant composition. These seven species comprised 75 percent of all stems collected from this area. Basal area averaged 5.3 percent, and mean ground cover was 35.6 percent. Height of vegetation averaged 36.8 centimeters. The mean density of stems was 266.0 stems per square meter.

Seven of the species found on the Bumbee Creek study area comprised 87.5 percent of the vegetation (Taylor and Brown, 1973). These seven species included P. dichotomum (47.7%), fescue (12.2%), blue stem grasses (9.6%), P. simplex (9.6%), goldenrod (Solidago spp.) (4.4%), L. procumbens (2.2%), and common ragweed (1.9%). Basal area averaged 8.9 percent, and mean cover was 62.0 percent. Height of vegetation averaged 30.23 centimeters. Mean density of stems was 346.5 stems per square meter.

Farm Lands

Location and Physiography

The portion of this study dealing with wildlife management on farm lands was conducted on two farms located in Hamblen County, Tennessee. The experimental area is a 121.5 hectare (300 acre) farm located 6.4 kilometers (4 miles) east of Morristown, Tennessee. The control farm is a 101.2 hectare (250 acre) area located 0.8 kilometers (0.5 miles) north of the experimental area.

Hamblen County occupies 453.3 square kilometers (175 square miles) in the northeastern part of Tennessee and is situated in the Great Valley of East Tennessee (Aandahl, 1946). The county is characterized predominantly by a rolling to hilly relief ranging from nearly level to steep. The elevation of the county ranges from 274.4 to 609.8 meters, but in most areas it is between 335.4 and 457.3 meters. The area is generally well drained by the Holston and Nolichucky Rivers, both of which empty into the Tennessee River.

The topography of the experimental area (Figure 3) is composed of two distinct land types. Approximately 63 percent (76.9 hectares) (190 acres) of the farm has a rolling to hilly relief, however, some portions are considered steep. The remaining 40 percent (44.5 hectares) (110 acres) of the area is bottom land located adjacent to the Nolichucky River. Two (2) small creeks provide a good supply of water to the farm during all seasons.

The Control Farm (Figure 4) is almost entirely composed of a rolling to hilly relief. There is, however, a small amount of nearly level land located along Flat Creek which borders the farm on the south and southwest. Two (2) additional small creeks are located on the east and west sides of the farm.

Geology and Soils

Dandridge soils are found on the majority of the two study areas (Aandahl, 1946). This soil has developed over calcareous (high-lime) shales. The parent rock of the gravelly Dandridge soil is interbedded with gravelly and nodular limestone. Surface soil and

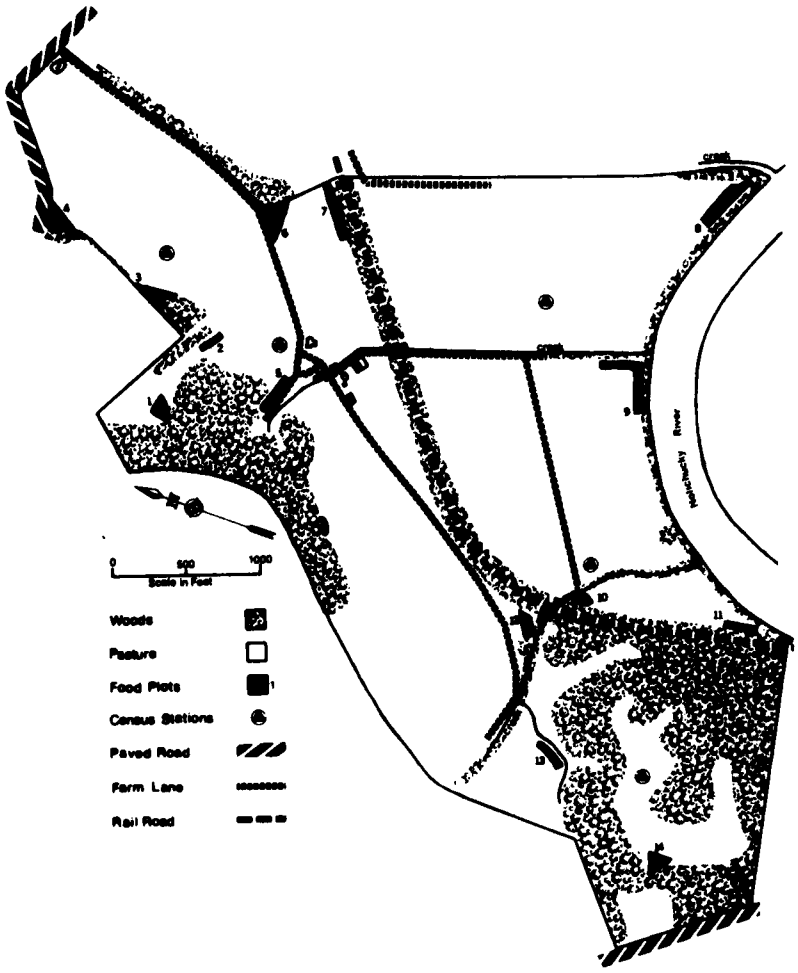

Figure 3. Map of the 300 acre experimental farm area near Morristown, Tennessee.

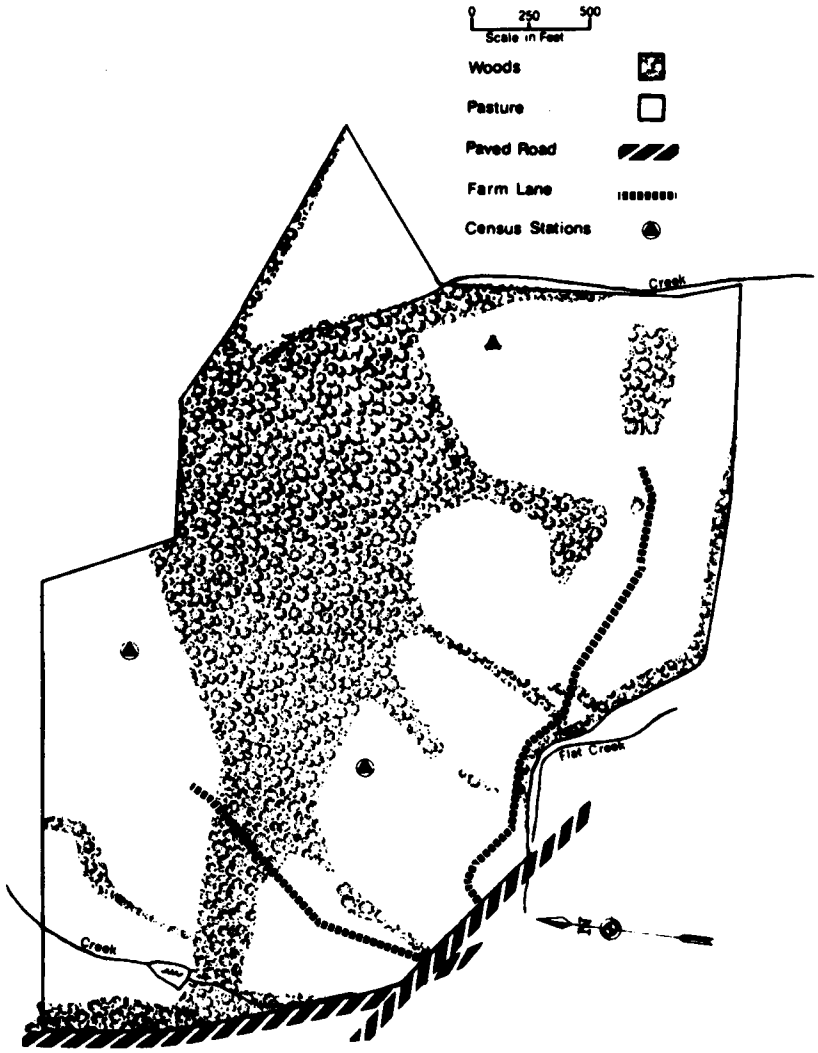

Figure 4. Map of the 250 acre control farm near Morristown, Tennessee.

subsoil layers have not completely developed in the Dandridge soils, and tillage and accelerated erosion have obliterated most of the minor differences between such layers. The depth to shale bedrock varies from 7.6 to 50.8 centimeters, however, shale outcroppings are found in some areas. The soil is generally a light brownish-yellow moderately friable silty clay loam but variations are common. Dandridge soils are recognized as being naturally productive for pasture plants especially blue grass (Poa spp.) and white clover, however, sloping areas are physically poorly suited for crops.

Whitesburg silt loam comprises approximately 40 percent of the soils found on the experimental area (Aandahl, 1946). This soil is found on the bottom land portion of the study area and is developed from accumulations of local wash at the foot of slopes occupied only by Dandridge soils. Whitesburg silt loam is very fertile and productive having from 25.4 to 38.1 centimeters of top soil. External drainage is good but internal drainage is only fair. Tyler silt loam, Hamblen silt loam, Altavista loam, Congaree very fine sandy loam, and State loam are also found on the bottom lands.

Dandridge gravelly silty clay loam, eroded phase, is found on the upland portion of the experimental area and accounts for approximately 30 percent of the soils on the entire area (Aandahl, 1946). This soil contains numerous dish-shaped pieces of limestone gravel and is underlain by calcareous shale interbedded with layers of nodular limestone. The surface soil is around 10.2 centimeters deep and the slope gradient is 25 to 60 percent. The next most common soil is Dandridge shaly silty clay loam, eroded phase (10%). This soil contains

shale fragments, is highly susceptible to erosion, and has a slope gradient of 12 to 25 percent. The remaining soils found on the experimental area include Dandridge shaly silty clay loam, eroded phase, Dandridge gravelly silty clay loam, eroded phase, hilly stony land, Talbott soil material, Talbott silty clay loam, eroded hilly phase, and Talbott silty clay loam, eroded phase.

Dandridge shaly silty clay loam, eroded phase, comprises approximately 35 percent of the control area (Aandahl, 1946). Thirty (30) percent of the soils are Dandridge shaly silty clay loam, steep phase, which has a slope gradient of 25 to 60 percent. Dandridge gravelly silty clay loam, eroded phase, Dandridge shaly silty clay loam, eroded rolling phase, Dandridge gravelly silty clay loam, eroded steep phase, Fullerton cherty silt loam, eroded phase, and Hamblen silt loam (found in stream bottoms) are found on the remaining land of this study area.

Climate

The climate of Hamblen County is temperate and continental with moderate winters characterized by short erratic cold spells and mild summers (Aandahl, 1946). Precipitation is well distributed with an annual mean of approximately 114.3 centimeters (45 inches) including approximately 25.4 centimeters (10 inches) of snow. Temperatures of -18° F and 103° F have been recorded but these are rare. The mean annual temperature is 56.9° F with the mean seasonal temperature of 74.1 degrees in the summer and 38.8 degrees in the winter. The average

frost-free season is approximately 200 days. Climatological data gathered at Jefferson City (located 9 miles west of Morristown, Tennessee) are presented in Table II.

Vegetation

The farms on which this study was conducted are managed primarily for the production of beef cattle. Burley tobacco was the only crop produced (except for pasture and hay crops) during 1972 and 1973.

Grasses (fescue and blue grass) constitute the major ground cover on fields used for pasture and hay. These grasses were very dense throughout most of the area. Herbaceous plants in these pasture areas include several species of blue stem grasses, goldenrod, Queen Ann's lace (Daucus carota), chicory (Cichorium intybus), trumpet creeper (Campsis radicans), thistle (Cirsium spp.), tick trefoil (Desmodium spp.), poke (Phytolacca americana), greenbriar (Smilax spp.), common ragweed, coreopsis (Coreopsis major), Aster spp., white clover, and lespedeza. Blackberry and Southern dewberry (Rubus Enslenii) were common enough to make accessibility difficult in portions of the study areas. Eastern red cedar (Juniperous virginiana), black locust (Robinia pseudoacacia), sassafras (Sassafras albidum), and winged sumac (Rhus Copallinum) thickets were also common over much of the areas. Closely associated with these briar and hardwood thickets was Japanese honeysuckle (Lonicera japonica).

TABLE II

TEMPERATURE AND PRECIPITATION DATA FROM JEFFERSON CITY, TENNESSEE

Month	Average Monthly Temperature in °F					Total Monthly Precipitation in Inches[a]				
	1953 to 1971	1972	Deviation[b] from mean	1973	Deviation from mean	1953 to 1971	1972	Deviation from mean	1973	Deviation from mean
January	36.8	41.8	+5.0	38.2	+1.4	4.01	7.33	+3.32	2.75	-1.26
February	40.6	39.2	-1.4	37.9	-2.7	4.61	4.58	-0.03	2.52	-2.09
March	48.0	48.3	+0.3	52.9	+4.9	4.73	4.30	-0.43	8.85	+4.12
April	56.6	55.3	-1.3	54.8	-1.8	4.14	4.85	+0.71	4.90	+0.76
May	65.3	63.6	-1.7	61.1	-4.2	3.33	5.02	+1.69	6.21	+2.88
June	72.1	67.9	-4.2	73.5	-1.4	3.74	5.66	+1.92	2.75	-0.99
July	75.5	74.2	-1.3	76.4	+0.9	4.27	5.86	+1.59	3.38	-0.89
August	74.9	74.5	-0.4	74.5	-0.4	2.94	1.74	-1.20	5.10	+2.16
September	69.3	71.4	+2.1	72.9	+3.6	2.61	5.18	+2.57	1.80	-0.81
October	57.9	55.2	-2.7	61.5	+3.6	2.70	5.71	+3.01	2.49	-0.21
November	47.6	46.1	-1.5	49.4	+1.8	3.48	3.99	+ .51	7.14	+3.66
December	39.9	42.2	+2.3			4.26	8.46	+4.20		
				Not Available					Not Available	
Annual	57.1	56.6	-0.5			44.83	62.68	+17.85		

[a]Source: U. S. Weather Bureau, Climatological Data, Tennessee, U. S. Dept. Commerce. Annual Summary, 1972 - 1973. Vols. 77, 78.

[b]Deviation from mean - determined by subtracting monthly data for years 1972 and 1973 from the average data collected during the years 1953 to 1971.

Approximately 20.2 hectares (50 acres) of the experimental area were in second-growth hardwoods (oak, hickory, and dogwood). The remaining area was pasture; however, only about 60.7 hectares (150 acres) were used extensively for livestock grazing and production of hay crops. The remaining portions were in various stages of late vegetational succession.

Hardwoods constituted approximately 40.5 hectares (100 acres) of the control farm with the remaining portions being used entirely for pasture. Because of the more extensive grazing by livestock, briar and hardwood thickets were not nearly as common as on the experimental area. However, several cedar thickets occurred on the southern portion of the control area.

CHAPTER III

METHODS

Food Plots

For wildlife management programs on privately owned land to be successful, the landowner's program should be the major concern in the establishment of food plots. On farm land, odd corners of fields or areas undesirable for crops may be used to avoid interference with the landowner's objectives. Food plots on forest lands may be designed to serve as fire breaks to help protect young pine plantations from fire. With the preceding criteria in mind, food plot locations were selected during the spring of 1972.

