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PROCEEDINGS

of the

# FOURTH NATIONAL WILD TURKEY SYMPOSIUM

March 2-5, 1980

Little Rock, Arkansas

Edited by

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University of Arkansas at Monticello

# Fourth National Wild Turkey Symposium

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ARKANSAS GAME AND FISH COMMISSION

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# FOREWORD

The Fourth National Wild Turkey Symposium was held in the Hilton Inn in Little Rock, Arkansas, March 2-5, 1980. The Symposium was organized and hosted by the Arkansas Chapter of The Wildlife Society. The Arkansas Game and Fish Commission assisted with the Symposium by sponsoring a tour of wild turkey habitat in Arkansas and by hosting a fish fry for symposium participants. The proceedings of the Symposium were published under a grant from the National Wild Turkey Federation.

The Symposium represents a continuing effort to consolidate the latest research findings and management practices on wild turkey. The first symposium was held in 1959 in Memphis, Tennessee, as the result of the desire of the Forest Game Committee of the Southeastern Section of The Wildlife Society to provide a forum for researchers, managers and private enthusiasts to discuss the current state-of-the-art in wild turkey management. New research projects and management experiences led to the convening of the second symposium in Columbia, Missouri, in 1970 and the third symposium in San Antonio, Texas, in 1975. Proceedings of the first symposium are now out of print, but proceedings for the second or third symposia can be obtained from the University of Missouri Press, Columbia, Missouri 65201 (2nd); or the Texas Parks and Wildlife Department, Austin, Texas 78744 (3rd).

The Fourth National Wild Turkey Symposium was made possible through the fine efforts of many individuals.

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I would especially like to acknowledge the assistance of Carlton Gwen in all aspects of the Symposium; and the professional expertise provided by June Clark of the Advance Printing Co. To all of these people, I offer my sincere thanks.

James M. Sweeney
James M. Sweeney
Symposium Chairman

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# THE WILD TURKEY STATUS AND OUTLOOK IN 1979

R. W. BAILEY, North Carolina Wildlife Resources Commission, Milton, N.C. 27305

Abstract: The wild turkey population in the United States and Canada now numbers about 1,845,000, a nearly 400% increase in the past 2 decades. The harvest rose from 66,400 in 1958 to 222,800 in 1978. The wild turkey occurs in 47 states and 1 Canadian province. It has been re-established in 15 states and introduced into 11 states and 1 province. Habitat availability is the principal factor that will limit future populations.

Papers on the status of the wild turkey were presented at the 3 previous turkey symposiums (Mosby 1958, 1973, 1975). The monitoring of turkey population trends is necessary in evaluating management programs and in directing management and research efforts to preserve the bird or increase its numbers. Hence, the objectives of this study were to determine the current national trend and to define existing or emerging problems. The data herein were obtained by a questionnaire sent to the central office of each state's wildlife agency or to one of the agency's turkey biologists. The difficulties in estimating turkey populations are well known and I shall not comment upon them. Harvest data are probably more indicative of trend than population estimates. In this study the two were generally in agreement.

This paper was a contribution from Federal Aid In Wildlife Restoration Project, North Carolina W-57.

## THE EASTERN WILD TURKEY

The eastern wild turkey *(Meleagris gallopavo silvestris)* has been re-established or introduced into 16 states since the 1940's and now occurs in 34 states (Figs. 1 and 2). The 1979 population was estimated at 1,200,000 in comparison to 239,000 in 1958 (Table 1). The harvest rose from 25,000 in 1958 to 172,000 in the combined 1978 fall and 1979 spring seasons (Table 2). Alabama, Michigan, Missouri, and Ohio reported their populations at, or near, peak. Twenty-nine states estimated their total population potential at 1.7 million, about 0.5 million higher than at present.

The reported 1978-79 harvest was about 12% of the population. Twenty-one states did not have a fall season; 6 of them did not allow any hunting (Table 2). Of the 3 states with populations estimated at 200,000 or more, Alabama and Mississippi do not permit either-sex hunting. Other than preserving habitat and restoring populations, the absence of either-sex seasons in those states is regarded as the greatest eastern turkey management problem. Failure to harvest a reasonable number of hens from a population that large is failure to utilize to a desirable degree a resource that is annually renewed.

The potential, unoccupied eastern wild turkey habitat is estimated at 50,000-100,000 km2. Kentucky, Louisiana, New York, and Texas have the greatest potential, totaling 38,400 km2 (Table 1). The recent, though belated, success of Kentucky and Texas in obtaining wild-trapped stock from sister states will surely expedite their restoration programs.

## THE FLORIDA WILD TURKEY

For the purpose of this discussion, turkeys in the state of Florida are regarded as the Florida wild turkey *(M. g. osceola)*. The 1979 population was estimated to be 80,000 (Table 1), an increase of 300% since the 1940's (Mosby 1959:6), but 20% below the 100,000 in 1970

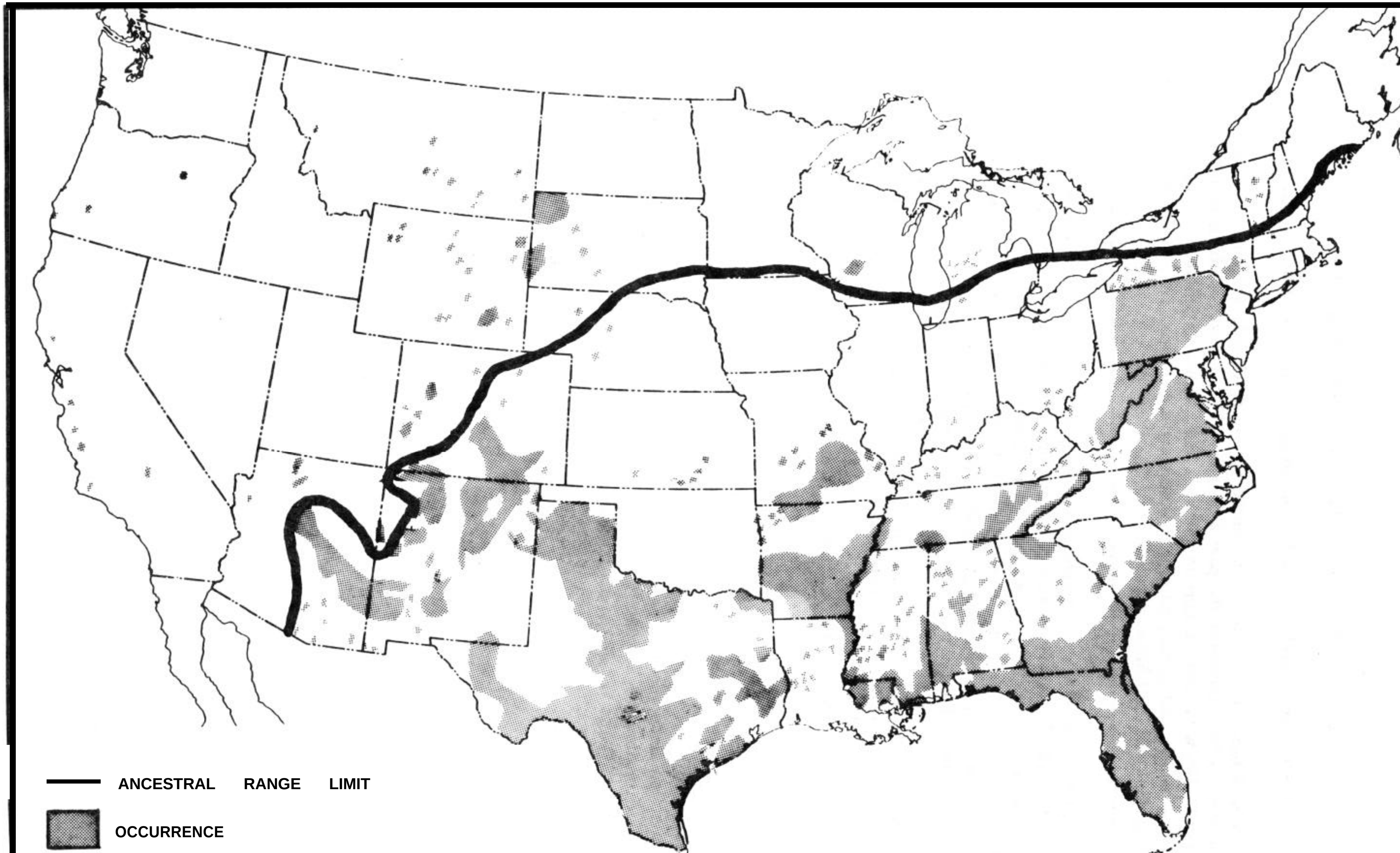
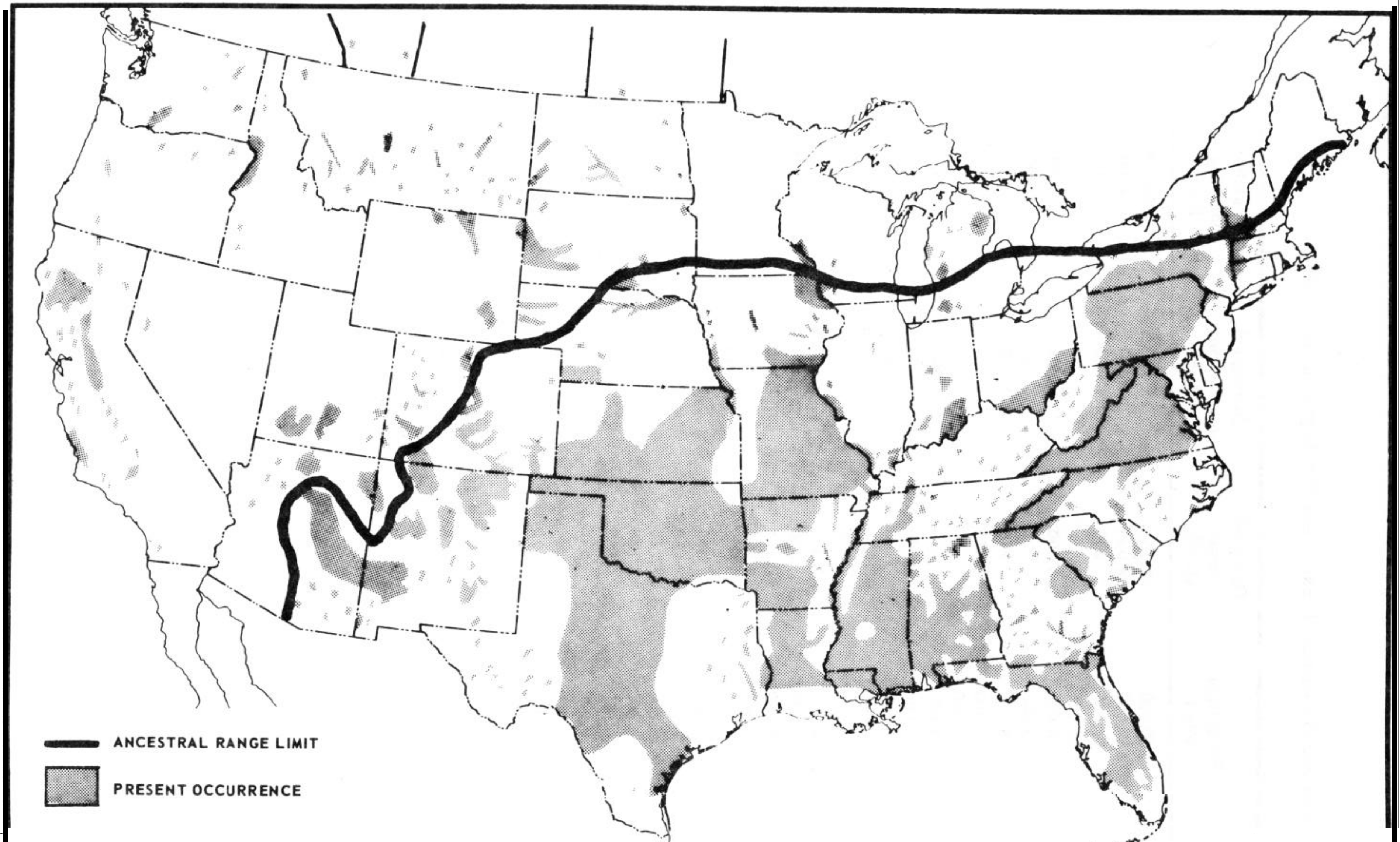



FIG. 1. STATUS OF WILD TURKEY, 1959 (MOSbY 1959)




THE TURKEY ALSO OCCURS ON THE HAWAIIAN ISLANDS OF HAWAII, LANAI, MAUI, AND MOLOKAI.

FIG. 2. STATUS OF WILD TURKEY, 1979

Table 1. Status and estimated potential of eastern and Florida wild turkeys, 1979.

| State | Population (No.) | Occupied range ($Km^2$) | Unoccupied potential range ($Km^2$) | Population potential (No.) |
|---|---|---|---|---|
| Alabama | 250,000 | 83,000 | 780 | 250,000 |
| Arkansas | 150,000 | 65,000 | 9,700 | 200,000 |
| Connecticut[a] | 1,000 | 13,000 | 6,800 | 7,000 |
| Florida | 80,000 | | 0 | |
| Georgia | 23,000 | 20,800 | 13,000 | 40,000 |
| Illinois[a] | 4,000 | 1,200 | 2,600 | 10,000 |
| Indiana[a] | 5,000 | 5,200 | 9,000 | 10,000 |
| Iowa[a] | 20,000 | 2,900 | 4,400 | 30,000 |
| Kansas[a] | 300? | 23,000? | 50,000? | 5,000? |
| Kentucky | 3,000 | 2,600 | 21,000 | 50,000 |
| Louisiana | 16,000 | 21,800 | 21,000 | 50,000 |
| Maine[a] | 125 | 100 | 500 | 500 |
| Maryland | 2,000 | 3,000 | 1,600 | |
| Massachusetts[a] | 1,200 | 2,800 | 9,000 | |
| Michigan[a] | 9,000 | 13,000 | 2,600 | 10,000 |
| Minnesota[a] | 2,700[b] | 1,300 | 2,500 | 8,000 |
| Mississippi | 200,000 | 67,300 | 1,300 | 250,000 |
| Missouri | 200,000 | 52,000 | 6,000 | 200,000 |
| Nebraska[a] | 15 | 26 | 150 | 50 |
| New Hampshire[a] | 1,000 | 2,600 | 12,000 | 7,000 |
| New Jersey | 400 | 470 | 5,200 | 5,000 |
| New York[a] | 25,000 | 52,000 | 69,000 | 50,000 |
| North Carolina | 6,000 | 14,200 | 52,000 | 12,000 |
| North Dakota[a] | 3,000 | 1,000 | 100 | 3,500 |
| Ohio[a] | 6,000 | 4,100 | 1,000 | 7,500 |
| Oklahoma[a] | 2,000 | 2,900? | | |
| Oregon[a] | 200 | 80 | 400 | 1,000 |
| Pennsylvania | 100,000 | 39,000[c] | 12,900 | 120,000 |
| Rhode Island | 0 | 0 | 1,000 | |
| South Carolina | 20,000 | 16,000 | 10,000 | 35,000 |
| Tennessee | 8,400 | 5,500 | 15,600 | 24,000 |
| Texas | 5,000 | 2,580 | 200,000 | 80,000 |
| Vermont[a] | 8,000 | 7,800 | 3,800 | 12,000 |
| Virginia | 65,000 | 46,000 | 4,800 | 100,000 |
| West Virginia | 25,000 | 26,000 | 13,000 | 45,000 |
| Wisconsin[a] | 400 | 325 | 7,800 | 15,000 |
| Totals (rounded) | 1,243,000 | 600,000 | 571,000 | 1,700,000 |

[a]Re-established or introduced the turkey in the last three decades.

[b]Includes an eastern-Merriam's hybrid.

[c]Includes woodlands only.

Table 2. Harvest trend, eastern and Florida wild turkey.

| State | 1958[a] | 1968[b] | 1978-79[c] |
|---|---|---|---|
| Alabama | 5,122 | 39,978 | 43,000 |
| Arkansas | 461 | 1,129 | 6,800 |
| Florida | 17,000 | 20,000 | 23,000 |
| Georgia | 5,000 | 3,000 | 3,000 |
| Illinois | | | 119 |
| Indiana | | | 48 |
| Iowa | | | 650 |
| Kentucky | | 17 | 50 |
| Louisiana | 80 | 350 | 1,200 |
| Maryland | 511 | 300 | 175 |
| Michigan | | 135 | 627 |
| Minnesota | | | 116 |
| Mississippi | 974 | 3,764 | 20,800 |
| Missouri | | 1,270 | 18,223 |
| Oklahoma | | | _[d] |
| New York | | 1,050 | 2,462 |
| North Carolina | 3,294 | 220 | 208 |
| North Dakota | | | 236 |
| Ohio | | 13 | 265 |
| Pennsylvania | 16,156 | 17,300 | 34,300 |
| South Carolina | 3,000 | 3,100 | 1,600 |
| Tennessee | 77 | 214 | 295 |
| Vermont | | | 882 |
| Virginia | 2,060 | 4,707 | 9,735 |
| West Virginia | 1,173 | 1,700 | 3,676 |
| Totals | 54,908 | 98,254 | 171,576 |

[a]Mosby, 1959:6.
[b]Mosby, 1973:72.
[c]Harvest from fall 1978 and spring 1979.
[d]See footnote "d," Table 4.

(Williams 1978:33). The population peaked in 1964, decreased considerably in 1965, had recovered by 1967, but slowly leveled off due to loss of habitat. Williams considered the population to be in “slow, downward, unmeasured decline” because of continuing loss of habitat. Earlier, Powell (1965:27) had expressed concern over loss of habitat.

Powell (1965:24) reported a nearly continuous increase in the turkey harvest from 1950 to 1964. The harvest of 23,000 in 1978-79, nearly 30% of the estimated population, appears to be one of the highest in the nation, possibly exceeded only by Pennsylvania (Tables 1 and 2). Biologists in both Florida and Pennsylvania have expressed concern over excessive fall either-sex harvests, at least in some areas (Williams, Austin, and Peoples, 1978; Wunz, 1978).

In summary, the Florida turkey appears to be on a downward trend, with little likelihood of a reversal.

## THE RIO GRANDE WILD TURKEY

The Rio Grande wild turkey *(M. g. intermedia)* originally occurred in Kansas, Oklahoma, Texas, and a small corner of southeast New Mexico (Schorger 1966:43). It is now present in 6 additional states. The reported population exceeds 400,000 and is still climbing (Table 3). California, Kansas. and Hawaii apparently have the greatest possibility for further increase of this race which thrives only in areas with 50-80 cm of rainfall annually.

Table 3. Status and estimated potential of Rio Grande wild turkey, 1979.

| State | Population (No.) | Occupied range ($Km^2$) | Unoccupied potential range ($Km^2$) | Population potential (No.) |
|---|---|---|---|---|
| California[a] | 24,000[b] | 33,700 | 13,000 | 40,000 |
| Hawaii[a] | 1,000 | 233,000 | 155,000 | 5,000 |
| Kansas | 6,000 | 30,000? | 60,000? | 15,000? |
| Nebraska[a] | 200 | | | |
| New Mexico | 200 | | | |
| North Dakota[a] | 1,000 | 650 | 260 | 1,500 |
| Oklahoma | 37,000 | | | |
| Oregon[a] | 125 | 26 | | |
| South Dakota[a] | 500 | 650 | 1,500 | 1,500 |
| Texas | 350,000 | 345,000 | 65,000 | 500,000 |
| Totals (rounded) | 420,000 | 643,000 | . 295,000 | 563,000 |

[a]Introduced the turkey in the last three decades.

[b]Includes the "California hybrid" described by Graves (1975).

The low harvest of 40,000 (10%) is largely due to the low fall-winter harvest of hens in Texas where only bearded hens are legal. Also, Kansas has no fall season (Table 4). The goal in managing Rio Grande turkey should be an annual harvest of about 100,000, nearly 3 times that at present. More important, however, is the preservation of habitat which is undergoing destruction at an alarming rate (Lay 1958:99; Gore 1973:253; De Arment 1975:189-190; Boyd and Oglesby 1975:41.

## MERRIAM'S WILD TURKEY

Fourteen states and the province of Alberta, Canada reported a total of 85,000 Merriam's wild turkey *(M. g. merriami)* in 1979 (Table 5). According to Schorger (1966:43), this race originally occurred only in Arizona, Colorado, New Mexico, and extreme west Texas. Recent harvests in Montana and Utah, which did not provide a population estimate (Tables 5 and 61, suggest that the continent's population may approach 100,000. Six states and Alberta reported having a total of about 5,600 $km^2$ of unoccupied, potential habitat (Table 51.

Harvest of Merriam's turkey increased nearly 300% from 1958 to 1979 (Table 6).

The future of Merriam's turkey is unpredictable. Populations have become static or are declining in some states where the bird was introduced. The increased need for grazing lands

Table 4. Harvest trend, Rio Grande wild turkey.

| State | 1958[a] | 1968[b] | 1978-79[c] |
|---|---|---|---|
| California | | 50 | 5,000 |
| Hawaii | | | 200 |
| Kansas | | | 100 |
| Nebraska | | | 10 |
| New Mexico | | | |
| North Dakota | | | 131 |
| Oklahoma | | | 8.630[d] |
| Oregon | | | |
| South Dakota | | | 25 |
| Texas | 7,500 | 24,412 | 28,000 |
| Totals | 7,500 | 24,462 | 40,096 |

[a]Mosby, 1959:6.

[b]Mosby, 1973:72.

[c]Harvest from fall 1978 and spring 1979.

[d]Eastern wild turkeys were a small part of the kill.

Table 5. Status and estimated potential of Merriam's wild turkey, 1979.

| State | Population (No.) | Occupied range ($Km^2$) | Unoccupied potential range ($Km^2$) | Population potential (No.) |
|---|---|---|---|---|
| Alberta, Can.[a] | 250 | 520 | 2,600 | |
| Arizona | 18,000 | 25,600 | 0 | 18,000 |
| California[a] | 2,500 | 2,600 | 7,800 | 3,000 |
| Colorado | 11,000 | 17,500 | 2,000 | 15,000 |
| Idaho[a] | 2,500 | 3,600 | 2,600 | 2,000 |
| Montana[a] | | 13,300 | | |
| Nebraska | 9,500[b] | 5,460 | | |
| Nevada[a] | 150 | 312 | 6,500 | 300 |
| New Mexico | 18,000 | | | |
| North Dakota[a] | 1,000 | 390 | 65 | 1,000 |
| Oregon[a] | 2,000 | 5,200 | | |
| South Dakota[a] | 8,200 | 9,100 | 10,000 | 15,000 |
| Texas | 50 | | | |
| Utah[a] | | | | 1,000 |
| Washington[a] | 1,800 | 6,500 | 6,500 | 3,000 |
| Wyoming | 10,000 | | | |
| Totals (rounded) | 85,000 | 89,800 | 38,100 | unknown |

[a]Introduced the turkey in the last three decades.

[b]Includes a Merriam's-game farm hybrid.

Table 6. Harvest trend, Merriam's wild turkey.

| State | 1958[a] | 1968[b] | 1978-79[c] |
|---|---|---|---|
| Alberta, Canada | | | |
| Arizona | 727 | 1,600 | 1,748 |
| California | | | 400 |
| Colorado | 343 | 325 | 913 |
| Idaho | | 9 | 22 |
| Montana | 90 | 400 | 1,390 |
| Nebraska | | | 1,496 |
| New Mexico | 1,800 | 2,192 | 2,476[d] |
| North Dakota | | | 99 |
| Oregon | | 45 | |
| South Dakota | 550 | 1,000 | 818 |
| Texas | | | |
| Utah | | 214 | 8 |
| Washington | | 100 | 105 |
| Wyoming | 393 | | 1,350 |
| Totals | 3,903 | 5,885 | 11,275 |

[a] Mosby, 1959:6.

[b] Mosby, 1973:72.

[c] Harvest from fall 1978 and spring 1979.

[d] 1977 fall and 1978 spring harvest (1978-79 data unavailable).

and the development of coal, forest, and mineral resources is adversely affecting the habitat and the future of the race is cloudy.

## SUMMARY AND DISCUSSION

The greatest expansion of the turkey in the last few decades occurred in the south central, middle, northern, and western portions of the country (Figs. 1 and 2). The eastern coastal plain from Virginia tidewater to Florida appears to be declining in occupancy, no doubt the result of increase in human developments and activities. The future of the Florida and Merriam's turkey is less optimistic than that of the other two races.

The steady increase in harvest since the 1940's would have been much greater were it not for the bias against fall either-sex hunting in a few states with large, well-established populations. Considering that the turkey has held its own, or greatly expanded, in several states that have for years held long fall either-sex seasons, it is obvious that such a season, subject to reasonable controls, should be the principal objective of management in any area with sufficiently large habitat.

Information obtained in preparation of this paper indicates that while the turkey may prosper nationwide for several more years, it will inevitably peak and decline due to the continuing loss of habitat. Overharvesting of hardwoods and their conversion to pine; the removal of forests for housing, industrial, agricultural, and other purposes; in fact, the multitude of demands increasingly exerted upon the land represent trouble for the turkey. However, this great game bird is adaptable and productive. We must initiate intensive studies that will result in better management of various and changing environments, management that will enable the production and harvest of more birds per unit area on a sustained yield basis. If our management efforts are supported by all that can be mustered in human intellect, foresight, and determination, old Meleagris will be around for a long time.

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# BASIC CONSIDERATIONS AND GENERAL RECOMMENDATIONS FOR TRAPPING THE WILD TURKEY

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Abstract: Key individuals engaged in wild turkey (*Meleagris gallopavo*) trapping programs throughout the southeastern United States have cooperated in the preparation of a detailed set of guidelines, techniques, and procedures that will enable inexperienced field personnel to conduct more efficient trapping operations. These procedures address the basic considerations that must be made in order to organize and conduct an effective wild turkey trapping program and minimize the many problems inherent in this type of activity. Included are sections on bait site selection, baiting, pre-trapping operations, use of cannon nets, capture with drugs, transportation, releasing techniques, and public relations. Information contained in this report is based on many years of practical field experience gained by many of the leaders of wild turkey restoration projects.

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Nationwide expansion of wild turkey (*Meleagris gallopavo*) restoration efforts in the last two decades and the refinement of live-trapping techniques have been accompanied by the occurrence of a variety of trapping problems and have drawn attention to the need of a check list of trapping procedures. To accomplish this, Vernon Bevill, 1978 Chairman of the SE Wild Turkey Subcommittee of the Forest Game Committee of the SE Section of the Wildlife Society, requested Subcommittee members to submit a list of guidelines for turkey trapping and subsequently appointed the authors to organize the materials. Thus, all members of the Subcommittee who submitted information or ideas contributed to this paper. The authors are also indebted to many other individuals who have trapped turkeys and helped to perfect present techniques.

The following material relates primarily to the trapping of *M. g. osceola* and *M. g. silvestris*, with considerable applicability to *M. g. merriami* and *M. g. intermedia* when the latter is captured with projectile-thrown nets or drugs. *M. g. intermedia*, however, is normally best captured with drop-nets-as described by Glazener, Jackson and Cox (1964).

## NET CAPTURE CONSIDERATIONS

The recommended procedures are well covered and thoroughly discussed in the papers of Austin (1965), Austin et al. (1972) and Bailey (1950) and serve as the fundamental guide for this type of trapping. A summary of the most important procedures is given in the following sections.

### Bait Site Selection

(l)* As a rule, locate bait sites no closer than 1.6km (1 mile) apart, otherwise, turkeys may visit more than one. However, in some situations more bait-sites will help the turkeys to locate bait faster.

(2)* Do not depend on only a few bait sites. Select as many as can be checked. The number of sites may be as important as knowledge of flocks. One site per 5km$^2$ (approximately 2 square miles) is generally sufficient after turkeys have found one of the sites.

(3) Do not locate bait sites so as to require firing of net up or down steep slopes or from the center of a field.

(4) Do not locate sites near public roads. This increases the possibility of disturbances, poaching, harassment, and equipment loss.

(5) Do not choose an opening smaller than the extended net, including projectiles.

(6) Select a "clear" bait site; if it is cluttered with brush, stumps, limbs, or weeds, clear it.

(7) Choose a site with a suitable place for a blind. The trapper in the blind should be able to look down the length of the net. Never locate blind in front of net.

(8) Do not locate bait sites in a poorly drained area.

(9)* Locate, if possible, where hogs or wild boar (*Sus scrofa*) will not find bait.

(10) Select a site that will prevent a loose projectile from damaging persons or property; consider what may be "down range."

*Applies equally to section on "DRUG CAPTURE CONSIDERATIONS".

Baiting and Pre-Trapping Operations

(1)* Select the best bait for local conditions. Make certain the bait is not treated with pesticides or other toxic chemicals. Small grains are usually best, but in some areas turkeys are more easily attracted by shelled corn. Birds do not always eat all species in mixed grain; hence, corn (whole or cracked kernels) is advisable for drugging. Small particle bait is better because more time is required for the birds to fill their crops. In some areas, small grains scattered on bare ground will attract turkeys but not deer (Odocoileus spp.)

(2) Prepare net camouflage material (grass, leaves, straw, etc.) as it will be when it conceals the net.

(3)* Hay or leaves scattered over small amounts of bait will sometimes attract birds when large, uncovered amounts of grain will not. Covering the bait following each visit by the birds appears to encourage return visits.

(4)* Bait lines can be so long as to prevent turkeys from finding the main site; local conditions should govern the length. Bait lines lightly; a handful of bait per 20-40 meters is usually sufficient.

(5)* Examination of sites between the hours of 1100 and 1500 is usually "safe"; nocturnal checking, when feasible, is best.

(6) After the first visit by turkeys, put bait only between the two end mortars.

(7)* Check sites from a vehicle whenever possible. If birds are on bait, stop the vehicle and remain in it until the birds are well out of the area.

(8)* Do not stay longer than necessary at bait sites and avoid making undue noise.

(9)* Note droppings, feathers, and tracks at bait site to enable estimate of number and flock composition. Remove feathers and step on droppings to assist in determining whether birds return the next day.

(10)* Crow (Corvus brachyrhynchos) activity at bait may often be discouraged by hanging a crow carcass from a limb over the site. Turkeys will seldom react adversely to it. Caution should be used to take crows only in accordance with regulations.

*Applies equally to section on "DRUG CAPTURE CONSIDERATIONS".

(ll)* Do not hold birds on bait too long; normally, they are usually capturable after 2 successive visits.

(12) In the summer and fall "bait shy" turkeys can often be attracted to choice dusting places. The attractiveness of such places is enhanced by daily loosening the soil with a rake or other tool. Gradually arrange the net camouflage materials day by day. This is an ideal way to net turkeys, as they will be normally lying down when the net is fired.

(13)* Do not overbait; too much bait may make attendance irregular and attract nuisance species.

(14) Turkeys attracted to a favorite spot or planting, such as chufa (Cyperus esculentus) plots, can often be trapped by setting a net at a carefully selected place in the field and waiting in a nearby blind. A long wait may be necessary in order to capture several birds. Two or more nets may be set in such a situation and arranged to be fired individually or in unison.

(15)* If site is on lands open to public and any hunting season is open, check areas regularly for unusual traffic. Poaching may be attempted in the vicinity of the site.

Capture Procedures

(1)* Do not use shoddy equipment; good equipment is the cheapest part of the operation.

(2) Do not use old charges; thoroughly test any suspect lot for dampness or deterioration.

(3) Always use shock absorbers on net anchor lines.

(4)** During periods of rain, snow or freezing conditions, the use of the box assembly will eliminate failure of the net. Use it whenever these conditions prevail.

(5) Double check all equipment, especially charges, battery, wires, and connections immediately prior to entering blind for trapping.

(6) Thoroughly clean and properly fold net prior to each placement.

(7) In placing the net, move the two ends of the leading edge of the net approximately 2 meters (6-7 feet) toward the center mortar or rocket.

*Applies equally to section on "DRUG CAPTURE CONSIDERATIONS".
**G. A. WUNZ, Wildlife Biologist, Pennsylvania Game Commission, Post Office Box 1567, Harrisburg, Pa. 17120, personal communication

(8) Keep the net as flat as possible so that it can be easily camouflaged.

(9) Be sure to secure the trailing edge of the net.

(10) Do not forget to attach projectiles to ropes and ropes to the net.

(11) Prior to placement, be sure to oil the inside and outside of mortars or rockets as well as the mortar projectiles. Also make sure projectiles slide freely in mortar barrels.

(12) Camouflage all cables and wires; do not use brightly-colored wires.

(13) Never stand in front of a net, mortar or rocket when loading charges or checking circuit.

(14) Remember to slightly angle the end rockets or mortars outward so that the projectiles will hit perpendicularly to the respective trailing corners of the net.

(15) Make certain the cannon or rockets are angled upward properly. To check, kneel on bait line and sight down top of cannon; the net should clear the turkeys' backs by 40-50 cm (approximately 15-20 inches).

(16) After completing assembly of circuit, test it with a continuity tester; repeat the test before entering the blind for trapping.

(17) Do not check individual charges with a circuit tester because they will fire; test them separately on the complete circuit.

(18)* Do not place the blind closer to the bait than is necessary for an adequate view.

(19)* Do not fail to conceal holding boxes if stored near the trap site.

(20) Do not use a wall-type switch to fire the net. A self-opening switch is satisfactory if the hook-up is not completed until the birds arrive.

(21)* Do not watch the trap site with your face against an opening in the blind.

(22)* Upon completing the trap set-up, determine where to hide the vehicle the next morning.

*Applies equally to section on "DRUG CAPTURE CONSIDERATIONS".

(23)* Unless the trap set-up is completed just before dark, leave a small quantity of grain on the bait site in case birds arrive after you leave.

(24)* Be sure to arrive at the trapping site before the turkeys do, preferably before daylight.

(25) Do not fire the net until all turkey heads are down and no birds are standing on net.

(26) Do not fire a net when it is frozen, wet, or snow covered. It can be protected from the elements by enclosing it in canvas, plastic, etc., or, preferably, by box assembly.

(27) Do not net-trap when the temperature exceeds 21.1°C (approximately 70°F.)

(28) Do not allow any person to trap who has a cold or who cannot control coughing.

Handling Techniques

(1) First remove birds at the edge of the net or those that might escape; thence, remove adults and finally poults. Get under the net to free those badly entangled and in center portion of net. Untangle their feet first and the rest is easier.

(2)* Do not grasp tail feathers along with the feet--the feathers will pull out.

(3)* Keep the birds cool at all times, regardless of the season of the year. Have plenty of holes in the box and keep it in shade or under an air conditioner, if necessary.

(4)* Do not grasp a turkey by one foot or by its wings. Hold legs in one hand at the point where the feathering starts, the other hand should be placed under the bird's breast to support its weight, or it may encircle the bird's body to prevent flopping and struggling. This will allow the bird to be rested on one's hip. Only those pressures should be applied that are necessary to secure the bird.

(5)* Do not put more than one turkey in a box.

(6)* Avoid holding turkeys in a sack for more than an hour or so.

(7)* Put an absorbent pad in each box; change the pads as needed. Wet or soiled pads may be cleaned, dried and reused.

*Applies equally to section on "DRUG CAPTURE CONSIDERATIONS".

(8)* A turkey may be prevented from struggling by holding it by both feet, placing it on its back, and pressing it gently against the ground.

(9)* A hood (*e.g.*, sock, handkerchief) over a turkey's head keeps it calm.

(10)* Birds held more than a day should probably be given water, especially in warm weather. A baby syringe or large medicine dropper for "force feeding" is useful for this purpose.

## DRUG CAPTURE CONSIDERATIONS

The techniques of trapping wild turkeys with drugs are presented in the reports of Bailey (1972), Mosby and Cantner (1956), Williams (1966, 1967), and Williams et al. (1966). Primary considerations for these procedures are outlined in the following sections.

### Bait Site Selection

(1) Select a site with the widest possible field of view.

(2) Do not select a site near water; drugged birds may drown.

(3) Do not select a site where interference by people, hogs, or dogs (*Canis familiaris*) is likely.

(4) Select, where possible, a site near a roost.

(5) If using tribromoethanol, select a site that receives the least sunshine. Alpha chloralose is unaffected by sunlight.

### Baiting-Pretrapping Operations

(1) If you have to "pick up" often, you may wish to use the largest bait locally attractive, normally whole corn. However, cracked corn is generally attractive and causes the birds to remain longer at the bait site and thus more likely to collapse within site. Cracked corn placed in small piles is easy to pick up, but in some areas turkeys shy away from piled bait.

(2) Establish and maintain the bait site as you want it to be when the capture attempt is made.

(3) Attempt to determine the number and sex of visiting birds. If using alpha chloralose, at the 2g./.25 liter (1 cup) dosage, it does not matter because of the inherent wide safety margin, as long as plenty of bait is present.

*Applies equally to section on "DRUG CAPTURE CONSIDERATIONS".

(4) Trap as soon as possible after 2-3 successive days of use; the longer the delay, the more non-target animals will be using the bait and the more likely some complication will occur.

## Capture Procedures

(1) Do not handle tribromoethanol without gloves; some persons are allergic to it.

(2) Carefully consider the tribromoethanol dosage in relation to number, sex, and (in summer) age of visiting turkeys, and accurately measure both drug and bait.

(3) A summary of suggested drug dosages is presented in Table 1.

(4) Lower dosage of tribromoethanol than indicated in Table 1 should be used if drug is pulverized into a fine powder.

(5) If unanticipated birds arrive, such as hens when a dosage for gobblers has been placed, they may be spooked away by barking like a dog (Canis familiaris).

(6) Do not put out less bait than may be consumed by the total number of turkeys that are expected.

(7) The larger the flock, the greater the competition for bait; hence, slightly lower dosages of tribromoethanol may be used.

(8) With tribromoethanol on sunny days, do not trap later than 1000 hours without replacing bait unless it is in heavy shade. Three to four hours of sunlight reduces its potency by 80% on. overcast days, the drug may be potent all day.

(9) With tribromoethanol, do not waste time in the blind during a steady rain. Conditions are usually favorable when the rain ceases; therefore, it is generally advisable to pick up the bait when rain starts and resume operations when weather improves. Alpha chloralose appears to be little affected by rain and probably could be left out during short periods of rain.

(10) Do not rush to get out of the blind if narcotized turkeys go down slowly; narcosis generally lasts at least a few hours. On the other hand, "downed" birds should not be permitted to lie too long, especially in cold weather or in direct sun during hot weather.

(11) Hand net birds even when they are down and seemingly "out."

(12) Come down firmly and swiftly with the hand net; gain control of the bird as quickly as possible.

Table 1. Suggested drug dosages suitable for live trapping wild turkeys.

| Drug | Dosage[a] Summer-Fall Adult Males | Dosage[a] Summer-Fall Others | Dosage[a] Winter Adult Males | Dosage[a] Winter Others | Comments |
|---|---|---|---|---|---|
| Tribromoethanol[b] | 11-12 | 8-9 | 11.5-13 | 9.5-10 | Capture is usually possible 15-40 minutes after feeding begins. One cup takes 2-3 turkeys. |
| Alpha Chloralose[c] | 2 | 2 | 2 | 2 | Capture is usually possible l-2 hours after feeding begins. Place one cup of bait per turkey. |
| Caffeine[d] | Inject into breast muscle of unconscious birds, using 1 cc for adult males, 0.5 cc for all others. Injection may be repeated after 3-4 hours. | | | | |
| Brevital[e] | Inject into breast muscle as per instructions on bottle for mammals. Inject only once. Use to calm birds cannon-netted in warm weather, thus preventing death from overheating or shock. May also be used to calm birds for long journeys. | | | | |

[a]Grams per standard cup of cracked corn. (Tribromoethanol and alpha chloralose dosages)

[b]Dosage should vary with type of bait. A slightly lower dosage for whole corn is recommended, but in North Carolina the listed dosage has been successfully used with both whole and cracked corn. Currently available from Chemical Dynamics Corp., Hadley Industrial Plaza, Hadley Rd., P. 0. Box 395, South Plainfield, New Jersey 07080. Telephone (201) 753-5000.

[c]Available from Fisher Scientific Co., P. 0. Box 829, Norcross, Georgia 30091.

[d]Available at most wholesale drug outlets. (3.75 grains/cc)

[e]Available (Methohexital sodium) from most wholesale drug outlets.

(13) When possible, approach standing, narcotized birds only from the rear.

(14) Note and record the various directions in which narcotized birds go and conduct intensive searches for missing birds.

(15) In trapping broods in summer and fall, hand net the adult hens first. They are less likely to be "down", but are often sufficiently affected to enable capture.

(16) Do not forget that narcosis deepens following exercise such as running or flying; hence, "spooked" narcotized birds may often be followed and captured. Birds may be captured after being flushed several times.

### Handling Techniques

(1) Occasionally a bird is lost to strangulation as a result of bait, especially whole corn, blocking the trachea. Inspection for this difficulty and immediate removal of the obstacle will save birds with blocked tracheas.

(2) For fully narcotized turkeys, inject pure caffeine in sodium benzoate (3.75 grains/cc) into the breast muscle (1.0 cc for adult males, 0.5 cc for others). This appears to prevent mortality in some marginal cases, but will not prevent all mortalities.

(3) If there is doubt that a bird will survive, immediately remove crop contents by surgery and flush the crop with water while holding the birds head down. Thus, if promptly treated, virtually none will die. The skin incision should not overlie the crop incision. The bird can be sewed up many hours later, but it is much easier done while the bird is unconscious. Two sutures are necessary, one for the skin and one for the crop. This technique is especially effective when using alpha chloralose. It should be done only by those properly instructed.

(4) Keep prostrate birds warm; cold feet means that they may be in trouble.

## TRANSPORTATION

(1) Do not stack carrying boxes in closed vehicle.

(2) Keep the birds well ventilated, even on cold days.

(3) Do not hold turkeys in hot weather unless under air conditioning.

(4) Keep narcotized turkeys warm.

(5) Securely seal the boxes; 2" (5 cm) nylon reinforced tape is recommended for this purpose.

## Release

(1) Examine the bird before release for injuries and dirt or feathers in eyes. Pluck broken or badly distorted feathers; they will be replaced in two weeks. Straighten malaligned tail and flight feathers and pluck feathers that might render the bird aerodynamically unstable.

(2) Do not toss a bird into the air. Place it on the ground and release or, if it is in obviously good shape, let it walk out of the box and flee.

(3) Where possible, release birds in large clearing.

(4) Do not release birds near a wire fence.

(5) Do not release drug-captured birds until they are fully recovered.

(6) Do not waste time in releasing turkeys. Have the release site pre-selected and all logistics arranged.

(7) Verify band numbers and other pertinent data before releasing birds.

## General Suggestions

(1) Occasionally on forest roads, turkeys may be 'yelped up' and encouraged to walk by or linger at a net or drug site, allowing a capture. This can be effective in netting males during the mating season, at which time they are little attracted by bait. A passing flock, at any time of the year, may be similarly lured.

(2) Always pick up treated grain if turkeys do not arrive.

(3) Snow provides ideal conditions for drug-capture; the birds can easily be followed.

(4) Loss of "butt-end" leg bands is high. "Lock" type leg bands or monel metal wing tags are rarely lost and are recommended.

(5) Keep perfect band and release records. An error will haunt you for years.

(6) Use special care in handling turkeys with patagial streamers; they are easily torn off.

(7) Follow through on releases; check for mortalities, area usage, etc.

(8) A good fall release is 8-10 males, 18-25 females; a good late winter-spring release is 5-6 males, 12-15 females.

(9) Small hand pumps, available at scientific supply and other sources, are ideal for washing surgically opened crops.

(10) Have a 2nd set of prepared charges or another grain and drug dosage in the blind in case an unanticipated capture is made. More than 1 flock may be using the site.

(11) Provide inexperienced personnel with adequate training before they attempt captures alone. They should assist experienced personnel several times before soloing.

(12) A check list of suggested equipment is presented in Table 2.

Public Relations

(1) Do not hold a public hearing before removing birds from an area. This often results in organized opposition by local self-interests and radicals. Work steadily on educational programs with clubs, civic groups and schools.

(2) Keep the public informed. Press coverage of a release should be encouraged. Information in the press stifles wild rumors. It is usually wise to invite key persons to witness the release.

(3) Do not pass up opportunities to get local hunting clubs or other groups interested in restoration and protection. It is important to stimulate local people or groups who will receive birds. Impress upon them that the birds are theirs and that the people will determine whether or not the turkeys will be successful.

(4) Do not pass up opportunities to stress the need for better habitat management and preservation.

(5) Do not misrepresent the restoration program in any way. You will never outlive an error in this regard.

Table 2. Suggested equipment and supplies check list for turkey trappings.

| Cannon Trapping | Rocket Trapping | Drug Trapping | All Trapping |
|---|---|---|---|
| (1) Bait | (1-12) Same as in cannon trapping | (1) Grain | (1) Blind(s) |
| (2) Bucket(s) | | (2) Bucket(s) | (2) Camouflage cloth |
| (3) Scythe or sickle | | (3) Drug | (3) Bands |
| (4) Axe | | (4) Measuring devices- grain, standard cup, drug, syringe, or shell | (4) Boxes, absorbent pads |
| (5) Fork or rake | | (5) Net(s), long-handled fish nets | (5) Pliers, long-nose |
| (6) Chain saw | | (6) Caffeine | (6) Pliers, banding |
| (7) Battery* or detonator | | (7) Syringe(s), small | (7) Pencil & paper |
| (8) Battery tester | | (8) Surgical kit | (8) Nylon plastic tape |
| (9) Circuit tester | | (9) Small pump | (9) Insect repellent |
| (10) Net | | (10) Jug of water | (10) Heater |
| (11) Detonating wire | | | (11) Camera |
| (12) Electrical tape | | | (12) Brevital |
| (13) 3 mortars | (13) 3 rockets | | (13) Turkey caller |
| (14) 3 projectiles | (14) 6 Good charges | | (14) Scales |
| (15) 6 charges, factory or hand-made<br>Ingredients for hand-made:<br>a. FFg powder<br>b. Squibbs<br>c. Toy baloons<br>d. Rubber bands<br>e. Measuring device (cut-off shot shell) | (15) 3 Rocket launchers | | (15) Hoods |
| | | | (16) Tape or ruler (mm) |
| | | | (17) Flashlight |
| | | | (18) Hand lantern |
| | | | (19) Walkie Talkie |
| | | | (20) Large, sturdy tool box for transporting all small equipment items |
| | | | (21) Chair(s) |

*Batteries last much longer if stored in deep freeze when not in use.

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# FIFTEEN YEARS OF WILD TURKEY TRAPPING, BANDING, AND RECOVERY DATA IN MISSOURI

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Abstract: A trapping, banding, and recovery study of Eastern wild turkeys (*Meleagris gallopavo silvestris*) was conducted from 1965 through 1979 in Missouri's northern Ozarks. Spring hunting of gobblers provided recovery data for 102 known-age, banded birds. Recovery rates were 12.3% for subadults the first season following banding; and 16.6% for adults the second year. Harvests averaged 0.4 gobbler per km$^2$ for the 15 year period, and represented 10.6% of the average winter population. Age-ratio data from 845 captures and recaptures, pooled for all years, suggested an average annual mortality of 52.4%. Calculation of mortality rates, using the composite dynamic method, was not possible because during 3 years of this study no individuals from the adult gobbler and adult hen segment of the population were captured.

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Wild turkeys were nearly extirpated from Missouri by the early 1950's. Today, huntable populations occur across much of the original range. This dramatic recovery can be attributed to a 30-year program of trapping and relocation, improved habitat conditions, and a change in public attitude that enhanced game law enforcement.

In April 1960, Missouri had its first wild turkey season in 23 years. Approximately 800 hunters harvested 94 gobblers in 14 counties. During the spring and fall seasons of 1979, 23,100 turkeys were harvested. The growing popularity of turkey hunting, especially during spring gobbler seasons, has created a need for a better understanding of harvest mortality and its effects on Missouri's turkey populations.

The purpose of this paper is to apprise recovery data associated with the spring gobbler-only seasons on a study area in the northern Ozarks and to discuss problems encountered in using these data to project mortality rates.

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## STUDY AREA

The study area was 31 km$^2$ of private land in Phelps and Dent counties, near Lake Spring, Missouri, and is representative of the northern Ozark region of the state, being roughly 49% forest, 21% old fields, 18%

permanent pasture, and 12% cultivated land. Beef cattle are the principal agricultural product; however, some cash grain crops are grown. No special management programs were used to sustain or maintain the turkey population on the area. For a more complete description of the area, see Ellis and Lewis (1967).

## METHODS

The Missouri Department of Conservation, in cooperation with the Missouri Cooperative Wildlife Research Unit, initiated a mobility and annual range study of wild turkeys in January 1965. Birds were trapped by cannon net, marked with patagial wing tags (Knowlton et al. 1964), and released at point of capture. Initially all turkeys were also banded with butt-end aluminum leg bands, but this was discontinued in 1967 in favor of "zip" lock wing bands on both wings. Use of leg bands was discontinued because retention was poor, especially on adult gobblers. Observation and retrapping of marked birds provided movement data reported by Ellis and Lewis (1967), Kelly (1969), and Batha (1972).

Trapping and banding were continued without interruption through the spring of 1979. Hunting mortality and recovery data were based on known-age banded birds shot during spring hunting seasons. Information of age and sex ratios, suggested mortality rates, and longevity was obtained from the capture, recapture data.

Missouri's turkey-hunting regulations required hunters to present their birds at a check station in the county of kill or an adjacent county. The location of each bird killed was plotted on a county map. These data, with harvest information obtained by landowners on the study area, provided an accurate account of hunting mortality.

For the purposes of this study a banding year started at the end of a hunting season and ended at the beginning of the next one. Spring hunting in Missouri increased from 4 days in 1965 to 2 weeks in 1972. The bag limit was increased from 1 to 2 birds in 1973, returned to 1 in 1974 and 1975, and has been 2 since then.

## RESULTS

### Trapping and Banding

From January 1965 to March of 1979, 669 turkeys were trapped and individually marked. Birds captured included 77 adult males, 175 adult females, 250 subadult males, and 167 subadult females (Table 1). Age of forty-four adults (27 males and 17 females) were known when they were captured. One hundred and seventy-six of the subadults were recaptured.

### Population Estimates

Dalke et al. (1946) reported that Missouri's highest turkey density in 1945 was on Drury Refuge in the southwestern portion of the state where 147 birds were found on 1,840 ha, or 1 bird per 12.5 ha. In contrast, population estimates of 1 bird per 10 ha were obtained on 1,760 ha portion of the Lake Spring study area in 1957 (Lewis 1957:93). No population information was obtained at Lake Spring from 1957 through 1965.

Table 1. Age and sex of turkeys trapped at Lake Spring, Missouri 1965-1979.

| Year | Adult male | | Adult female | | Juvenile male | | Juvenile female | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | New | RT[a] | New | RT | New | RT | New | RT | New | RT | Total |
| 1965 | 12 | 0 | 7 | 0 | 3 | 0 | 17 | 0 | 39 | 0 | 39 |
| 1966 | 13 | 3 | 4 | 1 | 9 | 0 | 4 | 0 | 30 | 4 | 34 |
| 1967 | 3 | 3 | 4 | 1 | 12 | 1 | 6 | 1 | 25 | 6 | 31 |
| 1968 | 0 | 0 | 21 | 6 | 13 | 3 | 15 | 1 | 49 | 10 | 59 |
| 1969 | 3 | 0 | 7 | 4 | 22 | 1 | 5 | 0 | 37 | 5 | 42 |
| 1970 | 9 | 7 | 11 | 3 | 21 | 0 | 5 | 0 | 46 | 10 | 56 |
| 1971 | 3 | 13 | 11 | 1 | 24 | 0 | 31 | 1 | 69 | 15 | 84 |
| 1972 | 7 | 1 | 12 | 1 | 50 | 0 | 28 | 0 | 97 | 2 | 99 |
| 1973 | 5 | 9 | 27 | 15 | 5 | 0 | 3 | 0 | 40 | 24 | 64 |
| 1974 | 9 | 5 | 15 | 19 | 8 | 1 | 4 | 3 | 36 | 28 | 64 |
| 1975 | 0 | 2 | 0 | 2 | 7 | 0 | 6 | 0 | 13 | 4 | 17 |
| 1976 | 2 | 2 | 2 | 0 | 39 | 8 | 8 | 0 | 51 | 10 | 61 |
| 1977 | 9 | 13 | 32 | 15 | 9 | 0 | 7 | 2 | 57 | 30 | 87 |
| 1978 | 2 | 5 | 13 | 14 | 26 | 1 | 13 | 0 | 54 | 20 | 74 |
| 1979 | 0 | 0 | 9 | 5 | 2 | 0 | 15 | 3 | 26 | 8 | 34 |
| Totals | 77 | 63 | 175 | 87 | 250 | 15 | 167 | 11 | 669 | 176 | 845 |

[a]Retraps

Table 2. Estimates of turkey populations at Lake Spring based on winter flock observations.

| Winter | Hens and Juveniles | Adult Gobblers | Total Population | Total Gobblers Harvested | Harvest as Percent of Total Population |
|---|---|---|---|---|---|
| 1964-65 | 116 | 39 | 155 | 16 | 10 |
| 1965-66 | 136 | 30 | 166 | 7 | 4 |
| 1966-67 | 85 | 25 | 110 | 12 | 10 |
| 1967-68 | 110 | 30 | 140 | 12 | 9 |
| 1968-69 | 120 | 35 | 155 | 16 | 10 |
| 1969-70 | 130 | 38 | 168 | 18 | 11 |
| 1970-71 | 120 | 26 | 146 | 21 | 14 |
| 1971-72 | 129 | 31 | 160 | 20 | 12 |
| 1972-73 | 60 | 75 | 135 | 30 | 22 |
| 1973-74 | 50 | 30 | 80 | 7 | 9 |
| 1974-75 | 40 | 20 | 60 | 8 | 13 |
| 1975-76 | 150 | 30 | 180 | 17 | 9 |
| 1976-77 | 90 | 35 | 125 | 10 | 8 |
| 1977-78 | 120 | 30 | 150 | 11 | 7 |
| 1978-79 | 40 | 5 | 45 | 3 | 7 |
| AVERAGE | 100 | 32 | 132 | 14 | 11 |

Annual winter counts were conducted from 1965 through 1979 (Table 2). The presence of identifiable wing-tagged birds plus the relatively open nature of the habitat, aided censusing. Population density averaged 1 bird per 23 ha, and ranged from a high of 1 per 17 ha in 1975 to a low of 1 per 68 ha in 1979.

The turkey density in the 2 counties adjoining the study area based on spring harvest data was 1 bird per 265 ha in 1965. Population levels off the study area increased throughout the study and in 1979 averaged 1 bird per 30 ha.

## Harvest and Recovery Rates

During the 15-year study, 102 known-age gobblers were recovered by hunting, a recovery rate of 36.8% of the 277 banded birds available. A similar number of unbanded birds were harvested during the same period. First season recovery rates averaged 12.3% (Table 3). The recovery rate following the second year after banding was 16.6%. The oldest known-age bird recovered was 6 years old.

The percentage of the total observed population removed annually by spring hunting ranged from 4.0% in 1966 to 22% in 1973 and averaged 10.6% (Table 2). These figures closely agree with reported spring harvests from other states (Mosby 1959).

Harvest of gobblers averaged 0.4 bird/$km^2$ for the 15-year study, and ranged between 1.0 bird/$km^2$ in 1973 and 0.1 bird/$km^2$ in 1979. The average harvest of 0.4 bird/$km^2$ caused no noticeable change in the gobbler population during the course of the study. The spring kill in 2 adjoining counties averaged 0.15 bird/$km^2$ during the same period; however, in 1979 the harvest was 0.33 bird/$km^2$.

## Age Ratios; Mortality Estimate

The age-ratio of 845 captures and recaptures, pooled for all years, was 47.6% adult and 52.4% subadult. The number of subadults captured each year varied and indicated changes in annual productivity and mortality rates. There was no consistent upward or downward trend of subadults captured during this study and pooled data from all years compensated for annual changes in productivity and mortality. The percentage of subadults suggested an average annual mortality of 52.4%.

Age-ratios, based on 13,750 birds from 2 fall hunting seasons (October 1978-1979) averaged 40% adults and 60% subadults. The fall hunting season age-ratios and age data from the study area were significantly different ($P<0.01$). The disparity between age-ratios was due to the time of year when data were collected. The majority of birds in this study were captured in mid-winter or early spring, after most natural mortality had occurred.

## Sex Ratios

Sex-ratio analyses were also based on capture and recapture data, although sex ratios fluctuated yearly, they were pooled for all years of this study (Table 1). Sex ratios for combined ages 48% males:52% females were not significantly different than 50:50; however, the differences within each age class were significant ($P<0.005$). The overall adult sex ratio was 35% males:65% females; and subadult ratios were 60% males:40% females. If a 50:50 sex ratio is assumed at hatching,

Table 3. Annual survival and recovery rates based on shot, known-age, subadult gobblers

| Year Banded | # Banded | Harvest by year following banding | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| 1965 | 6 | 1 | 1 | 2 | — | — | — |
| 1966 | 9 | — | 3 | 1 | 1 | — | — |
| 1967 | 12 | 1 | 2 | 1 | 1 | — | — |
| 1968 | 13 | 2 | 2 | — | — | — | — |
| 1969 | 26 | 3 | 5 | 4 | 2 | 2 | — |
| 1970 | 24 | 4 | 4 | — | — | 1 | — |
| 1971 | 31 | 5 | 5 | 2 | 2 | — | — |
| 1972 | 55 | 4 | 9 | — | 2 | — | 1 |
| 1973 | 5 | 1 | 1 | 1 | — | — | — |
| 1974 | 8 | 1 | — | — | — | — | — |
| 1975 | 9 | 2 | — | — | 1 | — | — |
| 1976 | 42 | 6 | 4 | 4 | — | — | — |
| 1977 | 9 | — | 1 | — | — | — | — |
| 1978 | 26 | 4 | 3 | — | — | — | — |
| 1979 | 2 | — | — | — | — | — | — |
| Banded birds alive at end of year | 277 | 243 | 201 | 160 | 142 | 97 | 87 |
| Banded birds available | -- | 277 | 241 | 175 | 151 | 100 | 90 |
| Annual survival rate | -- | 0.88 | 0.83 | 0.91 | 0.94 | 0.97 | 0.97 |
| Annual recovery rate | -- | 12.3 | 16.6 | 8.6 | 6.0 | 3.0 | 3.3 |

some differential mortality favoring males occurred before the first breeding season. Recaptures were slightly skewed in favor of females the first and second years, with a sharp increase favoring females the third year.

Distorted sex ratios in turkeys have been reported previously (Bailey and Rinell 1965). The discrepancy in the adult sex ratio data from this study may have been related to harvest mortality on gobblers during the spring seasons, but the reason(s) for the preponderance of males among the subadults is not clear.

## DISCUSSION

Lewis and Kelly (1973), reporting on the first 5 years of this study, used the composite dynamic (CD) method to estimate annual mortality and recovery rates, which was based on life tables compiled from harvest statistics as described by Hickey (1952). Other studies dealing with wild turkey population dynamics also employed the CD method of analysis (Bailey and Rinell 1965, Powell 1965, Mosby 1967).

The CD method has been used for years in estimating waterfowl mortality rates, but according to Burnham and Anderson (1979), mortality rates computed in this manner may be incorrect. Burnham and Anderson (1979) stated that a valid composite dynamic computation must satisfy 3 crucial assumptions: (1) annual mortality rate varies only by age of bird with no time-specific variation; (2) annual recovery rate is a constant fraction of annual mortality rate; and (3) virtually none of the banded birds remain alive when the data are analyzed. They also state that a variety of implications follow from these assumptions, with perhaps the most important being no year to year (time-specific) variation in either harvest rates or band reporting rates allowed. Many of the published computations of annual mortality rates for wild turkeys based on banding, recapture, and recovery information may be suspect in view of Burnham and Anderson's evaluation of the composite dynamic method. The banding, recapture and recovery data from the present study could not be analyzed properly to determine annual mortality rates based on the assumptions established by Burnham and Anderson (1979), because during 3 years no adult gobblers and hens were captured.

Another approach to estimating mortality rates focuses on annual population turnover as measured by the percentage of young in the population, and interpreted as the annual mortality rate. Pooled age-ratio data suggested that the average annual mortality rate was 52.4% during the 15 years of the present study. Age-ratios obtained from 2 recent fall hunting seasons in Missouri indicate a slightly higher mortality rate of 60%.

Caughley (1974) cautioned against using age ratios in monitoring population dynamics and suggested that sudden changes in age ratios should not be ignored; however, he stated that these age ratios indicated some change within the population has occurred and more information is needed to find out what has taken place. Caughley (1974) also stated that age ratios must be accompanied by rate of increase and survival or fecundity estimates to be interpreted critically. Nevertheless, in the present study, 15 years of age ratio data with no clear population trend shown can be assumed to present a base for annual mortality estimation.

Recovery data from this study suggests differential harvest vulnerability between subadult and adult gobblers. Adult gobblers are more vulnerable than subadults during spring hunting, because they are more responsive to hens calls and because their gobbling leads hunters to them. Subadult males rarely gobble during Missouri spring seasons, and hunters are normally not aware of their presence.

The ratio of subadults to adults in harvest correlates positively with production from the previous year. Subadults comprised an average of 23% of the spring harvest in Missouri between 1960-1970 during seasons averaging 4.5 days. During the period 1971-1979, subadults proportion in the harvest averaged 35% during seasons of 12 days average length. Increasing the length of the season accounted for 58% of the variability in hunting success, while the percentage of subadults accounted for only 39% of the change between 1960-1974 (Lewis 1975). Longer seasons and increased hunting pressure probably were responsible for the higher harvest of subadults in recent years. High subadult harvest over an extended period may ultimately reduce the number of trophy (adults) gobblers in the population.

Changes in Missouri hunting season regulations depends primarily upon annual production indexes and analysis of age ratios. These techniques have been adequate in providing base line data, but as hunting pressure and harvest increases a better understanding of population dynamics will be required to effectively manage wild turkey populations.

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# INTRODUCTION OF THE WILD TURKEY INTO THE CARLOS AVERY WILDLIFE MANAGEMENT AREA

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Abstract: During the winter of 1978-79, 19 wild turkeys (*Meleagris gallopavo*) were rocket-netted in the Whitewater Wildlife Management Area in southeastern Minnesota, equipped with radio-transmitters, and released into the Carlos Avery Wildlife Management Area in east-central Minnesota. The release area is approximately 160 km north of the northern limit of the historical range of the wild turkey in Minnesota. Fifty three percent of the wild turkeys released were lost to predation or starvation. Newly released wild turkeys traveled an average of 2.4 km from their release sites before settling into a wintering area and it was during this movement that predation generally occurred. Snow depth at the time of movement from the release site appeared important in determining whether or not predation occurred. Home ranges averaged 750.2 ha for the winter months and increased to an average of 1,520.8 ha for the spring months. During spring, both males and females made numerous long trips into surrounding residential and agricultural areas but always returned to the Wildlife Management Area. Spring dispersal distances averaged 2.77 km for females and 2.05 km for males. Summer movements were minimal and home ranges averaged only 174.8 ha. Reproductive success was limited. Although 5 out of 6 hens attempted to nest, only 1 hen was successful in hatching eggs. Egg predation was the major cause of nesting failure.

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Historically, Minnesota was at the northern edge of the range of the wild turkey. The only basis for including Minnesota within the historic range is a specimen in the University of Kansas Collection marked merely "Minnesota" without further data (Hewitt 1967). Schorger (1942) theorized that the turkey population in this region was subject to fluctuation due to weather, food supply, disease, or other causes. He envisioned the turkey becoming extirpated due to harsh winters only to become re-established during periods of mild winters by the expansion and dispersal of populations located further south. If the wild turkey occurred here, it probably was extremely rare or sporadic in occurrence and was limited to the extreme southeastern portion of the state.

In 1964, the Minnesota Department of Natural Resources (DNR) began efforts to establish wild turkey populations in southeastern Minnesota in the Whitewater Wildlife Management Area and Houston County. Using wild-trapped birds from other states, the DNR was successful in establishing 2 separate but converging populations that currently total several thousand birds (Johnson 1974a, 1974b, Porter 1979). Both M.g. silvestris and M.g. merriami were used in the introductions and the extent of interbreeding that has occurred is unclear.

These 2 populations have been extensively studied by Porter (1976, 1977a, 1977b, 1978), who attributed the success of these transplants to the interspersion of hardwood forests with agricultural lands. He stated that while hardwood habitats were obviously important, agricultural areas provided the reliable and abundant food resources necessary to sustain the populations through Minnesota's rigorous winters.

Based on these findings, the Minnesota DNR believes that the wild turkey has a reasonable chance of survival in other areas of the state (Minnesota DNR 1980). This study was undertaken to obtain information on the mortality, reproduction, dispersal, and subsequent movements of wild turkeys introduced into an area outside of southeastern Minnesota. The area selected for this study differs significantly from southeastern Minnesota in its topography, vegetation, soil type, and climate.

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## STUDY AREA

The area selected for this study was the Carlos Avery Wildlife Management Area (WMA) in east-central Minnesota approximately 48 km north of St. Paul, Minnesota (Fig. 1). This area is approximately 160 km north of the northern limit of the historical range of the wild turkey in Minnesota and no wild turkeys have been observed in this area in modern times. This WMA consists of over 8,750 ha that are principally managed for waterfowl with secondary emphasis on white-tailed deer (Odocoileus viginianus), squirrels (Sciurus carolinensis), and ruffed grouse (Bonasa umbellus (Minnesota DNR 1977a).

The Carlos Avery WMA is located on a gently rolling sand plain. It's soils are deep, moderately dark, sandy soils of glacial origin, interspersed in very poorly drained organic soils (Minnesota DNR 1977a). Over 36% of the total area of the Carlos Avery WMA is comprised of wetlands. The length of the growing season as defined by the number of

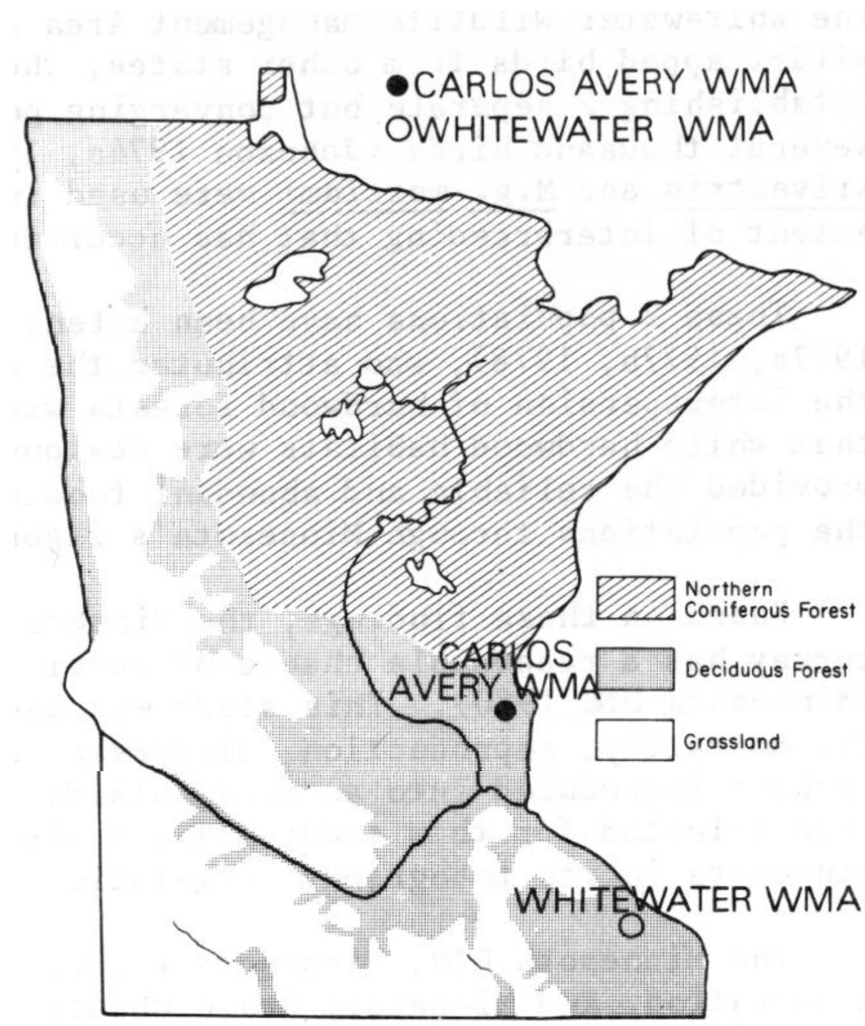


Figure 1. Locations of Carlos Avery and Whitewater Wildlife Management Areas in Minnesota. Also shown are the major vegetation formations that existed before settlement (as adapted from KÜchler, 1964).

days between the freezing threshold is 151 days while snowcover is present an average of 86 days each year[1]. Because of close proximity of a metropolitan area, considerable residential development is occurring in the vicinity of the Carlos Avery WMA. The density of people in the area surrounding the Carlos Avery WMA is 174 people/km$^2$ (Minnesota DNR 1977a).

The Carlos Avery WMA differs substantially from southeastern Minnesota in all of these features. Southeastern Minnesota is characterized by comparatively level uplands with deeply eroded bedrock valleys dropping 120 to 180 meters in elevation (Sims and Morey 1972). Wetlands comprise less than 2% of the total area. Soils are composed generally of loams and sandy loams derived from dolomites, sandstones, and loess (Porter 1978). The length of the growing season is 165 days and snowcover is present an average of 70 days each winter2. The population density for the area surrounding the Whitewater WMA in southeastern Minnesota is only 33 people/km$^2$ (Minnesota DNR 1977b).

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[1]Personal communication, Earl Kuehnest, Minnesota State Climatologist. University of Minnesota, St. Paul, MN.

[2]Ibid.

## METHODS

All wild turkeys were rocket-netted in the Whitewater WMA in southeastern Minnesota. They were transported to the Carlos Avery WMA, equipped with radio transmitters, and released within 24 hours of capture during daylight hours.

TWO different release sites were utilized. The main release site was on an upland area surrounded by marsh and was connected to other upland areas by roads and trails. A total of 15 birds were released on this site: 10 birds on 14 and 15 December 1978, 2 birds on 6 January 79, 1 bird on 2 February 79, and 2 birds on 8 March 79. The second release site was a small cornfield surrounded by large areas of upland. It was utilized on 17 January 79 for the release of 4 birds. A total of 8 males and 11 females was released.

Attachment of the transmitters followed the design used by Porter (1976, 1978). Each operated on an individual frequency in the 160 mHz range and produced a pulsed signal. They were equipped with lithium batteries that had an estimated power life of 400 days. All birds were monitored daily. Reference locations were chosen to provide an angle of triangulation between 60 and 120 degrees and were within 3 km of the location of the bird. These criteria were used to minimize errors in the telemetry technique (Heezen and Tester 1967). Home ranges were delineated using the Modified Minimum Area Method as described by Harvey and Barbour (1965). Spring dispersal was defined as the spring movement of individuals out of winter flocks and was measured as the straight line distance from the individual's wintering area to it's nest or middle of it's May home range (Porter 1978).

Determination of the cause of mortality was based upon characteristics of the kill (Einarson 1956), tracks left in the kill area by the predator and on any distinguishing marks left on the carcass. Characteristics given by Reardon (1951) were used as a guide in determining nest predators.

## RESULTS

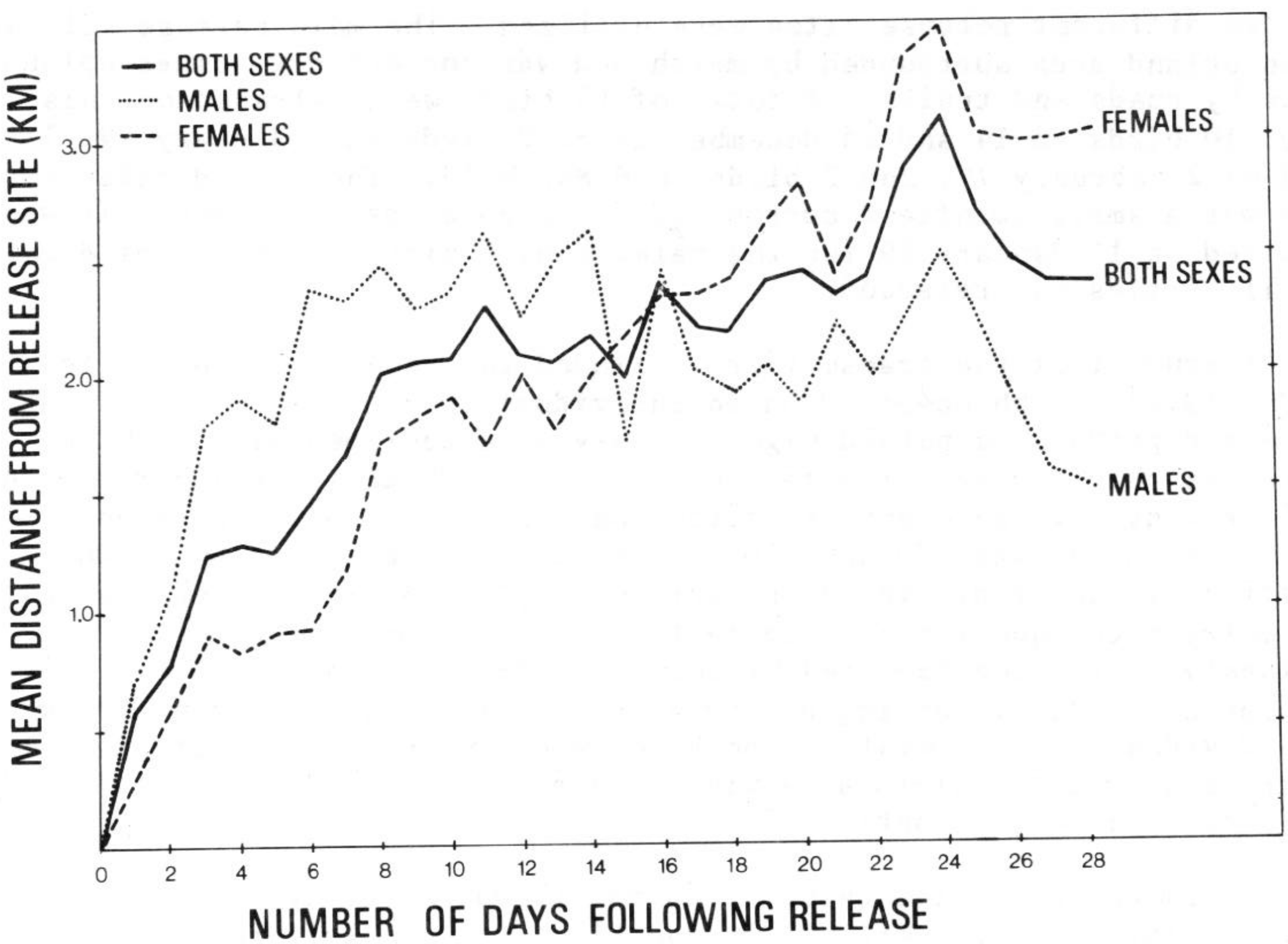
### Initial Movement from the Release Sites

The releases were characterized by an immediate movement from the sites of introduction. Males apparently dispersed at a faster rate than females but, on the average, females dispersed a greater distance. Twenty-eight days after release males were an average of 1.5 km from their release sites, whereas females averaged 3.1 km from their release sites (Fig. 2).

### Subsequent Movements

After initial movement away from the release site, turkeys generally settled into an area that included a dependable source of food such as an unharvested corn field. Birds readily used deer trails and

**Figure 2. Movement of wild turkeys from release sites on the Carlos Avery Wildlife Management Area, Minnesota, during the first 4 weeks following their release in winter 1978 -1979.**




snow-plowed roads for travel. The birds were separated into 3 to 4 groups throughout most of the winter with males and females generally staying in separate groups.

After snow melt, the turkeys greatly increased their movements. Most of the birds undertook "trips" out of the WMA into the surrounding countryside or to previously unvisited parts of the WMA. These trips lasted for 2 to 6 days and ended with the bird returning to the area it left. During one such trip, a juvenile male was observed 8.7 km from it's location on the previous day. An adult female made 3 trips between 16 April 1979 and 5 May 1979 that averaged 7.6 km in distance. All sex and age classes of birds made such trips. Also during this period, the separate groups that existed together through the winter months combined into 1 group for a period of 2 days in mid-April. Group number and composition after this period were highly variable until summer. Spring dispersal distances averaged 2.77 ± 0.68 km (n=6) for females and 2.05 km ± 0.38 km (n=3) for males.

Table 1. Summary of seasonal home ranges (ha) as determined by the Modified Minimum Area Method (Harvey and Barbour 1965) for wild turkeys released into the Carlos Avery Wildlife Management Area, Minnesota, 1978-1979.

| Season[a] | N | $\overline{X}$ | SE |
|---|---|---|---|
| Winter | | | |
| Both Sexes | 9 | 750.2 | 303.2 |
| Males | 3 | 643.1 | 523.2 |
| Females | 6 | 803.7 | 405.1 |
| Spring | | | |
| Both Sexes | 10 | 1520.8 | 189.6 |
| Males | 4 | 1317.5 | 84.7 |
| Females | 6 | 1656.4 | 309.4 |
| Summer | | | |
| Both Sexes | 8 | 174.8 | 30.6 |
| Males | 4 | 227.3 | 46.6 |
| Females | 4 | 120.3 | 17.5 |

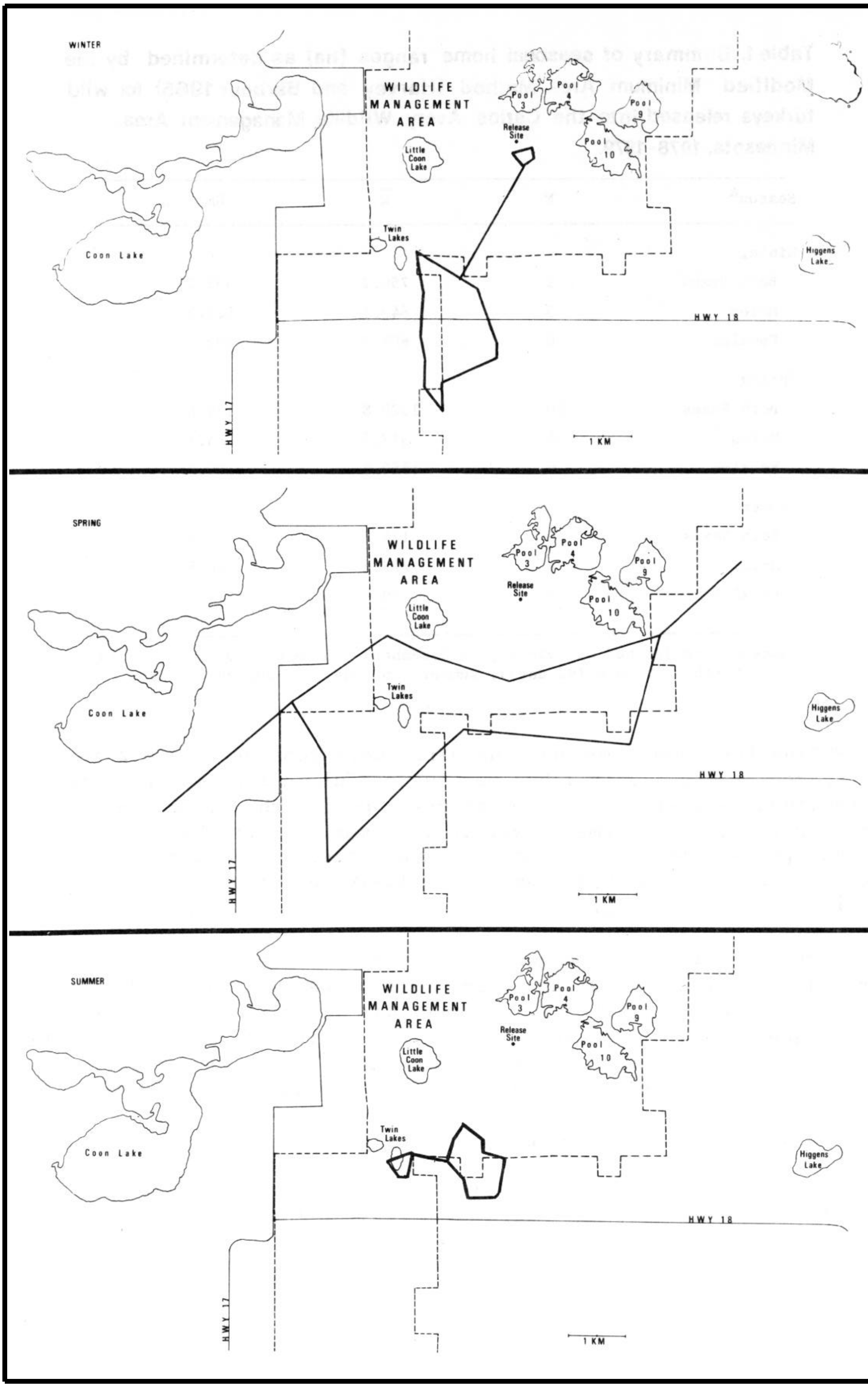
[a]Seasons are defined as: winter, 14 December - 15 March (90 days); spring, 16 March - 15 June (92 days); summer, 16 June - 31 August (78 days).

During the summer months, the birds were separated into 2 sexually segregated groups. Only 1 hen was successful in its nesting attempt and it remained separated from both groups. During this time the birds concentrated their movements within very small areas which had been part of the spring home ranges. No trips were observed during this time period. The seasonal home ranges, inclusive of trips, for a juvenile female are shown in Fig. 3.

Average spring home ranges for both sexes were more than 2 times as large as the winter home ranges and were almost 10 times the size of the summer home ranges (Table 1). Statistical analysis indicated significant differences among all seasons ($p < 0.10$). Male and female home ranges were significantly different for the summer ($p < 0.10$) but were not significantly different for the winter and spring ($p > 0.10$).

Monthly analyses showed that home ranges were relatively small in January and February but increased greatly during April and May (Fig. 4). This was followed by a steady decline in home range size through August. August home ranges were much smaller than February home ranges, the month with the greatest snow depth.

Figure 3. Winter, spring, and summer home ranges for a juvenile female released on the Carlos Avery Wildlife Management Area, Minnesota, 1978-1979. This hen was successful in nesting.



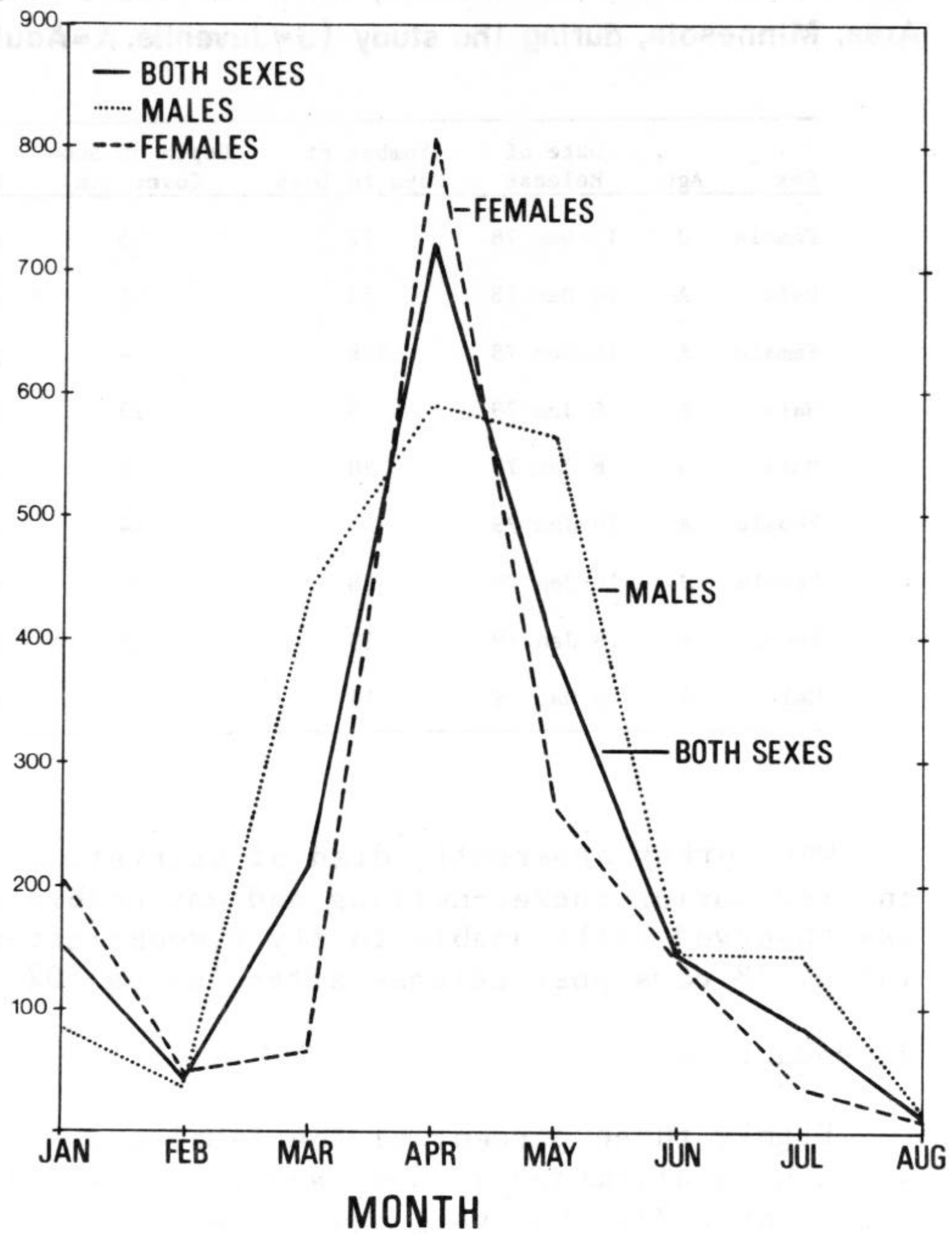



Figure 4. Monthly home ranges (ha) for male and female wild turkeys released on the Carlos Avery Wildlife Management Area, Minnesota, 1978-1979.

## Mortality

Fifty three percent of the wild turkeys released were lost to predation or starvation (Table 2). All but 1 of these losses occurred during the winter months when snow was on the ground. Eight birds were lost to predation. Predation usually occurred during the period of extensive movement immediately following release. Sixty three percent of the birds lost to predation had been released within the previous 28 days. The depth of the snow cover during this period appeared to be a factor in influencing whether or not predation occurred. Only 22% of the birds released in December before large accumulations of snow were present were lost to predation; 56% of those birds released during the period January through March when heavy snow accumulations were present were lost to predation.

Table 2. Summary of wild turkey losses on the Carlo's Avery Wildlife Management Area, Minnesota, during the study ( J=Juvenile, A=Adult).

| Sex | Age | Date of Release | Number of Days to Loss | Depth of Snow Cover (cm) | Cause of Loss |
|---|---|---|---|---|---|
| Female | J | 14 Dec 78 | 12 | 25 | predation-Great Horned Owl |
| Male | A | 14 Dec 78 | 63 | 51 | predation-eagle |
| Female | A | 15 Dec 78 | 218 | — | predation-undetermined |
| Male | A | 6 Jan 79 | 5 | 25 | predation-domestic dogs |
| Male | A | 6 Jan 79 | 28 | 43 | predation-undetermined |
| Female | A | 18 Jan 79 | 21 | 44 | predation-coyote |
| Female | J | 18 Jan 79 | 28 | 51 | starvation |
| Female | A | 18 Jan 79 | 33 | 52 | predation-undetermined |
| Male | A | 9 Mar 79 | 14 | 27 | predation-domestic dogs |

One turkey apparently died of starvation. This bird was badly injured during rocket-netting and was unable to fly when released. It was observed still unable to fly 2 weeks after release and was recovered intact 28 days post release after losing 50% of its body weight.

Reproduction

Eighty three percent of the females attempted to nest. All 3 of the adult hens attempted to nest and 2 of the 3 juvenile hens attempted to nest (Table 3). However, only 1 hen, a juvenile, was successful in hatching eggs. Egg predation was the major cause of nest failure. The nesting attempt that was successful produced 5 poults, but only 2 were observed to be alive 77 days after hatching.

Table 3. Summary of nesting activity for wild turkeys released at the Carlos Avery Wildlife Management Area, Minnesota.

| Age of Hen | Date Nesting Begun | Number of Days to Predation or Hatching | Clutch Size | Cause of Loss |
|---|---|---|---|---|
| Adult | 16 May 79 | 28 | 5 | predation-raccoon |
| Adult | 27 April 79 | 17 | — | undetermined |
| Adult | 3 May 79 | 12 | 6 | predation-woodchuck |
| Renest | 24 May 79 | 20 | — | undetermined |
| Juvenile | 28 April 79 | 19 | 15 | abandoned, reason unknown |
| Renest | 14 June 79 | 29 | 10 | predation-raccoon |
| Juvenile | 17 May 79 | 38 | 8 | nest successful |

# DISCUSSION

## Initial Movement from the Release Sites

Movement of the wild turkeys from the immediate area of their release site was characteristic of almost every release. The first release site was on an upland area surrounded by extensive areas of marsh. This marsh area did not present a barrier to movement of birds as they were able to follow deer trails to other upland areas. Corn was dropped in the vicinity of the release site to provide an additional source of easily accessible food for the birds. This seemed to have little effect in keeping the birds in the release area.

A second release site was selected in an area that was being used intensively by several birds released earlier. These birds were restricting their movements to a small oak woods and an adjoining cornfield. Of the 4 new birds released at this site, only 1 remained in the area. The other 3 dispersed, 2 were killed by predators and 1 starved.

The extensive initial movement away from the site of release observed in this study was not observed for birds released back into the area from which they were rocket-netted in the Whitewater WMA[1]. This extensive movement was a major problem in this introduction and will probably continue to be a problem for future releases in Minnesota. Besides contributing to mortality, this initial movement may prove to be a problem in releases that are made on smaller wildlife management areas. It is possible that newly introduced birds will move off these smaller areas in the first 2 or 3 weeks following release, hence making their management much more difficult during the critical early stages of the introduction.

## Subsequent Movements

Porter (1978) reported home ranges averaging 103.5 ha for winter, 768.0 ha for spring, and 314.0 ha for summer for wild turkeys in the Whitewater WMA in southeastern Minnesota. The mean winter home range size observed in the Carlos Avery WMA was almost 8 times larger than this, while the mean spring home range size was twice as large as Porter (1978) observed for birds in the Whitewater. In contrast, the summer home range size observed in the Carlos Avery WMA was almost half the size that Porter (1978) observed.

The initial movement away from the release site that was typical of most releases contributed to the large size of the winter home ranges. It was observed that after 2-3 weeks of movement, the birds restricted their movements to a small area that was used intensively for the remainder of the winter.

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[1]Persona1 communication, William F. Porter, College of Environment Science and Forestry, State University of New York, Syracuse, New York, 13210.

The large increase in size of the spring home ranges can be attributed to the difference in home range size for females. Porter (1978) found that home ranges averaged 243.2 ha for females during the spring months in the Whitewater WMA while Carlos Avery WMA females had home ranges averaging 1656.4 ha, almost 8 times larger. On the other hand, spring home ranges for males were comparable, averaging 1424.1 ha in the Whitewater WMA and 1317.5 ha in the Carlos Avery WMA. In the Whitewater WMA, Porter (1978) observed during the spring months that most males made extensive movements back and forth across large areas while females consistantly moved from their wintering area in one general direction until their nest was established. These movements resulted in large home ranges for males, but much smaller home ranges for females. In this study, extensive movement was observed for both males and females. This resulted in the large spring home ranges for both males and females.

From mid-April on, all female turkeys were seen frequently with males until they initiated incubation. This would seem to rule out searching for males for mating as the reason for the large home ranges for females. Food resources were also believed to be abundant. One possible explanation for the large female home ranges might be that extensive exploration by the females was necessary to locate suitable habitat for nesting. The low rate of nesting success that was observed may be a further indication that there is a lack of suitable nesting habitat in this area. The nests that were observed were located in a variety of habitat types and no general trends were discernible.

During the summer months, movement by the birds was minimal. The birds appeared to settle into an area and use it intensively for the remainder of the summer. Porter (1978) reported summer home ranges nearly twice as large in the Whitewater WMA.

Mortality

Most of the mortality occurred during the initial movement from the release sites. The birds were undoubtedly under considerable stress, having just been rocket-netted, radio-tagged, transported 160 km and released into an entirely new area. In addition, their travel routes from the release sites often took them through large areas without any foodplots. Depth of snow cover during the time they were traveling from their release sites was critical in determining whether or not mortality occurred. Birds released in December were able to disperse from their release site and settle into a wintering area before a great deal of snow had accumulated. Birds released in January through March had to contend with large snow accumulations during travel away from their release sites. A much higher percentage of birds that were released during January through March were lost to predation or starvation.

Porter (1978) concluded that mortality in the wild turkey populations in southeastern Minnesota was stress-related. He found that although predation was the direct cause of more than 70% of the winter mortality, the extent to which mortality occurred in a given year was not related to the predator population levels, but to the severity of the winter and the amount of stress it was placing on the birds. Our losses were also related to stress. Very few losses occurred after the initial movement away from the release sites. The extent to which losses occurred during the initial movement was related to the severity of the winter conditions present at the time of release.

Future releases in Minnesota should be made either in early winter, before large snow accumulations are present, or in late winter after considerable snow-melt has occurred. The losses that are likely to occur otherwise will seriously jeopardize the success of any release.

Reproduction

Reproduction was limited in this first year following release. All of the adult females and 2 out of the 3 juvenile females attempted to nest, but nesting success was very limited. Although 83% of the females attempted to nest only 20% of these hens were successful in hatching eggs. Egg predation was the major cause of nest loss. In contrast, Porter (1978) found that while more than 90% of the females in all age classes attempted to nest in the Whitewater WMA more than 80% of these were successful.

More research is needed to determine if this success rate will be typical for this area. It is possible that newly released hens are still under some stress from the release at nesting time, resulting in the lower success rate. A second alternative is that suitable nesting habitat is not present in this area. A third alternative is that this area provides for a larger and/or more effective nest predator population than southeastern Minnesota.

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# WILD TURKEY RESTORATION IN "MARGINAL" IOWA HABITATS

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*Abstract:* An aggressive restoration program has resulted in the release of 930 eastern wild turkeys *Meleagris gallopavo silvestris* at 64 sites in Iowa sine 1965. Only 1 release has failed, as evidenced by known reproduction at every site and growth and dispersal of turkey flocks. Iowa's remnant timber stands total 0.6 million ha. Individual forest stands in all regions are small and are generally linear, paralleling major drainage systems on lands too steep to clear. Private farm ownership constitutes 98% of the timber resource; most farm woodlots are grazed and are poorly stocked. Established and expanding turkey populations currently inhabit 247,700 ha of forest land while natural dispersal and further stocking will probably bring this total to 431,000 ha. Winter densities in established turkey populations range from 23 to 31 turkeys per $km^2$ of forest in the best habitats, and average a conservative 8-12 per $km^2$ throughout established range. These populations support spring gobbler harvests of l-4 per $km^2$ where hunting pressure is greatest. The success of this release program indicates that qualitative and quantitative timber requirements for the eastern subspecies are not as stringent as previously believed.

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Post-settlement history of the wild turkey in Iowa closely parallels trends documented for turkey populations throughout the eastern half of the United States in the last 2 centuries (Mosby 1975). The eastern wild turkey was found throughout Iowa at the time the first white settlers crossed the Mississippi River in the 1830's (Scott and Hendrickson 1939) but uncontrolled hunting and habitat loss led to the elimination of Iowa's turkey flocks in just 80 years. Only 1.1 million ha of forest remained by 1956, a reduction of 63% in 1 century, and perhaps half of the remaining timber was badly overgrazed (Thornton and Morgan 1959). The last wild turkey was shot in Lucas County in southcentral Iowa in 1900, and the last verified sighting was made in Lucas County in 1910 (Musgrove et al. 1941).

This paper summarizes early, unsuccessful attempts to restore turkeys to Iowa's marginal timber resources and more recent successes achieved with the native eastern subspecies. Iowa's turkey restoration program is funded cooperatively by the Iowa Conservation Commission and the Federal Aid in Wildlife Restoration Act (Pittman-Robertson Projects W-115-R and FW-45-3).

# IOWA’S FOREST HABITATS

Iowa is an agricultural state, normally ranking among the top 5 states annually in the production of corn, soybeans, hay and oats (USDA 1978). Soil is the State's most valuable natural resource and economic asset, with 25% of the nation's top quality farm land found here. Competition for agricultural land has driven land prices to $7,500 per ha in the most productive regions in recent years; consequently 98% of the State is in private ownership and 85% is under cultivation (Huemoeller et al. 1976). These economic realities have directly affected the status of forest land and potential wild turkey habitat. Generally forests are found only on marginal agricultural lands too steep to-clear economically, although improved technology has resulted in the loss of l-2% of forested lands annually in the past 2 decades (Ostrom 1976).

Iowa’s remnant forests total 607,000 ha (Ostrom 1976), just 7% of the land area of the State and 33% of presettlement forests, with perhaps 200,000 ha of shrub lands. providing some additional wildlife benefits. This timber is concentrated in 4 regions defined by minor differences in physiography, configuration of timber stands, forest composition and climate (Prior 1976).

The Northeast or "driftless" region contains 118,000 ha of forest land, the largest concentration of nearly continuous timber stands in the State (Fig. 1). This region is unglaciated and is characterized by deep, narrow, V-shaped stream valleys and long, rounded, angular ridges, with maximum relief approaching 110 m. Ridgetops and flat alluvial valleys have been cleared for agriculture and timber is restricted to steep, rocky slopes.

The Southern region retains the greatest total timber area (193,000 ha), but forests are more widely scattered and few timber stands as large as 1,000 ha remain intact. Topography is characterized by steeply rolling hills interspersed with uniformly level uplands between major drainage systems. Relief is less dramatic, usually less than 35 m, with timber restricted to narrow ridgetops and slopes connected by bands of riparian timber. Generally stands become smaller, more widely dispersed and interrupted by agricultural clearings proceeding from the southeast westward across the region and toward the source of drainage systems.

Timber in the Western region is concentrated in a narrow 5-32 km wide band of steep hills running along the southern two-thirds of the western border of the State, and totals just 46,000 ha. These "loess hills" are derived from alluvial silt deposits originating in the Missouri river basin and deposited along its eastern border by prevailing winds. The hills have a corrugated appearance of alternating waves and troughs produced by sharp, broken ridge crests, intersecting spurs and steep slopes (Prior 1976). Timber is restricted to protected slopes, with only relatively flat valley bottoms under cultivation. The loess hills are interrupted for several stretches of 1.5-3 km by major tributaries of the Missouri River which penetrate from the east.

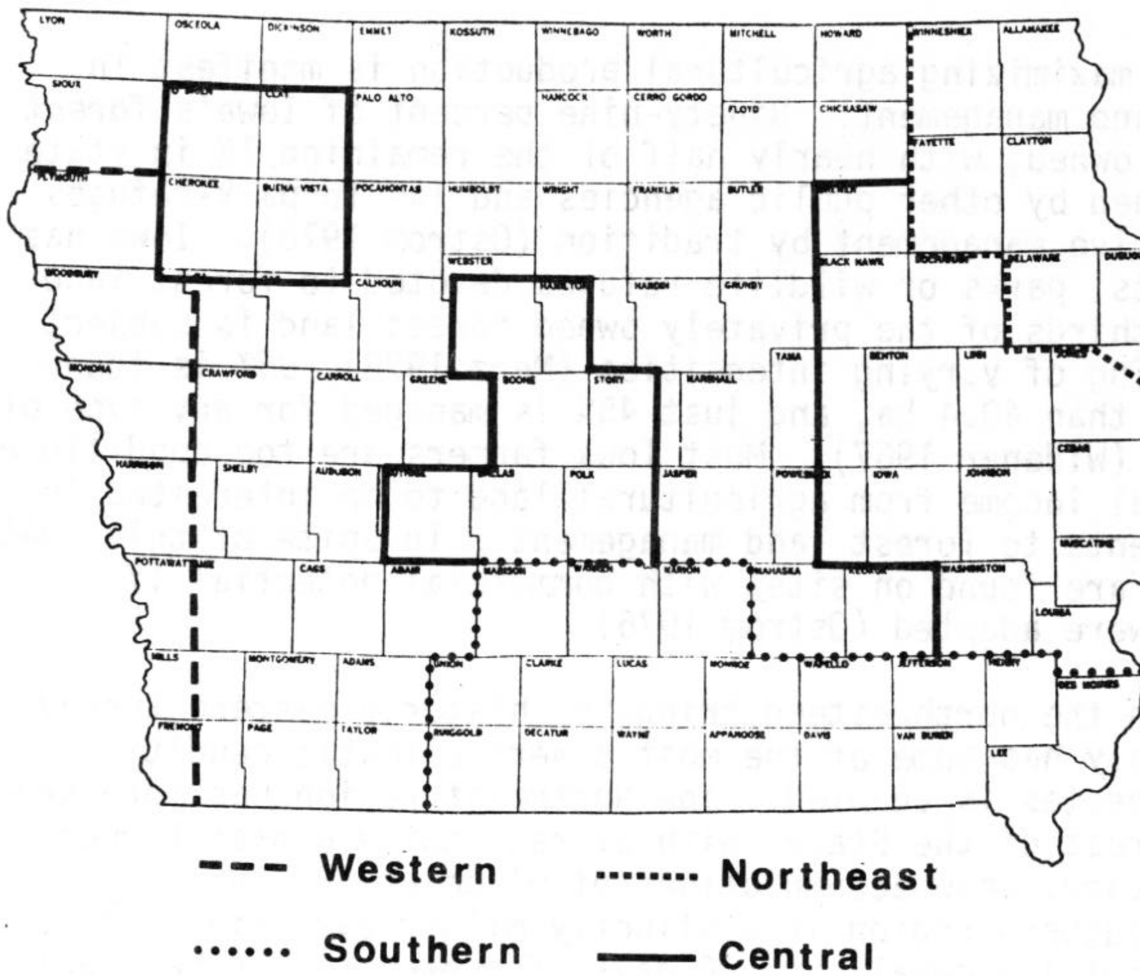


Fig. 1. Distribution of potential wild turkey habitat. Forest regions lie within boxes.

The fourth region is a combination of similar physiographic situations scattered mostly throughout the central third of the State, all associated with major drainage systems. The Little Sioux, Raccoon, Des Moines, Iowa, Cedar, Wapsipinnicon and Maquoketa Rivers have cut floodplains of varying depths from flat to rolling uplands which are entirely cultivated. Timber is found on steep slopes and short spur ridges emanating from these uplands or in narrow riparian stands, resulting in forests which are generally more linear than in other regions. Although a considerable timber area may be available along the length of any river system (i. e. this region contains 189,000 ha of forest land, second only to the Southern region), stands are relatively narrow and may be interrupted at many points.

Forest types throughout the State are second or third growth oak-hickory on uplands and elm-ash-cottonwood on floodplains (Ostrom 1976). Oak types constitute 55% of all forest stands, with red oak-white oak-hickory (Society of American Foresters 1954) dominant in all regions (35% of all forests). Maple-basswood stands (10%) are found-on mesic sites and are climax in the Northeast and Central regions, but are replaced by white oak (10%) and short, scrubby bur oak (10%) in the Southern and arid Western regions, respectively. Aspen and other northern hardwoods (1%) are found occasionally in the Northeast. Statewide 54% of all commercial stands are entering sawtimber stages and nearly 46% are in poletimber.

Concern for maximizing agricultural production is manifest in forest ownership and management. Ninety-nine percent of Iowa's forest land is privately owned, with nearly half of the remaining 1% in state ownership, 38% owned by other public agencies and 14% in park-refuges withdrawn from active management by tradition (Ostrom 1976). Iowa has no national forests, parks or wildlife refuges devoted to forest land management. Two-thirds of the privately owned forest land is subject to livestock grazing of varying intensities (Merz 1978), 95% is found in stands of less than 40.4 ha, and just 45% is managed for any type of timber production (Widener 1967). Most Iowa farmers are too conditioned to realizing annual income from agricultural land to be interested in long-term commitments to forest land management. In spite of this, 94% of Iowa's forests are found on sites with commercial potential if management plans were adopted (Ostrom 1976).

Iowa lies on the northwestern fringe of historic eastern turkey range and presumably has some of the most severe climatic conditions to which the subspecies is adapted. The Northeast region has more severe weather than the rest of the State, with average daily winter temperatures of -12° C. in January, snow accumulations of 91 cm and 80 days of snowcover. The Southern region is distinctly milder averaging -6° C. to -9° C., 61 cm of total snowfall and 40 days of snowcover. Other regions are intermediate to these extremes (Merz 1978).

Iowa's 2.8 million people are concentrated in several cities in the Central region. Rural populations in most forested counties are fairly sparse, ranging from 0-10 per $km^2$ in the Southern and Western regions to 10-20 per $km^2$ in the Northeast and Central (Merz 1978). This is somewhat misleading in that nearly all residents are rural. Few counties in the forested regions have a city as large as 10,000 population. Farmsteads tend to be placed on the least productive sites along the margins of timber stands, and there has been a recent trend to locating housing developments in wooded areas, particularly in the Northeast and Central regions. Isolation of wildlife from human contacts is not possible in most habitats.

In summary, although there are regional differences, Iowa forests may be characterized as small, linear stands of pole to sawtimber on steep lands associated with drainage systems. Forests are heavily interspersed with agricultural lands and farmsteads and are generally unmanaged or mismanaged for both timber and wildlife production.

## RESTORATION EFFORTS

### Experimental Releases

The Iowa Conservation Commission began experimenting with turkey restoration as early as 1920 using first pen-reared turkeys and then wild-trapped stock of the Rio Grande *M. g. intermedia* and Merriam's *M. g. merriami* subspecies (Fig. 2).

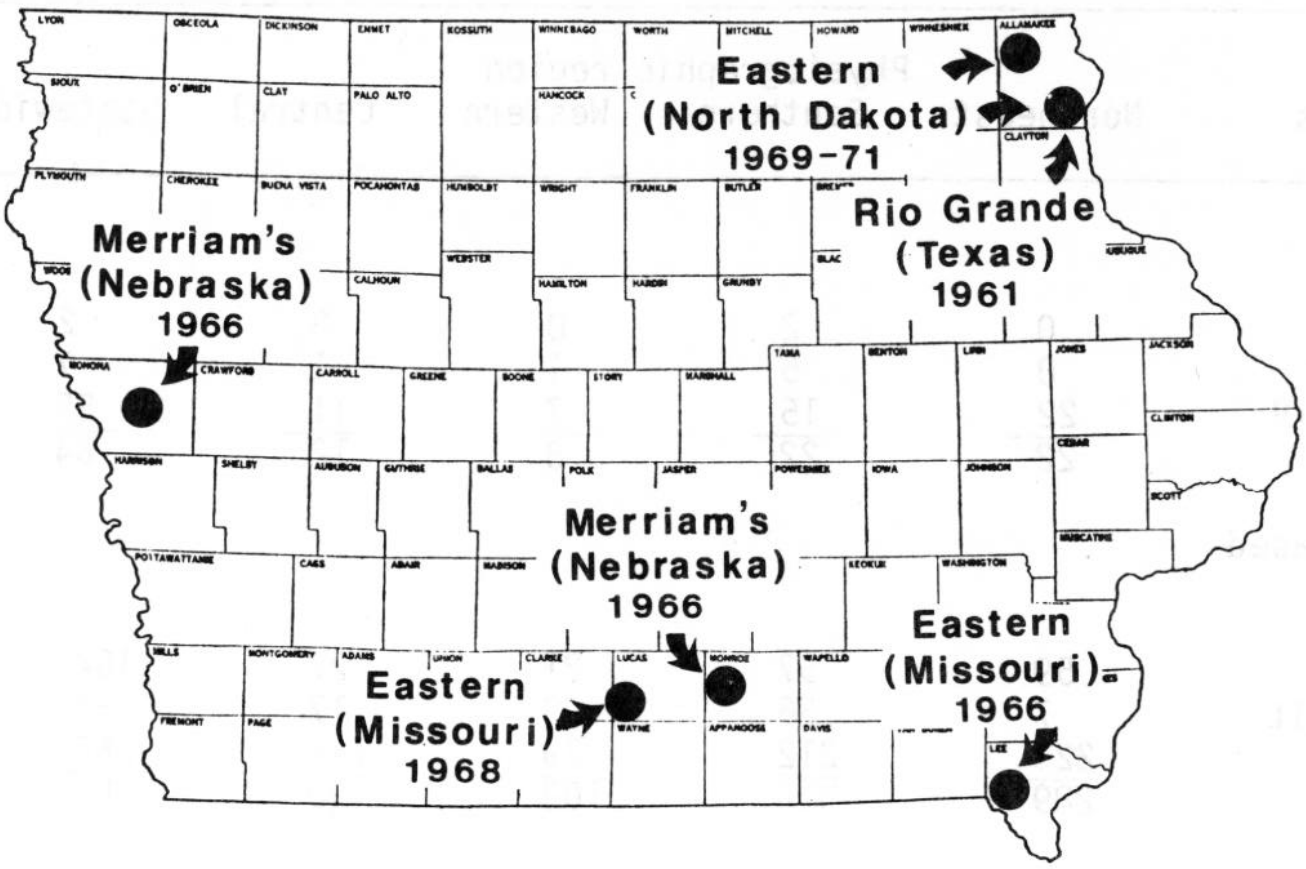


Fig.2. Early releases of wild-trapped turkeys of various subspecies imported from other states.

Releases of these game-farm and non-native subspecies failed. There is extensive literature detailing the failure of game-farm turkeys to establish viable wild populations (Bailey and Putnam 1979, Mosby 1975, Wunz 1973, and Leopold 1944). Greater precipitation and lower temperatures during the brood season than *M.g. intermedia* poults could tolerate were implicated as possible limiting factors on Rio Grande populations (Wigal 1973). Winter flocks of Merriam's turkeys spent considerable time feeding in farmlots and may have been susceptible to poaching, poultry diseases or domestic animal predation (Klonglan et al. 1970). Neither subspecies was apparently adapted to Iowa’s oak-hickory forests.

Eastern Subspecies Releases

The first releases of eastern wild turkeys were made in Shimek State Forest (Lee County) in 1965-66 and in Stephens State Forest (Lucas County) in 1968 (Fig. 2). The response of turkey populations at both sites was phenomenal; survival of released adults, reproduction and poult survival all appeared to be excellent (Klonglan et al. 1970). Turkey numbers at both sites were estimated at 400-500 birds in the vicinity of the state forests alone by 1974; they had begun dispersing onto surrounding privately owned timbers within 3 years of their release and inhabited about 10,000 ha of forest at each site within 7 years.

Table 1. Status of Iowa's eastern wild turkey restoration program, 1979.

| Release sites | Physiographic region Northeast | Southern | Western | Central | Statewide |
|---|---|---|---|---|---|
| Chronology | | | | | |
| 1965-68[a] | 0 | 2 | 0 | 0 | 2 |
| 1970-74[b] | 0 | 5 | 1 | 1 | 7 |
| 1975-79[a,b] | 22 | 15 | 7 | 11 | 55 |
| Total | 22 | 22 | 8 | 12 | 64 |
| Turkeys released | | | | | |
| Males | | | | | |
| Adult | 59 | 57 | 21 | 27 | 164 |
| Subadult | 7 | 56 | 3 | 17 | 84 |
| Hens | 223 | 212 | 79 | 146 | 660 |
| Total | 289 | 325 | 103 | 190 | 907 |
| Status | | | | | |
| Successful | 11 | 15 | 3 | 4 | 33 |
| Promising | 2 | 2 | 4 | 6 | 14 |
| Uncertain | 9 | 5 | 0 | 2 | 16 |
| Unsuccessful | 0 | 0 | 1 | 0 | 1 |

[a] Release stock from Missouri.

[b] Release stock from southern Iowa.

By 1970 it was obvious that, if the wild turkey could be restored to Iowa, the native *M.g. silvestris* was the most likely candidate. As a second attempt to restore turkey populations in northeast Iowa, turkeys of supposedly *M.g. silvestris* lineage were obtained from North Dakota and released along the Upper Iowa River in 1969 and in Yellow River State Forest in 1971 (Fig. 2). Although these birds survived and reproduced, winter populations on the state forest built to a peak of only 140 turkeys in 1974 and declined thereafter. Apparently they had adapted to North Dakota's more open, brushy habitats and could not acclimate themselves to northeast Iowa.

Sufficient turkey numbers had developed in Shimek and Stephens Forests by 1971 to supply transplant stock for other potential turkey habitats in Iowa. Winter rocket-netting efforts began in that year at both sites and have supplied 455 wild-trapped turkeys for 30 release sites during 1971-1979. In addition, a trade of adult ringnecked pheasants for turkeys initiated with the Missouri Department of Conservation in 1975 has brought in 452 turkeys for 34 sites. By March 1979, 930 *M.g. silvestris* strain wild turkeys had been released at 64 sites around the State at a rate of approximately 10 hens and 3 adult gobblers per site (Table 1, Fig. 3).

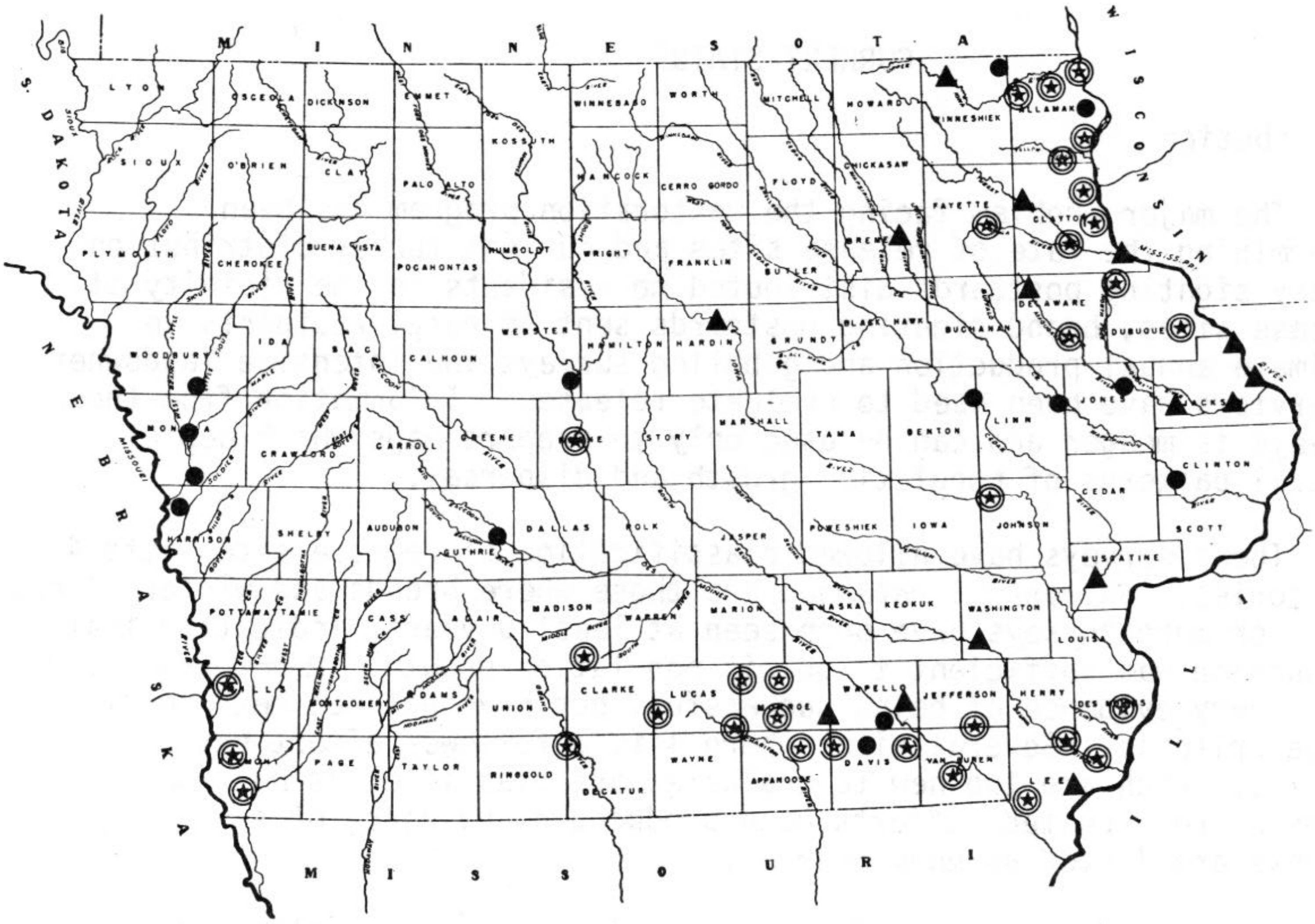


Fig. 3. Distribution and fate of eastern wild turkey release sites (◎ = Successful; ● = Promising; ▲ = Uncertain).

Initial release sites were chosen in the largest, most mature timber tracts available, generally in state-owned forests or parks. By 1974 evidence had accumulated that turkeys were dispersing from these stands and maintaining viable populations in adjacent, scattered tracts of poorer quality timber. The stocking strategy was revamped at that time and subsequent release sites were selected with just 2 principles in mind-potential for dispersal from the site and "block stocking." Block stocking was devised to speed up dispersal in areas with-widely scattered timber stands. Under this concept, all potential release sites within a habitat block (county size or smaller) were stocked at the same time even though some sites were of low quality. This allowed maturation of turkey populations at all sites in the shortest possible time and permitted opening the entire area to turkey hunting within 5 years. Under the old system, several widely scattered sites developed huntable populations concurrently, necessitating complicated hunting zones to protect new release sites or population voids between established sites. As many as 5 releases have been made in a single county, some sites no more than 6 km apart, where habitat blocks have been highly interrupted by agricultural lands (e. g. the Western region, Fig. 3).

# CURRENT STATUS

## Distribution

The major problem facing the restoration program has been determining the fate of release sites and current turkey distribution. Turkey sighting postcards distributed to residents in the vicinity of release sites, brood sighting postcards sent to rural residents to estimate annual production and gobbling surveys and intensive landowner interviews have been used to evaluate releases. Information from these surveys is meager and can be used only to prepare maps which depict general patterns of population growth and dispersal.

These surveys have allowed classification of release sites into 4 categories. *Successful releases* are those where broods and winter flocks of 20 or more turkeys have been seen at least 3 years, indicating that production was sufficient to permit population growth. *Promising sites* give every evidence of being successful, but have not yet met one of these criteria. Several sites where little follow-up effort has been made, or which are too new to evaluate, are classified as *uncertain.* Sites where repeated efforts have produced no evidence of surviving turkeys are listed as *unsuccessful.*

Growth and dispersal of turkey populations at new release sites have been impressive. More than 70% of the 64 releases are now classified as successful or promising, and only 1 has been a definite failure (Table 1, Fig. 3). Turkeys at 1 release in the Western region in 1976 were apparently heat stressed during transportation and disappeared shortly after their release. A subsequent stocking at that site is currently listed as promising. Virtually all of the sites in the Southern and Northeast regions old enough to evaluate have been classified as successful. The remaining promising and uncertain sites are primarily in the Western and Central regions, or are less than 3 years old.

Turkey populations are currently established on 93,400 ha of forest land, most in the Southern region where original stockings were made, and have recently expanded into an additional 181,300 ha (Table 2). *Established populations* are defined as those where turkeys have dispersed throughout all available timber and have been present several years, although peak densities may not have been attained. Regional distributions of established and expanding populations reflect the more recent stockings in the Western and Central regions, but suggest that turkeys are well on their way to inhabiting a quarter million hectares of forest. Perhaps an additional 157,000 ha, most in the central river systems, will eventually be occupied by dispersal from existing releases or will require further stocking. If these unoccupied habitats prove suitable, potential turkey habitat in Iowa may approach 432,000 ha, or 79% of remaining forests, far in excess of original projections.

Table 2. Current distribution of eastern wild turkey populations, 1979.

| | Physiographic region | | | | |
|---|---|---|---|---|---|
| | Northeast | Southern | Western | Central | Statewide |
| Area (1000's ha) occupied by: | | | | | |
| Established popn. | 6.0 | 69.9 | 7.7 | 9.8 | 93.4 |
| Expanding popn. | 70.0 | 63.6 | 5.9 | 41.8 | 181.3 |
| | 76.0 | 133.5 | 13.6 | 51.6 | 274.7 |
| Potential unoccupied habitat (1000's ha): | | | | | |
| To be filled by dispersal | 19.5 | 7.1 | 16.7 | 57.2 | 100.5 |
| Remaining to be stocked | 5.1 | 13.6 | 6.7 | 31.1 | 56.6 |
| Total | 24.6 | 20.7 | 23.4 | 88.3 | 157.1 |
| Total potential habitat (1000's ha) | 154.2 | 100.6 | 37.0 | 139.9 | 431.7 |
| % of total forest | 85 | 80 | 79 | 74 | 79 |

## Hunting Seasons

Spring, gobblers-only hunting seasons were initiated in 1974. The small size of timber stands and their interrupted nature make it possible for hunters to saturate local habitats and result in severe interference problems between hunters, particularly on the few small public hunting areas available. Restricted hunting zones with 2 or 3 seasons per zone have been utilized to control hunter density and maintain a semblance of hunting quality. Maintenance of a quality hunting experience was chosen as a primary management objective to protect novice turkey hunters until a hunting tradition could be established. Hunters apply for a $15 hunting license for 1 season in 1 zone and are selected randomly. Harvests and hunter success rates are estimated from a 2-stage questionnaire mailed to all license holders (Little 1978).

Table 3. Synopsis of Iowa's wild turkey hunting seasons, 1974-79.

| Year | No. zones | Seasons per zone | Days per season | No.[a] licenses | Estimated[b] harvest | Statewide[c] success rate |
|---|---|---|---|---|---|---|
| 1974 | 3 | 2 | 7,7 | 450 | 113±18 | 29% |
| 1975 | 3 | 3 | 7,7,9 | 825 | 142 ± 4 | 19% |
| 1976 | 4 | 3 | 5,7,11 | 975 | 190 ± 11 | 23% |
| 1977 | 4 | 3 | 7,7,11 | 1,005 | 215 ± 8 | 24% |
| 1978 | 6 | 3 | 7,7,11 | 1,815 | 366 ± 40 | 23% |
| 1979 | 8 | 3 | 7,7,11 | 3,156 | 688 ± 32 | 24% |

[a] Total licenses issued for all zones.

[b] Harvest ±95% confidence interval.

[c] Confidence intervals (95%) on success rates were ±l% in each year.

Table 3 summarizes hunting season formats and the growth in hunter numbers and gobbler harvests. Three zones were opened initially--2 around Stephens and Shimek Forests in the Southern region and 1 in the Northeast region. Just 14 gobblers from remnant populations of North Dakota and Texas transplants were shot in the Northeast zone after 2 years and hunter success rates averaged a relatively low 6%. This zone was closed in 1976, restocked with *M.g. silvestris* transplants and reopened to hunting in 1979 after only 4 reproductive seasons had passed. The area open to hunting in southern Iowa has increased 10-fold in 6 years as turkey populations grew and dispersed, until virtually all of the region was hunted by 1979.

For the 6-year period, 8,226 licenses were issued, 11% of the license holders did not hunt and 1,714 turkeys were bagged (Table 3). After a 2-year adjustment period, statewide hunter success rates based on active hunters stabilized at 23-24%.

Statewide totals do not reflect the magnitude of hunter success which has been achieved in many areas. Hunters have not dispersed themselves uniformly in spite of the zone system. In 1979, for example, cumulative hunter densities (3 seasons combined) averaged 0.9 hunters per $km^2$ of forest in the Southern region, but one-third of the total turkey habitat in 4 counties open to hunting the longest sustained two-thirds of the hunting pressure and harvest, in spite of good turkey populations present in other counties. Hunter densities in these 4 counties ranged from 1.8 to 4.9 hunters per $km^2$ of timber, while hunter densities on public hunting areas were even higher (9.4-10.1 per $km^2$). Harvests have ranged from 1.1 to 3.5 turkeys per $km^2$ on public hunting areas, but just 0.2-0.4 per $km^2$ on private lands under these levels of hunting pressure. In the 4 counties which sustained the greatest hunting pressure, however, gobbler harvests on private lands ranged from

0.5 to 1.3 per $km^2$ of forest. Therefore, I believe that overall harvests could have been greater in most years if hunters had dispersed more uniformly.

Much of the Southern region has been hunted only 1 or 2 years and harvests and success rates have probably not yet stabilized. The Shimek and Stephens Forests have been hunted 6 years, yet still averaged 15-31% hunter success and 1.4-3.2 gobblers harvested per $km^2$ of forest in 1979.

## Populations

Best estimates of turkey densities are based on extrapolations of spring harvest estimates and intensive studies on Stephens State Forest. In traditional eastern turkey range spring gobbler hunting seldom harvests more than 10% of the previous fall's population or 40% of the gobbler segment (Lewis and Kelley 1973, Mosby 1968). Mark-recovery studies and winter track counts at Stephens Forest suggest Iowa gobbler harvests also fall in this range.

Winter populations at Stephens Forest ranged from 23-31 turkeys per $km^2$ of forest the past 2 years and harvest estimates suggest populations have been stable at this level for at least 6 years. This is 1 of our best turkey areas and may not represent turkey densities rangewide. Harvest levels throughout the turkey range indicate fall populations of 3 turkeys per $km^2$ of forest throughout the Southern region. The unequal distribution of hunting pressure makes this a minimum estimate. Sightings of winter flocks of 50-100 turkeys are not uncommon in the Southern region and are beginning to be reported from the Northeast and Western regions as well. I believe that turkey densities conservatively average 8-12 per $km^2$ throughout established range and perhaps half that in areas where populations are expanding. Using these estimates, Iowa probably has 15,000-20,000 turkeys statewide, most in the Southern region, with an increase to 30,000-50,000 possible if the remaining uninhabited areas are successfully colonized and support turkey populations of this density.

These estimates are for recently established populations. If the widely recognized "irruptive phenomenon" occurs, populations may eventually stabilize at somewhat lower levels. The Stephens and Shimek Forest populations have been established at least 12 years, yet still retain high turkey densities, suggesting that eventual turkey population levels may not be substantially lower than current estimates.

# DISCUSSION

In spite of a good deal of research, specific habitat requirements for the eastern wild turkey are not well understood. Five factors are often-cited as being important: 1) Extensive timber stands, with 2,000-20,000 ha commonly stated as the minimum management unit, 2) low human populations, with protection from poaching stated or implied,

3) timber management which results in 40-60% in mast-producing age classes, 4) availability of water, and 5) maintenance of 5-10% of the unit in forest openings (Dickson et al. 1978, Bailey 1973, Dellinger 1973, Donohoe and McKibben 1973, Holbrook 1973, Hillestad and Speake 1970, Chapters 9-14 *in* Hewitt 1968, Lewis 1964, Kozicky and Metz 1945, Mosby and Handley 1943).

Iowa clearly does not have extensive or well-managed timber stands in the classical sense. Few stands of 400 ha remain, most stands are widely scattered, and grazing and lack of management greatly reduce their quality as wildlife habitat. Yet turkeys have adapted well to these habitats and apparently thrive wherever timber exists. Population densities, spring gobbler harvests per unit of habitat and hunter success rates are among the highest reported for the eastern subspecies and are much higher than are generally found in the majority of eastern turkey range (Lewis 1975 and 1968, Bailey 1973, Donohoe and McKibben 1973 and 1970, Holbrook 1973, Bailey and Rinnell 1968).

The other 4 criteria are more nearly met. Most of Iowa’s forests are in mast-producing pole or sawtimber stages, though not managed properly for maximum mast production. The turkey program has been immensely popular; in spite of much human-turkey contact, landowners have been protective of turkey flocks during the first critical years after release and poaching has been limited until large concentrations develop, at which time its impact is probably minimal. Nearly all potential turkey habitat is associated with drainage systems and permanent sources of water. The size and configuration of timber stands tends to maximize the amount of edge between timber and crop- and pasturelands. Turkey broods and adults have ready access to insect-rich grasslands and waste agricultural grains for supplemental winter foods. Food habits studies in traditional habitats have not indicated that turkeys, rely heavily on agricultural foods (Eaton et al. 1970, Korschgen 1967, Schmenitz 1956), but studies in Minnesota (Porter 1977) and preliminary results of research in southern Iowa indicate an extensive reliance on waste corn by overwintering turkeys.

A review of the literature suggests that Iowa’s experience with eastern turkeys in limited forest habitats is not as surprising as it appears. Schorger (1966), summarizing reports of historic turkey populations and habitats, stated "Under primitive conditions, trees were not essential to (eastern) turkeys except for roosting." He emphasized that the greatest turkey densities, similar to those found in southern Iowa today, were found in open hardwoods with mast-bearing trees. Closer to the Iowa scene, Schorger related "... from Van Buren County to the Missouri River. The small groves dotting the 'boundless plains' were swarming with wild turkeys." This area is the heart of Iowa’s Southern region. More recently Bailey and Rinnell (1968) reported turkey populations surviving in small woodlots in western New York. Commenting on this development, they stated " . .. it is apparent that we are on the threshold of great advances in extending the range of the turkey... ." The Iowa experience is perhaps just another step in the extension of this range.

I believe it is likely that the modern concept of extensive requirements for the eastern wild turkey developed in the early part of this century when turkeys were able to escape persecution and survive only in the most remote and inaccessible areas. Eventually turkey habitat became equated with extensive forest lands. Our studies are beginning to suggest that perhaps a 50:50 mixture of timber and open lands is better eastern turkey habitat than extensively forested areas. Certainly if carrying capacity is a measure of habitat quality, Iowa's mixed forest-farmland habitats are of superior quality.

Some reservations must be stated before Iowa's restoration program can be labeled an unqualified success. The Northeast, Western and Central regions have not yet demonstrated that they can support long-term populations comparable to the Southern region. Porter (1978) has shown that severe winters may be a limiting factor in Northeast Iowa. The biggest question, however, and thus the key to the ultimate success of the program, seems to be the Central river systems, since all releases in the other regions are extremely promising. Nor has the question of minimum timber requirements been resolved. We are currently stocking areas as small as 400 ha to determine their suitability, which will take several years to determine. Whatever the lower limit is, it is certainly less than we originally expected.

As the stocking is completed in the next 5 years, spring and fall hunting opportunities should increase as turkey populations mature. Perhaps as many as 10,000 hunters could be accomodated twice a year and still maintain quality hunting if they learn to disperse.

In the long term the picture is much more clouded. Permanent timber loss continues at the rate of l-2% annually as the demand for agricultural land escalates. Economics now make it feasible to clear land that was once thought inviolate. If this trend continues, the wild turkey could well face a decline on private lands as disastrous as that of the last century, but this time with little hope of recovery. Whatever the long-term prospects, Iowa's restoration program has already demonstrated that the eastern wild turkey is more adaptable than previously thought possible and that potential habitat may be more widespread than is currently recognized.

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# USE OF GOBBLING COUNTS TO MONITOR THE DISTRIBUTION AND ABUNDANCE OF WILD TURKEYS

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Abstract. Two forms of call count surveys were used to monitor populations of wild turkeys (*Meleagris gallopavo*) in Minnesota during 1973-1979. An intensive survey involving daily counts of gobblers during 1 April-15 June was conducted annually on 2 routes. An extensive survey was conducted annually on 9-17 different routes, on 2 days during peak gobbling periods. Data obtained defined the phenology of gobbling activity in this region and provided estimates of changesin distribution and abundance during the early growth phases of introduced turkey populations. An assessment of the reliability of data showed that extensive surveys were able to monitor range expansion and trends in population growth. A combination of extensive and intensive survey data provided good estimates of relative abundance and correlated well with spring hunter success rates ($r=0.99$, $p < 0.02$). Costs of the survey were less than 100 man-days per year. Applications of the survey data to turkey management in Minnesota are presented.

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Wildlife populations are dynamic and often change dramatically from 1 year to the next. Effective harvest management of such populations requires reliable information gathered at frequent intervals. Frequent, intensive inventory work is costly, however. Many agencies, therefore, have sacrificed some reliability or precision in inventory data gained through intensity of survey for greater frequency of survey.

A common, low cost survey technique is the call count. This has been applied to a variety of species, including wild turkeys (Scott and Boeker 1972, Bevill 1975). However, the ability of call counts to provide data useful for management of turkeys has been questioned because of the difficulties associated with estimating precision.

Gobbling count surveys were initiated in Minnesota in 1973 to monitor gobbling phenology and the expansion in newly established populations of wild turkeys. Reported here are the techniques used in this program, data obtained to date, and an assessment of the ability of the data to provide reliable information concerning the distribution and abundance of turkeys.

We acknowledge the assistance of all those who have aided in this survey, particularly A. Berner, N. Gulden, J. Lightfoot, K. Mattson, B. Neil, G. Nelson, D. Porter and R. Tangen.

## STUDY AREA

The study area included approximately 2000 $km^2$ in the southeastern Minnesota counties of Houston, Wabasha and Winona. The region is characterized by a rugged physiography covered by a patchwork of mature hardwood forest and agricultural land in a 60:40 distribution. There are approximately 2 km of roads for each 1 $km^2$ of land area.

Turkey populations in this area were derived from transplants of wild birds from Arkansas, Missouri, Nebraska and South Dakota. Transplants were made during 1964-1973 and resulted in the establishment of 2, geographically distinct populations. These populations occupied areas designated here as the "northern" and "southern" ranges. In the fall of 1978 these populations were estimated to occupy approximately 1700 km2.

## METHODS

Gobbling count surveys were conducted along county and town roads. Each survey route included 9-12 listening positions. Positions were selected to maximize the area of survey, and minimize the degree of survey overlap and the driving time between positions. All surveys were begun at 40 minutes before sunrise. At each listening position observers stood 10-20 m behind their vehicle and listened for 4 minutes. Data recorded included the number of gobbles, the number of distinct groups of gobbling males, the general location of the groups, and any interfering noise.

Two survey systems were employed. An "extensive survey" system was used to monitor distribution and relative abundance of the 2 populations. This system involved 9-17 routes that were run during the peak of spring gobbling activity. All of these routes were traversed simultaneously, and only during favorable weather conditions (low wind and no rain). Routes were run twice during a 5 day period in opposite directions. The routes selected for survey changed annually as the population expanded. Maximum effort was concentrated on the periphery of the ranges of the populations.

An "intensive survey" was used to monitor gobbling phenology and relative abundance. Two routes were located near the centers of the populations and were run on a daily basis, 1 April-15 June. These routes included 9 listening positions. The starting positions on the routes were rotated each day to reduce the systematic variation incurred because of the pronounced gobbling activity peak around sunrise (Beville 1975). Intensive survey counts were conducted under all weather conditions.

The potential of these survey systems to provide reliable information concerning the distribution and abundance of turkeys was evaluated at 3 levels of resolution: 1) the ability to document the presence or absence of turkeys in an area, 2) the ability to document gross differences in population abundance between years and between different parts of the range, and 3) the ability to identify the magnitude of the differences in abundance, spatially and temporally. Evaluations were based on comparisons of data obtained from gobbling count surveys with those acquired by a variety of other methods during a study of the demography and behavior of turkeys in southeastern Minnesota (Porter 1978).

## RESULTS

Intensive gobbling count data were available for 1975-79 on 1 route in the northern range and 1977-79 on 1 route in the southern range. To define the general phenology of gobbling activity in this region, data for these routes were pooled by 5-day intervals. All analyses were based on the average number of groups of gobblers heard per day. Data showed gobbling was most pronounced during April 13-28. The exact timing of the primary peak in gobbling activity was quite consistant among years and between ranges and occurred during the third or fourth week in April 88% of the time. A secondary peak was observed during May in 4 of 5 years. The maximum daily count of groups of gobblers on these routes ranged from 12-28 between ranges and years.

Extensive survey data were obtained on a total of 22 different routes during 1973-79. Nine routes were included in the survey in 1973 when the 2 populations were relatively small. More routes were added in subsequent years as the populations expanded. Data obtained from these surveys were summarized as: 1) the percent of listening positions on a route at which gobbling was observed, and 2) the average number of groups of gobblers heard per listening position (Table 1). Data showed considerable variation among routes each year and among years for a given route. The percent of listening positions with gobbling activity ranged from 0-100 and the average number of groups of gobbling males heard per position ranged from 0-1.88. Pooling data for all routes in each the northern and southern ranges showed distinct differences in the amount of gobbling activity between the 2 ranges during some years.

Despite this variation, several patterns were apparent in the data. First, once turkeys were observed on a particular route, they were rarely absent in subsequent years. Second, the percent of active listening positions and the average number of groups of gobblers consistently showed increases during the first 2 or 3 years after the initial observation of gobbling activity. Finally, exceptions that occurred in these patterns corresponded directly with very severe winters when heavy mortality was suspected. These patterns suggested that the survey data could be used to monitor changes in the abundance as well as distribution of turkeys in this region.

Table 1. Gobbling count survey results for southeastern Minnesota, 1973-79. Given are the average % of stops at which gobbling activity was heard (% Active) and the average number of gobblers or groups of gobblers heard per stop (Gg/stop) for northern and southern ranges. N indicates number of routes.

| | N | Northern Range | | N | Southern Range | |
|---|---|---|---|---|---|---|
| | | % Active | Gg/stop | | % Active | Gg/stop |
| 1973 | 6 | 22 | ——— | 3 | 22 | ——— |
| 1974 | 5 | 26 | ——— | 4 | 32 | ——— |
| 1975 | 4 | 18 | 0.11 | 6 | 24 | 0.31 |
| 1976 | 6 | 26 | 0.53 | 5 | 40 | 0.60 |
| 1977 | 3 | 54 | 0.63 | 8 | 40 | 0.84 |
| 1978 | 6 | 43 | 0.59 | 9 | 24 | 0.39 |
| 1979 | 7 | 26 | 0.42 | 7 | 15 | 0.14 |

To critically examine the ability of the gobbling count survey to establish the presence or absence of turkeys in a given area 3 techniques were used. First, data obtained via surveys at recent transplant sites (not included in Table 1) were examined. These sites were each stocked with 3 or 4 adult males. Examination of data obtained at these releases represented a test of the ability of the survey to detect turkeys at low density. Males were observed in 3 of 3 cases during the extensive gobbling count period. Second, during 1977 and 1978, the results of the extensive survey were compared with spring dispersal data obtained via radiotelemetry. Good correlation was observed in the range expansion documented by the 2 methods. The only exception was an instance in which telemetry showed females to be present in an area 1 year before males were detected by the gobbling count survey. Finally, the survey data were compared with public observation reports. Surveys confirmed reports by the public in areas where survey routes were not previously conducted and showed turkeys were present in some areas before public reports were received.

To evaluate the potential of the extensive survey at a higher level of resolution, documenting trends in population growth, survey data were compared with existing demographic data. Natality, mortality and dispersal data derived from more than 200 radio-tagged turkeys were used to model the populations in the northern and southern ranges. Modeling showed rapid growth in the population during 1975-77. The growth rate declined in 1978 and 1979, slightly in the northern range but very sharply in the southern range as a result of mortality associated with severe winter conditions (Porter et al. 1980). These changes in growth rate were documented by the gobbling survey and a variety of other data (Porter 1978).

The use of gobbling count survey data to determine the magnitude of differences in population abundance required still greater resolution. To assess to ability of intensive surveys to provide this resolution, survey data were used to estimate spring population densities. These estimates were then compared with estimates made during the previous winter. Spring density estimates were obtained by calculating the product of the maximum number of groups of gobblers heard on 1 day during the spring and the average number of individuals in a group of males (as determined by visual observations of males through the spring). Winter density estimates were obtained by direct counts of individuals in all flocks known to winter in the area encompassed by the intensive surveys. These density estimates for-the 2 ranges (Table 2) during each of 2 years showed extremely high correlation (r=0.99, $p < 0.05$).

Table 2. Estimates of winter and spring population densities (birds/$km^2$) for wild turkeys in southeastern Minnesota.

| | Winter | Spring |
|---|---|---|
| 1977 | | |
| Northern Area | 6.6 | 6.5 |
| Southern Area | 6.7 | 6.4 |
| 1978 | | |
| Northern Area | 13.4 | 16.7 |
| Southern Area | 6.8 | 5.9 |

r = 0.997
P < .05
Winter density = 2.697 + 0.640 (spring density)

Extensive survey data did not provide maximum count information and thus the potential of this technique to provide an index of abundance appeared low. However, the counts obtained on intensive routes on the dates of the extensive survey were calculated as a percentage of the maximum peak count obtained during the spring on the intensive routes (Table 3). Counts obtained on the extensive routes were adjusted proportionally by this percentage to predict the peak count that would have been expected on each extensive route.

Predicted peak values were averaged for all extensive routes in the northern and southern ranges, and compared with the number of gobblers harvested in the two ranges during 1978 and 1979 (Table 4). Analysis showed excellent correlation (r=0.994, $p < 0.02$).

Table 3. Relationship between peak turkey gobbling counts observed during the spring and counts observed on the dates of the extensive surveys for routes of the intensive survey in southeastern Minnesota.

| Peak Count During Spring | Count on Dates of Extensive Survey | Percent of Peak |
|---|---|---|
| 1.88 | 1.44 | 77% |
| 1.44 | 1.38 | 94% |
| 2.77 | 1.39 | 50% |
| 3.11 | 1.56 | 50% |
| 2.55 | 1.27 | 50% |
| 1.33 | 0.44 | 33% |
| 1.22 | 0.61 | 50% |

Table 4. Predicted mean peak gobbling counts (Gg/stop) and hunter success for routes occurring within hunting zones in southeastern Minnesota.

| | Predicted Peak | Hunter Success |
|---|---|---|
| Northern Hunting Zone | | |
| 1978 | 2.45 | 28% |
| 1979 | 1.57 | 17% |
| Southern Hunting Zone | | |
| 1978 | 1.69 | 17% |
| 1979 | 1.09 | 11% |

$r = 0.994$
$P < .02$
Hunter Success = -0.0303 + 0.125 (Predicted peak count)

## DISCUSSION

A variety of factors influence the data obtained with gobbling count surveys. Among the more prominent are: 1) weather conditions as they affect gobbling activity or observer ability, 2) varying intensity of gobbling activity through the spring and during the morning hours on any given day, 3) interfering sounds, and finally, 4) the density of the turkey population in the area. Previously, the variability added by the first 3 factors has appeared to be of such magnitude that the ability of the data to reflect primarily variations in population density has been in doubt.

While absolute control cannot be obtained for all of these factors, some measure of control is possible as demonstrated by the use of surveys in Minnesota. Evaluations of data obtained using these techniques indicated that gobbling count surveys can be used to monitor range expansion, trends in population growth and the magnitude of differences in population abundance.

Most of the control of extrinsic variation was accomplished by the standardization of techniques, careful selection of listening positions and appropriate weather conditions for the surveys, and the large sample of simultaneous survey records. However, an equally important feature aiding control in the survey was the combination of intensive and extensive surveys. Timing of the extensive surveys was important to monitoring the distribution of turkeys. The greatest potential for detecting the presence of turkeys seemed to be during the primary peak of gobbling activity. The intensive surveys defined the phenology of the primary peak, providing a framework of dates within which the extensive survey could be conducted. Further, extensive surveys conducted within this framework could be used to monitor trends in population growth. When the extensive surveys were conducted in conjunction with intensive surveys they provided estimates of the magnitude of the differences in population abundance between years and between areas the size of counties (approximately 900 $km^2$). The potential for estimating differences on a finer scale (e.g. 30 $km^2$ areas) using these techniques is difficult to assess with the Minnesota data. However, the strong relationship between winter densities and those determined via the intensive survey suggest that the system may contain the necessary precision.

Information derived from both the intensive and extensive surveys is currently being used to manage turkeys in Minnesota. The distribution of turkeys in the state still includes less than 2000 $km^2$ and hunting demand is high (less than 10% of the applicants received spring permits in the first 2 hunting seasons). Survey data are used to monitor range expansion and population growth in peripheral areas and ultimately to set hunting zone boundaries. An abbreviated intensive survey is used to document survival and early growth in new transplants. Phenology of gobbling activity is used to time spring hunting seasons to coincide with the primary peak. Finally, data are being used to document the growth and expansion of introduced populations of turkeys in this region.

The original intention of the gobbling count surveys conducted in Minnesota was to provide the most reliable information possible for minimal cost. Costs have been held to less than 100 man-days/year for the extensive and intensive surveys combined. The data obtained with this combination of surveys have proven to be of much better quality than was anticipated. The results of this evaluation suggest that the gobbling count survey can be a cost effective means of monitoring changes in the distribution and abundance of turkeys.

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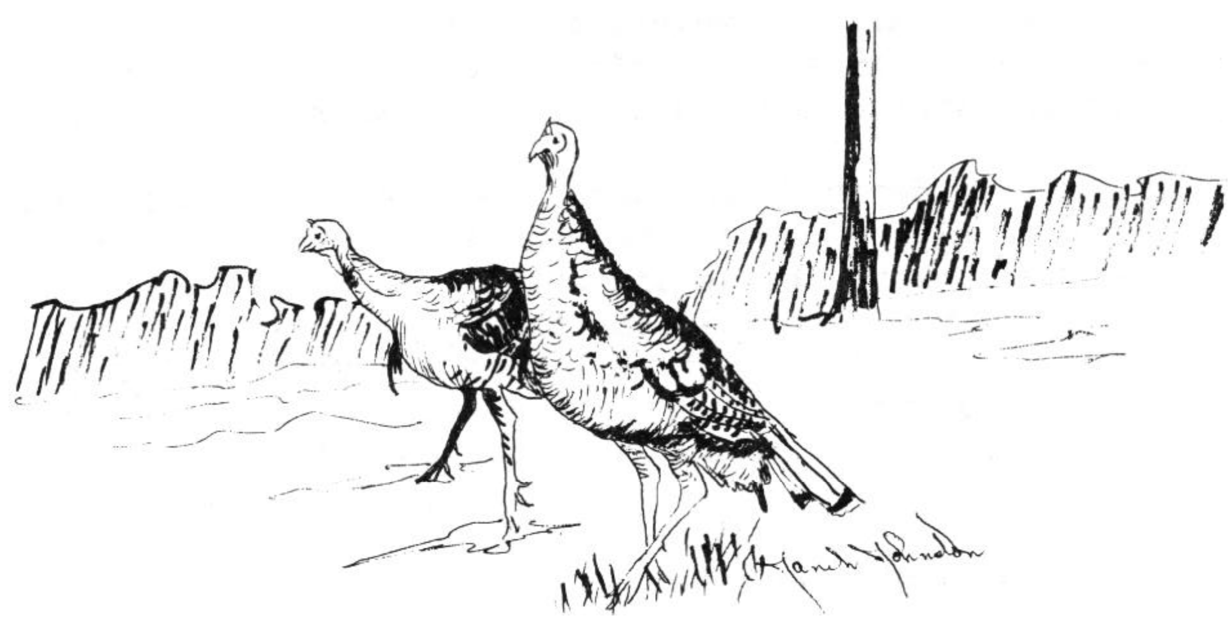

# TURKEY BROOD SURVEY IN PENNSYLVANIA AS IT RELATES TO HARVEST

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Abstract: Statewide wild turkey (*Meleagris gallopavo silvestris*) brood surveys have been conducted for 26 years in Pennsylvania. We found that brood census data could be simplified and improved by using only one number, the number of poults and hens seen, instead of the more complicated comparisons of poults per hen ratios and the number of broods. Although the brood counts have always appeared to be reliable indicators of populations, the more recent evidence of a positive correlation with statewide harvest estimates gives greater support to the counts as potential predictors of fall harvest.

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The problem of counting the numbers of wild turkeys caused Mosby (1967) to write, "There is no reliable method of determining the total numbers present in any large area except in the case of the Rio Grande turkey which has unique flocking habits and congregates at isolated woods for roosting". Thus the best one could hope for in dealing with the population dynamics of the eastern subspecies of wild turkey on a statewide basis would be an index that might indicate trends.

Bag checks to obtain population structure information were discontinued in Pennsylvania when evidence of bias was found in the sex and age ratios obtained, and also because this after the fact information appeared to have little use in planning future hunting seasons. Needed instead were statewide indices that would provide current population information in time for setting fall hunting seasons and bag limits. With this goal in mind, a turkey reproduction census was begun in 1953, which provided 26 years of data for this evaluation.

We thank H. A. Roberts, who compiled the brood survey results from 1953 to 1958, R. L. Snyder who conducted the harvest estimate survey from 1965 to 1970, and all Game Commission field officers who collected turkey brood observation data.

## METHODS

One hundred and thirty-six Pennsylvania Game Commission field officers submitted records of turkey broods they and their deputies observed during their routine duties and patrols from 1953 to 1970. After 1970 the field districts involved were reduced to 96 when the counts were discontinued in counties with no or low wild turkey populations and where game farm turkeys were still released.

Initially, broods seen during the months of May through August were tallied. In 1961 the count period was extended through September, and the May tallies were discontinued in 1970. Brood sighting records were kept each June, July, and August during the entire 26 year period covered by this study.

Prior to 1964, the statewide turkey harvest was estimated from the opinion of field officers. From 1965 to 1970 harvest estimates were based on data from an in-season postal survey. The survey yielded daily success rates. These rates were applied to man days of hunting effort, obtained from the first (1965) mail survey, to determine the harvest estimate.

In 1971, a post-hunt random mail survey was initiated to provide data for current harvest estimates. A 3% sample of hunters (approx. 40,000) is selected annually to receive this mail survey questionnaire. About 40% of the selected hunters have returned completed questionnaires each year. Total usable sample from the current mail survey is about three times as large as that obtained from the 1965 to 1970 period.

Statewide brood survey data were compared to harvest data using linear correlation analysis.

## RESULTS

### Brood Data

The number of hens accompanying broods, which should also represent the approximate number of individual broods seen, varied from 332 to 831, and averaged 526 per year, during the 26 year period. The number of poults seen varied from 2,187 to 8,395 and averaged 4,173. The observed poults per hen ratios ranged from 6.20 to 10.10. The 26 year average brood size was 7.85 with a standard deviation of 0.90.