Complete records were kept on the cost of establishing and maintaining food plots and on man-hours of labor involved. These data were used to evaluate the economic feasibility and management practicality of food plots.

Forest Lands

A procedure of shearing, windrowing, and disking was used as the preparatory measure for planting pine on the Stinging Fork and Bumbee Creek areas. This procedure involved the use of bulldozers to cut and windrow the hardwood vegetation which remained after logging operations. The windrows were then either burned or allowed to decay. The cleared portions were disked to retard vegetative growth and to prepare the soil for pine planting operations.

At this stage in the procedure, the soil was in excellent condition for the establishment of wildlife food plots. The sites were devoid of any vegetative cover, raw mineral soil was exposed, and the soil was tilled and loose to a depth of 30.5 or more centimeters.

The procedure used by Hiwassee Land Company in the establishment of food plots (Table III) included (1) the establishment of a heavy-seeding annual species (soybeans, varieties Lee, Hood and Dare) on 1 percent of the area, (2) establishment of a mixture of perennials or reseeding annuals (kobe lespedeza, Korean lespedeza, white dutch clover, and red clover) on 5 percent of the area, (3) establishment of a perennial shrub lespedeza on 1 percent of the area, (4) hand planting of small plots of autumn olive in wet areas, and (5) hand planting of small plots of shrub lespedeza. All food plots were established on the southern segment (220 acres) of the Stinging Fork study area. The northern segment of the Stinging Fork area and the Bumbee Creek area were used as controls 1 and 2 respectively.

Soybean strips were designed to serve as fire breaks to help protect the plantation from destruction by fire. These strips divide the area into several segments. Fire occurring on one section of the plantation could be controlled by backfiring from the soybean strips thus preventing the fire from consuming the entire plantation. The lespedeza-clover strips and the shrub lespedeza strips were designed with overall coverage of the area in mind. All food plots planted are shown graphically in Figure 5.

TABLE III

THE AVERAGE SEEDING AND FERTILIZATION RATES PER ACRE AND THE TOTAL ACREAGE OF PLANT FOOD SPECIES PLANTED ON THE STINGING FORK EXPERIMENTAL AREA

Species	Seeding rate per acre[a]	Fertilization rate per acre[a]	Total acres
Soybeans	286	343	3.71
Bicolor lespedeza			
sprigged	N/A	N/A	0.15
seeded	24	200	1.33
Mixed legumes	65	146	13.85
Autumn olive			
sprigged	N/A	N/A	0.78
Total	---	---	19.82

[a]Average rates shown in pounds per acre.

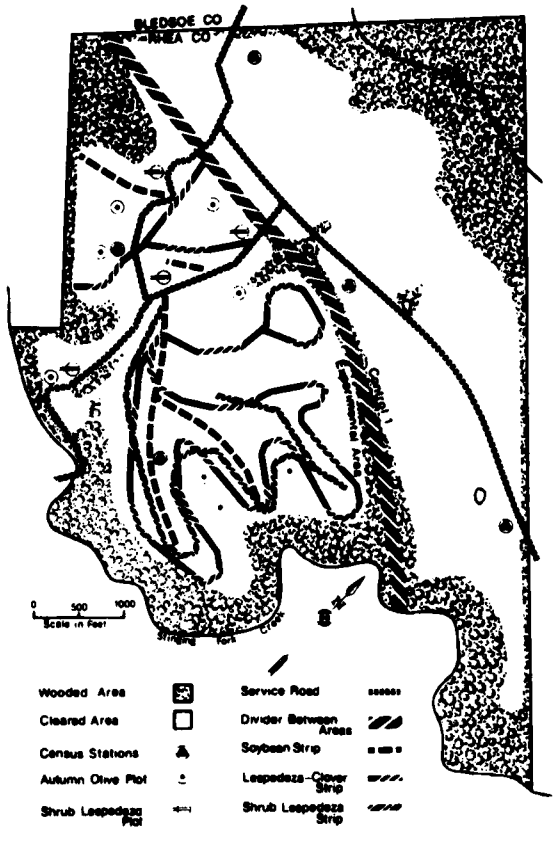

Figure 5. Location of food plots and food strips on the Stinging Fork experimental area.

Food strips were established by broad-casting the seed with a cyclone seeder. Kobe lespedeza, Korean lespedeza, white Dutch clover, and red clover were applied as a mixture while the soybeans and shrub lespedeza were sowed as separate strips. The different varieties of soybeans (Lee, Hood, and Dare) were used with the supposition that their different maturity dates would allow seed to be available for wildlife over a longer period of time. After sowing, soybeans were disked lightly to cover the seed. Application of fertilizer on these food strips varied from 85 to 600 pounds per acre and the composition of fertilizer used was 0-25-25 and 16-16-16. Details of the 1972 food plot plantings, except for the hand planted shrubs, are found in Appendix A, Table XX.

Shrub lespedeza plots were planted on a 1.2 meter square spacing using a dibble bar. A handful of tobacco fertilizer was placed on top of the ground next to each plant. Four hundred shrubs were planted in 4 plots with no plot being over .02 hectare in size. One hundred fifty plants of autumn olive were planted in 8 plots using the same procedure described above. This species, however, was planted on a 4.6 meter square spacing and ammonium nitrate 33-0-0 was substituted for the tobacco fertilizer.

In 1973, several changes were made in the procedure used to establish soybean strips (Appendix A, Table XX). All soybean strips except strip 6 were replanted with Dare and Lee soybeans at the rate of 90 pounds per acre. Strip 9 was planted at 45 pounds per acre, and strip 6 was not replanted. Most strips were fertilized with 800 pounds per acre of 6-12-12 fertilizer, however, strip 5 received 400 pounds per acre. Seeds were covered by disking.

Farm Lands

Mrs. Helen Cooper, cooperating with The University of Tennessee, agreed to supply land and equipment for the project and The University of Tennessee Forestry Department established the wildlife food plots. Plots were established of variable size between 0.04 and 0.3 hectares. Fourteen plots (Figure 3, Page 14) were planted totaling 1.5 hectares, which is 1.2 percent of the 121.5 hectare study area.

Plant species used in the food plots were Lee soybeans, browntop millet (Panicum fasciculatum), and German millet (Setaria italica). In 1972 each plot was divided into three roughly similar areas; a different species was planted on each of the three sub-plots. However, in 1973 German and browntop millets were mixed together and sowed on one-third of each plot. The remaining two-thirds of each plot was planted with soybeans. Eubanks (1972) indicated that millet as a food supply for bobwhites decreased in importance during the late winter months in West Tennessee. For this reason, a larger percentage of each plot was planted in soybeans under the assumption that seeds from this plant species would be available for wildlife during the months when food supply is most critical.

Plot sites were first plowed and disked as seedbed preparation for planting the different plant species. Seed and fertilizer were broadcast with the use of a hand-operated cyclone seeder. Soybeans were then disked lightly to cover the seed and millets were covered with the use of a cultipacker. Soybeans were planted at the rate of 90 pounds per acre and millets were sowed at 30 pounds per acre. Fertilizer was applied evenly over each plot at 200 pounds per acre.

Planting occurred between June 12 and June 26 during 1972. The initial planting in 1973 was from May 16 to June 12, however, the soybeans in several plots failed to grow and were replanted on July 10, 1973. More problems occurred when livestock from a neighboring farm destroyed five of the unfenced food plots located on portions of the farm where cattle normally were not grazed. These plots were reseeded with buckwheat (Fagopyrum esculentum) on August 15, 1973, and August 17, 1973. Buckwheat was planted at the rate of 60 pounds per acre. No additional fertilizer was used during this planting.

Population Surveys

Several methods were used to survey wildlife populations. Call indices were used in the spring of 1972 and 1973 to survey bird populations. Bobwhite quail, mourning doves and cottontails were censused by direct flush count in early spring when populations are the lowest and during the fall when populations are highest. Small mammals were surveyed by snap-trapping.

Call Indices

Several permanent listening stations were established on all study areas (Figures 1, 2, 3, and 4). Stations were located to allow the investigator to hear all quail calling on the entire census area. Five minutes were allotted at each station at which time all bobwhite quail and mourning doves heard, and their total number of calls, were recorded. At stations where a large number of birds were calling, the number of calls were counted, then an additional time period was allotted to determine the number of birds.

The Morristown and Spring City study areas were visited one day per week during the normal breeding season. Surveys were initiated as soon as possible after sunrise and generally lasted three to four hours. The experimental and control portions of each study area were surveyed the same day. For this reason, the area visited first was rotated each week to reduce bias due to decreased bird activity during late morning hours. Surveys were conducted from June 27 to August 9 during 1972 and from April 10 to August 8 during 1973.

The value of mating call indices for measuring bobwhite quail and mourning dove populations has been discussed by many authors. Bennitt (1951), Reeves (1951), and Rosene (1957) report summer whistling cock counts of quail to be a reliable indicator of wintering populations. However, Norton et al (1961) could not find a substantial statistical basis for this type comparison. The calling activity of mourning doves related to population density has been researched by Foote and Peters (1952) and McClure (1939).

In conjunction with the spring call index, all songbirds heard or seen at the permanent listening stations, as well as those seen or heard while traveling from one station to another, were recorded. Approximate locations of all birds were plotted on a map of each area. This method is similar to that used by Hooper (1967). However, the objectives of the present study are not intended to include an extensive examination of songbird ecology.

The data on the call index from the Stinging Fork experimental area at Spring City can not be separated from its adjacent control (Control 1). The distance over which sound carried prevented the

listener from determining the precise location of many calling birds of all species. Thus, this technique was not adequate for comparing songbird populations of the experimental area with populations on Control 1.

Direct Flush Counts

Quail, dove, and cottontail densities were determined on both the Morristown and Spring City research areas by direct census conducted during November, 1972 and March and November, 1973. Direct flush counts employed 5 to 7 persons walking abreast approximately 20 meters apart. The number of bobwhite coveys flushed and the number of birds per covey were tabulated. The numbers of doves, rabbits and ruffed grouse flushed were also recorded.

Small Mammal Surveys

The procedure used to survey small mammal populations on the Morristown and Spring City projects were similar; however, due to the inherent differences between the two areas, slight variations in the technique were necessary. A line trapping technique was implemented using snap traps (Museum Specials) with two traps per station along each line. A 10-meter interval was used between each station. This interval was described by Martin (1956) as providing the best possible trapping efficiency. Each trapping session lasted for four days and three nights due to a tendency for the number of captures to level off after this period of time (Chitty and Kempson, 1949). A mixture of peanut butter and oatmeal was used as bait. This mixture was easy to apply and readily taken by small mammals. The baited

traps were then set across small mammal runways (if such runways could be found). Traps were set within a two-meter radius of each station site. Trapping sessions were conducted during October, 1972, February, 1973, and October, 1973.

Trapping sessions on the Spring City research area were composed of 10 trap lines (5 on Control 1 and 5 on the Stinging Fork experimental area). The locations of these lines (Figure 6) were determined on indexed map and a table of random numbers. The lines on the experimental area over-lapped a food strip or plot at some point along each line. Each trapping session consisted of 600 trap-nights and totaled 1800 trap-nights for the entire study. The Bumbee Creek area (Control 2) was not sampled for small mammal populations.

Small mammal surveys on the Morristown area consisted of 1620 trap-nights (540 trap-nights per trapping session). Six food plots (Figure 7) were randomly selected as the base area for 3 parallel trap lines composed of 5 stations per line. Trap lines at the individual food plots were approximately 10 meters apart. The first line was 5 meters inside the food plot and the second and third lines were 5 and 15 meters respectively outside the food plot.

Captured animals were examined to determine their age and sex. Each individual was placed in one of three age classes (juvenile, subadult, or adult) primarily on stage of molt and sexual development. Sex organs were examined to determine reproductive status of individuals. Since no individuals were dissected, the degree which

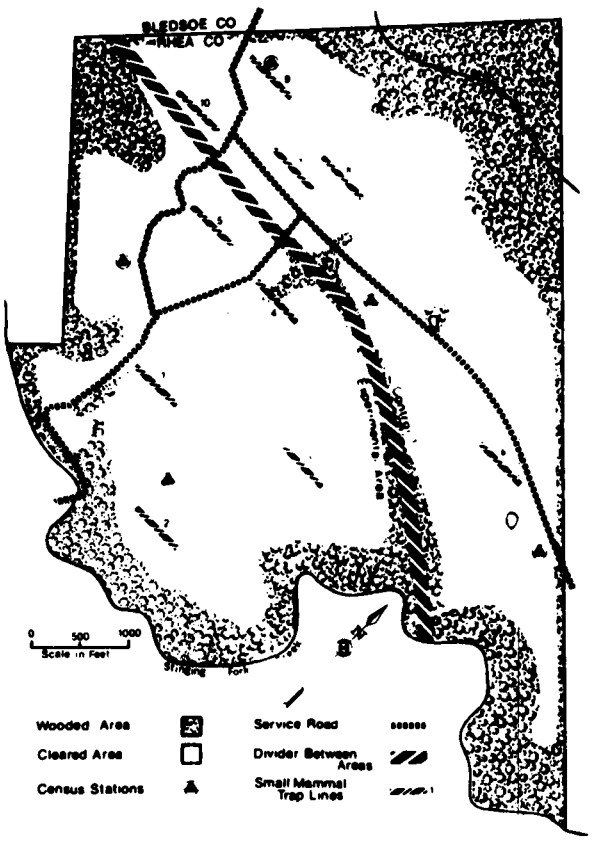

Figure 6. Location of small mammal trap lines on the Stinging Fork experimental area and the adjacent control area (Control 1).

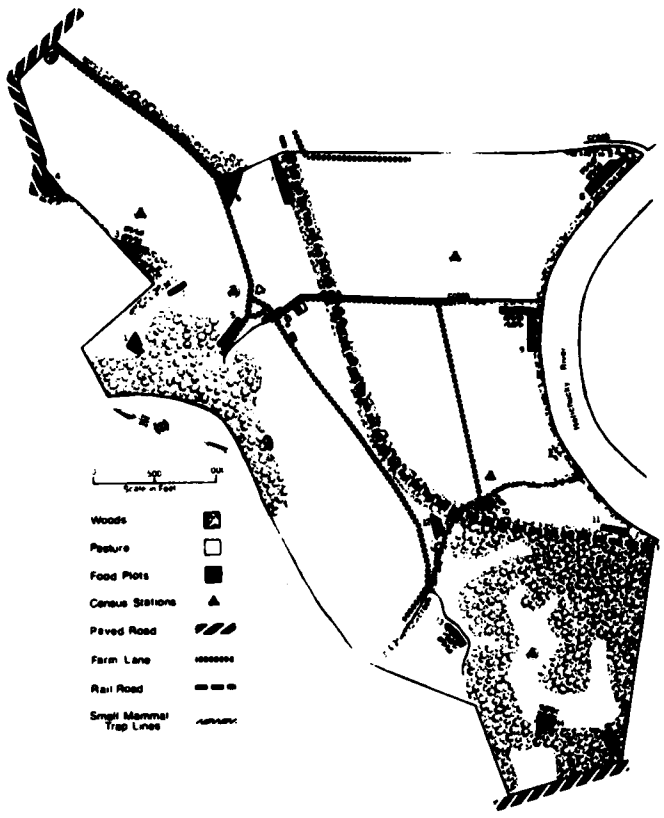

Figure 7. Location of small mammal trap lines on the Morristown experimental area.

the testes were descended into the scrotum was the criterion used to determine reproductive status in males. The size of the testes, however, is not the best criterion for aging males since testis size may vary seasonally regardless of the size of the individual (Goertz, 1965). The criteria used for females included the condition of the vaginal aperture (i.e. perforate or imperforate), presence or absence of lactation, and obvious pregnancy (Fitch, 1957).