Observations graphed in Fig. 1 show a close relationship between poult and hen counts ($r = 0.92$, $P<.01$). Consequently they were combined into one number to simplify comparisons for this evaluation.

The brood counts show a general decreasing trend from the early years of the brood surveys to a low point in 1968 (Fig. 1). This reflected the boom and decline period after turkeys had spread into and occupied the vast northcentral range. Since 1968 there has been an increasing trend on a statewide basis because an additional 7,700 $km^2$ has been occupied by turkeys.

The proportions of the poult observations by months, portrayed in Table 1, were 2.6% in May, 18.1% in June, 26.0% in July, 25.8% in August, and 27.5% in September. The proportions for the number of hens seen with broods each month were similar. Brood size decreased at a uniform rate from 8.90 poults per hen in May to 7.78 in September.

The May counts were discontinued in 1970 because of the small amount of data collected.

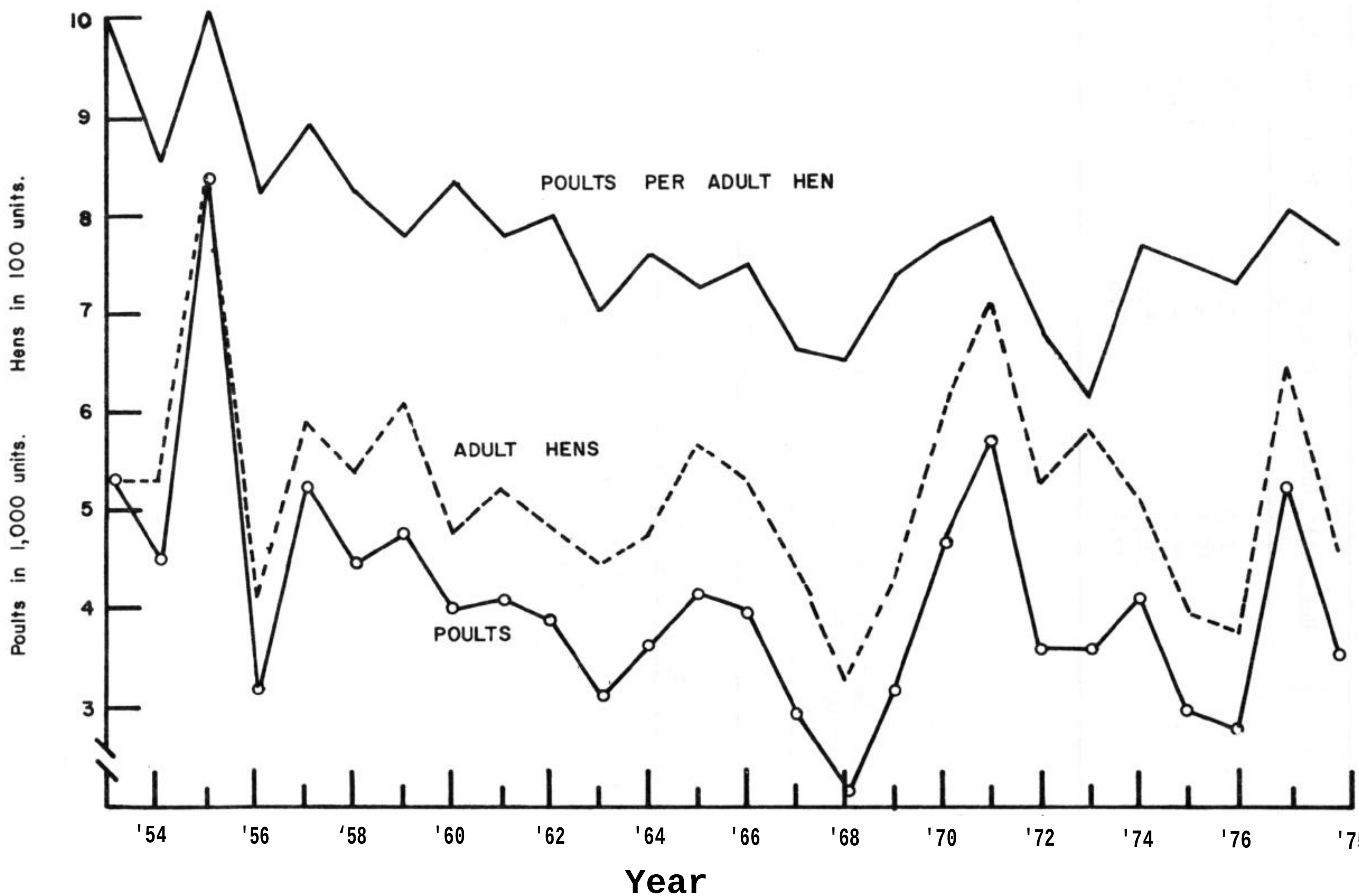



Fig. 1. Trends for 26 years of wild turkey brood survey data in Pennsylvania

Table 1. Proportions of brood observations by month.

| | Hens with Broods (%) | Poults Seen (%) | Poults per Hen |
|---|---|---|---|
| May | 2.3 | 2.6 | 8.90 |
| June | 17.1 | 18.1 | 8.27 |
| July | 25.5 | 26.0 | 7.97 |
| August | 26.0 | 25.8 | 7.75 |
| September | 29.1 | 27.5 | 7.78 |

Table 2. Statewide turkey harvest estimates and brood survey data for the 1965 through 1978 period.

| | | Total Poults and Hens Seen | | | | | |
|---|---|---|---|---|---|---|---|
| Year | Estimated Harvest | June | July | August | Sept. | Total | July+August |
| 1965 | 35,000 | 1,377 | 1,680 | 1,714 | 1,846 | 6,617 | 3,394 |
| 1966 | 50,000 | 1,178 | 1,612 | 1,762 | 1,905 | 6,447 | 3,374 |
| 1967 | 35,000 | 742 | 1,599 | 1,080 | 1,247 | 4,668 | 2,679 |
| 1968 | 28,000 | 525 | 884 | 1,110 | 1,261 | 3,735 | 1,994 |
| 1969 | 32,000 | 917 | 1,343 | 1,402 | 1,647 | 5,309 | 2,745 |
| 1970 | 36,000 | 1,270 | 1,885 | 2,184 | 2,302 | 7,641 | 4,069 |
| 1971 | 43,925 | 967 | 2,458 | 3,100 | 4,254 | 10,779 | 5,558 |
| 1972 | 35,984 | 882 | 1,414 | 1,905 | 2,196 | 6,397 | 3,319 |
| 1973 | 32,839 | 1,269 | 1,665 | 1,308 | 2,080 | 6,322 | 2,977 |
| 1974 | 36,000 | 926 | 1,899 | 1,900 | 1,937 | 6,662 | 3,799 |
| 1975 | 30,733 | 584 | 1,399 | 1,475 | 1,751 | 5,209 | 2,874 |
| 1976 | 37,018 | 625 | 1,341 | 1,255 | 1,211 | 4,432 | 2,596 |
| 1977 | 38,229 | 1,311 | 2,121 | 2,544 | 2,058 | 8,034 | 4,665 |
| 1978 | 32,035 | 1,034 | 1,137 | 1,862 | 2,144 | 6,177 | 2,999 |

## Comparisons with Harvest Data

The total hens and poults seen during the months of June, July, August and September for the years 1965 through 1978 followed the trend in harvest estimates (Table 2). Only harvest data for 1966 appear to deviate significantly from the overall pattern. The larger turkey harvest in 1966 may have been the result of an extra week of turkey hunting in the primary turkey range in northcentral Pennsylvania. This extra week coincided with bear season which attracts about 150,000 hunters into that section of the state. Therefore, we compared poult and hen totals to harvest estimates which both included and excluded the 1966 data.

Significant linear correlations were obtained between the poult and hen totals for June through September observations and the harvest estimates for the 1965 through 1978 period ($r = 0.56$, $P<.05$). When the 1966 data were excluded from the analysis, a much stronger correlation was obtained ($r = 0.80$, $P<.01$). About 64% of the variation observed in the harvests was also observed in the poult and hen totals with the 1966 data excluded.

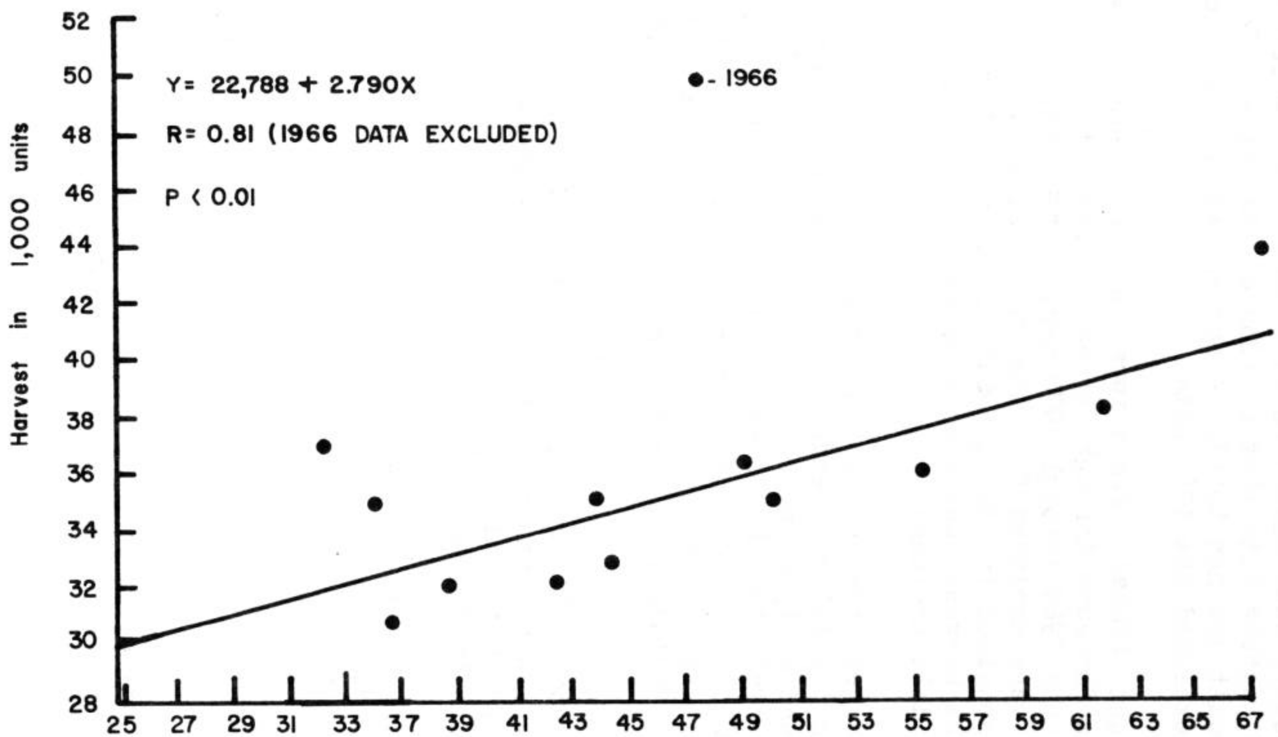
Poult and hen observations collected in September are not useful for evaluating population trends in Pennsylvania because they cannot be collected and analyzed prior to the start of the fall turkey season; therefore, we evaluated the potential use of June through August data as a trend indicator. For the 14 year period, these data were significantly correlated to harvest changes ($r = 0.59$, $P<.05$). When the 1966 data were excluded, a correlation coefficient of 0.81 ($P<.01$) was obtained.

When hen and poult counts, collected in the two month periods of July and August, were compared with harvest estimates, an r value of 0.58 ($P<.05$) was obtained for all 14 years. An r value of 0.86 ($P<.01$) was obtained when the 1966 data were excluded.

Since both correlations were significant for the June, July, and August data combined, these data are adequate to evaluate population trends. Fig. 2 shows the harvest plotted against the June, July, and August observations. The regression equation in Fig. 2 is for all years except 1966.

# DISCUSSION

The few references in the literature relating to statewide brood counts differed from our study in the conduct of the census or the type of information analyzed. In Virginia, Schultz and McDowell (1957) studied poult per hen ratio data and concluded that grouping dissimilar populations in an attempt to obtain usable information on a statewide basis is apparently not practical. Shaw (1973) found that a standardized roadside survey may be a useful indicator of Merriam's turkey population trends in Arizona. In Nebraska, Menzel (1975) found no relation




Hens and Poults in 100 units

Fig. 2. The relationship of Pennsylvania turkey harvest estimates to total hens and poults seen in June, July and August, 1965 to 1978 (1966 data excluded).

between the average number of Merriam's turkeys seen on established survey routes and hunter harvest.

We recognize that the type of census evaluated in our study lacks the standardization that special census assignments over fixed routes can give. But the fact that even the researchers working daily in Pennsylvania's turkey habitat see very few broods, except those baited or with radio tagged hens, strongly suggests samples from a standardized special census effort would be too small to be meaningful.

The brood counts have always appeared to be credible indicators of populations, even on a regional basis. The positive correlation between brood data and harvest gives more credence to the counts as predictors of fall harvest.

This evaluation also showed the brood surveys could be considerably simplified and improved. The June, July and August counts should be continued, but September counts are too late to be included in management decisions. June counts could also be eliminated, but they probably will be needed to increase sample size on a regional basis. Hens and poults should be counted together as one number which will simplify recording and analyzing data.

The results of our analysis indicate that the total hens plus poults reported by field officers in Pennsylvania during their summer brood surveys is significantly correlated to subsequent turkey harvests despite the fact that the survey is not standardized for effort. This suggests that the total hen plus poult survey data for the months of June, July, and August are reflecting annual changes in turkey populations. Thus, brood survey data in terms of total count could be useful for setting fall hunting seasons.

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# AN EXAMINATION OF FALL WILD TURKEY HUNTING STATISTICS FROM DIFFERENT ECOLOGICAL AREAS OF SOUTHWESTERN NEW YORK

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Abstract: Seven years' wild turkey population data, and ten years' fall hunting pressure, harvest and hunting success data from 87 towns open to hunting in southwestern New York were summarized and normalized. These data were subjected to simple linear regression analysis along with ecological subzone and land use data. Statistically significant relationships were noted between late summer wild turkey population densities and fall hunting pressure, harvest and hunting success; and between ecological subzone and fall hunting pressure, harvest and hunting success. Hunting pressure, harvest and hunting success were found to vary between eco-subzones. These subzones could be the basis for formulation of Wild Turkey Management Units. Hunting regulations would vary from Unit to Unit, reflecting different range potentials and levels of hunting pressure. Recommendations for the direction of future work are made.

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Wild turkeys (Meleagris gallapavo silvestris) reappeared in New York during the late 1940's following a century of absence. The birds were noted in southern Cattaraugus County, having moved into the area from an expanding wild population in adjacent Pennsylvania. During the next decade, wild turkey populations became well established in Cattaraugus and adjacent counties. By 1959 the wild turkey population in Cattaraugus and Allegany counties was estimated to be approximately 1500 birds. That year the 2 counties were opened to hunting for 3 days in early October. One hundred seventeen birds are known to have been taken; the total kill was estimated to be about 250 birds. No attempt was made to quantify or to estimate hunting pressure. The area has been open to fall hunting ever since. Spring hunting began in 1968.

Today, as a result of trap and transfer efforts, wild turkeys have become established in almost all of New York's primary wild turkey range - nearly 50,250 $km.^2$. Approximately 28,490 $km.^2$ of this range, in all or portions of 30 counties, is now open to fall hunting. Fall seasons vary in length from 3 to 5 weeks. In recent years as many as 30,460 fall turkey hunters have expended 102,400 mandays of effort to harvest 1, 680 turkeys (J.P.R. W-81-R-25:I-16). Nearly all occupied range is now open to spring hunting for 4 weeks. In the spring of 1978 (the most recent year for which complete data is available) 12,330 hunters harvested 820 wild turkeys while expending 46,500 mandays of effort (J.P.R. W-81-R-26:I-6).

Prior to 1968 turkey hunting was open to all small game license buyers without restriction, or was handled by permit through Department of Environmental Conservation Regional Offices. In 1968 a statewide turkey hunting permit system was established, with permits available through the mail from DEC headquarters in Albany. This system incorporates mandatory reporting of hunting activity and success and has been described by DeGraff (1973) and DeGraff and Austin (1975). This paper is part of an effort to summarize and analyze all data collected with the system since it was established.

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STUDY AREA

The area under examination consists of the counties of Allegany, Cattaraugus and Chautauqua, in southwestern New York (Fig. 1). The area was selected because wild turkey hunters have had 20 years to develop turkey hunting interest and skill, wild turkeys have had 30 years to become established and reach carrying capacity, and the area displays ecological diversity.

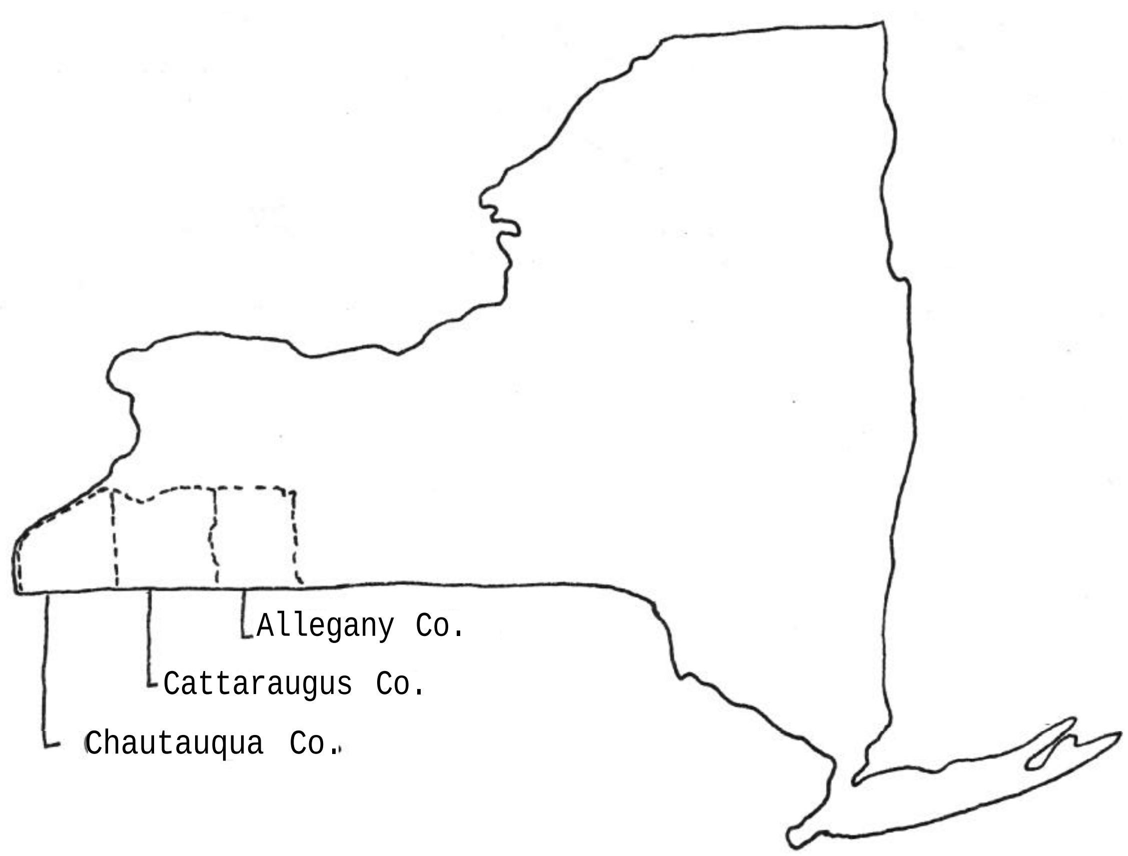


Fig. 1. Location of the study area in southwestern New York State.

The area encompasses a total surface area of approximately 9106 $km.^2$. Four distinct ecological subzones occur within the area - ranging from the flat, rather intensively farmed plain adjacent to Lake Erie, to the rugged, heavily forested hill country near the Pennsylvania border in Allegany and Cattaraugus counties (Fig. 2).

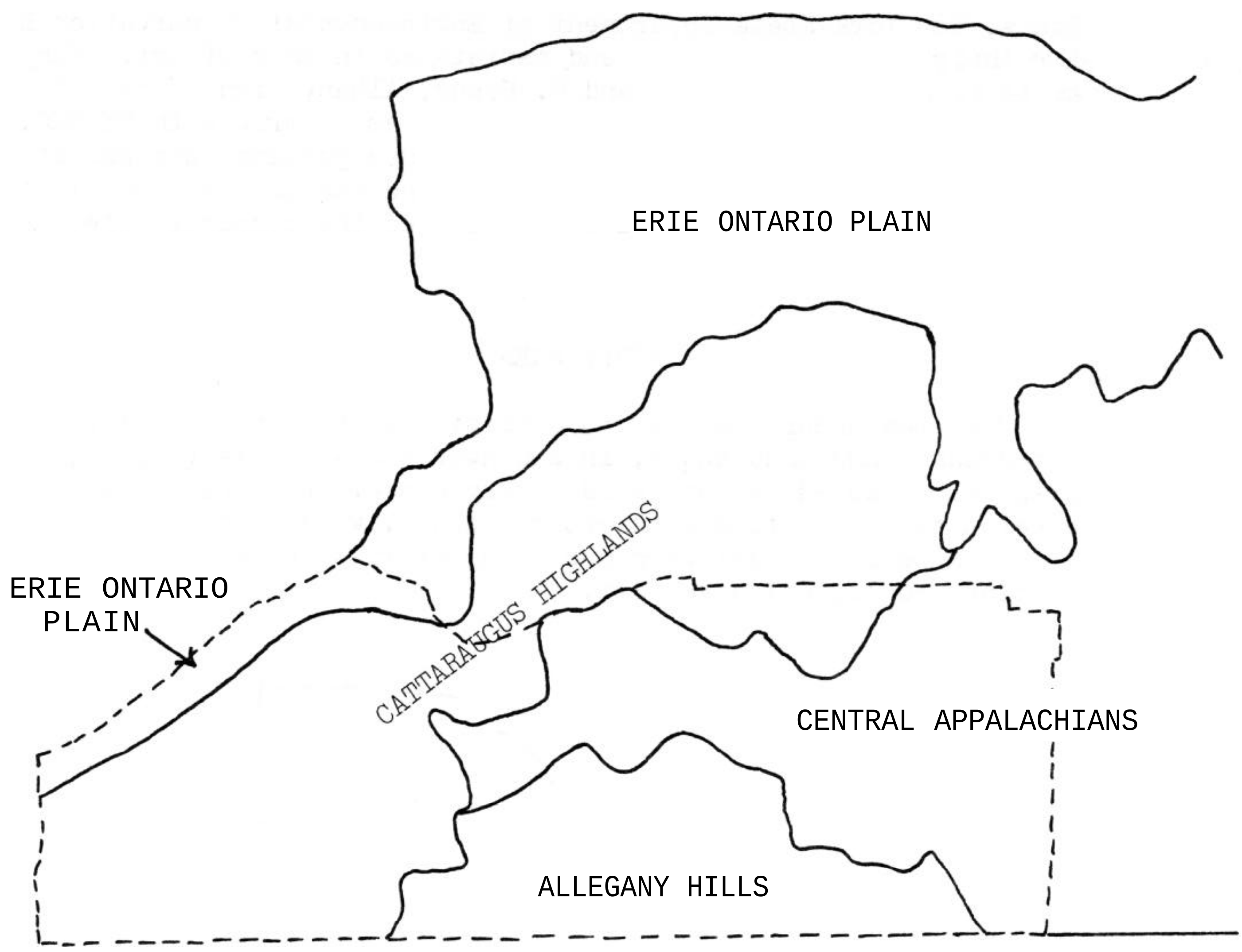


Fig. 2. Delineation of ecological subzone boundaries in southwestern New York State.

The Erie-Ontario Plain encompasses a land area of 703.68 $km.^2$. The terrain is flat to rolling and elevations range from 158 m. to 300 m. The growing season ranges from 160 to 180 days, and annual snowfall ranges from 100 cm. to 150 cm. Soils in this subzone are fertile, medium to fine textured, moderately well drained, on glacial till or lake sediments. About 41% of the land area is actively farmed, with fruit and dairy operations predominating. About 24% of the area is in brushland and 20% of the area is forested. The forest type is northern hardwoods, with a component of elm and red maple. The Cattaraugus Highlands encompass a land area of 3057.65 $km.^2$. The terrain is a dissected, upland plateau with elevations ranging from 300 m. to 600 m. The growing season ranges from 120 to 160 days and snowfall ranges from 150 cm. to 255 cm. annually. Soils are generally shallow, acid, moderately to poorly drained, on glacial till. Dairy farming is the main agricultural activity and approximately 37% of the land area is farmed. Twenty-one percent of the land area is in brushland, and 28% is forested. Northern hardwoods is the forest type with oaks occurring on south slopes and poor sites. The Central Appalachians encompass 3104.94 $km.^2$. The terrain is hilly with elevations ranging from 300 m. to 690 m. The growing season ranges from 100 to 140 days and annual snowfall ranges from 150 cm. to 255 cm. Soils are generally the same as in the Cattaraugus Highlands. Approximately 27% of the land area is actively farmed, with dairy operations predominating. About 29% of the area is in brushland, and 34% of the area is forested. The forest type is similar to the Cattaraugus Highlands with less occurrance of sugar maple and more oaks. The Allegany Hills encompass 2063.56 $km.^2$. The terrain is very hilly, with elevations ranging from 420 m. to 750 m. The growing season ranges from less than 100 to 120 days. Snowfall ranges from 100 cm. to 255 cm. annually. Soils are the same as the Cattaraugus Highlands. Twelve percent of the area is actively farmed. Again, the mainstay of agricultural activity is dairy operations. Fifteen percent of the area is in brushland and 52% of the area is forested. Northern hardwoods is the forest type with a greater occurrance of oaks than the other subzones.

These ecological subzones were delineated and described by N.R. Dickenson (J.P.R. W-162-R-2:II-1). This delineation follows natural boundaries and does not coincide with county or town (political) boundaries. Therefore each town in the study area was assigned to one of the 4 subzones, following the delineated boundary as closely as possible. Towns split by the ecological boundary were assigned to the subzone encompassing more than half the area of the town. Land use data were calculated for each group of towns (from Land Use and Natural Resources Inventory, 1969, N.Y.S. Office of Planning Services).

## METHODS

Wild turkey population estimates were made each summer, August through September from 1969 through 1975, in conjunction with preseason tagging studies conducted in a 492 $km.^2$ study area - the towns of Ellicottville, Franklinville, Great Valley and Humphrey - in Cattaraugus county (J.P.R. W-81-R-17 through 23:I-5). Two of these towns lie in the Central Appalachians and the other two in the Allegany Hills. These annual population estimates, summary counts of all wild turkeys observed in the study area (with duplications eliminated) throughout the 2 month observation period, were reduced to annual population density figures and subjected to linear regression analysis with annual fall harvest per $km.^2$, hunting pressure per $km.^2$ and hunting success information tabulated for the four towns.

Wild turkey harvest and hunting pressure data were taken from annual computer tabulations of hunting activity and success reported by wild turkey hunter permit holders. Because the data are used to make annual comparisons of wild turkey harvest and hunting pressure, and because reporting rates vary from year to year and between the three classes of permit holders - successfuls, unsuccessfuls, and did not hunts - the reported data were adjusted to a standard, hypothetical 100% reporting rate. Details concerning this process of calculating the harvest and hunting pressure can be found in annual Job Progress Reports W-81-R-17 through 19:I-2, and W-81-R-21 through 26:I-6.

Calculated wild turkey harvest and hunting pressure data for the 1969 through 1978 fall seasons were summarized for each of the 87 towns open to hunting in the study area. Total harvest (all turkeys taken during the 10 seasons) and hunting pressure (all mandays of effort expended during the 10 seasons), land area, forest area, brush area, agricultural area, and the appropriate ecological subzone code were stored in a computer file by town. The data were then manipulated to produce the following for each town:

1) mean fall harvest, <u>turkeys per $km.^2$,</u>
((total harvest ÷ 10)÷ Land area);

2) mean fall hunting pressure, <u>mandays per $km.^2$,</u>
((total. hunt. press. ÷ 10) ÷ land area);

3) fall turkey hunting success index, <u>mandays per turkey,</u>
(total hunt. press. ÷ total harvest);

4) percent forest (forest area ÷ land area);

5) percent brush (brush area ÷ land area);

6) percent agriculture (agriculture area ÷ land area); and

7) percent forest & brush ((forest area ÷ brush area) ÷ land area).

Mean fall harvest, hunting pressure and hunting success were calculated for the 3 county area and each ecological subzone. These data were then subjected to linear regression analysis.

# RESULTS

In the 4 town study area, late summer wild turkey population densities averaged 0.76 birds per km.$^2$, with annual figures ranging from 0.26 to 1.06. These figures are minimum population density figures since brood flocks are the most readily observable during the observation period; broodless hens and toms were only seen occasionally, Annual fall hunting pressure ranged from 9.72 mandays per km.$^2$ to 22.42 mandays per km.$^2$ and averaged 15.99. Annual fall harvest averaged 0.29 turkeys per km.$^2$ and ranged from 0.09 to 0.49. Fall hunting success varied from 111.16 to 39.39 mandays/turkey and averaged 63.72. Annual wild turkey harvest and hunting pressure were both highly correlated with annual wild turkey population densities (Table 1.).

Table 1. Linear, correlation coefficients between annual wild turkey harvest (turkeys/km.$^2$), success (mandays/turkey), hunting pressure (mandays/km.$^2$) and observed (late summer) wild turkey population density for 4 towns in Cattaraugus County between 1969 and 1975 (n=7).

| | Turkeys/ km.$^2$ | Mandays/ turkey | Mandays/ km.$^2$ | Observed turkey pop./km.$^2$ |
|---|---|---|---|---|
| Turkeys/km.$^2$ | 1.00 | — | — | — |
| Mandays/turkey | -0.89 | 1.00 | — | — |
| Mandays/km.$^2$ | 0.90 | NSS | 1.00 | — |
| Observed turkey pop.km.$^2$ | 0.89 | -0.83 | 0.87 | 1.00 |

NSS = Not Statistically Significant

For the 3 county study area, fall hunting pressure averaged 6.13 mandays/km.$^2$. Fall harvest averaged 0.10 turkeys/km.$^2$. The fall hunting success index was 60.01 mandays/turkey (Table 2). Hunting pressure and harvest were highly correlated for the 3 county area (Table 3) and in all four eco-subzones (Table 4).

Table 2. Comparison of fall wild turkey harvest, hunting pressure and hunting success by eco-subzone.

| Ecological subzone | Turkeys/ $km.^2$ | Mandays/ $km.^2$ | Mandays/ turkey |
|---|---|---|---|
| Erie Ontario Plain | 0.01 | 0.91 | 87.90 |
| Cattaraugus Highland | 0.05 | 3.27 | 65.80 |
| Central Appalachians | 0.13 | 8.02 | 63.23 |
| Allegany Hills | 0.17 | 9.30 | 53.48 |

Table 3. Linear correlation coefficients between harvest, hunting pressure, success, eco-subzone and cover type (n=87).

| | Turkeys $km.^2$ | Mandays $km.^2$ | Mandays turkey | Eco-subzone | % Forest | % Brush | % Agri. |
|---|---|---|---|---|---|---|---|
| Turkeys/$km.^2$ | 1.00 | - | - | - | - | - | - |
| Mandays/$km.^2$ | 0.94 | 1.00 | - | - | - | - | - |
| Mandays/turkey | -0.51 | -0.33 | 1.00 | - | - | - | - |
| Eco-subzone | 0.71 | 0.66 | -0.47 | 1.00 | - | - | - |
| % Forest | 0.51 | 0.48 | -0.39 | 0.66 | 1.00 | - | - |
| % Brush | 0.01 | 0.01 | 0.03 | 0.07 | -0.40 | 1.00 | - |
| % Agriculture | -0.59 | -0.55 | 0.41 | -0.75 | -0.68 | -0.04 | 1.00 |
| % Forest+Brush | 0.54 | 0.51 | -0.39 | 0.65 | 0.80 | -0.24 | -0.75 |

Table 4. Linear correlation coefficients between wild turkey harvest (turkeys/$km^2$) and cover types within four eco-subzones.

| Ecological subzone | Mandays/ $km^2$ | % Forest | % Brush | % Agri. |
|---|---|---|---|---|
| Erie Ontario Plain (n=6) | 0.98 | 0.87 | NSS | NSS |
| Cattaraugus Highlands (n=31) | 0.92 | 0.59 | NSS | NSS |
| Central Appalachians (n=32) | 0.87 | NSS | NSS | NSS |
| Allegany Hills (n=l8) | 0.90 | NSS | NSS | NSS |

NSS = Not Statistically Significant.

A highly significant, inverse correlation was found between hunting success and hunting pressure (Table 3). The relationship was significant in one of four eco-subzones (Table 5). No annual relationship was noted (Table 2).

A highly significant, inverse relationship between hunting success and harvest was found within the whole study area (Table 3). The relationship was significantly inverse in three of four eco-subzones (Table 5) and highly correlated (inverse) annually (Table 2).

Table 5. Linear correlation coefficients between wild turkey hunting success (mandays/turkey) and five variables, within four eco-subzones.

| Ecological subzone | Turkeys/ $km^2$ | Mandays/ $km^2$ | % Forest | % Brush | % Agri. |
|---|---|---|---|---|---|
| Erie Ontario Plain (n=6) | -0.82 | NSS | NSS | NSS | NSS |
| Cattaraugus Highlands (n=31) | -0.47 | NSS | NSS | NSS | NSS |
| Central Appalachians (n=32) | -0.36 | NSS | NSS | -0.40 | NSS |
| Allegany Hills (n=l8) | NSS | 0.56 | NSS | NSS | NSS |

NSS = Not Statistically Significant

Hunting success, harvest and hunting pressure were all found to correlate significantly (positively or negatively) with ecological subzone and two of three land use variables, percent forest and percent agriculture (Table 3).

## DISCUSSION

Wild turkey populations are thriving and expanding in New York because of an active wild trap and transfer program. Hunting seasons continue to be opened in new areas of the state as a result of these population establishment efforts. It is imperative that turkey harvest management efforts be carried out as actively and effectively as population establishment efforts.

The ecological principal that wildlife populations are a function of their environment is indirectly illustrated by the findings reported here. Both hunting pressure and harvest were shown to be significantly correlated with wild turkey population density; and both were shown to correlate significantly with ecological subzone.

That wild turkey populations, hunting, pressure and turkey harvest levels vary between ecological subzones has important management implications, since it facilitates establishment of hunting regulations suited to local conditions. Regulations can be tailored to increase hunting pressure, if so desired, as well as limit future growth in hunting pressure if necessary.

To a certain extent this is already being done, in a gross manner. Fall seasons in central and eastern New York are now two weeks longer than in southwestern New York where hunting pressure has been, and continues to be, higher than elsewhere in the state. These regulations could be much further refined and liberalized.

The average harvest, hunting pressure and hunting success figures resulting from this analysis can be used as guidelines to establish objectives for future turkey harvest management actions. Applying the average figures for the Central Appalachians, for example, indicates that this subzone alone might sustain a harvest of nearly 3000 birds annually, while offering sportsmen over 180,000 mandays of recreational opportunity. This would represent an increase of nearly 100% over the current statewide harvest and a 200% increase in hunting pressure. These figures are probably conservative estimates, since the maximum harvest and hunting pressure levels for a small portion of this subzone during the early 1970's were 3 to 4 times higher than average.

The highly significant relationships shown to exist between wild turkey population densities and turkey harvest, and hunting pressure and turkey harvest, demonstrates the necessity for collecting hunting pressure data each season. An increase in turkey harvest may be due to either higher wild turkey populations or higher hunting pressure. Lacking a systematic, statewide means of assessing wild turkey populations each year, the only alternative method of interpreting changes in the harvest is consideration of hunting pressure.

Much more work must be done before major changes in wild turkey hunting regulations are proposed. The results of this analysis, while interesting and useful, represent only a beginning. The same kind of analysis should be extended to all-parts of New York open to hunting. Spring harvest, hunting pressure and hunter success should be incorporated. Annual trends in harvest, hunting pressure and hunter success, should be documented. Assignment of towns to ecological subzones should be examined, particularly the border towns, and adjusted accordingly. Efforts should be made to identify and quantify wild turkey ecological range from available land use data. Productivity indices, both spring and fall, should be examined to determine if productivity varies between subzones.

When, these analysis are completed and useful information and techniques identified, Wild Turkey Management Units can be formulated based on their capability to sustain a harvest commensurate with the well being of the wild turkey population, while providing the hunter a satisfactory hunting experience and a reasonable expectation for success.

## LITERATURE CITED

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# PREDATION ON WILD TURKEYS IN ALABAMA[1]

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Abstract: Predation rates were measured on adult wild turkeys (*Meleagris gallopavo*) and turkey nests on 4 study areas in Alabama from 1973 through summer 1979. Poult losses were also measured on 3 areas. Most of the data were obtained through the extensive use of radio telemetry and a predator control experiment. Gobblers were seldom killed by predators. Mortality of hens due to predation varied among locations and seasons. Nesting season losses of hens could be high enough to seriously limit population increase. Poult losses were high with an average of 74.5 % being lost by 1 September. Most poult loss occurred during the first 2 weeks after hatching but the proportion of this loss caused by predation was difficult to determine. Some evidence suggests that predators play a major role in poult loss. The predator species was identified in many instances of predation on both birds and eggs. Data from dummy nests yielded additional information about nest predators. Management implications are discussed.

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Predation on wild turkeys has been the subject of much discussion in the past and turkey predators have been identified through food habit studies and observed cases of predation. Most investigators have concluded that losses of healthy adult turkeys to predators are rare (Hewitt 1967). Several workers have documented nesting failure of turkeys attributable to predators. Blakey (1937), Mosby and Handley (1943), Dalke et al. (1946), Wheeler (1948), McDowell (1956) and others have cited nest predation and have identified some of the predators. Davis (1959) conducted a study of the fates of 107 dummy nests in southern Alabama and found that 85% were molested by predators. Until the development of radio telemetry no technique was available that could yield adequate samples of the type of data needed to measure the loss rates of turkeys to various causes.

Recent research using radio telemetry (Williams et al. 1968, Hillestad 1973, Wright 1975, and others) indicated that turkey nest predation is sometimes high. Studies in Alabama (Speake et al. 1969, Hillestad 1973, Gardner 1972) suggested that nest predation or poult loss, or both, limited expansion and buildup of a turkey population over a 7-year period.

This paper presents data about adult turkey and nest loss rates due to predators on 4 Alabama study areas between 1973 and 1979. Loss rates of poults from 3 study areas were measured between 1975 and 1979. Data are also presented from an experiment where reproductive success was measured, attempts were made to reduce or prevent losses through predator removal, and to detect and measure an effect on annual turkey production between 1971 and 1975.

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[1]A contribution of the Alabama Cooperative Wildlife Research Unit, Auburn University Agricultural Experiment Station; Game and Fish Division of the Alabama Department of Conservation, the U. S. Fish and Wildlife Service and the Wildlife Management Institute cooperating.

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## STUDY AREAS

Data for this paper come from a total of 5 Alabama study areas that were used in telemetry studies measuring limiting factors on turkeys or effects of predator control, or both. Three of these areas are in the Lower Coastal Plain and have been previously described: Choctaw Bluff (Speake et al. 1975, Everett 1975), Fred T. Stimpson Sanctuary (Johnson 1970, Speake et al. 1975), and Scotch Management Area (Everett et al. 1979). One study area (Saco) is in the Upper Coastal Plain of east-central Alabama and has been described by Speake et al. (1975) and Lynch (1978). Data from a mountainous region of northern Alabama came from the Thomas study area which has been described by Everett et al.(1979).

Turkey populations were high at Choctaw Bluff (about 12.4 birds per $km^2$) during winter of the study period and even higher at Stimpson Sanctuary and Saco (Speake et al. 1975). Scotch Management Area supported a lower population which was estimated from sightings of marked birds at about 5.6 turkeys per $km^2$ in the fall of 1978 (Everett et al. 1979). Thomas study area supported a much lower turkey population density than the south Alabama areas during the period of study. Fall populations, estimated from flock counts and marked-unmarked ratios, for the falls of 1976 through 1978, respectively, were 0.7, 1.5, and 1.7 turkeys per $km^2$.

## METHODS

### Measurement of Adult Losses

Estimates of adult turkey losses were derived from a sample of 294 radio-instrumented birds from 3 of the study areas between 1973 and 1979. Turkeys were captured with alpha-chloralose treated baits (Williams 1966) or rocket-projected nets, instrumented, and released, in most cases, at the capture site. All except 68 of the turkeys which were at Choctaw Bluff in 1973 and 1974 had multi-purpose transmitters with solar cells and motion switches. Most also had mortality transmitters. Telemetry equipment and techniques employed in the equipment's use are described in detail by Everett et al. (1978). All radio instrumented turkeys were located at least twice weekly and more frequently during critical periods.

When a mortality signal was received and no movement was indicated, the bird was located and examined as quickly as possible to determine the cause of death before scavengers disturbed the carcass. The carcass was examined for tooth marks, talon marks, and gunshot wounds and the surrounding area examined for tracks, hair, and feathers to identify the probable cause of mortality. In each case the judgment about the probable cause of death was based on careful evaluation of field sign.

Loss rates were figured as a percentage loss to predators per month. The total number of turkeys transmitting at the first of the month minus any turkeys that had been released less than 10 days, was the base figure used. Recently captured turkeys were not counted to reduce possible bias due to the effects of capture and handling.

## Nest Losses

Nest predation rates from 4 study areas were based on a sample of 119 nests most of which were those of incubating instrumented hens that were under observation until their eggs hatched, were preyed upon, or deserted. Probable nest predators were determined from careful evaluation of field sign.

## Poult Losses

Overall poult losses were estimated from periodic counts of poult groups of 41 instrumented hens. In each case the number of eggs hatching was determined and periodic counts of the poult groups were made until 1 September or until they joined other poult groups. Weekly counts of poult groups after the first week or 10 days of hatching were attempted.

In 1979, at Thomas, 18 small poults of 6 instrumented hens were fitted with miniature transmitters. Data on causes of losses were obtained directly by close radio monitoring and observation during the 2-3 week life of the miniature transmitters.

## Effects of Predator Control on Reproductive Success

This experiment began in 1971 and continued through 1975 to evaluate the effects of nesting season control of egg-eating animals on wild turkey reproductive success. The principal study area was Choctaw Bluff with Stimpson Sanctuary being used as a check area in 1974 and 1975.

Control was with strychnine alkaloid injected chicken eggs, live cage traps, steel leg-hold traps, and shooting. An attempt was made to remove as many predators as possible from the treatment area which varied in size from a low of 1,879 ha in 1973 to a high of 4,471 ha in 1972 and 1975. In each year except 1975 (when trapping was started the previous November) predator control began in February and continued into May or early June until trapping success became very low and eggs were no longer being taken. The eggs were placed in groups of 3 at selected stations distributed over the entire treatment area. Usually a small piece of odorous meat or fish was deposited with the eggs to attract animals. Stations were usually 0.32 km apart, marked, and numbered. The fate of the baits was checked at weekly or shorter intervals and fresh baits were placed where needed. To identify the animals eating the eggs, weekly or more frequent searches for carcasses were made around bait stations.

During the course of the study, modifications were made in location of the treatment and check areas (Fig. 1) so that any natural differences in nesting and rearing range would be minimized and to conform with landowner wishes. During 2 years the treatment area was about doubled in size in an attempt to increase the effect. In 1971 the treatment area (Area A) and the check area (Area B) were adjacent. Areas A and B were combined into one large treatment area in 1972 but control efforts were not as intensive as they had been during 1971. A new check area (Area C) separated from Areas A and B by the Alabama River was used in the summer of 1972 for poult:hen counts. In 1973, Area C was eliminated because of transportation problems and the intensity of predator control was greatly increased on the treatment area (Area B that year). The check area in 1973 was Area A. In 1974 treatment and control areas were to be reversed but control appeared to have been so effective the previous year (almost no predator sign could be found in Area B) that a new check area (Area D) was established several kilometers away at Stimpson Sanctuary and predator control was carried out on Area A but both Area A and B were considered the treatment area. In 1975 intensive predator control was carried out on both Area A and B and the Stimpson Sanctuary (Area D) was again the check. In only 1 year (1973) had the check area previously been a treatment area.

Each year a 24.1 km route for counting turkeys (to obtain poult:hen ratios) was set up to run through the major habitat types of the treated area and the check area. The routes were run 2 or 3 times weekly (depending on availability of manpower and vehicles) from the first week in June through August. Turkeys seen were recorded as either hens, gobblers, poults, or sex and age unknown. Ages of poults were estimated when possible (Nixon 1962). The effect of the control effort was assessed by comparing poult:hen ratios.

## RESULTS

### Adult Losses

Gobblers were only rarely killed by predators (Table l), all such incidents involved sub-adults. Three were killed in September by bobcats (*Lynx rufus*), 1 in December by a golden eagle (*Aquila chrysaetos*), and 1 by a gray fox (*Urocyon cinereoargenteus*) in March. Two additional unsuccessful golden eagle attacks on gobblers were witnessed at Choctaw Bluff.

Hens were subject to a low monthly predation rate for most of the year except during the nesting and early brooding season (April, May and June) when the rate was considerably higher (Table 1, Fig. 2). Identification of hen predators was not possible in 19 cases but in 12 cases the following agents were judged to be responsible: bobcat 6, gray fox 3, dog (*Canis familiaris*) 2, and golden eagle 1. In addition, 1 uninstrumented

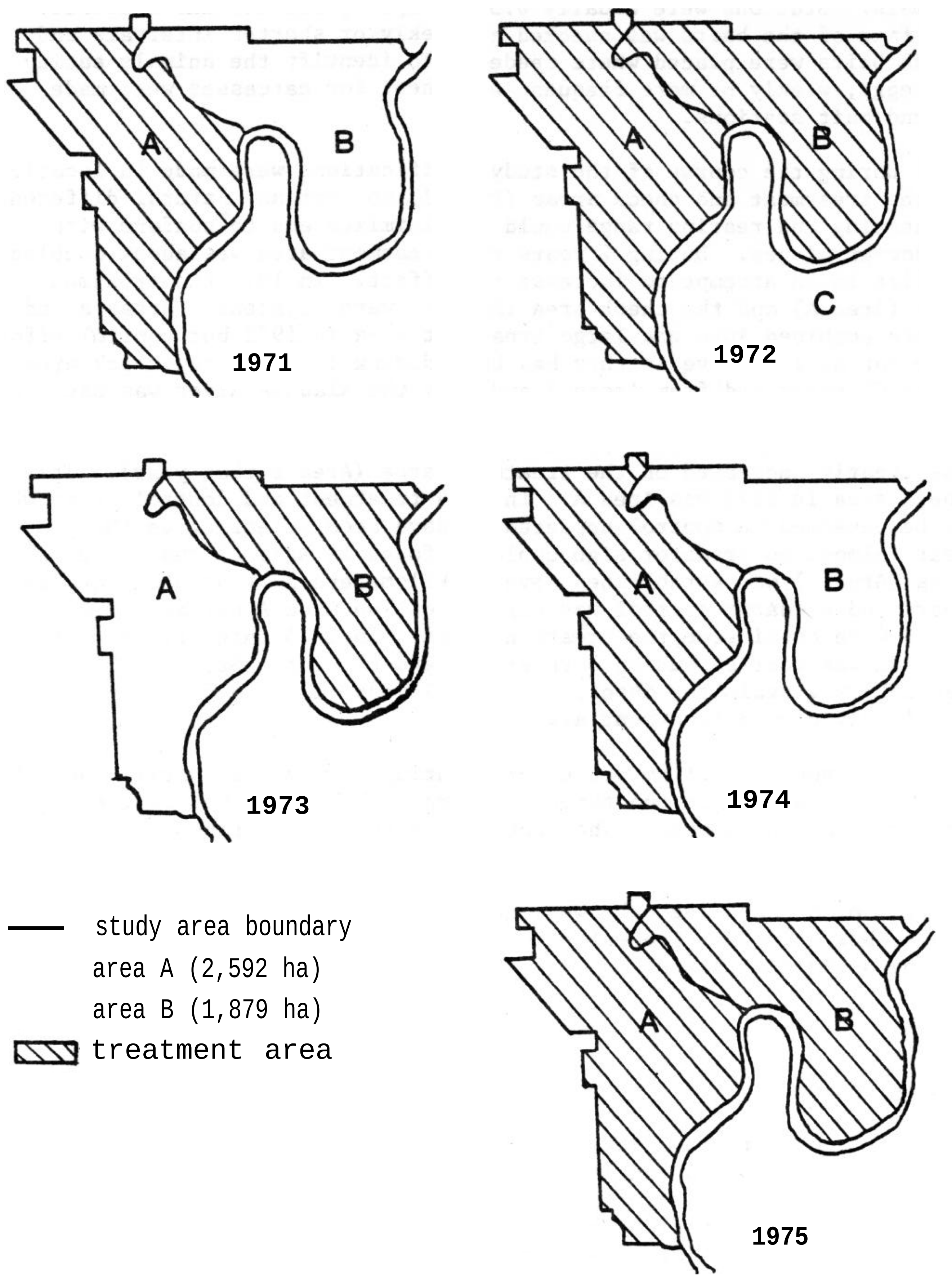


Fig. 1. The Choctaw Bluff study area in Alabama divided into treatment and check areas 1971-73. In 1974 and 1975 treatment areas are as shown. The check area was several miles away (not shown).

Table 1. Monthly mortality rates of instrumented wild turkeys to predation at 3 Alabama study areas (1973-79).

| Study area | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hens | | | | | | | | | | | | |
| Choctaw | 22[a] | 20 | 119 | 108 | 95 | 66 | 42 | 35 | 24 | 24 | 24 | 22 |
| Bluff | 0 | 0 | 0.8 | 0.9 | 2.1 | 4.6 | 0 | 2.9 | 0 | 0 | 0 | 0 |
| Scotch | 7 | 7 | 32 | 33 | 28 | 25 | 24 | 7 | 7 | 14 | 9 | 7 |
| | 0 | 0 | 0 | 0 | 3.6 | 0 | 0 | 0 | 0 | 21.4 | 0 | 0 |
| Thomas | 48 | 52 | 84 | 83 | 75 | 62 | 57 | 50 | 38 | 61 | 55 | 51 |
| | 2.1 | 0 | 0 | 2.4 | 9.3 | 4.8 | 1.8 | 0 | 2.6 | 0 | 1.8 | 2.0 |
| Areas | 77 | 79 | 235 | 223 | 198 | 153 | 123 | 92 | 69 | 99 | 88 | 80 |
| combined | 1.3 | 0 | 0.4 | 1.4 | 5.1 | 3.9 | 0.8 | 1.1 | 1.5 | 3.0 | 1.1 | 1.3 |
| Gobblers | | | | | | | | | | | | |
| Choctaw | | | 28 | 24 | 12 | 10 | 9 | 2 | | | | |
| Bluff | | | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| Scotch | 10 | 9 | 9 | 9 | 6 | 6 | 4 | | 1 | 13 | 13 | 12 |
| | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 8.3 |
| Thomas | 31 | 35 | 60 | 55 | 45 | 44 | 41 | 40 | 37 | 47 | 36 | 32 |
| | 0 | 0 | 1.7 | 0 | 0 | 0 | 0 | 0 | 8.1 | 0 | 0 | 0 |
| Areas | 41 | 44 | 97 | 88 | 63 | 60 | 54 | 42 | 38 | 60 | 49 | 44 |
| combined | 0 | 0 | 1.0 | 0 | 0 | 0 | 0 | 0 | 7.9 | 0 | 0 | 2.3 |

[a]Top number indicates samples size (includes turkeys transmitting at beginning of month minus those that had been released for less then 10 days) and lower number indicates percent loss by predation.

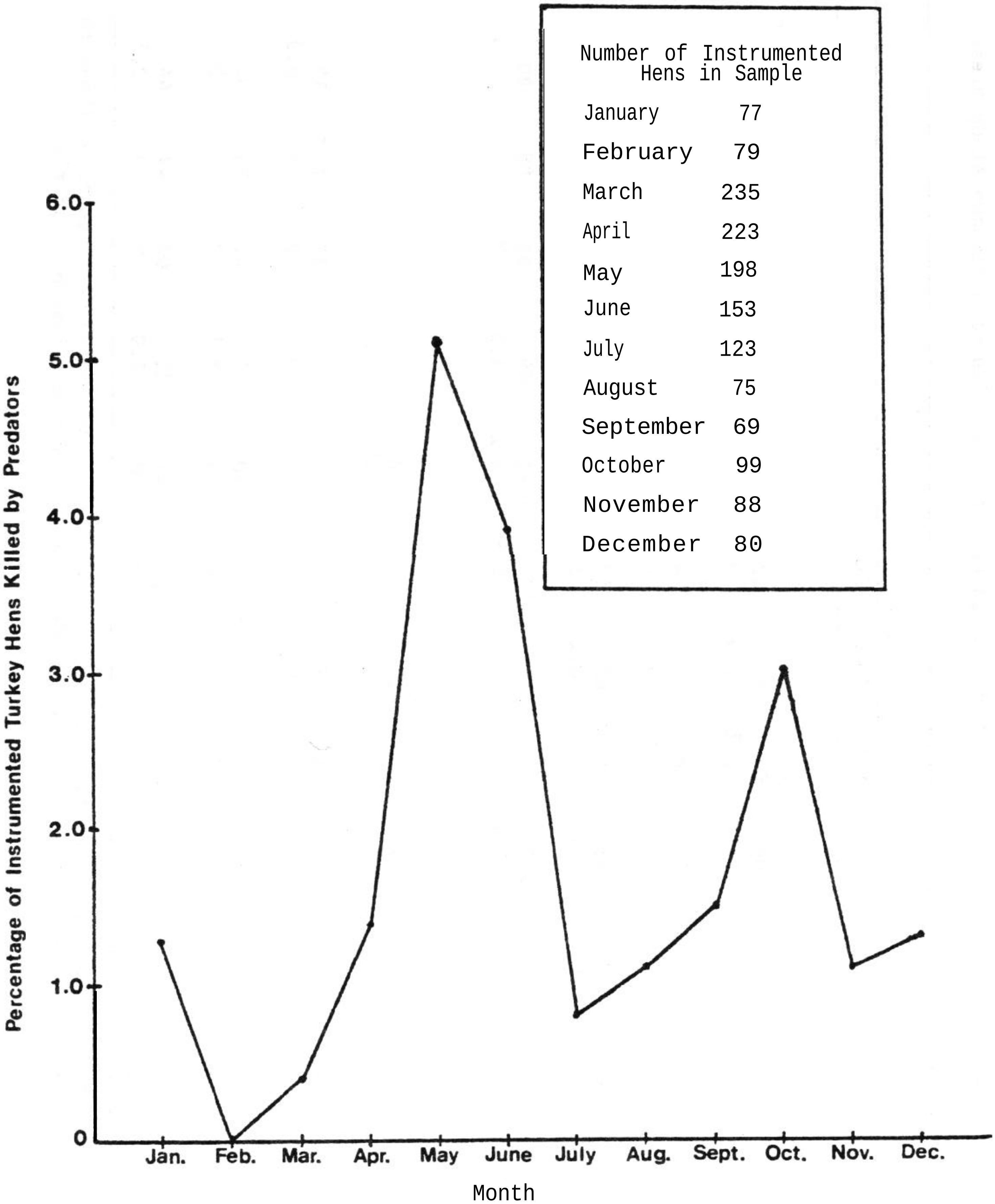


Figure 2. Monthly loss rate of instrumented wild turkey hens to predators on 3 study areas in Alabama. (1973-79).

hen at Choctaw Bluff was severely injured and later died from a golden eagle attack at a bait site, At Scotch Management Area 1 uninstrumented hen was killed on the nest by a dog. At Thomas dog packs were observed attacking hens and their young broods twice but in 1 case the dogs detected the observer and left and in the other case the hen successfully decoyed the dogs away from the poults and escaped. Hens were most vulnerable while incubating and during the first 10-14 days of the poults' lives. Three sub-adult hens were killed in October 1978 at Scotch Management Area but these were all small, recently instrumented birds of the year and some or all may have been affected by the transmitter package. It is also possible that at that time of the year young turkeys suffer a higher predation rate because 3 sub-adult gobblers were killed by predators in September 1976 at Thomas.

Nest Losses

The nest predation rate (Table 2) for all areas combined (119 nests) was 44.5%. Almost all of these nests were discovered after incubation had begun so this is not a complete picture of the impact of predators on turkey nests. No attempt was made to locate the nests until hens exhibited incubating behavior and numerous nests could have been, and probably were, destroyed during the period of egg laying.

Table 2. Fate of 119 wild turkey nests from 4 study areas in Alabama (1973-79).

| Study area | Years | Nests | No. preyed on | Percentage Preyed on | Percentage Deserted | Percentage Hatched |
|---|---|---|---|---|---|---|
| Saco | 1973-74 | 16 | 7 | 43.8 | 25.0 | 31.2 |
| Choctaw Bluff | 1973-76 | 34 | 22 | 64.7 | 17.6 | 17.6 |
| Scotch | 1978-79 | 15 | 7 | 46.7 | 6.7 | 46.7 |
| Thomas | 1976-79 | 54 | 17 | 31.5 | 5.6 | 63.0 |
| Total | | 119 | 53 | 44.5 | 11.8 | 43.7 |

Nest predators were identified in 40 cases of nest destruction and in 13 cases evidence was insufficient to identify the predator. The raccoon (Procyon lotor) was the number 1 nest predator and the second most important was free ranging dogs (Table 3). Opossums (Didelphis virginiana), crows (Corvus brachyrhynchos and C. ossifragus), snakes, skunks (Mephitis mephitis and Spilogale putorius), and gray foxes were also implicated as nest predators. Bobcats caused destruction of the nests by killing the hens in 3 cases but they did not eat the eggs.

Table 3. Predatory agents judged responsible for destruction of 53 wild turkey nests in Alabama (1973-79).

| | | Predatory agent | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Study area | No. of nests | Unknown | Raccoon | Dog | Opossum | Crow | Snake | Bobcat | Skunk | Gray fox |
| Saco | 7 | 2 | 3 | 1 | 1 | | | | | |
| Choctaw Bluff | 22 | 4 | 7 | 2 | 2 | 1 | 4 | 1 | 1 | |
| Scotch | 7 | 5 | | 1 | | 1 | | | | |
| Thomas | 17 | 2 | 1 | 5 | 2 | 2 | | 2 | 1 | 2 |
| Total | 53 | 13 | 11 | 9 | 5 | 4 | 4 | 3 | 2 | 2 |

## Poult Losses

The overall loss rate for 41 poult groups of instrumented hens at the last count of the summer averaged 74.5%. It is important to note that most of this loss, 71.3%, had occurred within 14 days after hatching (Table 4). The overall loss in this study is similar to the "nearly 80 percent" poult loss reported by Glidden and Austin (1975) in New York. It was possible to determine loss rates or causes of poult loss in only a few cases during the first week or 10 days of hatching. The poults were difficult to count and no determined effort was made to obtain counts during this period because of the danger of killing or injuring the poults. However counts of the 41 brood groups were obtained by the end of 2 weeks except for 3 of the 4 broods at Scotch. One hen and 7 poults were killed by a bobcat 3 days after hatching. One hen had 9 poults left by 1 September and all poults were gone from 2 groups at first opportunity to count, 25 and 36 days post hatching.

Constant surveillance of the 18 instrumented-poults with instrumented hens revealed that 7 of these died within 2 weeks after instrumentation. One of the poults died from a birth defect (Omphalitis) and 6 were killed by predators. This suggests that predation may be a major factor causing early poult loss on the Thomas study area.

Table 4. Loss rates of wild turkey poults from 41 broods at 3 study areas in Alabama (1975-79).

| Study area | Years | No.of nests | No.of eggs hatching | Poult loss by interval after hatch: 14 days Number | 14 days Percent | Last count[a] Number | Last count[a] Percent |
|---|---|---|---|---|---|---|---|
| Choctaw Bluff | 75 & 76 | 5 | 25 | 12 | 48.0 | 17 | 68.0 |
| Scotch | 78 & 79 | 4 | 38 | | | 29 | 76.3 |
| Thomas | 76 - 79 | 32 | 309 | 226 | 73.1 | 231 | 74.8 |
| All Areas | 75 - 79 | 41 | 372 | 267 | 71.3[b] | 277 | 74.5 |

[a]Last count of Choctaw Bluff poults was 6 weeks after hatch and for Scotch and Thomas areas it was 1 September.

[b]Only Choctaw Bluff and Thomas data.

## Effects of Predator Control on Reproductive Success

Opossums, raccoons, and feral and free ranging dogs were removed from the treatment areas in large numbers. Smaller numbers of crows, foxes (mostly gray), and skunks (both striped and spotted) were also removed (Tables 5 and 6). The scarcity of predator sign and the decrease of trapping success and the taking of treated eggs indicated that egg-eating predators were greatly reduced on the treatment areas by late May or early June. Control efforts were affecting the important turkey nest predators as can be seen by comparing Tables 3 and 6.

Table 5. Predator control effort and success on the Choctaw Bluff area.

| Year | Hectares treated | Trap nights | Predators trapped or shot[a] | Total poisoned baits | Predators known poisoned[b] | Predators removed | Total predators removed /$km^2$ |
|---|---|---|---|---|---|---|---|
| 1971 | 2,592 | 1,250 | 52 | 2,458 | 144 | 196 | 7.6 |
| 1972 | 4,471 | 5,800 | 32 | 1,407 | 167 | 199 | 4.6 |
| 1973 | 1,879 | 6,400 | 178 | 2,665 | 184 | 362 | 19.3 |
| 1974 | 2,592 | 8,100 | 175 | 3,360 | 125 | 300 | 11.6 |
| 1975 | 4,471 | 6,500 | 351 | 3,725 | 180 | 532 | 11.9 |

[a]Predators shot amounted to no more than 10% of the trapped total in any year.

[b]A large number of poisoned animals probably died in burrows and tree dens or traveled so far before dying that they were undetected.

Table 6. Nest predators removed by various methods from the Choctaw Bluff Area (1971-75),

| Predator | Shot or trapped | Poisoned | Total | Percent of total |
|---|---|---|---|---|
| Opossums | 366 | 398 | 764 | 48.1 |
| Raccoons | 285 | 265 | 550 | 34.6 |
| Dogs | 44 | 73 | 117 | 7.4 |
| Skunks | 33 | 27 | 60 | 3.8 |
| Crows | 18 | 24 | 42 | 2.6 |
| Foxes | 23 | 8 | 31 | 2.0 |
| Others | 19 | 5 | 24 | 1.5 |
| Total | 788 | 800 | 1,588 | |

Data from systematic observations of hens and poults on the Alabama treatment and check area routes from June through August showed a higher poult:hen ratio each year on the treatment area than on the check area (Fig. 3).

There was a significant difference ($P<0.05$) between treatment and check area poult:hen ratios for the 5 years. Results of this experiment agree with those of Beasom (1974) who found higher wild turkey reproductive success, as measured by poult:hen counts and estimates of total poult production, on areas where predators were controlled than on check areas in Texas. A similar study in New Mexico (MacDonald 1966 cited by Beasom 1974) failed to show an increase in turkey populations in the predator removal area.

On treatment areas a total of 55.1% of the hens (1971-75) was accompanied by poults compared to only 24.4% on the check areas. This difference suggests that predator control had a beneficial effect on hatching success.

The method of estimating total reproductive success, which was to count hens and poult groups after the poults were large enough to be seen from a vehicle, precluded any measurement of poult losses during the early brooding stage when poults are most vulnerable. Comparison of average size of poult groups with single hens from the 5-year period on treatment and check areas shows little difference in poult group size between treatment areas (6.0 poults/hen) and check areas (5.7 poults/hen). This data suggests also that most of the beneficial effect was through increased hatching success although the method used would not take into account possible cases where the hen and entire brood were killed at hatching or in the early brooding state.

| | Total Number Hens Sighted | |
|---|---|---|
| | Treatment | Check |
| 1971 | 23 | 31 |
| 1972 | 57 | 11 |
| 1973 | 26 | 31 |
| 1974 | 36 | 40 |
| 1975 | 23 | 24 |

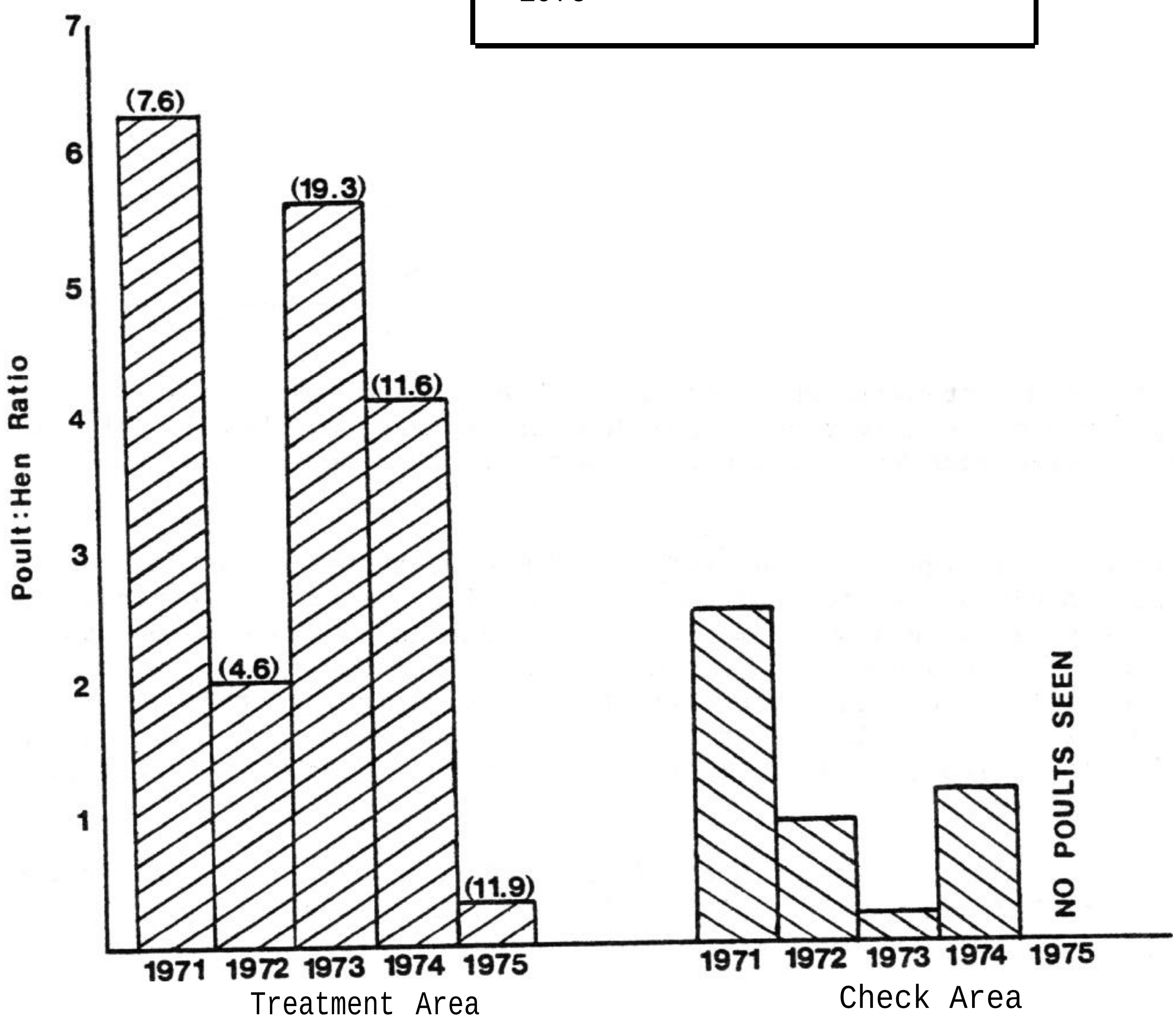


Fig. 3. Ratios of turkey poults to hens seen during June-August on observation routes in predator control areas and check areas (1971-75). Number in parenthesis represents predators removed per $km^2$.

Total poult production was much higher on treatment areas than non-treated areas for the 5 years. This conclusion is based on sightings of 176 hens and 609 poults seen on 4,692 km of treatment area routes compared to 156 hens and 169 poults on 2,854 km of check area routes. A rough estimate of the benefit produced by the predator control effort can be figured from the 5-year average poult:hen ratio of treatment (3.5 poults/hen) compared to check areas (1.1 poults/hen). Assuming equal numbers of hens per ha on treatment and check areas the number of poults produced and raised past the time of heaviest poult loss would be about 3 times higher on treatment areas. A total cost of $3,270.00, at 1975 prices, was calculated for the poison bait effort including supplies and materials, labor, supervision, and gas and oil per year per 2,024 ha. Trapping costs were not considered a necessary expense since the services of trappers can usually be obtained by giving them access to an area that has a high furbearer population.

## DISCUSSION

Predation did not seem to be a serious decimating factor on adult wild turkeys except on hens during nesting and early brooding season. Most of the adults caught by predators, except nesting-season hens, which were also vulnerable to gray foxes and dogs, were caught by bobcats. Predation does take a heavy toll on nesting hens, nests, and poults in Alabama but the species is apparently able to sustain these losses and usually maintain or increase fall populations.

Intensive predator control is expensive and is probably seldom justified. However, there is evidence that intensive control of nest predators can increase turkey production. Such control probably would produce higher fall populations on areas where populations are well below the carrying capacity of the range. Predator control may have value as a management tool on protected areas where turkey populations are being built up primarily for restocking, especially if a considerable proportion of the surplus turkeys were captured and moved during the late summer and early fall.

On several areas in Alabama turkeys are known to make long range shifts during the fall and spring (Speake et al. 1975), consequently, there is no assurance that predator control efforts on small areas of nesting habitat would benefit landowners or persons who have hunting rights. Much of the turkey population increase may disperse, depending on land use patterns and other factors, onto adjoining property. The intensive control of turkey nest predators over very large areas would be prohibitive in cost and the larger the area, the more likely would be the probability of serious conflicts with other users of the land.

Although the effective control of small furbearers such as raccoons, opossums, bobcats, skunks, and foxes by the methods used in this experiment may not often be a practical turkey management tool, the trapping of furbearers during the trapping season can be encouraged, especially when fur prices are high. Control of feral and free-ranging dogs is thought to be a desirable activity that should be carried out every spring because dogs not only cause nest desertion and destroy eggs but they sometimes kill nesting and brooding hens thereby causing the loss of entire broods. They are also a decided nuisance to turkey hunters, seriously interfering with spring gobbler hunting. Dogs are not a natural fauna1 element, thus, their impact on turkeys can hardly be justified and it could be greatly decreased by keeping them out of the woods from March through July or by control efforts.

Additional research should further clarify the role of predators in limiting turkey production and perhaps explain the interplay of predation with other poorly understood factors that also have an important impact on reproductive success. Turkey managers should always attempt to measure reproductive success which can vary widely (poult:hen ratios from 0 to 6.3) between years and localities. This information should be used in the formulation of hunting rules and regulations.

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# TURKEY NESTING SUCCESS OM A FLORIDA STUDY AREA

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Abstract: Nesting success of wild turkeys (*Meleagris gallopavo*) was measured for 108 nests of radio-tracked hens on a Florida study area during an 8-year period. During 4 years of the study, poisoned eggs were distributed in a part of the study area to measure their effect in reducing nesting losses and to obtain carcasses of predators for identification. Most predation was by 4 mammal species; several potential predators, including feral hogs (*Sus scrofa*), common crow (*Corvus corvus*), and armadillo (*Dasypus novemcinctus*) were not significantly involved. Nesting success was 59% in 4 of the years when no poisoned eggs were distributed and 72% during 4 years in the treated area. A high rate of compensatory nesting was detected, the effect of which would probably negate any advantages of such a control effort.

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In 1968 through 1976 wild turkey nesting success was measured and the major nest predators were identified on a study area. As far as we can determine, this is the first report of its kind on turkey nesting success. We thank Charles P. Lykes and Ben Swendsen of Lykes Brothers, Inc., owner of the study area; and William B. Frankenberger, Jerry Peoples, and Neal F. Eichholz for assistance in the field. This is a contribution of Florida Pittman-Robertson Project W-41.

## METHODS

This work was done in connection with a larger study of turkey ecology and behavior on Lykes Fisheating Creek Wildlife Management Area in Glades County, Florida. The study area has been described in detail (Williams et al. 1973).

One hundred forty hens were radio-tracked to find their nests so that they could be checked to determine their fates. Other objectives of the study required a certain amount of disturbance to the turkeys which led to occasional nest desertion (i.e., eggs were deliberately taken in order to observe the tendency to renest following nest loss). Only data from 108 undisturbed nests are used in this report.

Turkey and chicken eggs injected with sodium monofluoracetate ("10-80") or strychnine alkaloid were placed in about one-half the study area to test whether this would materially lower the level of nest predation, and to help identify the major predators involved. Regular searches for predator carcasses were made to identify which species of animal were eating eggs. Steel leghold traps were occasionally placed in predated nests to capture predators that visited the nests a second time or to capture secondary nest predators.

## RESULTS AND DISCUSSION

### Predators Involved

Although there was no means of accurately counting the numbers of predators killed by the poisoned eggs, we found many dead skunks (Spilogale putorius and Mephitis mephitis), raccoons (Procyon lotor) and opossums (Didelphis virginianus). It is safe to say that they had eaten the poisoned eggs. It is likely that they would also eat unpoisoned turkey eggs and that they were the predators of turkey nests in this study. These 4 species were frequently captured when traps or poisoned eggs were placed in predated nests. In many cases, the sign that different predators left at predated nests could be recognized which further implicated these same mammals as the main species involved.

Only 2 gray foxes (Urocyon cinereoargenteus), 1 bobcat (Lynx rufus), and 1 crow that we know of, and no hawks, owls, armadillos, or feral hogs were killed, although these were abundant on the study area. This indicates that these species were not important predators of turkey nests on our study area. Armadillos have been suspected of serious predation on ground nesting birds but this was not so in this study. An armadillo was suspected of eating eggs in only 1 case, because of sign at the destroyed nest, and we know that 2 nests were abandoned when armadillos rambled through and rolled out some of the eggs without breaking them.

Feral hogs were almost as abundant as turkeys in parts of the study area but did not take poisoned eggs or destroy a turkey nest as far as could be determined. Cattle were also abundant but in no case did we think that one had stepped in a turkey nest.

Although dogs are rare on the study area, at least 1 nest was destroyed by a dog and dogs were suspected in another case. In several cases the evidence suggested that the usual predatory species were not involved. These cases included dime-sized holes in eggs, which indicated a small animal, probably a rat or mouse; and gradual disappearance of part of the clutch without destruction of the nest, which may have been done by a snake.

It has been said that gobblers will destroy nests. Although this has been generally discredited, there has been no definite evidence against it. In this study we found no evidence of a gobbler molesting a nest. Indeed, the behavior of laying and setting hens virtually precluded the gobblers from knowing the location of the nests.