Crop Analysis

Bobwhite quail were collected by shooting during the Tennessee quail hunting season (November 22 to February 23). Crops were either removed immediately or the entire quail was frozen until a later date.

The amount of each food item was estimated by volume displacement in water as described by Korschgen (1948). Food items were identified, and the total volume of each food in each crop was measured by water displacement to the nearest 0.1 cc. A zoom lens, binocular, dissecting microscope was a useful aid when counting and identifying food items.

Food items in the crops were identified to the lowest taxon possible. The following parameters were tabulated for each food item (Eubanks, 1972).

Relative volume - total volume of one item as a percentage of the total volume of all items.

Relative frequency - number of occurrences of one item as a percentage of the total occurrences of all items.

Relative number - number of individuals of one item as a percentage of the total number of individuals of all items.

Frequency of occurrence - percentage of crops in which an individual food occurred.

Haugen (1955) and Stoddard (1931: 72-83) were used as guides to aging bobwhite quail.

References

References used in this study for the identification of plants, animals, and food items, and to provide sources for common and scientific names included: Blomquist and Oosting (1959), Burt and Grossenheider (1964), Clewell (1966), Fernald (1950), Gleason (1968), Harlow (1941), Hillman and Henry (1935), Jaques (1947), Martin (1935), Martin and Barkley (1961), Peterson (1947), and Shanks and Sharp (1950). The seed collection of the Forestry Department, The University of Tennessee, was also used for seed identification.

CHAPTER IV

RESULTS AND DISCUSSION

I. Evaluation of Food Plots in Pine Plantations

Biological Impact

The biological impacts of food plots were measured primarily by their effect on the population densities of several species of wildlife. The various census techniques were designed to evaluate the distribution of these wildlife species in relation to the distribution of food plots. The utilization of natural varieties of plant food by bobwhites was also considered an important facet of this research.

Bobwhite Quail

Bobwhite quail are good indicators of habitat change because of several traits inherent to this species. These traits include a high biotic potential coupled with a high turn-over rate and a limited mobility. Various census techniques have also been developed for bobwhites which enhance interpretation of data.

a. Population Density

Population densities of bobwhite quail were estimated using a call index in the spring and summer and flush counts during the fall and spring. The average number of bobwhite males calling during the peak of the breeding season increased from 1972 to 1973 on both

the Stinging Fork area and Bumbee Creek area (Table IV). Average counts on the Stinging Fork area increased from a mean of 9 birds per day in 1972 to 23 birds per day in 1973. The number of calling males on the Bumbee Creek area increased from a mean of 3 in 1972 to 6 in 1973. These results show a 156 percent increase in calling males on the Stinging Fork area compared to a 100 percent increase on the Bumbee Creek area from the spring of 1972 to the spring of 1973.

The flush census on the Stinging Fork area (Table V) indicated a trend in the bobwhite populations similar to that detected by spring and summer call censuses. Quail density increased from 1 bird per 11 acres in 1972 to 1 bird per 1.7 acres (550 percent increase) during the fall of 1973. A small percentage of this increase in quail density may be due to migration of coveys from surrounding areas. A similar trend occurred on the adjacent control area (Control 1) with a 388 percent increase in quail density (1 bird per 18 acres to 1 bird per 4.2 acres).

Although the spring and summer call census indicated an increase in quail populations on the Bumbee Creek area from 1972 to 1973, the fall flush census failed to show a similar trend. The population density decreased from 1 bird per 3.9 acres in 1972 to 1 bird per 10.7 acres in 1973, a decrease of 63 percent from the previous year.

Spring flush census indicated that quail populations increased by 15 percent on the Stinging Fork experimental area from the density found during the previous fall census (1972), whereas, populations

TABLE IV

BOBWHITE SPRING CALL COUNTS ON THE SPRING CITY STUDY AREAS DURING 1972 AND 1973

Type of Call Index	Stinging Fork Exp. Area (including Control 1)			Bumbee Creek Area (Control 2)		
	1972	1973	Percent Change	1972	1973	Percent Change
Average number of calling males[a]	9	23	+156	3	6	+100
Largest number of males calling during one day	10	27	+170	6	11	+83

[a]The average number of calling males was determined by averaging the number of males heard during the peak of the breeding season.

TABLE V

RESULTS FROM THE BOBWHITE QUAIL SPRING AND FALL FLUSH CENSUS ON THE SPRING CITY STUDY AREAS

Area	Type Parameter	Fall 1972	Spring 1973	Fall 1973
Stinging Fork Experimental Area	Number of coveys	1	2	8
	Number of birds	20	23	130
	Acres per bird	11	9.7	1.7
	Percent change	N/A	+15	+550
Stinging Fork Control 1	Number of coveys	2	1	5
	Number of birds	17	8	73
	Acres per bird	18	38.3	4.2
	Percent change	N/A	-54	+388
Bumbee Control 2	Number of coveys	5	2	3
	Number of birds	77	2	28
	Acres per bird	3.9	150	10.7
	Percent change	N/A	-97	-63

on Control 1 and Control 2 decreased by 54 percent and 97 percent respectively. The density during spring, 1973 on the Stinging Fork area was 1 bird per 9.7 acres. Spring quail densities on the control areas were 1 bird per 38.3 acres on Control 1 and 1 bird per 150 acres on Control 2.

The increase in quail populations on the Stinging Fork experimental area in the spring of 1973, coupled with the decrease in quail populations on both control areas during the same time period indicates the importance of food plots for supplying adequate food for wintering bobwhite quail. This conclusion is supported by field observations indicating increased covey usage of the lespedeza food strips during late winter months.

b. Utilization of Food Plots

Percent relative volume was the criterion for evaluating the utilization of various plant foods by bobwhite. Additional information including times occurred, percent frequency of occurrence, percent relative frequency, total number of items, and percent relative number of each plant food found in quail crops collected from the various research areas is listed in Appendix B, Tables XXII thru XXV.

A total of 26 bobwhites were collected from the Spring City study areas during the 1972-1973 and 1973-1974 hunting seasons (Table VI). Twenty-one of these quail were from the Stinging Fork experimental area. One bird was collected from Control 1 in 1973-1974

TABLE VI

SIXTEEN IMPORTANT FOOD ITEMS OF BOBWHITES COLLECTED DURING THE 1972-1973 AND 1973-1974 HUNTING SEASONS ON THE SPRING CITY STUDY AREAS

	Percent of Volume			
	Stinging Fork		Control 1	Control 2
Food Items	1972-1973 (14)[a]	1973-1974 (8)	1973-1974 (1)	1972-1973 (4)
Plant Foods				
Glycine max		45.3		
Lespedeza striata	74.0	40.1		
Lespedeza stipulacea	19.2	1.6		
Ambrosia artemisiifolia	4.5	3.1		
Galactia regularis	1.1	2.1		
Aster spp.	1.1			12.8
Viola spp.		1.6		
Panicum spp.		1.6		
Cassia nictitans		1.0		25.6
Rhus copallina		0.5		
Desmodium spp.		0.5		
Rhus typhina			100.0	
Desmodium viridiflorum				5.1
Lespedeza repens				46.2
Unknown				10.3
Animal Foods				
Formicidae (ants)		1.0		

[a]Sample size.

and the remaining 4 birds were collected on the Bumbee Creek area during the 1972-1973 season. Males comprised 57.7 percent of the birds while females accounted for 42.3 percent.

During the 1972-1973 season, kobe lespedeza was the most important food source of quail on the experimental area. This species accounted for 74.0 percent of the total food volume. Kobe lespedeza was followed in importance by Korean lespedeza (19.2%), common ragweed (4.5%), milk pea (Galactia regularis) (1.1%), and Aster spp. (1.1%).

Although soybean food strips were destroyed by heavy grazing of whitetail deer during the fall of 1972 and were not available to wintering bobwhites during the 1972-1973 season, this plant species proved a highly desirable food for quail during the following year. On the experimental area during the 1973-1974 season, soybeans composed 45.3 percent of the diet. This species was followed in importance by kobe lespedeza (40.1%), common ragweed (3.1%), milk pea (2.1%), and panic grass (1.6%).

L. repens (46.2%) was the most important food source on the Bumbee Creek area (Table VI). Wild sensitive plant (C. nictitans) (25.6%) was second in importance followed by Aster spp. (12.8%), an unknown species (10.3%), and Desmodium viridiflorum (5.1%). Staghorn sumac (Rhus typhina) was the only food species found in significant amounts in crops of quail collected on Control 1.

The preceding data indicate the importance of soybeans, kobe lespedeza and Korean lespedeza as food sources for bobwhite quail on

cleared forest lands. Several other workers also stressed the importance of these plant species as quail food (Baldwin and Handley, 1946; Barnes and Klimstra, 1964; Cady, 1944; Davison, 1943; Eubanks, 1972). However, bicolor lespedeza, clovers, and autumn olive did not contribute significantly to the diet of quail collected during this study. Bicolor lespedeza was found only in trace amounts in 37.5 percent of the crops during the 1973-1974 season despite the large quantities of these seeds available. Gehrken (1956), Rosene (1956), and Webb (1960) found bicolor lespedeza to be a very important constituent of the bobwhite quail diet in the Southeast.

Autumn olive and clover seeds were not found in any of the crops examined. Davison (1958) considered clovers as inferior food for quail. Data collected during the present study similarly indicated a low preference for clover seed as food by bobwhites. Autumn olive generally does not produce berries until the third to fifth year after planting (Allen and Steiner, 1959) and obviously could not be utilized as a food source during the two years of the present study.

It may also be important to note that certain food items might be important simply because of availability; however, availability alone does not explain food habits of quail (Korschgen, 1960). This point is emphasized by the high availability of bicolor lespedeza seed and the low utilization of this species by bobwhites. The decrease in utilization of kobe lespedeza during the 1973-1974

season when soybeans were available probably indicated that preference for certain seeds (in this case, soybeans) strongly influences diet patterns.

c. Movements

The establishment of food plots was the only habitat manipulation not common to all study areas. Therefore, it is concluded that these wildlife food plantings were responsible for the increase in quail density on the experimental area. It is likely also that quail populations on Control 1 were influenced at least moderately by the management practices on the adjacent experimental area. The quail population on the Bumbee Creek area did not increase comparably.

Saunders (1973) indicated that quail may move as much as 0.5 miles from their late winter covey range to their individual ranges during the breeding season. Thus, quail from coveys near the northern border of the experimental area may incorporate almost any area on Control 1 in their home range. Covey movements during the fall months could also influence flush census data on any given day. Yoho (1970) recorded an average daily movement of 427 yards by coveys on Ames Plantation in West Tennessee. Other authors in the Southeast indicated that covey movements during the winter may be as much as one mile from the point of initial capture (Lewis, 1954; Murphy and Baskett, 1952; Stoddard, 1931:174). Agee (1957), however, stated that Missouri quail may remain within a few hundred yards of their brood range if habitat is adequate. The movement data presented by these authors, coupled with the failure of quail

populations in the present study to show significant increases on the Bumbee Creek area, dictates the conclusion that quail populations on Control 1 were influenced by food plots on the experimental area.

Mourning Doves

Population densities determined by call indices during the spring and summer months decreased on both the Stinging Fork and Bumbee Creek areas during the two years surveyed (Table VII). The average number of mourning doves calling on the Stinging Fork area decreased by 33 percent from 1.5 birds per census day in 1972 to 1.0 birds per day in 1973. Cooing doves on the Bumbee Creek area decreased by 70 percent from a mean of 1.0 bird per day during the 1972 census to 0.3 birds per day in 1973.

Foote and Peters (1952) showed that the relatively stable period of calling activity of mourning doves was about May 20 to June 10. However, dove calling activity during the present study did not conform to any obvious peak or a period of time when cooing was consistent. Research by LaPerriere and Haugen (1972) suggested that calling activity of doves decreases as the population density decreases. Therefore, the obviously low dove density on the Spring City study areas should account for the inconsistent calling activity of this species.

The number of mourning doves observed during the spring call census increased on both research areas. Doves observed on the Stinging Fork area increased by 38 percent from a mean of 5 doves per census day (1972) to 6.9 doves per day (1973). A similar trend

TABLE VII

RESULTS OF THE MOURNING DOVE SPRING CALL INDEX ON THE SPRING CITY STUDY AREAS DURING 1972 AND 1973

Type of Call Index	Stinging Fork Experimental Area (including Control 1)			Bumbee Creek Area (Control 2)		
	1972	1973	Percent Change	1972	1973	Percent Change
Average number of calling doves per census day	1.5	1.0	-33	1.0	0.3	-70
Largest number of doves calling during one day	4	4	0	2	2	0
Average number of doves observed per census day	5.0	6.9	+38	0	1.3	+130

occurred on the Bumbee Creek area with the number of doves observed increasing from 0 birds per day in 1972 to 1.3 birds per day during 1973.

A marked decline in fall dove populations on all study areas was observed during the 1972 and 1973 flush censuses (Table VIII). Dove densities on the Stinging Fork experimental area decreased by 99 percent from 1 bird per 3.2 acres in 1972 to 1 bird per 220 acres in 1973. The same trend was observed on the Control 1 and 2 areas. One dove per 4.2 acres was recorded during the 1972 flush census on Control 1; this density decreased to 1 bird per 153 acres (a 97 percent decrease) in 1973. Dove density on Control 2 decreased from 1 dove per 1.9 acres in 1972 to 0 doves per acre in 1973.

Dove populations appeared to be influenced more by the stage of vegetational succession rather than the food plant species which were established on the Stinging Fork area. The preceding data indicated the establishment of food plots on the experimental area had no significant effect on mourning dove populations. The large number of doves flushed on all study areas during the 1972 fall census probably was due to the pioneer stage of vegetation during the first year after site preparation.

Food habit studies show that soybeans, lespedeza, and clover are not major foods for mourning doves (Davison and Sullivan, 1963; Korschgen, 1958). Field observations during the present study indicate that these food species may be utilized by doves during the late winter and early spring periods.