## Nesting Success

In this study, the turkey had a 59% success rate in the natural (no poisoned eggs used) area and a 72% success where predator control was being carried out during the nesting season (Table 1). Galliform birds in general have nesting success of about 45% (Hickey 1955). It is interesting to note that the galliform species with the best nesting success seem to be those that occupy principally natural habitat--these are ruffed grouse (Bonasa umbellus) with 61% (Darrow, 1947), willow Ptarmigan (Lagopus lagopus) with 80% (Kristoffersen 1937), and sage grouse (Centrocercus urophasianus) as high as 60% (Rassmussen and Griner 1938); while the ring-necked pheasant (Phasianus colchicus), a species normally associated with farms and highly altered habitats, averages about 36% (Hickey 1955) and is sometimes as low as 20% (Randall 1940). The bobwhite quail under manipulated conditions in southern Georgia and northern Florida, had only about 36% nesting success (Stoddard 1931) and about 20% (Simpson 1976). Turkey nesting success in our study compares with success rates usually given for species of grouse and is substantially higher than is usually observed in pheasant and bobwhite, or the average for the galliformes.

Table 1. Numbers of successful and unsuccessful turkey nests on the study area.

| | Treated Area | | Control Area | | Years of No Treatment | |
|---|---|---|---|---|---|---|
| Year | Hatched | Predated | Hatched | Predated | Hatched | Predated |
| 1968 | No treatment | | | | 12 | 9 |
| 1969 | 3 | 0 | 1 | 4 | | |
| 1970 | 6 | 1 | 5 | 4 | | |
| 1971 | 5[a] | 1 | 6 | 0 | | |
| 1972 | 2 | 3 | 5 | 0 | | |
| 1973 | 5 | 3 | 3 | 0 | | |
| 1974 | No treatment | | | | 3 | 7 |
| 1975 | No treatment | | | | 8 | 3 |
| 1976 | No treatment | | | | 7 | 2 |
| Total | 21 (72%) | 8 (28%) | 20 (71%) | 8 (29%) | 30 (59%) | 21 (41%) |

[a]Includes nests from which eggs were removed by predators but which still resulted in at least some eggs hatching.

## Effect of Predator Control

Nesting success was 72% on the treated portion of the study area while poisoned eggs were being distributed (during 1969 through 1973) and was 71% on the nearby control area (Fig. 1) during the same years (Table 1). It was only 59% in the 4 years during which no poisoned eggs were distributed, suggesting the possibility that the predator control effort had an effect on the nearby study area (Fig. 1). The combined success rates for the untreated parts of the study area (during predator control years) and for the total nesting in years when there was no predator control was 63%. Thus, the true success rate was between 59% and 63% when predator control was not practiced.

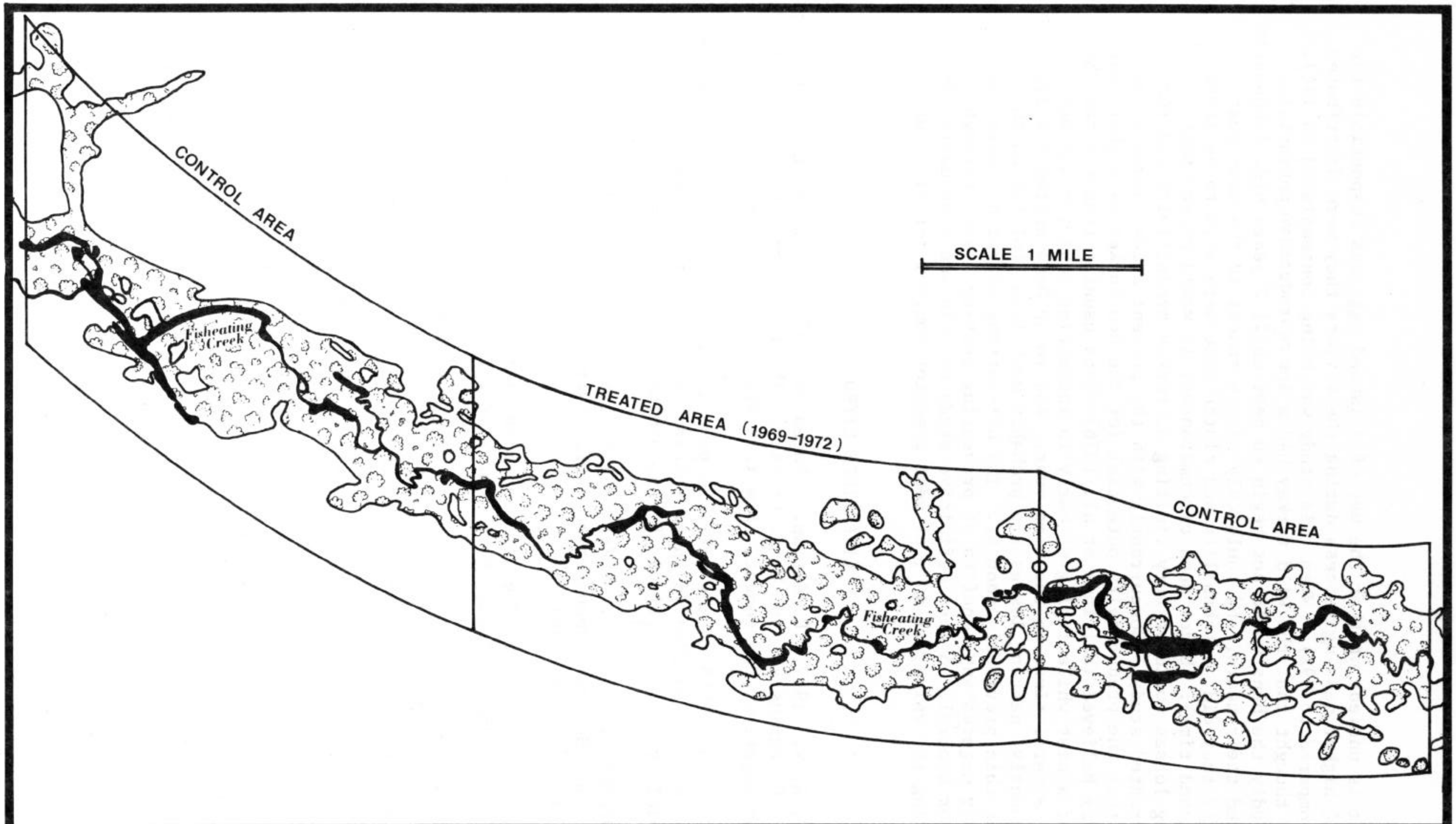


Fig. 1. Study area map showing the approximately 3 square mile treated area joined on east and west by the untreated parts (control). Turkey habitat is entirely along the creek--there was no nesting habitat immediately to the north or south.

It is unclear whether the use of poisoned eggs was responsible for the 13% higher nesting success during the 4 years they were distributed (72% compared to 59%). When this study was being contemplated in 1967, it was thought that the wild turkey had a low reproductive potential. Supposedly the hens would not begin to nest until 2 years old, frequently deserted their nests, and would only rarely renest in the same year (and, if they did, hatchability and clutch size were said to be lower the second time). Under such circumstances, it would appear that nesting losses could be very limiting on turkey productivity and that it warranted study. Concurrently with the present study, however, we found that the productivity potential for the hen turkey is higher than formerly believed (Williams et al. 1976)--hens usually renest after the loss of a nest while laying or early in incubating behavior and may renest several times in the same year. And young hens nested freely. Consequently, nesting losses are probably much less limiting on the species than previously thought. The off-setting effect of renesting probably negates any benefits of preventing nesting losses through predator control. A more definitive study of this would be useful in assessing the value, if any, of nest predator control for wild turkeys.

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# AN EVALUATION OF ARTIFICIAL WILD TURKEY NESTS MONITORED BY AUTOMATIC CAMERAS

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Abstract: Artificial/dummy wild turkey nests monitored by an automatic camera system were designed to determine predator identification and characteristic methods of nest destruction. Additional experimental groups of artificial wild turkey nests permitted examination of the effects of the camera equipment and human scent on nest predation rates. Nests visited while wearing rubber boots were 2.5 times more successful and deviated significantly from nests observed while wearing leather boots. The use of automatic camera systems for nest predator identification is evaluated. Characteristic methods of nest destruction and factors affecting nesting studies are discussed.

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Recent technological advances in inexpensive automatic photographic equipment and radio telemetry have facilitated recent investigations into unexplored aspects of wild turkey ecology. An investigation into the compatibility of the eastern wild turkey (*Meleagris gallopavo silvestris*) with recreational and land management activities at Land Between the Lakes indicated that nest predation was a significant factor limiting reproduction. The nests of all 11 radio instrumented adult hens, monitored over a 2-year period, were destroyed by nest predators and a loss ratio of 55% on 80 artificial nests was observed during a 2 week period (Wright 1975).

Gallinaceous birds are subject to nest predation by a variety of reptiles, birds and mammals. Predation of wild turkey nests has been documented by several investigators through the aid of radio instrumented turkeys, however, identification of nest predators and their methods of nest disturbance have not been adequately documented (Williams et al. 1968, Baker 1979).

In January, 1978, the Tennessee Valley Authority contracted with Murray State University to conduct an artificial or "dummy" nest study to identify the primary nest predators of the eastern wild turkey at Land Between the Lakes. Considering the environmental educational goals of the Land Between the Lakes, development of an environmentally safe method of identification of nest predators was deemed appropriate.

The purpose of this study was to determine the identify of primary nest predators of wild turkeys and their methods of nest destruction with a specially modified automatic camera system. An inexpensive automatic camera system, capable of sustained exposure to the elements and requiring a minimum of field maintenance, was developed for this investigation.

Artificial nest studies have been used in the past to study nest predation and nest survival rates for several species of ground nesting birds. In addition, these studies have also attempted to determine methods of nest destruction. However, these investigations have generally yielded very low nest survival rates when compared with the 50%

survival rates expected from natural nests (Kalmbach 1939). Factors reported in the literature as adversely affecting artificial nest survival rates include human scent trails leading between nests and markers used to locate nests (Davis 1959, Schranck 1972, Cook 1973). To overcome these problems, additional experimental and control groups of artificial nests were constructed to permit examination of the effects of the camera equipment and human scent on nest survival rates.

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## STUDY AREA

The Land Between the Lakes is a 72,845 ha national recreation area located in Lyon and Trigg Counties, Kentucky, and Stewart County, Tennessee. This inland peninsula was formed by the impoundments of the Tennessee River, by the Tennessee Valley Authority in 1944, and the Cumberland River by the Corps of Engineers in 1966. Barkley Canal connects the two lakes and forms the northern boundary. Land Between the Lakes is bounded by water on three sides and has approximately 480 km of continuous shoreline. U.S. Highway 68 and the Trace (formerly Kentucky Highway 453) cross the area from east to west and north to south, respectively. A 560 km network of paved and graveled roads allows access to most of the area. A system of recently constructed foot trails permits access to remote areas of Land Between the Lakes.

The climate of the study area is temperate; consisting of moderately cold winters and warm humid summers. The mean annual temperature is 14°C, and approximately 122 cm of precipitation are recorded annually at Golden Pond. The growing season averages 190 days.

Mixed hardwood forest has increased since 1966 and covers approximately 90% of the area. A mixed hardwood forest of the oak-hickory association composed 88% of the inventory. Bottomland hardwoods and blackjack oak add another 5%, and pine cover plantings of 1 to 3 ha complete the forest inventory.

Open land makes up about 10% of the area and consists of bottomland fields, utility rights of way and recently constructed woods opening of 1 to 3 ha. These areas are currently managed on a 4-year rotation of bush-hogging, discing, and wildlife food plots.

## MATERIALS AND METHODS

Thirty Polaroid One-Step automatic cameras were modified for use with a remote switch associated with an artificial nest platform. The modifications to the camera are described in more detail elsewhere (Goetz, unpublished report)[1]. A resistor-capacitor unit was added to prevent discharge of the battery located in the film pack.

The cameras were placed in boxes constructed from 9.5 mm exterior plywood. The boxes were painted flat black for additional weather-proofing. The boxes were mounted on 15.8 mm x 914 cm dowel rods. Flashbars allowing five consecutive photographs, and a maximum of 10 photographs were added at the time of nest construction. Plastic boxes for catching and protecting exposed photographs from the elements were also attached at the nest site.

The experimental design for evaluating the effects of the camera equipment and human scent on nest survival rates required the following experimental and control groups:

1. Artificial nests equipped with automatic cameras, and constructed, monitored, and maintained while wearing rubber boots and gloves composed experimental group number 1 (El).
2. Experimental group number 2 (E2) consisted of artificial nests constructed, monitored, and maintained while wearing rubber boots and rubber gloves.
3. Control group number 1 (Cl) consisted of artificial nests constructed, monitored, and maintained while wearing leather shoes and no gloves.
4. Artificial nests equipped with dummy cameras and constructed, monitored, and maintained while wearing leather shoes and no gloves composed control group number 2 (C2).

The effect of the camera equipment and human scent on nest survival rates were determined by statistical analysis of the differences between control and experimental groups ($x^2$;P=.05). Control and experimental groups of artificial nests located north of U.S. 68 were analyzed statistically; as were control and experimental groups of artificial nests south of U.S. 68. Control and experimental groups from all portions of Land Between the Lakes were summed and compared by statistical analysis.

The following criteria were employed in the placement of all artificial nests in this investigation.

Annual wild turkey brood surveys conducted at Land Between the Lakes from 1970 through 1978 indicated an equal distribution of broods north and south of U.S. Highway 68. This highway is one of two traditional boundaries separating census units; the second is the Tennessee-Kentucky state line located about 19 km south-of U.S. 68.

An equal distribution of artificial nests with and without automatic cameras were maintained in all areas of Land Between the Lakes. One half of all artificial nests, with and without cameras, were established north of U.S. 68 and one half of all artificial nests, with and

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[1]GOETZ, R. C. 1979. An automatic camera set-up for night and day field application. Pending publication. Murray State Univ., Murray, KY.

without cameras, were established south of U.S. 68. One half of all artificial nests with and without cameras established south of U.S. 68 were located in the Tennessee portion of Land Between the Lakes.

Habitat preferences for nesting wild turkeys were described by Speake et al.(1975). Old fields, woods openings, and upland hardwood areas are preferred sites. All artificial nests employed in this investigation were established either in open areas or within 50 m of an opening or woods road. All artificial nests were placed within 200 m of a permanent water supply.

Nests were established with 6 to 10 fresh white chicken eggs. Eggs were replaced at two week intervals in nests not destroyed by predators to minimize the possibility of the odor of rotten eggs attracting predators (Wright 1975).

Previous nest predation studies have been conducted over a 42-day period (Davis 1959, Matschke 1965). This corresponds to a 14-day laying period and a 28-day incubation period. All artificial nests surviving 42 days and those not destroyed by predators at the termination of this investigation were considered successful. No new nests were established during the final month of the study. Annual brood survey data indicated an average peak hatch date for wild turkeys at Land Between the Lakes during the first week of June (TVA-LBL, unpublished reports 1970-1977). This investigation was conducted from April 19 through June 20, 1978.

Once an artificial nest was destroyed by predators, a new artificial nest was constructed in a new location to increase the sample sizes in all experimental and control groups. The nests were checked every 24 to 36 hours.

Method of nest destruction was recorded at each disturbed nest. Qualitative observations of the method of opening eggs and the distance eggs were removed from the nest were noted. Artificial nests equipped with cameras permitted identification of specific nest predators and their characteristic methods of nest destruction. Criteria for identification of nest predators of artificial nests without cameras were based on information from nests equipped with cameras, and that provided by Davis (1959).

## RESULTS AND DISCUSSION

Fifty-four artificial nests with automatic camera systems were established. The cameras performed well under field conditions with only one temporary failure in 1297 camera-days of exposure. The temporary failure of a single camera was attributed to condensation on a night of heavy dew. The camera was dryed on the dashboard of the research vehicle and returned to service the following day.

The automatic camera was remarkably maintenance-free once established in the field. Each unit required 5 to 10 minutes for site preparation and positioning of the camera. Routine maintenance included repositioning camera, replacement of discharged film packs, and installation of the resistor-capacitor units.

Early in the investigation it was necessary to add resistor-capacitor units to all the cameras. The plywood nest platform and the nesting material became water soaked and would depress the switch resulting in a discharged film pack battery. The film pack battery would discharge in 1-4 hours if the switch remained depressed. Installation of the resistor-capacitor units stored the electrical energy of the battery. Adjustment of the nest platform tension spring compensated for the additional weight and reset the switch in the "off" position. There were no additional film pack failures after the installation of the resistor capacitor units.

Photographs of nest predators obtained from the automatic camera systems were of exceptional quality. Nest predators of wild turkeys commonly reported in the literature include raccoons (Procyon lotor), opossum (Didelphis virginianus), striped skunk (Mephitis mephitis), grey fox (Urocyon cinereoargenteus), armadillo (Dasypus novemcinctus), ground hog (Marmota monax), common crow (Corvus brachyrhynchus), coachwhip snake (Masticophis flagellum), dogs (Canis familiaris), and coyote (Canis latrans). Nest predators identified in this investigation and their rates of predation on artificial nests are listed in Table 1.

One hundred twenty-nine artificial nests of a total of 133 were utilized in all calculations in this investigation. One nest was excluded because it became impossible to monitor due to administrative problems. Three additional nests destroyed by a fallow deer (Dama dama) were also excluded from all calculations.

Table 2 lists nest survival data for all experimental and control groups of nests. No significant differences existed between experimental and control groups of nests located north of U.S. 68. South of U.S. 68, significant differences between experiment and control groups were attributed to human scent. Analysis of summed control and experimental groups of nests indicated significant deviation for the effects of human scent. Analysis for the influence of the camera equipment on nest survival yielded no significant differences.

The camera equipment, actual or dummy, had no effect on nest survival rates. However, significant differences were found between the survival rates of artificial nests constructed, maintained and monitored while wearing rubber boots and rubber gloves, and artificial nests constructed, maintained and monitored while wearing leather shoes and no gloves. These differences are attributed to the attraction of nest predators by human scent left in the vicinity of the nests by the investigator.

Previous investigators utilizing artificial nests to study nest predation have suggested that human scent may have been an important contributing factor contributing to low nest survival rates (Davis 1959, Schranck, 1972). The results of this investigation illustrate the effects of human scent on decreasing nest survival rates. Nest predation rates for ground nesting birds are assumed to be about 50% (Kalmbach 1939). Nesting success of wild turkeys reported in the literature is usually less than 50% (Speake et al. 1969). Investigators locating natural wild turkey nests by radio telemetry and other means have reported predation rates of 43%, 44%, and 62.5% (Williams et al. 1968, Hillestad and Speake 1970, Cook 1973). Most artificial nesting studies have resulted in predation rates between 55% and 85% (Davis 1959, Matschke 1965, Wright 1975). Predation rates of experimental and control subgroups in this investigation varied from 58% to 94% and averaged 80% for all artificial nests. Predation rates of artificial nests probably exceeds predation rates for natural nests. Consequently, the application of the results

Table 1. Numbers of nests predatorized and percentages for identified nest predators at Land Between the Lakes.

| Species | # of nests destroyed | % |
|---|---|---|
| Raccoon (*Procyon lotor*) | 52 | 48.6 |
| Opossum (*Didelphis virginianus-*) | 21 | 19.6 |
| Striped Skunk (*Mephitis mephitis*) | 17 | 15.9 |
| Grey Fox (*Urocyon cinereoargenteus*) | 6 | 5.6 |
| Birds | 5 | 4.6 |
| Ground Hog (*Mannota monax*) | 4 | 3.7 |
| Small Rodents | 2 | 2.0 |
| TOTAL | 107 | 100.0 |

Table 2. Results of experimental and control artificial wild turkey nests at Land Between the Lakes, 1978.

| | North of U.S. 68 | | South of U.S. 68 | | Total | |
|---|---|---|---|---|---|---|
| | # of Nests | % | # of Nests | % | # of Nests | % |
| Experimental Group 1 | | | | | | |
| Successful | 6 | 23.1 | 6 | 21.4 | 12 | 22.2 |
| Predatorized | 20 | 76.9 | 22 | 78.6 | 42 | 77.8 |
| Experimental Group 2 | | | | | | |
| Successful | 1 | 10.0 | 5 | 41.7 | 6 | 27.3 |
| Predatorized | 9 | 90.0 | 7 | 58.3 | 16 | 72.7 |
| Control Group 1 | | | | | | |
| Successful | 2 | 15.4 | 1 | 5.6 | 3 | 9.7 |
| Predatorized | 11 | 84.6 | 17 | 94.4 | 28 | 90.3 |
| Control Group 2 | | | | | | |
| Successful | 1 | 11.1 | 1 | 7.7 | 2 | 9.1 |
| Predatorized | 8 | 88.9 | 12 | 92.3 | 20 | 90.9 |

of artificial nest predation studies to the effect of nest predators on the productivity of wild turkeys, or other species are biased by the influence of the investigator. Investigations of the effects of nest predation on productivity, ideally, should include only natural nests. Where time and money are limiting, carefully designed artificial nesting studies may provide a gross indication of the effects of nest predation on productivity.

Artificial nest predation studies are beneficial in identifying primary species of nest predators, and facilitate reasonable management decisions. The automatic camera system employed in this investigation provides a means of accurately correlating specific nest predators with their methods of nest destruction.

Raccoons were the primary predator of artificial nests at Land Between the Lakes; 48.6% of all artificial nests in this investigation were destroyed by raccoons. The most distinguishing feature of a nest disturbed by a raccoon is the method of opening the egg. Raccoons preferred to open eggs along the long axis, or at an angle slightly diagonal to the long axis. This method of opening the egg is also illustrated by Davis (1959). The eggs were often removed a short distance from the nest.

The opossum accounted for 19.6% of the artificial nests disturbed. Opossums opened eggs indiscriminately, resulting in a crushed mass of egg shell. This species seldom removed the eggs more than 1 m from the nest.

Striped skunks destroyed 15.9% of the artificial nests. The eggs of a nest disturbed by a skunk were opened along the narrow axis, and were usually within a 0.5 m of the nest site.

Grey fox destroyed 5.6% of the artificial nests. The eggs were removed 3 to 10 m from the nest and were cached under forest floor litter if not eaten immediately. Grey fox opened the egg on the side along the long axis without biting through it.

Ground hogs disturbed 3.7% of the artificial nests constructed. However, the camera equipment frightened them, and no eggs in the four nests disturbed were broken or eaten.

Birds and small mammals were suspected in 6.5% of the nests determined to have been disturbed but specific identities were not determined.

## CONCLUSIONS

The artificial nesting study of predation of wild turkey nests conducted during the spring of 1978 at the Land Between the Lakes utilized an automatic camera system for nest predator identification and determining characteristics of nest destruction. The employment of experimental and control groups of artificial nests permitted examination of the effects of human scent and the camera equipment on predation rates. The results of this investigation yielded the following conclusions:

1. The automatic camera system employed in this investigation was reliable under field conditions and permitted correlation of predator identity with methods of nest destruction.

2. Human scent was determined to be a significant factor in increasing nest predation rates.

3. The camera equipment did not significantly affect nest predation rates.

4. Raccoons, opossums, and skunks were the primary nest predators at the Land Between the Lakes. Grey fox and ground hogs were secondary nest predators.

5. Individual variation in the methods predators used to destroy nests do exist and the automatic camera system employed in this investigation permitted correlation of methods of nest destruction and egg opening.

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# NATALITY AND MORTALITY OF A NORTH ALABAMA WILD TURKEY POPULATION[1]

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Abstract: A study of natality and mortality in a wild turkey (*Meleagris gallopavo*) population was conducted in the mountains of northern Alabama from 1976-1978. Fifty-one hens and 38 gobblers were radio-instrumented with 56% of the instrumented hens nesting successfully. All 13 instrumented juvenile hens exhibited incubating behavior. Average clutch size of initial nests was 10.8 eggs. Poult loss rates obtained for broods of 21 instrumented hens were 80%, 73%, and 100% for the three reproductive seasons. All except 3 poult losses occurred within 14 days after hatching. Hen:poult ratios from September sightings provided a better indicator of overall reproductive success than radio telemetry data when less than 40% of the hen population was instrumented. Twenty-eight mortalities of instrumented turkeys were noted and many of the causal agents identified. There was a 19% hen loss during the 3 nesting seasons and 35% of the gobblers were harvested during a 10-day spring hunt in 1978. Population estimates using the Schnabel method agreed closely with flock count estimates. Winter mortality rates of radio-tagged birds were 12% in 1976-77 and 23% in 1977-78 while Schnabel estimates indicated decreases of 11% and 29% respectively. The turkey population increased from 1 per 142 ha to 1 per 58 ha during the study. High poult mortality was the major factor controlling population density.

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Since 1945, 8 state wildlife management areas in northern Alabama have been stocked with wild turkeys. After apparent initial stocking success, populations on 6 of these areas were considered adequate to sustain spring gobbler hunting. Turkey hunting was later terminated on 5 of the areas when the population declined, as indicated by declining harvest rates. Populations have persisted on all 8 areas originally stocked, but are considered low when compared to state management areas in the southern part of the site.

In 1976, a study of factors limiting wild turkey populations in the mountainous regions of northern Alabama was begun. This paper described natality and mortality in such a population between January 1976 and January 1979.

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[1]A contribution of the Alabama Cooperative Wildlife Research Unit, Auburn University Agricultural Experiment Station; Game and Fish Division of the Alabama Department of Conservation, the U. S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating.

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## STUDY AREA

The 14,175 ha study area consisted of lands on and adjacent to the Thomas Wildlife Management Area, located in northwestern Alabama in Colbert and Franklin counties, in the westward extension of the Appalachian Plateau. Most of the area had high, winding, narrow ridges and deep valleys (Hodgkins et al. 1976). The major habitat types were mature upland hardwoods, creekbottom hardwoods, pine stands established by "timber stand improvement" (TSI) methods, pine plantations, pastures and croplands. The dominant plant species in the upland forests were oaks (*Quercus* spp.) and hickories (*Carya* spp.). American beech (*Fagus grandifolia*), sweetgum (*Liquidambar styraciflua*), white oak (*Q. alba*) and scarlet oak (*Q. coccinea*) were the dominant species in the creekbottoms. The pastures and field were well distributed on 3 sides of the management area. The long, winding pastures were primarily vegetated with fescue (*Festuca arundinacea*) and occasional patches of clover (*Trifolium repens*). The croplands were in corn (*Zea mays*) and soybeans (*Glycine max*). That portion of the Thomas Wildlife Management Area used by wild turkeys had about 2% of its area in openings maintained as game food plots, most of which were planted in annual ryegrass (*Lolium* spp.) each Fall.

Turkey hunting was initiated on the study area in 1961 after stocking in 1945. Harvest rates decreased from 28 gobblers in 1962 to 2 in 1970, after which the season was closed until April 1978 when a 10-day spring gobbler hunt was held.

## METHODS

Between January 1976 and April 1978, 89 wild turkeys were captured with rocket-projected netting (Dill 1969) and alpha chloralose treated baits (Williams et al. 1973) and subsequently fitted with solar powered radio transmitters. The receivers, antennas, activity-location-mortality transmitters and the techniques employed in their use are described by Everett et al. (1978).

Instrumented birds were located at least twice each week throughout the year and their locations plotted by triangulation (Cochran and Lord 1963). When an instrumented bird could not be found from the ground, an aerial search was made. During critical periods, such as immediately before and after public hunts, turkeys were located daily. During the nesting season instrumented hens were monitored closely. When the hens were not moving during the day, as indicated by the motion switch of the activity transmitter, the hens were assumed to be incubating eggs unless a mortality signal was received. After 1 week to 10 days of incubation, an effort was made to approach nesting hens to within 30 m. Then from at least 4 points around the incubating hens, compass bearings were taken to the nest as indicated by the directional hand-held antenna. The nest was located later by following the converging compass bearings when the activity transmitter indicated that the hen was off the nest. At that time the nest was checked to determine its condition and count the eggs. Nest sites were also examined immediately after hatching to determine hatching success.

Radio-locations of hens with poults were taken twice weekly to determine movements and habitat preference. A visual observation of each hen with poults was attempted each week throughout the summer to determine poult loss rates. Frequently, the roosting hens were located before sunrise and their poults were counted as they flew off the roost. In some cases various brood groups combined making identification of groups impossible.

When a mortality signal was received and no movement was indicated by the transmitter, the turkey was located as quickly as possible to determine the cause of death before scavengers disturbed the carcass. The carcass and surroundings were examined for tracks, tooth marks, hair, feathers, talon marks, and gunshot wounds to determine the probable cause of death.

The wild turkey population on the study area was estimated each 1 May and 1 October of 1976, 1977 and 1978 using the Schnabel method (Schnabel 1938). The estimate was based on the number of instrumented turkeys with functional radios and uninstrumented turkeys sighted during each April and September and the number of instrumented turkeys with functional radios which were tracked during the same time periods.

The population was estimated according to the following formula:

where: $$N = \frac{\Sigma nM}{\Sigma m}$$

N = The number of turkeys in the population.
n = The total number of turkeys sighted.
M = The number of instrumented turkeys in the population.
m = The number of instrumented turkeys which were sighted.

Sighting records were also maintained throughout the year in order to determine hen:poult ratios (DeArment 1959) and to record habitat use.

## RESULTS

### Nesting Success

During the 3 nesting seasons, 46 radio-tagged hens, 33 adults and 13 juveniles (hens from the previous hatching season) were monitored (Table 1). Twelve adult hens were radio-tracked throughout the 1976 nesting season and all exhibited incubating behavior on their initial nesting attempt. Four hens hatched poults. Two of the 8 unsuccessful hens were known to have renested and reached incubation and 1 was successful. Average size of initial clutches was 10.6 eggs (Table 2) while both of the clutches of renesting hens contained 8 eggs. Two eggs failed to hatch, 1 disappeared from the nest before the clutch hatched and the other showed no evidence of embryonic development. A summary of fertility and hatchability is presented in Table 3.

Table 1. Nesting rate, nesting success, and renesting success of radio-tagged hens on and around the Thomas Wildlife Management Area, 1976-78.

| Parameter | Adult hens | | Juvenile hens | |
|---|---|---|---|---|
| | No. | Percent | No. | Percent |
| First nesting attempts | | | | |
| Number of hens | 33 | | 13 | |
| Incubated | 29 | 88 | 11 | 85 |
| Hatched | 15 | 52 | 7 | 64 |
| Renesting attempts | | | | |
| Number available for renesting | 13 | | 4 | |
| Incubated | 3 | 22 | 0 | 0 |
| Hatched | 2 | 67 | 0 | 0 |

Table 2. Average clutch sizes of 33 nests by radio-tagged hens on and around the Thomas Wildlife Management Area, 1976-78.

| | 1976 | | 1977 | | 1978 | | TOTAL | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| Parameter | A[a] | J[b] | A | J | A | J | A | J | |
| First clutch | | | | | | | | | |
| Total eggs | 51 | 0 | 129 | 43 | 18 | 49 | 200 | 92 | 292 |
| Eggs/clutch | 10.6 | 0 | 11.7 | 10.8 | 9.0 | 9.8 | 11.1 | 10.2 | 10.8 |
| Second clutch | | | | | | | | | |
| Total eggs | 16 | 0 | 8 | 0 | 0 | 0 | 24 | 0 | 24 |
| Eggs/clutch | 8.0 | 0 | 8.0 | 0 | 0 | 0 | 8.0 | 0 | 8.0 |

[a] Adult.
[b] Juvenile.

Table 3. Fertility and hatchability of eggs of the 24 successful radio-tagged hens 1976-78 on the Thomas Wildlife Management Area.

| Eggs | Adult hens | | Juvenile hens | | Total | |
|---|---|---|---|---|---|---|
| | No. | Percent | No. | Percent | No. | Percent |
| First Nests | | | | | | |
| Laid | 149 | | 71 | | 220 | |
| Fertile | 143 | 97 | 66 | 93 | 209 | 95 |
| Hatched | 141 | 95 | 61 | 86 | 202 | 92 |
| Renests | | | | | | |
| Laid | 16 | | 0 | 0 | 16 | |
| Fertile | 15 | 94 | 0 | 0 | 15 | 94 |
| Hatched | 15 | 94 | 0 | 0 | 15 | 94 |

Six of the 9 unsuccessful nests were broken up by predators and 1 other was deserted, probably due to our activities. Hair lost by predators at unsuccessful nest sites were identified as grey fox (Urocyon cinereoargenteus) in 2 instances and at 1 of these nests the hen was killed. Raccoon (Procyon lotor) hair was found at a third nest. No trace of eggshells or other identifying sign could be found at 3 unsuccessful nests. Free-ranging dogs (Canis familaris) are believed to have destroyed these 3 nests. Dog tracks were found in the roads and fields near the nest sites and dogs frequently eat the whole egg. The fates of 2 nests could not be determined.

Twenty-one hens, 15 adults, and 6 juveniles were tracked through the 1977 nesting season. Eighteen exhibited incubating behavior in their initial attempt, including the 6 juveniles. Thirteen (72%) hens were successful on their initial attempt, of which 9 were adults and 4 were juveniles. Only 1 hen, an adult, was known to have renested after her initial nest was lost. She hatched all 8 eggs on 19 June. Average clutch size was 11.7 eggs and 10.8 eggs for adults and juveniles respectively (Table 2). Adult hens hatched 11.6 poults per clutch or 96% while the juveniles hatched 8.3 poults per clutch or 76%. One hundred-thirty-four poults were hatched from 148 eggs. Upon examination of the eggs we found that 4% of the 105 eggs laid by adult hens appeared to be infertile. An additional 12% of the eggs laid by the juvenile hens began development but did not hatch.

The fates of the 5 unsuccessful nests were as follows: 1 clutch was destroyed by birds believed to be crows (Corvus brachyrhynchos) from evidence of tracks near the nest and peck holes in the eggshells; 1 hen was killed on her nest and bobcat (Lynx rufus) hair was found on the carcass and at the nest site; 2 other clutches were eaten by predators and opossum (Diedelphis marsupialis) hair was found at 1 site and dogs were seen at the other; 1 hen deserted her nest on the day that hay mowing and baling took place about 20 meters from her nest.

Thirteen instrumented hens were tracked during the 1978 nesting season, 6 of these were adults and 7 were juveniles. Five adults and 5 juveniles demonstrated incubating behavior. Nesting efforts by 2 adults and 3 juveniles were successful. One adult hen hatched 9 eggs. The other adult's clutch hatched and she was seen with 3 poults about 1 km from the nest site. No eggshells could be found at the nest site so her clutch size is not known. The average clutch size was 9.8 eggs for the juveniles (Table 2). For nests with known clutch sizes, 34 of 37 eggs hatched. Two eggs appeared to be infertile and the third began development but did not hatch. None of the hens were known to have renested. Two hens were killed at the nest site by predators. Hair from 1 carcass was identified as bobcat and no hair was found on the other carcass or at the nest. Oppossum hair was collected from nest in which the eggs had been eaten. At another nest, the eggs had disappeared and dog tracks were found nearby. One hen deserted her nest but the causal agent could not be identified.

The average peak hatching period for nests of radio-tagged hens was the week of May 22-28. Forty percent of the nests hatched during this time. The hatching period extended from May 1 to June 24.

## Poult Loss Rates

Poult loss rates were obtained from 21 of 23 broods hatched by radio-tagged hens. During 1976, 49 poults were hatched by 5 radio-tagged hens. Weekly counts of these broods showed that 80% were lost be 1 September. All losses were noted within 14 days after hatching. Ten poults of radio-tagged hens survived until September.

Fourteen instrumented hens hatched 134 poults in 1977. Failure of 1 hen's transmitter precluded obtaining any poult loss data from 1 brood of 8. Thirty-four poults of radio-tagged hens survived until September, thus exhibiting a loss rate of 73%. All except 3 poult losses were within 14 days after hatching.

During 1978, 4 radio-tagged hens hatched 34 poults. One other instrumented hen was sighted 2 days after hatching with 3 poults across a rain-swollen creek from her nest. Eight days after hatching she was sighted with no poults. None of the poults of radio-tagged hens were known to have survived the entire summer and only 2 survived until 14 days after hatching.

Poult survival was directly related to the type of brood habitat selected by successful hens. Nine hens nested on the Thomas Wildlife Management Area and used small food plots and the adjacent mature hardwood forest as brood range. Eight of 86 (9.3%) poults hatched by these hens survived for up to 14 days after hatching. Twelve hens with 116 poults used grazed pastures and woods adjacent to the management area and 40 (36%) of their poults were known to have survived for at least 14 days. The food plots on the management area were planted to annual rye grass each fall and by the next spring the growth was rank, seeded out and dying. The pastures adjacent to the management area were in heavily grazed fescue and clover which remained green throughout the spring and summer.

## Hen-Poult Ratios

Sightings of hens and poults were recorded for June, July, August and September for 1976, 1977 and 1978 (Table 4). During 1978, no poults of the 5 instrumented hens that hatched broods were known to have survived. Telemetry data alone would indicate a very poor reproductive year for the population, but from our sighting records, which included a much larger sample of hens and poults, we know that the 1978 season, in fact, was the best of the 3 reproductive seasons. Hen:poult ratios from September sightings increased from 1:1.9 in 1976 to 1:3.0 in 1977 and 1:3.6 in 1978.

## Population Estimates

From January 1976 until September 30, 1978, 283 sightings of radio-instrumented turkeys and 1002 sightings of uninstrumented birds were recorded. The estimated population increased from 99.4 + 22 (mean ± SE), 30 April, 1976 to 244 ± 51, 30 September, 1978. Spring to fall increases were 6% in 1976, 125% in 1977 and 64% in 1978. Estimates made using the Schnabel estimator concur with those made using flock counts tabulated during routine field activities. The spring to fall increases represent the reproductive success of the turkey population for each year. An 11% population reduction was noted for

Table 4. Hen:Poult ratios from counts of all hens and poults seen on and around the Thomas Wildlife Management Area 1976-1978.

| Year | June | July | August | September |
|---|---|---|---|---|
| 1976 | 1:2.1 | 1:2.3 | 1:3.1 | 1:1.9 |
| 1977 | 1:2.6 | 1:3.2 | 1:2.2 | 1:3.0 |
| 1978 | 1:1.7 | 1:2.1 | 1:3.3 | 1:3.6 |

the period 1 October 1976 to 30 April 1977 and a 12% loss of radio-tagged birds to predation and poaching was measured for the same period. A 20% population loss was noted for the October 1977 through April 1978 period and reflects the effect of the 1978 spring gobbler season in which 28 gobblers were killed. There was an 8% loss of radio-tagged-birds to predation and poaching for the same period, but the combination of predation, poaching and turkey hunting caused a 23% loss of the instrumented turkeys.

## Mortality

Twenty-eight mortalities were noted for the 89 radio-tagged turkeys. Ten hens and 4 subadult gobblers were killed by predators. Nine of the 10 hens preyed on were killed during the nesting season (April, May and June). This represents an average 19% loss of hens during this critical period. One adult hen was preyed on in November. Three of the hens were believed killed by bobcats, 2 by grey foxes, and no predator could be identified for the other 5 hens. All 4 gobblers killed by predators were juveniles. Three were killed in late September and 1 in March. No adult gobblers were killed by predators. Two of the immature gobblers were believed to have been killed by bobcats, one by a grey fox and the predator of the other gobbler is unknown. Our sighting records from January 1976 to April 1978 show a ratio of 62 gobblers to 38 hens in the population. In an "unhunted" population as this was from May 1970 until April 1978, the different susceptibility of hens and gobblers to predation would account for the higher number of gobblers in the population than hens, even though the sex ratio during the first year of life is about equal (Mosby 1967). After the spring 1978 gobbler hunt, the gobbler:hen ratio was altered to 60:40, according to our sightings from 1 April to 30 September 1978.

Twenty gobblers were instrumented during the 1978 spring turkey season: 7 (35%) were harvested and 1 died of wounds received during the hunt. Four of the 20 tagged gobblers were juveniles, but none were harvested. The adult birds were apparently easier for the hunter to locate since they gobble and responded more readily to calling than the immature gobblers. Hunting mortality, poaching and crippling losses on the Thomas Wildlife Management Area have been described in more detail by Everett et al. (1979). Other causes of mortality include 3 hens and 1 gobbler killed illegally, 1 adult gobbler died of unknown causes, and 1 adult hen died of a compaction of the small intestine.

## DISCUSSION

Natality, mortality, and movements are the phenomena which cause numerical and structural changes within a population. In this study the effects of movements were minimized since we were studying an isolated population and our radio-instrumented birds utilized all parts of the study area where wild turkeys ranged. The combination of techniques employed enabled us to measure natality and mortality as they applied to the turkey population under study. An overall average of 10.8 eggs per clutch, 92% hatchability and 85% nesting attempts by juvenile hens are all indicative of a high reproductive potential for this population. Twenty-two percent renesting was somewhat lower than found by Williams et al. (1968) in south Florida where most adult hens renested after losing their initial clutches. We must agree with Wheeler (1948) and Speake et al. (1969) that renesting does not contribute much to population increment in Alabama. The overall nesting success (56%) found for this population is much better than the 33% reported by Mosby and Handley (1943) in Virginia or the 37% found by Williams et al. (1968) in Florida. Overwinter mortality rates of adult and juvenile turkeys were low with no losses due to stress and disease. Adult mortality was due to predation, hunting, and to a minor extent, poaching.

Based on the estimated number of hens in the population each spring, we had 41% of the hens radio-instrumented in 1976, 50% in 1977 and 24% in 1978. During the summers of 1976 and 1977, we had good agreement between percentage poult survival of radio-tagged hens and the survival of poults noted for the whole population estimated from hen-poult counts. During 1978, telemetry data alone indicated a very poor reproductive year for the population, but from our sighting records we know that 1978 was in fact the best of the 3 reproductive seasons. We therefore feel that poult survival studies based entirely on radio-telemetry may not be an accurate indicator of overall productive success when only a small percentage of the hens are radio-tagged. There is wide variation between the fates of broods. Some broods are lost entirely, while others hardly lose a member.

We found that poult survival was directly related to the type of brood habitat available and that most of the poult mortality occurred within 2 weeks after hatching. This concurs with Glidden and Austin's (1975) findings in a study of instrumented hens in New York.

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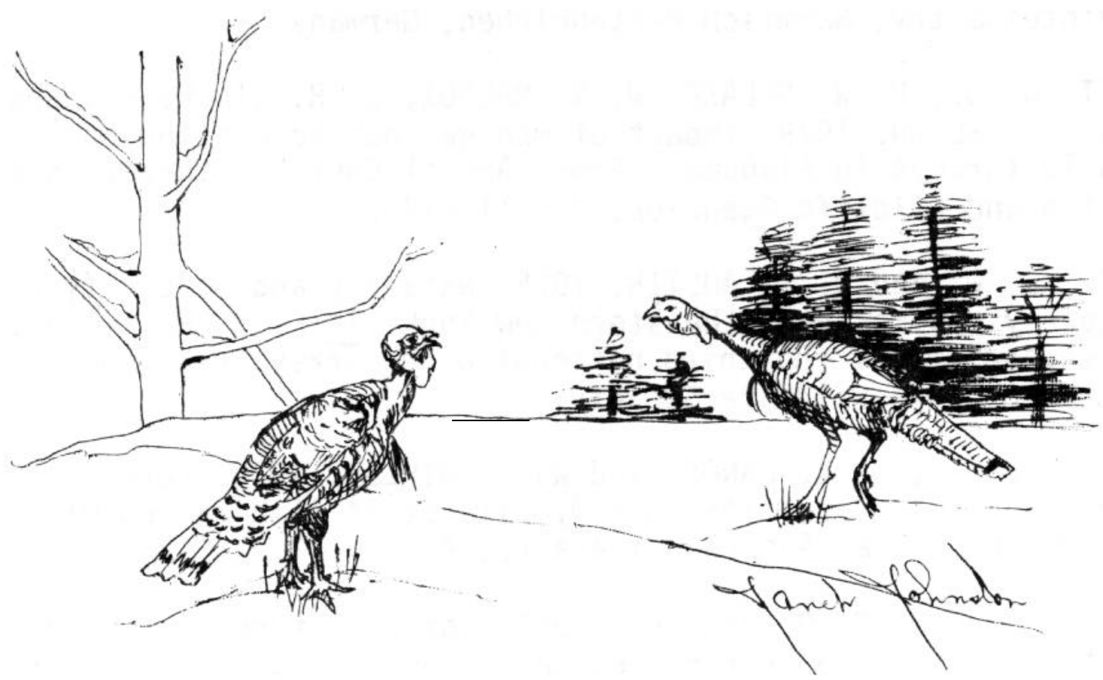

# THE EFFECT OF SELECTED CLIMATIC VARIABLES ON WILD TURKEY PRODUCTIVITY

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Abstract. Net reproductive success of Rio Grande wild turkey (*Meleagris gallopavo intermedia*) was monitored yearly between the months of June and August from 1968 through 1977 on 2 study locations in south Texas by way of repetitive road transect counts. Rainfall and temperature data were compiled from U.S. Climatological Records and soil moisture data were calculated from these parameters. Between-year turkey production fluctuated from 0-576 poults per 100 hens on the Santa Gertrudis area near Kingsville and from 8-443 on the Encino area near Falfurrias. The maximum $R^2$ determination indicated that 97.3% of the variability in annual rate of turkey productivity on Santa Gertrudis was explainable by a model composed of soil moisture storage the previous August, combined total precipitation for the previous September and October, and total precipitation for the current March. Similarly, 98.3% of this variability on Encino was explainable by a model composed of combined total precipitation for the previous August and September, soil moisture storage in the previous September, and soil moisture storage in the current May.

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The extreme fluctuations in Rio Grande wild turkey productivity in parts of Texas have been recognized for many years by local ranchers, sportsmen, and biologists but are poorly documented in the literature. These fluctuations seem to be governed by direct and/or indirect effects of weather. Years of above average rainfall have generally been marked by a good crop of young turkeys in southern Texas whereas drought years have been characterized by poor turkey production (Beasom 1973). In the Edwards Plateau of Texas, Thomas and Green (1957) reported poor turkey production during the drought years of the early 1950's followed by an increase with favorable rainfall after the drought ended in 1957. DeArment (1969) reported similar fluctuations in the Texas Panhandle.

Since the wild turkey is highly valued not only for the sport hunting it provides, but also for its aesthetic qualities, it is beneficial to maintain more stable populations. Management techniques

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to alleviate the problem of poor turkey production in certain years need to be developed. Before any effective management program can be implemented, however, causes of low productivity must be documented. The objective of the present study was to isolate and identify those climatic variables which exert the most influence on turkey net reproductive success.

Thanks are extended to King Ranch, Inc. who provided study areas and technical support in many ways. W. H. Kiel, Jr. provided advice and assistance throughout the study, and D. Stiles conducted some or all of the transect counts in 1973-1977. F. S. Guthery provided valuable statistical support and W. H. Kiel, Jr., J. G. Teer, and W. G. Swank provided many helpful comments from manuscript review. The research was supported financially by the Ceasar Kleberg Research Program in Wildlife Ecology through the Texas Agricultural Experiment Station, and the manuscript was approved by the Director, TAES, as TA15498.

## STUDY AREA

Two study areas were selected on the Santa Gertrudis and Encino divisions of the King Ranch in Kleberg and Brooks and Kenedy counties, respectively, in the Gulf Coastal Prairie (Gould 1975) of Texas. The Santa Gertrudis area was approximately 11,000 ha and the Encino approximately 7,700 ha in size. For 4 years (1971-72 and 1975-76) during the data collection, however, turkey counts from only about 50% of each area were utilized for this investigation because the remaining area was artificially treated by intensive predator control or supplemental feed to enhance reproductive success (Beasom 1973, Pattee 1977, Pattee and Beasom 1979).

The vegetative type on the Santa Gertrudis area was a mesquite (*Prosopis glandulosa*)-grassland and on the Encino a live oak (*Quercus virginiana*)-grassland (Beasom 1970). The soils of the mesquite study areas are in the Orelia-Goliad (Carter 1931) and Willacy-Orelia and Miguel-Willacy Series (Soil Conservation Service 1963 soils map).

The live oak area lies within the Coastal Sand Dunes Region (Tharp 1939). This region consists of an approximately 16-km wide belt that extends from the Gulf of Mexico westward for about 40 km. The soils are classified in the Tivoli-Nueces Series (Soil Conservation Service 1963 soils map).

The 150 cm annual open pan evaporation in the region (Bloodgood et al. 1954) exceeds the 63 to 71 cm average annual precipitation (Blood 1960). Thornthwaite (1948), therefore, classifies the area as semiarid. Average precipitation values mean little, however, in a region with such extremes as south Texas. Periodic droughts of varying duration and intensity are characteristic of the climate. Extremes in annual rainfall may range from as low as 30 cm to as high as 150 cm. During extended droughts ground vegetation becomes severely limited. Lehmann (1957:765) reported an extensive die-off of turkeys and other wildlife during one such drought.

U.S. Weather Bureau records (1967 to 1977) indicate an uneven distribution of rainfall throughout the year also, the majority usually associated with the fall tropical storm season. The month of September receives, on the average, nearly 20% of the annual total. Winter and early spring are the lowest rainfall periods of the year.

Average soil moisture relationships (Thornthwaite and Mather 1957) reveal a soil water deficit in every month of the year except January, February, and September. January and February generally receive only a fraction as much rainfall as September, but water demands of vegetation at this time are not as great.

## METHODS

Field work for this investigation was conducted from June-August 1968-1977. One permanent road transect, approximately 48 km in length, was established in each area. Turkey roadside counts were made by traversing each transect in a slow moving vehicle from 9-11 times each year except in 1973 when only 4 repetitions were possible. Counts were restricted to early morning or late afternoon hours when turkeys were most active.

Turkeys on both sides of the road transects, as far as could be seen, were enumerated then sexed and aged by plumage and size characteristics (Keiser and Kosicky 1943, Williams 1961, Nixon 1962, Powell 1965). Occasionally hen-poult groups were flushed, by approaching on foot, to obtain an accurate count. Counts from groups in which numbers or sex or age determinations were incomplete or questionable were omitted. The average number of poults/100 hens and percent hens with poults were utilized as indicators of reproductive success. If more than 1 hen was with any particular hen-poult group all were assumed to have contributed poults although it is recognized that this likely does not always occur.

Average monthly temperature and total monthly precipitation data were obtained from published weather records of U.S. Weather Bureau stations convenient to each study area. The Santa Gertrudis and Encino areas were represented by Kingsville and Armstrong stations, respectively, both of which are no more than 16 km from the center of the areas. Soil moisture storage and deficit values were calculated from the weather data using the methods of Thornthwaite and Mather (1957). The soil moisture holding capacity for soils on the Santa Gertrudis and Encino areas was estimated from Soil Conservation Service soil series description sheets at approximately 6.7 and 1.3 cm/dm, respectively.

Annual average turkey poult/hen ratios were correlated with monthly soil moisture storage and deficits and all possible monthly and combined monthly precipitation totals for each biological year, 1 July - 30 June. The resulting 125 climatic variables were tested individually by simple regression and by the maximum 3 variable $R^2$ (multiple regression) determination.

## RESULTS

Turkey productivity fluctuated dramatically during this investigation (Table 1). On the Santa Gertrudis area average production indices ranged from over 500 poults/100 hens in 1968 and 1972 to 0 in 1971 and 1975. Similarly, the poult/hen indices on the Encino area ranged from about 200 to 440 and from 8 to 12 during the same, respective years. The values in intervening years were intermediate but consistently at least 60% below the maxima.

Table 1. Average annual productivity of wild turkeys on 2 King Ranch study areas in south Texas, 1968 - 1977. Numbers in parentheses represent average number of hens observed per transect.

| Year | Poults/100 hens | | % hens with poults | |
|---|---|---|---|---|
| | Santa Gertrudis | Encino | Santa Gertrudis | Encino |
| 1968 | 543 (50) | 195 (55) | 71 | 70 |
| 1969 | 39 (36) | 82 (39) | 8 | 22 |
| 1970 | 32 (30) | 37 (88) | 7 | 4 |
| 1971 | 0 (22) | 8 (105) | 0 | 1 |
| 1972 | 576 (8) | 443 (30) | 93 | 44 |
| 1973 | 43 (49) | 23 (91) | 10 | 7 |
| 1974 | 147 (32) | 24 (72) | 25 | 6 |
| 1975 | 0 (8) | 12 (15) | 0 | 3 |
| 1976 | 148 (21) | 23 (19) | 29 | 6 |
| 1977 | 134 (62) | 51 (37) | 27 | 14 |

The percent hens with poults, which was presumed to represent the number of hens successfully hatching a clutch, closely paralleled the poults/hen age ratios (Table 1). These values on the Santa Gertrudis area ranged from 0 in the years of lowest age ratios to 71 to 93 in the years of the highest. Similarly, the values on the Encino area were 1-3 and 44-70, respectively, in the low- and high-age-ratio years.

Variability also was notable in between year climatic moisture relationships. Total rainfall for the 1 July to 30 June biological year ranged from about 46 to 107 and 30 to 137 cm, respectively, on the Santa Gertrudis and Encino areas (Table 2). Monthly precipitation and soil moisture deficit and storage values also fluctuated widely between years. For example, precipitation in September ranged from about 5 to 38 cm on Santa Gertrudis and 3 to 63 cm on Encino during the 10-year period (Table 2). Similarly, soil moisture deficits ranged from 0 to approximately 10 cm and soil moisture storage from 0 to the maximum possible (20 cm for Santa Gertrudis and 4 cm for Encino).

The maximum $R^2$ determination indicated 97.3% of the variability in turkey age ratios between years on the Santa Gertrudis study area was explainable by a model composed of soil moisture storage in August prior to the breeding season, combined total precipitation for September and October prior to the breeding season, and total precipitation for March during the breeding season. Similarly, 98.3% of the variability in this reproductive parameter on the Encino area was explainable by the model composed of combined total precipitation for August and September prior to the breeding season and soil moisture storage in September, prior to the breeding season, and in May during the breeding season.

Table 2. Selected climatic moisture related parameters, compiled for the 2 King Ranch study areas in south Texas, which demonstrated the variability between years.

| | Santa Gertrudis area | | | | Encino area | | | |
|---|---|---|---|---|---|---|---|---|
| | | September | | | | September | | |
| | | | Soil moisture | | | | Soil moisture | |
| Year | Annual[a] ppt (cm) | ppt (cm) | Deficit (cm) | Storage (cm/dm) | Annual[a] ppt (cm) | ppt (cm) | Deficit (cm) | Storage (cm/dm) |
| 1967-68 | 94.18 | 38.38 | 0.00 | 6.67 | 138.22 | 63.53 | 0.00 | 1.25 |
| 1968-69 | 61.42 | 12.78 | 0.33 | 0.87 | 43.26 | 4.65 | 8.56 | 0.00 |
| 1969-70 | 76.05 | 9.30 | 5.46 | 0.00 | 63.98 | 8.38 | 5.61 | 0.00 |
| 1970-71 | 45.62 | 10.29 | 3.71 | 0.00 | 31.09 | 12.80 | 0.41 | 0.00 |
| 1971-72 | 107.82 | 31.29 | 0.00 | 6.67 | 78.54 | 23.98 | 0.00 | 1.25 |
| 1972-73 | 84.00 | 15.06 | 0.18 | 0.86 | 84.68 | 9.04 | 5.72 | 0.00 |
| 1973-74 | 98.58 | 32.00 | 0.00 | 7.88 | 48.23 | 6.17 | 7.80 | 0.00 |
| 1974-75 | 52.04 | 10.08 | 2.31 | 0.41 | 86.41 | 27.10 | 0.00 | 1.25 |
| 1975-76 | 87.17 | 11.02 | 2.18 | 0.00 | 69.16 | 13.82 | 0.00 | 0.20 |
| 1976-77 | 105.87 | 5.61 | 2.29 | 1.01 | 86.89 | 3.40 | 10.44 | 0.00 |

[a]1 July through 30 June.

# DISCUSSION

There are several species of gallinaceous birds, other than wild turkeys, in the southwestern United States that experience the "boom-bust" phenomenon of reproductive success. This phenomenon doubtless is keyed to the fluctuating nature of the climate. Francis (1965, 1967, 1970) and Leopold et al. (1976) reported a drastically fluctuating immature/adult ratio of California quail (Lophortyx californicus) from year to year. In western Texas, Smith (1917) and Wallmo (1956) and Wallmo and Uzzell (1958) recorded a drop in population of Montezuma quail (Cyrtonyx montezumae) and scaled quail (Callipepla squamata), respectively, after several successive dry years. Bobwhite (Colinus virginanus)and scaled quail in southwestern Texas have been described as undergoing spectacular irruptions following atypically favorable rainfall and virtually disappearing during severe drought (Lehmann 1946, 1953). Swank and Gallizioli (1954), working with Gamble's quail (Lophortyx gambelii) in Arizona, and Raitt (1977) and Campbell (1968) working with scaled quail in New Mexico, demonstrated the general importance of rainfall on reproductive success. MacGregor and Inlay (1951) reported a complete reproductive failure in the Gambel's quail in California during a dry period.

Lehmann (1953) and Hungerford (1964) speculated that the fluctuations in reproductive success resulted from varying amounts of Vitamin A in vegetation from year to year; however, this idea has been discounted as the cause of reproductive fluctuations (Fletcher 1971). Leopold et al. (1976) suggested that phytoestrogens are produced by food plants of quail in dry years and that these substances act as reproductive inhibitors. It has been clearly demonstrated that these compounds inhibit reproductive success in certain mammals (Davis and Bennett 1962, Beck 1963, Labov 1977); however, more work is necessary before this hypothesis can be generally accepted in birds. Interpretation of the data from the present and other of our studies on the Rio Grande turkeys (Beasom 1973, Pattee 1977) implies that these birds can reproduce successfully when the proper "triggering" mechanism is present but does not negate the possibility of a retardant. These birds generated moderate productivity indices (41-88 poults/100 hens) in areas that were artificially fed a commercial turkey breeder ration in relatively dry 1975 and 1976, whereas on unfed areas only 12-23 poults/100 hens were produced. The birds on the fed areas had access to and utilized native vegetation, as did those on unfed areas, and were exposed to any chemical retardant present. Their use of artificial supplement, however, likely reduced the amount of retardant they would have received.

It is unproven whether reproductive success in Rio Grande turkeys is regulated by a stimulant, a suppressant, or a combination of both, but it is apparent that the mechanism is tied closely to the climatic regime in the late summer-early fall period prior to the onset of breeding. That the mechanism acts on the turkeys at this time is, however, doubtful. More likely, abundant rainfall at this time charges the soil moisture to capacity which is largely carried over winter because of much reduced evapotranspiration. Subsequently, if the soil moisture storage is high at the onset of the growing season, the vegetation is better able to respond to any additional rainfall that may occur in the spring. Such conditions are conducive to more vigorous (Cable 1975) and higher nutritional quality plant growth (Hsiao 1973). Of added benefit are the relatively high insect populations in such vegetation (Jones 1963). Conversely, spring rainfall occurring when soil moisture storage is low is relatively less valuable for plant growth because evapotranspiration rates have elevated by that time. Coincident with the increased moisture stress in dry years is the obvious reduction in quality of the vegetation (including the possible reproductive inhibitors) and the characteristically apparent abortive reproductive effort by turkeys.

It is apparent that management to alleviate poor reproductive success in turkeys in this region must be directed at enhancing gonadal development. Beasom (1973) showed that the bird's net reproductive output was directly correlated with ovary and oviduct weights and that complete failure of gonadal reproductive development was common in "dry" years. Egg development seems to be the paramount stage in the total reproductive process that mandates the ultimate net productivity; nesting and poult mortality is generally of much less importance (Beasom 1973). The direct causative agent affecting gonadal development in wild turkeys is unknown, but it likely is nutritionally-based. Such a problem should be manageable through the use of irrigated food plots or other artificial supplementation of the diet, however, the kinds of foodstuffs or chemicals needed also are unknown at present.

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# REPRODUCTIVE POTENTIAL OF RIO GRANDE TURKEY HENS IN THE EDWARDS PLATEAU OF TEXAS[a]

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Abstract: Between 1973 and 1978, 123 Rio Grande turkey (*Meleagris gallopavo intermedia*) hens were equipped with radio transmitters. Due to transmitter malfunction, antenna breakage and natural mortality, only 53 of the hens (21 adults and 32 yearlings) were radio-tracked through the nesting season. Eighteen adults and 10 yearling hens were confirmed nesters. Yearling hens renested at about the same frequency as adults (50% for yearlings and 54% for adults). The average clutch size for all hens was 9.8 eggs. Yearling clutches were slightly larger than adult clutches. Ten of the 53 hens (19%) that were tracked hatched poults. This study indicates that yearling Rio Grande turkey hens will nest, but not as frequently as adults. The percentage of yearlings that produced successful nests was less than l/2 that of adult hens.

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Recent changes in game regulations that allowed either-sex turkey hunting during the fall season and the addition of a spring season for gobblers have provided increased hunting opportunity. Turkey harvest is light, probably less than 10% of the annual population (Cook 1972). As hunting pressure increases, specific information on the turkey's reproductive potential will be required since Texas game laws are established prior to the nesting season. Previous data indicate the age composition of turkey hens may be a significant factor affecting flock increment.

We would like to thank Mrs. R. Davis and J. Vanderstucken for allowing the use of their ranches for this study. Appreciation is expressed to the following former or present employees of the Texas Parks and Wildlife Department who assisted in the considerable amount of field work that was performed: A. C. Briscoe, J. L. Butler, B. K. Carroll, D. S. Cooke, D. J. Davis, D. E. Harmel, R. G. Marburger, H. M. Otto, J. R. Perkins, D. R. Synatzske, F. C. Van Hoozer, I. G. Willmann and D. E. Wilson. G. A. Boydston was very helpful by analyzing the numerical data. B. K. Carroll, R. L. Cook and G. W. Litton reviewed the manuscript.

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## STUDY AREAS

Two study areas representing the eastern and western portions of the Edwards Plateau were selected. The Edwards Plateau is located in the central portion of Texas. The soils of the region are principally lithosols, shallow and rocky, and suitable primarily for livestock production (Stoddart and Smith 1943). The primary types of livestock are beef cattle, sheep and angora goats (Cook 1972).

The Blanco County study area which represented the eastern portion of the Edwards Plateau was located approximately 18 km south of Blanco on the 2,024 ha Hereford Hills Ranch. This area was situated in a live oak savanna vegetative type, interspersed with dense cedar brakes on hillsides and canyons. The turkey wintering area was primarily a riparian habitat traversed by the Little Blanco River. The flood plain of the Little Blanco River is deep and fertile. It is cultivated primarily with winter small grains and hay crops. Approximately 0.4 km south of the river, the flood plain meets low lying hills of rocky shallow soils. The woody vegetation of this area consisted of Ashe juniper (Juniperus ashei), Texas persimmon (Diospyros texana), elm (Ulmus spp.), live oak (Quercus virginiana), black cherry (Prunus serotina) and sugar hackberry (Celtis laevigata). Bald cypress (Taxodium distichum) and pecan (Carya illinoensis) were dominant along the river.

The Sutton County study area which represented the western portion of the Edwards Plateau was located approximately 13 km south of Sonora on the 2,915 ha Vanderstucken ranch. The study area was comprised of low rolling hills with an overstory cover of mesquite (Prosopis chilensis), juniper and liveoak. The area was arid with most surface water provided by windmills and stock tanks. There were no perennial streams on the study area. This ranch was under development for the production of natural gas and was well traversed with surface roads making most portions easily accessible by vehicle. Due to a declining turkey population and equipment problems, the study was terminated at the Sutton County study area after the 2nd year.

## METHODS

Rio Grande turkey hens were baited with milo and captured with drop nets. The hens were banded, fitted with radio transmitters to obtain nesting and poult production data and released. The transmitters used during the 1st 3 years of the study were battery powered. Both battery and solar-powered transmitters were used during the last three years of the study. A 24-channel crystal-controlled receiver produced acceptable results for tracking the telemetered turkeys. Hand-held yagi antennas were used for short range tracking and in determining exact locations. Truck-mounted whip antennas were used for long range tracking. Daily locations of transmittered turkeys were established and recorded by use of 2 or more directional readings taken at fixed locations.

Attempts were made to locate nests without disturbing the hens. The nest locations were estimated by triangulation, then approached only when hens were off the nests.

The G-test was used to test adult versus yearling nesting attempts and success. The G-test was described by Sokal and Rohlf (1969) as being superior to the chi-square test.

# RESULTS

## Tracking Success

During this 6-year study, 123 turkey hens (48 adults and 75 yearlings) were equipped with radio transmitters. Eighty-one of these birds were located on the study area in Blanco County and 42 were on the Sutton County study area.

Due to transmitter malfunctions, antenna breakage and natural mortality, only 53 hens (21 adults and 32 yearlings) were radio-tracked throughout the nesting season. Tracking success was poor during the 1st 3 years of the study, when inferior radio-tracking equipment was used. Because of these equipment problems and also due to a declining turkey population, the investigation was terminated at the Sutton County study area after the 2nd year. During the last 3 years of the study (1976-1978), transmitters were obtained from a different source and tracking efforts were much more successful. Eighty-five hens were instrumented during the 1st 3 years, but radio-tracking through the nesting season was possible with only 19 (22%) of these birds. An increase in tracking success was experienced during the last 3 years when 34 of 38 hens (89%) were successfully tracked throughout the nesting season.

## Nesting Attempts

Of the 53 transmittered hens that were tracked, 28 hens (53%) were confirmed nesters. Some hens may have had nests that were destroyed by predators before they were located. This may have occurred during the laying or early incubation stages. Eighteen of the 21 adult hens (86%) were confirmed nesters (Table 1). Ten of the 32 yearling hens (31%) nested (Table 2).

Seven of the adult hens that were unsuccessful at their 1st attempt renested and 3 hens established a 3rd nest. There were 4 2nd nesting attempts by yearlings and 1 3rd attempt. Both adult and yearling hens that were unsuccessful on their 1st attempt renested at approximately the same frequency.

## Nest Predation

There were 43 clutches laid by the 28 nesting hens (Table 3). nine of the clutches were deserted by the hen, 24 were destroyed by predators and 10 hatched. Mammalian predators were suspected of destroying 12 nests and 11 destroyed nests were attributed to snakes. Three Texas rat snakes (*Elaphe, obsoleta, lindheimeri*) and 2 bull snakes (*Pituophis melanoleucus*) were observed in or near nests that had been destroyed. The snakes all had eggs in their stomachs. A rock squirrel (*Spermophilus variegatus*) was observed destroying 1 nest.

To our knowledge, no nesting hen was significantly injured by predators, although feathers and other signs of struggle were found

Table 1. Adult turkey hen nesting data collected in the Edwards Plateau of Texas, 1973-1978.[a]

| Year | No. of Radio-Equipped Hens | No. of Hens Tracked | 1st Attempt | | 2nd Attempt | | 3rd Attempt | |
|---|---|---|---|---|---|---|---|---|
| | | | No. of Nests | No. of Nests Hatched | No. of Nests | No. of Nests Hatched | No. of Nests | No. of Nests Hatched |
| 1973 | 18 | 0 | -- | -- | -- | -- | -- | -- |
| 1974 | 12 | 5 | 4 | 1 | 2 | 0 | 1 | 0 |
| 1976 | 6 | 4 | 3 | 0 | 1 | 0 | 1 | 0 |
| 1977 | 5 | 5 | 5 | 2 | 2 | 0 | 0 | -- |
| 1978 | 7 | 7 | 6 | 2 | 2 | 0 | 1 | 1 |
| Total | 48 | 21 | 18 | 5 | 7 | 0 | 3 | 1 |

a Transmitters were not placed on adult hens in 1975.

Table 2. Yearling turkey hen nesting data collected in the Edwards Plateau of Texas, 1973-1978.

| Year | No. of Radio-Equipped Hens | No. of Hens Tracked | 1st Attempt | | 2nd Attempt | | 3rd Attempt | |
|---|---|---|---|---|---|---|---|---|
| | | | No. of Nests | No. of Nests Hatched | No. of Nests | No. of Nests Hatched | No. of Nests | No. of Nests Hatched |
| 1973 | 24 | 0 | -- | -- | -- | -- | -- | -- |
| 1974 | 21 | 12 | 0 | -- | -- | -- | -- | -- |
| 1975 | 10 | 2 | 1 | 0 | 0 | -- | -- | -- |
| 1976 | 4 | 4 | 4 | 0 | 2 | 1 | 0 | -- |
| 1977 | 9 | 8 | 4 | 2 | 2 | 0 | 1 | 1 |
| 1978 | 7 | 6 | 1 | 0 | 0 | -- | -- | -- |
| Total | 75 | 32 | 10 | 2 | 4 | 1 | 1 | 1 |

Table 3. Comparison of adult and yearling turkey hen nesting attempts collected in the Edwards Plateau of Texas, 1973-1978.

| Age Classification | Hens Tracked | Percent Nested | First Nest | Second Nest | Third Nest | Total Nests |
|---|---|---|---|---|---|---|
| Adults | 21 | 86 | 18 | 7 | 3 | 28 |
| Yearlings | 32 | 31 | 10 | 4 | 1 | 15 |
| Total | 53 | 53 | 28 | 11 | 4 | 43 |

in the vicinity of 2 nests.

### Average Clutch Size

The average clutch size of all hens was 9.8 eggs (Table 4). The average clutch size of yearlings was slightly greater than that of adult hens (10.2 eggs for yearlings and 9.6 eggs for adults). First clutches of all hens were usually larger than 2nd and 3rd clutches. The 2 largest clutches in the study were produced by yearling hens with each clutch being comprised of 15 eggs. An adult hen produced the smallest clutch which was comprised of 5 eggs.

### Brood Production

Of the 28 confirmed nesting hens, 6 of 18 adults produced broods and 4 of 10 yearlings nested successfully. Seven of the 28 1st nesting attempts were successful. One of 11 2nd nests hatched and 2 of 4 3rd nesting attempts were successful.

Of the 53 hens that were tracked, 10 (19%) nested successfully. Six of 21 adults (29%) hatched broods and only 4 of 32 yearling hens (13%) nested successfully.

## DISCUSSION

During this 6-year study, only 4 years (1974, 1976, 1977 and 1978) provided sufficient data to be analyzed individually. Turkey production data collected in the Edwards Plateau Regulatory District during these 4 years compared favorably with data from this study. The Edwards Plateau turkey production data was compiled from incidental turkey observations recorded throughout the region during June, July and August.

During the 4-year period, 1977 was the most productive year for turkeys in the Edwards Plateau, based on observed poults per hen (2.9) and the percentage of adult hens with poults (63%). It was also the most productive year of this study, as 38% of all hens tracked through the breeding season nested successfully.

The 2 least productive years for turkeys in the Edwards Plateau, 1974 and 1976, were also the least productive years of this study. The Edwards Plateau turkey production data indicated that 0.7 and 0.5 poults per hen were observed in 1974 and 1976, respectively. Twelve percent of the hens in the Edwards Plateau produced broods in 1974 and 15% produced broods in 1976. Only 6% of radio-tracked hens in this study nested successfully in 1974 and 13% nested successfully in 1976.

Nest predation was common during this study. Snakes appeared to be a major predator, particularly Texas rat snakes and bull snakes, which are common to the study areas. Although snake predation is minimal in other areas of Texas (Baker 1978), it appeared to be equal to mammalian predation in this study.

This study indicates that yearling Rio Grande hens will nest; however, not as often as adults ($P<0.01$). When yearling hens did nest, they were as successful as adults and their clutches were slightly larger. The average clutch size of all hens (9.8 eggs) was lower than the average clutch size of 10.4 eggs reported by Cook (1972) for the

Table 4. Average number of eggs in clutches of adult and yearling turkey hens, 1973-1978, with number of nest observations (n) and standard error of the mean (SE). Edwards Plateau of Texas.

| Age Class | First Nest | Second Nest | Third Nest | Combined |
|---|---|---|---|---|
| Adults | 9.9 (n=15;SE=O.54) | 9.4 (n=5;SE=1.03) | 8.7 (n=3;SE=0.67) | 9.6 (n=23;SE=0.42) |
| Yearlings | 11.0 (n=9;SE=O.85) | 8 . 3 (n=4;SE=0.67) | - - | 10.2 (n=13;SE=0.71) |
| Combined | 10.3 (n=24;SE=0.47) | 8.9 (n=9;SE=0n.63) | 8.7 (n=3;SE=0.67) | 9.8 (n=36;SE=0.37) |

Edwards Plateau.

Williams et al. (1976) reported that yearling hens in Florida did not attempt to renest as often as adults. In this study, yearlings and adult hens exhibited an equal tendency to renest. The percentage of yearling hens that produced successful nests was less than l/2 of that of adult hens, although small sample sizes precluded a valid statistical test.

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# TURKEY PRODUCTIVITY AND HABITAT USE ON SOUTH TEXAS RANGELANDS[1]

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Abstract: Productivity and habitat use of Rio Grande turkeys (*Meleagris gallopavo intermedia*) were evaluated from May 1976 through November 1977 on the Welder Wildlife Refuge and the Rooke Ranch near Sinton, Texas. Turkey productivity ranged from 0.5 poults:hen in 1976 to 1.2 poults:hen in 1977. Higher productivity in 1977 may have been related to heavy late summer-early fall rainfall in 1976 which contributed to an early spring green-up, resulting in the early onset of nesting behavior. Average hatching dates were 6 June 1976 and 30 May 1977. From the mating season to the period of winter flock stability, turkeys decreased their use of the open savannah habitat and increased their use of the dense riparian-woodland habitat. During the mating season, turkeys frequently used mowed pastures and roads for strutting, especially areas adjacent to unmowed brushy cover. Observations of lone, presumably nesting, hens during April and May indicated that their habitat preference differed from the remainder of the turkey population. Brush clearing of a mesquite-bristlegrass pasture immediately attracted turkey broods which intensively used the disturbed sites for feeding during July and August. During September and October, the turkey population underwent a "shuffling" period as poults and hens combined into larger flocks, and turkeys returning to the Refuge from summer ranges joined the resident flocks or formed new flocks. During the winter months, over 60% of the turkey observations were in the dense riparian-woodland habitat which bordered the Arkansas River.

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Knowledge of productivity and habitat use is essential to the management of Rio Grande turkeys, however, few ecological studies have been conducted in South Texas. Beasom (1969, 1973) studied

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productivity and reproductive success and Pattee (1977) investigated some nutritional requirements for reproduction. Watts (1969) and Smith (1977) studied social organization at different population densities on the Welder Wildlife Refuge. Merrill (1975) evaluated the effects of various grazing management practices on turkey nesting and productivity. However, basic information on habitat use is still incomplete. This study provides information concerning wild turkey productivity and habitat use on the Welder Wildlife Refuge during 1976 and 1977.

We thank W. C. Glazener for valuable consultation during the project, F. Rooke Jr. for access to his property, and C. R. Hopkins for reviewing the manuscript. This study was supported by the Welder Wildlife Foundation and Texas A&M University.

## STUDY AREA

The study was conducted on the 3,158-ha Rob and Bessie Welder Wildlife Refuge and approximately 200 ha of the Rooke Ranch near Sinton in South Texas. Annual rainfall averages 89 cm, however, vegetation is controlled by extremes and many plants of more arid zones occur in the flora. The Welder Refuge occurs in a grassland climax found along the Gulf of Mexico. However, it has presently developed into a brush-grass complex, partially as a result of a long history of grazing use by domestic livestock (Drawe et al. 1978, Lehmann 1969). Drawe et al. (1978) described in detail the climate, soils, vegetation, and land-use patterns.

In August 1974, the Refuge began a long-term comparison of the continuous, 4-pasture deferred rotation, and high intensity-low frequency grazing systems, using an average stocking rate of 5.1 ha per animal unit of cattle. The 4-pasture system used 3 herds grazing 4 pastures. Each pasture had a 12-month grazing period followed by a 4-month deferment period causing successive rest periods to fall at different seasons. The high intensity system had 1 herd rotated among 7 pastures. Each pasture was grazed from 2-7 weeks depending on range condition and pasture size. The Rooke Ranch used continuous grazing with a stocking rate of 4.0 ha per animal unit. Both areas operated a cow-calf program which consisted of selling calves produced from relatively stable herds of cattle.

## METHODS

Field research was conducted from May 1976 through November 1977. Drawe et al. (1978) mapped and identified plant communities on the Welder Wildlife Refuge using aerial photographs and vegetational data. Using the same methods, plant communities were delineated on the Rooke Ranch. Foliar cover of herbaceous vegetation was measured using an inclined 10-point frame (Brown 1954). Woody vegetation over 2 m high was quantified in the riparian-woodland and riparian-savannah plant communities using the point-center quarter technique (Cottam and Curtis 1956). In addition, herbaceous vegetation height was measured at 120 locations in the riparian-woodland and riparian-savannah plant communities.

During December 1976 and January 1977, we continued an ongoing project of trapping (Glazener et al. 1964) and marking (Knowlton et al. 1964) turkeys on the Refuge, which resulted in a majority of the population being marked with individually color-coded patagial wing tags.

Productivity and habitat use data were collected by repeatedly driving all passable roads on the study area and making observations of turkeys from a vehicle. Whenever possible, the following data were recorded for each observation: date, time, pasture, plant community, map coordinates, number of turkeys, sex, age, patagial tag codes, distance from turkeys to road, distance from turkeys to observation vehicle, and behavior when sighted. Productivity was determined from August observations of individually recognizable turkey broods. Time spent censusing different areas was directly proportional to the number of turkeys observed using those areas. Standardized census routes were not established due to unpredictable road conditions caused by frequent heavy rains.

Habitat use data was analyzed seasonally by calculating a visibility index equal to the average turkey-to-road distance (m) for all observations within a particular plant community. This index was used to convert the actual number of turkey observations within each plant community to a weighted value based on the visibility of turkeys within that habitat. Observations were weighted in this manner to reduce bias caused by differential visibility among plant communities. Observations of turkeys at roost sites were not included in this analysis because such observations were often predetermined or non-random and would therefore bias the conclusions. Poults (1-16 weeks) were identified as to sex and age by the methods of Nixon (1962) and juveniles (16+ weeks) were identified by covert patch configuration (Williams 1961).

## RESULTS AND DISCUSSION

### Vegetational Analysis

Drawe et al. (1978) described 16 plant communities on the Welder Wildlife Refuge of which 5 (riparian-woodland, mesquite-bristlegrass, bunchgrass-annual forb, live oak-chaparral, and colubrina-bunchgrass) were identified on the Rooke Ranch during this study (Fig. 1). One additional community (riparian-savannah) was described for the Rooke Ranch.

Differences in woody vegetation between riparian-woodland and riparian-savannah were substantial. Total density was 460.8 plants/ha in riparian-woodland and 29.9 plants/ha in riparian-savannah. Canopy cover was 127.9% in riparian-woodland and 11.3% in riparian-Savannah. However, species composition was similar between areas, with 12 species occurring in riparian-woodland and 8 species in riparian-savannah (Baker 1979). Sugar hackberry (*Celtis laevigata*) was clearly the dominant tree in both communities, with an importance value (relative density + relative dominance + relative frequency) of 155.5% in riparian-woodland and 218.6% in riparian-savannah. Other species

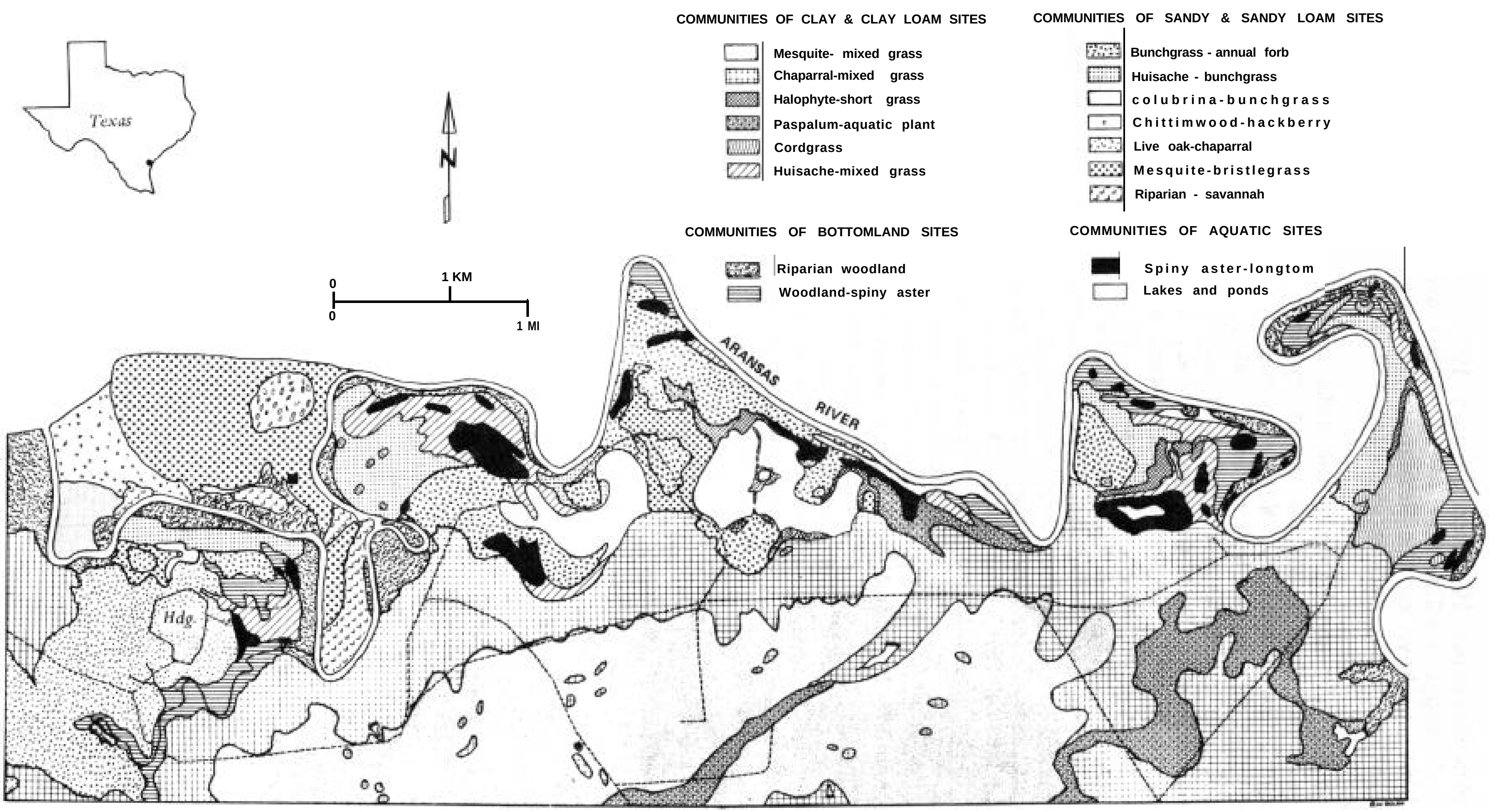


Fig. 1. Plant communities of the Welder Wildlife Refuge and the Rooke Ranch, San Patricia and Refugio Counties, Texas. Welder Wildlife Refuge communities, located south of the Aransas River, were taken from Drawe et al. (1978).

important to both communities were netleaf hackberry (C. reticulata), chinaberry (Melia azedarach), and lime pricklyash (Zanthoxylum fagara). The openness observed in the riparian-savannah community was partly caused by recent hurricanes which severely damaged or destroyed many hackberry trees, and by periodic brush control which has restricted the general regrowth of woody vegetation (Frank Rooke Jr., pers. comm.[1]).

The 22.4 cm average height of herbaceous vegetation in riparian-woodland was significantly greater ($P<0.05$) than the 39.6 cm height in riparian-savannah. The major herbaceous species in riparian-woodland (Table 1) were rusty seed Paspalum (Paspalum langei) and bermudagrass (Cynodon dactylon). In riparian-savannah, the major species were false ragweed (Parthenium hysterophorus) and longtom (P. lividum). In general, the greater average height of the herbaceous vegetation in the riparian-savannah community was caused by the abundance of false ragweed, a large forb.

Mesquite-bristlegrass occurred mostly on upland, clay soil sites on the Rooke Ranch and was characterized either by large, widely spaced mesquite (Prosopis glandulosa) trees in brush-cleared savannahs, or by dense brushland dominated by mesquite. Major herbaceous species were broomweed (Xanthocephalum texanum) and knotroot bristlegrass (Setaria geniculata The bunchgrass-annual forb community occurred on deep sandy soils and was virtually a treeless prairie (Drawe et al. 1978). The dominant grasses were Pan American balsamscale (Elyonurus tripsacoides) and seacoast bluestem (Schizachyrium scoparium). Woolly Croton (croton capitatus) was a dominant forb, especially during the summer and fall months.

Live oak-chaparral was a complex 3-layered community which consisted of live oak (Quercus virginiana), chaparral, and bunchgrasses (Drawe et al. 1978). Dominant herbaceous species were brownseed Paspalum (P. plicatulum) and western ragweed (Ambrosia psilostachya). In the chaparral-mixedgrass community the canopy cover of brush ranged from 35 to 55% and was dominated by blackbrush acacia (Acacia rigidula). Major herbaceous species included vine mesquite (Panicum obtusum) longtom, and Texas wintergrass (Stipa leucotricha).

Huisache-mixedgrass occurred in low areas with clay soils where knotroot bristlegrass and hairyseed Paspalum (P. pubiflorum) were the major herbaceous species (Drawe et al. 1978). Huisache-bunchgrass occurred in low areas with sandy soils; herbaceous vegetation was similar to the bunchgrass-annual forb community, except that shade-tolerant species replaced some of the prairie grasses. The remaining communities were described by Drawe et al. (1978).

Productivity

During winter 1976-77, turkeys occurred in 2 relatively isolated populations on the study area. The majority were located near the west end of the Refuge and on the adjacent Rooke Ranch on the north side of the Aransas River (Fig. 1). The winter population numbered approximately 107 birds, including at least 60 hens, 37 adult males, and 10 immature males. The population was fairly sedentary with a limited range of about 500 ha. However, during spring and summer over 50% of the hens dispersed from their winter range to presumed

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Table 1. Percent foliar cover of the most common herbaceous plants occurring in 6 major plant communities on the Welder Wildlife Refuge and the Rooke Ranch: riparian-woodland (RW), riparian-savannah (RS), mesquite-bristlegrass (MB), bunchgrass-annual forb (BF), live oak-chaparral (OC), chaparral-mixedgrass (CM).

| Species | RW | RS | MB | BF | OC[a] | CM[a] |
|---|---|---|---|---|---|---|
| Grasses | | | | | | |
| Seacoast bluestem | | | | 14.7 | | |
| Buffalograss | | | | | | 5.3 |
| Bermudagrass | 8.8 | 6.3 | 8.0 | | | |
| Pan American balsamscale | | | | 26.3 | | |
| Filly Panicum | | | | | 4.0 | |
| Vine-mesquite | | | | | | 9.7 |
| Panic grass | | | | | 7.0 | |
| Rustyseed Paspalum | 12.3 | 5.3 | | | | |
| Longtom | | 7.8 | | | | |
| Brownseed Paspalum | | | 5.2 | | 16.3 | |
| Knotroot bristlegrass | | | 10.8 | 2.0 | 6.3 | 6.7 |
| Southwestern bristlegrass | 4.8 | | | | | |
| Texas wintergrass | | | | | | 6.7 |
| Broadleaf uniola | 6.2 | | | | | |
| Forbs. | | | | | | |
| Western ragweed | | | 5.3 | 2.3 | 8.0 | |
| Straggler daisy | 5.7 | 4.8 | | | | |
| Woolly croton | | | | 6.7 | | |
| Texas croton | | 3.5 | | | | |
| Silverleaf sunflower | | | 7.0 | | | |
| Horsemint | | | | 3.0 | | |
| False ragweed | | 17.7 | | | | |
| Upright prairie-coneflower | | | | | | 5.7 |
| Broomweed | | | 11.2 | | 5.7 | |
| Turk's cap | 2.5 | | | | | |

[a]Foliar cover measurements made by D. Lynn Drawe, Assistant Director, Welder Wildlife Foundation.

nesting areas on the Refuge and adjacent land, Glazener (1967) stated that Rio Grande hens may disperse 40 km or more to nest.

Turkey productivity was over twice as high in 1977 as in 1976. In 1976, 10 hens produced 25 poults and the overall poult/hen ratio was 0.5:l. Estimated hatching dates ranged from 1 May to 1 July, and averaged 6 June. By contrast, 8 hens produced 41 poults in 1977 and the overall poult/hen ratio was 1.2:1. Estimated hatching dates ranged from 7 May to 18 June and averaged 30 May

During the 4-month period of July-October 1976, the Refuge received 71 cm of rainfall (Table 2), which was over 80% of the yearly

Table 2. Rainfall data (cm) for the Welder Wildlife Refuge in South Texas, January 1976 - August 1977.[a]

| Year | Jan<br>Jul | Feb<br>Aug | Mar<br>Sep | Apr<br>Oct | May<br>Nov | Jun<br>Dec |
|---|---|---|---|---|---|---|
| 1976 | 0.8<br>27.5 | 0.1<br>5.8 | 0.7<br>18.3 | 13.0<br>19.6 | 13.3<br>11.3 | 3.0<br>11.4 |
| 1977 | 8.9<br>4.9 | 3.3<br>2.2 | 2.2 | 16.5 | 14.8 | 3.7 |

[a]Compiled for the Refuge Headquarters station by D. Lynn Drawe, Welder Wildlife Refuge.

average (Drawe et al. 1978). In addition, the Refuge received nearly 9 cm of rain in January 1977, which, coupled with warmer than normal temperatures in February, caused an early spring green-up. Strutting behavior was initiated in late February following this green-up and probably contributed to the observed early nesting season and subsequent high reproductive success.

Beasom (1973) and Beasom and Pattee (1980) also found a direct positive correlation between late summer-early fall rainfall and high reproductive success of turkeys the following spring. Abundant rainfall at this time can replenish soil moisture to capacity which can carry over to the following spring and result in an early growth of vegetation. In addition, Beasom (1973) suggested that the verdant nature of the vegetation may be important in causing the onset of breeding in South Texas turkeys. During a poor reproductive year he observed that male display behavior was delayed until spring rainfall caused sprouting of green vegetation.

## Habitat Use

Analysis of seasonal habitat use indicated that throughout the year, from the mating season to the period of winter flock stability, turkey use of open riparian-savannah decreased while use of dense riparian-woodland increased (Table 3, Fig. 2). Use of mesquite-bristlegrass was high during the mating season and moderate throughout the remainder of the year. Huisache-bunchgrass was frequented during the nesting and fall-shuffle seasons when turkey movements were at a high level. Other habitats received little use, except for live oak-chaparral which was often used by adult gobblers during the fall-shuffle and winter stability periods.

Mating. Approximately 80% of the turkey observations during mating season occurred in riparian-savannah and mesquite-bristlegrass plant communities (Fig. 2). The majority of the area in these communities was mowed in November of 1976; subsequently, herbaceous vegetation grew to a height of only 10-20 cm by the following March.

Table 3. Analysis of seasonal habitat use (%) by wild turkeys on the Welder Wildlife Refuge and Rooke Ranch in South Texas. Visibility index is the average turkey-to-road distance (m) for all observations within a particular plant community and season.

| Plant community | Visibility index (m) | Actual. obs. (n) | Weighted obs.[a] (n) | Habitat use (%) |
|---|---|---|---|---|
| Mating | | | | |
| Riparian-woodland | 43.0 | 124 | 124.0 | 22.3 |
| Riparian-savannah | 71.6 | 304 | 183.6 | 33.0 |
| Mesquite-bristlegrass | 45.8 | 239 | 224.4 | 40.4 |
| Huisache-bunchgrass | 60.0 | 34 | 24.4 | 4.4 |
| Nesting | | | | |
| Riparian-woodland | 26.9 | 43 | 43.0 | 22.5 |
| Riparian-savannah | 47.7 | 82 | 46.2 | 24.1 |
| Mesquite-bristlegrass | 75.6 | 102 | 36.3 | 19.0 |
| Huisache-bunchgrass | 46.3 | 78 | 45.3 | 23.7 |
| Oak-chaparral | 92.2 | 27 | 7.9 | 4.1 |
| Chaparral-mixedgrass | 109.0 | 52 | 12.8 | 6.7 |
| Brooding | | | | |
| Riparian-woodland | 25.3 | 713 | 713.0 | 48.1 |
| Riparian-savannah | 31.8 | 367 | 292.0 | 19.7 |
| Mesquite-bristlegrass | 44.4 | 542 | 308.8 | 20.8 |
| Huisache-bunchgrass | 37.1 | 73 | 49.8 | 3.4 |
| Huisache-mixedgrass | 63.8 | 69 | 27.4 | 1.8 |
| Bunchgrass-annual forb | 37.2 | 133 | 90.5 | 6.1 |
| Fall shuffle | | | | |
| Riparian-woodland | 24.0 | 346 | 318.6 | 40.9 |
| Riparian-savannah | 38.3 | 68 | 39.2 | 5.0 |
| Mesquite-bristlegrass | 45.0 | 252 | 123.8 | 15.9 |
| Huisache-bunchgrass | 30.5 | 244 | 176.8 | 22.7 |
| Huisache-mixedgrass | 93.6 | 165 | 39.0 | 5.0 |
| Oak-chaparral | 22.1 | 82 | 82.0 | 10.5 |
| Winter stability | | | | |
| Riparian-woodland | 28.2 | 353 | 160.2 | 64.4 |
| Mesquite-bristlegrass | 45.0 | 121 | 34.4 | 13.8 |
| Huisache-bunchgrass | 40.0 | 53 | 17.0 | 6.8 |
| Oak-chaparral | 12.8 | 37 | 37.0 | 14.9 |

[a]Weighted observation$_i$ = actual observation$_i$ (lowest visibility index per season / visibility index$_i$)

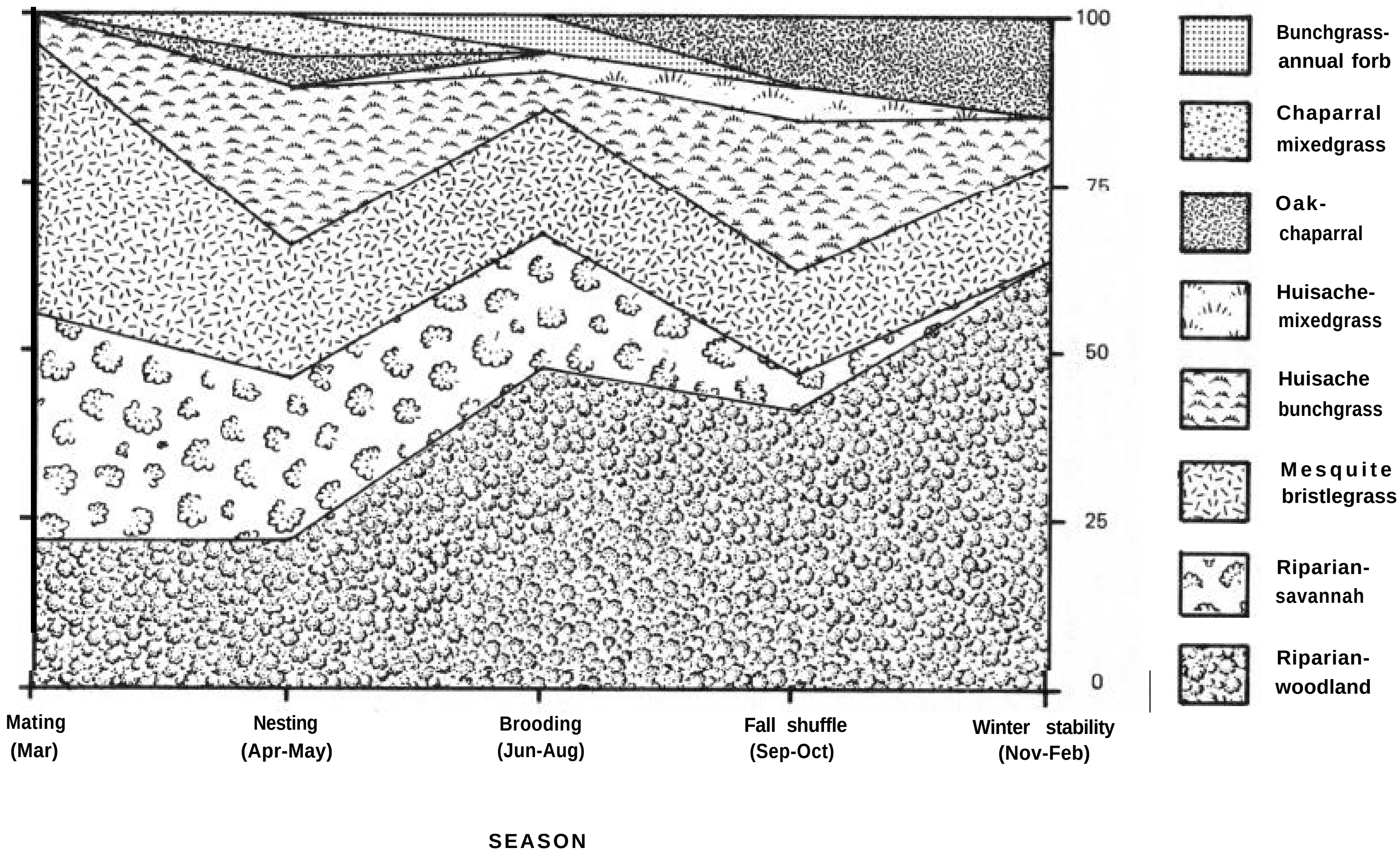


Fig. 2. Seasonal habitat use by wild turkeys on the Welder Wildlife Refuge and Rooke Ranch in South Texas. Percentages were weighted by an index of visibility (average turkey-to-road distance) for each plant community and were based on the following number of turkey observations (individuals) in each season: mating - 701, nesting - 384, brooding - 1897, fall shuffle - 1157, winter stability - 564.

Turkeys frequently used these mowed pastures for strutting grounds, especially those areas adjacent to unmowed brushy cover. Unpaved roads and other artificial sites, such as lawns, were also used as display grounds.

Turkeys were observed in riparian-woodland less often during mating season (22%) than at any other time of year. In fact, many of these observations were of turkeys moving to or from riparian roosting areas. During mating season only 5% of turkey observations occurred in habitats other than riparian-savannah, mesquite-bristlegrass, and riparian-woodland.

Nesting. During April and May, nesting hens dispersed within their winter range and into adjacent unoccupied habitat. Non-nesting hens and males remained near their winter range and continued using the same strutting grounds throughout the nesting season. Observations of flocks indicated that individual hens left and returned to hen flocks daily, possibly indicating nesting activity in those hens.

Turkeys used riparian-woodland, riparian-savannah, mesquite-bristlegrass, and huisache-bunchgrass equally during nesting season (Fig. 2). Most of these observations were of males and non-nesting hens which were less secretive than nesting hens. Riparian-woodland was used primarily as a roosting and resting area. Turkeys that roosted there spent the early morning on strutting grounds in open areas of riparian-savannah and mesquite-bristlegrass and sought the shade of brushy cover or riparian growth during the heat of the day. Turkeys were observed more often in huisache-bunchgrass (24%) during nesting season than at any other time of year (Fig. 2). They used this community for feeding and as a travel lane, primarily along a paved road near the Refuge headquarters, from which most of the turkey observations in this community were made.

Observations of lone hens during the nesting season may indicate nesting behavior in those hens (Glazener pers. comm.[1]). A total of 23 observations (numbers in parentheses) of lone hens were made during April and May in the following communities, live oak-chaparral (7), chaparral-mixedgrass (6), riparian-savannah (3), huisache-bunchgrass (2), riparian-woodland (2), mesquite-bristlegrass (2), and woodland-spiny aster (1). These figures indicate that the habitat preference of nesting hens differed from the remaining turkey population (Fig. 2). Nesting hens may have been attracted to dense brush mottes in the live oak-chaparral and chaparral-mixed grass which offer potentially good nesting cover.

Brooding. During the summer brooding period of June-August 1976-77, nearly 50% of the turkey observations occurred in riparian-woodland (Fig. 2). Riparian-savannah and mesquite-bristlegrass also were used by turkeys.

During summer, flocks of hens with gobblers continued to frequent strutting grounds in early morning and prior to roosting in the evening; however, frequency and duration of these visits dropped off rapidly as summer progressed. The size of these hen flocks increased gradually throughout the summer, probably as a result of hens that were unsuccessful in nesting attempts. Male flocks ranging from 5-12 individuals remained in fairly cohesive units and did not associate with female flocks. Frequency of poult observations increased throughout

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[1]Past Director, Welder Wildlife Foundation, P.O. Drawer 1400, Sinton, TX 78387.

the summer as broods returned from nesting areas and increasing age of poults enhanced their observability.

In riparian-woodland, rustyseed Paspalum and southwestern bristlegrass (Table 1) were common forage grasses which produced large seedheads during late summer that seemed highly desirable as turkey food. When mustang grapes (*Vitis mustangensis*) ripened in riparian areas during the summer, turkeys were often seen perched in hackberry and other trees foraging on grapes. In addition, hackberries ripened in August and September and were readily consumed by turkeys.

Turkeys were observed in the open riparian-savannah and mesquite-bristlegrass more often in early morning and evening during the hot summer months. During the midday heat, turkeys sought the shade of dense riparian-woodland habitat or were occasionally observed resting in the shade of a mesquite or hackberry tree in more open habitat. Long-tom, rustyseed paspalum, and Texas croton were common forage for turkeys in riparian-savannah; whereas knotroot bristlegrass and brownseed paspalum were highly desirable seed-producers in mesquite-bristlegrass.

During 10-15 July 1977, a portion of the mesquite-bristlegrass plant community on the Rooke Ranch was bulldozed as part of a brush control program to increase livestock forage production. Prior to bulldozing, the pasture was covered with dense brush and scattered large mesquite and live oak trees. Most brush and associated herbaceous vegetation was bulldozed into large piles, while all live oak trees and many of the larger mesquite trees were left standing. These scattered trees provided shade for both livestock and wildlife.

Turkey broods took immediate advantage of brush-cleared areas and were observed actively feeding within 50 m of an operating bulldozer. Two broods, 1 with 2 hens and 16 poults and 1 with 1 hen and 3 poults, were seen on the cleared area almost daily until censuses on the area were terminated in August. Prior to brush removal, these broods had consistently foraged in an area of uncleared mesquite-bristlegrass and riparian-savannah located 200-1000 m south and southeast of the newly cleared pasture. However, a change in their feeding area did not seem to affect their roosting site, as they continued to roost in an area of riparian-woodland about 600 m south of the cleared pasture. In addition, a flock of 12 gobblers and a flock of 20-30 hens occasionally foraged in the cleared pasture. Brush clearing may have made the area more attractive by increasing the availability of seeds (bristlegrass, paspalum) and insects which were probably more conspicuous on the bare ground.

In general, brush control practices have severely restricted turkey populations in South Texas (Gore 1973). Large-scale operations can remove all available cover and roosting sites resulting in extirpation of turkey populations. However, limited brush removal, as described here, may benefit turkeys on both a short-term basis by increasing food availability and a long-term basis by increasing production of herbaceous forage.

*Fall shuffle*. During September and October turkeys returned to their winter range from outlying nesting areas and from nearby summer range. About 8% of the turkeys that spent the summer on the Rooke Ranch moved across the Aransas River to winter primarily on the Welder

Refuge. During fall, turkeys on the Refuge underwent a "shuffling" period when poults and hens combined into larger composite flocks, and turkeys moving onto the Refuge from summer ranges joined these resident flocks or formed their own.

Habitat use by turkeys during September and October reflected a high degree of daily movement (Fig. 2). Although riparian-woodland continued to receive the greatest use, hulsache-grassland and live oak-chaparral received an unusually high degree of use. Turkeys used riparian areas for roosting and often moved into the adjacent huisache-grassland to feed. During fall, use of the open riparian-savannah habitat continued to decrease.

Winter flock stability. By November or December, most turkey flocks had become relatively cohesive and underwent few changes until the onset of mating in late February-early March. Over 60% of the winter turkey observations were in the riparian-woodland plant community (Fig. 2). Turkeys used this habitat for roosting, loafing, and feeding. Turkey observations in riparian-savannah continued a decreasing trend resulting in less than 5% use during the winter. Mesquite-bristlegrass, huisache-bunchgrass, and live oak-chaparral all received moderate winter use.

On 21 November 1976 a drop-net trap site, located about 300 m west of riparian-woodland habitat was baited with corn and milo. Approximately 50 hens and 10-20 gobblers used this bait site every morning until 29 December 1976, when 36 turkeys were trapped and marked. The presence of this bait may have biased the results by increasing the proportion of observations in riparian-woodland, which they used for roosting and cover.

## Management Implications

Maintaining mature riparian woodland is important to the management of turkey populations in South Texas. Hackberry woodlands provided preferred year-round roosting sites, winter cover, brood rearing habitat, and summer shade. On the Welder Refuge, large stands served as a "core" of optimum habitat where the turkey population maintained itself during poor years and expanded into adjacent marginal habitat during years of high populations. During the late 1970's, when only about 100 birds occurred on the area, turkeys were primarily restricted to riparian areas and adjacent habitat; whereas during the early 1960's, when the Refuge supported a winter population of over 700 birds, turkeys were widely distributed over most of the Refuge, but were tied closely to riparian zones (Watts 1969).

Mowing pastures to create openings near roosting areas may be a desirable management practice where strutting grounds are limited. The smallest strutting ground in this study was about 30 m in diameter and had brush on 1 side and riparian woodland on the other. In large mowed pastures, areas near brushy escape cover were favored for strutting.

Brush removal on a limited basis may benefit turkeys by increasing the food availability and creating openings in dense brush. However, more research is needed to determine both the short-term and long-term effects of brush control at different intensities of removal and with different techniques.

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# MANAGEMENT OF THE WILD TURKEY ON NATIONAL FOREST LANDS IN NORTH CAROLINA

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*Abstract:* Wild turkeys (*Meleagris gallopavo silvestris)* were extirpated from most of their former range in North Carolina by the late 1800's and early 1900's. As turkey habitat disappeared due to extensive logging and landclearing for agriculture, turkeys were forced into marginal habitat. The few remaining flocks found refuge in inaccessible bottomland swamps, pocosins, and remote mountains. Remnant flocks persisted in the mountains and piedmont. Currently, there are approximately 145,800 ha (46%) of timber in the 40-60 year age class on 8 U.S. Forest Service ranger districts in the mountains. Roundwood and firewood thinnings are being implemented to increase mast production and timber yield. Presently, where turkeys are located on national forest land, direct habitat improvements include seeding and gating of logging roads and decks, daylighting old logging roads and releasing and maintaining homesites and orchards. Wilderness designation on 12,708 ha of existing wilderness and 26,924 additional hectares proposed on national forest land may have detrimental effects on future management of wild turkeys on these areas. Restocking efforts by the North Carolina Wildlife Resources Commission on U.S. Forest Service lands from the 1950's to the present have restored the wild turkey to a large portion of its original range. Harvest rates of turkeys have increased on national forest land during the past few years.

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Wild turkeys were extirpated from most of their former range in North Carolina by the late 1800's and early 1900's. Turkey habitat disappeared due to extensive logging and landclearing for agriculture. These factors, in combination with pressure from unrestricted hunting, forced turkeys into marginal habitat. The few remaining flocks found refuge in inaccessible bottomland swamps, pocosins, and remote mountains (Thornton 1955, Bailey 1976).

Presently, turkey populations in the coastal plain are largely confined to northeastern counties along the Roanoke River and the U.S.M.C. Base at Camp Lejune. Although turkeys continue to decline in some areas of the piedmont due to human, agriculture, and industrial expansion, scattered flocks still remain in a group of counties in the north-central part of the state (Bailey 1976). Most of the western mountain counties have turkey populations, some reproducing and expanding their range while others are declining.

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## DESCRIPTION OF THE NATIONAL FORESTS IN NORTH CAROLINA

The National Forests in North Carolina which total approximately 486,000 ha are composed of four Forests from the mountains to the coastal plain. The Pisgah (199,655 ha) and Nantahala National Forests (189,945 ha) are situated in the mountains. The Uwharrie (19,035 ha) is a piedmont forest while the Croatan (66,420 ha) is located in the coastal plain.

There are diverse physiographic and climatological differences between these Forests. Elevations range from almost sea level on the coast to over 1,829 m in the mountains. Temperatures in the mountains average 23°C in July and 4°C in January. Annual precipitation varies between 97 to 203 cm. Snowfall is frequent during the winter months, but rarely remains over several days except at higher elevations and north aspects. Piedmont temperatures vary between averages of 26°C in July to 6°C in January. Annual precipitation ranges from 109 to 122 cm. The climate of the coastal plain is fairly mild due to the influence of the Atlantic Ocean. Average temperatures in July are 27°C and in January it is almost 10°C. Annual rainfall varies between 112 and 140 cm.

Hardwood forests are dominant on the national forests in the mountains with species composition varying with elevation, aspect, and slope position. Pitch pine (*Pinus rigida*), scarlet oak (*Quercus coccinea*), hickory *(Carya* spp.), and other upland hardwoods are commonly found on the xeric ridge tops. Northern aspects typically contain sugar maple (*Acer saccharum)*, beech (*Fagus grandifolia*), and birch *(Betula* spp.) depending on elevation. Coves are mixtures of yellow poplar (*Lirodendron tulipifera*), northern red oak (*Q. rubra*), cucumber tree (*Magnolia acuminata*), red maple (*A. rubra),* and black locust (*Robinia pseudoacacia*). White pine (*P. strobus)* and hemlock (*Tsuga canadensis*) occur in pure or mixed stands along streams and lower moist slopes (Sanders 1977).

The national forest in the Piedmont reflects the past history of farming. Natural stands of shortleaf (*P. echinata*), and Virginia pine (*P. virginia*) are common due to the destruction of hardwood rootstock from repeated cultivation and the subsequent invasion of abandoned fields by pines. Creek bottoms and transition zones contain water oak (*Q. nigra),* white oak (*Q. alba*), sweetgum (*Liquidambar styraciflua*), blackgum (Nyssa sylvatical, loblolly pine (P. taeda) and other associated tree species.

A large percentage of the national forest in the coastal plain is composed of pocosin vegetation. Pond pine (*P. serotina*), titi *(Cyrilla racemiflora*), zenobia (*Zenobia pulverulenta)*, and fetterbush *(Lyonia* spp.) grow in thick tangles which are almost impossible to penetrate. Slash pine (*P. elliottii*)-flatwoods occur on more elevated sites. Xeric sites are occupied by stands of longleaf pine (*P. palustris*) and turkey oak (*Q. laevis*). Stream bottoms are a diverse mixture of baldcypress (*Taxodium distichum*) and hardwoods.

## PRESENT STATUS AND MANAGEMENT

Almost all of the counties which have national forest land have turkeys within their boundaries (Fig. 1). The Croatan National Forest has scattered populations which appear to be barely maintaining their low level. A major portion of the Croatan is pocosin and largely unsuitable as turkey range which may partially account for the low density of turkeys.

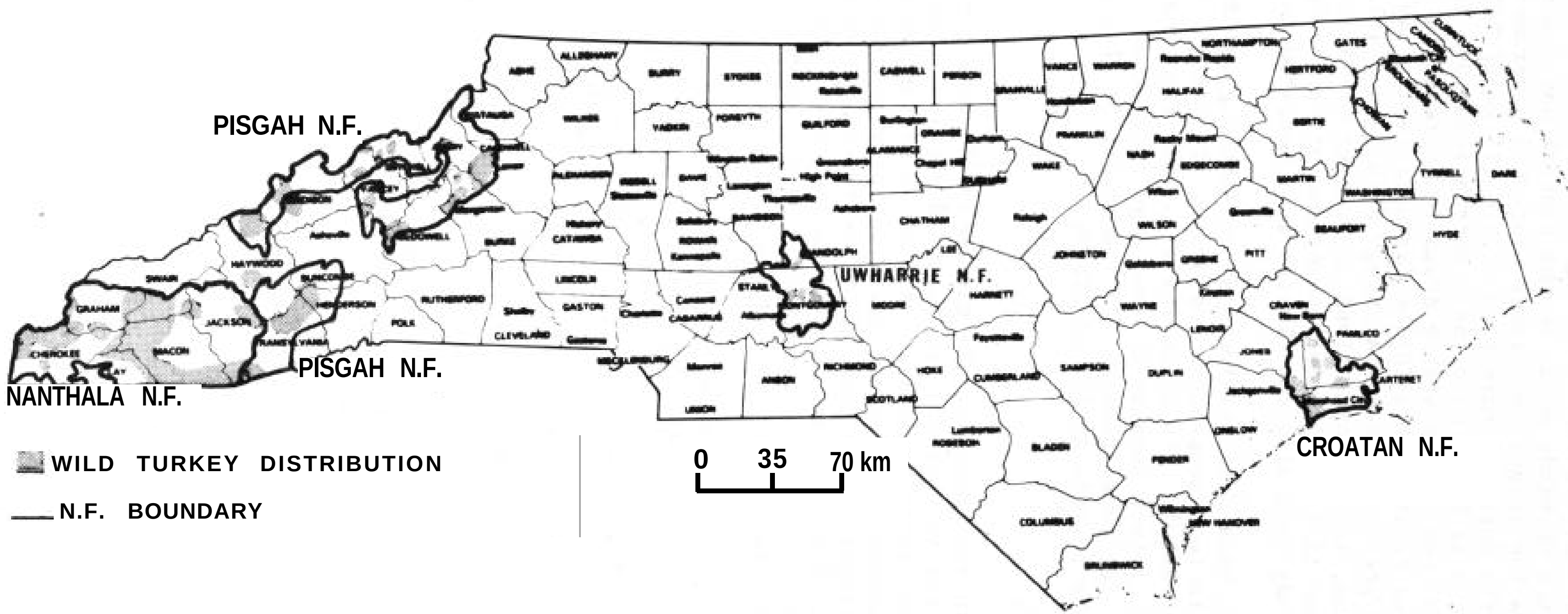


Figure 1. Distribution of wild turkeys on National Forests in North Carolina.

Turkey populations are doing slightly better on the Uwharrie National Forest. Highest densities of birds occur in the central and lower portion of the forest where the larger contiguous blocks of government land are located. The Uwharrie National Forest is within 121 km of 20% of the total human population of North Carolina. Recreational use is heavy on the Forest. This, in combination with a dramatic increase in the number of deer hunters since the early 1970's (Betsill 1978), may be factors in the turkey's present status. Although data is unavailable to substantiate these claims, turkey populations are higher on adjacent private land where access is limited. The conversion of hardwoods and pine-hardwoods to pine may have also contributed to a decrease in the turkey's range.

The Pisgah and Nantahala National Forests have the highest density turkey populations. With few exceptions, restocking efforts in the mountains have been successful. The mountains also hold the greatest promise for the turkey's future because of the large contiguous blocks of national forest lands. For these reasons, the remainder of this paper will deal mainly with the Forests in the mountains.

## Silvicultural Treatments

Timber rotations in the mountains are currently 80 years for hardwood and 70 for pine where turkeys are the featured species. Under these current timber management guidelines, 12.5% and 14.3% of the forest in hardwood and pine management types respectively may be regenerated every 10 years. Presently, slightly more than 5% of the forest is being regenerated during this time. Clearcuts are limited to 16.2 ha in size with the average being between 10-12 ha. According to data from the U.S. Forest Service Continuous Inventory of Stand Conditions (CISC) data, approximately 145,800 ha. (46%) are in the 40-60 year age class. These forest stands contain a few old remnant trees as a reminder of prior logging in the early 1900's. A small proportion (9%) of the stands are 80-plus years of age while a similar amount (10%) is in the seedling and sapling stage. This distribution of age classes is similar to other Appalachian forests (Bailey and Rinell 1968, Gill et al. 1975).

The present condition of the mountain forests will provide unique and challenging opportunities in managing the timber and wildlife resource, in particular for turkeys. Most stands in the 40-60 year age class which are entering the period for optimum mast production (Zeedyk 1973) will be thinned for the first time. Roundwood and firewood thinnings are being implemented to increase mast production and timber yield (Table 1). These thinnings reduce competition for sunlight, water, soil nutrients, and encourage greater production of mast in the remaining trees. An additional benefit is more sunlight reaching midstory and understory soft mast producers such as dogwood (*Cornus florida)*, hawthorne *(Crataegus* spp.), serviceberry (*Amelanchier arborea*), and viburnum *(Viburnum* spp).

Table 1. Hectares of commercial and firewood thinnings on national forest lands in the mountains and piedmont from 1976-1979.

| | 1976 | 1977 | 1978 | 1979[a] |
|---|---|---|---|---|
| Commercial Thinning | 2,025 | 1,764 | 2,059 | --- |
| Firewood Thinning | 361 | 415 | 688 | 935 |

[a]Sales have not been completed, so area unavailable.

During thinning operations in cove hardwood stands, the Wildlife Habitat Management Handbook (USDA 1971) recommends that mast-bearing hardwoods not be reduced below 50% of the stand on site 70+ for oak or below 20% of stands below site 70. This avoids conversion entirely to yellow poplar and ensures that the majority of the mast producers will not be removed. Thinning in the oak-hickory, northern hardwoods, and mixed hardwoods stands should also leave a mixture of beech, hickory, cherry (*Prunus serotina)*, blackgum, and cucumber trees. The majority of the remainder of the stand should contain a combination of red and white oaks.

Requests for firewood permits and the area affected by firewood cutting have increased dramatically since 1976 (Table 1). The current energy shortage and the popularity of woodburning stoves will put increased demands on national forest lands to provide firewood. Firewood thinning areas provide excellent opportunities to improve the quality of existing turkey range. Wildlife biologists with the Forest Service, both in the Supervisor's Office and on the districts, along with North Carolina Wildlife Resource Commission biologists have provided advice and assistance to marking crews. Firewood marking crews are instructed to leave understory and midstory softmast producers such as dogwood, hawthorne, and serviceberry as they offer no competition to remaining crop trees. Trees which contain grape *(Vitis* sp.) vines in most instances are also left for wildlife. Oak, blackgum, beech, cherry, and other mast producers should be left and sourwood (*Oxydendrum arboreum*), maple and yellow poplar, which produce excellent browse when cut for white-tailed deer (*Odocoileus virginianus)* in the mountains, should be removed.

Roads

A potential side effect on turkey populations is the building of roads necessary for timber harvests. Bailey and Rinell (1968) stated that the best turkey populations occurred on areas where no more than 6 miles of roads per 10,000 acres were left open to public vehicular traffic. It must be realized, however, that without roads for logging operations, openings in the forest canopy would not be feasible. At a cost of $30,000 per mile in the mountains for construction of system roads, it would not be possible to build them solely for turkey management. However, certain actions will diminish the negative effects of road construction. New system roads constructed where turkey and black bear (*Ursus americanus)* populations are present may need to be closed by the placement of gates (gated) if access appears to contribute to a decline in population levels. These roads should only be opened to the public if absolutely necessary. Temporary logging roads should be gated or closed with earthen barriers to prohibit vehicular access. Existing system roads can be gated from April to July where they are located in prime brood range.

Direct Habitat Improvements

Presently, where turkeys are located on national forest lands in the mountains, direct habitat improvements include seeding temporary logging roads and decks, daylighting old logging roads, and releasing and maintaining orchards and homesites. Roads and decks are being seeded to orchard grass (*Dactylis glomerata*) -white Dutch clover (*Trifolium repens*) except where erosion is a problem and then fescue *(Festuca* spp.) and a legume are substituted. Daylighting of roads consists of trimming the forest canopy and cutting brush to allow more sunlight to reach the road and encourage better production of grasses and forbs. This is periodically repeated as vegetation encroaches on and shades the road. Old orchards and homesites are common in some areas of national forest land. Invading and overtopping non-mast producing trees are removed to provide more sunlight to reach fruit-producing trees such as apple and crabapple *(Malus* spp.), black walnut (*Juglans nigra*), and hawthorne which are typically found on these areas. All of these activities are directed toward maintaining the clearings and openings in a grass stage.

## Wilderness

There are currently 12,708 ha of existing wilderness and another 26,924 ha proposed during RARE II on the National Forests in North Carolina. This represents 2.5% and 6% respectively of the total national forest land in the state. Further planning has been proposed for an additional 7,473 ha (1.5%).

Most wildlife biologists who work with wild turkeys generally have the intuitive feeling that wilderness designation will be detrimental to the turkey's future. This is primarily due to the elimination of timber harvests and also development and maintenance of wildlife openings. Stoddard (1963), Lewis (1964), Speake et al. (1969), Hillestad and Speake (1970), Hamrick and Davis (1971), and others have stressed the importance of clearings, openings, and pastures for turkeys during the nesting and brooding season.

As mast producing trees become overmature and decline in production and as mortality increases, the option to regenerate them is also not present under wilderness management. Boyce (1980) has illustrated a model for the relative production of turkeys under a wilderness mode of management. Turkey populations remain extremely low under this hypothetical example.

More specifically, certain proposed wilderness areas on national forest lands in North Carolina will probably cause declines in turkey populations and restrict harvest if Congress approves their designation. Two proposed wilderness areas on the Croatan National Forest currently have turkey habitat management projects in place or planned. These include bahia grass *(Paspalum* spp.) openings, prescribed burns, and small regenerations.

The Uwharrie National Forest has only one proposed wilderness area of 2,332 ha. It was restocked with turkeys in 1979 following an apparent early failure at stocking in the mid-1970's. Although some habitat improvements will be lost, the overall effect on turkey populations is not clear. Prohibition of vehicular and ORV traffic which is extremely heavy on the Uwharrie will undoubtedly be of benefit. However, wilderness designation of small acreage may cause overutilization of an area. If the amount of utilization can be controlled, then this may be an illustration of where turkeys respond positively to wilderness management.

The majority (68%) of the existing and proposed wilderness areas are in the Nantahala and Pisgah National Forests. There are 7,466 ha in 3 locations which have low to medium turkey densities. Wildlife habitat improvements are also located on them. The option to continue or increase habitat manipulation will be lost on these areas. This may cause a decrease in turkey populations.

## Restocking and Harvests

Restocking efforts on Forest Service land since 1953 have generally been successful, some with more success than others. Turkeys stocked in the mountains appear to have increased in population and expanded their range in most areas. Birds released in the Piedmont and coastal plain forests initially expanded their ranges but have since declined or remained static, in almost all cases. There were 121 turkeys stocked in the mountains from 1953-1969. Since 1970 as restoration efforts increased, 237, 40, and 21 turkeys have been released on national forest lands in the mountains, piedmont, and coastal plain respectively. Turkeys were trapped and restocked by crews from the North Carolina Wildlife Resource Commission. Biologists with the Forest Service assisted in providing input on proposed restoration rates. There are indications that native mountain birds are better suited for restocking in the mountains, while piedmont birds respond likewise when restocked in the piedmont. Research being conducted by the North Carolina Wildlife Resource Commission (Bowman 1978) will hopefully provide more information toward future restocking efforts and increase their chance of success.

Harvest of wild turkeys within counties that have national forest land is shown in Table 2. The spring of 1975 was the first year in which mandatory reporting of kills was required. Harvests on the Croatan have been very low the past several years and have only occurred on 2 of the 3 counties present. The number of birds harvested on the Uwharrie National Forest is slightly higher. Most of the reported kills are from Montgomery County which has 80% of the Uwharrie within its boundaries. If recent restocking efforts in Randolph County are successful, the harvests should increase in this area.

Table 2. Wild turkey harvests from 1975-1979 in counties which have national forest land[a]

| Croatan N. F. | | | | | | Uwharrie N.F. | | | | | | Pisgah-Nantahala N.F. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 197-5[b] | 197-6 | 197-7 | 197-8 | 197-9 | | 197-5 | 197-6 | 197-7 | 197-8 | 197-9 | | 197-5 | 197-6 | 197-7 | 197-8 | 197-9 |
| Craven | 1 | 0 | 0 | 1 | 0 | Montgomery | 2 | 7 | 3 | 7 | 6 | Burke | 2 | 2 | 1 | 1 | 1 |
| Jones | 0 | 3 | 0 | 0 | 0 | Randolph | 0 | 0 | 1 | 0 | 2 | Caldwell | 0 | 1 | 1 | 0 | 0 |
| | | | | | | | | | | | | Cherokee | 0 | 4 | 17 | 5 | 11 |
| | | | | | | | | | | | | Clay | 2 | 1 | 0 | 0 | 2 |
| | | | | | | | | | | | | Henderson | 1 | 0 | 0 | 0 | 2 |
| | | | | | | | | | | | | Jackson | 0 | 0 | 0 | 0 | 1 |
| | | | | | | | | | | | | Macon | 1 | 2 | 0 | 4 | 11 |
| | | | | | | | | | | | | Madison | 0 | 1 | 0 | 0 | 5 |
| | | | | | | | | | | | | McDowell | 0 | 1 | 1 | 0 | 0 |
| | | | | | | | | | | | | Mitchell | 0 | 1 | 0 | 1 | 2 |
| | | | | | | | | | | | | Swain | 0 | 0 | 0 | 0 | 1 |
| | | | | | | | | | | | | Transylvania | 0 | 0 | 1 | 0 | 1 |
| TOTALS | 1 | 3 | 0 | 1 | 0 | | 2 | 7 | 4 | 7 | 8 | | 6 | 13 | 21 | 11 | 37 |

[a]Harvest records do not differentiate between private and Forest Service lands. Counties in which there were no harvests recorded were not listed in table. These figures include known birds killed but not reported.

[b]Mandatory reporting since 1975.

The number of turkeys harvested in the mountains has increased steadily since 1975, except for a decline in 1978. Seven of the 18 counties containing Forest Service land did not report any harvest. Expanding populations from successful stockings in the mid and late 1970's should reflect increased harvests in the 1980's. Weather, being fairly unpredictable during the spring turkey season in the mountains (season in 1979 was from April 14 - May 5), may affect the harvest. Season structure in 1980 has been altered with the season being set from April 12 - May 10. This is an attempt to increase the number of gobblers available for harvest and reduce the number of hens available for potential illegal kill as most of them should be nesting. Bailey and Rinell (1967) and Bevill (1975) have noted that as the number of hens nesting increase, there is a corresponding increase in gobbling.

Turkey populations on national forest lands should increase and expand their range. The outlook is very good in the mountains and less so in the piedmont and coastal plain. Bailey (1976) estimates there are 5,180km$^2$ of potential, unoccupied range remaining in the mountains. Close cooperation between the U.S. Forest Service and the N.C. Wildlife Resources Commission will insure proper timber-wildlife coordination and the future of this magnificent bird on the National Forests in North Carolina.

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# GROWTH PARAMETERS AND SEX AND AGE CRITERIA FOR JUVENILE EASTERN WILD TURKEYS

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Abstract: Most information on the growth and development of juvenile wild turkeys (*Meleagris gallopavo*) has been obtained from game-farm stock and little data is available for young poults. One or more of the following data were recorded from hatching to approximately 210 days of age for 97 hand-reared wild turkeys: body weight, leg length, primary molt patterns, and length of postjuvenile primaries 7 and 8. From hatching to 35 days, age could be determined from leg length or juvenile primary patterns but sex could not be distinguished.. Between 35 and 56 days of age, weights and leg lengths of males and females began to diverge but not enough to positively determine sex. Age was most accurately determined from the postjuvenile primary molt pattern. Between 56 and 98 days, there was sexual dimorphism in leg length, body weight, and molt sequence, and both sex and age could be determined. Beyond 98 days of age, leg length alone separated the sexes. Age could be determined up to about 177 days for females and 190 days for males by measuring the length of postjuvenile primaries 7 and 8. Use of the combination of body weight, leg length, and primary molt pattern provided the most accurate method for determining sex and age. Data from hand-reared poults compared favorably with that from wild-trapped, known-age poults from several northeastern states. The data indicate that techniques now used in the Northeast are overaging juveniles.

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This paper presents criteria for determining the age and sex of wild turkey poults from various body measurements, and reports poult body weights from hatching until 196 days of age.

Techniques for aging young wild turkeys are in common use. The dates when hens nest, which are used to establish dates for spring gobbler season, are usually calculated from estimates of the ages of poults observed during summer or killed by hunters in the fall. It has generally been easier to obtain these data than to observe nesting hens.

Hayden (1961) and Nixon (1962) provided a key for field aging poults based on qualitative descriptions of down replacement and feather development, head and neck color, and height and relative size. Knoder (1959) and Hayden and Wunz (1962) presented methods for aging juvenile turkeys based on the rates of growth and molt of the primary feathers. Although these studies provided the first methods by which hatching dates of young turkeys captured or killed could be determined, the average lengths of postjuvenile primary 8 for a given age differed considerably between studies. Both studies used game farm stock that originated from the same source, and disease and stress due to handling were factors that could have affected growth and primary molt. We found no published information on the growth and development of free-ranging poults.

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## METHODS

### Hand-reared Poults

Eggs were collected from abandoned nests each year from 1973 to 1975. The geographic areas (Austin 1965) from which nests were obtained include the Glaciated Allegheny Plateau, 1 nest; Northern Appalachian Ridge and Valley, 4 nests; Southern Appalachian Ridge and Valley, 2 nests; and Eastern Allegheny Plateau and Mountains, 1 nest. In 1976 and 1977 we raised another 5 broods that were progeny of these wild birds. Thus, the birds should represent existing populations in northern and eastern West Virginia, western Maryland, and central Pennsylvania.

Eggs were hatched in incubators and all poults were imprinted to humans. Details of the imprinting process and the uses made of poults have been published (Healy and Goetz 1974, Healy et al. 1975, Nenno and Healy 1979, Nenno and Lindzey 1979), but several points are important here. First, the authors acted as surrogate parents to poults, and handling poults to obtain measurements did not stress them. Second, poults were raised on natural light cycles and fed adlibitum a combination of commercial turkey feed, grain, and natural foods that they obtained themselves in the field. Third, through the period of observation, poults were taken into the field on an average of 3 times per week for 2 or more hours per trip. These sessions gave the birds more opportunity for exercise, including flight, than would normally be associated with captive rearing. Finally, measurements were taken only on birds that showed no pathological lesions or serious injury.

### Measurements

Poults were individually marked, weighed, and measured shortly after hatching. Thereafter, at approximately weekly intervals, 1 or more of the following measurements were taken: body weight, leg length, primary molt pattern, and length of postjuvenile primaries 7 and 8.

Poults weighing less than 1.2 kg were weighed on a electronic balance reading to 0.1 g. Heavier birds were weighed on a 13.6-kg capacity scale reading to 14 g. Leg length measurements were taken from the apex of the tarsometatarsus to the tip of the nail of the middle phalanx (Fig. 1a). This measurement was taken with the poult held in the observer's lap and its head and shoulders tucked under the observer's arm. The leg to be measured was flexed at approximately a right angle with the toes fully extended and the distance was determined to the nearest millimeter.

The primary molt pattern was described with the system of Parr (1975) in which each primary is classified as either juvenile or postjuvenile and its growth stage classed as either an empty follicle, in the pulp, in the sheath, almost full grown, or full grown (Fig. 1b). For analysis these data were coded as empty = 0.0, pulp = 0.3, sheath = 0.6, almost grown = 0.8, and full grown = 0.9. The integer showed the primary number, for example, the feather value of postjuvenile primary 3 in the pulp stage would be 3.3 (Fig. 1c). In addition, postjuvenile primaries 7 and 8 were measured from the calamus to the tip as described by Knoder (1959). These primaries were measured from 1st appearance until growth had terminated.

## Hen-reared Poults

We obtained a few observations of known-age poults reared by wild hens that had been instrumented with radio transmitters. Weights and primary molt patterns were provided by J. Glidden for 11 poults from 2 broods captured in Cataragus County, New York, and by A. Hayden for 6 poults from Tioga County, Pennsylvania. We collected weight, leg length, and primary molt information from 13 poults that were raised by radio-instrumented, human-imprinted hens in Monongalia County, West Virginia. One brood was captured on 3 successive occasions at ages 28, 70, and 141 days. These data were used to test the regressions calculated from measurements of hand-reared poults.

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Fig. 1. Highlights in the development of wild turkey poults: (A) Stage I, hatching to about 28 days of age; age is best estimated from leg length and juvenile molt, sex is not apparent. (B) Stage II lasts from the shedding of juvenile primary 1 until postjuvenile primary 7 reaches the sheath stage. On the left is the wing of a 35-day-old poult with postjuvenile primary 1 in the pulp. On the right are the stages of feather development and their corresponding values. (C) Underside of the wing of a 56-day-old poult; from this point on, sex can be predicted from leg length if age has first been estimated from molt pattern. (D) Stage III lasts from the appearance of postjuvenile primary 7 in the sheath until postjuvenile primary 8 is almost grown; sex can be positively determined from leg length; age is best estimated from the lengths of postjuvenile primaries 7 and 8.

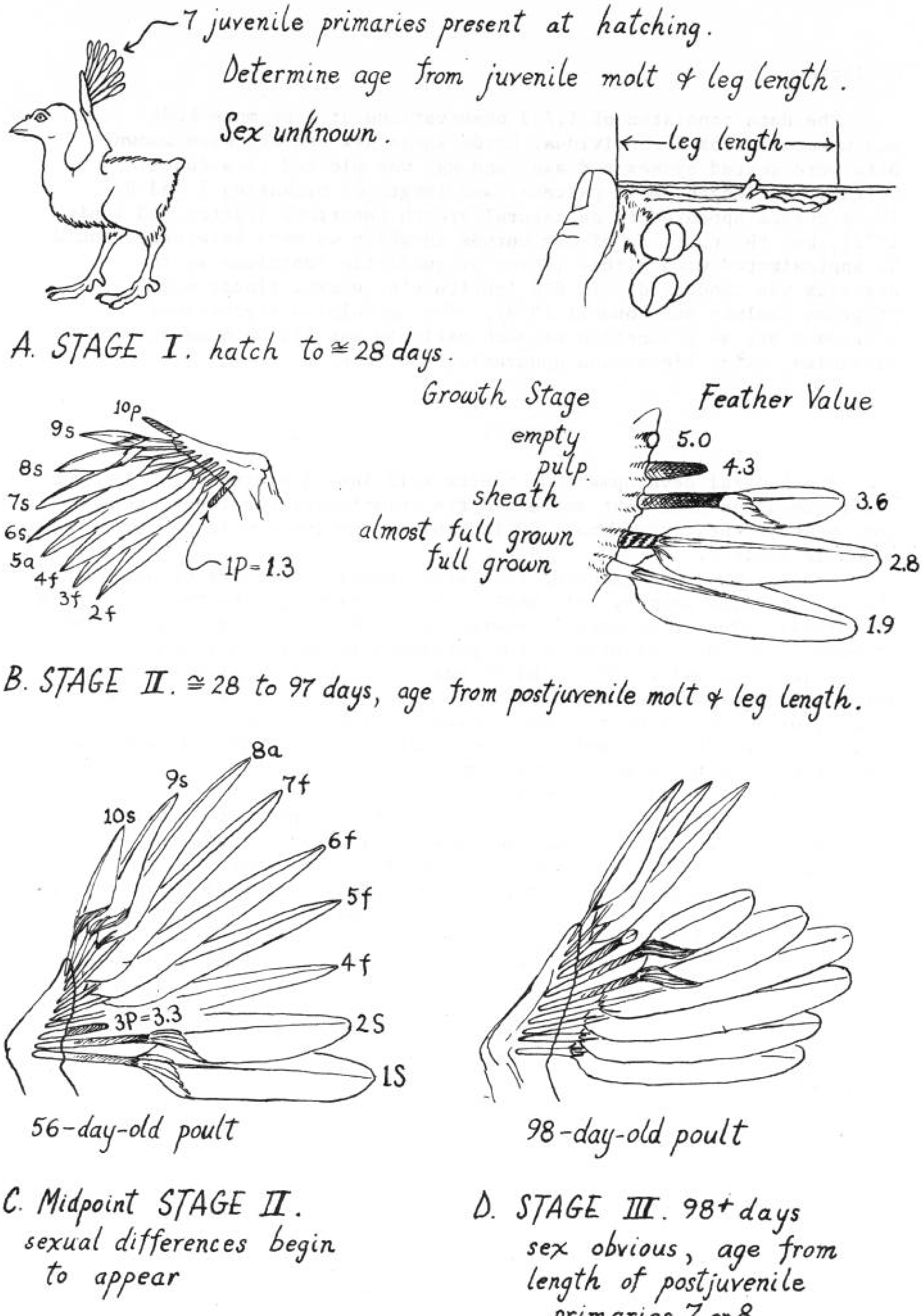


Fig 1. Highlights in the development of wild turkey poults.

## Analysis

The data consisted of 1,282 observations of 1 or more body measurements from 97 individual birds whose sex and age were known. Data were sorted by sex and age, and age was plotted as a function of weight, leg length, molt pattern, and length of primaries 7 and 8. These curves appeared to be natural growth functions (Parton and Innis 1972), but the portions of the curves in which we were interested could be approximated with either linear or quadratic functions so the analysis was conducted with SAS Institute's general linear model programs (Helwig and Council 1979). The calculated regressions expressed age as a function of each variable and all combinations of variables, using linear and quadratic functions.

# RESULTS

The general development of poults fell into 3 stages (Fig. l), and the regressions that best expressed the relationships between age and body measurements are summarized in Table 1. Primary molt patterns are given in Table 2.

Stage 1 began at hatching and lasted until 28-35 days of age when the postjuvenile primary molt began. At hatching, poults had 7 juvenile primaries; juvenile primary 10 emerged about the same time as postjuvenile primary 1, so the beginning of the postjuvenile molt overlapped the end of the juvenile molt. Sex of birds was not apparent during Stage 1. Age could be estimated from juvenile molt pattern, leg length, body weight, or combinations of these variables (Table 1, eq. 1-4). A linear combination of juvenile molt and leg length (Table 1, eq. 4) gave the best results in terms of $R^2$ value, goodness of fit, and ability to predict the age of wild-reared poults (Table 3).

Stage II began with the shedding of juvenile primary 1 during 28-35 days of age and continued until about 100 days of age when postjuvenile primary 7 was growing beyond the pulp stage. Stage II was characterized by a rapid progression of the postjuvenile primary molt and rapid increases in leg length and body weight. Early in Stage II, we could not distinguish sex by looking at the birds, but average body weights were greater for males than for females from week 1 onward ($P = 0.05$, Table 4). Average leg lengths differed by sex from week 2 onward ($P = 0.05$, Table 5).

For Stage II birds with sexes combined, the feather value of the last postjuvenile primary acquired was the best single estimator of age (Table 1, eq. 5). Including leg length and weight in the regression (Table 1, eq. 8) produced a better fit, but had little effect on $R^2$ values of the accuracy of age predictions. For birds of known sex, a variety of linear combinations of pastjuvenile molt, leg length, and weight produced regressions with high $R^2$ values and low sums of squared residuals that accurately predicted age of wild-reared poults (Table 1, eq. 9-16). All of these equations are potentially useful, but for ease of measurement and calculation we prefer to use postjuvenile molt first, then leg length, and finally weight.

By Stage III, sex was obvious. Birds with legs longer than 240 mm were males. From about 16 weeks onward, plumage and head characteristics also distinguished the sexes. The end of stage III was characterized by decreasing growth rates and increasing difficulty in predicting age from

Table 1. Regression equations to predict age (days since hatching) of juvenile eastern wild turkeys from 1 or a combination of body measurements.[a]

| Growth stage | sex | Equation | N | $R^2$ |
|---|---|---|---|---|
| I Age = 0-35 days | M&F | (1) AGE = -0.7 + 0.114 WEIGHT - 0.00007 WEIGHT$^2$ | 285 | 0.95 |
| | | (2) AGE = -26.9 + 0.535 LEGLN | 266 | 0.94 |
| | | (3) AGE = -33.3 + 0.638 LEGLN - 0.011 WEIGHT | 265 | 0.95 |
| | | (4) AGE = -85.5 + 0.183 LEGLN + 9.88 JUVPRI | 21 | 0.99 |
| II Age = 28-112 days | M&F | (5) AGR = 19.2 + 11.16 POSTJP | 472 | 0.96 |
| | | (6) AGE = 10.7 + 9.37 POSTJP + 0.092 LEGLN | 340 | 0.97 |
| | | (7) AGE = 21.9 + 8.81 POSTJP + 0.006 WEIGHT | 251 | 0.98 |
| | | (8) AGE = 28.2 + 9.21 POSTJP - 0.062 LEGLN + 0.008 WEIGHT | 251 | 0.98 |
| | M | (9) AGE = 17.8 + 11.63 POSTJP | 235 | 0.97 |
| | | (10) AGE = -3.0 + 7.08 POSTJP + 0.213 LEGLN | 145 | 0.97 |
| | | (11) AGE = 22.8 + 6.84 POSTJP + 0.010 WEIGHT | 107 | 0.98 |
| | | (12) AGE = 0.4 + 3.27 POSTJP + 0.227 LEGLN + 0.007 WEIGHT | 107 | 0.98 |
| | F | (13) AGE = 20.3 + 10.77 POSTJP | 237 | 0.97 |
| | | (14) AGE = 20.5 + 10.73 POSTJP + 0.0005 LEGLN | 195 | 0.97 |
| | | (15) AGR = 24.3 + 5.64 POSTJP + 0.015 WEIGHT | 144 | 0.99 |
| | | (16) AGE = 24.8 + 5.71 POSTJP - 0.005 LEGLN + 0.016 WEIGHT | 144 | 0.99 |
| III Male Age = 102-190 days Female Age = 97-177 days | M | (17) AGE = 93.8 + 0.186 PJSEVLN | 129 | 0.93 |
| | | (18) AGE = 119.0 + 0.183 PJEGTLN | 128 | 0.90 |
| | | (19) AGE = 95.4 + 0.120 PRILN | 116 | 0.91 |
| | | (20) AGE = 79.7 + 0.141 PJSEVLN + 0.005 WEIGHT | 81 | 0.94 |
| | | (21) AGE = 134.8 + 0.206 PJEGTLN - 0.004 WEIGHT | 89 | 0.91 |
| | | (22) AGE = 105.5 + 0.021 PJSEVLN + 0.0004 PJSEVLN$^2$ | 129 | 0.97 |
| | | (23) AGE = 125.0 + 0.071 PJEGTLN + 0.0003 PJEGTLN$^2$ | 128 | 0.93 |
| | F | (24) AGE = 84.9 + 0.209 PJSEVLN | 98 | 0.90 |
| | | (25) AGE = 109.1 + 0.198 PJEGTLN | 131 | 0.91 |
| | | (26) AGE = 87.2 + 0.131 PRILN | 106 | 0.91 |
| | | (27) AGE = 50.1 + 0.088 PJSEVLN + 0.020 WEIGHT | 26 | 0.96 |
| | | (28) AGE = 60.2 + 0.108 PJEGTLN + 0.019 WEIGHT | 54 | 0.94 |
| | | (29) AGE = 101.6 - 0.022 PJSEVLN + 0.0006 PJSEVLN$^2$ | 98 | 0.96 |
| | | (30) AGE = 116.7 + 0.052 PJEGTLN + 0.0005 PJEGTLN$^2$ | 131 | 0.94 |

[a] WEIGHT = Weight in grams; LEGLN = Leg length (mm); JUVPRI = Juvenile primary values; POSTJP = Postjuvenile primary value; PJSEVLN = Postjuvenile primary 7 length (mm); PJEGTLN = Postjuvenile primary 8 length (mm); PRILN = Sum of postjuvenile primaries 7 and 8 lengths (mm).

Table 2. Primary molt patterns[a] and the lengths ($\bar{x}$ ± SD, mm) of postjuvenile primaries 7 and 8 of wild turkey poults by age in days.

| Sex | Age | N | 1 | 2 | 3 | 4 | 5 | 6 | 7 | length | a | length | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M&F | 1 | 11 | S | S | S | S | S | S | S | | | | | |
| M&F | 7 | 12 | S | S | S | S | S | s | S | | | | | |
| M&F | 10 | 12 | sa | S | S | S | S | S | S | | P | | | |
| M&F | 14 | 8 | af | sa | S | S | S | S | S | | S | | | |
| M&F | 21 | 5 | f | a | S | S | S | S | S | | S | | | |
| M&F | 24 | 5 | f | f | a | S | S | S | s | | S | | Ps | |
| M&F | 28 | 4 | f | f | f | a | S | S | S | | S | | S | |
| M&F | 35 | 20 | PS | f | f | f | a | S | S | | S | | S | Ps |
| M&F | 42 | 27 | S | fEP | f | f | f | a | S | | S | | S | s |
| M&F | 49 | 32 | S | PS | f | f | f | f | a | | S | | S | S |
| F | 56 | 24 | S | S | PS | f | f | f | f | | sa | | S | S |
| M | 56 | 26 | S | S | EPS | f | f | f | af | | S | | S | S |
| F | 63 | 20 | A | S | S | EP | f | f | f | | a | | S | S |
| M | 63 | 16 | SA | S | S | fEP | f | f | f | | sa | | S | S |
| F | 70 | 23 | F | S | S | S | fEP | f | f | | f | | S | S |
| M | 70 | 26 | AF | S | S | S | fE | f | f | | af | | S | S |
| F | 77 | 27 | F | A | S | S | PS | f | f | | f | | S | S |
| M | 77 | 24 | F | SA | S | S | EPS | f | f | | f | | S | S |
| F | 84 | 26 | F | F | S | S | S | fEP | f | | f | | a | S |
| M | 84 | 24 | F | A | S | S | S | fE | f | | f | | sa | S |
| F | 91 | 20 | F | F | A | S | S | PS | fE | | f | | af | sa |
| M | 91 | 16 | F | AF | s | S | S | EPS | f | | f | | a | S |
| F | 98 | 18 | F | F | F | SA | S | S | PS | 36.2 ± 18.6 | f | | f | a |
| M | 98 | 16 | F | F | A | S | S | PS | fEP | | f | | af | sa |
| F | 105 | 23 | F | F | F | A | S | S | S | 92.8 ± 21.4 | f | | f | f |
| M | 105 | 19 | F | F | A | S | S | S | PS | 42.8 ± 25.2 | f | | f | a |
| F | 112 | 20 | F | F | F | AF | SA | S | s | 138.5 ± 19.6 | fEP | | f | f |
| M | 112 | 17 | F | F | AF | SA | S | S | S | 95.4 ± 25.4 | f | | f | f |
| F | 119 | 14 | F | F | F | F | A | S | s | 183.8 ± 14.2 | PS | 42.9 ± 23.4 | f | f |
| M | 119 | 17 | F | F | F | AF | S | S | S | 146.0 ± 23.1 | fE | | f | f |
| F | 126 | 16 | F | F | F | F | AF | S | S | 215.3 ± 11.3 | S | 87.1 ± 26.3 | f | f |
| M | 126 | 15 | F | F | F | F | SA | S | s | 190.5 ± 21.1 | EPS | 34.2 ± 23.1 | f | f |
| F | 133 | 15 | F | F | F | F | F | A | S | 245.3 ± 9.3 | S | 138.1 ± 20.9 | f | f |
| M | 133 | 15 | F | F | F | F | AF | S | s | 231.0 ± 18.0 | S | 86.7 ± 24.2 | f | f |
| F | 140 | 16 | F | F | F | F | F | AF | S | 271.7 ± 6.5 | S | 178.3 ± 17.8 | f | f |
| M | 140 | 13 | F | F | F | F | AF | SA | S | 265.7 ± 14.5 | S | 136.6 ± 21.5 | f | f |
| F | 147 | 16 | F | F | F | F | F | F | A | 287.3 ± 5.1 | S | 211.8 ± 15.9 | f | f |
| M | 147 | 13 | F | F | F | F | F | A | s | 293.9 ± 11.8 | S | 180.2 ± 20.0 | f | f |
| F | 154 | 15 | F | F | F | F | F | F | AF | 297.4 ± 6.1 | S | 237.1 ± 14.2 | f | f |
| M | 154 | 10 | F | F | F | F | F | AF | SA | 318.6 ± 11.6 | S | 216.9 ± 16.7 | f | f |
| F | 161 | 9 | F | F | F | F | F | F | F | 302.1 ± 7.0 | S | 261.2 ± 8.7 | f | f |
| M | 161 | 14 | F | F | F | F | F | F | A | 336.9 ± 10.9 | S | 254.7 ± 14.9 | f | f |
| F | 168 | 9 | F | F | F | F | F | F | F | 303.7 ± 7.4 | A | 277.0 ± 8.3 | f | f |
| M | 168 | 14 | F | F | F | F | F | F | A | 350.9 ± 9.6 | S | 281.4 ± 14.0 | f | f |
| F | 175 | 9 | F | F | F | F | F | F | F | Same | A | 285.7 ± 7.5 | f | f |
| M | 175 | 14 | F | F | F | F | F | F | AF | 354.9 ± 8.7 | S | 301.5 ± 10.6 | f | f |
| F | 182 | 9 | F | F | F | F | F | F | F | Same | AF | 289.3 ± 8.5 | f | f |
| M | 182 | 14 | F | F | F | F | F | F | F | 355.6 ± 9.2 | S | 320.1 ± 11.4 | f | f |
| F | 189 | 9 | F | F | F | F | F | F | F | Same | F | 291.4 ± 6.4 | f | f |
| M | 189 | 14 | F | F | F | F | F | F | F | Same | SA | 332.1 ± 11.4 | f | f |
| F | 196 | 9 | F | F | F | F | F | F | F | Same | F | Same | f | f |
| M | 196 | 14 | F | F | F | F | F | F | F | Same | A | 337.9 ± 9.3 | f | f |
| F | 203 | 9 | F | F | F | F | F | F | F | Same | F | Same | f | f |
| M | 203 | 14 | F | F | F | F | F | F | F | Same | AF | 340.7 ± 7.3 | f | f |
| F | 210 | 9 | F | F | F | F | F | F | F | Same | F | Same | f | f |
| M | 210 | 14 | F | F | F | F | F | F | F | Same | F | 342.0 ± 6.6 | f | f |

[a] Small letters indicate juvenile molt, capitol letters indicate postjuvenile molt. The growth of a primary progresses by the following code: E = empty feather follicle; p, P = new feather in pulp, and shaft not broken from quill; s, S = feather in sheath; i.e., growing; a, A = feather almost full-grown, little blood in the lower end of quill, and sheath still obvious, and f, F = full-grown feather, no blood in lower end of quill, no sheath on feather.