TABLE VIII

RESULTS FROM THE SPRING AND FALL FLUSH CENSUS INCLUDING THE TOTAL NUMBER OF MOURNING DOVES FLUSHED AND THEIR DENSITIES PER ACRE ON THE SPRING CITY STUDY AREAS

Area	Type Parameter	Fall 1972	Spring 1973	Fall 1973
Stinging Fork Area	Total number of birds	68	4	1
	Acres per bird	3.2	55	220
	Percent change	N/A	-94	-99
Control 1	Total number of birds	73	1	2
	Acres per bird	4.2	306	153
	Percent change	N/A	-99	-97
Control 2	Total number of birds	166	2	0
	Acres per bird	1.9	153	0
	Percent change	N/A	-98	-

Other Game Species

a. Ruffed Grouse

Ruffed grouse heard drumming during the spring call census or observed during the spring and fall flush censuses were recorded on the Spring City study areas. Grouse were not found on the Bumbee Creek area during the two years of this study. One grouse was flushed during the fall of 1972 near the Stinging Fork experimental area. Four grouse were flushed near the experimental area and one near Control 1 in the spring of 1973. No grouse were found during the 1973 fall flush census. All grouse flushed were approximately 5 to 10 meters inside the hardwood borders of the clear-cut areas. Only one grouse was heard drumming near Control 1 during the research period.

Although the preceding data are insufficient to show trends in grouse populations, food plots probably did not affect grouse populations significantly. It is possible that lespedeza and clover used in food plots were utilized by grouse to some extent. Food habit studies by Korschgen (1966) and Phillips (1967) indicate these plant species are relatively good food sources for ruffed grouse. Adult grouse tend to leave conifer plantations during late morning hours in search for food (Bailey and Alexander, 1960); thus food planting in pine plantations may eventually benefit this age class. The establishment of herbaceous cover for grouse brood habitat is regarded as good habitat management for this species (Sharp, 1963).

Accepted management practices for ruffed grouse are concerned primarily with clear-cutting forest lands to maintain successional stages which provide suitable cover (Berner and Gysel, 1969; Hale and Dorney, 1963). These authors suggested that clear-cutting be confined to 5 to 10 acre blocks and limiting management units to 160 acres rather than a single large management area. Therefore, the large clear-cut areas of the present study may, in fact, limit the ruffed grouse populations during the first few years of reforestation.

b. White-tailed Deer

Clear-cut areas are used extensively by white-tail deer populations primarily because of the large quantities of hardwood sprouts generated after land clearing operations (Cook, 1946). During the present study, all areas received extensive use by white-tail deer. These deer caused considerable difficulty in maintaining soybean production in the food plots on the experimental area. Soybean strips were completely destroyed during the summer and fall of 1972, but damage to soybeans in 1973 was insignificant. It is believed that the advanced vegetative cover during the second year of succession provided sufficient browse to eliminate the dependence of deer on the soybean strips.

c. Cottontail Rabbits

Cottontail rabbit populations appeared sparse on the Spring City areas during both years surveyed. Rabbit populations showed a

slight increase during the fall of 1973. The flush census during the fall of 1972 found one rabbit on each of the three study areas. The number of rabbits found on the Stinging Fork experimental area and Control 1 remained the same during the spring census (1973). Four rabbits were found on the Bumbee Creek area during this census. During the fall flush census (1973), three rabbits were found on the Stinging Fork experimental area, four on Control 1 and two on Control 2.

Cottontail populations are closely associated with the stage of vegetational succession. The stage of vegetative succession and its value to wildlife has been demonstrated by Beckwith (1954). As vegetative cover becomes more advanced on the present research areas, cottontail populations may increase to a level where reasonable evaluation of food plot benefits for this species can be made.

The value of lespedeza and clover as a food source for cottontail rabbits is well documented (Dalke and Sime, 1941; Davison, 1943; Dusi, 1952; Rosene, 1955). These plant species are generally more important during the spring and summer months. However, Rosene (1955) found bicolor lespedeza to be a highly desirable food source for rabbits during the winter months. He observed that rabbits would sever bicolor stems in order to drop the seed heads so they could be eaten.

Songbird Populations

Bird species found on the Stinging Fork Creek area (Table IX) included 36 species in 1972 and 39 species in 1973. Twenty-eight species were common to both years surveyed. On the Bumbee Creek area (Control 2), 21 species were recorded in 1972 and 29 species during the 1973 census. Twenty species were common to both years. During 1972, 21 species were common on both areas, whereas, surveys in 1973 found 26 identical species. The mean number of individuals observed per day increased from 47.4 (1972) to 96.6 (1973) on the Stinging Fork area and from 26.4 (1972) to 43.9 (1973) on the Bumbee Creek area. A complete list of scientific and common names of birds used in this thesis is found in Appendix C, Table XXVII.

On the Stinging Fork area, the mean number of field sparrows (Spizella pusilla) observed per day increased more dramatically than any other songbird species. This species increased by a mean of 14 individuals per day from the 1972 to the 1973 breeding season. Indigo buntings (Passerina cyanea) had the second largest increase of 7.7 individuals per day. This species was followed by prairie warblers (Dendroica discolor) which increased by a mean of 6.6 birds per day, grackles (Quiscalus quiscula) 5.9, yellow-breasted chats (Icteria virens) 4.2, horned larks (Eremophila alpestris) 3.3, American goldfinches (Spinus tristis) 2.9, starlings (Sturnus vulgaris) 1.6, rufous-sided towhees (Pipilo erythrophthalmus) 1.4, and yellowthroats (Geothlypis trichas) 0.8 individuals per day.

TABLE IX

CHECK LIST OF BIRDS FOUND ON THE SPRING CITY STUDY AREAS WITH EACH SPECIES REPRESENTED BY THE AVERAGE NUMBER BIRDS PER CENSUS DAY

Species	Stinging Fork Area		Bumbee Creek Area	
	1972	1973	1972	1973
Black vulture	.1	0	0	0
Red-tailed hawk	.8	.2	.2	.1
Sparrow hawk	.4	0	0	.1
Yellow-billed cuckoo	1.4	.4	1.4	.4
Whip-poor-will	0	.1	0	0
Nighthawk	.1	0	0	0
Chimney swift	0	.1	0	0
Belted kingfisher	.4	0	0	0
Yellow-shafted flicker	1.0	1.8	.2	.6
Pileated woodpecker	1.3	.6	.8	.3
Red-bellied woodpecker	0	.4	0	0
Eastern kingbird	0	0	0	.1
Eastern phoebe	.4	0	0	0
Horned lark	1.6	4.9	0	.6
Barn swallow	.6	.3	1.2	.3
Blue jay	2.6	3.1	.8	1.6
Crow	3.5	3.6	1.6	1.8
Carolina chickadee	.9	.2	.8	0

TABLE IX (continued)

Species	Stinging Fork Area		Bumbee Creek Area	
	1972	1973	1972	1973
Tufted titmouse	0	.8	0	.4
Carolina wren	2.6	2.6	.8	1.0
Mockingbird	.3	0	0	0
Brown thrasher	2.3	3.3	.2	1.0
American robin	.3	.1	0	0
Wood thrush	1.1	1.3	.4	.1
Eastern bluebird	4.4	1.7	.4	.1
Blue-gray gnatcatcher	0	.3	0	0
Starling	.1	1.7	0	.1
White-eyed vireo	0	.2	0	.4
Red-eyed vireo	.5	.1	.2	.2
Black and white warbler	0	.1	0	0
Prairie warbler	0	6.6	1.0	5.0
Ovenbird	0	.6	0	.2
Kentucky warbler	.5	.1	0	0
Yellowthroat	.4	1.2	0	2.0
Yellow-breasted chat	1.5	5.7	.6	1.4
Hooded warbler	.1	.1	0	0
Eastern meadowlark	0	.4	0	0
Redwinged blackbird	0	.3	0	0
Grackle	1.0	6.9	0	0

TABLE IX (continued)

Species	Stinging Fork Area		Bumbee Creek Area	
	1972	1973	1972	1973
Brown-headed cowbird	.6	0	.4	0
Scarlet tanager	.4	.2	0	.1
Summer tanager	.1	0	0	0
Cardinal	1.1	3.6	1.2	2.1
Blue grosbeak	0	.2	0	0
Indigo bunting	6.4	14.1	4.6	6.1
American goldfinch	.5	3.4	1.2	2.3
Rufous-sided towhee	4.9	6.3	3.6	3.9
Field sparrow	1.6	15.6	2.4	10.8
Song sparrow	.6	0	.8	.1
Unknowns	1.1	3.2	1.6	1.0
Daily average of total individuals	47.4	96.6	26.4	43.9
Total number of species identified	36	39	22	29

Approximately the same trend existed in the species showing increases in the mean number of individuals observed per day on the Bumbee Creek area. Field sparrows increased most dramatically, by 8.4 individuals per day. Prairie warblers (4 birds per day) were second, followed by yellowthroats (2 per day), indigo buntings (1.5 per day), American goldfinches (1.1 per day), yellow-breasted chats (0.8 per day), horned larks (0.6 per day), and rufous-sided towhees (0.3 per day). Starlings, however, were not observed on this area either of the years surveyed.

Blue jays (Cyanocitta cristata), cardinals (Richmondena cardinalis), and brown thrashers (Toxostoma rufum) also increased noticeably on both the Stinging Fork and Bumbee Creek areas. These birds are common inhabitants of hardwood and pine forest edges.

The majority of species observed were found near the borders of hardwood and pine forest and in areas where cover strips had been left during clear-cutting operations. These areas represented the optimum marginal habitats (Martin, 1960). Woodland and clearing interiors have fewer niches for wildlife than marginal areas; however, the influence of clearings usually extends approximately one hundred yards into the interior of woodlands (Lay, 1938). It also may be assumed that as the marginal influence of clearings on wildlife extends into the interior of the woodlands, so does the influence of forests extend into the interior of clearings.

An annual-biennial stage of vegetative succession generally represents the primary invasion of plants on a cleared area (Beckwith, 1954). This stage usually lasts for approximately three years after

initial abandonment and produces large quantities of seed-producing weeds which are important to a large number of granivorus birds. A shrub layer, important to birds requiring a certain amount of overhead or protective cover, becomes evident during the mixed herbaceous-perennial vegetative stage. The study areas, however, developed a modest shrub layer as early as the second year from sprouting of old tree stumps and roots. The presence of these sprouts combined with the more advanced vegetative cover of seed-producing weeds on the areas in 1973 were probably responsible for the increase in populations of bird species in the interior of the clear-cuts. These species included the starling, prairie warbler, yellowthroat, yellow-breasted chat, indigo bunting, field sparrow, grackle, American goldfinch, and rufous-sided towhee. Increases in other species are believed due to advanced vegetational stages in the marginal habitat.

Interior areas of clear-cuts also provide an excellent habitat for horned larks. These birds prefer open, wind-swept habitats and feed primarily on weed seeds (Beal and McAtee, 1922; Allen, 1938). This is evidenced by the dramatic increase in the number of horned larks found on both the Stinging Fork Creek and Bumbee Creek areas during 1973.

Literature relating the importance of food plots, such as those used on the Spring City study area, to songbird populations is sparse. The importance of food plots for migrating slate-colored juncos has been recorded by Hooper (1967). Wallace (1942) found food plots to be utilized by fringillids during the early fall months. Autumn olive is considered to be a very important food source for

songbirds, especially robins (Allen and Steiner, 1959). Data obtained during this study are too inconclusive to evaluate the impact of food plots on either study area. Therefore, continuing research on these areas is necessary to assess the value of food plots to songbirds over the life of the projects.

Small Mammal Populations

House mice (Mus musculus), white-footed mice (Peromyscus leucopus), hispid-cotton rats (Sigmodon hispidus), eastern harvest mice (Reithrodontomys humulis), and least shrews (Cryptotis parva) were the only species captured (Table X). However, species composition and relative abundance changed over time, indicating that succession of small mammal populations was paralleling succession of the vegetation.

White-footed mice were the most common species trapped during October 1972 and February 1973. Gashwiler (1970) and LoBue and Darnell (1959) also recorded increases in white-footed mice populations following the removal of vegetative cover. The fact that white-footed mice are primarily nocturnal and may require less cover may explain increases in their population densities on cleared areas. During the October 1973 trapping session cotton rats replaced the white-footed mice as the dominant species. As the vegetative complex advances, the small mammal populations should become more stable. At present the impact of food plots on small mammal communities are not clear.

TABLE X

THE RELATIVE INDEX OF SMALL MAMMAL POPULATIONS SNAP-TRAPPED DURING 1972 AND 1973 ON THE SPRING CITY STUDY AREA

	Stinging Fork Creek Area			
	Experimental Area		Control 1	
Year	Species	Number Captured	Species	Number Captured
October 1972	White-footed mice	11	White-footed mice	6
	House mice	4	House mice	1
	Cotton rats	3		
	Harvest mice	1		
February 1973	White-footed mice	4	White-footed mice	6
	Cotton rats	1		
			House mice	1
October 1973	Cotton rats	7	Cotton rats	6
	House mice	3	House mice	2
	Least shrews	2	Least shrews	1
			White-footed mice	1

Cost of Manipulation

A total of 15.8 acres of food plots was established on the Stinging Fork experimental area at a cost of $303.25 (Table XI). The average cost per acre planted was $19.19 and the average cost per acre for the 220-acre treated area was $1.38. Explicit details of all planting expenses projected for a 500-acre wildlife management unit are listed in Appendix D, Table XXVIII.

The only maintenance of this management program necessary on an annual basis is the re-establishment of soybean food strips. Based on present costs, an additional $76.58 must be added to the total cost for each year these strips are replanted. During the two years of the present study, expenditures were $379.83. This increased the cost per acre for the 220-acre management unit to $1.73 for the two year period, but decreased the cost per acre per year to about $0.87. Cost per acre planted would increase to $24.04. Similar costs ($17 to $24 per acre seeded) were reported by Webb and Patric (1961).

Cost-Return for Bobwhite Quail

Bobwhite quail provide the best criterion for analyzing cost-return benefits because of traits inherent to the species mentioned earlier. These traits included a high biotic potential, high turn-over rate, limited mobility, and well developed census techniques.

TABLE XI

ACTUAL COST OF THE INITIAL ESTABLISHMENT OF WILDLIFE FOOD PLOTS ON A 220 ACRE MANAGEMENT UNIT[a]

Plant Species	Acres Planted	Cost per Acre	Total Cost
Soybeans	2.2	$34.81	$ 76.58
Lespedeza-clover mixture	11.0	13.78	151.58
Shrub lespedeza	2.2	29.77	65.49
Autumn olive	0.4	24.00	9.60
Total acres planted	15.8	Total cost	$303.25
Average cost per acre planted			$19.19
Average cost per acre for area treated			$1.38

[a]Cost data from a progress report submitted to the University of Tennessee Forestry Department by Hiwassee Land Company.

It was assumed that food plots on the Stinging Fork experimental area were responsible for the observed increase in quail population density. It has been shown previously that food plots were the only habitat manipulation which was not common to both areas. Therefore, this assumption should be valid.