Table 3. Comparison of the actual ages of hen-reared wild turkey poults with the ages predicted for these birds from the regression equations in Table 1.

| N | Known age days | Predicted age days $\bar{x}$ | Predicted age days range | Equation |
|---|---|---|---|---|
| 3 | 11 | 10 | 9-12 | 2 |
| | | 11 | 9-13 | 4 |
| 1 | 15 | 12 | | 2 |
| | | 13 | | 4 |
| 4 | 28 | 22 | 20-22 | 2 |
| | | 25 | 23-26 | 4 |
| 2 | 28 | 30 | | 5 |
| | | 28 | | 6 |
| | | 34 | | 8 |
| 1 | 38 | 37 | | 5 |
| | | 36 | | 6 |
| 1 | 48 | 48 | | 5 |
| | | 46 | | 6 |
| | | 49 | | 8 |
| 1 | 52 | 56 | | 5 |
| | | 54 | | 6 |
| | | 55 | | 8 |
| 1 | 55 | 56 | | 5 |
| | | 55 | | 6 |
| 1 | 61 | 67 | | 5 |
| 4 | 66 | 69 | 67-70 | 5 |
| | | 68 | 66-69 | 6 |
| | | 68 | 66-69 | 8 |
| 6 | 70 | 69 | 67-70 | 5 |
| | | 68 | 64-69 | 6 |
| | | 68 | 65-69 | 8 |
| 5 | 82 | 80 | 75-82 | 5 |
| | | 79 | 75-83 | 7 |
| 9 | 99 | 97 | 93-101 | 5 |
| 5 M | 99 | 95 | | 9 |
| | | 100 | 99-101 | 11 |
| 4 F | 99 | 99 | | 13 |
| | | 104 | 102-107 | 15 |
| | | 98 | 98-99 | 24 |
| 2 F | 99 | 103 | | 29 |
| 1 M | 140 | 141 | | 18 |
| | | 138 | | 19 |
| 1 M | 141 | 159 | | 18 |
| | | 155 | | 19 |
| 3 F | 141 | 138 | 134-142 | 25 |
| | | 139 | 134-143 | 26 |
| 2 F | 143 | 138 | 137-139 | 25 |
| | | 138 | 138-139 | 26 |

Table 4. Body weights (g) of male and female wild turkey poults.

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Age (days) | N | $\overline{x}$ | SE | N | $\overline{x}$ | SE |
| 1 | 15 | 48 | 1 | 10 | 46 | 1 |
| 7 | 8 | 75 | 2 | 13 | 61 | 2 |
| 14 | 14 | 141 | 5 | 18 | 110 | 7 |
| 21 | 14 | 241 | 7 | 17 | 189 | 10 |
| 28 | 14 | 364 | 14 | 17 | 281 | 14 |
| 35 | 14 | 510 | 17 | 17 | 394 | 17 |
| 42 | 3 | 614 | 28 | 8 | 470 | 16 |
| 43 | 5 | 701 | 22 | 4 | 569 | 12 |
| 49 | 14 | 890 | 26 | 17 | 671 | 19 |
| 56 | 6 | 1124 | 40 | 7 | 850 | 17 |
| 63 | 6 | 1378 | 37 | 7 | 1072 | 25 |
| 70 | 6 | 1686 | 38 | 7 | 1305 | 20 |
| 77 | 6 | 1941 | 42 | 7 | 1520 | 37 |
| 84 | 6 | 2259 | 60 | 7 | 1784 | 41 |
| 91 | 6 | 2547 | 52 | 7 | 1959 | 33 |
| 98 | 10 | 2808 | 65 | 5 | 2046 | 44 |
| 105 | 10 | 3222 | 102 | 8 | 2398 | 55 |
| 112 | 12 | 3559 | 79 | 10 | 2652 | 43 |
| 119 | 5 | 3652 | 71 | 4 | 2811 | 77 |
| 127 | 5 | 4147 | 63 | 4 | 3135 | 76 |
| 133 | 5 | 4376 | 52 | 4 | 3310 | 66 |
| 140 | 6 | 5034 | 124 | 6 | 3482 | 45 |
| 148 | 7 | 5253 | 151 | 6 | 3626 | 50 |
| 154 | 7 | 5408 | 138 | 6 | 3733 | 48 |
| 161 | 5 | 5902 | 154 | 2 | 3870 | 99 |
| 168 | 5 | 6078 | 139 | 2 | 3933 | 120 |
| 174 | 7 | 6205 | 135 | 2 | 3997 | 170 |
| 181 | 7 | 6350 | 147 | 2 | 4096 | 184 |
| 189 | 5 | 6572 | 199 | 2 | 4110 | 198 |
| 196 | 5 | 6798 | 190 | | | |

Table 5. Leg lengths (mm) of male and female wild turkey poults.

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Age(days) | N | $\overline{X}$ | SE | N | $\overline{X}$ | SE |
| 1 | 9 | 61 | 1 | 6 | 60 | 1 |
| 7 | 8 | 64 | 1 | 13 | 63 | 1 |
| 14 | 14 | 78 | 1 | 18 | 74 | 1 |
| 21 | 14 | 92 | 1 | 17 | 86 | 2 |
| 28 | 14 | 107 | 1 | 17 | 100 | 2 |
| 35 | 14 | 120 | 1 | 17 | 111 | 2 |
| 42 | 3 | 133 | 4 | 8 | 120 | 2 |
| 43 | 5 | 137 | 2 | 4 | 129 | 2 |
| 49 | 14 | 148 | 1 | 17 | 135 | 1 |
| 57 | 9 | 165 | 2 | 8 | 151 | 4 |
| 63 | 12 | 180 | 2 | 12 | 163 | 1 |
| 70 | 12 | 195 | 2 | 12 | 177 | 2 |
| 77 | 12 | 210 | 2 | 12 | 190 | 1 |
| 85 | 9 | 227 | 2 | 9 | 204 | 3 |
| 91 | 12 | 235 | 2 | 12 | 208 | 1 |
| 98 | 10 | 244 | 2 | 5 | 216 | 2 |
| 105 | 16 | 255 | 1 | 13 | 218 | 2 |
| 112 | 11 | 263 | 2 | 8 | 223 | 1 |
| 119 | 5 | 265 | 1 | 4 | 227 | 1 |
| 127 | 9 | 269 | 2 | 9 | 229 | 1 |
| 134 | 8 | 276 | 3 | 7 | 229 | 1 |
| 140 | 6 | 280 | 3 | 6 | 228 | 1 |
| 148 | 7 | 280 | 2 | 6 | 228 | 1 |
| 154 | 7 | 281 | 2 | 6 | 229 | 1 |
| 161 | 5 | 283 | 3 | 2 | 228 | 0 |
| 168 | 5 | 284 | 3 | 2 | 229 | 1 |
| 174 | 7 | 283 | 2 | 2 | 229 | 1 |
| 181 | 7 | 283 | 2 | 2 | 230 | 0 |
| 189 | 5 | 285 | 3 | 2 | 229 | 1 |
| 196 | 5 | 285 | 3 | | | |

body measurements. Stage III ended at about 190 days for males and 177 days for females when postjuvenile primary 8 approached terminal length.

The lengths of postjuvenile primaries 7 and 8 were reliable indicators of age during the sheath stage when growth was approximately linear. During the pulp and almost-grown stages, neither feather accurately indicated age because age of first appearance was variable, and growth rate decreased rapidly as terminal length was approached (Table 2).

The growth of postjuvenile primaries 7 and 8 overlapped so that primary 8 was in the sheath stage when primary 7 was almost grown. Thus, either primary 7 or 8 was in the sheath stage during the period from about 102 to 190 days for males and 97 to 177 days for females. Juvenile primary 9 was molted in only 4 females at ages from 140 to 155 days, giving it limited value.

Terminal lengths of postjuvenile primaries 7 and 8 from our sample were equal to those obtained from a sample of birds killed in December 1978 in West Virginia. But, the terminal lengths reported here (Table 2) are longer than those previously reported for game-farm turkeys (Knoder 1959, Hayden and Wunz 1962).

Legs approached terminal length at around 17 weeks, for females and 20 weeks for males. Body weights continued to increase until 28 weeks of age when we stopped weighing birds.

Reasonable estimates of age were obtained when the regression equations were applied to data from known-age, hen-reared poults (Table 3). All but 1 estimate was within 0-6 days of true age; there was no consistent pattern in the deviations of estimated ages from true ages. The age of a 141-day-old male with postjuvenile primary 8 in the sheath was overestimated by 14-18 days. But age estimates for 6 other birds in the same stage of development were within a few days of the true age. A brood of 6, 28-day-old poults in transition between Stages I and II, was of particular interest. Using leg length alone, we underestimated the age of the 4 Stage I birds by 6 days. However, for both the Stage I birds and the 2 poults that had started the postjuvenile molt, a linear combination of molt pattern and leg length produced a good estimate of age (Table 1, eq. 4, 6). Knoder's (1959) technique applied to the same set of data consistently overestimated age. For example, estimated age for the 11, 99-day-old poults from New York ranged from 102 to 121 days, averaging about 10 days more than the known age.

## DISCUSSION

It is important to distinguish betweenthe theoretical value of individual variables for predicting age and the application of these data for estimating the age of wild poults. All variables contained information about age, but the pattern of variation differed among variables and utility of the variables differed with the stage of development. In terms of average coefficient of variation, the parameters ranked from least-to-most variable as leg length, postjuvenile molt, weight, primary 7 length, and primary 8 length. The proportion of variation in leg length and weight did not change with age, but postjuvenile molt and primary lengths were most variable in the early stages of growth.

No single variable could be used to predict age from hatching until body growth stopped in the fall. For Stage I, the best predictions of age were obtained from a linear combination of leg length and juvenile molt (Table 1, eq. 4). We did not have enough data to test the combination of molt, leg length, and weight, but inclusion of weight might have improved the regression. For Stage II, a linear combination of postjuvenile molt, leg length, and weight produced the best regression (Table 1, eq. 8). For Stage III, a quadratic function of primary 7 or 8 length gave the best estimate of age (Table 1, eq. 22-23, 29-30). By Stage III, legs had almost stopped growing and although weight continued to increase, its inclusion in the regression had little effect on $R^2$ values or goodness of fit. The additional equations in Table 1 fit our data well and provide a wide range of options for using existing data.

Tests of our data for aging wild poults were encouraging (Table 3) but in applying these data to wild birds, variations in turkey populations and possible bias due to captive rearing should be considered. Our poults probably developed at nearly their maximum potential rate because they were free from disease, protected from severe environmental stress, and fed adlibitum. Starvation had little effect on primary growth of red-tailed hawk (Buteo jamaicensis) and great horned-owl (Bubo virginianus) nestlings (Petersen and Thompson 1977), and we believe that our rearing program would have been most likely to affect weight and least likely to affect primary molt. Therefore, in using our data to predict the age of wild poults we are most confident using primary molt and least confident using body weight.

With these considerations in mind, the following key and figures were developed for aging turkey poults. The key can be used to select the appropriate regression equation from Table 1, or age can be estimated directly from the figures without further calculation.

Use of the key requires the ability to locate the most recently acquired primary, identify it as either juvenile or postjuvenile, determine its stage of growth, and assign it a numeric value. The growth stages and values are: empty feather follicle = 0.0, new feather in the pulp and shaft not broken from quill = 0.3, feather in sheath = 0.6, feather almost full grown with little blood in the lower end of quill and sheath still obvious = 0.8, and full-grown feather with no blood in lower end of quill and no-sheath on feather = 0.9. To visualize the process, look at Fig. lb which shows the wing of a 35-day-old poult and represents the only potentially confusing period in the primary molt sequence. Here, both juvenile primary 10 and postjuvenile primary 1 are in the pulp stage. Since primary molt always progresses from 1 through 10, primary 1 must be a postjuvenile feather and should be used for aging. It is assigned a feather value of 1.3 indicating postjuvenile primary 1 in the pulp stage. Fig. lc shows the wing of a 56-day-old poult. Here primaries 1 and 2 are clearly large, barred postjuvenile feathers and primary 3, which is in the pulp stage, is the most recently acquired feather. It is assigned a value of 3.3. Fig. 1d shows the wing of a 98-day-old poult with the postjuvenile molt well underway. Primary 7 is the most recently acquired feather, and therefore, the one used for aging. Postjuvenile primary 7 is in the sheath stage and will have a feather value of 7.6 but the key will direct you to age birds in this stage by measuring the length of primary 7 from the point of emergence to the tip. To examine the primaries, I placed the bird across my lap, grasped the nearest wingtip and extended the wing upward so the undersurface of the wing faced me. Primary status must be determined by viewing the underside of the wing because coverts on the upper surface cover the bases of the primaries.

Key to Aging Wild Turkey Poults

1. Examine the underside of the wing.
   a) postjuvenile molt has not begun......2.
   b) postjuvenile molt has begun......3.

2. The poult is <35 days old, sex cannot be determined. Measure leg length and determine the feather value of the last juvenile primary acquired to estimate age (Table l,eq. 4; Fig. 2). The best accuracy can be obtained from the primary molt pattern (Table 2).

3. Postjuvenile primary 7 absent or in the pulp......4.
   Postjuvenile primary 7 and/or 8 in the sheath......5.

4. The postjuvenile molt is underway but primary 7 has not reached the sheath stage. First, determine the feather value of the last postjuvenile primary acquired to estimate age (Table 1, eq. 5; Fig. 3). Then measure leg length to determine sex and read age from the scale for that sex (Table 1, eq. 10, 14; Fig. 3).

5. Postjuvenile primaries 7 or 8 are in the sheath stage.
   a) leg length >240 mm, bird is male......6.
   b) leg length <240 mm, bird is female......7.

6. Measure the length of postjuvenile primary 7 and/or 8 from calamus to tip using the primary that is in the sheath stage (Table 1, eq. 17, 18; Fig. 4).

7. Measure the length of postjuvenile primary 7 and/or 8 from calamus to tip using the primary that is in the sheath stage (Table 1, eq. 24, 25; Fig. 5).

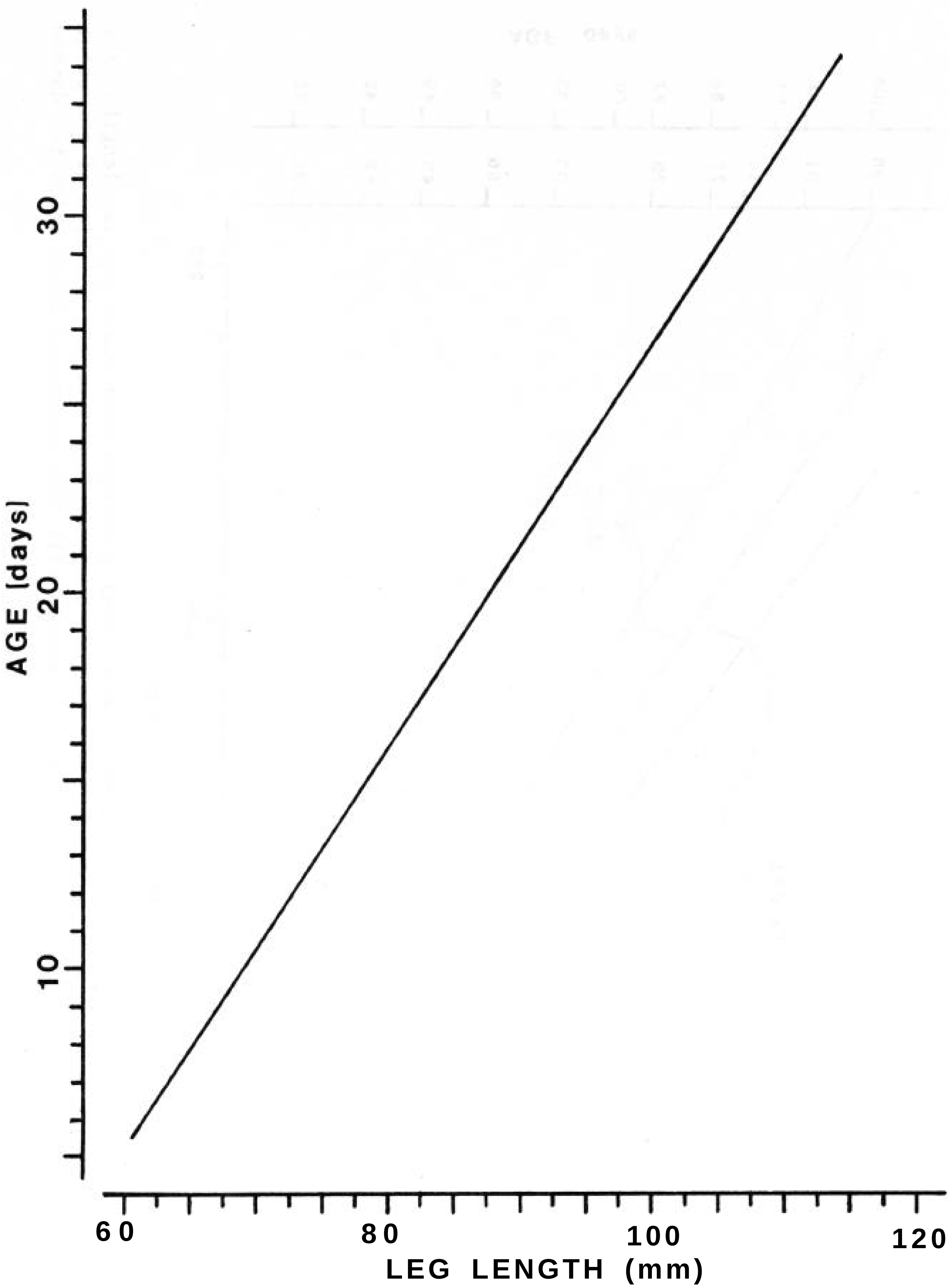


Fig. 2. Age of wild turkey poults expressed as a function of leg length.

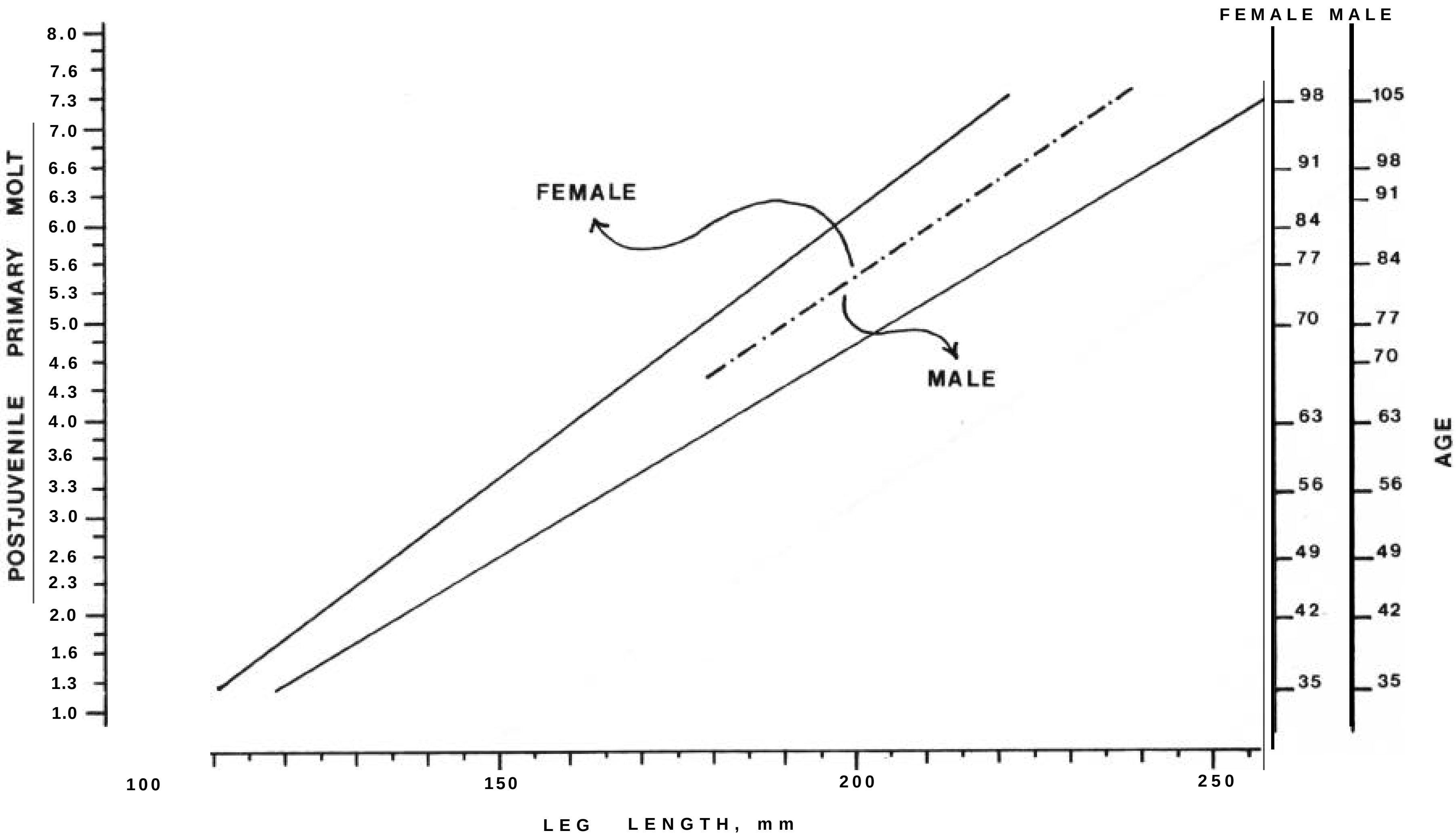


Fig. 3. Age of turkey poults expressed as a function of postjuvenile primary molt value and leg length. The solid lines are regressions for male and female poults. Sex can be determined from the location of the point formed by the intersection of a molt value and leg length; females will fall above and males below the dashed line. Age is then read from the appropriate scale.

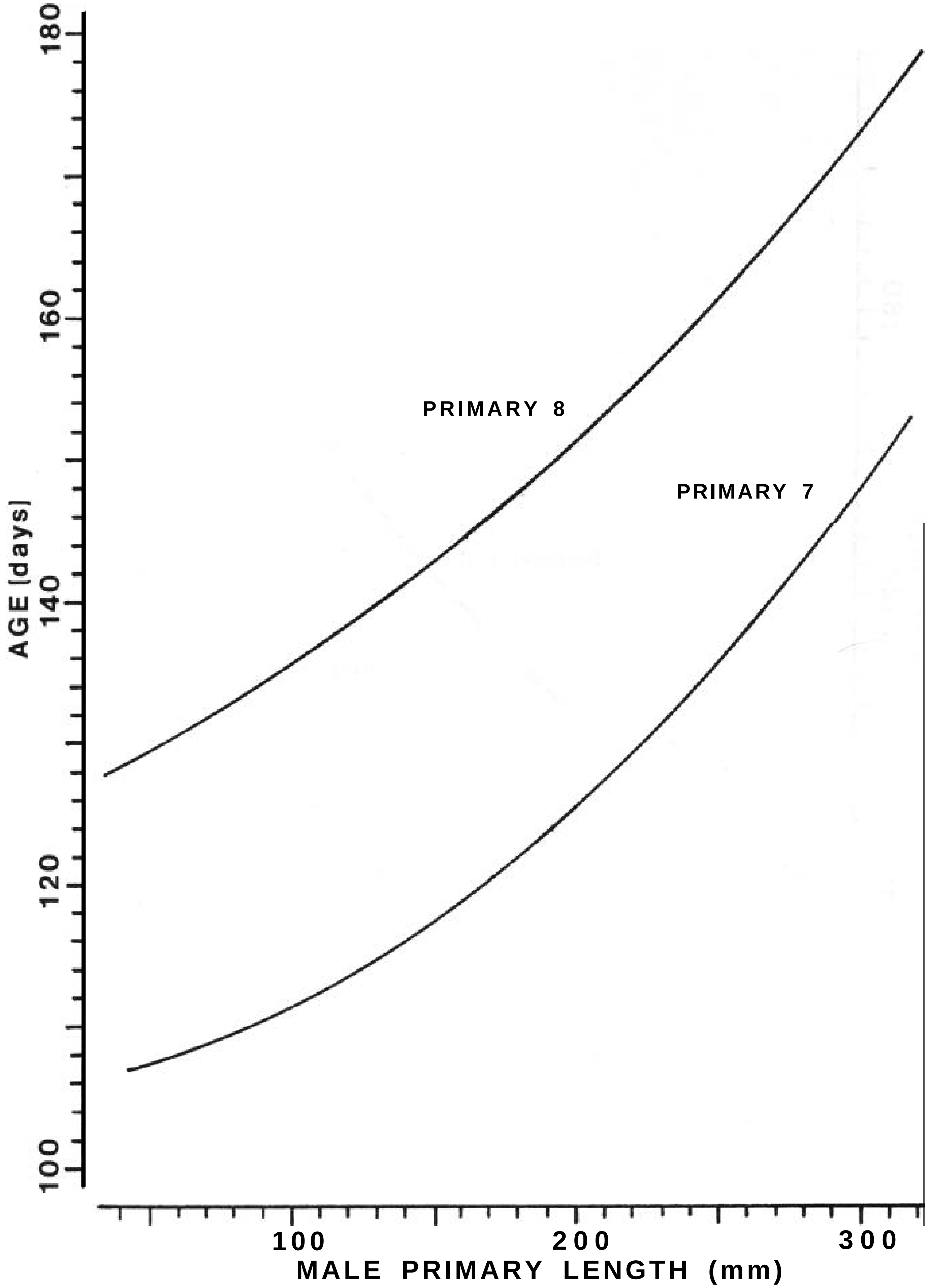


Fig. 4. Age of male poults expressed as a function of the length of postjuvenile primaries 7 and 8.

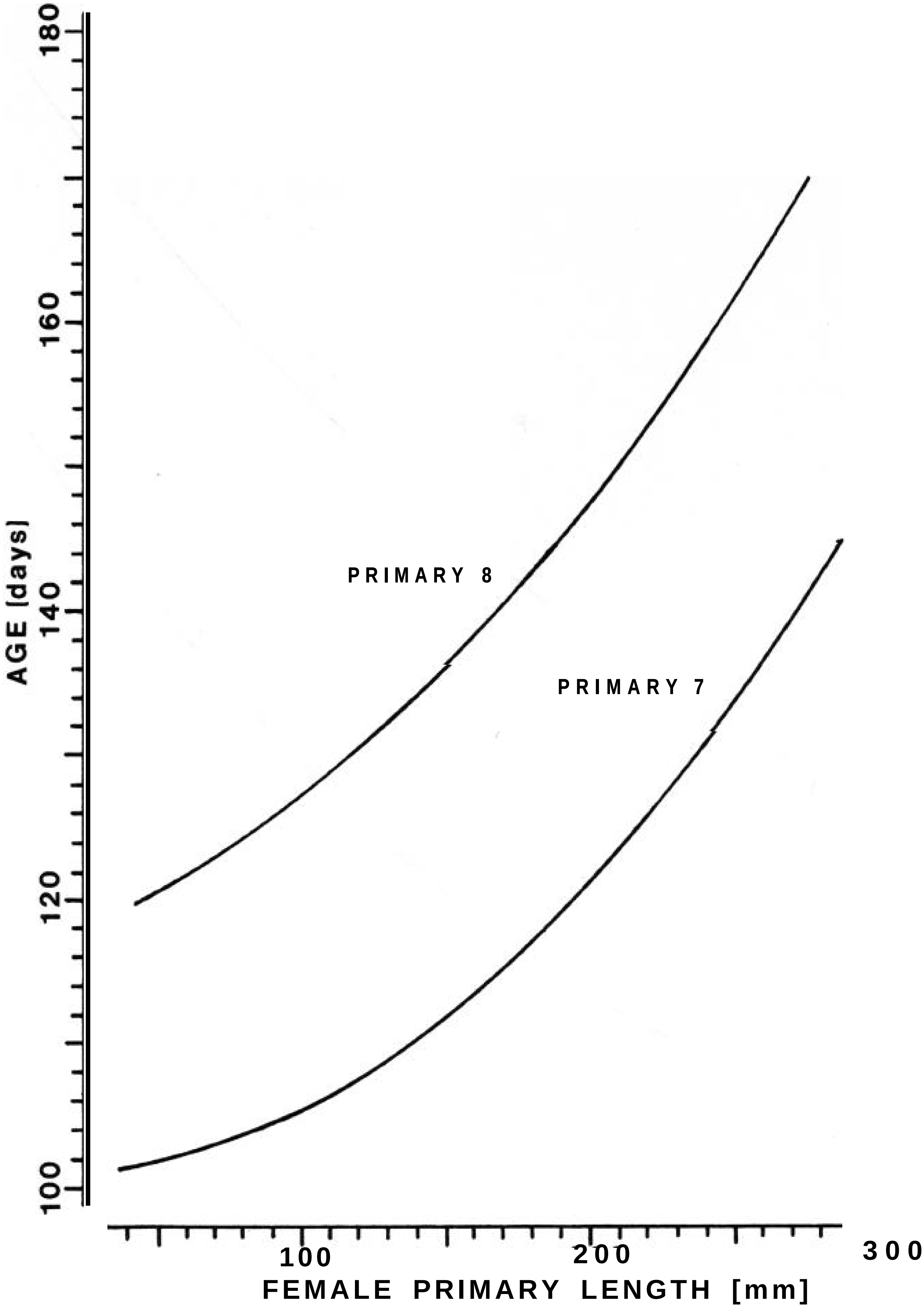


Fig. 5. Age of female poults expressed as a function of the length of postjuvenile primaries 7 and 8.

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# EVALUATION OF RECLAIMED SURFACE MINES AS WILD TURKEY BROOD RANGE

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*Abstract:* A surface mine classification system was developed based on subjective evaluation of vegetation types. Five vegetation classifications and a control site (unmined) were tested with two broods (one early and one later) of imprinted wild turkey poults *(Meleagris gallopavo silvestris*). Feeding behavior and distress reaction observations indicated classes 2 (sapling with grass legume understory) and 5 (primarily volunteer under and overstory) provided the best combination of invertebrate availability and cover density for wild turkey broods when compared to unmined control sites.

Classes 1 (grassland), 3 (grassland with pole stage overstory) and 4 (plantation) appeared to be marginal habitat. There was, however, increased feeding observed on class 1 mines during the late brood period. Numbers of invertebrates consumed were directly related to availability. Invertebrate availability was highest on class 2 ($P <.05$), sites. Class 5 ranked second, but showed no significant difference in invertebrate productivity ($P <.05$) when compared to unmined control sites. The remaining classes 1, 3 and 4 showed significantly less invertebrate productivity ($P >.05$) than classes 2, 5 and the unmined control site.

Classes 2, 5 and the control provided a denser vegetation mat, hence, better escape cover than classes 1, 3 and 4. Management recommendations are presented.

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Much of Pennsylvania's prime eastern wild turkey range lies within areas of surface mining activity (Hutchins 1978, Wunz 1967). Even so, influences of surface mining and surface mine reclamation on turkeys and turkey habitat remain unknown. Although brood use of undisturbed sites is well documented, little is known about use of reclaimed surface mines. Surface mining creates openings in continuous forests which may be beneficial to wildlife; but use of these openings by wild turkey broods has not been evaluated (Davidson and Davis 1968).

By 1971 surface mining had disturbed 385,500 ha. in 12 Appalachian states ranging from 100 ha. in Georgia to 100,000 ha. in Pennsylvania. Revegetation has been established on only 239,400 ha., leaving 146,100 ha. to be reclaimed (Hutchins 1978). This study was designed to provide guidelines for future reclamation that minimize detrimental effects on turkey habitat.

Primary study objectives were to: (1) Classify vegetation on reclaimed surface mines in southwestern Pennsylvania; (2) Evaluate invertebrate and vegetation availability and use by turkey poults on the classified mines; and (3) Make management recommendations to improve turkey brood habitat on reclaimed surface mines.

## STUDY AREA

Cambria (177,152 hectares) and Somerset (275,968 hectares) Counties (70° 30' - 78° 45' longitude and 39° 45' - 40° 45' latitude) have reclaimed surface mines which represent the different reclamation procedures used throughout Pennsylvania. These counties (Fig. 1) are among the 66 Pennsylvania counties sustaining wild turkey populations on second and third class turkey range (Wunz 1967).

## METHODS

A classification system based on spoil condition and plant structure established 5 different vegetative classes for reclaimed surface mines (Table 1). Control areas were selected that appeared to be good brood habitat, so that undisturbed vs. disturbed comparisons could be made. Control sites met the minimum standards for brood habitat requirements as described by Kozicky (1948) and Korschgen (1967). For 10 weeks in 1977, 2 broods of 4 poults each were investigator imprinted (Healy and Goetz 1974). These simulated normal (mid-May) and late (late-June) broods and were used to sample 5 mines from each class and 5 non-mine control sites weekly. Each brood was used for data collection for 5 weeks.

Three variables were measured with each brood: 1) Animal items eaten, 2) vegetable items eaten, and 3) use of escape cover. The first (normal) brood started field data collection on May 23 and the second (late) started July 1, 1977. The number of vegetation classes visited per day including the non-mined control site, depended on the weather. No more than 2 classes were visited in any single day, and all classes were visited once each week.

Plant and animal items eaten per minute were recorded for 10 minutes each for 3 of the 4 poults. This provided 30 minutes of feeding data per vegetation class per week. These data were averaged and mean items eaten per minute computed for each class and the non-mine control site for each of the 10 weeks.

Escape cover was evaluated on each vegetation class by observing the behavior of poults immediately after giving an alarm call. Since good escape cover should hide all poults, if any part of a poult was observed, it was counted as .5; if totally seen it was counted as 1.0. Escape cover value was estimated by summing the value assigned to each poult.

An evaluation of invertebrate abundance was conducted with sweep nets (Beall 1935). A single hectare plot in each vegetation class and the control was sampled by walking 5 linear transects and taking 25

Pennsylvania Turkey Range

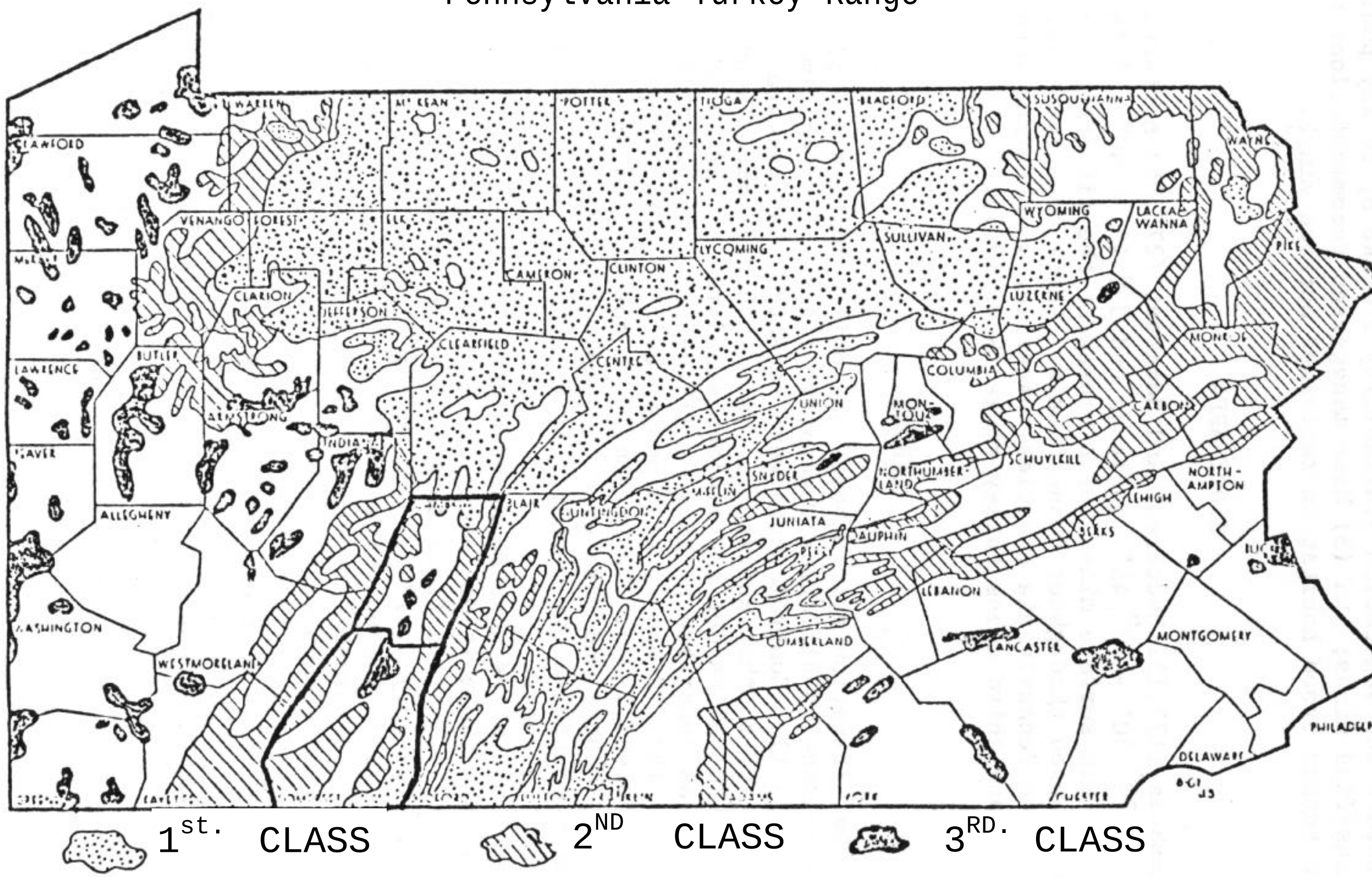


Figure 1. The 2 county study area in second and third class turkey range (Wunz 1967).

Table 1. Structural vegetation classification system for reclaimed surface mines.

| | Vegetative Makeup | | |
|---|---|---|---|
| Class[a] | Understory | Overstory | Spoil Condition |
| 1 | grasses[b], legumes[c]<br>tree seedlings[d]<br>usually locust<br>(*Robinia* spp.) Autumn<br>olive (*Elaeagnus umbellata*) | none | 35-45% bare spoil<br>reclaimed to contour |
| 2 | grasses, legumes<br>with tree seedlings<br>(locust, autumn olive<br>conifers) | none | 25-35% bare spoil,<br>reclaimed to contour |
| 3 | grasses<br>volunteers[f] | pole timber[e],<br>locust<br>conifers<br>cherry (*Prunus*<br>spp.)<br>maple *Acer* spp.)<br>poplar (*Liriodendron* spp.)<br>(or any combination) | 50-60% bare spoil<br>reclaimed to contour |
| 4 | grasses<br>volunteers | plantations<br>conifers<br>locust and/or<br>mixed hardwoods | 45-55% bare spoil,<br>reclaimed to contour |
| 5 | volunteers<br>with some<br>grasses | planted or<br>volunteer<br>sapling[g], pole[h]<br>and saw timber<br>mixed hardwoods<br>and conifers | 15-25% bare spoil,<br>highwalls or<br>rolling spoil banks |

[a]Estimates of age classes are:
Class 1, 1-3 yrs. Class 3, 5-15 yrs. Class 5, 15&>Yrs.
Class 2, 3-5 yrs. Class 4, 3 & >yrs.

[b]Grasses = all species of the family *Gramineae (Poaceae).*

[c]Legumes = all species of the family *Fabaceae.*

[d]Seedlings = 3 feet tall.

[e]Pole timber = 4-12" DBH.

[f]Volunteer - any plant species that has appeared naturally.

[g]Sapling = 3-10 feet tall.

[h]Saw timber = 12-24" DBH.

sweeps per line (one sweep consisted of 2 passes through the vegetation with a horizontal, figure-eight motion). After each of 25 sweeps, insects were bagged and killed with ethyl acetate. Specimens were classified, counted and weighed according to taxonomic order. Three collections were made during the 10 week research period the weeks of May 16, June 20 and July 25. Samples were taken 1 week before the first and second broods hatched, and immediately after the behavioral field work was finished.

A vertical vegetation board was used to determine cover density indices (Devos and Mosby 1971). A sample was taken in each of the 4 corners and in the center of the plots used for sweep net evaluation. Vegetation density was determined by counting and averaging the number of 10 $cm^2$ blocks on the vegetation board that contained vegetation. Subjective evaluation of these 5 samples consisted of assigning values of .5 for a block between one-quarter and one-half covered by vegetation and 1.0 for more than one-half covered. The means obtained for each vegetation class and the control were used for analysis.

The percentage of unvegetated spoil was estimated on representative parts of each classification and the control by the step-point or pace transect method. This technique consists of recording the soil as vegetated or unvegetated at 100 m. intervals beginning at a random point (Costello 1962). Data were collected on the same sites examined earlier.

Poult behavior, quantitative vegetation and invertebrate data were all analyzed and tested for significant differences by using the analysis of variance module of the Statistical Analysis System, General Linear Models Procedure. The model shown in Table 2 was used to test the different variables and their interactions. The "Least Significant Difference" (LSD) multiple comparisons test was used to separate means. All differences were tested at the ($P < .05$) probability level.

## RESULTS

Surface mines within the study area were classified into 5 classes based on the structure of the vegetation present (Table 1). Classes 1, 2 and 3 are products of succession, similar to that of grasslands. The initial crops are grasses and legumes. Through natural seed dispersal over time, changes seem to occur which do not fit the seral stage changes normally associated with grassland succession.

Instead of the sequential changes described in the literature, certain stages are omitted. For example, grasses are normally present in an old field ecotype when the shrub stage appears, but grasses are essentially absent on old surface mines when the shrub stage is established. This phenomenon is exemplified by comparing classes 2 and 3 of the classification system (Table 1). The difference in bare spoil percentage for these classes indicates an absence of an intermediate stage between these classes. There were instances where both classes were found on the same site, but sharp delineation was evident.

Class 4 supported vegetation arising from an attempt to establish conifer and conifer-hardwood plantations. Plantings consisted of grasses, legumes, and seedling tree combinations and when initially seeded could be classified as class 1. As trees grew and the mine aged, understory plants were shaded, creating a relatively barren spoil covered by sparse, shade tolerant grasses and volunteer species.

Table 2. Example of an analysis of variance summary for the combined plant and animal items eaten by broods one and two.

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F Value |
|---|---|---|---|---|
| Model | 39 | 30965.42 | 793.99 | 7.89* |
| Age[a] | 4 | | | 5.81* |
| Brood[b] | 1 | | | 1.76 |
| Class[c] | 5 | | | 41.52* |
| Age X Brood | 4 | | | |
| Class X Age | 20 | | | 1.72 |
| Class X Brood | 5 | | | 1.33 |
| Error | 20 | 2011.43 | 100.57 | |
| Corrected Total | 59 | 32976.85 | | |

*Significant at $P < .05$.

[a]Age of turkey broods by weeks.

[b]Turkey broods one and two.

[c]Vegetation classification system.

[d]Offset figures are a partitioning of the model.

Class 5 mines were characterized by highwalls and sparse tree plantings. These sites contained a greater diversity of understory and overstory species than all other classes except the unmined control sites. This was attributed to leaching of toxic chemicals from the spoil which was, in turn, directly related to the site's age and establishment of a variety of volunteer species.

The replicability of the classification was tested by 4 wildlife management graduate students. After preliminary instructions, classification by the students agreed with the author's classification for 15 of 16 mined sites. One discrepancy arose when one site contained two classes. This area could have been rated in either class depending on the portion of the mine evaluated.

The average number of animal and plant items eaten by both broods were significantly different for the 5 vegetation classes and unmined control sites. Vegetation class 2 mines were not significantly different from the unmined control site (Table 3). Both broods consumed the most combined animal and plant items on class 6 (control) areas. Class 2 was second highest for both broods, but this was not statistically different from vegetation class 5 during the second brood. Data for both broods indicated that total numbers of animal and plant items eaten were lowest on vegetation classes, 3, 4 and 1.

The number of animal and plant items eaten were also analyzed separately to determine if their combined interactions affected the overall results. Animal items eaten by brood 1 (early brood) were significantly different for the different vegetative classes and for brood age (Tables 4 and 5). Animal items eaten by brood 2 (late brood) showed differences for the vegetation class, but not for brood age (Table 4 and 5). Both broods consumed the most animal items on the control sites (class 6). Brood 1 consumed more insects on vegetation class 2 sites than the other mined areas. Class 6 was significantly different from all other classes for items consumed by brood 2. There was no significant difference in animal items eaten by brood 2 on vegetation classes 2 and 5; both classes received heavy utilization. Vegetation classes 3 and 4 had the lowest number of animal items eaten by both broods.

Animal items eaten by brood 1 in week 1 was significantly lower than weeks 2, 3 and 5, but not statistically lower than week 4. Week 4 was significantly lower than week 5 but not lower than weeks 2 and 3 (Table 5).

No significant differences in the amount of plant items eaten occurred between vegetation classes or the unmined control sites for either brood (Table 6). Brood 1 showed significant differences in the amount of plant items eaten when analyzed by age but brood 2 did not. Brood 1, week 1 had the lowest plant feeding rates and was significantly different from all other ages except week 2. Week 2 was not significantly different from any of the other ages. Brood 1's diet contained 16 percent vegetable matter while brood 2 consumed only 9 percent (Table 7).

There were no significant differences among the weights of invertebrates collected during the three collection periods. Significant differences were found among weights of invertebrates collected on the various vegetation classes (Table 8). Vegetation class 3 sites had the fewest invertebrates while class 2 sites had the most.

Table 3. Average number of plant and animal items eaten by both broods on 5 surface mine vegetation classes and the unmined control (6) areas[a].

| | VEGETATION CLASS | | | | | |
|---|---|---|---|---|---|---|
| BROOD | 4 | 3 | 1 | 5 | 2 | 6 (CONTROL) |
| 1 | 47.8 | 45.0 | 57.6 | 74.4 | 78.2 | 91.0 |
| 2 | 35.4 | 40.4 | 57.6 | 63.2 | 84.2 | 92.6 |

[a]Means not connected by underlining are significantly different (P <.05 , L.S.D. Test).

Table 4. Average number of invertebrate items eaten by both broods on 5 surface mine vegetation classes and the unmined control (6) areas[a]

| | VEGETATION CLASS | | | | | |
|---|---|---|---|---|---|---|
| BROOD | 4 | 4 | 1 | 5 | 2 | 6 (CONTROL) |
| 1 | 34.4 | 37.4 | 48.4 | 64.6 | 66.0 | 83.4 |
| 2 | 31.6 | 29.0 | 52.8 | 57.2 | 77.4 | 87.6 |

[a]Means not connected by the same line are significantly different (P <.05, L.S.D. Test).

Table 5. Average animal items eaten by week of age for both broods[a].

| | AGE (Weeks) | | | | |
|---|---|---|---|---|---|
| BROOD | 1 | 2 | 3 | 4 | 5 |
| 1 | 38.8 | 58.3 | 59.1 | 52.5 | 69.6 |
| 2 | 63.8 | 63.1 | 53.6 | 43.1 | 55.8 |

[a]Means not connected by underlining are significantly different (P <.05 , L.S.D. Test).

Table 6. Average number of plant items eaten by both broods on 5 surface mine vegetation classes and the unmined control (6) areas[a].

| | VEGETATION CLASS | | | | | |
|---|---|---|---|---|---|---|
| BROOD | 3 | 4 | 1 | 5 | 2 | 6 (CONTROL) |
| 1 | 10.6 | 10.4 | 9.2 | 9.8 | 12.2 | 7.6 |
| 2 | 8.8 | 6.4 | 4.8 | 6.0 | 6.8 | 5.0 |

[a]Means not connected by underlining are significantly different (P <.05, L.S.D. Test).

Table 7. Contribution of plant matter eaten to total plant items eaten and to total diet by week and brood.

| | Percent contribution to vegetation eaten by week | | Percent vegetation of total diet by week | |
|---|---|---|---|---|
| Weeks | Brood 1 | Brood 2 | Brood 1 | Brood 2 |
| 1 | 8.3 | 8.6 | 1.3 | .8 |
| 2 | 15.7 | 12.9 | 2.5 | 1.2 |
| 3 | 20.4 | 24.n1967 | 3.3 | 2.3 |
| 4 | 33.1 | 23.7 | 5.3 | 2.2 |
| 5 | 22.7 | 30.1 | 3.6 | 2.8 |
| | 100% | 100% | 16.0% | 9.3% |

Table 8. Average fresh weight (g) of invertebrates collected in sweep net samples of 5 vegetation classes and an unmined control[a].

| | VEGETATION CLASS | | | | | |
|---|---|---|---|---|---|---|
| | 3 | 4 | 1 | 5 | 6 (CONTROL | 2 |
| | .02 | .03 | 1.2 | 1.2 | 2.4 | 10.2 |

[a]Means not connected by underlining are significantly different (P< .05, L.S.D. Test).

Although not statistically evident invertebrate availability increased during the season on vegetation classes 1 and 5 and decreased on vegetation classes 2, 3 and 4. Class 6 (control) peaked during the second collection period (Fig. 2).

Significant differences were observed in the escape cover availability utilization parameter among vegetation classes (Table 9). No differences were attributable to individual broods or to poult age. Both broods found more cover or were less visible on vegetation classes 2, 6 and 5.

The vertical distribution of vegetation as measured by a density board was not different over the 3 collection periods, but significant differences were observed among the vegetation classes (Table 10). Although, not statistically evident vegetation density increased between sample periods on vegetation classes 6, 2 and 5 and decreased on classes 3, 4 and 1 (Fig. 3).

## DISCUSSION

Three reclamation practices leading to five different classes of vegetation structures were evaluated. The first reclamation practice consisted of grassland plantings (classes 1, 2 and 3). The second practice was tree plantations (class 4). The third consisted of abandoned mines located near adequate seed sources promoting development of natural vegetation (class 5). Testing the classification system indicated that there are visually discernible differences in vegetation structure. Quantitative measurements confirmed a biological difference on the different mine sites.

Animal items eaten and sweep net collections showed a significant correlation (Table 11). This correlation indicates that vegetation classes 2, 5 and the unmined control 6 had the most available invertebrates of the 6 vegetation classes. Brown (1978) in West Virginia found that imprinted bobwhite quail *(Colinus virginianus)* had high feeding rates on burned grass-trefoil reclaimed surface mines (comparable to vegetation classes 1 and 2). Kimmel (1979 per. comm.) evaluated similar grass-trefoil reclaimed mines in West Virginia and found them to contain inadequate brood habitat for ruffed grouse *(Bonasa umbellus).* He also tested older sites with class 5 vegetation and found that a 60 percent canopy of autumn olive and black locust was excellent brood habitat based on feeding rates, available insects and cover density. Classes 3 and 4 produced fewer invertebrates probably because of sparse vegetation and high surface temperatures.

No significant differences were found between the amounts of vegetation consumed on the six vegetation classes for the two-5-week test periods. This is probably because turkey poults make a radical change in diet from invertebrates to vegetation between the 5th and 6th week of life (Healy et al. 1975). Since both broods were each used for only 5 weeks of testing, the change was not observed and the percentage of plant items in the diet remained relatively low.

Vertical vegetation density and poult distress reactions showed a significant correlation (Table 11). This correlation indicates that vegetation classes 5, 2 and 6 (those with the highest vegetation densities) provided the best cover for poults less than 5 weeks old.

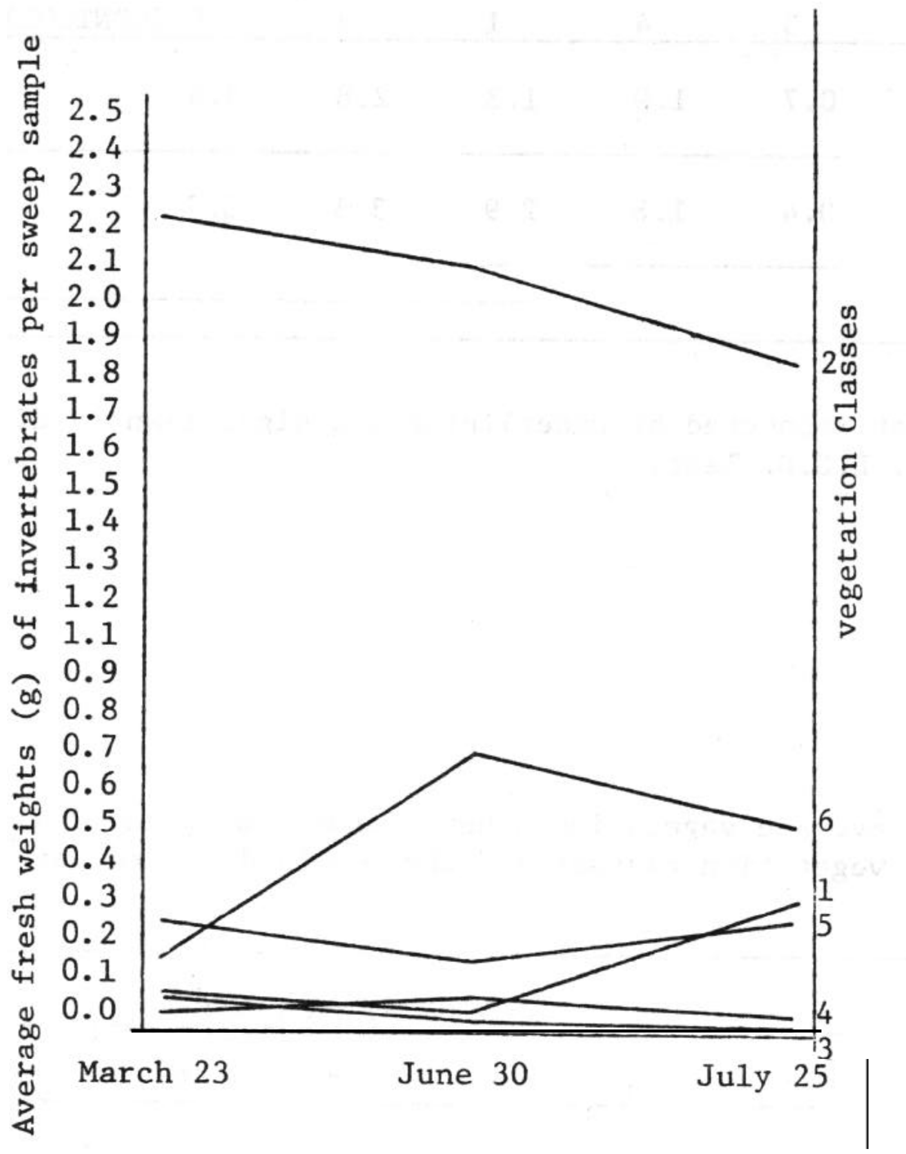


Figure 2. Sweep netted insects plotted by weights per sample, per vegetation class vs. sample time.

Table 9. Average number of poults hidden in 30 trials per brood using a simulated alarm call[a].

| | VEGETATION CLASS | | | | | |
|---|---|---|---|---|---|---|
| BROOD | 3 | 4 | 1 | 5 | 6 (CONTROL) | 2 |
| 1 | 0.7 | 1.0 | 1.3 | 2.8 | 3.4 | 4.0 |
| 2 | 0.4 | 1.8 | 2.9 | 3.3 | 3.7 | 3.7 |

[a]means not connected by underlining are significantly different (P <.05, L.S.D. Test).

Table 10. Average vegetation density index[a] samples of the 5 vegetation classes and the unmined control areas[b].

| VEGETATION CLASSES | | | | | |
|---|---|---|---|---|---|
| 3 | 4 | 1 | 2 | 5 | 6 (CONTROL) |
| 1.25 | 1.47 | 1.56 | 1.88 | 1.92 | 2.02 |

[a]Vegetation density was determined by averaging the number of 10 $cm^2$ blocks on the vegetation board containing vegetation.

[b]Means not connected by the same line are significantly different (P <.05, L.S.D. Test).

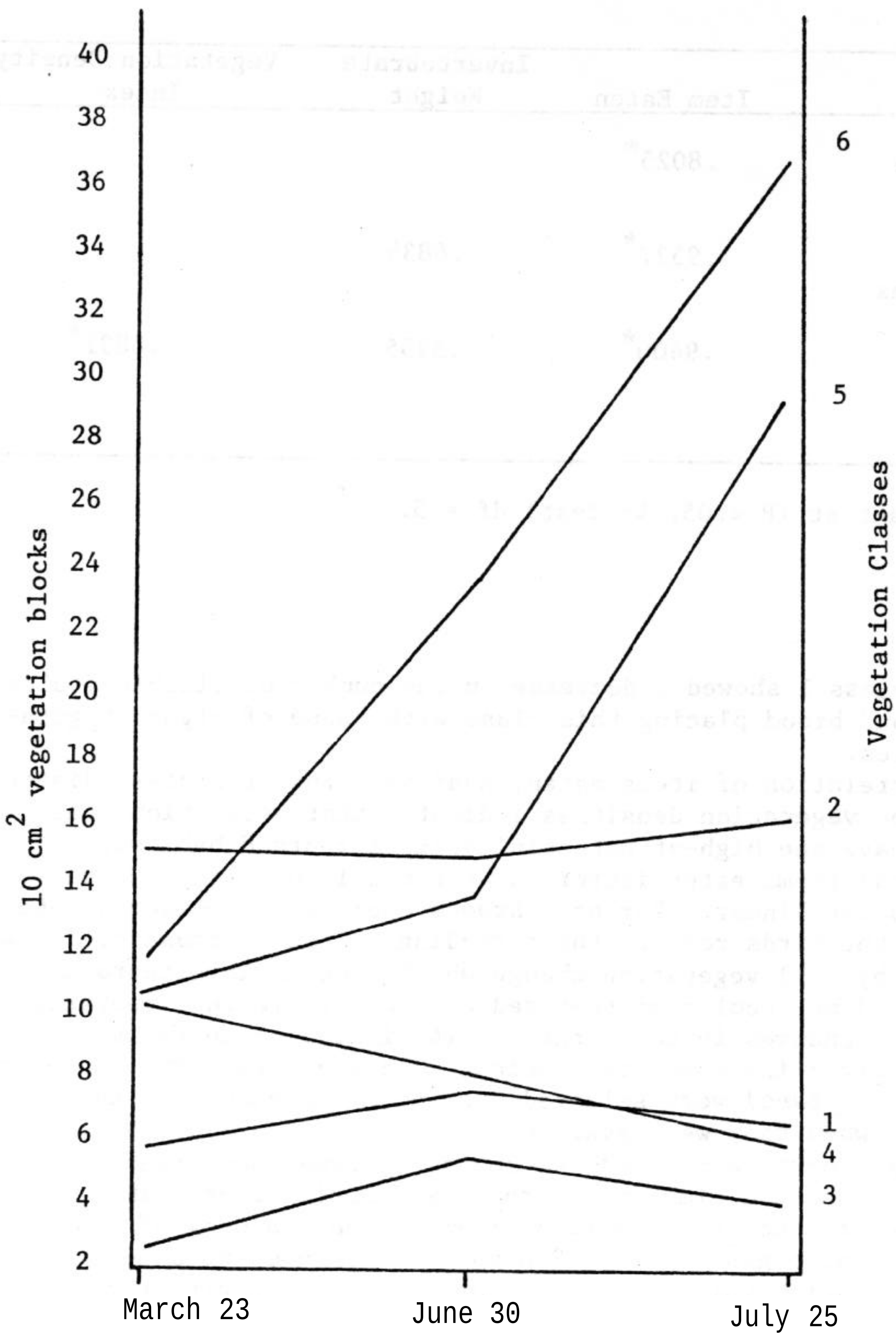


Figure 3. Vegetation density plotted by the number of 10 $cm^2$ blocks at least one-half full per sample per vegetation class vs. sample time.

Table 11. Correlation matrix (r) for variables measured on 5 vegetation classes and unmined control areas (P <.05).

| | Item Eaten | Invertebrate Weight | Vegetation Density Index |
|---|---|---|---|
| Invertebrate weight | .8025* | | |
| Vegetation Density Index | .9527* | .6835 | |
| Distress Reaction | .9400* | .5955 | .8891* |

*Significant at (P <.05, t- Test) df = 5.

Vegetation class 1 showed a decrease in the number of visible poults for the second brood placing this class with those of higher vegetation densities.

The correlation of items eaten, available invertebrates, distress reactions and vegetation densities indicates that vegetation classes 5, 2 and 6 have the highest potential value for brood habitat.

The total items eaten increased as brood 1 got older but the increase was not linear. For both broods there were periods at about week 4 when the birds reduced their feeding. This decrease could have been caused by: (1) vegetation change which reduced invertebrate numbers; (2) damp, cooler weather reducing available invertebrates; (3) physiological changes in the birds; or (4) increased selectivity by the birds for a given invertebrate species. Grasshoppers *(Orthoptera)* and crane flies *(Diptera)* were selected over ants *(Hymenoptera)* and beetles *(Coleoptera)* when they were available.

Cool damp periods reduced the amount of time spent feeding for brood 1 and increased time spent brooding. During these times the poults ranged farther and ate fewer items. The 4th week of testing for the second brood began on July 19th and corresponded to a period of very heavy precipitation which decreased the number of invertebrates available to the poults during this period.

Animal items consumed by both broods and available invertebrates peaked simultaneously between June 20 and July 2, (i.e. the last week of the first brood and the first week of the second brood). This peak was also observed in the sweep net data on the unmined control sites. This suggests that the number of invertebrates eaten by the poults parallels the invertebrates available on vegetation class 6 (control). The correlations between the available invertebrates and invertebrates consumed were positive and significant. This (r) value might have been higher it: (1) The number of sweep net or feeding samplings were increased; (2) numbers of invertebrates on the vegetation classes showed greater seasonal variation; (3) plant diversity was higher causing invertebrate densities to increase; (4) the comparisons of sweep net indices and invertebrate items eaten by imprinted turkey poults were more comparable measures for evaluating this classification system. The last possibility is unlikely for the reasons discussed by Janzen (1973) and Healy (1978). Direct observation of imprinted turkey poults as reported by Healy (1978) accurately reflects insect availability.

Of the remaining 3 possibilities we feel that premise 2 and 3 are the reasons that invertebrate availability showed a lower correlation. After initial reclamation, mines are somewhat stagnant for several years before exhibiting noticeable, seasonal growth changes. This lack of change is caused by the types of vegetation planted coupled with a lack of plant diversity. Since most reclamation practices produce monocultures aimed at rapid revegetation, seasonal increases in available invertebrates are not significant.

## MANAGEMENT RECOMMENDATIONS

(1) Grain drill row spaces: The use of a grain drill to plant cover crops on reclaimed mines seems to be a practice of the past. If a grain drill was used to plant the perimeters of surface mines the results could help increase brood use through increased poult mobility. The present techniques of hydroseeding is less costly and more efficient. Hydroseeding eliminates row spaces commonly found when a grain drill is used by forming a mat of vegetation. On mines where a grain drill was used, row spaces gave the poults greater mobility for invertebrate stalking and provided a larger dispersal area during escape reactions. Spaces also limit poult contact with early morning dew. This leaves more time for feeding and less brooding. Matted vegetation provides limited mobility and reduces poult efficiency.

(2) Fertilization: Periodic (yearly) soil testing followed by prescribed fertilization would aid the productivity of most mines. The results of this study indicated that vegetation classes 3 and 4 were deficient in the production of vegetation and hence, less attractive to invertebrates. This situation might be alleviated if a modified farm type fertilization program was initiated. A fertilization program would not only benefit turkeys, but other wildlife species that require vegetated openings for part of their life cycles.

(3) Reclamation of old abandoned sites: In accordance with surface mine reclamation act (PL-9587, Title IV) some abandoned mines are to be reclaimed. This study has shown that not all old abandoned sites should be redisturbed. In certain instances where acid drainage and bare spoil are causing nonproductive, unsightly areas, reclamation is needed. Where productivity appears high (Class 5), invading volunteers provide food and cover for turkey poults and further reclamation would not be economical.

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# AN EVALUATION OF WILD TURKEY BROOD HABITAT IN SOUTHEASTERN MINNESOTA

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Abstract. Brood habitat was examined in southeastern Minnesota during the summers of 1975, 1977 and 1978. Habitat quality was evaluated using four parameters: home range, habitat use, female survival and poult survival. Data were acquired via telemetric and visual observation of 75 radio-tagged females and their broods. Summer home ranges of broods included approximately 250 ha but use of the ranges was not uniform. Females with broods spent an average of 45% of the diurnal hours in fields of alfalfa and corn with peak use occurring in the seventh week following hatching. Moderate grazing of woodlands, early mowing of alfalfa and reduction of edge habitat resulting from maximum use of tillable land did not affect survival of females or poults during the summer. Brood habitat in this region is characterized by mature hardwood forest interspersed with agricultural fields in an approximate ratio of 4:l. Females with broods show preference for areas of moderate interspersion (17 habitat patches/$km^2$). Areas containing mature oak (*Quercus* spp.) and a combination of corn and alfalfa appear optimal. A density of 2 good brood raising areas/township (93 $km^2$) may be sufficient for established populations but greater densities are recommended at transplant sites.

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Wild turkeys from Arkansas, Missouri, Nebraska and South Dakota were transplanted into southeastern Minnesota during 1964-1973. This region lies on the northern fringe of the known native range for the species but the populations that were established have shown excellent growth. Recent demographic studies have shown a finite growth rate ($\lambda$) averaging 2.15/year (Porter 1978). In the fall of 1978, the population was estimated to number approximately 9,000 birds. Much of this growth can be attributed to high natality rates and excellent survival of poults through the summer months.

Plans were made in 1977 to begin transplanting birds from these established populations into other parts of Minnesota. To evaluate future release sites information was needed concerning the habitat requirements for wintering, nesting and brood raising. Reported here are the results of a study designed to: 1) describe general habitat-use patterns of broods, 2) assess the impact of agricultural land-use practices on brood raising and 3) identify the environmental features important in defining brood habitat.

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## STUDY AREA

The study area included 600 km$^2$ in southeastern Minnesota. The area was characterized by a rolling upland, deeply and extensively dissected by the Mississippi River and small tributaries. Soils were calcareous and well-drained. Vegetation in this region was a patchwork of mature hardwood forest and agricultural land in a 60:40 distribution. Oaks, especially red (*Quercus borealis*) and white (*Q. alba*), composed approximately 50% of the trees in all size classes (DeBald and Stone 1964). Canopy closure in forested areas averaged 80% and understories were dominated by shrubs such as gooseberry (*Ribes missouriense*), prickly ash (*Xanthoxylum americanum*) and hazel (*Corylus, americana*). Agricultural lands were planted primarily to corn and alfalfa (61% of the agricultural land) or were in pasture (19% of the agricultural land).

The northern portion of the study area, designated the "northern range", included the 100 km$^2$ Whitewater Management Area and 120 km$^2$ of state forest. The southern portion of the study area, or "southern range", was composed primarily of privately owned farmland (Fig. 1). These two areas were generally similar except: 1) 80% of the forested land in the southern range was moderately grazed while all state wildlife and forest lands were closed to grazing; 2) hay mowing was initiated during the first week in June on private lands but delayed until June 15 on state lands; 3) forest-field edges were less numerous and more sharply defined in the southern range. The abundance of edges, as measured along 2.7 km transects (sampling procedure modified from Baxter and Wolfe 1972) averaged 2.7 ± 0.23 and 1.9 ± 0.12 ($\bar{x}$ ± SE) edges/km in the northern and southern ranges, respectively. Edges were less sharply defined in the northern range as invasion of field edges by woody vegetation was permitted on state agricultural lands.

## METHODS

To identify the features important in defining brood habitat, the response of turkeys to the southeastern Minnesota environment was examined. Four response parameters were measured: home range size, habitat use, survival of mature females and survival of poults through the summer. Estimates for the first 2 of these parameters were obtained using radio-telemetry. Radio-tagged females were located visually during nesting and the exact date of hatching was determined (Porter 1978). Knowledge of hatching data allowed analyses of movement and habitat use on an age-specific basis. After hatching radio-tagged females were located via triangulation at least once every two days using techniques previously described (Porter et al. 1979). Location data were obtained during both diurnal and nocturnal hours; timing of locations for each individual was varied systematically. Home ranges were delineated for 4 and 12 week intervals after hatching using modified minimum area procedures (Harvey and Barbour 1965). Habitat use was estimated for diurnal periods only and was quantified as the proportion of telemetric locations occurring in each habitat type.

Habitat cover-maps were prepared for the study area through photo interpretation of 1:20,000 scale aerial photographs and field reconnaissance. Two sets of features were mapped, terrain (classified as upland, bench, floodplain, ravine and slope) and vegetation (classified as open field, hardwood, conifer and mixed hardwood-conifer). Where field reconnaissance was done, specific habitat types were defined by species composition.

A general analysis of habitat-use patterns was conducted using data acquired throughout the 600 km study area. More specific analyses, designed to examine habitat selection, were employed for birds that used a 90 $km^2$ portion of the study area (Fig. 1). The cover map for this 90 $km^2$ area was gridded into 29 ha squares. This grid square size conformed to estimates of the weekly home range size of brood flocks. Five habitat features were measured within each grid square: 1) the percent of area composed by each of the terrain and vegetation classes, 2) the number of specific vegetation types, 3) the number of distinct habitat patches (defined by the combination of terrain and vegetation classes, 4) the diversity index, H', of the habitat types (Shannon and Weaver 1949), and 5) the presence of a spring, stream or pond. Estimates of the use of each grid square by brood flocks were derived from telemetry data. Only data for those birds whose entire summer range occurred within this 90 $km^2$ area were included in the analysis. Habitat selection was evaluated via multiple regression and chi-square analyses.

Post-nesting survival of mature females was estimated through daily monitoring of all radio-tagged females (Porter et al. 1979). Survival of poults through the summer months was estimated from visual counts of all broods encountered in 1977 and repeated counts of broods with radio-tagged females in 1978.

## RESULTS

Home range data were available for 10 females (3 southern and 7 northern) that successfully hatched young and were associated with different brood flocks throughout the summer. Movements of brood flocks during the summer season generally included approximately 250 ha. However, broods did not use this summer range uniformly. After a period of restricted movement during the first 4 weeks, brood flocks

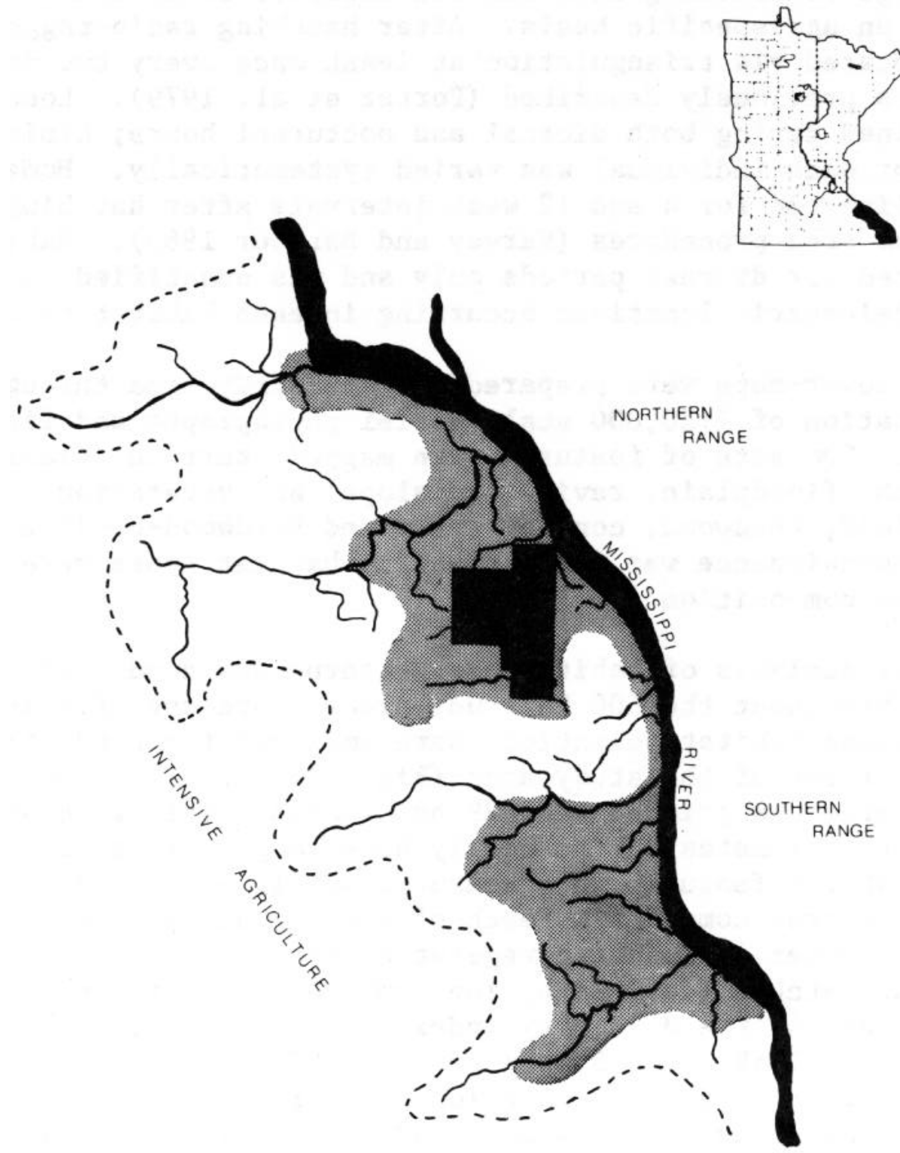


Fig.1. Potential turkey range (enclosed by the dashed line), northern and southern portions of occupied turkey ranges (shaded) and the 90 km$^2$ portion of study area (black) in southeastern Minnesota.

made intensive use of 10-30 ha areas with frequent shifts to other areas. This resulted in home ranges that were frequently disjunct and averaged 71.7 ± 11.3 ha ($\bar{x}$ ± SE, N = 9) and 67.5 ± 16.8 ha (N = 10) during the second and third 4 week intervals, respectively. Different portions of the home range of a brood were often 0.8-2.0 km apart. There were no differences in home range sizes for brood flocks in the northern and southern ranges (Table 1).

Habitat use data were available for 15 radio-tagged females and their broods (7 southern and 8 northern). The general analysis showed approximately 90% of the diurnal period was spent in two habitat classes: ravine-hardwood and upland-agriculture. Little use was made

Table 1. Home range sizes (ha) for turkey broods in southeastern Minnesota. Time intervals are weeks after hatching.

| Interval | N | $\bar{X}$ | SE |
|---|---|---|---|
| 1st 4 weeks | 9 | 34.0 | 5.0 |
| 2nd 4 weeks | 9 | 71.7 | 11.3 |
| 3rd 4 weeks | 10 | 67.5 | 16.8 |
| Season (12 weeks) | 8 | 250.7 | 25.5 |

of lowland areas and no use was observed for coniferous or mixed hardwood-coniferous habitat classes. Birds spent an average 45% of their time in agricultural habitat. Peak use of agricultural areas occurred during the seventh week after hatching (Fig. 2). Use of these types during the summer period did not differ significantly between the 2 ranges.

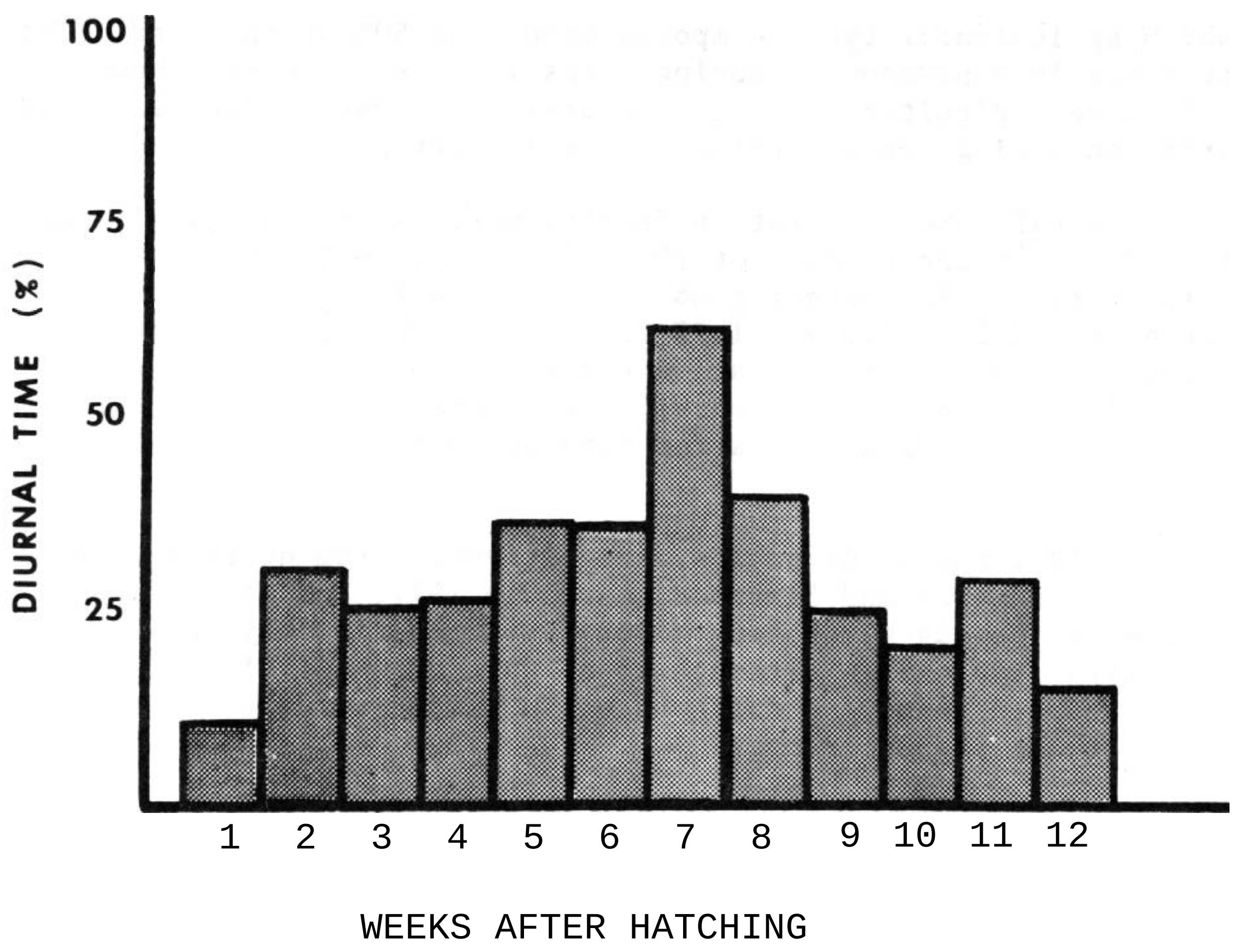


Fig. 2. Diurnal time (%) spent in agricultural habitats per week following hatching by broods in southeastern Minnesota.

Agricultural areas receiving the greatest amount of use were those composed of corn and alfalfa planted in alternating contour strips 10-20 m wide. Hardwood types were dominated by mesic species such as red oak, sugar maple (Acer saccharum) and basswood (Tilia americana), with relatively open understories composed of gooseberry and hazel.

The summer movements of 8 radio-tagged females and their broods were contained within the 90 $km^2$ portion of the study area. Broods showed use of 24% of the grid squares within this area. Most broods spent the entire 12 weeks following hatching in 4 or 5 grid squares. Three habitat characteristics were found to be important in accounting for the variability in the use observed among the grid squares. These were, in order of importance, the patchiness or number of habitat types, the diversity (a combination of the number of types and equitability of patch size), and the percent of the grid square composed of ravine habitat types ($p< 0.05$). Grid squares with 4, 5, or 6 habitat types accounted for more than 75% of the use. More than 60% of the use occurred in grid squares having a diversity index of 0.50-0.70. These observations contrasted sharply with those expected assuming random use of the grid squares, indicating a selection was occurring ($p < 0.05$). Selection was also shown for grid squares composed of 10-30% upland-agriculture and 70-90% ravine-hardwood classes ($p < 0.05$). During weeks 1-6 after hatching, brood flocks selected against grid squares in which agricultural types composed more than 50% of the area. This pattern was less pronounced during weeks 7-12 as the birds showed limited use of large agricultural areas. No preference was evident for grid squares containing ponds, springs or active streams.

Survival rates for mature females were estimated for 75 females monitored during the summers of 1975 (4 birds), 1977 (19 birds) and 1978 (52 birds). Post-nesting mortality rates for June, July and August averaged 5.3, 1.5 and 1.7% for each of the months, respectively. Modeling a hypothetical population through a set of monthly mortality rates yielded an over-summer survival estimate of 91.6%. No differences were evident in survival rates for females in the northern and southern ranges.

Survival rates for poults were estimated from nesting data of 11 radio-tagged females and 51 brood counts in 1977, and 14 radio-tagged females whose broods were observed at least once in July and again in August, 1978 (Table 2). Although these data showed differences in survival between years, no differences in summer survival rates were evident between the two ranges.

## DISCUSSION

The environment in southeastern Minnesota differs markedly from that thought to be typical for the eastern turkey. It lacks the extensive stands of contiguous forest with infrequent openings or the grassy understories considered important for brood raising (Mosby and Handley 1943, Martin and McGinnes 1975, Wanless 1976). However, a comparison of poult survival rates observed in Minnesota with those reported

Table 2. Hatching and survival rates for turkey poults in southeastern Minnesota. Units are poults/female.

| | 1977 | | | 1978 | | |
|---|---|---|---|---|---|---|
| | $\bar{X}$ | SE | N | $\bar{X}$ | SE | N |
| Hatching | 9.25 | 0.72 | 11 | 9.79 | 0.63 | 14 |
| July | 5.44 | 1.21 | 26 | 3.77 | 0.45 | 17 |
| August | 5.28 | 0.79 | 25 | 2.65 | 0.30 | 17 |

from other regions (Thomas 1955, Lewis 1976, 1977, Glidden 1977) suggests that the environment in this region is suitable for brood raising. The behavioral and demographic data allow identification of some of the environmental features that make this area suitable.

Habitat use data suggest that birds have substituted agricultural fields for woodland openings. Some use of agricultural habitats, especially pastures, has been observed in other regions (Lewis 1964, Ellis and Lewis 1967, Gusey and Maturgo 1973, Speake et al. 1975). However the use of these types, in terms of the amount of diurnal time spent in them, appears far greater in Minnesota. Hurst and Stringer (1975) and Healy and Nenno (1978) noted large protein components in the diet of poults and observed that protein intake was most rapid in open fields of native grasses, sedges and forbs. While no data are available regarding total protein content in agricultural areas in Minnesota, alfalfa fields probably constitute one of the richest sources of plant and animal protein. The seasonally heavy use of these fields by broods in Minnesota suggests that agriculture provides a very important feeding habitat in the region.

Agricultural habitats also appear well suited to brood raising because of their physical structure. Broods appear able to move through alfalfa of any height without difficulty. During the period of peak use of open areas by broods alfalfa regrowth (following the first harvest) reaches 20-30 cm. At this height, poults are completely concealed while hens are permitted unobstructed views of large areas, reducing the potential for loss due to predation. The value of these fields appears further enhanced when they are juxtaposed to corn. While corn is of little value for feeding, it provides cover suitable for rapid escape from either avian or mammalian predators.

Comparative analysis of data for broods in the northern and southern ranges provides further insight into the effects of farming activity. The moderate grazing of woodlands, prevalent in the southern range did not produce a measurable effect on movement, habitat use or poult survival. Similarly, early hay mowing and reduction of edge width and abundance as a result of farming did not show a detrimental impact on the broods. The data suggest that, at present levels of farming activity, these characteristics should not be considered as negative aspects when evaluating brood habitat. With respect to grazing, Dickson et al. (1978) reach a similar conclusion.

In assessing potential brood habitat in the upper Midwest, four characteristics appear important. First, and most basic, the area should be composed of both agricultural fields and hardwood forests. Second, areas should be primarily forested with 10-30% of the land in agriculture. Third, habitat types should be arranged in neither large contiguous blocks nor extensively broken patches. Rather the pattern should be one of moderate interspersion (approximately 17 patches/km$^2$) with relatively homogeneous patch sizes (patch size $s/\bar{x} < 1$). Finally, forests should contain mature red oak-white oak and maple-basswood types; agricultural fields should contain an interspersion of alfalfa and corn, preferably contour strips. The presence of a water source does not appear important.

These observations correspond closely with those reported from Missouri (Lewis 1957), Michigan (Lewis 1964) and Mississippi (Dickson et al. 1978). Missouri data showed the highest turkey densities occurred on areas of 70% woodland and wooded pasture, and 30% open pasture and cultivation. Michigan data indicate that areas composed of a minimum of 10% open field habitat were optimal for broods while Mississippi data suggest maximum poult production occurs in areas having 20-30% open field habitat. Broods in Michigan showed selective use of fields of 4-6 ha. Lewis (1964) also notes that broods in Tennessee prefer agricultural fields of small grain and clover instead of fields of natural vegetation.

The amount of land in a given area that must meet these habitat specifications for optimal poult production is difficult to determine. The 29 ha estimate of weekly brood home range appears reasonable and this grid square size may be appropriate for habitat evaluation. Squares meeting the recommended specifications need not be contiguous as movement data show broods can move extensively to locate preferred areas. Four or five 29 ha blocks of optimal habitat in a 10 km$^2$ area (1.8 km radius) appear to provide for the summer requirements of turkey broods.

The number and proximity of brood raising areas necessary to maintain a viable population is more difficult to estimate. Four such areas on the 90 km$^2$ study area produced 60-145 poults annually. This density of brood raising areas appears sufficient but is probably not necessary to maintain the population. Assuming an average population density of 2 turkeys/km$^2$ and an average annual survival rate for adults of 70%, 56 poults would have to be produced/township (93 km$^2$), annually. Thus, two or three brood-raising areas/township appear adequate. However higher densities of brood-raising areas are recommended for transplant sites to promote growth in the population during the first years, enhancing the probability of success of the transplant.

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# HABITAT UTILIZED BY WILD TURKEY BROODS WITHIN OAK-HICKORY FORESTS OF WEST VIRGINIA

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*Abstract:* Oak-hickory habitat utilized by 17 wild turkey *(Meleagris gallopavo silvestris)* broods was studied during a 5-year period. Majority of brood activity occurred under a forest overstory. Characteristics of forest overstory including cover type, basal area, size-density, average tree diameter, stand condition, site index, stand age along with aspect and slope were determined and tested for preferred use ($P \leq .10$), family C.I. Habitat preference was tested for entire brood period, early brood period (May-July 19) and late period (after July 19). Brood habitat appeared to be limited, and the area containing heavily used habitat was a minor portion of the home ranges. Broods preferred openings, white oak *(Quercus alba)* cover type, 9-18 $m^2$/ha (41-80 $ft^2$/acre) basal areas, medium stocked sawtimber stands, 0-30% sloping terrain, and northern aspects. White pine *(Pinus strobus),* chestnut oak *(Q. prinus),* and Virginia pine *(P. virginiana)* cover types, clearcuts, basal areas equal to or exceeding 23 $m^2$/ha (101 $ft^2$/acre), slopes exceeding 30%, sapling stands, and east to southeast aspects were avoided.

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Forest game biologists frequently must speak in generalities about wild turkey habitat. In many cases habitat elements are not described in terms that can be readily understood by foresters. This paper describes overstory conditions of forests utilized by wild turkey broods in oak-hickory forests during a 5-year period (1973-77). This information represents an initial step in refining habitat knowledge in West Virginia. Ultimately, our goal is to obtain information that will enable land managers to make precise turkey habitat recommendations when coordinating turkey and timber management practices.

We wish to thank all Wildlife Division personnel, private landowners in the area, and local U. S. Forest Service personnel who helped with the study. Assistance, support, and advice from Arlie White, Ralph Sharp, James Hill, Thomas Allen and Charles Waggy made the study possible, Bill Healy offered advice and rechecked some habitat conditions with imprinted turkeys. Lois Klatt and Walter Kordek spent many hours to assure accuracy of analyses. The study was partially financed by Federal Aid in Wildlife Restoration Project W-39-R.

## STUDY AREA

The study was centered on Middle Mountain located within the Monongahela National Forest in southeastern West Virginia. Middle Mountain has been described in detail by Gill et al. (1975). Elevations range between 600 and 1100 m. The area is primarily forested with small amounts of nonforested private land occurring along parts of the lower slopes. Timber types common on the driest sites of the study area are pitch pine *(Pinus rigida)* and Virginia pine while white pine, white pine-hemlock *(Tsuga canadensis),* hemlock in pure stands, and American beech *(Fagus grandifolia)-sugar* maple *(Acer saccharum)* occur on wet areas usually in close proximity to streams. Between the above two extremes occur the most common timber types which are white oak-red oak *(Q. rubra)-hickory (Carya* spp), white oak, chestnut oak, red oak, scarlet oak *(Q. coccinea),* and white pine-chestnut oak.

The wild turkey is classified as the featured game species for management on the study area by the U. S. Forest Service and West Virginia Department of Natural Resources. Middle Mountain is a popular turkey hunting area and supports a population of 11 turkeys per $km^2$ (Pack 1970).

## METHODS

A total of 55 hens were captured by use of cannon nets (Austin 1965) or by tribromoethanol (Williams et al. 1973). Trapping was conducted from January through April during 1973-1977. A radio transmitter operating in the 151 MHz range was attached to each hen. Twelve and 48 channel AVM receivers were used along with handheld two-element yagis and double yagi antennas with peak-null capability. Day and night tracking began in late April to locate nesting hens. Telemetered hens with broods were monitored at least one day per week, with locations fixed at 30 minute intervals from dawn to evening. Tracking continued each year until broods shifted from summer to fall range (usually during the first week of September). Three simultaneous bearings were taken by 3 personnel with receivers for each fix, and an attempt was made to maintain a distance of 400 m from the hen being tracked.

Fixes were plotted and home range shape determined by the modified minimum area method (Harvey and Barbour 1965). This method was selected because it eliminates large non-utilized areas. Within the home range boundary, all timber stands were sampled by line transects. Variables sampled were those used by the U. S. Forest Service on the Monongahela National Forest for timber inventory (U. S. Forest Service 1971). Basal area, size (sapling, poletimber, sawtimber)-density (percent stocking), average diameter (DBH), stand condition, site index, and stand age were collected. In addition, each stand was typed using Society of American Foresters (1973) cover types. Aspect was classified into nine categories, and average percent slope was determined.

Brood preference was determined by a method described by Neu et al. (1974). This method calculates a family of confidence intervals about the actual number of fixes in each category. The method permits the comparison of upper and lower confidence limits to the expected number of fixes (proportional area in each category). This is considered a conservative method of determining significance. Analysis was performed for the entire brood rearing period, for the first part of the brood period (May-July 19) and for the second part (after July 19). The reason the entire brood rearing period was divided in two parts was to detect changes in habitat use because of changes in food habits observed by Healy et al. (1975).

In this study preference is defined as significantly greater use of a category than the calculated expected value (outside the confidence interval) while avoidance is less than expected use. Also, home range refers only to the area occupied during the brood rearing period.

## RESULTS

Nineteen of 55 telemetered hens (35%) succeeded in producing broods. Seventeen of these 19 hens with broods were monitored to determine habitat preference. Ranges of these hens with broods were comprised of 6,631 ha determined by 2,171 plotted fixes. Habitat preference was determined for all 17 broods, but six broods were not monitored throughout the entire brood period. The average size of the home range of the 11 broods monitored throughout the brood rearing period was 455 ha.

Within a typical home range of the above 11 broods 33% of the area was typed white oak-red oak-hickory followed by chestnut oak (18%), white oak (15%), white pine (12%), and Virginia pine (6%). No other cover type occupied more than 5% of a home range. Majority of the above stands were poletimber (54%) followed by sawtimber (43%) and saplings (3%). Eighty-seven percent of the stands had a basal area greater than 18m$^2$/ha (80 ft$^2$/acre). Ninety percent of the stands were using all the available growing space (fully stocked). Where site index was determined, 95% of the timber stands had a red oak site index greater than 45. Three quarters of the stands were on slopes greater than 30% and faced southwest to northwest.

Chi-square analysis ($P \leq .10$), family C.I. showed the 17 broods preferred white oak, wildlife clearings, and pastures and avoided white pine, chestnut oak, Virginia pine and clearcut types (Table 1). The normal treatment applied on clearcut areas that were avoided consisted of removal of all merchantable timber. Residuals left after cutting were girdled. No prescribed burning or choppers were used for site preparation. On areas where treatment date was known, 2 to 6 growing seasons had passed when brood usage was measured.

Broods preferred areas having basal areas that ranged between 9-18 m$^2$/ha (41-80 ft$^2$/acre) and stands with a basal area equal to or exceeding 23 m$^2$/ha (101 ft$^2$/acre) were avoided (Table 2). Medium stocked

Table 1. Chi-square analysis of cover types utilized by 17 wild turkey broods.

| Cover Type | Actual Fixes | Expected Fixes | Confidence Intervals |
|---|---|---|---|
| Clearcuts | 31 | 67 | 14-46[a] |
| Pastureland and Wildlife Clearings | 70 | 26 | 48-92[a] |
| Red Pine *(Pinus resinosa)* | 4 | 3 | 0-9 |
| White Pine *(P. strobus)* | 127 | 164 | 47-157[a] |
| White Pine-Hemlock *(P. strobus-Tsuga canadensis)* | 26 | 18 | 12-40 |
| Hemlock *(T. canadensis)* | 23 | 20 | 10-36 |
| Scarlet Oak *(Quercus coccinea)* | 23 | 24 | 10-36 |
| Chestnut Oak *(Q. prinus)* | 270 | 338 | 228-312[a] |
| Pitch Pine *(P. rigida)* | 116 | 104 | 87-145 |
| White Pine-Chestnut Oak *(P. strobus-Q. prinus)* | 15 | 12 | 5-25 |
| White Oak-Red Oak-Hickory *(Q. alba-Q. rubra-Carya* spp.) | 775 | 798 | 714-836 |
| White Oak *(Q. alba)* | 556 | 418 | 501-611[a] |
| Northern Red Oak *(Q. rubra)* | 46 | 61 | 28-64 |
| Beech-Sugar Maple *(Fagus grandifolia-Acer saccharum)* | 5 | 4 | 0-11 |
| Virginia Pine *(P. Virginiana)* | 84 | 114 | 60-108[a] |

[a]Significant at ($P \leq .10$), family C.I.

Table 2. Chi-square analysis of basal area of forest stands utilized by 17 wild turkey broods.

| Basal Area $m^2$/ha | Basal Area $ft^2$/acre | Actual Fixes | Expected Fixes | Confidence Interval |
|---|---|---|---|---|
| 0 | 0 | 89 | 87 | 67-111 |
| 1-9 | 6-40 | 10 | 13 | 3-17 |
| 9-18 | 41-80 | 199 | 145 | 167-231[a] |
| 19-23 | 81-100 | 625 | 590 | 575-675 |
| $\geq$ 23 | $\geq$ 101 | 1248 | 1336 | 1194-1302[a] |

[a]Significant at ($P \leq .10$), family C.I.

Table 3. Chi-square analysis of timber size-density of forest stands utilized by 17 wild turkey broods.

| Size-Density | Actual Fixes | Expected Fixes | Confidence Interval |
|---|---|---|---|
| Non-stocked (openings) | 79 | 34 | 57-101[a] |
| Sapling (10-39% stocked) | 5 | 23 | 0-11[a] |
| Sapling (40-69% stocked) | 10 | 18 | 2-18 |
| Sapling (70+% stocked) | 27 | 43 | 14-40[a] |
| Poletimber (40-69% stocked) | 58 | 40 | 39-77 |
| Poletimber (70+% stocked) | 1221 | 1252 | 1162-1280 |
| Sawtimber (40-69% stocked) | 34 | 18 | 19-49[a] |
| Sawtimber (70+% stocked) | 737 | 743 | 681-793 |

[a]Significant at ($P \leq .10$) family C.I.

sawtimber (40-69% use of available growing space) and non-stocked (openings) were preferred, but sapling stands were generally avoided (Table 3).

Average stand diameter alone did not affect brood usage with no significant preference or avoidance detected ($P \leq .10$), family C.I. Turkey broods showed preference for slopes less than 30% and northern aspects; they avoided steep terrain and east to southeast aspects ($P \leq .10$), family C.I.

Eighty percent of the stands within the home ranges of the 17 broods would be classed by stand condition as immature and more than 5 years from rotation age. Only 14% of the timber stands within the home ranges were considered low quality, and less than 1% of the area was mature timber. Stand condition variables did not detect any preferred or avoided habitat condition that could not be detected by cover type information.

During the entire brood period, only areas where site indices and stand age were not determined (primarily private land) were frequented more than expected ($P \leq .10$), family C.I. When the entire brood rearing period was divided into two time periods, preference or avoidance varied (Tables 4 and 5). The scarlet oak and red oak types were added as avoided cover types during the early brood period. Preference for habitat with lower basal areas and avoidance of high basal area timber was evident. Although no significant use was detected by average stand diameter during the entire brood period, the early period showed significant use of 0 DBH areas. Timber stands exceeding 23 cm DBH were preferred and 13-20 cm DBH were avoided in the late period.

During both periods, broods avoided steep terrain, but a strong preference for areas of less than 15% slope was indicated during the early brood period.

Aspect results were similar to those observed during the entire brood period with north or northeast aspects preferred and southeast to southwest being avoided. Use during the late period indicated avoidance over a greater site index range, and the only incident of a known site index stand being preferred occurred during this period. Low site index stands in the range of 1-49 were preferred along with the unknown site index stands.

Both time periods showed a common avoidance of young timber falling within the 28-59 year range.

There was an indication that brood habitat was limited. Nine of 17 broods had overlapping home ranges. One area had five broods with overlapping home ranges. Another area had two broods with overlapping ranges, and on a third two more broods overlapped. Hens trapped throughout the study area gravitated to these preferred areas. In one incident, a hen moved her brood 8 km to an area utilized by four other broods. It is also important to note that the number of hectares of significantly used habitat variables were quite small. Except where site index and stand age data were not collected, significantly used habitat variables occurred on less than 20% of the combined home ranges (Table 6).

Table 4. Habitat preferred or avoided[a] by wild turkey broods during May-July 19.

| Class | Preferred | Avoided |
|---|---|---|
| Cover Type | Pasture and wildlife clearings<br>White Oak | Clearcuts<br>White pine<br>Scarlet Oak<br>Chestnut Oak<br>Red Oak |
| Basal Area | 0 $m^2$/ha | $\geq$ 23 $m^2$/ha<br>(101ft$^2$/acre) |
| Timber Size-Density | Non-stocked (openings) | Saplings (10-39% stocked) |
| DBH (cm) | 0 | |
| Slope (5) | 5-14 | $\geq$ 50 |
| Stand condition | Non-stocked (openings) | Immature |
| Aspect | North | Southeast |
| Site Index | No significant preference | $\geq$ 74 |
| Age (Yrs.) | No significant preference | 28-59 |

[a]Significant at (P $\leq$ .10) family C.I.

Table 5. Habitat preferred or avoided[a] by wild turkey broods after July 19.

| Class | Preferred | Avoided |
|---|---|---|
| Cover Type | Pasture and wildlife clearings | Clearcuts<br>White Pine |
| Basal Area | 9 $m^2$/ha (41-80 ft$^2$/acre) | |
| Timber Size-density | Non-stocked (openings) | Saplings (10-39% stocked) |
| DBH (cm) | $\geq$ 23 | 13-20 |
| Slope (%) | 5-29 | 30-50+ |
| Stand Condition | Non-stocked (openings) | Immature<br>Regenerated |
| Aspect | Northeast | Southwest |
| Site Index | Unknown-private land<br>1-49 | 50-59<br>$\geq$ 74 |
| Age (Yrs.) | Unknown-private land | 78-59 |

[a]Significant at (P $\leq$ .10), family C.I.

Table 6. Area and percent area of the combined brood ranges occupied by significantly used variables of 17 wild turkey broods

| Variable Class | Area (ha) | Percent Area |
|---|---|---|
| Pastures and Wildlife Clearings | 80 | 1 |
| White Oak | 1278 | 19 |
| Basal Area (9-18 $m^2$/ha or 41-80 $ft^2$/acre) | 441 | 7 |
| Non-stocked (openings) | 103 | 2 |
| Sawtimber (40-60% stocked) | 54 | 1 |
| Slope (0-14%) | 326 | 5 |
| Aspect (North) | 453 | 7 |
| Unknown Site Index | 2774 | 42 |
| Unknown Age | 2857 | 43 |

## DISCUSSION AND CONCLUSIONS

Recent studies have shown the importance of openings for turkeys (Ellis and Lewis 1967, Hillestad and Speake 1971, and Speake et al. 1975), but Williams et al. (1974) indicated that turkeys will tend to remain near forest cover anytime birds find preferred food. This study showed preferred usage of openings, but as Williams et al. (1974) observed in cypress woods, broods in our study spent more time in forested habitat. Our broods had larger home ranges than those in the above studies. Perhaps our broods had to range over more forested habitat to fulfill nutrition requirements because of lower insect populations as reported by Martin and McGinnes (1975).

The conifer types in this study were poorly utilized by turkey broods. No conifer type was preferred and two (white pine and Virginia pine) were avoided. Some conifer stands were devoid of any understory vegetation while others on poor sites contained thick woody understories. In addition, the white pine and hemlock types were common near streams and farmland which coincided with a major source of human disturbance.

The white oak-red oak-hickory cover type occupied the largest area of any type; however, no significant preference was observed for this type. The lack of significant utilization does not mean it is not important. Gill et al. (1975) had greater utilization of this timber type than any other when both summer and fall ranges were grouped. Since it is so abundant, it may be where habitat alteration could be performed to benefit brood range more than in any other type.

Zero basal area sites were not significantly preferred during the entire brood period, but it should be pointed out that this basal area class includes clearings and some clearcuts. A few clearcuts fell into the category because reproduction was not sufficient to permit basal area measurements.

The basal areas reported were measurements of all stems down to 2.54 cm. Foresters often ignore stems this small or only consider the stem basal area for featured species they wish to manage (Roach and Gingrich 1968). Therefore, if small stems are eliminated, basal area measurements would be lower than we report.

Average tree diameter did not stand out as an important variable during the entire brood period. However, when diameter is used with basal area to determine timber size-density a better picture of a stand results. Basal area data alone does not reveal whether trees are large or small. Also, acceptable basal area levels desired for timber management vary with average tree diameter.

The preference of gentle slopes by broods agrees with the findings of Covert and Michaels (1975) who studied seasonal habitat usage. Why this occurs is speculative, but on the study area better timber sites occur on gradual sloping and level terrain. The white oak cover type and clearings are more frequently located on gentle slopes. Another condition prevalent on lower slopes but not on steep terrain is an abundance of water. The availability of water could be a very important factor because many streams found on steep terrain near the main ridgetops are dry in the summer.

Stand condition is based on species, age, size, quality, and stocking of trees to be featured in management. The reason it may not have been an important characteristic is due to the variability caused by subjective judgment to determine quality of standing timber. Non-significant results may also be due to timber size variability and wide range of basal areas. For example, an immature stand would include both poletimber and sawtimber more than 5 years from rotation age that could range from 9 $m^2$/ha (40 $ft^2$/acre) to over 23 $m^2$/ha (101 $ft^2$/acre).

The overall preference for north facing aspects was expected because of the likelihood of more herbaceous vegetation. However, there appears to be some variability among broods with respect to aspect. Burkert (1978) studied five of these 17 broods and found significant use of south facing slopes.

Preference for unknown site indices and stand age data hampered evaluation because these data were not collected on private land. The majority of the private land was on lower slopes, and the results indicate preference for conditions on these lower slopes more than actual differences between the site index classes.

Pybus (1977) investigated the understory habitat of four of the 17 broods monitored during this study. He determined that broods showed an overall preference for forest understories high in herbaceous plant matter and avoidance of stands with heavy densities of woody vegetation. In consideration of his findings, it is evident that more than expected use of openings, white oak timber type, lower basal areas, medium stocked sawtimber, and gentle terrain depict conditions conducive to understory development. Conversely, less than expected use in white pine, Virginia pine, chestnut oak types, high basal areas, steep slopes, and regenerated timber stands depict situations of less understory or more woody vegetation.

When results are compared by time periods, some significant variables were similar to the entire brood period, but other variables showed significant use during a certain period. During the early period broods had a noticeable preference for conditions that appear to be more conducive to a herbaceous understory. The late period depicted similar preferences or non-preference of several of the same variables as the early period, but in addition, preferred use of lower site indices, steeper terrain and non-avoidance of poor site timber types was indicated. This description depicts stands on poorer sites with somewhat less herbaceous vegetation and more woody vegetation. Based on field observations, this reflects broods utilizing areas where huckleberries *(Gaylussacia* spp.), blueberries *(Vaccinium* spp.), and other soft mast become available in late summer. It may also reflect a general expansion of range into a greater variety of habitats.

Based on the amount of brood use in forested habitat and the abundance of forested areas in the Appalachian Region, forest habitat alteration to increase or maintain brood habitat should receive additional study. Speake et al. (1975) wrote of the desirability of including 12 to 25% of an area in well dispersed openings for broods. In some places it may not be possible to reach this optimum because of timber values and lack of wildlife funds. Changes in forest overstory may be accomplished by coordinating timber harvesting with wildlife management practices without a direct outlay of wildlife funds. Prescribed burning and thinning are two practices that should receive further investigation in the Appalachians. Hurst. (1978) produced brood habitat by prescribed burning in southern pine forests. Perhaps this practice could be expanded into other forest types. Partial overstory removal by thinning will encourage understory development. However, the correct manner to apply this treatment should be investigated because thinnings do not always result in a desirable herbaceous understory.

If habitat alteration cannot be performed, it would be important to protect the brood habitat in some areas. On our study area, maintaining the preferred conditions of pastureland and clearings, white oak timber type, and low basal area stands (9-18 $m^2$/ha or 40-80 $ft^2$/acre) on gentle slopes would be very important.

Examining wild turkey brood range by use of forest overstory information is an indirect examination of understory conditions; hence, it is not as precise. An exact evaluation of brood range on a specific site may sometimes require additional information on the forest understory. However, overstory data can minimize the amount of understory information necessary to evaluate brood range. Forest overstory data used by foresters was shown to be useful in our study, and this type of information is more readily available than understory data. Based on our results and experience, overstory data can serve as a valuable guide to indicate areas to search for preferred understory and as a guide to depict conditions unsuitable for herbaceous understories.

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# EFFECTS OF MOWING ON ARTHROPOD DENSITY AND BIOMASS AS RELATED TO WILD TURKEY BROOD HABITAT

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Abstract: Arthropod density and biomass were significantly higher ($P<0.01$) on unmowed subplots than on mowed subplots 2 weeks aftermowing. The differences had declined 3 weeks after mowing. By the fifth week arthropod density and biomass were slightly higher on a mowed subplot than on an unmowed subplot. Mean arthropod density and biomass were significantly higher ($P<0.05$) on an unmowed strip at the edge of a hayfield after mowing the entire field from the center, outward, than before mowing the field. To improve brood habitat for wild turkey poults (*Meleagris gallopavo silvestris*), hayfields should be mowed from the center, outward, and an unmowed strip should be left at the edge of the field.

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Wild turkey brood habitat can be permanent pastures or mowed fields near woodlands (Stoddard 1963, Speake et al. 1975). Hillestad and Speake (1970) reported that hens with broods used the edges of fields. Poults have a high protein demand and meet this requirement by consuming arthropods, mainly insects, in the first 2 weeks of their lives (Hurst and Stringer 1975). Insects are more abundant in fields and other clearings than in forests (Wheeler 1948, Stoddard 1963, Owen 1976, Stringer 1977, Hurst 1978). The objective of this study was to determine the effects of mowing on arthropods as they relate to brood habitat.

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## STUDY AREA

The study was conducted on Noxubee National Wildlife Refuge, Noxubee County, Mississippi. The refuge is 29 km south of Starkville and consists of 19,035 ha of which 324 ha are hayfields. The fields are harvested twice a year through cooperative agreements with local farmers and no cutting is allowed before 15 June or after 15 September.

The study site is a 12.2 ha hayfield. The field is flat, poorly drained, and remains waterlogged for long periods during the winter. Native grasses (*Andropogon* spp., *Panicum* spp., *Paspalum* spp., *Festuca* spp.), sedges and rushes (*Scleria* spp., *Carex* spp., *Juncus* spp.) and forbs (*Vicia* spp., *Solidago* spp., *Aster* spp., *Lespedeza* spp.) were the most prevalent plants. Wild turkeys inhabit the surrounding mixed pine-hardwood forest.

## METHODS

Seven plots, each divided into 2 subplots (10 x 80 m), were established at the edge of the hayfield and about 3 m from the forest. Each subplot was further divided into 4 subcells, 10 m wide and 20 m long. For each plot, 1 randomly chosen subplot was mowed by a rotary mower on 23 May 1975 and the hay was removed. The remainder of the field was not mowed.

On 27 June, 5 weeks after the initial mowing, the entire field was mowed, from the center, outward and the hay removed. The original study plots were not mowed. Both subplots of one plot were sampled by sweep-net before the entire field was mowed and then again after the field had been mowed.

Three methods were used to sample arthropod density and biomass. A sweep-net with 38 cm diameter and bag depth of 79 cm was used to take 75 strokes per subcell. The strokes were taken while walking at a fast pace and the bag was swept as close to ground level as possible and remained parallel to the ground during the stroke. Samples were taken when the vegetation was dry and from 4-6 pm. Contents of the sweep-net were transferred to large plastic bags, sprayed with carbon tetrachloride, and frozen.

A D-vac® vacuum insect net machine was the second sampling method (Dietrick 1961). The nozzle had a diameter of 16.5 cm and was held about 10.2 cm from the ground. The machine was carried across the sample area at a slow-walk pace. A sample consisted of 4 trips across each subcell for a total of 80 m. The nylon bag was removed and the contents were treated as above.

The third sampling method employed was the McCoy Insect Collector (McCoy and Lloyd 1975). This machine has a dual directional blower and vacuum system. The intake nozzle is 30 cm wide and 38 cm high and was kept as close to the ground as possible. The machine traveled at about 8 km/h and was too large to sample subcells. A sample consisted of 2 trips along each subplot or 320 m. The contents of the plastic mesh bag were handled as with the other sampling methods. The preserved arthropods were identified, counted, oven-dried at 80 °C for 7 hrs, and weighed.

When only 1 plot was sampled, i.e. 1 mowed subplot versus 1 unmowed subplot, the statistical procedure was to calculate the confidence limits of the mean, from the 4 subcells, of each subplot at the $P=0.05$ level (Steele and Torrie 1960). A one-way analysis of variance was used to test the mean arthropod numbers and weights on the 7 plots sampled by the McCoy Insect Collector.

## RESULTS

### Samples from Mowed Versus Unmowed Subplots

Mean arthropod number in a sweep-net sample on the mowed subplot was 349 compared to 654 on the unmowed subplot on plot number 2, 10 days after mowing. Arthropod weight was also much higher on the unmowed subplot, 1.05 g, compared to 0.40 g on the mowed subplot (Table 1). However, the means were not significantly different. Spiders (Arachnida), true bugs (Hemiptera), grasshoppers (Orthoptera), and beetles (Coleoptera) were more abundant on the unmowed subplot. However, leafhoppers (Homoptera) had a mean number of 206 (0.22 g) on the mowed subplot and a mean number of 232 (0.26 g) on the unmowed subplot.

In the D-vac® sample, mean number of arthropods on the mowed subplot was 457, weighing 0.23 g, and on the unmowed subplot the mean number was 578, weighing 0.23 g (Table 1). These means were not significantly dif-

Table 1. Mean number and weight (g) of arthropods on mowed (hay removed) and unmowed subplots at the edge of a hayfield, 1975.[a]

| Sample type | Date | Plot No. 1 | | | | Plot No. 2 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mowed | | Unmowed | | Mowed | | Unmowed | |
| | | Number | Weight | Number | Weight | Number | Weight | Number | Weight |
| Before mowing: | | | | | | | | | |
| sweep-net | 22 May | 806 | 1.27 | 786 | 1.50 | -- | -- | -- | -- |
| D-vac® | 23 May | 1,159 | 0.42 | 956 | 0.35 | -- | -- | -- | -- |
| After mowing: | | | | | | | | | |
| sweep-net | 2 Jun | -- | -- | -- | -- | 349 | 0.40 | 654 | 1.05 |
| D-vac® | 2 Jun | -- | -- | -- | -- | 457 | 0.23 | 578 | 0.23 |
| McCoy insect collector | 6 Jun | 1,260 | 0.88 | 2,273 | 2.73 | 1,238 | 1.39 | 2,141 | 3.05 |
| sweep-net | 13 Jun | 654 | 0.83 | 677 | 1.23 | -- | -- | -- | -- |
| D-vac® | 13 Jun | 797 | 0.30 | 1,087 | 0.34 | -- | -- | -- | -- |
| sweep-net | 27 Jun | 411 | 0.98 | 354 | 0.95 | -- | -- | -- | -- |

[a] Subplots were mowed on 23 May.

ferent (P>O.O5). Spiders, true bugs, flies (Diptera) and small wasps (Hymenoptera), grasshoppers, and beetles were more abundant on the unmowed subplot. Leafhoppers had a higher mean number (182) and weight (0.14 g) on the mowed subplot than the unmowed subplot, with a mean number of 126 weighing 0.08 g. The D-vac® machine always obtained more, smaller arthropods than the sweep-net method (Hurst 1972).

Two weeks after mowing, arthropod number and weight were significantly higher (P<0.01) on the 7 unmowed subplots than on the 7 mowed subplots (Table 2). All arthropod types, except flies and leafhoppers, were more abundant on the unmowed subplots than the mowed subplots. Snails (Gastropoda) had a mean number of 13 on unmowed subplots and only 1 on the mowed subplots.

No significant difference (P>O.O5) in the pretreatment sweep-net and D-vac® samples was found for arthropod number or weight on plot number 1. Two weeks after mowing, the mean arthropod number in the McCoy Insect Collector on the unmowed plot was 2,273 compared to only 1,260 for the mowed subplot. Arthropod weight was also much higher, 2.73 g on the unmowed subplot to 0.88 g on the mowed subplot. Three weeks after mowing, the mean number of arthropods collected by the sweep-net was about the same on the unmowed subplot (677) as on the mowed subplot (654). Mean dry weight was higher, no significant difference (P>O.O5), on the unmowed subplot (1.23 g) than on the mowed subplot (0.83 g). Spiders and true bugs accounted for the weight differences between the subplots. There were more leafhoppers on the mowed subplot (387) than on the unmowed subplot (248).

In the D-vac® sample the mean arthropod number was higher on the unmowed subplot, 1,087, compared to 797 on the mowed subplot, but the mean weights were the same, 0.03 g. Spiders and true bugs again accounted for the differences between the subplots. Leafhopper mean numbers were nearly identical, 261 on the mowed subplot and 262 on the unmowed subplot.

A sweep-net sample on plot number 1, 5 weeks after mowing, resulted in a mean arthropod number of 411 (0.99 g) on the mowed subplot and slightly less, 354 (0.96 g) on the unmowed subplot. Flies and leafhoppers were more numerous on the mowed subplot than the unmowed subplot. A total of 88 tree crickets (Oecanthus sp.) was caught on the mowed subplot and only 1 was caught on the unmowed subplot. However, true bugs and spiders were still more numerous on the unmowed subplot.

### Samples Taken Before and After Mowing Entire Hayfield

Mean number and dry weight of arthropods were significantly higher (P<0.05) on the 2 uncut subplots at the edge of the field after mowing the entire field than before cutting the entire field (Table 3). The average number and weight of all types of arthropods increased on all 8 subcells. The average number of arthropods increased 42% and dry weight increased 24%.

## DISCUSSION

Arthropods were more abundant on unmowed subplots than on mowed subplots 2 weeks after mowing. Mowing eliminates food and cover thus creating unfavorable conditions for arthropods. Since the subplots were small, most arthropods probably moved to unmowed parts of the hayfield (van den Bosh & Stern 1969).

Table 2. Number and dry-weight of arthropods on mowed versus unmowed subplots 2 weeks after mowing.[a]

| Plot number | | Number | | Weight (g) | |
|---|---|---|---|---|---|
| | | mowed | unmowed | mowed | unmowed |
| 1 | | 1,260 | 2,273 | 0.88 | 2.73 |
| 2 | | 1,515 | 3,445 | 1.51 | 2.68 |
| 3 | | 1,369 | 2,570 | 1.45 | 3.97 |
| 4 | | 829 | 1,539 | 0.89 | 1.99 |
| 5 | | 852 | 2,121 | 1.42 | 2.03 |
| 6 | | 1,039 | 1,805 | 1.06 | 1.94 |
| 7 | | 1,238 | 2,141 | 1.39 | 3.05 |
| | mean | 1,157 | 2,270** | 1.23 | 2.63** |

[a] Sampled by the McCoy Insect Collector machine, 6 June 1975.

** Highly significant difference, P<0.01.

Table 3. Arthropod number and dry-weight (g) on an uncut strip at the edge of a hayfield before and after mowing the entire field, June, 1975.

| Subplot and Subcell Number | Before Mowing | | After Mowing | |
|---|---|---|---|---|
| | Number | Weight | Number | Weight |
| subplot 1[a] | | | | |
| subcell 1 | 443 | 0.86 | 734 | 1.30 |
| subcell 2 | 245 | 1.18 | 691 | 1.38 |
| subcell 3 | 457 | 1.20 | 895 | 1.54 |
| subcell 4 | 500 | 0.68 | 596 | 0.92 |
| subplot 2 | | | | |
| subcell 1 | 395 | 1.13 | 574 | 1.29 |
| subcell 2 | 421 | 1.24 | 648 | 1.28 |
| subcell 3 | 283 | 0.64 | 590 | 1.10 |
| subcell 4 | 315 | 0.79 | 552 | 1.35 |
| Total | 3,059 | 7.77 | 5,280 | 10.17 |
| Average | 382 | 0.97 | 660** | 1.27** |

[a] This subplot had been mowed previously, on May 23, and vegetation had re-grown. Subplot 2 had not been mowed.

** Significantly different ($P<0.05$).

Abundant rainfall and warm temperatures promoted rapid vegetative growth on mowed subplots providing an abundance of food for herbivorous insects. Leafhoppers, well adapted to exploit cut grasslands (Morris 1970)) were the first to repopulate mowed subplots.

The large difference in arthropod density and biomass found 2 weeks after mowing had diminished 3 weeks after mowing. Bulan and Barrett (1971) reported that the effects of mowing on arthropod density and biomass were brief, lasting about 2 weeks, when a monoculture oats field was mowed in Ohio.

Five weeks after mowing, total arthropod density and biomass were slightly higher on the mowed subplot than on the unmowed subplot. Spiders and true bugs continued to be more numerous on the unmowed subplot, but the other insect types were more numerous on the mowed subplot.

Hens with poults less than 2-weeks-old will probably not use mowed fields because of the lack of protective cover. Hillestad and Speake (1970) found that during the first week after hatching, hens and broods spent most of the day in or along the edges of fields. Williams et al. (1973) observed that poults 2- or 3-weeks-old did not venture more than a few yards from concealing ground vegetation and overstory cover. Therefore, the area to manage for very young poults is the edge of the field/forest.

The first hay-cutting or pasture-clipping takes place in eastcentral Mississippi in late May to early June, which is the peak of the wild turkey hatch period. Results from this study suggest that to benefit turkeys an unmowed strip, at least 5 m wide, should be left at the edge of the fields, particularly where there is turkey nest habitat (forest). The field should be mowed from the center, outward, to increase arthropod abundance, even if only temporarily, in the unmowed strip. To prevent hardwood encroachment into the field, half of the unmowed strip should be mowed or burned annually (Hurst 1972). An ecotone, between the field and forest, should be developed (Hillestad and Speake 1970, Williams et al. 1973). Late winter fire could be used on a 2- or 3-year rotation to maintain an open, park-like area next to the field (Hurst 1978).

The combination of forest, forest/field ecotone or savanna-like area, unmowed strip, and mowed field should provide excellent brood habitat for wild turkeys. The ecatone would provide nest habitat and brood habitat for newly hatched poults, thus eliminating the risk of moving broods great distances (Speake et al. 1975).

Hens with poults less than 2-weeks-old could use the ecotone and unmowed strip, which would provide food and concealing cover. As the poults mature they could feed on the mowed field, which would be a "preferred insect catching ground" (Stoddard 1963). Hillestad and Speake (1970) reported that poults 2-6-weeks-old used fields much more after mowing than before mowing.

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# A COMPUTERIZED WILD TURKEY HABITAT EVALUATION SYSTEM

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Abstract: An economical, user-oriented computer system for delineating areas of differing habitat suitability for wild turkeys (*Meleagris gallopavo*) is presented. A linear additive model is used to add computer maps of seven key habitat criteria. Output is a 30.5 x 38.1 cm line printer map consisting of 10 symbols, each representing a habitat suitability category. Users must have access to a keypunch, batch processing terminal, and line printer.

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Habitat evaluation may be defined as the process of (1) analyzing a habitat, (2) determining the importance of various habitat characteristics with respect to meeting the life requirements of the species under study and (3) merging information obtained in (1) and (2) in order to generate information useful in the decision-making process of wildlife management. Once habitat analysis data are available from field observations and/or by using remote sensing techniques, habitat suitability may be determined. This step requires an appropriate evaluation algorithm and the transformation of analysis data into useful information.

Digital computers are suited for processing large amounts of such data. Since accessibility to computers is increasing rapidly, it is likely that computers will play an increasingly important role in wildlife habitat evaluations and inventories. The unique feature of our technique is not that we used a computer for data processing, but that the final output was in an easily comprehended form, a computer-produced map of habitat suitability.

Computer mapping systems are divided into two general categories based on the manner of map production. The first type produces maps on a flatbed plotter, and some systems, such as COMLUP (Allen 1973), can produce maps comparable to conventionally drafted maps. The second type of mapping system, such as Harvard GRID (Sinton and Steinitz 1971) and SYMAP (Dougenik and Sheenan 1975), utilize line printers to produce maps. Such maps are composed of character strikes, each corresponding to a uniform cell unit on the original base map.

Excellent resolution is possible with plotter produced maps. Unfortunately, such systems characteristically require more programming and special processing equipment than line printer systems. To avoid the expense of additional equipment and to insure compatibility with existing equipment at computing centers of potential users, our system requires only a line printer (or hardcopy terminal for producing maps and a card reader for data input.

## METHODS

The study area was located on Peters Mountain in the James River District of the George Washington National Forest, Alleghany County, Virginia. The area was representative of the Appalachian region and comprised approximately 1,925 ha (4,760 ac) of mountainous terrain. The white oak-red oak-hickory (*Quercus alba* L., *Q. rubra* L., *Carya* spp.) cover type was typical of the forest stands at the lower elevations (549-610 m, 1800-2000 ft), while chestnut oak (*Q. prinus* L.) bear oak (*Q. ilicifolia* Wang.) and pitch pine (*Pinus rigida* Miller) were common on the drier sites and at higher elevations (762-914 m, 2500-3000 ft). Vegetative and topographic data in the form of maps and reports for the study area were supplied by the Harrisonburg Office of the United States Forest Service.

The initial step was to develop a habitat evaluation algorithm. A modification of the methodology developed by Whelan et al. (1979) was used, resulting in a generalized method entailing seven criteria. Each criterion represented a habitat factor affecting wild turkey habitat suitability. The criteria chosen were mast availability, mast species diversity, competition for food from other wildlife species, proximity to permanent water, degree of forest contiguity, proximity to forest openings, and proximity to roost sites.

Each habitat factor was assigned a relative importance value indicating its degree of influence in affecting habitat suitability. These values were assigned on a scale from 0 (minimal influence) to 9 (maximal influence). Next, intensity levels within each factor were categorized into 10 strata ranging in value from 0 (weakest intensity) to 9 (most intense). Habitat factors with their relative intensity levels and appropriate relative importance values are provided in Appendix I.

The algorithm was a linear additive model. A qualitative measure of habitat suitability for any specific location (cell) in the study area was calculated using the following formula:

$$V_j = \sum_{i=1}^{n} b_i x_{ij} \qquad (1)$$

where $V_j$ = habitat value of jth location (cell)

$b_i$ = relative importance of ith habitat factor

$x_{ij}$ = relative intensity of ith habitat factor at jth location

$i = 1, 2, \ldots n$

$j = 1, 2, \ldots m$

m = number of locations

n = number of habitat factors

Individual maps, representing the area1 extent of each factor, were input into a FORTRAN program in the form of a 120 row by 120 column numerical matrix. Each cell represented the relative intensity value of a given habitat factor within that cell.

The coding process was expedited by using a Numonics Model 237 Graphics Calculator/digitizer (Numonics Corp., Landsdale, Pennsylvania) and a Tektronix 4051 minicomputer (Tektronix, Inc., Beaverton, Oregon) to electronically record factor maps. An auxiliary program (Federation of Rocky Mountain States 1977) was used to convert the digitized data into the required cellular format and to produce punched cards containing map data. For users not having this special equipment, factor maps may be coded manually by overlaying a 120 x 120 unit transparent grid sheet on the study area map and recording the values for each cell. These data then may be placed onto 80 column punch cards.

After all factor maps were coded, the mapping program was used to produce a final map of habitat suitability. Habitat suitability values were calculated by summing the weighted values for each cell over the seven factor matrices (Equation 1). That is, individual factor maps were weighted by appropriate scalar ($b_i$), and then added on a cell by cell basis to produce a matrix of summed values [v].

The values in the resulting matrix (map) were scaled into a maximum of 10 categories and a subroutine was used to assign all values into a scale category prior to map generation. In the composite map, values were translated into contrasting symbols to enhance visual discrimination between habitat suitability categories. Areas designated by the same printer symbol represented an area within a particular range of habitat suitability. More suitable areas were denoted by darker symbols, and a summary of the total cell count within each category was supplied with each map.

## RESULTS

An example of a habitat factor map is shown as Fig. 1. Since these maps were only presentations of input data, cell values were displayed as the appropriate integer values and not as symbols. While contrast was not a prime consideration in the production of factor maps, we found little difficulty in distinguishing major inter-factor intensity areas. The final habitat suitability map for turkey is presented as Fig. 2. It was readily apparent from this map that the most suitable turkey habitat was in the south central portion of the study area. Those areas designated by the "0" symbol, representing the most suitable habitat, comprised 18.95% of the study area. The next two most suitable categories, represented by the "/" and "+" symbols, respectively comprised 49.71% and 21.92% of the study area. Categories of lesser suitability constituted the remaining 9.42%, indicating the overall suitability of the area for turkey habitat was above average. For either map type the original output map was 30.48 cm (12 in) wide and 38.1 cm (15 in) long and a printed character represented approximately .42ha (1.05 ac).

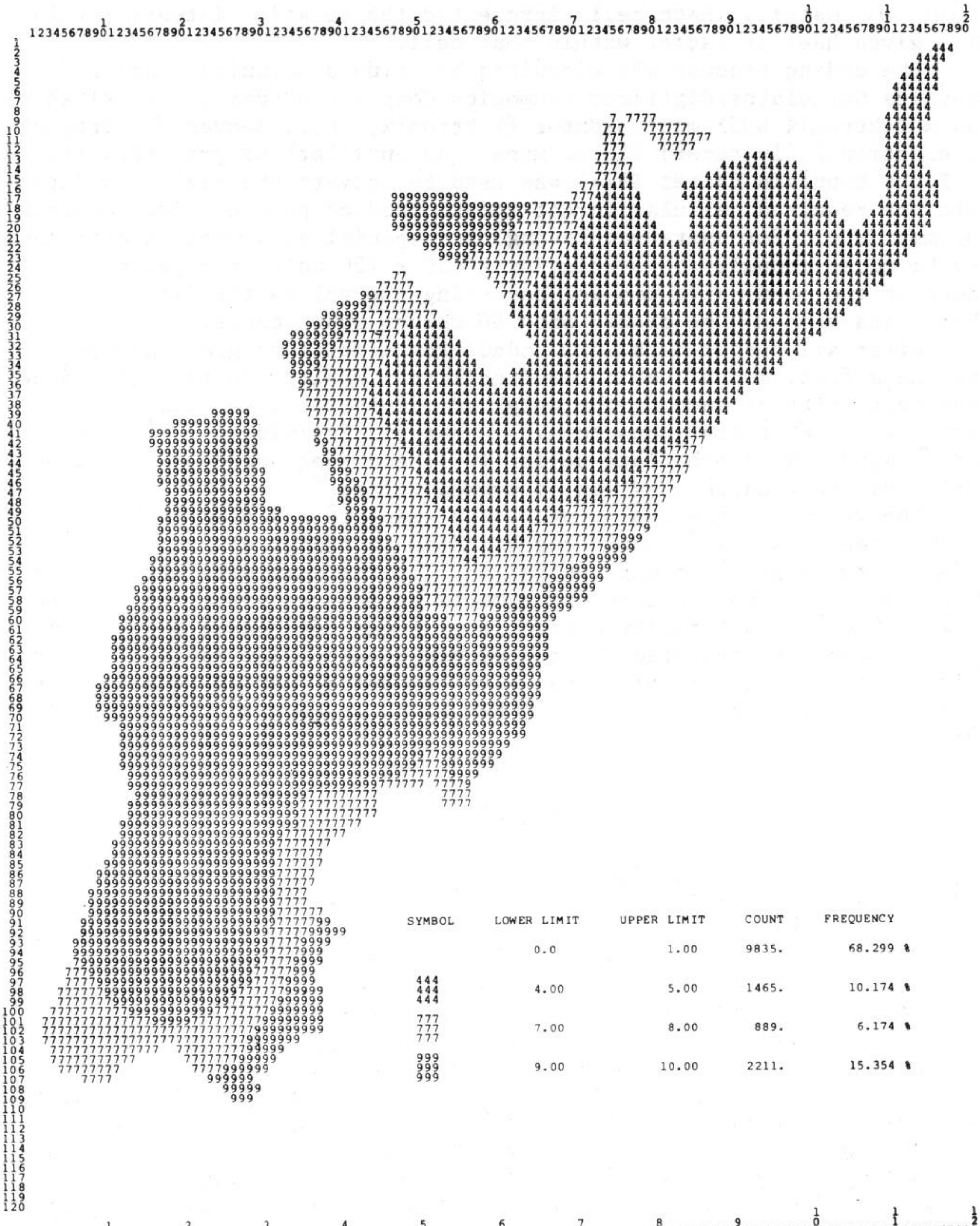
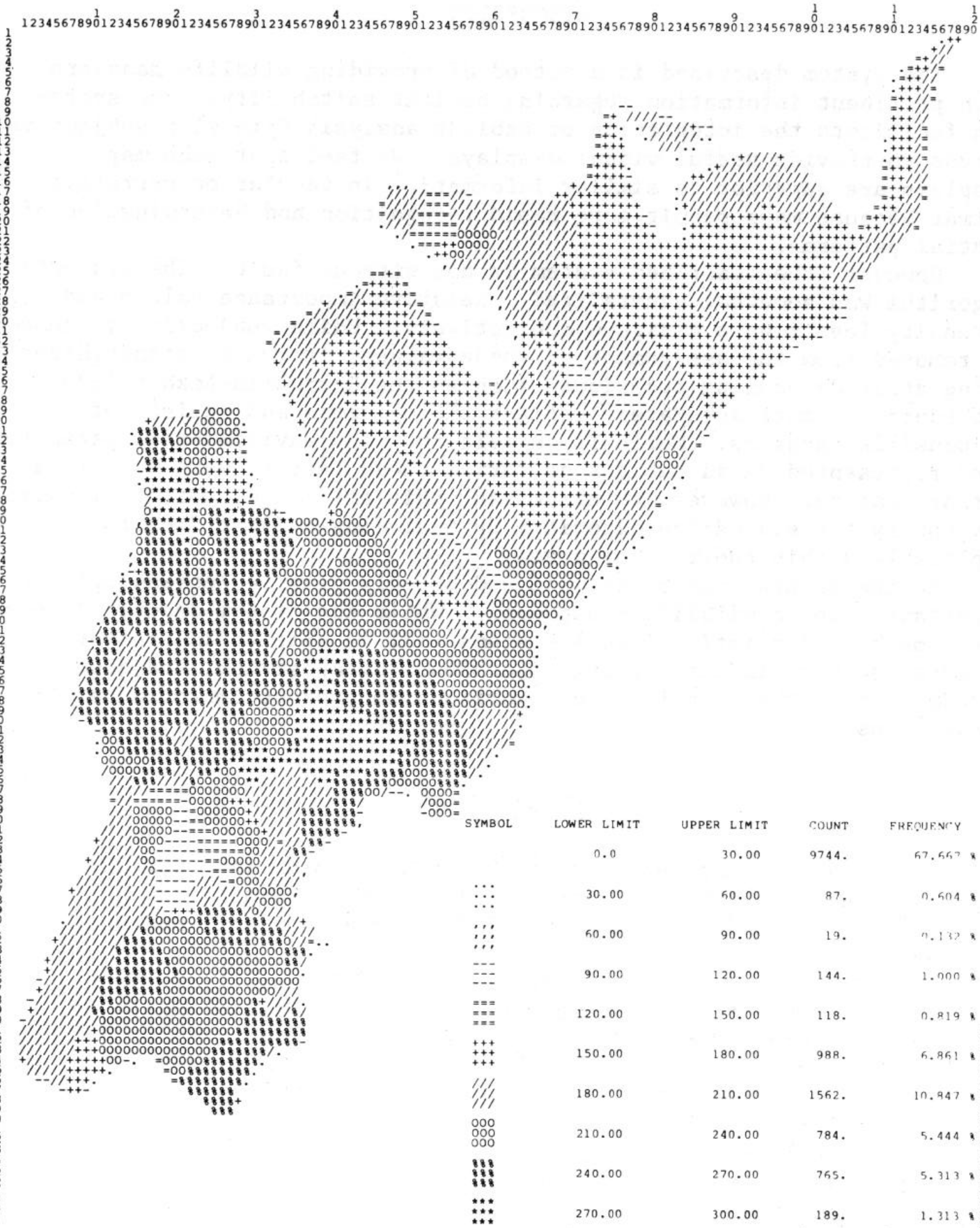



Fig. 1. Habitat factor map showing proximity to permanent water.



| SYMBOL | LOWER LIMIT | UPPER LIMIT | COUNT | FREQUENCY |
|---|---|---|---|---|
| | 0.0 | 30.00 | 9744. | 67.667 % |
| ... | 30.00 | 60.00 | 87. | 0.604 % |
| ,,, | 60.00 | 90.00 | 19. | 0.132 % |
| --- | 90.00 | 120.00 | 144. | 1.000 % |
| === | 120.00 | 150.00 | 118. | 0.819 % |
| +++ | 150.00 | 180.00 | 988. | 6.861 % |
| /// | 180.00 | 210.00 | 1562. | 10.847 % |
| 000 | 210.00 | 240.00 | 784. | 5.444 % |
| %%% | 240.00 | 270.00 | 765. | 5.313 % |
| *** | 270.00 | 300.00 | 189. | 1.313 % |

Fig. 2. Habitat suitability map

## DISCUSSION

The system described is a method of providing wildlife managers with pertinent information regarding habitat suitability. The system can facilitate the integration of habitat analysis data with subjective values to provide useful visual displays. We feel that such map displays are superior to similar information in tabular or narrative format because maps permit more rapid recognition and determination of spatial patterns.

However, the described system is not without fault. The evaluation algorithm was somewhat generalized. Relative importance values and intensity levels were assigned subjectively. While subjectivity cannot be removed from the assignment of these values, it can be standardized using attitude scaling techniques such as the Churchman-Ackoff (1954) procedure, to more accurately reflect the opinions and beliefs of responsible managers. While it is felt that the environmental parameters used represented valid habitat criteria, these factors were used in a cursory nature. However, to circumvent this criticism, potential users may modify the evaluation algorithm by including habitat factors applicable within their local areas.

In the future, computers will undoubtedly play an increasingly important role in wildlife management. While the system described here was somewhat simplistic, future systems will be able to incorporate measures such as indices of interspersion, juxtaposition, and edge abundance into their evaluation algorithms to produce improved habitat evaluations.

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Appendix I. Importance values and intensity levels for seven criteria used to evaluate habitat suitability for wild turkey.

| Habitat Factor | Relative Intensity Value | Relative Importance Value |
|---|---|---|
| 1. Mast species diversity | | 6 |
| a) 1 mast spp. per stand | 0 | |
| b) 2-3 mast spp. per stand | 3 | |
| c) 4-5 mast spp. per stand | 7 | |
| d) over 5 mast spp. per stand | 9 | |
| 2. Proximity to permanent water | | 5 |
| a) over 1.50 miles | 0 | |
| b) .75-1.50 miles | 4 | |
| c) .50-.75 miles | 7 | |
| d) within .5 miles | 9 | |
| 3. Proximity to forest openings | | 8 |
| a) over .5 miles | 0 | |
| b) within .5 miles | 6 | |
| 4. Mast availability | | 9 |
| a) 0-9 lbs/ac. | 0 | |
| b) 10-19 lbs/ac. | 1 | |
| c) 20-29 lbs/ac. | 4 | |
| d) 30-39 lbs/ac. | 5 | |
| e) 40-50 lbs/ac. | 7 | |
| f) over 50 lbs/ac. | 9 | |
| 5. Competition | | 5 |
| a) heavy | 0 | |
| b) moderate | 3 | |
| c) light | 7 | |
| d) none apparent | 9 | |
| 6. Forest contiguity | | 3 |
| a) 0-4999 ac. block | 0 | |
| b) 5000-9999 ac. block | 4 | |
| c) 10000-25000 ac. block | 6 | |
| d) over 25000 ac.block | 8 | |
| 7. Proximity to roost sites | | 3 |
| a) pine stand over .5 mi | 0 | |
| b) pine stand .25-.5 mi | 4 | |
| c) pine stand within .25 mi | 9 | |

# HABITAT PREFERENCES OF EASTERN WILD TURKEYS ON AN AREA INTENSIVELY MANAGED FOR PINE IN ALABAMA

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Abstract: Habitat preferences of the eastern wild turkey (*Meleagris gallopavo silvestris*) were studied from 1973 through 1976 on a 4,900-ha area managed intensively for pine timber. The study area, located in Choctaw and Sumter counties, Alabama, was composed of 57% pine plantations, 22% natural pine, 7% natural hardwood, 9% natural pine-hardwood and 4% natural hardwood-pine vegetation types. Pine plantations ranged from l/2 to 12 years old. Data from 32 radio-instrumented wild turkeys indicated a preference for natural timber stands in the greater than 21 year age classes. Thirty-five percent of the observations in the spring months occurred in pine plantations. Pine plantations were used least during the winter period. Observations in the natural pine stands ranged from 34% to 56% for all seasons. Observations in the natural pine-hardwood stands varied from 17% to 37%. The hardwood stands were used most in the winter period (28%) and least during the summer (4%). The 565 sight observations of wild turkeys recorded on the 26 km of roads on the study area (52 km of habitat frontage) showed 27% were associated with the pine plantation × pine plantation type, 21.2% in natural pine-hardwood × natural pine-hardwood, and 14.3% in the pine plantation × natural pine. During the study period, wild turkeys preferred natural habitat types 21 years and older. Pine plantations were used but not in proportion to the available habitat. The habitat composition necessary to maintain a population of eastern wild turkeys under the conditions of this study remains to be determined.

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Markley (1967) attributed the low eastern wild turkey (*Meleagris gallopavo silvestris*) population in the southeast during the early 1930's to habitat disturbances such as agricultural clearing, logging, burning, and other land management practices associated with human settlement. The reduction of wild turkey populations has been primarily

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attributed to habitat destruction (Bailey et al. 1951, Holbrook 1973, Hollis 1950).

Many biologists believe that hard times are ahead for the wild turkey. Markley (1967) stated forest management practices such as intensive logging have in the past and will in the future continue to adversely influence wild turkey numbers more than any other limiting factor. Schaffer and Gwynn (1967) suggested large-scale timber conversions and short-rotation pine forest management could have disastrous effects on wild turkey numbers in the Coastal Plain of South Carolina. Davis (1976) reported in Alabama, fair and good turkey range is being converted into marginal and sub-marginal wild turkey habitat at an alarming rate through the forestry practice of converting areas into large even-aged pine plantations. Mosby (1975) attributed the decline in wild turkey populations in long-established habitats in Alabama to industrial forestry practices that favored a pine monoculture.

The objective of this study was to determine the habitat preference by wild turkeys in an area under intensive pine management. Financial support was provided by the Rob and Bessie Welder Wildlife Foundation, the National Rifle Association of America and the Auburn University Agricultural Experiment Station.

## THE STUDY AREA

The 4,900-ha study area is located in the Clay Hills Region of the Coastal Plain Physiographic Province in south Sumter and north Choctaw counties, Alabama. The clay soils of the area are best suited for forest use. The topography is rolling to hilly with elevations ranging from 21 to 106 meters mean sea level (Swenson et al. 1941). Since the turn of the century, timber has been harvested by the single-tree selection method until 1964 when clear-cutting began.

Forest cover-types of the study area were 57% pine (*Pinus taeda* and *P. echinata*) plantation, 22% natural pine, 7% natural hardwood, 9% natural pine-hardwood (51-79% basal area in pine) and 4% natural hardwood-pine (51-79% basal area in hardwood). The ages of the pine, pine-hardwood, hardwood-pine and hardwood were 21 years and older. Ages of pine plantations ranged from l/2 to 12 years. Plant species composing the various habitat types found on the study area have been described by Kennamer et al. (1980).

## METHODS

Thirty-two wild turkeys were trapped from 1973 through 1976 using alpha-chloralose (Williams 1966) or with a rocket net (Austin 1965). All turkeys were fitted with patagial wing tags and radio transmitters. All birds were released at their respective capture sites.

Telemetry locations were determined by triangulation with azimuths taken from three to five fixed positions (Cochran and Lord 1963). Telemetry observations were later plotted on aerial photographs.

A modified habitat preference index (MPI) was calculated using the telemetry locations (Wenstrom 1973). The MPI was determined by dividing the percentage of each cover-type within the study area into the percentage of telemetry locations taken within that particular cover-type times the number of radio-marked turkeys using that cover-type divided by the total number of radio-marked turkeys.

The locations of all wild turkeys observed along 26 km of roads through the study area were recorded on aerial photographs.

## RESULTS AND DISCUSSION

The 1,027 observations of the 32 radio-marked wild turkeys showed a preference for the natural pine (22% of the area) and natural pine-hardwood (9% of the area) habitat types (Table 1). Modified habitat preference indices (MPI) for these types were above 1.0 for all four seasons of the year. Pine plantations (57% of the study area) were used primarily in spring during which time they showed an MPI value of 0.47. The least number of observations (9%) were recorded in pine plantations during the winter. The highest recorded use of the natural hardwood type (7% of the area) was during the winter (28%).

The 565 observations of wild turkeys along the 26 km of roads in the study area showed 27% occurred in the pine plantation × pine plantation type which was found on 63.3% of the roads (Table 2). In comparison, pine-hardwood × pine-hardwood type had 21.2% of the observations but only occurred on 5.3% of the road system.

These data indicate pine plantations were used by turkeys but not in proportion to the available habitat. The habitat composition necessary to maintain a population of eastern wild turkeys under the conditions of this study remain to be determined.

Table 1. Modified habitat preference index (MPI)[a] for 32 radio-marked eastern wild turkeys, Choctaw and Sumter counties, Alabama, 1973-76.

| Habitat type | Area % | Season | Turkeys observed No. | Turkeys observed % | MPI |
|---|---|---|---|---|---|
| Pine plantation | 57 | Winter[b] | 5 | 9 | 0.02 |
| | | Spring[c] | 156 | 35 | 0.47 |
| | | Summer | 42 | 14 | 0.15 |
| | | Fall[e] | 25 | 11 | 0.10 |
| Pine | 22 | Winter | 23 | 43 | 1.77 |
| | | Spring | 152 | 34 | 1.33 |
| | | Summer | 172 | 56 | 2.31 |
| | | Fall | 89 | 39 | 1.55 |
| Pine-hardwood | 9 | Winter | 10 | 19 | 1.68 |
| | | Spring | 74 | 17 | 1.33 |
| | | Summer | 66 | 22 | 1.69 |
| | | Fall | 84 | 37 | 3.59 |
| Hardwood | 7 | Winter | 15 | 28 | 1.21 |
| | | Spring | 48 | 11 | 0.94 |
| | | Summer | 13 | 4 | 0.20 |
| | | Fall | 20 | 9 | 0.47 |
| Hardwood-pine | 4 | Winter | 0 | 0 | 0 |
| | | Spring | 12 | 3 | 0.13 |
| | | Summer | 11 | 4 | 0.45 |
| | | Fall | 10 | 4 | 0.28 |

[a] $MPI = \frac{\text{\% locations in a cover-type}}{\text{\% of cover-type in the study area}} \times \frac{\text{no. of radio-marked turkeys in a cover-type}}{\text{total no. of radio-marked turkeys}}$

[b] Winter = December, January, and February
[c] Spring = March, April, and May
[d] Summer = June, July, and August
[e] Fall = September, October, and November

Table 2. Number of eastern wild turkeys observed along 26 km of roads with each habitat type combination, Choctaw and Sumter counties, Alabama, 1973-76.

| Habitat type combination | Turkey observations No. | Turkey observations % | % of total road in this combination |
|---|---|---|---|
| Pine plantation[a] × pine plantation | 153 | 27.0 | 63.30 |
| Pine-hardwood[b] × pine-hardwood | 120 | 21.0 | 5.30 |
| Pine plantation × pine[c] | 81 | 14.3 | 7.20 |
| Pine × pine | 60 | 10.6 | 10.70 |
| Pine plantation × hardwood-pine[d] | 53 | 9.4 | 0.40 |
| Pine × hardwood-pine | 30 | 5.3 | 3.80 |
| Hardwood[e] × hardwood | 29 | 5.1 | 0.23 |
| Pine plantation × pine-hardwood | 15 | 2.7 | 5.00 |
| Pine-hardwood × hardwood-pine | 11 | 1.9 | 0.40 |
| Hardwood-pine × hardwood-pine | 8 | 1.4 | 0.95 |
| Pine × hardwood | 3 | 0.5 | 0.07 |
| Pine plantation × hardwood | 2 | 0.4 | 0.40 |
| Total | 565 | 99.8 | 97.75 |

[a]Pine plantation = planted loblolly or short-leaf pines, ages l/2 to 12 years of age
[b]Pine-hardwood = 51 to 70% basal area (BA) natural loblolly or short-leaf pine
[c]Pine = greater than 80% BA natural loblolly or short-leaf pine
[d]Hardwood-pine = 51 to 70% BA natural hardwoods
[e]Hardwood = greater than 80% BA natural hardwoods

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# FOOD HABITS OF THE EASTERN WILD TURKEY ON AN AREA INTENSIVELY MANAGED FOR PINE IN ALABAMA

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Abstract: The food habits of the eastern wild turkey (*Meleagris gallopavo silvestris*) were determined by dropping analysis on a 4,900-ha area managed intensively for even-aged pine in Choctaw and Sumter counties, Alabama from 1973 through 1977. The area was composed of 57% pine (*Pinus taeda* and *P. echinata*) plantations (l/2 to 12 years of age), 22% natural mature pine, 9% natural pine-hardwood, 4% natural hardwood-pine and 7% hardwood vegetation types. Analysis of habitat and food habits data indicate the majority of the food items used during the winter, spring, and fall were most abundant in the pine, pine-hardwood, hardwood-pine, and hardwood vegetation types. The food items used primarily in summer were most available in pine plantations.

## INTRODUCTION

The most important research needs for the wild turkey listed by Bailey and Rinell (1968) were (1) determination of yearly range and habitat requirements and (2) investigations of the effectiveness of land management practices relative to habitat requirements. Mosby (1973) stated the most pressing problems facing managers of the wild turkey include the influence of the current practices of even-aged forest management.

Throughout the Southeast, wildlife biologists have a limited knowledge of the fundamental habitat requirements of the eastern wild turkey (*Meleagris gallopavo silvestris*). Most of the concepts of what comprise good wild turkey habitat are based upon observations and other data obtained from areas that have supported well-established populations in suitable habitat. Consequently, there is little information concerning wild turkey populations where the habitat has been dramatically altered such as areas which have been converted to even-aged pine stands.

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The objectives of this study were to determine the food items most frequently utilized by eastern wild turkeys on an area intensively managed for pine and to relate food use to the plant species composition of available habitat types on the area. Financial support was provided by the Rob and Bessie Welder Wildlife Foundation, the National Rifle Association of America and the Auburn University Agricultural Experiment Station.

## THE STUDY AREA

The 4,900-ha study area is located in south Sumter and north Choctaw counties, Alabama. It is located in the Clay Hills Region of the Coastal Plain Physiographic Province. The clay soils of the area have been described as best suited for forest use as the topography of the area is characterized as rolling to hilly with elevations ranging from 21 to 106 m mean sea level (Swenson et al. 1941).

Since the turn of the century, the timber was harvested by the single-tree selection method. Beginning in 1964 clear-cutting has been used. Forest cover types during the study period were 57% pine (*Pinus taeda* and *P. echinata*) plantation, 22% natural pine, 7% natural hardwood, 9% natural pine-hardwood and 4% natural hardwood-pine. The study area has been described in detail by Gwaltney (1977).

## METHODS

### Habitat Analysis

Habitat types in the study area were identified by using aerial photographs and ground reconnaissance. Percent basal area (BA) of the overstory woody vegetation determined habitat types as follows: (1) pine--greater than 80% BA pine, (2) hardwood--greater than 80% BA hardwood, (3) pine-hardwood--51-79% BA pine, (4) hardwood-pine--51-79% hardwood and (5) pine plantation--even-aged timber stands l/2 to 12 years old.

One representative stand of each habitat type was sampled in May and August. During the study period, a total of 25 sample plots were located in each habitat type along paced compass lines. Nested circular plots with a common plot center were used to sample the three vegetation strata. The overstory woody stratum [diameter at breast height (DBH)] 12 cm or greater was sampled using a 10-factor BA wedge prism (Dillworth and Bell 1973). The understory woody stratum (trees, saplings and shrubs less than 12 cm DBH) and herbaceous stratum were sampled using fixed radius plots (Phillips 1959, Oosting 1956) of 40 and 4 $m^2$ respectively.

Trees occurring in the overstory woody stratum were recorded by species and the DBH of each tree was measured with a tree diameter tape. Species found in the understory woody stratum were recorded as stem counts. Species occurring in the herbaceous stratum plots were estimated as percent ground cover (Oosting 1956). Plant nomenclature follows that of Radford et al. (1968).

### Food Habit Analysis

Food habits were determined by analysis of 1,706 wild turkey droppings collected at random over the study area. Each dropping was placed individually in a 200 g paper bag and allowed to air dry. Dried droppings were then stored individually in 60 ml plastic cups until analyzed. Droppings were ground with mortar and pestle, placed in a glass petri dish, and viewed under a binocular scope. Food items were identified with the aid of Martin and Barkley (1961), Musil (1963), and a collection made by the investigators with seeds collected from the study area. The % volume of each food item was visually estimated.