Increases in quail density on the Stinging Fork experimental area due to the existing management practices were calculated in the following manner. The 0.09 birds per acre found on the Bumbee Creek area during the 1973 fall flush census was assumed to be representative of the density on the experimental area had food plots not been established. This density would have represented a population level of 20 quail. Subtracting this number from the total of 130 quail observed during the fall flush census indicated a difference of 110 quail due to the presence of food plots, an increase of 550 percent in quail density.

Under the conditions of the present research, the bulk of the cost was incurred during the first year and the bulk of the benefits was obtained the second year. Considering the above statement, the cost of population increases in bobwhite quail would be $3.45 per bird for the year 1973. This figure is more precise than is warranted, as my census technique did not quantify the population density accurately enough to determine cost-return figures to the final penny. However, a cost of $3.00-$4.00 is believed to be a reasonable estimate. This value should decrease to approximately $1.24 per bird per year if one prorates the cost of the project over a six-year period. Six years is believed to be the approximate length of time

hunting will benefit from this management program. However it must be emphasized that food plant species established on the Stinging Fork area may influence wildlife populations for several additional years. The above figures do not consider price inflation of materials and labor and assumes quail population densities will be similar to those found on the area during 1973. It should also be noted that quail found on Control 1 were not included in these figures even though their "population" was influenced by the management practices on the Stinging Fork experimental area.

Food plots do not replace or retard growth of pine trees and soybean strips serve the areas as fire breaks. Thus, alternative land uses need not be considered in cost-benefit analyses.

II. Evaluation of Food Plots in Farm Lands

Biological Impact

The biological impacts of food plots on farm land near Morristown, Tennessee were determined by measuring changes in wildlife population densities and the location of animals in relation to food plots. As on the Spring City research area, the utilization of natural varieties of plant food by bobwhite quail was an important facet of this research.

Bobwhite Quail

a. Population Density

The average number of bobwhite males calling on the Morristown experimental area increased by 26 percent from a mean of 6.9 birds in 1972 to 8.7 birds in 1973 (Table XII). The number of quail calling on the control area decreased by 12 percent from an average of 4.3 calling males in 1972 to 3.8 males during the 1973 breeding season. Results of the fall flush census show quail populations decreased by 11 percent on the experimental farm and by 63 percent on the control farm (Table XIII). Quail density on the control area decreased from one quail per 11.7 acres in 1972 to one quail per 31.8 acres in the fall of 1973. The fall flush census on the experimental area recorded a decrease in quail density from one bird per 5.5 acres in 1972 to one quail per 6.1 acres during 1973. The spring flush census found one bird per 30 acres (82 percent decrease) on the experimental area. No quail were flushed on the control farm during the spring census.

The presence of food plots is believed to be responsible for the relatively high quail density sustained on the experimental area during the two years of this research. On the other hand, a more desirable vegetative cover for wildlife was available on the experimental area, and for this reason it is probable that quail density on the experimental area would be somewhat greater than on the control area. The control farm was used extensively for livestock

TABLE XII

BOBWHITE SPRING CALL COUNTS ON THE MORRISTOWN STUDY AREAS DURING 1972 AND 1973

Type of Call Index	Cooper Farm 1 (Exp.)			Cooper Farm 2 (Control)		
	1972	1973	Percent Change	1972	1973	Percent Change
Average number of calling males[a]	6.9	8.7	+26	4.3	3.8	-12
Largest number of males calling during one day	9	12	+33	8	5	-38

[a]The average number of calling males was determined by averaging the number of males heard during the peak of the breeding season.

TABLE XIII

RESULTS FROM THE SPRING AND FALL FLUSH CENSUS INCLUDING THE NUMBER OF COVEYS FLUSHED, THE TOTAL NUMBER OF BIRDS, AND THE NUMBER OF BIRDS PER ACRE ON THE MORRISTOWN AREAS

Area	Type Parameter	Fall 1972	Spring 1973	Fall 1973
Cooper Farm 1 (Experimental area)	Number of coveys	5	1	4
	Number of birds	55	10	49
	Acres per bird	5.5	30.0	6.1
	Percent change	N/A	-82	-11
Cooper Farm 2[a] (Control area)	Number of coveys	2	0	1
	Number of birds	30	0	11
	Acres per bird	11.7	0	31.8
	Percent change	N/A	-100	-63

[a]An additional 100 acres of an adjoining farm was censused to increase the size of the control area. The total area censused was approximately 350 acres.

grazing which retarded growth of desirable cover species, particularly Japanese honeysuckle (Handley, 1945). The importance of honeysuckle as cover for quail was demonstrated by Yoho (1970) on Ames Plantation in West Tennessee.

The decrease in quail density on the experimental area during 1973 was believed to be due partially to the destruction of five food plots by livestock during the summer of 1973. These plots were then seeded with buckwheat to replace the destroyed soybeans and millets. Buckwheat was used because of its short growing season. However, Eubanks (1972) has shown this plant species to be less desirable than either soybeans or millet as a quail food. Neither buckwheat nor millets ususally are available for quail during late winter periods (Eubank, 1972; Leopold, Moore, and Sowls, 1939).

Another factor which may be responsible for the slight decrease in quail density on the experimental area was the planting of approximately 20.2 hectares (50 acres) of soybeans on a near-by farm. This soybean field was adjacent to the Cooper farm and large amounts of seed were left after harvesting operations. The presence of this field, coupled with the loss of the food plots mentioned earlier, may have attracted coveys from the Cooper farm.

Flush census data on the experimental area are probably affected to a large extent by the heavy vegetative cover found on a large portion of the area. Yoho (1970) reports two occasions when all efforts to flush coveys with a telemetered quail in dense vegetation failed. This hesitancy of coveys to flush from dense cover may greatly reduce the number of quail flushed by direct census.

"Clean" farming practices, including pasture improvement, is an important factor limiting farm quail populations (Frye, 1961). This statement is supported by Burger and Linduska (1967) in Maryland who found winter cover and nest cover, not food, to be the most important requirements of bobwhite quail. Other authors, however, indicate that food plots on farm land can increase quail populations. Increases in quail densities were reported by Schumacher (1969) where landowners established food and cover crops on 5 percent of their land. Webb (1960) found that after bicolor food plots on farm lands in South Carolina were destroyed, quail populations dropped approximately 33 percent. Murray (1958) and Wunz (1959), however, found no significant increase in quail populations on areas where food plots were located.

b. Utilization of Food Plots

Twenty-three quail (17 males, 6 females) were collected from the Morristown study area during the 1972-1973 and 1973-1974 hunting seasons. Twenty of these quail were collected from the experimental area during 1972-1973. Only 3 quail were collected on this area during the 1973-1974 season. Efforts during both hunting seasons failed to locate coveys on the control area.

Soybeans were the most important food source on the experimental area during the 1972-1973 hunting season (Table XIV). This species accounted for 79.13 percent of the total volume eaten and was found in 70.0 percent of all crops examined. Forestiera spp. was second in importance comprising 14.0 percent of the total volume and

TABLE XIV

IMPORTANT FOOD ITEMS FROM CROP ANALYSIS OF 20 QUAIL COLLECTED ON THE MORRISTOWN EXPERIMENTAL AREA DURING THE 1972-1973 HUNTING SEASON

	VOLUME		FREQUENCY			NUMBER	
Food Items	Total cc	% Rel. Vol.	Times Occur.	% Freq. Occur.	% Rel. Freq.	Total No. of Items	% Rel. Number
Glycine max	63.3	79.1	14	70.0	20.0	637	26.9
Forestiera spp.	11.2	14.0	5	25.0	7.1	359	15.2
Lespedeza stipulace	3.2	4.0	4	20.0	5.7	1071	45.3
Euonymus atropurpureus	1.0	1.3	1	5.0	1.4	6	0.3
Desmodium viridiflorum	0.3	0.4	3	15.0	4.3	73	3.1
Lespedeza striata	0.3	0.4	2	10.0	2.9	109	4.6
Bidens mitis	0.3	0.4	1	5.0	1.4	78	3.3
Green leafy material	0.2	0.3	6	30.0	8.6	N/A	N/A
Lespedeza repens	0.1	0.1	3	15.0	4.3	77	3.3
Cassia fasciculata	0.1	0.1	1	5.0	1.4	13	0.6

occurring in 25.0 percent of the crops. This species was followed by Korean lespedeza (4.0%) and Euonymus atropurpureus (1.3%). A list of plant foods found only in trace amounts are tabulated in Appendix B, Table XXVI.

Two of the three crops collected during the 1973-1974 season were empty. The contents of the remaining crop contained soybeans (95.2% of total volume) and Sida spinosa (4.8% of total volume).

It was noted previously that millet is not an important food source for bobwhites during the late winter months. The absence of browntop and German millets in the quail crops collected during this late winter verified this conclusion. Field observations of heavy quail usage of millet food patches during the late summer and early fall months but not during the winter months provided additional support. It is believed that millet may be an important early season food source for quail on farm lands where pastures comprise the majority of the land-use pattern, but that is not sufficient for maintaining quail through the late winter period.

No significant amounts of soybean seeds could be found in any food plot after the first of February, 1973. Covey flushing success during the 1972-1973 hunting season also decreased noticeably. It is possible that the end of the available food supply was responsible for the large drop in quail density during the spring flush census.

Coveys were seldom found further than 25 yards from food plots and generally were flushed from within the boundaries of the soybean plots. During the 1973-1974 season, coveys were found only near those

plots which had not been destroyed by livestock, indicating that the loss of these plots decreased the carrying capacity of the area.

Mourning Doves

The average number of calling doves on the Morristown experimental area decreased by 87 percent from a mean of 4.4 birds per day in the summer of 1972 to 0.6 bird per day in 1973 (Table XV). Only one cooing dove was heard on the control farm during each year surveyed.

The number of mourning doves observed during the spring call census increased by 118 percent on the experimental area and decreased by 48 percent on the control area. The average of 1.4 doves per day observed on the experimental area in 1972 increased to a mean of 3.1 birds per day in 1973. Doves observed on the control area decreased from an average of 1.8 birds per day in 1972 to 0.9 birds per day during the 1973 census.

An increase in the number of doves was noted during the fall flush census (Table XVI). Only five doves were flushed on the experimental area during the 1972 fall census with this number increasing by 420 percent to 26 doves during the 1973 census. Eighteen doves were found on this area in the spring of 1973. No doves were found on the control area during either the 1972 fall flush census or the 1973 spring census. Eleven doves were sighted on the control farm during the 1973 fall census.

The above data suggest that the food plots on the experimental area had no significant impact on mourning dove populations.

TABLE XV

RESULTS OF THE MOURNING DOVE SPRING CALL INDEX ON THE MORRISTOWN STUDY AREAS DURING 1972 AND 1973

Type of Call Index	Cooper Farm 1 (Experimental Area)			Cooper Farm 2 (Control area)		
	1972	1973	Percent Change	1972	1973	Percent Change
Average number of calling doves per census day	4.4	0.6	-87	0.2	0.3	+65
Largest number of doves calling during one day	9	3	-67	1	1	0
Average number of doves observed per census day	1.4	3.1	+118	1.8	0.9	-48

TABLE XVI

RESULTS FROM THE SPRING AND FALL FLUSH CENSUS INCLUDING THE TOTAL NUMBER OF MOURNING DOVES FLUSHED AND THEIR DENSITIES PER ACRE ON THE MORRISTOWN STUDY AREAS

Area	Type Parameter	Fall 1972	Spring 1973	Fall 1973
Cooper Farm 1 (Experimental area)	Total number of birds	5	18	26
	Acres per bird	60	16.6	11.6
	Percent change	N/A	+260	+420
Cooper Farm 2[a] (Control area)	Total number of birds	0	0	11
	Acres per bird	0	0	31.8
	Percent change	N/A	0	+1100

[a]An additional 100 acres of an adjoining farm was censused to increase the size of the control area. The total area censused was approximately 350 acres.

Mourning doves were known to utilize the millet portion of food plots to some extent during the late summer and early fall months. However, the number of dove flushes from such areas decreased sharply as the season progressed. If the millet food plots had any effect on dove populations or the retention of these birds on the experimental area, this effect was minimal, and was confined to the period when millet seed was available.

Food habit studies generally indicate that the feeding activity of mourning doves are centered around such agricultural crops as corn (Zea mays) and wheat (Triticum spp.) (Carpenter, 1971; Davison and Sullivan, 1963; Korschgen, 1958). These authors also recognized that millets are highly preferred food for this bird species. Soybeans were classified by Davison and Sullivan (1963) as a fair food source for doves. Although millets and soybeans are recognized as important food sources, it is believed that food plots used during the present study are too small to supply these seeds in sufficient quantities to increase dove populations.

Cottontail Rabbits

The number of cottontail rabbits flushed on the experimental farm remained constant during this research period. Flush censuses tabulated five rabbits on this area during the 1972 fall census, six during the 1973 spring census, and six during the fall, 1973 census. On the control area, the number of rabbits flushed decreased steadily during both years surveyed: 4 during the fall of 1972, 2 in the spring of 1973, and 1 during the fall 1973 census.

The presence of food plots were probably not responsible for the higher rabbit population on the experimental area. As mentioned earlier, the experimental area has a more desirable vegetative cover for wildlife than the control area. This fact is believed to be responsible for the difference in rabbit populations on the two areas.

The importance of food plots to supplement the cottontail winter diet is documented by Trippensee (1948:36-37). Soybean was included in the list of plants he considered excellent food for rabbits. More recent work by Dusi (1952) indicated that food should not be the most important management consideration. He also stressed the value of bluegrass as an all season food source for rabbits. This plant species was found in abundance on many portions of the Morristown study areas. The importance of grasses was also recorded by Dalke and Sime (1941). Shrubby vegetation, which is important as a late winter food source for rabbits (Beckwith, 1954), is also found in large quantities on these study areas. Therefore, food plots such as the ones established on farm lands during the present research, may not be of significant value as a food source for cottontail rabbit.