## RESULTS

The most abundant species occurring in the woody over-story stratum of pine plantations, pine, pine-hardwood, and hardwood-pine vegetation types were loblolly pine (Pinus taeda), short-leaf pine (Pinus echinata), post oak (Quercus stellata) and sweetgum (Liquidambar styraciflua). Hickory (Carya sp.), sweetgum, post oak, and ash (Fraxinus sp.) were most abundant in the hardwood vegetation type. Oaks (Quercus sp.) of mast producing size were found primarily in the pine, pine-hardwood, hardwood-pine, and hardwood vegetation types.

Loblolly pine, sweetgum, red maple (Acer rubrum), winged elm (Ulmus alata) and blueberry (Vaccinium sp.) were the most abundant species comprising the understory woody stratum of pine plantations, pine, pine-hardwood, and hardwood-pine vegetation types. Ironwood (Carpinus caroliniana), red buckeye (Aesculus pavia) and oaks comprised the understory woody stratum in the hardwood vegetation type.

The herbaceous stratum of pine plantations was primarily Uniola sessiliflora, broom sedge (Andropogon virginicus), vasey grass (Paspalum urvillei), panic grasses (Panicum sp.) and blackberry (Rubus sp.). The most abundant species in the herbaceous stratum of pine, pine-hardwood, hardwood-pine, and hardwood vegetation types were Uniola sessiliflora, broom sedge, hog peanut (Amphicarpa bracteata), panic grasses, and cane (Arundinaria gigantea).

Analysis of 1,706 droppings showed 39 identifiable food items were used by wild turkeys from January through October. The importance of each food item, except green vegetation, varied from season to season.

The most utilized food items in order of importance used were:

Winter (December-February)--green vegetation, seeds from Pinus sp., acorns, and insects.

Spring (March-May)--green vegetation, seeds from panic grasses, acorns, blackberries, pine seeds, and insects.

Summer (June-August)--green vegetation, seeds from Paspalum sp., panic grasses, fruits from blackberries, and insects.

Fall (September-November)--green vegetation, fruits from dogwood (Cornus florida), seeds from Paspalum sp., panic grasses, crab grass (Digitaria sp.), fruits from French mulberry (Callicarpa americana), and insects.

## DISCUSSION

The food habits data indicates a change in plant species utilized as food items during each season of the year. Green vegetation was an important food item throughout the year.

Seeds from pine (Pinus sp.) and acorns were the most important forms of mast used during the winter. The habitat data shows loblolly pine, short-leaf pine, and various species of oaks of mast producing size were most abundant in the pine, pine-hardwood, hardwood-pine, and hardwood vegetation types. No mast producing pines or oaks were observed in the pine plantations.

Insects were an important food item during all seasons, but were particularly high during late winter and early spring. They were apparently over-wintering insects found in the ground litter.

Seeds from Paspalum sp., panic grasses and crab grass were important food items during the summer and early fall. These species were most abundant in pine plantations, but they did occur in the other vegetation types.

Fruits of blackberries were utilized most during the late spring and summer. Blackberries were most abundant in the young through middle age pine plantations, with low densities recorded in the older pine plantations and the other vegetation types.

Fruits from dogwood and French mulberry were heavily used during the fall. Although their densities were not abundant in any vegetation type, they were most abundant in the pine, pine-hardwood, and hardwood-pine vegetation type.

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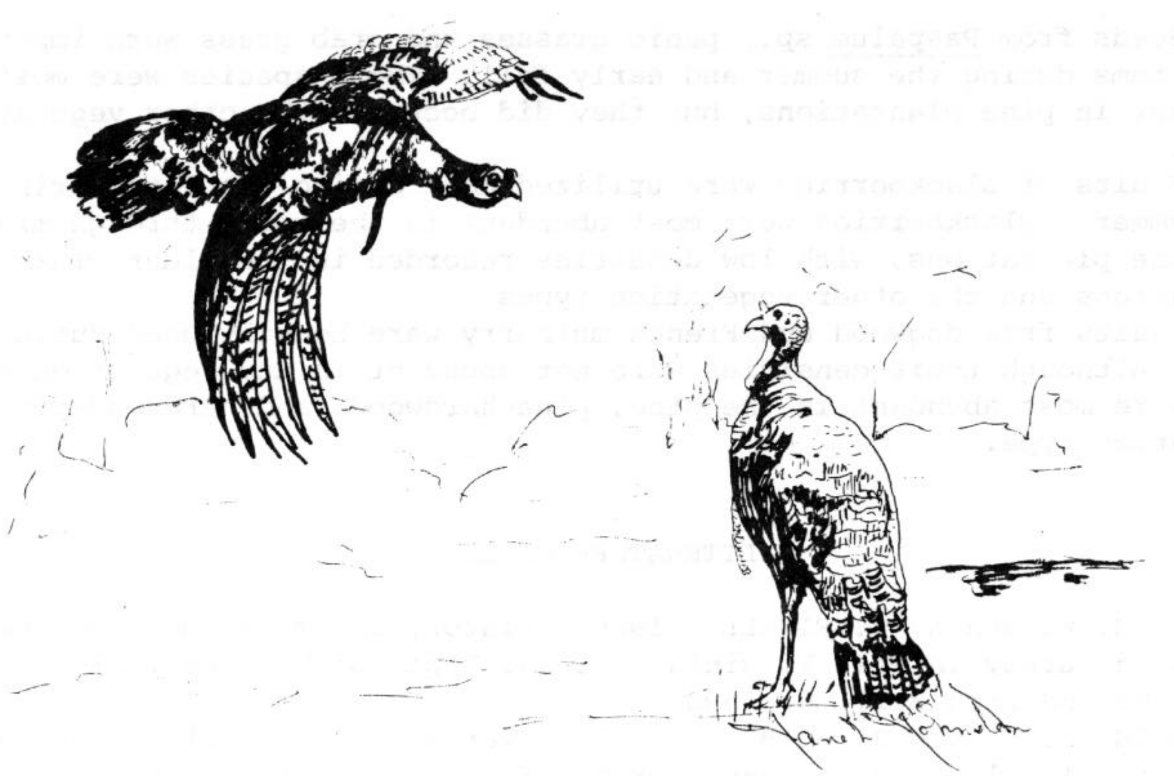

# HOME RANGE AND MOVEMENTS OF WILD TURKEYS -- A REVIEW

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*Abstract:* Home range is defined and information presented on methods of collecting data and computing home range of wild turkeys, on distances traveled and dispersal from managed areas, and on the variability of factors influencing the measurement of home range. Reported annual ranges of wild turkeys varied from 140 ha in Alabama to 553 ha in Missouri; seasonal ranges varied from a spring range of 95 ha in South Carolina to a winter range of 683 ha in Michigan. Linear distances traveled for wild turkeys ranged from 1.5 km in Virginia to 20.1 km in Texas.

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Wild turkey managers have continually faced the problem of determining the range requirements of the managed flock. Over 35 years ago, Mosby and Handley (1943) considered the problem of variation of wild turkey range requirements. Since that time, home range and movement patterns of wild turkeys have been studied intensely over many geographic regions and for the several turkey subspecies. This paper discusses the variability occurring among reports of wild turkey home ranges and movements over the past decades.

## DEFINITION OF HOME RANGE

Leopold (1933) stated that a species cannot successfully inhabit a unit of range smaller or larger than its cruising radius, its inherent mobility. Such an area in which an individual animal spends the majority of its time is referred to as the "home range" (Burt 1943). Dice (1952) referred to the home range as the area an animal covers in its day-to-day travels. An inherent property of the home range is that it is fixed; the animal does not wander through space at random but repeatedly covers the same general area. Goin and Goin (1962) expanded this idea to the concept of total range: the area covered by an individual animal in its lifetime. Ligon (1946) stated that the size of the home range of the turkey depends on suitability of available resources, especially the food supply. The more nearly the habitat approximates optimum conditions, the smaller the home range will be.

## CALCULATING THE HOME RANGE

Several methods have been used to calculate the size of the home range of wild animals. Dalke and Sine (1938) included the area connected by straight lines that joined outermost observation points. The animal's range of movement was the area within the known points of observation, and conservatively represented the "minimum home range" for the period of investigation.

Hayne (1949) considered the geographic center of all points of observation to be the center of activity. The only biological significance of the center of activity was that it was a two-dimensional average of all observation points. Home range was calculated from points of observation lying the farthest from the center of activity. The average distance to all outlying observation points, the activity radius, represented the long axis of the home range, an elliptical definition. The probability of an animal being observed in a particular area decreased with its distance from the apparent center of activity. The longer the period of observation, the more likely the animal was observed at those distant points it visited infrequently (Calhoun and Casby 1958).

Calhoun and Casby (1958) assumed that the extent to which an animal interacts with its physical environment, for example in food consumption, is proportional to the time it is present in a given area. Therefore, Hayne's (1949) concept of home range was basically one of relative intensity of usage of the environment while its measurement was an expression of the relative probability of observation of the animal at various locations within the "total" range.

## FACTORS AFFECTING VARIABILITY OF THE HOME RANGE

Variation among individuals with regard to size of the home range may be affected by: (1) number of observations, (2) distribution and frequency of observers' activities, (3) density of vegetation, and (4) total number of individuals in the group under observation (Michael 1965). The size of the home range tends to increase as the observation period increases (Dalke 1942). Seasonal ranges for turkeys in 4 states (Table 1) averaged only 270 ha while annual ranges in 2 states averaged 417 ha. Also, differences in the calculated home range for the same species in the same area can be attributed to the use of different methods of calculating the size of the range (Mohr 1947). Annual range for gobblers in Alabama was 398 ha (Table 1) as determined by radio-telemetry techniques (Barwick and Speake 1973) and 244 ha as determined by band returns and wing streamers (Davis 1973). Brown (1962) stated that only general comparisons can be made using estimates of home ranges of animals of even the same species. Biological variation, as well as variation in experimental design, will be apparent in the results. It may, therefore, not be appropriate to develop management strategies from home range comparisons, but to develop management plans from individual investigational results.

Table 1. Average sizes of wild turkey home ranges in 6 states.

| Source | $\overline{X}$ Range Size (ha) | Sample Size (n) | Comments |
|---|---|---|---|
| Lewis 1963 | 683 | 34 | winter, gobblers only |
| | 435 | 29 | winter, hens only |
| | 492 | 69 | winter, gobblers and hens; Michigan |
| Ellis and Lewis 1967 | 553 | 4 | annual range, gobblers; telemetry |
| | 303 | 4 | annual range, gobblers; bands |
| | 448 | 3 | annual range, hens; bands; Missouri |
| Raybourne 1968 | 198 | 4 | 2 months, gobblers; telemetry; Virginia |
| Barwick and Speake 1973 | 398 | 12 | annual range, gobblers |
| | 171 | 6 | autumn, gobblers |
| | 270 | 6 | winter, gobblers |
| | 204 | 6 | spring, gobblers |
| | 133 | 6 | summer, gobblers; telemetry; Alabama |
| Davis 1973 | 140 | 12 | annual range, hens |
| | 244 | 15 | annual range, gobblers, band returns and wing streamers; Alabama |
| Hillestad 1973 | 79 | 4 | spring, nonnesting juvenile hens |
| | 150 | 8 | spring and summer, nesting hens; telemetry; Alabama |
| Fleming 1975 | 95 | 8 | spring, gobblers; telemetry; South Carolina |
| Eichholz and Marchinton 1975 | 376 | 14 | spring, early summer, transplants; telemetry; Georgia |
| Speake et al. 1975 | 425 | 77 | spring-summer, hens |
| | 350 | 16 | spring-summer, gobblers; telemetry; Alabama |
| Porter 1977 | 65 | 32 | 10 months, hens |
| | 179 | -- | 10 months, gobblers; telemetry; Minnesota |
| Total $\overline{X}$ | 286 | -- | |

In any study of home range activity it is important to relate use of space to resource availability and distribution (Burt 1943). Habitat preference is usually closely linked with the availability of suitable food and cover (Williams 1955). Korschgen (1967) stated that the size of area and range over which the turkey travels is governed by food supply. When food is abundant, seasonal movements are reduced. The large number of food types consumed by turkeys is evidence that movements are most often to available food supplies.

Each species is influenced by specific activity periods governed by both physiological and environmental factors (Harker 1958). Two physiological rhythms control an animal's activities: a 24-hour rhythm determined mainly by periods of waking and sleeping, and one of shorter duration, governed largely by food requirements (Brown 1962). Daily behavior of turkeys is influenced by light intensity (Bailey 1967). As light intensity increases turkeys descend from the roost to begin daily activities. Decrease in light intensity stimulates the birds to roost. Korschgen (1967) described feeding movements of turkeys "as nomadic within limits, seemingly aimless, yet purposeful in search for food". Turkeys have 2 distinct daily periods of intense feeding activity, mid-morning and mid-afternoon (Davis 1949). Areas of activity determined by these rhythms are not fixed rigidly, but vary with season, age of the animal, and competition.

Variability among home range sizes for wild turkeys is influenced largely by accessibility of an area, hunting pressure, the area's proximity to human population, quality of the range, and genetic character of the turkey stock involved (Bailey and Rinell 1967). Within the last 20 years, studies on rather limited ranges have clarified many issues regarding these aspects of turkey management. One example is the 2430 ha Camp Creek State Forest in West Virginia. In 1956 and 1957, 13 wild-trapped turkeys were released in the area and in 1958 the population was estimated at 100 birds (Bailey and Rinell 1967). Population establishment in small woodlots in Chautauqua County, New York further exemplifies the possibility of managing turkeys on small ranges. Wunz (1971) believed it was possible to establish turkeys on forested areas as small as 200 ha. Wild-trapped turkeys in Pennsylvania showed an amazing ability to survive and adapt to limited range conditions.

Habitat improvement can reduce the size of the turkey's home range appreciably (Mosby and Handley 1943). Various types of supplemental food are often desirable and may be a necessary aid in controlling turkey movements (Stoddard 1963). Landowners have had success in holding Rio Grande turkeys *(M. g. intermedia)* in an area through supplemental feeding, but during drought conditions turkeys left the range regardless of food supplied (Walker 1951). Depending on the seasonal availability of preferred foods, turkeys in Alabama used from 162 to 405 ha as a home range (Wheeler 1948). Average range sizes for hens were smallest at two of four study areas in Alabama which had the highest total percentage of better distributed openings (Speake et al. 1975).

The average home range of 286 ha reported from trap-tag and radiotelemetry studies of wild turkeys in six states (Table l), indicates the possibilities for turkey management in much smaller areas than previously suggested. Earlier studies indicated that 4,400 to 8,100 ha were necessary to manage turkeys effectively, with 20,000 ha or-more being optimum for public hunting (Mosby and Handley 1943, Edminster 1954, Latham 1956, Stoddard 1963). Davis (1973) stated that an area managed for wild turkeys should contain at least 243 ha with a long axis of about 2.4 km and a short axis of about 1.6 km. There may be many complexities involved in determining the size of the range required for adequate turkey management, and precise statements are nearly impossible (Bailey and Rinell 1967).

## WILD TURKEY DISPERSAL

A still unsolved problem in turkey management is dispersal from the managed area. There is a great deal of variability in linear distances traveled by wild turkeys (Table 2). The normal distance traveled by turkeys in Virginia was 5 to 8 km, the longest straight line distance being 21 km (Mosby 1941). In mountainous country, dispersal was often more than 16 to 24 km (Mosby and Handley 1943). Hunter kills in West Virginia showed that a flock of trapped, banded, and released turkeys moved 24 to 32 km (Bailey 1957). Following release of 35 turkeys in Florida, 43% of the birds traveled from 8 to 40 km from the point of release (Stanberry and Gainey 1950). The remainder stayed within a radius of 3.2 km. The greatest distance traveled by any Rio Grande turkey in Texas was 24 km (Goodrum 1941). Merriam's *(M. g. merriami)* turkeys released in Arizona traveled distances of up to 64 km. Powell (1967) concluded that turkeys sometimes travel great distances, but that average dispersal is usually no more than 3 to 5 km. During winter, spring and early summer the majority of fall-released, pen-raised birds on an enclosed preserve in Pennsylvania were located only 1 to 2 km from the original release site.[1]

It is not certain that dispersal from the place of hatching or release is due to the unsuitability of the range (Schorger 1966). Variation in distances traveled by turkeys may be due to variation in geographic regions (Raybourne 1968). In Alabama, movement patterns of turkeys stocked on an area, and those raised on the same area appeared similar in every respect (Speake et al. 1969). Leopold (1944) found that annual variations in local acorn production caused turkeys to use different wintering areas. In most winters in Missouri, the location of food supplies controlled the movements of wild turkeys (Ellis and Lewis 1967). Spring dispersal was thought to be one cause for population losses on some range. Loss of juvenile hens resulted

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[1]Unpublished Rachelwood Wildlife Research Preserve data. G. D. Eckes, 4112 S. Vrain, Denver, Colorado 80236

Table 2. Average linear distances traveled by wild turkeys in 9 states.

| Source | $\overline{X}$ Distance (km) | Sample Size (n) | Comments[a] |
|---|---|---|---|
| Walker 1951 | 20.1 | -- | *M. g. intermedia;* Texas |
| McDonald 1963 | 15.0 | 6 | *M. g. merriami* ; New Mexico |
| Ellis and Lewis 1967 | 3.1[b] | 55 | hens |
| | 2.1 | 32 | gobblers; Missouri |
| Raybourne 1968 | 1.46 | 4 | 2 months; telemetry; Virginia |
| Speake et al. 1969 | 5.23 | 27 | 3½ years; Alabama |
| Barwick and Speake 1973 | 2.33 | 16 | 4 years; Alabama; telemetry; spring |
| Davis 1973 | 2.9[c] | 28 | adult hens |
| | 3.5[d] | 15 | juvenile hens |
| | 4.02 | 22 | gobblers; leg band returns for 1947-1967 |
| | 2.09 | 12 | hens; 11 months |
| | 3.54 | 6 | gobblers; 11 months; Alabama |
| Hillestad 1973 | 3.14 | 4 | spring; nonnesting hens |
| | 2.74 | 8 | spring-summer; nesting hens; telemetry; Alabama |
| Hurt et al. 1973 | 3.38 | 189 | wing streamers |
| | 5.63 | 41 | individuals identified |
| | 3.75 | 93 | color-marked leg bands *M. g. merriami;* Nebraska |
| Fleming 1975 | 4.3 | 8 | breeding season, gobblers; telemetry; South Carolina |
| Eichholz and Marchinton 1975 | 2.82 | 15 | spring, early Summer, transplants; telemetry Georgia |
| Speake et al. 1975 | 7.4 | 77 | hens; telemetry |
| | 5.6 | 16 | gobblers; telemetry; Alabama |
| Porter 1977 | 5.6 | 2 | adult hens; telemetry |
| | 8.6 | 1 | juvenile hen; telemetry |
| | 2.6 | 6 | gobblers, distance from center of activity; Minnesota |

[a]Includes only information available for each investigation.

[b]Unless otherwise stated, *M. g. silvestris.*

[c]If a 36.2 km record of one juvenile hen is excluded, the average distance is 1.45 km.

[d] If a 25.7 km record of one adult hen is excluded, the average distance is 1.9 km.

from egress caused by competition for nest sites, and spring dispersal resulted in redistribution of turkeys over the entire range of the study area. Ligon (1946) reported that adult Merriam's turkey hens returned to previously used nesting areas if the areas were not seriously disturbed.

During seasons of poor mast production turkey movements might be restricted by providing supplemental winter food (Ellis and Lewis 1967). McDonald (1963) reported that turkeys tended to return to the same winter range, even though winter and summer ranges were separated by great distances. Summer dispersal in Missouri was generally minimal (Ellis and Lewis 1967). Dalke et al. (1946) and Lewis (1963) concluded that turkeys move in a rather circular path.

Pen-raised turkeys have often been used in attempts to increase occupied turkey range. Liberated wild turkeys show a strong inclination to drift soon after release (Mosby and Handley 1943). Pen-raised turkeys sometimes wander extensively following release, but wandering ceases when birds adopt unoccupied range or attach themselves to an established flock or farmyard (Knoder 1959, Preston 1959, Sickels 1959, Wunz 1973). Movements of pen-raised turkeys on a hunting preserve depended largely on the presence of readily available food sources rather than on the quality of natural habitats (Rundquist 1973).

## CONCLUSIONS

Home ranges and movements of wild turkeys are not only highly variable in themselves, but the various methods of collecting and reporting data result in highly variable accounts of home range and movements of the species. Present developments of reliable radiotelemetry equipment and techniques have added much to the turkey biologists' ability to gather accurate data on home range and movements of wild turkeys. Using radiotelemetry techniques, it is now possible to instrument a sample population, track the individuals through an entire year, and obtain representative data necessary to analyze productivity, survival, and movements within a specified area. In the future, these techniques may help standardize wild turkey home range and movement data and improve wild turkey management strategies.

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# A COMPUTER TECHNIQUE FOR ANALYZING RADIO-TELEMETRY DATA

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Abstract: An interactive computer system to analyze radio-telemetry data has been developed and used on turkey observations. The program calculates home range by the convex polygon, capture radius, and non-circular home range methods. Geometric center of use, total and daily travel distance, circumference of the area of use, and mean activity radius are also calculated. Users are able to select appropriate computer graphics of animal movements, home ranges, geometric center locations, and habitat map overlays. minimum inputs to the system include: animal identification number, code for the known-location from which the readings are made, time of day, azimuth direction from station to animal, date, and the x-y coordinates for each known-location. Coordinate systems such as the Universal Transverse Mercator System, the State Plane Coordinate System, Or any user defined system with equal size units in north-south and east-west directions may be used. The system is designed to reduce the time from collection of field data to the final analysis, improve accuracy of the analysis, make graphical displays of the data, and allow access to the data for future use.

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Radio-telemetry, a valuable tool for wildlife researchers, provides information for improving wildlife management decisions. However, costs are high for both equipment investments in telemetry systems and personnel time spent in data collection and analysis. Improved methods for analyzing, interpreting, and communicating findings from radio-telemetry studies are needed more urgently than are new techniques for data collection (Sanderson 1966, Silvy et al. 1979).

In typical radio-telemetry studies a vast amount of data is acquired, necessitating data manipulation with computers. To facilitate the collection, analysis, and storage of data from a radio-telemetry study of daily activities of eastern wild turkeys (*Meleagris gallopavo*) [Schumacher 1977), an interactive computer system, TELEM, was developed.

This paper describes TELEM and its use. The system consists of various modular packages designed to be run interactively using the FORTRAN G1 compiler of the IBM 370 series computers. Graphical output from the system can be direct to a flat-bed plotter or an output data file can be generated, and later this file submitted to drum or electro-static plotters. Plotting routines utilize standard CALCOMP calls. Use of subroutines in TELEM facilitate modifications by users.

Examples of the use of TELEM are taken from Schumacher's (1977) study of the effects of evenaged cottonwood silviculture on wild turkeys conducted on Huntington Point, Mississippi, 4000 ha of privately owned forested land between the levee and the Mississippi River. Huntington Point consists of a 320 ha cottonwood plantation and 100 ha of various aged experimental cottonwood cultivations surrounded by mixed batture forest.

The U.S. Forest Service, Southern Forest Experiment Station, New Orleans, Louisiana and Southern Hardwoods Laboratory, Stoneville, Mississippi (USFS Agreement Number 19-177, Cooperative Agreement 16 USC 581); the Department of Wildlife and Fisheries, Mississippi State University, Mississippi, State, Mississippi, and the Department of fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, Virginia are acknowledged for their financial assistance in developing this system. I am also indebted to Drs. D. E. Wesley, A.R. Tipton, and R.H. Giles, Jr. for their assistance and encouragement. Finally, special appreciation is due to users of the system, R.W. Schumacher, T.B. Wigley, and D. Otto, who suggested many improvements; and to my wife Linda for her assistance in the preparation of this manuscript.

## DATA COLLECTION AND PREPARATION

TELEM, requires two types of inputs: 1) data on each radio-telemetry reading and 2) the x-y coordinates for known-location stations from which the telemetry readings are made. Readings are defined as a magnetic azimuth from a known-location station to a monitored animal. (Magnetic azimuths are adjusted for the Magnetic declination of the study area.) In addition, habitat maps can be digitized and added to TELEM for display with various graphical analyses of animal activities.

### Radio-telemetry Readings

Data associated with each radio-telemetry reading include: species (e.g., T for turkey, D for deer, etc.), animal identification number, radio-telemetry station identification number (see below), time of the reading, magnetic azimuth from the station to the animal, and date.

Frequently, conditions in the field necessitate readings taken in slightly modified form. For example, monitored animals may be visually observed when an azimuth is taken. In this case triangulation of animal position is not necessary, and only the distance (in meters) and the magnetic azimuth from the station to the animal is recorded. A keyword ("LOC") is used to identify this unique situation. As another example, occasionally a reading for an animal location could not be made adequately from a particular station and in such cases the investigator moved to a position from which a reading could be made. The required data were recorded as above in addition to the distance and direction of this temporary station from a known station. An example of coded data is given in Table 1.

Before processing, coded data of the telemetry readings must be sorted sequentially in ascending order by animal species, code, animal identification number, year, month time and hour. Sorting can be done by mechanical card sorters or sort packages available at most computer facilities. This sorted data and data on radio-telemetry stations are processed by a sub-system of TELEM before being entered into the main system.

## Known-location Stations

Known-location stations were selected as points readily identifiable on topographic maps or aerial photos. Such points included road and trail intersections, corners of abutting habitat types, curves in roads, utility poles or other distinguishable positions. Each station was marked on the ground, given a unique identification number, and assigned x-y coordinates. Any coordinate system (e.g., Universal Transverse Mercator, State Plane, or user-defined system) with units of equal length in north-south and east-west directions can be used. Examples shown in this paper utilize a coordinate system defined by Schumacher (1977). In his coordinate System, an arbitrary point southwest of the study area was assigned the x-y value of 0,0 and each unit north or east was equal to 609.6 m (2000 ft) on the ground. Coordinates of the stations were obtained with a commercially available digitizer. TELEM can transform maps of various scales or coordinate systems to a common scale and coordinate system, thus allowing the coordinates of known-station locations or habitat data to be digitized from maps of various scales.

Table 1. Sample of data used as input to TELEM, a computer system for analyzing radio-telemetry data. Variables include animal species code (col. l), animal identification number (col. 2-4) 8 radio-telemetry station identification number (col. 6-11) time of reading (col. 13-16), azimuth from station to animal (col. 18-20), date (col. 21-29), azimuth from station to temporary station (CCL 31-33), distance in meters from station to temporary station (col. 35-38), and key word identifying as a location record and not a reading (col. 40-42).

Card Columns

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....:....1....:....2....:....3....:....4 ....:.... 5

[1]T 22 G 0007 1140 100 06/12/76 270 0152
 T 22 G 0007 1320 042 06/14/76     0060 LOC
 T 22 G 0007 1605 244 06/14/76
 T 22 G 0008 1610 005 06/14/76
 T 22 F 0003 1620 050 06/14/76
 T 22 G 0002 2020 321 06/14/76
 T 22 G 0006 2025 244 06/14/76
 T 22 G 0007 1025 270 06/15/76
 T 22 G 0008 1040 332 06/15/76
 T 22 F 0003 1050 036 06/15/76
 T 22 G 0007 1625 319 06/15/76
 T 22 F 0004 1655 085 06/15/76
 T 22 G 0007 1210 291 06/22/76 090 0152
 T 22 G 0008 1545 350 06/25/76 270 0152
 T 22 G 0008 1545 309 06/25/76 270 0076
 T 22 G 0005 2155 215 06/26/76
 T 22 G 0006 2200 202 06/26/76
 T 22 G 0007 2205 185 06/26/76
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[1]The first record shown is for turkey #22 located 100° from a point, 270° and 152 m from telemetry station G 0007, at 1140 hr on 12 June 1976. The next record indicates that turkey #22 was spotted 60 m and 42° from station G 0007.

# PROCESSES AND OUTPUTS

TELEM operates in an interactive mode and prompts the user for the selection of various options in processes and output. The user can enter each response through a terminal or create a file of program control data to be read by the program with no further user interaction. By entering code for animal species, animal identification number, and period of desired analysis, the user specifies what data are to be used for subsequent calculations. The data can also be coded to discriminate data selection based on weather conditions, observers, animal activity, or other factors. The system is capable of producing graphical output of any portion (or total) of the study area at any suitable scale (Figs. 1 and 2).

Location of a monitored animal obtained by intersecting 2 or more telemetry readings is termed a fix. As standard field procedure to reduce locational error, readings should be taken over as short a period as possible. TELEM allows the user to select the maximum allowable time interval between readings to be used to calculate a fix. When azimuth differences between readings equal 90° the difference between the triangulated position and actual animal location is minimized. As the azimuths approach being parallel the resulting error polygon increases (Heezen and Tester 1967). TELEM allows the user to enter a range of acceptable intersection angles for triangulating location. Angles exceeding this range are not used to calculate a fix.

TELEM can calculate fixes by two different techniques. The first technique calculates a fix by intersecting consecutive pairs of readings that are within the maximum allowable time between readings as specified above. For example, if four readings were found to be within the maximum time limit, three fixes would be created by the first technique. In the second technique, one fix is calculate as the average of all possible combinations of fixes within the specified time limit. By this technique, if four readings were found to be within the time limit, one fix would be calculated as the average of the six possible combinations of four readings.

For the animal and period selected, TELEM reports the following: 1) the number of readings found; 2) the number of fixes made from those readings; 3) the area of use or home range calculated by the convex polygon method (Mohr 1947), capture radius method (Hayne 1949), and non-circular method (Jennrich and Turner 1969); 4) the geometric center (i.e., the means of the x and y coordinates for all fixes, originally defined as the "center of activity" by Hayne (1949); 5) the circumference of the area; 6) the mean activity radius (i-e., the average distance from geometric center to each fix (Dice and Clark 1953); 7) a shape index; and 8) travel statistics.

The procedures for calculating home range by the capture

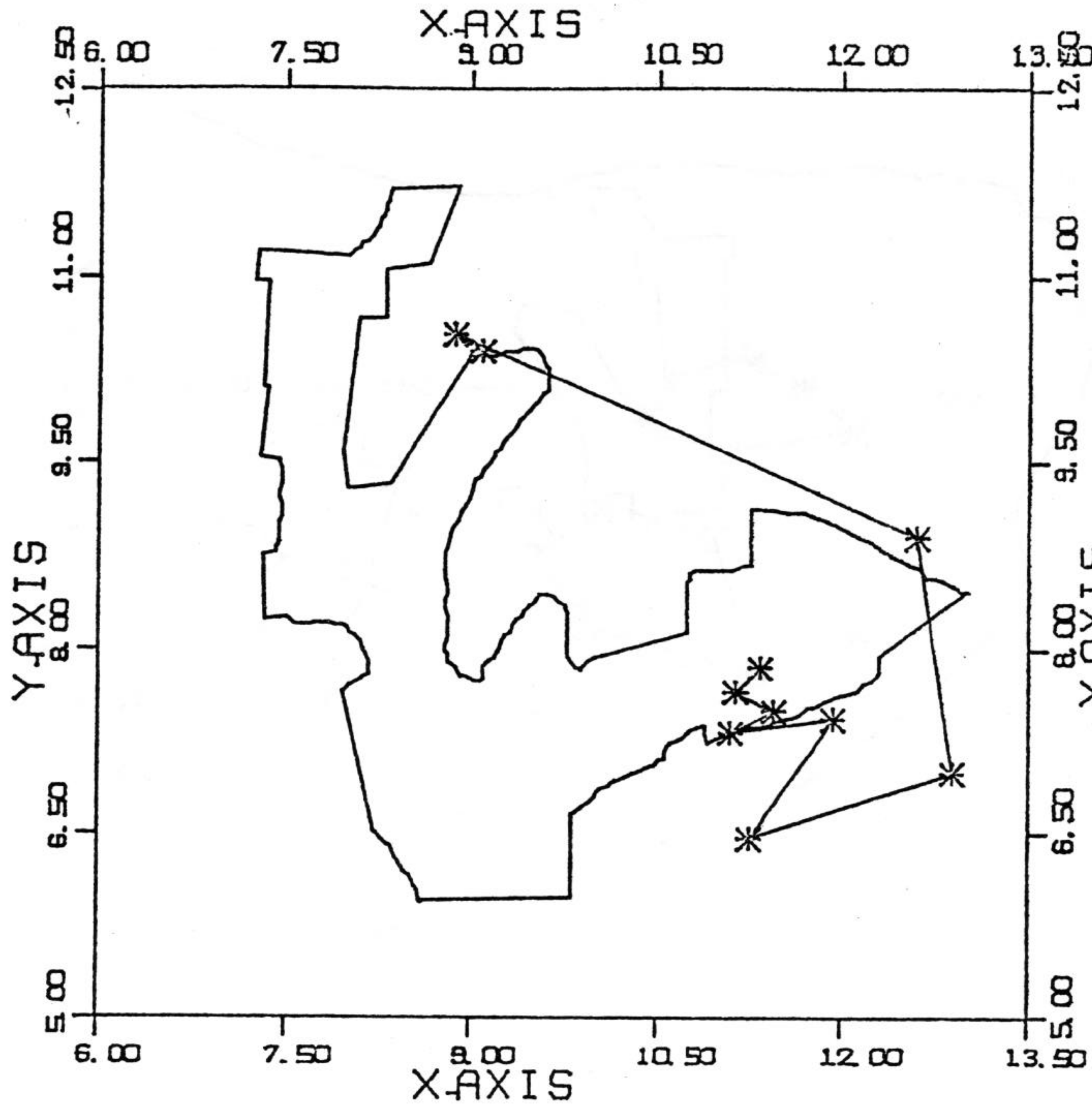


Fig. 1. TELEM allows the display of consecutive fixes connected with a straight line to show travel pattern over time, and the overlay of habitat maps such as this cottonwood plantation on Huntington Point, Mississippi. Scale equals 1:36000.

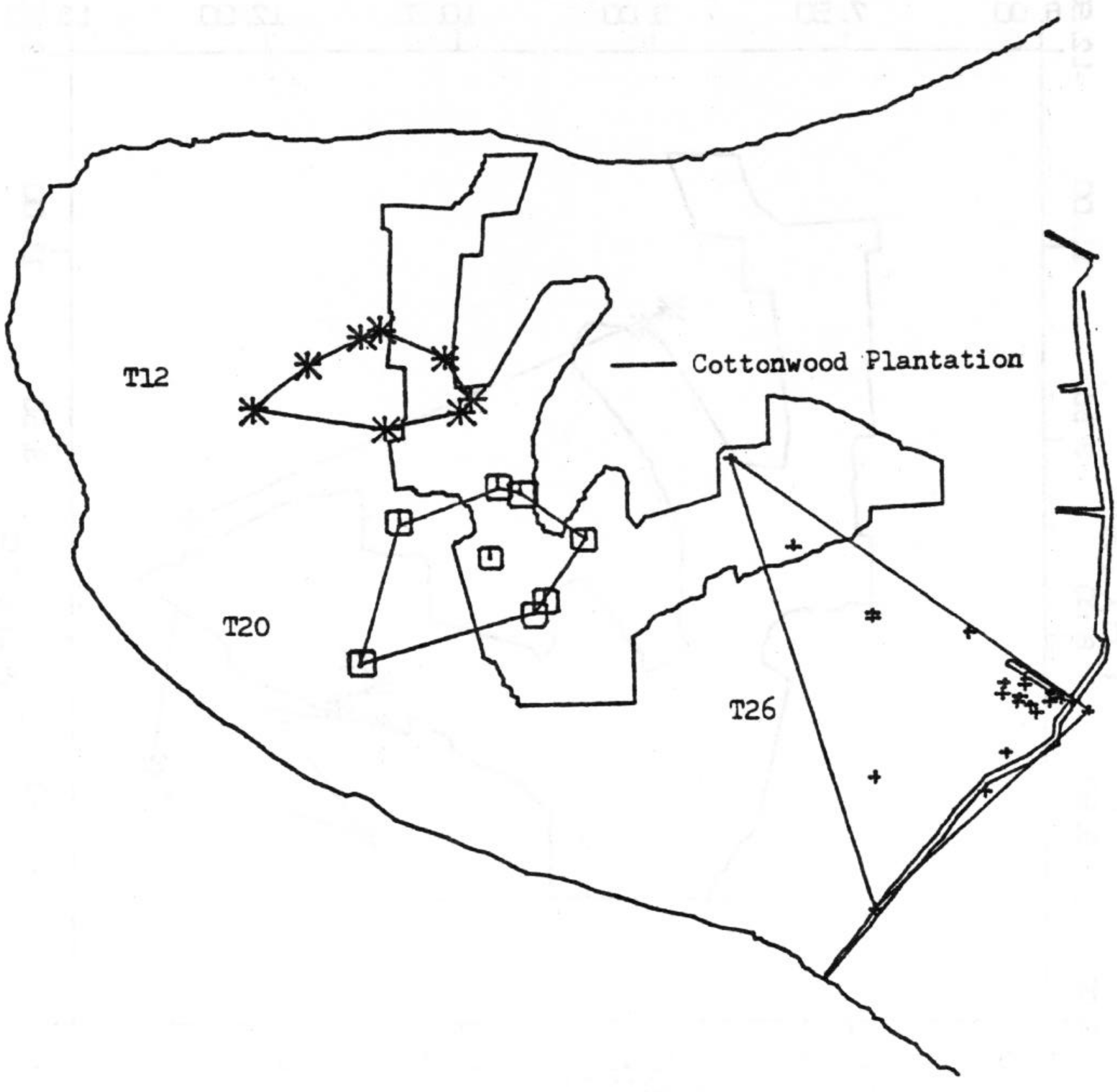


Fig. 2. Home ranges for three turkeys monitored by radio telemetry during May 1976 are illustrated. For turkey T12, only home range is shown; for T20, home range and geometric center for the home range are shown; and for T26 home range and every location are shown. The outlines of Huntington Point, Mississippi, a cottonwood plantation, and various levees and dikes were also drawn by the TELEM system. Scale equals 1:48000.

radius method and the non-circular method have previously been discussed by others. The convex polygon method is based on the minimum area method (Dalke 1942, Mohr 1947). In calculating home range by the convex polygon method, TELEM utilizes an algorithm similar to the one described by Silvy et al. (1979). The area of this convex polygon is calculated by the continuous product method (Husch 1963).

The shape index is the perimeter of the area (calculated by the convex polygon method) divided by the circumference of a circle with the same area. A similar statistic has been used to characterize the shape of habitat types by Millar (1969), Fried (1975) and Patton (1975). A home range having the shape of a circle would have a shape index of "1.0" As the home range becomes less circular, the shape index increases.

The travel statistics indicate movement patterns by calculating average movements between consecutive locations and between consecutive time intervals. For example, if four locations are recorded for an animal over 2 complete days and the distances between the locations are 1000 m, 2000 m, and 3000 m, then the first statistical procedure reports a sample size of three and a mean of 2000 m, while the second reports a total time of 2 days and a mean of 3000 m per day.

Various graphical outputs of turkey activities plotted by the system are shown in Figs.1 and 2. In Fig. 1 consecutive fixes were connected with a straight line to show travel patterns over time. Fig. 2 shows the plotting of home range of three turkeys for 1 month, the geometric center for one of these birds, and every location of one other bird.

In addition to graphical output, the coordinates for fixes for each animal as well as the time, date and azimuth difference for each fix can be printed or directed to a tape or disk file. Similarly the coordinates of the corner points of the convex polygon may also be displayed or written to a file for storage. The stored coordinates could be used by other programs for further analyses.

## CONCLUSION

Investigators utilizing TELEM {Schumacher 1977, Wigley 1977. Otto 1978) have found it to reduce the time between collecting data and reporting the study conclusions. In addition it has reduced errors in plotting animal locations as determined by radio telemetry, improved the quality of reports on the activities and movements of animals, and provided a means of storing data for re-analysis in the future when more advanced computational procedures become available.

The system was written as modules to facilitate updating existing procedures or adding new ones. A new procedure being developed determines the number of fixes located in various user specified habitat types. A non-interactive system has been suggested and may be developed in the future.

A manual for the use of the system including documentation of the computer program is available at a minimal cost from the Department of Fisheries and wildlife Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. Those wishing the source program on computer tape should mail a 9-track tape to the above address.

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# MOVEMENTS OF TURKEYS IN A HIGH DENSITY POPULATION IN THE MISSISSIPPI DELTA

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Abstract: Movements and reproduction of an eastern wild turkey (*Meleagris gallopavo silvestris*) population in Bolivar and Washington counties, Mississippi were studied from 1968-1972. During the study, 85 adult hens, 83 subadult hens, and 65 subadult gobblers were captured and wing-marked. The fall turkey population following high reproductive seasons approximated 1 turkey per 6 ha. During the first year of observation, total turkey loss (egress and/or natural mortality) was 70% or less with no difference between sex and age classes. Subadults were more mobile than hens captured as adults. Further dispersal occurred after the subadult hens became adults, but subadult gobblers did not substantially increase movement from capture site as adults. The mean maximum dispersal for turkeys captured as subadult hens was 4.2 km, subadult gobblers 3.7 km, and adult hens 2.2 km. The gobbler harvest peaked at 2.5/km$^2$ during the 1971-1972 hunting season. The loss rate (egress and/or natural mortality) was similar for gobblers and hens which indicated that the hen segment of the population was under harvested.

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Most of the research on movements of the eastern wild turkey has been conducted where turkey densities were expanding or moderate. As turkey populations increase in the southeastern forest, it is important to examine movements in areas of high turkey density. This paper presents wild turkey movement data collected over a 5-year period (1968-1972) in the Mississippi Delta on an area where the turkey population was unusually high. Observations on hunter harvest and turkey repro-

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duction were also included. Information on turkey productivity with particular reference to environmental conditions were presented by Kennamer et al. (1975) for this study area.

We are indebted to members of Huntington Point Hunting and Fishing Club, Catfish Point Hunting Club and Westside Hunting Club for their cooperation during this study. We thank Chicago Mills and Lumber Company, U.S. Gypsum, Anderson-Tully Lumber Company, and Delta Pine Land Company who owned the majority of the land within the study area.

## STUDY AREA

The study area included 3 hunting clubs in Bolivar and Washington counties, Mississippi. The majority of the 9,000 ha study area was in the batture of the Mississippi River. The narrow band of batture hardwoods was dominated in the overstory by sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), and box elder (*Acer negundo*). In addition to the natural occurring plant associations there were approximately 920 ha of cottonwood (*Populus deltoides*) plantations. The part of the study area east of the Mississippi River levee was comprised primarily of agricultural lands with scattered hardwood woodlots. The vegetation on the study area was described in detail by Kennamer et al. (1975).

Turkeys were hunted during spring "gobbler only" seasons and fall "either sex" seasons. Catfish Point and Westside Hunting Clubs have been harvesting hens during the fall for a number of years. Huntington Point had its first hen season in 1972.

There was limited access to the study area. Each club had a caretaker who lived on the area throughout the year to protect wildlife from poaching. Loss of turkeys to poaching was insignificant.

## METHODS

During this study, 233 turkeys (85 adult hens, 83 subadult hens, and 65 subadult gobblers) were captured and marked with patagial wing tags essentially as described by Knowlton et al. (1964). Marked birds were released at the capture site. Alpha-chloralose or cannon nets were used to capture the birds during late winter, late summer, and early fall.

### Data Collection

The principal observation period was from May through September. Incidental observations were made during late winter trapping operations. All turkey sightings were recorded as to marked or unmarked, location, time of day, sex, and age class.

Most sightings of marked turkeys were made along a 35 km stretch of the Mississippi River levee which separated Catfish Point and Huntington Point from Westside Hunting Club. Identification of marked turkeys off the levee was difficult in the summer due to dense vegetation. An effort was made to locate marked turkeys which had moved off the study area. During 1972, Mississippi hunting clubs within 50 km of the study area and personnel of the Arkansas Game and Fish Commission working across the Mississippi River were contacted concerning sightings of wing-marked turkeys. Hunters were encouraged to provide information on location and date of kill of marked turkeys.

### Data Analysis

A direct sampling method (Mendenhale et al. 1971), using marked and unmarked birds, was used to estimate the adult turkey population during the summers of 1970 and 1972. The number of marked turkeys sighted during the year of estimate minus known deaths prior to the estimate was considered the number of marked birds in the population. Nine field days from each of the summers were randomly selected as sample days with the stipulation that at least 1 marked turkey was observed. A population estimate was computed for each day and the 9-day average was considered the adult estimate for that summer.

For birds captured during February and March, the first observation year was from date of capture through 31 December. The first observation year for birds captured during August, September, and October was from date of capture through their second December. Thereafter, an observation year was from 1 January through 31 December.

Locations of the marked turkeys were plotted on a study area map and airline distances between observation points and capture sites were measured to determine movements. The mean dispersal from release site was calculated using the average for each individual. Means were tested for significant differences using analysis of variance and Duncan's New Multiple Range Test according to Ott (1977).

## RESULTS

### Population Estimate

During the summers of 1970 and 1972, the adult turkey population along the Mississippi River levee was estimated at 449 ± 114 (P=0.10) and 336 ± 204, respectively. The estimates represent about 4,500 ha of the study area.

### Accountability of Wing-marked Turkeys

Eighty-four (36%) of the 233 wing-marked turkeys were either observed on at least 1 occasion or harvested or found dead. Seventy-seven percent of the first observations occurred during the first year of observation.

A higher percentage of gobblers were accounted for than hens. Also, a higher percentage of the gobblers were not observed prior to harvest or finding dead. Forty-eight percent (31) of the gobblers captured as subadults were seen at least once, 29% (24) of the subadult hens, and 34% (29) of the adult hens. Twenty-two percent (14) of the gobblers and 5% (8) of the hens were not observed prior to harvest or finding dead.

Of the marked birds available for observation during the summer of their first observation year (i.e. subtraction of known deaths), 21% of the subadult hens were sighted. Slightly more adult hens (25%) and subadult gobblers (29%) were sighted during their first observation year.

## Dispersal From Capture Site

During the first year of observation, gobblers and hens captured as subadults did not demonstrate significant ($P > 0.05$) differences in average dispersal distance from capture sites (Table 1). For subadult hens, the average distance moved from capture sites significantly ($P < 0.05$) increased from the first to the second plus observation year. Movement by subadult hens increased 2.7 km. One hen sighted as a subadult 3.5 km from release site was sighted 2 years later 19.3 km from release site. There was no significant ($P > 0.05$) difference between the first and second plus observation year for subadult gobblers and adult hens.

Table 1. Average kilometers traveled from release site for wing-marked turkeys, 1968-1972.

| Age class when captured | 1st year | | | 2nd+ year | | |
|---|---|---|---|---|---|---|
| | N | $\overline{X}$ | Range | N | $\overline{X}$ | Range |
| Subadult Gobblers | 19 | $2.9^a$ | 0.5-14.4 | 10 | $3.5^a$ | 1.6-5.6 |
| Subadult Hens | 19 | $3.2^a$ | 0.0-10.7 | 8 | $5.9^b$ | 0.8-19.2 |
| Adult Hens | 21 | $2.2^a$ | 0.2-8.8 | 14 | $1.4^a$ | 0.3-3.7 |

[a,b]Means with different superscripts indicate significant differences at $P < 0.05$ according to Duncan's New Multiple Range Test.

The greatest mean maximum movement (4.2 ± 1.8 km, P=0.05) from capture site was exhibited by hens captured as subadults. The mean maximum movement for gobblers captured as subadults was 3.7 ± 1.1 km and for adult hens was 2.2 ± 0.9 km.

Table 2 depicts percentages of turkeys accounted for within average distances from capture sites. All but 1 of the gobblers were accounted for within 6 km of its release site. Six of the hens captured as subadults and 3 of the hens captured as adults moved more than 6 km. Fifty-four percent of the marked turkey observations were within 2 km and 84% within 5 km of release sites.

Table 2. Percentage of wing-marked turkeys accounted for by mean distances from release sites, 1968-1972.

| Mean distance accounted for within kilometer classes | Subadult[a] gobblers | | Subadult hens | | Adult hens | |
|---|---|---|---|---|---|---|
| | 1st[b] | 2nd+[c] | 1st | 2nd+ | 1st | 2nd+ |
| 1 | 21 | | 16 | 12 | 38 | 43 |
| 2 | 42 | 10 | 48 | 50 | 76 | 79 |
| 3 | 58 | 30 | 69 | 62 | 81 | 93 |
| 4 | 84 | 60 | 79 | 62 | 81 | 100 |
| 5 | 95 | 70 | 79 | 62 | 86 | |
| 6 | 95 | 100 | 84 | 62 | 91 | |
| 7 | 95 | | 84 | 62 | 96 | |
| 8 | 95 | | 89 | 62 | 100 | |
| 9 | 95 | | 89 | 74 | | |
| 10 | 95 | | 89 | 86 | | |
| 10+ | 5 | | 11 | 12 | | |
| N | 19 | 10 | 19 | 8 | 21 | 14 |

[a]Age class when wing-marked.
[b]First year of observation.
[c]Second-year of observation plus following years.

There were only 2 individually recognized marked turkeys off the study area with the furthest movement (19.3 km) by an adult hen which was captured as a subadult. Personal interviews with members and caretakers of hunting clubs within 50 km of the study area revealed that wing-marked turkeys had traveled at least 26 km from the study area boundary. The number of wing-marked birds reported ranged from 1 to 5/year/club.

## Harvest

Turkey harvest was 151 or 1.7/km$^2$ on Catfish Point and Huntington Point for the 1970-1971 hunting season. During the 1971-1972 hunting season, 262 birds or 2.9/km$^2$ were harvested. Approximately 2.5 gobblers per km$^2$ were harvested during the 1971-1972 hunting season. During these 2 hunting seasons, Catfish Point harvested 76 hens in the fall. Huntington Point did not harvest hens.

Thirty-two percent of the wing-marked gobblers were reported harvested. Of these 21 birds, 43% were subadults. Of 309 gobblers harvested during the spring seasons of 1970-1972 on Catfish and Huntington Points, 15 (5%) were marked.

Five percent (8) of the marked hens were harvested. One hen was harvested during the first year of observation.

## Poult Production

Forty-eight marked hens were observed during the period of 15 June to 1 October when their poult production could be determined. Of 11 hens observed as subadults, 2 (18%) produced 1 or more poults. Of 37 hens observed as adults, 7 (20%) produced poults and the reproductive success of 3 were undetermined.

# DISCUSSION

We believe that the adult turkey summer population estimates of 1/10 ha and 1/13 ha are underestimates. These estimates were made when the adult population was near its lowest point and total fall populations would be higher. Considering the high harvest of turkeys and our field observations, the total fall population reaches or possibly exceeds 1/6 ha in years when reproduction is good.

Including the legal harvest, during the marked birds' first year of observation loss rate was 70% or less. This approximates the "normal" annual turnover rate for turkey populations (Mosby 1966).

On this study area with its unusually high turkey density there were only slight differences in egress and/or natural mortality between turkeys captured as subadult hens, subadult gobblers, and adult hens based on percent accountability. We attribute the higher percent accountability for gobblers (48%) to the higher gobbler harvest. Including only sightings subadult hen accountability was the lowest with 21%; however, this was only 8% lower than the highest accountability which was for subadult gobblers. In an estimated stable turkey population of l/10 ha, Ellis and Lewis (1967) found that loss of subadult hens from their study area was substantially higher than that for subadult gobblers and adult hens. The losses were attributed to egress and mortality with population pressures a possible explanation.

Subadult turkeys were more mobile than hens captured as adults. We believe that the increased movement by the subadults resulted from efforts to establish new home ranges.

Considering the mean movement and mean maximum dispersal, hens marked as subadults were the most mobile sex and age class. This coincides with earlier investigations by Ellis and Lewis (1967) and Fleming and Speake (1976).

The greatest difference in average dispersal distance between hens captured as subadults and gobblers captured as subadults occurred during the second plus observation year (i.e. as adults). Hens captured as subadults increased their distance from capture site an average of 2.7 km and subadult gobblers increased their distance only 0.6 km. The increase was significant ($P < 0.05$) for only the hens. We believe the increased movement after the hens were adults may have been an attempt to find less crowded conditions for reproduction. The reduction in the gobbler population by harvest may have provided niches for the gobblers; thus, movement to find less crowded conditions was less for gobblers.

At least some of the 149 (64%) turkeys which were unaccounted for moved off the study area with some traveling at least 26 km from the study area. Some probably died on the study area but were not found. The chances of finding the remains of a wing-marked turkey on the study area were remote.

Even though the gobbler harvest reached 2.5/$km^2$ during the 1971-1972 hunting season, the loss of gobblers from the population was similar to that observed for hens. We believe that an increase in the hen harvest would take birds which would be lost from the population either through egress or natural mortality.

Subadult hens reproduced as well as adult hens. However, in only 1 of 5 years did subadult hens produce poults. Further study is needed in this eastern population to adequately address the contribution of subadult hens to the total poult production.

## CONCLUSIONS

The major past efforts of researchers and managers concerned with eastern turkeys have been primarily establishment and increase of turkey populations to huntable levels. As eastern turkey populations increase, information on the effects of high densities on population dynamics is essential for informed management. This study was a prelude to detailed studies on high density populations. Our study provided these suppositions for an area where the eastern turkey population was unusually high:

(1) The annual loss rate was "normal".
(2) Harvest was an important factor in accounting for more gobblers captured as subadults as compared to hens.
(3) There were slight differences in accountability of age classes when only field sightings were used. There were no marked differential losses (egress and/or natural mortality) between sex and age classes.
(4) Subadults were more mobile than hens captured as adults.
(5) Hens marked as subadults dispersed significantly ($P < 0.05$) further from their capture site as adults than subadults.
(6) For hens marked as adults and gobblers marked as subadults there was no significant ($P > 0.05$) increase in average movement from capture site between the first and second plus year of observation.
(7) Based on the loss rate of hens and gobblers from a population sustaining a high gobbler harvest, additional hens could be removed (harvest or relocation) without adverse effects on the population.

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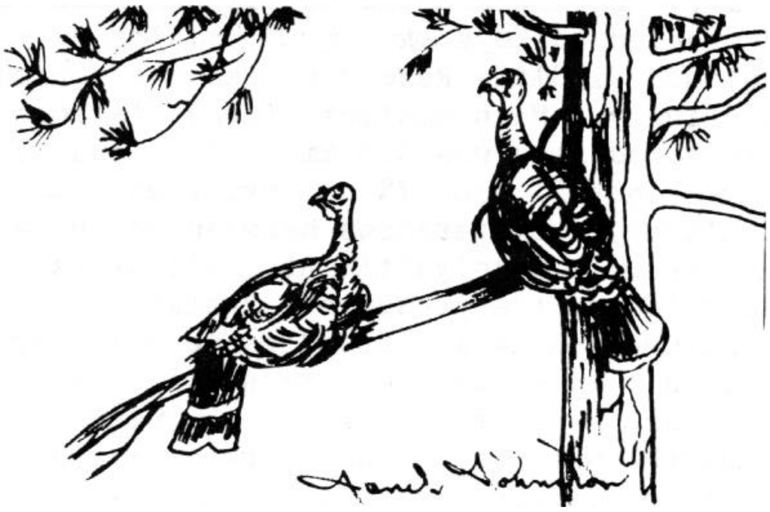

# MOVEMENTS AND MORTALITY OF PEN RAISED WILD TURKEYS RELEASED ON A HUNTING PRESERVE

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*Abstract:* Spring and summer minimum home ranges of radiotelemetry instrumented turkeys *(Meleagris gallopavo silvestris)* released at Rachelwood Wildlife Research Preserve averaged 288 ha and 309 ha respectively. Mean maximum linear distance traveled for 6 instrumented hens was 3.0 km. Fifty and 75% areas of activity averaged only 21 and 47% of spring and summer range size, respectively. Differences between spring and summer range sizes and movements were nonsignificant. All nests of instrumented hens were located inside the preserve. Predators destroyed five or six nests of instrumented hens. Brood range size for one hen was very restricted and did not increase over the summer. Between 1972 and 1975, only 14% of all leg bands from turkeys returned to Rachelwood were recovered outside the preserve. Considerations found to be important in evaluating dispersal of wild turkeys were: (1) availability of supplemental feed within a turkey's seasonal range, (2) amount and arrangement of favorable turkey habitat inside the preserve, and (3) survival rates of released turkeys.

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Wild turkeys were raised and released at Rachelwood Wildlife Research Preserve, New Florence, Pennsylvania, for sport-shooting and perpetuating a self-sustaining, wild flock within the preserve. Developing a self-sustaining, huntable population was a major problem. Basic needs were for development of suitable habitat necessary to retain turkeys released within the preserve and to enhance survival and production.

Rachelwood's turkey population consisted of "established" birds (survivors of past years' releases and their progeny), plus an autumn increment of 200 to 400 pen-raised juveniles and possibly native birds from surrounding areas. Turkeys have been raised and released annually at Rachelwood since the preserve was enclosed in 1951. Initially, turkeys were produced at Rachelwood from captive breeding stock; thebreeding program was terminated in 1973. Turkeys recently were obtained as day-old poults from the Pennsylvania State Wild Turkey Farm and pen-raised until their banding and release as 12 to 16 week old juveniles. A supplemental feed mixture of shelled corn, oats, molasses, and vitamin-mineral supplements was available to turkeys the entire year. This ration was distributed 3 to 4 times per week to about 125 feeders located throughout the preserve. Study objectives included determination of minimum spring and summer home ranges of pen-raised wild turkeys released within Rachelwood Wildlife Research Preserve and evaluation of turkey movements and survival.

Appreciation is extended to A. Woolf and R. Sapalio for their guidance and assistance in this study, which was supported by a research grant from Rachelwood Wildlife Research Preserve. The Pennsylvania Game Commission, Southwest Division Office, also provided assistance in accomplishing study objectives.

## STUDY AREA

Rachelwood Wildlife Research Preserve is a 2,105 ha area in Westmoreland County, Pennsylvania. The preserve was enclosed by a 2.4 m high woven steel wire fence with a 0.6 m barbed-wire overhang. The 96 km of dirt and gravel roads throughout the preserve provided easy access to all areas. The forest at Rachelwood was in a widespread state of decadence characterized by a closed canopy, a pronounced browse line, minimal forest regeneration, and negligible understory vegetation. The relatively poor condition of the forest was primarily the result of an overabundance of wild ungulates, which included approximately 1,500 white-tailed deer *(Odocoileus virginianus),* 200 mouflon sheep *(Ovus musimom),* 50 elk *(Cervus elaphus canadensis),* and 10 to 20 red deer *(Cervus elaphus elaphus).*

## METHODS AND MATERIALS

This study was conducted from January through September 1977. Turkeys were captured during early spring using double-entrance, baited box traps and wire mesh, funnel-entrance "walk-in" traps. Thirteen juvenile turkey hens were weighed and fitted with radio transmitter packages upon capture. Radio transmitters were harnessed to the birds' backs with plastic sheathed wire neck loops and surgical tubing wing loops. Each transmitter weighed 126 g and operated on an individual frequency between 151.500 MHz and 151.425 MHz. All monitored transmitters operated continually throughout the 7 months observation period. Telemetric location by triangulation of each radio-instrumented hen was established approximately 3 times per week from March through June and once per week from July through September. At the outset of the study, visual observations, following initial telemetric location, verified telemetric locations to be within 25 m of a turkey's actual position. Spring and summer minimum home ranges were determined for each instrumented hen using the "minimum home range" method (Dalke and Sine 1938). Maximum linear distance traveled (Stickel 1954), center of activity, activity radius (Hayne 1949), and 50 and 75% areas of activity were computed for each instrumented hen. Maximum linear distance traveled from the center of activity, distance from the center of activity to the nearest supplemental feed source, and number of feeders in each home range and area of activity also were computed. Band recovery records for turkeys from Rachelwood releases were analyzed for the period 1972 through 1975 to estimate percent recoveries from outside the preserve and distance of recovery from the preserve.

## RESULTS

Spring and summer minimum home ranges and maximum linear distances traveled were compared for 6 juvenile turkey hens (Table 1). Home range and movement calculations were not performed for all 13 instrumented hens due to predation losses or transmitter failures. Minimum spring and summer ranges were determined from an average of 64 and 91 days of observations, respectively. Spring and summer range sizes for 6 hens did not differ significantly ($t = 0.332$, $P = 0.75$). Maximum linear distances traveled for 6 juvenile hens for spring and summer were not significantly different ($t = 0.209$, $P = 0.84$) and averaged 3.0 km and 3.1 km, respectively (Table 1).

The center of activity was determined for 6 spring and summer ranges. Maximum linear distance traveled from the center of activity and the activity radius were computed for each spring and summer range (Table 1). Comparison of the activity radius with maximum distance traveled from the center of activity indicated the general shape of the seasonal range (Hayne 1949). Mean difference between the two values was 1.07 km (spring) and 0.98 (summer).

Areas of activity, those including 50 and 75% of all observations, were compared for spring and summer ranges. The size of the areas of activity for spring and summer did not differ significantly ($t = 0.381$, $P = 0.71$, 75%; $t = 0.145$, $P = 0.89$, 50%). Although these areas represented a majority of all observations, they were areas of only 22 and 47% of the spring range size and 20 and 44% of the summer range size, respectively (Table 1). These areas did not remain fixed, but varied with season.

The distance from the center of activity to the nearest supplemental feeding area and the number of feeders in the 50% area of activity, 75% area of activity, and total seasonal range (Table 1) were compared for 6 instrumented turkey hens for spring and summer to examine the significance of supplemental feed as it might affect the size of the range and areas of activity. The mean distance from the center of activity to the nearest feeder was 390 m (spring) and 410 m (summer). The number of feeders in each area for spring and summer averaged 4 and 3 for the 50% area of activity, 10 and 8 for the 75% area of activity, and 18 and 16 for the seasonal range. Distance from the center of activity to the nearest feeder for 6 hens did not differ significantly ($t = 0.088$, $P = 0.96$) for spring and summer. It could not be shown that the number of feeders in the seasonal range and areas of activity of 6 hens differed significantly ($P > 0.50$ for all areas) for spring and summer.

Table 1. Means and standard error for seasonal range, center of activity, and movement data for 6 radiotelemetry instrumented turkey hens, March through September, 1977, Rachelwood Wildlife Research Preserve, New Florence, Pennsylvania.

| | Spring | | Summer | |
|---|---|---|---|---|
| | $\bar{X}$ | Standard error (±) | $\bar{X}$ | Standard error (±) |
| Minimum range (ha) | 288 | 51 | 303 | 39 |
| Linear distance traveled (km) | 3.0 | 0.5 | 3.1 | 0.3 |
| Maximum linear distance traveled from center of activity (km) | 1.8 | 0.3 | 1.8 | 0.3 |
| Activity radius (km) | 0.7 | 0.1 | 0.8 | 0.1 |
| 50% area of activity | | | | |
| size (ha) | 63 | 15 | 60 | 19 |
| % of range | 22 | -- | 20 | -- |
| 75% area of activity | | | | |
| size {ha) | 144 | 32 | 130 | 19 |
| % or range | 50 | -- | 44 | -- |
| Distance from center of activity to nearest feeder (m) | 390 | 100 | 410 | 140 |
| number of feeders | | | | |
| 50% area of activity | 4 | -- | 3 | -- |
| 75% area of activity | 10 | -- | 8 | -- |
| seasonal range | 18 | -- | 16 | -- |

Egress, or dispersal from the managed area, associated with pen-raised turkeys has been observed to some extent among Rachelwood's released birds. Only 14% of all band returns for the years 1972 through 1975 came from outside the preserve. Recovery distances were estimated for all bands returned from outside the preserve between 1972 and 1975. Twenty-eight percent of these returns came from within 100 m or less of the preserve fence. Except for brief periods spent just outside the preserve fence, all-instrumented hens, but one, remained inside the preserve during the study period.

Six instrumented turkey hens nested in the preserve during the study. All hens nested in the lower topographic areas of the preserve. Five of 6 nests were located within an area of about 75 ha and were within an average of 470 m from each hen's respective center of activity. Five nests were located in relatively exposed situations and were destroyed by predators. Additional data for nesting success and productivity are reported elsewhere (Brown 1978). Following hatching, daily movements of one instrumented hen and its brood were often restricted to 12 ha or less during summer. This brood flock remained in an area of 26.5 ha during the entire summer.

An average of 50% of turkeys banded and released at Rachelwood between 1972 and 1975 were recovered (Table 1). Although not all bands from dead birds were recovered, this indicates a survival rate of only 50%. Average densities at Rachelwood ranged from as many as 25 birds per $km^2$ in winter following autumn releases to as few as 5 birds per $km^2$ the following summer.[1]

## DISCUSSION

The mean spring and summer range sizes (Table 1) calculated for instrumented turkey hens were about the average reported for the species (Lewis 1963, Raybourne 1968, Barwick and Speake 1973, Hillestad 1973, Fleming 1975, Speake et al. 1975, Porter 1977). Seasonal range sizes varying from 79 ha (Hillestad 1973) to 683 ha (Lewis 1963) have been reported for turkeys. Ellis and Lewis (1967) found the average annual range of free-ranging hens in Missouri was 448 ha. Davis (1973) reported an average annual range of only 111 ha for 13 adult hens in Alabama. The average annual range for juvenile hens was 101 ha. The largest area utilized by a juvenile hen was 208 ha. Calculated dispersal distances of turkeys (Table 1) also were similar to those reported in the literature (Ellis and Lewis 1967, Raybourne 1968, Speake et al. 1969, Barwick and Speake 1973.

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[1]Unpublished Rachelwood Wildlife Research Preserve data.
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Fleming 1975, Porter 1977). In Nebraska, Hurt et al. (1973) found the average movement of color-marked turkeys from trap sites was 3.0 km for adults and 6.8 km for juveniles. Dispersal distances of 1.5 km to 4.2 km have been reported for turkeys in Alabama (Hillestad 1973, Davis 1973, Speake et al. 1975).

The mean difference between the maximum distance traveled from the center of activity and the activity radius for spring (1.07 km) and summer (0.98 km) indicated seasonal ranges of generally elliptical proportions. Davis (1973) stated that an area managed for wild turkeys should contain at least 250 ha with a long axis of about 2.4 km and a short axis of about 1.6 km.

Six instrumented turkey hens were monitored throughout the study period. Four of these hens nested. All 6 hens began the summer broodless, and no hen renested. Mosby and Handley (1943), Schorger (1966), Korschgen (1967) and Williams et al. (1968) stated that, during the incubation period, the hen seldom goes far to feed and water. Having selected suitable brood rearing range, the hen usually remains in the vicinity until the poults are well-developed. Because the nesting hen is behaviorally and physiologically bound to the nest during incubation, it was assumed that nesting activities would limit spring range size and movements, while summer range size and movements of broodless hens would be unaffected. Summer range sizes and movements would therefore be naturally greater than spring range sizes and movements, unless the presence of supplemental feed in the study area exerted a stronger influence on turkey movements than did mating, nesting and brooding.

Spring and summer range sizes did not differ significantly for 6 instrumented hens that nested but began the summer broodless. This indicated that the overall effect of feeders, based upon observation points, was a tendency to concentrate turkey movements in an area providing a sufficient number of feeders for daily feeding activities. This concentration of activity resulted in a decrease in seasonal movements away from supplemental food supplies. Davis (1949) reported that turkeys generally do not feed in the same area on successive days, and that birds make a circuit, even when the area is rather restricted. Korschgen (1967) stated that the size of the area and the place over which the turkey wanders is governed by the food supply. Turkeys generally have shifts in location between seasonal ranges, but when food is abundant, they may spend the entire year on the same range.

It was assumed that if the presence of supplemental feed exerted an effect on home range, it would be to reduce the size of seasonal ranges and areas of activity. Dasmann (1964) stated that for many animal species, movements are much more restricted than those expected from consideration of the animal's apparent mobility. Frequently, much of its activity will center around some favored feeding ground. Feeders at Rachelwood were located along main trails for ease of feed distribution and were not uniformly distributed throughout the preserve. These feeders appeared to have a direct effect upon the center of a turkey's activity. The close proximity of feeders to the center of activity ($\overline{X}$ = 390 m, spring; $\overline{X}$ = 410 m, summer) for 6 instrumented hens tended to substantiate the idea that feeders did affect turkey movements in and around the preserve. Five instrumented hens had at least 11 feeders within their spring and summer ranges. In a majority of cases (67%, spring; 83%, summer) there were at least 8 feeders within the 75% area of activity. Rundquist (1973) found that nearly all movements of pen-raised turkeys on a hunting preserve in Illinois were to supplemental feeding areas. The extent of movement depended largely on the presence of readily available supplemental feed.

The need for providing an additional food source to supplement natural food supplies, and its results, have been strongly debated by managers of turkey populations. Provision of supplemental feed at Rachelwood was not an issue of major concern because feed must be provided to support the high density ungulate populations found on the preserve (Schenbeck 1975). This feed, although not directly distributed for turkey management, was available to turkeys in several types of box feeders throughout the year. The large percent of corn (55.6) and oats (37.1) provided needed nutrition for turkeys. Although agricultural crops have not been found to comprise a major part of the turkey's diet, Glover and Bailey (1949) found that about 90% of corn and 40% of oats were utilized physiologically by turkeys.

Because of the ungulate feeding program, provision of feed specifically for turkeys was not an issue concerning Rachelwood's turkey management. However, other possible methods of supplementing natural turkey foods should be considered. Data showing the importance of supplemental feed in limiting turkey movements in a small, intensively managed area are supported by findings of other studies. Food plantings serve to localize wild turkey flocks by making food available within the management area (Mosby and Handley 1943). Supplemental plantings of various foods are often necessary to sustain high populations and to aid in controlling turkey movements (Stoddard 1963). Dreis et al. (1973) stated that planting of food patches was the only land management effort that could benefit turkeys on the Meadow Valley Wildlife Area in Wisconsin. Rundquist (1973) found that most turkey movements on a hunting preserve in Illinois depended on the availability of supplemental feed. He believed that dispersal could be reduced by providing supplies of supplemental feed on the preserve and by fencing the preserve. Landowners in Texas had success in holding wild turkeys in an area through supplemental feeding (Walker 1951). Providing supplemental feed throughout the year appeared to have kept Rio Grande turkeys on marginal range (Glazner 1967). Ellis and Lewis (1967) also believed that turkey movements could be restricted by providing supplemental winter feed.

In addition to the supplemental feed at Rachelwood, other habitat requirements which act to reduce dispersal tendencies of turkeys are found throughout small portions of the preserve. These include well interspersed grassy openings, conifer stands along numerous drainages, and extensive mast producing hardwood stands (Mosby and Handley 1943, Kozicky and Metz 1948, Stoddard 1963, Speake et al. 1975). The major habitat characteristic lacking at Rachelwood is early successional undergrowth vegetation for natural food and escape cover. Acceptable turkey range may be developed in any area through intensive management for some factors (Stoddard 1963). Because Rachelwood existed primarily as a wildlife research institute and private hunting preserve, intensive management for specific turkey requirements that were lacking could prove useful and practical in establishing a productive turkey population on the preserve.

Recovery distances of bands returned from outside the preserve varied extensively. The highest percentage of returns came from within 100 m or less of the preserve fence, and 43% came from within 2 km or less of the fence. The majority of turkeys released at Rachelwood dispersed up to 3 km from release points, but still remained inside the preserve.[2] Fifty-five percent of banded turkeys in Florida were recovered within 1.6 km of release points up to 3 years following banding (Powell 1967).

Six instrumented hens nested inside the overbrowsed preserve in 1977 despite the availability of dense cover just outside the preserve. Five of these nesting attempts were unsuccessful. Mosby and Handley (1943) found that restocked, wild turkeys showed a tendency to nest in more exposed situations than did native wild hens. In Florida, even though dense understory was available to nesting hens, 3 of 21 hens nested in relatively exposed situations (Williams et al. 1968). In Pennsylvania, liberated, game-farm hens showed an inability to select safe nesting sites and to remain secretive during laying and incubating periods (Latham 1956). Rundquist (1973) found that pen-raised hens on a hunting preserve nested in comparatively exposed situations. All nests were destroyed accidentally by human activity or by predators or were deserted.

Data from this study indicated limited dispersal of turkeys from Rachelwood Wildlife Research Preserve. This was evidenced by: (1) the low percentage of turkey bands recovered from outside the preserve between 1972 and 1975 (2) the number of bands recovered from within 100 m outside the preserve fence, (3) the overall restricted size of seasonal ranges and distances traveled of instrumented

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turkeys, (4) the extremely restricted size of the brood rearing range of one instrumented hen, (5) selection of nesting sites inside the preserve by instrumented hens, and (6) restriction of daily and seasonal activities to the preserve by instrumented hens.

Rachelwood's pen-raised turkeys were highly susceptible to predation. The supplemental feeding program attracted large numbers of small mammals to the preserve. Presence of many small mammals attracted large numbers of mammalian and avian predators. An average of 50% of turkeys banded and released at Rachelwood between 1972 and 1975 have been recovered. This indicates a minimum mortality of about 50%. Five of 13 instrumented turkeys were found dead during the study and 2 others were not recovered. Total, minimum mortality for turkeys released in 1975 at Rachelwood was 44%.[3] Over half of the recovery came from birds harvested inside and outside the preserve. Harvests within the preserve accounted for 21% of the total release. Survival rates for cohort releases for 1972, 1973, and 1974 of only 39, 15, and 11% respectively were reported for Rachelwood's released birds. Mortality rates of 8, 13, and 22% were recorded immediately following release on the preserve of small groups of turkeys. Markley (1967) stated that pen-raised turkeys generally showed a poor survival and establishment record. Leopold (1944) reported that survival and establishment of hybrid stock, even under protected conditions, was only 23% the first year following release. In Virginia, winter survival was only 47.5% among 16-week-old turkeys released the previous fall (Mosby and Handley 1943). Mortality rates of pen-raised birds released on a hunting preserve during a 2-year period were 97 and 92% respectively (Rundquist 1973). Hardy (1959) reported a 22% loss of game-farm turkeys within a few days following release. In one case, 23 of 30 birds released were dead within 2 days.

## MANAGEMENT RECOMMENDATIONS

Because of its unique character, Rachelwood Wildlife Research Preserve lended itself to intensive management for a huntable population of wild turkeys. Both dispersal and survival of released turkeys was low, and therefore releases could be timed to coincide with primary harvest dates. Intensive management to increase survival and productivity of released turkeys seems needed at Rachelwood. Further studies should be conducted to determine the effects of predation and disease on population growth and survival

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of the Rachelwood turkey flock. Additional information on dispersal rates of turkeys from Rachelwood is needed for any intensive management to proceed.

To sustain a huntable population over time, it may be necessary to plant and fence food and cover plots to enhance survival and productivity. Bailey and Rinell (1967) believed that habitat improvement is, or should be, the primary objective of all turkey management efforts. Mosby and Handley (1943) believed that the principal value of food plots was to obtain an even distribution of turkeys and to prevent them from moving beyond the boundaries of the managed area. Supplemental feed, such as that provided at Rachelwood may be a short-term method of reducing dispersal from the range until improvement is completed. As use of supplemental feeding areas is reduced, mortality from disease and predation also may decrease, while dispersal still would be limited by availability of food plantings.

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