Songbird Populations

Surveys on the Morristown experimental area (Table XVII) yielded 46 species in 1972 and 47 species during 1973. The daily average number of individuals observed during the two years was 157.6 and 155.3 respectively. Thirty-six species were common to each

TABLE XVII

CHECK LIST OF BIRDS FOUND ON THE MORRISTOWN STUDY AREAS WITH EACH SPECIES REPRESENTED BY THE AVERAGE NUMBER BIRDS PER CENSUS DAY

Species	Experimental Area		Control Area	
	1972	1973	1972	1973
Great blue heron	.1	0	0	.1
Green heron	1.6	0	0	0
Black-crowned night heron	.1	0	0	0
Wood duck	.1	.3	0	0
Turkey vulture	.1	0	0	0
Red-tailed hawk	0	.1	.2	.1
Red-shouldered hawk	.1	0	0	0
Sparrow hawk	.6	.1	0	.2
Killdeer	0	.2	.8	0
Wilson's snipe	0	0	.2	0
Rock dove (domestic pigeon)	6.7	.9	0	0
Yellow-billed cuckoo	.9	.4	.7	.4
Chimney swift	0	.8	0	.1
Ruby-throated hummingbird	.1	.1	0	0
Belted kingfisher	0	0	0	.3
Yellow-shafted flicker	.3	.6	1.0	.8
Pileated woodpecker	.7	.2	0	.3
Red-bellied woodpecker	0	.3	0	.4
Downy woodpecker	0	.1	0	.1
Eastern kingbird	.3	.3	.5	0
Crested flycatcher	0	0	0	.2

TABLE XVII (continued)

Species	Experimental Area		Control Area	
	1972	1973	1972	1973
Eastern phoebe	.7	.1	.2	0
Eastern wood pewee	0	0	.3	.1
Barn swallow	8.3	.7	5.7	1.2
Purple martin	.3	0	0	0
Blue jay	1.9	3.0	2.3	3.8
Crow	6.0	5.2	5.7	4.1
Carolina chickadee	2.7	1.8	.8	.7
Tufted titmouse	.1	.3	0	.4
Carolina wren	5.6	3.1	3.5	1.6
Mockingbird	1.4	.7	1.7	.9
Catbird	.6	0	0	0
Brown thrasher	.6	.5	.2	0
American robin	.6	.4	1.3	.3
Wood thrush	.1	0	.3	.4
Eastern bluebird	.4	.6	.3	.7
Blue-gray gnatcatcher	2.1	2.7	0	.5
Loggerhead shrike	.4	0	0	0
Starling	46.1	23.1	30.5	3.2
White-eyed vireo	.3	1.9	0	0
Warbling vireo	.1	0	0	0
Prothonotary warbler	0	.3	0	0
Worm-eating warbler	0	.1	0	0
Prairie warbler	0	1.8	0	.1

TABLE XVII (continued)

Species	Experimental Area		Control Area	
	1972	1973	1972	1973
Yellow throat	.6	2.4	.2	.1
Yellow-breasted chat	.4	4.5	0	.1
Eastern meadowlark	9.6	11.7	4.0	8.4
Redwinged blackbird	8.7	8.7	.2	1.2
Grackle	3.0	8.7	2.8	2.0
Brown-headed cowbird	2.3	1.9	1.0	.9
Scarlet tanager	0	.1	0	.1
Summer tanager	0	0	0	.1
Cardinal	6.9	12.6	1.3	4.2
Blue grosbeak	.1	.2	0	0
Indigo bunting	8.3	12.6	1.8	3.5
Dickcissel	1.7	1.7	0	0
American goldfinch	5.7	3.6	.5	1.7
Rufous-sided towhee	3.6	9.3	.3	1.4
Grasshopper sparrow	0	1.2	0	.6
Field sparrow	10.7	22.7	5.2	14.8
White-throated sparrow	0	.3	0	.1
Song sparrow	4.3	1.4	1.2	.9
Unknowns	1.6	1.2	.7	.7
Daily average of total individuals	157.6	155.3	74.7	61.7
Total number of species identified	46	47	30	41

year. Birds found on the control area included 30 species in 1972 and 41 species in 1973. However, the daily average of individuals observed declined from 74.7 during 1972 to 61.7 in 1973. Twenty-five species were common to both years surveyed. During 1972, only 26 species were common to both the experimental and control areas; however, during 1973 this number increased to 35 species.

The most abundant species on both the experimental and control areas were those associated with woodlands and brushy habitat. These habitats normally support more niches and available foods than meadows or areas in a perennial grassy stage (Beckwith, 1954). Meadows, on the other hand, were important for species such as killdeer (Charadrius vociferus), eastern meadowlarks (Sturnella magna), redwinged blackbirds (Agelaius phoeniceus), dickcissels (Spiza americana), grasshopper sparrows (Ammodramus savannarum), and field sparrows. The association of the preceding bird species with a grassy stage of succession was also made by Dambach (1940), Warback (1958), and Beckwith (1954).

Examination of the data collected on the experimental area indicates no significant differences between the years 1972 and 1973. Therefore, it appears that food plots have no significant effect on songbird populations at least after a two-year period. The changes in the type species present, the number of species, and the number of individuals of each species are believed due to the normal fluctuation in bird densities on any given area.

Wallace (1942) established a seed plot to determine impacts of this practice on songbird species. Millets and buckwheat were included

in the plant species used during his research. He found a heavy concentration of seed-eating fringillids utilized this plot from mid-September through October. The food supply in the plot, however, was exhausted by mid-November. No large concentrations of songbirds were observed using food plots during the present study. Such species as starlings, grackles, and redwinged blackbirds did frequent these areas regularly.

Small Mammal Populations

A total of 209 small mammals representing seven species were snap-trapped on the Morristown area during this study. These species included house mice, white-footed mice, hispid cotton rats, eastern harvest mice, least shrews, pine voles (Pitymys pinetorum), and southern bog lemmings (Synaptomys cooperi). A total of 153 individuals (0.3 individuals per trap night) were captured during the fall of 1972, 2 in the spring of 1973 (0.003 individuals per trap night), and 54 during the 1973 fall session (0.1 individuals per trap night).

Results of the three trapping sessions show a significant difference in food plot usage (line 1) when compared to sampling areas located five meters (line 2) and fifteen meters (line 3) from the edges of food plots (Table XVIII). During October, 1972, 95 individuals were captured on food plots, 36 individuals on line 2, and 22 on line 3. Although small mammal population densities were much lower during October, 1973, the same trend in food plot usage was evident. Twenty-five individuals were trapped on food plots during this year, 12 were trapped on line 2, and 17 on line 3. Only two individuals were trapped during the March, 1973 session; 1 on line 2, and 1 on line 3.

TABLE XVIII

THE RELATIVE INDEX OF SMALL MAMMAL USAGE OF FOOD PLOTS ON THE MORRISTOWN EXPERIMENTAL AREA

Trap Location	Species	Trapping Session: October 1972 Number Captured	March 1973 Number Captured	October 1973 Number Captured
Food plot (line 1)	House mice	84		16
	White-footed mice	10		6
	Cotton rats	1		1
	Least shrews			2
	Total	95	0	25
Five meters from food plot (line 2)	House mice	27		1
	Harvest mice	3		5
	Pine voles	5		1
	Least shrews			4
	Cotton rats	1		
	White-footed mice		1	1
	Total	36	1	12
Fifteen meters from food plot (line 3)	House mice	7		
	Pine voles	5	1	3
	Harvest mice	5		4
	Cotton rats	3		
	Least shrews	1		10
	Southern bog lemming	1		
	Total	22	1	17
Total Individuals per Session		153	2	54

House mice, comprising 83.3 percent of all species captured, were the most numerous species found on the food plots. White-footed mice (13.3%) were the second most numerous followed by least shrews (1.7%) and cottonrats (1.7%).

Blair (1948) studied small mammal populations on bluegrass meadows and reported year to year fluctuations in density similar to that found during the present study. He also stated that winter reductions in population density is explained principally as the result of the failure to breed during the winter months. This may partially explain the tremendous decrease in small mammal density during the March trapping session on my study area.

The importance of food plots on pastures for house mice and white-footed mice are clearly demonstrated by the preceding data. It is believed that food plots were responsible for increasing the population densities of these small mammal species. Either the availability of millet and soybean seeds, a more open vegetative ground cover, or a combination of both factors may be responsible for small mammal preference of food plot areas.

Cost of Manipulation

The cost of establishing food plots on the Morristown experimental area was $406.90 in 1972 and $265.05 in 1973 (Table XIX). The average cost incurred during the two year period was $335.99. The average yearly cost per acre planted was $90.32 and the average yearly cost per acre treated was $1.12. Explicit details of planting cost for 1972 and 1973 are listed in Appendix D, Tables XXIX and XXX.

TABLE XIX

COST OF THE ESTABLISHMENT OF WILDLIFE FOOD PLOTS ON THE MORRISTOWN EXPERIMENTAL AREA

Type Expense	Cost Incurred 1972	Cost Incurred 1973	Average Cost for Two years
Diesel farm tractor	$133.59	$106.38	$119.99
Labor	123.75	85.50	104.63
Equipment repair (parts)	13.09		6.55
Seed and fertilizer	34.17	73.17	53.67
Fencing	102.30		51.15
Total Planting Cost	$406.90	$265.05	$335.99

Total Cost for 1972 and 1973	$671.95
Average Cost per Area Treated	$ 2.24
Total Acreage Planted	3.72 acres
Average Yearly Cost per Acre Planted	$ 90.32
Average Yearly Cost per Area Treated	$ 1.12

The higher cost incurred during 1972 was primarily because of the initial establishment of necessary fencing around two food plots. Also, less time was required in 1973 for seedbed preparation due to the absence of the dense grass sod found on food plots sites in 1972. This reduced both labor and equipment cost.

Livestock and woodchucks (Marmota monax) posed serious problems in maintenance of the food plots. In pastures where food plots were located, barbed wire fences were necessary to protect food plots from livestock. During the summer of 1973, cattle broke through one of these fences inflicting considerable damage to the food plot. Woodchucks were responsible for destroying soybean sprouts on one plot during the summer of 1973. These incidences made reseeding necessary, causing additional expenses.

Research relating specifically to the cost of establishing food plots on farm lands was not found during an extensive literature review. Ellis, Edwards, and Thomas (1969) do present hypothetical cost figures for establishing food plots in southern Illinois. The cost per acre treated given was $4.57 which is approximately four times the cost incurred during the present study. However, 14 percent of the area was treated during the Illinois research compared to 1.24 percent on the Morristown experimental area.

Cost-Return

For reasons mentioned in the preceding discussion of cost-return analysis on the Spring City research area, bobwhite quail is the only

species considered on the Morristown area to evaluate cost-return parameters. The assumption necessary for this analysis is that densities of bobwhites on the experimental area was primarily due to the presence of food plots.

Considering the preceding assumption valid, the average cost per bird produced each year would be $9.74. This figure was determined by dividing the average planting cost for 1972 and 1973 ($335.99) by the average differences in bobwhite densities (34.5 birds) on the experimental and control areas. Again, the cost per bird should be considered approximate, as census techniques were not accurate enough to determine costs to the penny.

An additional expense not included above will be realized by the landowner. Land used for food plots is removed from production of the particular crop responsible for his source of income. On the present research area, the farming practice was primarily a registered beef cow and calf operation. Assuming land requirements of 1.3 acres for pasture and 0.7 acres for hay are necessary for the production of one animal unit, 1.9 animal units was removed from the landowners herd. A potential net return of $50 per animal unit (depending on market prices and management expenses at any particular time) resulted in a loss of an additional $95 to the landowner. The loss in production of livestock combined with the planting cost of food plots increased the average cost per quail produced to $12.46.

The preceding value should decrease to approximately $11.05 per bird when costs are prorated over a 10 year period. Existing fences

should last approximately 10 years. The preceding figures include $60.00 for fence maintenance, but do not include price inflation of materials and labor.

The size of the farming operation will, of course, determine the importance of the loss of land to the establishment of wildlife food plots. Small farming operations must produce the maximum yield from every acre of land in order to realize a profit from their business. Larger farming operations can better absorb this loss.

Some wildlife income source may be necessary to make management programs similar to the one utilized in the present research attractive to private landowners. Although some landowners may wish to increase bird populations for their own enjoyment, others may find it necessary to lease hunting rights or other recreational benefits to the public in order to make wildlife management ventures economically feasible.

It should be noted that the results of this research are from the initial two years of a long term management program. Data at this stage of research are insufficient to accurately predict wildlife population benefits from the planting of food plots on farm areas. It is hoped that during the next several years data will be available to better analyze the cost-return benefits of food plot establishment for both game and nongame species of wildlife.

CHAPTER V

SUMMARY

This thesis is concerned with the initial two year survey of a long-term wildlife management research project on two distinct areas: forest lands and farm lands. The portion of this research utilizing forest lands was conducted on two pine plantations located near Spring City, Tennessee. The two farm lands were a beef cattle operation near Morristown, Tennessee.

Wildlife food plots were established on each area in the spring of 1972 and re-established, where necessary, in the spring of 1973. The procedure used in the establishment of food plots on the pine plantation included (1) the establishment of a heavy-seeding annual species (soybeans) on 1 percent of the area, (2) establishment of a mixture of perennials or reseeding annuals (kobe lespedeza, Korean lespedeza, white dutch clover, and red clover) on 5 percent of the area, (3) seeding perennial shrub lespedeza on 1 percent of the area, (4) small hand planted plots of autumn olive in wet areas, and (5) sprigging small plots of shrub lespedeza. These food plots occupied 9 percent of the experimental area. Cost incurred in the establishment of food plots was $379.83 for the two-year period. The average cost per acre planted was $24.04 and the average cost per acre for the treatment of the 220-acre experimental unit was $1.73 for the two-year period ($0.87 per acre per year). Two areas were used as controls; one adjacent to the experimental plantation and the other several miles away.

A total of 3.7 acres (1.2 percent of the area) was established in food plots on the beef cattle farm. Plant species utilized in food plots were soybeans, browntop millet, and German millet. The average cost incurred during the two year period was $335.99. The average yearly cost per acre planted was $90.32 and the average yearly cost per acre treated was $1.12. A near-by farm of the same land-use management type was used as the control area.

Population densities and food plot utilization were surveyed by several techniques. Call indices were used in the spring of each year to survey all bird populations. Bobwhite quail, mourning doves and cottontails were censused by direct flush count in the spring and fall, and small mammals were surveyed by snap-trapping. Utilization of plant food species was determined by crop analysis of bobwhite quail during the winter months.

The average number of bobwhite males calling on the Stinging Fork area near Spring City during the peak of the breeding season increased by 156 percent from a mean of 9 birds per day in 1972 to 23 birds per day in 1973. This area included the experimental area and Control 1. The number of calling males on the Bumbee area (Control 2) increased by 100 percent from a mean of 3 in 1972 to 6 in 1973. The 1973 fall bobwhite population densities on the Spring City treated area increased by 550 percent from the 1972 fall density. Quail density on this area increased from 1 bird per 11 acres in the fall of 1972 to 1 bird per 1.7 acres in 1973. Quail populations on the adjacent control (Control 1) showed a similar increase of 388 percent from 1 bird per 18 acres (1972) to 1 bird per 4.2 acres (1973).

A decrease of 63 percent in quail density from 1 bird per 3.9 acres in 1972 to 1 bird per 10.7 acres in 1973 was noted on Control 2. The presence of food plots on the experimental area was the only habitat manipulation not common to all areas. Therefore it was concluded that these food plots were responsible for the tremendous increase in quail populations on the clear-cut area. It is believed that the increase in quail population density on Control 1 was due to the wildlife management practices on the adjacent experimental area.

The average number of bobwhite males calling on the Morristown experimental area increased by 26 percent from a mean of 6.9 birds in 1972 to 8.7 birds in 1973. The number of quail calling on the control area decreased by 12 percent from an average of 4.3 calling males in 1972 to 3.8 males during the 1973 breeding season. Fall quail densities decreased over the two-year period by 11 percent on the experimental farm and 63 percent on the control farm. The number of quail on the experimental farm decreased from 1 bird per 5.5 acres in 1972 to one quail per 6.1 acres during 1973. The quail population on the control farm decreased from one bird per 11.7 acres in 1972 to one quail per 31.8 acres in the fall of 1973. The presence of food plots is believed to be responsible for the higher quail density sustained on the experimental area (compared with the control) during the two years of this research.

Analysis of 14 bobwhite quail crops collected on the Spring City experimental area found kobe lespedeza (74.0 percent of total volume)

to be the most important food source for this species during the winter of 1972-1973. Kobe lespedeza was followed in importance by Korean lespedeza (19.2 percent), common ragweed (4.5 percent), milk pea (1.1 percent), and Aster spp. (1.1 percent). Crop analysis from 8 quail collected during the winter of 1973, however, indicated that soybeans (45.3 percent) was the most important plant food species during that year. Crops examined from 4 quail collected on Control 2 show that L. repens (46.2%) was the most commonly eaten food, followed by wild sensitive plant (25.6%), Aster spp. (12.8%) and an unknown species (10.3%). The preceding data suggest the importance of lespedezas and soybeans utilized in food plots on the experimental area to the bobwhite winter diet. The fact that bicolor lespedeza and clover seeds were available in large quantities but not eaten to a large extent by quail, indicates the importance of seed preference for influencing quail dieting patterns.

Soybeans was the most important food source for bobwhites on the Morristown experimental farm. Examination of 20 quail crops during the winter of 1972-1973 found soybeans to comprise 79.1 percent of the total volume of seeds eaten. Forestiera spp. was the next most common (14.0 percent) followed by Korean lespedeza (4.0 percent) and Euonymus atropurpureus (1.3 percent). Soybeans (95.2 percent) was also the most important food source found in three quail collected during the 1973-1974 season. No quail were collected on the control farm. These data indicate the importance of soybeans to bobwhite populations. The absence of millets in quail crops collected suggest

these plants species are not important in the diet of quail during the winter months. However, it is believed that millets may be an important food source for quail during late summer and early fall.

Results of the mourning dove surveys on the Spring City areas failed to show a significant response to the wildlife management practices utilized in this study. The 1973 spring call census revealed an increase in the number of cooing males on both the experimental and control areas. However, the 1973 fall flush census found a 99 percent decrease in the number of doves on the experimental area compared to the previous fall. A 97 percent decrease in dove density was noted on Control 1 and the population declined to zero on Control 2. The decrease in dove densities on these research areas indicates the importance to doves of vegetation in early stages of succession.

The failure of dove populations to increase significantly on the Morristown experimental area suggested that food plots used in this study had no effect on dove density. Mourning doves were known to utilize the millet portion of food plots to some extent during the late summer and early fall months when millet seed was available. It is believed that the food plots were too small to supply these seeds in sufficent quantities to increase dove populations.

Data collected at the Spring City areas are insufficient to show trends in ruffed grouse population densities; however, food plots probably did not affect grouse populations significantly. The large areas cleared during pine planting operations may in fact limit grouse populations during the first few years of reforestation. Grouse were not found on the Morristown study areas.

Food plots failed to increase cottontail rabbit populations on either the pine plantation or farm areas. The number of cottontails flushed on the Spring City areas increased slightly during the 1973 fall flush census. Cottontail populations on these areas are believed to be closely associated with the development of vegetational succession on clear-cut areas. The number of cottontails flushed on the Morristown experimental farm remained constant during this research period, whereas, rabbit populations on the control farm decreased. This decrease was attributed to the less desirable vegetative cover found on the control farm when compared to the experimental area.

Call indices taken during the peak of the breeding season found 36 species of birds on the Spring City experimental area and Control 1 during 1972. This number increased to 39 species in 1973. Twenty-one bird species were found on Control 2 in 1972 and 29 species during the 1973 census. The mean number of individuals observed per day increased from 47.4 (1972) to 96.6 (1973) on the experimental area (including Control 1). An increase from 26.4 (1972) to 43.9 (1973) was noted on the Bumbee Creek area. Bird species having the most significant increase in the average number of individuals observed per day included field sparrows, indigo buntings, prairie warblers, grackles, yellow-breasted chats, horned larks, American goldfinches, starlings, rufous-sided towhees, and yellowthroats. Insufficient data preclude evaluating the effect of food plots on songbird populations. It is believed, however, that food plots did not affect these populations, at least

during the first two years of this research. The increases in the number of species and the number of individuals probably resulted from the advancement of vegetative succession.

Songbird surveys on the Morristown experimental area yielded 46 species in 1972 and 47 species during 1973. The daily average of the number of individuals observed during the two years was 157.6 and 155.3 respectively. Thirty-six species were common to each year. Birds found on the control farm included 30 species in 1972 and 41 species in 1973. Twenty-five species were common to both years surveyed. The daily average of individuals was 74.6 during 1972 and 61.6 in 1973. The changes in the type species present, the number of species, and the number of individuals of each species were believed to be random fluctuations. The data indicated that food plots had no significant effect on songbird populations at least during the first two years.

A total of 1800 trap nights on the Spring City research area resulted in the capture of 60 small mammals. Thirty-six of these individuals were captured on the experimental area and 24 on Control 1. House mice, white-footed mice, hispid-cotton rats, eastern harvest mice, and least shrews were the only species captured. Species composition and relative abundance changed over time, probably influenced by succession of the vegetation rather than the presence of food plots.

Local distribution of small mammals on the Morristown research area was clearly influenced by food plots. A total of 1620 trap-nights yielded 209 captures. Examination of data showed a significant

difference in mammal densities in food plots (line 1) compared to trap lines located five meters (line 2) and fifteen meters (line 3) from the boundaries of these areas. One hundred and twenty individuals were captured within food plots, 49 individuals on line 2, and 40 on line 3. House mice, comprising 83.3 percent of all species captured, were the most numerous species found on food plots. White-footed mice (13.3%) were the second most numerous followed by least shrews (1.7%) and cottonrats (1.7%). The importance of food plots on pastures for house mice and white-footed mice is clearly demonstrated by the preceding data.

Cost-return analysis for bobwhite quail on the Spring City experimental area was $3.45 per bird. This seems to be a reasonable expense when consideration is given to the public relations benefits received by the owners of the pine plantation. Cost-return data on the Morristown area was $12.46 per quail (including the loss of land for livestock production). The landowner must consider objective priorities in order to justify the expense and returns realized by this wildlife management program. Continuing research on these areas is necessary in order to analyze more accurately cost-return benefits. Insufficient data coupled with physical traits not conducive to cost-return analysis prevented these parameters from being applied to other wildlife species.

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LITERATURE CITED

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APPENDICES

APPENDIX A

TABLE XX

GAME FOOD PLANTING RECORD ON THE STINGING FORK EXPERIMENTAL AREA, 1972[a]

Plot No.	Species[b]	Mixture (lbs.)	Dimensions (feet)	Acres	Date Planted	Fertilizer (Lbs./acre)
1	Mix A	22.5	30x2,600	1.79	4-13-72	250 0-25-25
2	Mix A	22.5	30x1,300	0.90	4-13-72	125 0-25-25
3	Mix A	22.5	30x4,800	3.31	4-13-72	125 0-25-25
4	Mix A	22.5	30x11,400	7.85	4-13-72	85 0-25-25
			Total	13.85		
5	Mix B	150	30x500	0.34	7-11-72	300 16-16-16
6	Mix C	150	15x300	0.10	7-12-72	300 16-16-16
7	Mix C&D	150	30x400	0.28	7-11-72	600 16-16-16
8	Mix C	150	30x300	0.21	7-12-72	300 16-16-16
9	Mix D	155	30x2,700	1.86	7-11-72	300 16-16-16
10	Mix C	150	30x1,300	0.90	7-12-72	300 16-16-16
11	Mix D	155	15x15	0.02	7-11-72	300 16-16-16
			Total	3.71		
12	Mix E	216	7x3,500	0.56	4-11-72	200 0-25-25
13	Mix E	216	7x4,800	0.77	4-11-72	200 0-25-25
			Total	1.33		

[a]Data from progress report submitted to the University of Tennessee Forestry Department by Hiwassee Land Company.

[b]Mixtures of species planted are presented in Table XXI, page 104.

TABLE XXI

MIXTURE COMPOSITION OF PLANT FOOD SPECIES PRESENTED IN TABLE XX

Mix A - -	Korean Lespedeza (10 lbs.) Kobe Lespedeza (10 lbs.) White Dutch Clover (½ lb.) Red Clover (2 lbs.)
Mix B - -	Lee Soybeans (85 lbs.) Dare Soybeans (35 lbs.) Hood Soybeans (30 lbs.) Molybdenum added
Mix C - -	Lee Soybeans (150 lbs.) Innocculant and Molybdenum added
Mix D - -	Lee Soybeans (45 lbs.) Dare Soybeans (60 lbs.) Hood Soybeans (50 lbs.) Molybdenum added
Mix E - -	Lespedeza Bicolor (16 lbs.) 0-25-25 Fertilizer (200 lbs.)

APPENDIX B

TABLE XXII

FOOD ITEMS FROM CROP ANALYSIS OF 13 QUAIL COLLECTED ON THE STINGING FORK EXPERIMENTAL AREA DURING THE 1972-1973 HUNTING SEASON

Food Items Plant Foods	VOLUME Total c c	VOLUME % Rel. Vol.	FREQUENCY Times Occur.	FREQUENCY % Freq. Occur.	FREQUENCY % Rel. Freq.	NUMBER Total No. of Items	NUMBER % Rel. Number
Lespedeza striata	13.1	74.0	11	84.6	29.0	4306	77.8
Lespedeza stipulacea	3.4	19.2	4	30.8	10.5	944	17.1
Ambrosia artemisiifolia	0.8	4.5	3	23.1	7.9	55	1.0
Aster spp.	0.2	1.1	2	15.4	5.3	151	2.7
Galactia regularis	0.2	1.1	2	15.4	5.3	7	.2
Cassia nictitans	trace		1	7.7	2.6	2	.0
Ceanothus americanus	trace		1	7.7	2.6	2	.0
Rhus glabra	trace		1	7.7	2.6	1	.0
Panicum spp.	trace		5	38.5	13.2	32	.6
Andropogon spp.	trace		1	7.7	2.6	1	.0
Viola spp.	trace		2	15.4	5.3	31	.6
Scleria ciliata	trace		1	7.7	2.6	1	.0
Polygonum pennsylvanicum	trace		1	7.7	2.6	1	.0
Green Leafy Material	trace		2	15.4	5.3		
Animal Foods							
Insect Parts	trace		1	7.7	2.6		

TABLE XXIII

FOOD ITEMS FROM CROP ANALYSIS OF EIGHT QUAIL COLLECTED ON THE STINGING FORK EXPERIMENTAL AREA DURING THE 1973-1974 HUNTING SEASON[a]

Plant Foods	Total cc	% Rel. Vol.	Times Occur.	% Freq. Occur.	% Rel. Freq.	Total No. of Items	% Rel. Number
Glycine max	8.7	45.3	2	25.0	3.9	41	1.4
Lespedeza striata	7.7	40.1	6	75.0	11.8	2479	81.7
Ambrosia artemisiifolia	0.6	3.1	2	25.0	3.9	26	0.9
Galactia regularis	0.4	2.1	3	37.5	5.9	19	0.6
Viola spp.	0.3	1.6	3	37.5	5.9	135	4.5
Lespedeza stipulacea	0.3	1.6	1	12.5	2.0	75	2.5
Panicum spp.	0.3	1.6	5	62.5	9.8	116	3.8
Cassia nictitans	0.2	1.0	1	12.5	2.0	49	1.6
Cassia fasciculata	0.2	1.0	1	12.5	2.0	12	0.0
Rhus copallina	0.1	0.5	1	12.5	2.0	6	0.2
Desmodium spp.	0.1	0.5	3	37.5	5.9	35	1.2
Lupinus spp.	0.1	0.5	1	12.5	2.0	2	0.1

TABLE XXIII (continued)

Food Items Plant Foods	Total cc	% Rel. Vol.	Times Occur.	% Freq. Occur.	% Rel. Freq.	Total No. of Items	% Rel. Number
Scleria spp.	trace		2	25.0	3.9	2	0.1
Lespedeza bicolor	trace		3	37.5	5.9	19	0.6
Rhus typhina	trace		1	12.5	2.0	3	0.1
Cassia occidentalis	trace		1	12.5	2.0	1	0.0
Brassica nigra	trace		2	25.0	3.9	6	0.2
Green leafy material	trace		3	37.5	5.9		
Dry vegetative material	trace		2	25.0	3.9		
Unknown #4	trace		2	25.0	3.9	8	0.3
Animal foods							
Formicidae (ants)	0.2	1.0	6	75.0	11.8		

[a]One empty crop.

TABLE XXIV

FOOD ITEMS FROM CROP ANALYSIS OF FOUR QUAIL COLLECTED ON THE BUMBEE CREEK AREA (CONTROL 2) DURING THE 1972-1973 HUNTING SEASON

Food Items Plant Foods	VOLUME Total cc	VOLUME % Rel. Vol.	FREQUENCY Times Occur.	FREQUENCY % Freq. Occur.	FREQUENCY % Rel. Freq.	NUMBER Total No. of Items	NUMBER % Rel. Number
Lespedeza repens	1.8	46.2	3	45.0	9.7	421	32.8
Cassia nictitans	1.0	25.6	4	100.0	12.9	190	14.8
Aster spp.	0.5	12.8	4	100.0	12.9	503	39.2
Unknown #4	0.4	10.3	4	100.0	12.9	94	7.3
Desmodium viridiflorum	0.2	5.1	2	50.0	6.5	49	3.8
Cassia occidentalis	trace		1	25.0	3.2	1	0.1
Galactia regularis	trace		1	25.0	3.2	3	0.2
Lespedeza bicolor	trace		1	25.0	3.2	1	0.1
Rhus copallina	trace		1	25.0	3.2	4	0.3
Panicum spp.	trace		2	50.0	6.5	6	0.5
Verbena spp.	trace		1	25.0	3.2		

TABLE XXIV (continued)

Food Items	VOLUME		FREQUENCY			NUMBER	
	Total cc	% Rel. Vol.	Times Occur.	% Freq. Occur.	% Rel. Freq.	Total No. of Items	% Rel. Number
Ceanothus americanus	trace		1	25.0	3.2	1	0.1
Desmodium spp.	trace		1	25.0	3.2	3	0.2
Unknown #7	trace		1	25.0	3.2	6	0.5
Green leafy material	trace		1	25.0	3.2		
Animal Foods							
Arthropoda (spider)	trace		1	25.0	3.2	1	0.1
Insect parts	trace		2	50.0	3.2		

TABLE XXV

FOOD ITEMS FOUND IN THE QUAIL CROP COLLECTED ON THE STINGING FORK AREA (CONTROL 1) DURING THE 1973-1974 HUNTING SEASON

Food Item	VOLUME		Total No. of Items
	Total cc	% Rel. Vol.	
Plant Foods			
Rhus typhina	0.4	100.00	26
Lespedeza bicolor	trace		3
Viola spp.	trace		2
Panicum spp.	trace		9
Lespedeza repens	trace		5
Cassia nicitans	trace		5
Green leafy material	trace		1
Animal Foods			
Coleoptera (beetle)	trace		1
Insect parts	trace		N/A

TABLE XXVI

FOOD ITEMS FOUND ONLY IN TRACE AMOUNTS FROM CROP ANALYSIS OF TWENTY QUAIL COLLECTED ON THE MORRISTOWN EXPERIMENTAL AREA DURING THE 1972-1973 HUNTING SEASON

Food Items Plant Foods	FREQUENCY			NUMBER	
	Times Occur.	% Freq. Occur.	% Rel. Freq.	Total No. of Items	% Rel. Number
Vitis baileyana	1	5.0	1.4	1	0.0
Geum spp.	1	5.0	1.4	3	0.1
Sida spinosa	4	20.0	5.4	7	0.3
Desmodium spp.	1	5.0	1.4	1	0.0
Festuca spp.	1	5.0	1.4	2	0.1
Amorpha fruticosa	1	5.0	1.4	1	0.0
Papaver dubium	1	5.0	1.4	1	0.0
Juniperus virginiana	2	10.0	2.9	5	0.2
Rhus glabra	2	10.0	2.9	7	0.3
Ranunculus spp.	1	5.0	1.4	2	0.1
Geum canadense	1	5.0	1.4	2	0.1
Polygonum pennsylvanicum	1	5.0	1.4	1	0.0
Ambrosia artemisiifolia	1	5.0	1.4	1	0.0
Sorghum halapense	2	10.0	2.9	5	0.2
Unknown #3	1	5.0	1.4	1	0.0
Dactylis glomerata	2	10.0	2.9	2	0.1
Dry vegetative material	5	25.0	7.1	N/A	N/A
Animal Foods[a]	2	10.0	2.9	N/A	N/A

[a]Coleoptera (Silvanidae), Cydnidae, Lepidoptera (pupa), Nitidulidae (larvae), Gastropoda (snails).

APPENDIX C

TABLE XXVII

A COMPLETE LIST OF SCIENTIFIC AND COMMON NAMES OF BIRDS USED IN THIS THESIS

Ardeidae	
Ardea herodias	Great blue heron
Butorides virescens	Green heron
Nycticorax nyclicorox	Black-crowned night heron
Anatinae	
Aix sponsa	Wood duck
Cathartidae	
Cathartes aura	Turkey vulture
Coragyps atratus	Black vulture
Accipitridae	
Buteo jamaicensis	Red-tailed hawk
Buteo lineatus	Red-shouldered hawk
Falconinae	
Falco sparverius	Sparrow hawk
Tetraonidae	
Bonasa umbellus	Ruffed grouse
Phasianidae	
Colinus virginianus	Bobwhite quail
Charadriidae	
Charadrius vociferus	Killdeer
Scolopacidae	
Capella gallinago	Wilson's snipe
Laridae	
unknown species	Gulls
Columbidae	
Columba livia	Rock dove (domestic pigeon)
Zenaida macroura	Mourning dove
Cuculidae	
Coccyzus americanus	Yellow-billed cuckoo

TABLE XXVII (continued)

Strigidae	
Otus asio	Screech owl
Caprimulgidae	
Caprimulgus vociferus	Whip-poor-will
Chordeiles minor	Nighthawk
Apodidae	
Chaetura pelagica	Chimney swift
Trochilidae	
Archilochus colubris	Ruby-throated hummingbird
Alcedinidae	
Megaceryle alcyon	Belted kingfisher
Picidae	
Colaptes auratus	Yellow-shafted flicker
Dryocopus pileatus	Pileated woodpecker
Centurus carolinus	Red-bellied woodpecker
Dendrocopus pubescens	Downy woodpecker
Tyrannidae	
Tyrannus tyrannus	Eastern kingbird
Myiarchus crinitus	Crested flycatcher
Sayornis phoebe	Eastern phoebe
Contopus virens	Eastern wood pewee
Alaudidae	
Eremophila alpestris	Horned lark
Hirundinidae	
Hirundo rustica	Barn swallow
Progne subis	Purple martin
Corvidae	
Cyanocitta cristata	Blue jay
Corvus brachyrhynchos	Crow
Paridae	
Parus carolinensis	Carolina chickadee
Parus bicolor	Tufted titmouse
Troglodytidae	
Thryothorus ludovicianus	Carolina wren

TABLE XXVII (continued)

Mimidae	
Mimus polyglottos	Mockingbird
Dumetella carolinensis	Catbird
Toxostoma rufum	Brown thrasher
Turdidae	
Turdus migratorius	American robin
Hylocichla mustelina	Wood thrush
Sialis sialis	Eastern bluebird
Sylviidae	
Polioptila caerulea	Blue-gray gnatcatcher
Laniidae	
Lanius ludovicianus	Loggerhead shrike
Sturnidae	
Sturnus vulgaris	Starling
Vireonidae	
Vireo griseus	White-eyed vireo
Vireo olivaceus	Red-eyed vireo
Vireo gilvus	Warbling vireo
Parulidae	
Mniotilta varia	Black and white warbler
Protonotaria citrea	Prothonotary warbler
Helmitheros vermivorus	Worm-eating warbler
Dendroica discolor	Prairie warbler
Seiurus aurocapillus	Ovenbird
Oporornis formosus	Kentucky warbler
Geothlypis trichas	Yellow throat
Icteria virens	Yellow-breasted chat
Wilsonia citrina	Hooded warbler
Icteridae	
Sturnella magna	Eastern meadowlark
Agelaius phoeniceus	Redwinged blackbird
Quiscalus quiscula	Grackle
Molothrus ater	Brown-headed cowbird
Thraupidae	
Piranga olivacea	Scarlet tanager
Piranga rubra	Summer tanager

TABLE XXVII (continued)

Fringillidae	
Richmondena cardinalis	Cardinal
Guiraca coerulea	Blue grosbeak
Passerina cyanea	Indigo bunting
Spiza americana	Dickcissel
Spinus tristis	American goldfinch
Pipilo erythrophthalmus	Rufous-sided towhee (chewink)
Ammodramus savannarum	Grasshopper sparrow
Spizella pusilla	Field sparrow
Zonotrichia albicollis	White-throated sparrow
Melospiza melodia	Song sparrow

APPENDIX D

TABLE XXVIII

PROJECTED COST OF ESTABLISHING WILDLIFE FOOD PLOTS ON A 500 ACRE CLEAR-CUT INCLUDING THE COST OF MATERIALS, EQUIPMENT USAGE, AND LABOR FOR EACH PLANT FOOD SPECIES[a]

Type of Expense		Costs
I.	5 Acres of Soybeans	
	A. Strip width - 30 feet	
	B. Strip length - 7,260 feet	
	C. Cost:	
	Materials	
	10 bushels Soybeans @ $6.00/bu.	$60.00
	1,000 lbs. Fertilizer @ $85/ton	42.50
	1 5-acre-size bag of Innocculant & Molybdenum	5.00
	Sub-Total	$107.50
	Equipment Usage	
	(Single disk) Diesel Farm Tractor @ $4/hr.	$10.00
	(Sow seed) Diesel Farm Tractor @ $4/hr.	5.00
	(Spread fertilizer) Diesel Farm Tractor @ $4/hr.	5.00
	(Cover seed) Diesel Farm Tractor @ $4/hr.	10.00
	Sub-Total	$30.00
	Labor	
	8 Hrs. for Tractor Operator @ $2.67/hr.	$21.36
	Fringe benefits for Operator @ 25%	5.34
	Sub-Total	$26.70
	Total Planting Costs	$164.20
	Cost Per Acre	$32.84

TABLE XXVIII (continued)

Type of Expense		Costs
II. 25 Acres of Lespedeza-Clover Mixture		
A. Strip width - 30 feet		
B. Strip length - 36,300 feet		
C. Costs:		
Materials		
250 lbs. Kobe Lespedeza @ 26 cents/lb.		$65.00
250 lbs. Korean Lespedeza @ 21 cents/lb.		52.50
12.5 lbs. White Dutch Clover @ 60 cents/lb.		7.50
50 lbs. Red Clover @ 40 cents/lb.		20.00
2500 lbs. Fertilizer @ $85/ton		106.25
	Sub-Total	$251.25
Equipment Usage		
(Spread fertilizer) Diesel Farm Tractor @ $4/hr.		$16.00
(Sow seed) Diesel Farm Tractor @ $4/hr.		8.00
	Sub-Total	$24.00
Labor		
6 Hrs. for tractor Operator @ $2.67/hr.		$16.02
Fringe benefits for Operator @ 25%		4.01
	Sub-Total	$20.03
	Total Planting Costs	$295.28
	Cost Per Acre	$11.81
III. 5 Acres of Shrub Lespedeza		
A. Strip width - 7 feet		
B. Strip length - 31,114 feet		
C. Cost:		
Materials		
50 lbs. Lespedeza bi-color @ $1.50/lb.		$75.00
750 lbs. Fertilizer @ $85/ton		32.00
	Sub-Total	$107.00

TABLE XXVIII (continued)

Type of Expense	Costs
Equipment Usage	
(Single disk) Diesel Farm Tractor @ $4/hr.	$12.00
Sub-Total	$12.00
Labor	
3 Hrs. for tractor Operator @ $2.67/hr.	$8.00
3 Hrs. for laborer seeding Lespedeza @ $2.67/hr.	8.00
Fringe benefits for above @ 25%	4.00
Sub-Total	$20.00
Total Planting Costs	$139.00
Cost Per Acre	$27.80

IV. 1 Acre of Autumn Olive Plantings in Small Patches

A. Plot size - approximately 1/16 of an acre
B. Costs:

Materials	
200 Autumn Olive plants @ $10/1,000	$2.00
Sub-Total	$2.00
Labor	
6 Hrs. for laborer @ $2.67/hr.	$16.02
Fringe benefits for laborer @ 25%	4.01
Sub-Total	$20.03
Total Planting Cost	$22.03
Cost Per Acre	$22.03

TABLE XXVIII (continued)

Type of Expense		Costs
V. Additional Expenses		
4 Hrs. Operators' & Laborers' overtime (2 days)		$16.02
Operators' & Laborers' expenses (2 days)		30.00
Cost of move (average per block)		25.00
	Total Cost	$71.02
	Cost Per Acre	$1.97
VI. Summary of Planting Costs		
A. Actual cost per acre:		
Soybeans		$34.81
Lespedeza-Clover Mixture		$13.78
Shrub Lespedeza		$29.77
Autumn Olive		$24.00
B. Total cost for a 500-acre area:		
5 acres Soybeans @ $34.81/acre		$174.05
25 acres Lespedeza-Clover @ $13.78/acre		345.25
5 acres Shrub Lespedeza @ $29.77/acre		148.85
1 acre Autumn Olive @ $24.00/acre		24.00
	Total Cost	$692.15
	Total Acres Planted	36
	Average Cost Per Acre Planted	$19.22
	Average Cost Per Acre for Area Treated	$1.37

[a]Cost data from a progress report submitted to the University of Tennessee Forestry Department by Hiwassee Land Company.

TABLE XXIX

COST OF ESTABLISHING FOOD PLOTS ON THE MORRISTOWN EXPERIMENTAL AREA DURING 1972

Type Expense	Quanities Used	Cost
Diesel farm tractor[a]		
a. Fuel @ $0.19/gal.	96.8 gal.	$ 18.39
b. Tractor cost/hr. @ $2.88	40 hrs.	115.20
	Sub-Total	$133.59
Labor		
a. Tractor operator @ $1.65/hr.	40 hrs.	$66.00
b. Miscellaneous labor @ $1.65/hr.	25 hrs.	41.25
c. Repair labor @ $1.65/hr.	10 hrs.	16.50
	Sub-Total	$123.75
Equipment repair cost (parts)		$13.09
	Sub-Total	$13.09
Seed and fertilizer		
a. Lee soybeans @ $4.80/bu.	1.86 bu.	$8.93
b. Browntop millet @ $0.18	23 lb.	4.25
c. German millet @ $0.20/lb.	23 lb.	4.82
d. Fertilizer (6-12-12) @ $57.50/ton	562.5 lb.	16.17
	Sub-Total	$34.17
Fencing cost		
a. Materials @ $0.11/ft.	720 ft.	$79.20
b. Labor @ $1.65/hr.	14 hrs.	23.10
	Sub-Total	$102.30
	Total Planting Cost	$406.90

[a]Average fuel consumption for 2020 John Deere diesel is 2.42 gallons per hour (University of Nebraska Agriculture Experiment Station, 1966). Cost per hour with tractor use of 400 hours per year and a three year old tractor (Bowers, 1970).

TABLE XXX

COST OF ESTABLISHING FOOD PLOTS ON THE MORRISTOWN EXPERIMENTAL AREA DURING 1973

Type Expense	Quanities Used	Cost
Diesel farm tractor[a]		
a. Fuel @ $0.30/gal.	71.4 gal.	$21.42
b. Tractor cost/hr. @ $2.88	29.5 hrs.	84.96
	Sub-Total	$106.38
Labor		
a. Tractor operator @ $1.80/hr.	29.5 hrs.	$53.10
b. Miscellaneous labor @ $1.80/hr.	18 hrs.	32.40
	Sub-Total	$85.50
Seed and fertilizer		
a. Lee soybeans @ $10.50/bu.	3.75 bu.	$39.38
b. Browntop millet @ $0.20/lb.	19 lb.	3.80
c. German millet @ $0.22/lb.	19 lb.	4.18
d. Buckwheat @ $10.00/bu.	1 bu.	10.00
e. Fertilizer (6-12-12) @ $57.50/ton	550 lb.	15.81
	Sub-Total	$73.17
	Total Planting Cost	$265.05

[a]Average fuel consumption for 2020 John Deere diesel is 2.42 gallons per hour (University of Nebraska Agriculture Experiment Station, 1966). Cost per hour with tractor use of 400 hours per year and a three year old tractor (Bowers, 1970).

VITA

Lowell Wayne Brown, son of Mr. and Mrs. Arnold Brown was born in Chuckey, Tennessee, on June 7, 1946. He attended elementary school in Chuckey and was graduated from Chuckey-Doak High School in 1964. The following September he entered the University of Tennessee majoring in Animal Husbandry. In August, 1968, he entered the U. S. Army and served two years active duty including a tour in Viet Nam with the 25th Infantry Division. He was honorably released in June, 1970. He returned to the University of Tennessee and received the degree of Bachelor of Science in Agriculture in June, 1971.

In September, 1971, he began graduate study in the school of Ecology, The University of Tennessee, with emphasis in wildlife management. In June, 1972, he accepted a Graduate Research Assistantship in the Department of Forestry, The University of Tennessee, sponsored by the Tennessee Game and Fish Commission. He received the Master of Science Degree in Ecology in June, 1974. He is a member of Xi Sigma Pi, national forestry honorary. He is married to the former Virginia Rhea Cargile of Jamestown, Tennessee.