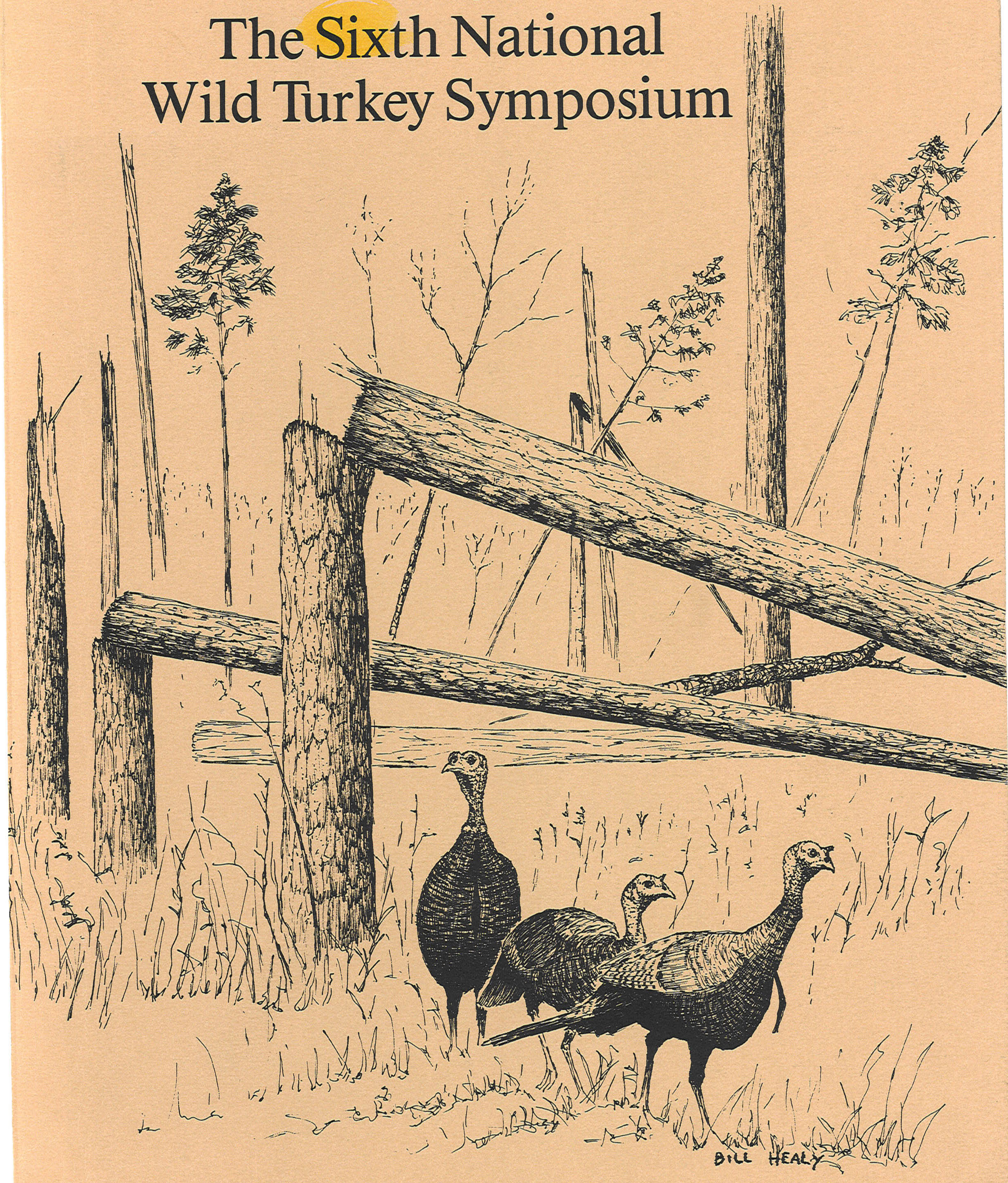
Proceedings of

The Sixth National Wild Turkey Symposium



PROCEEDINGS OF THE
SIXTH NATIONAL WILD TURKEY SYMPOSIUM

26 February - 1 March 1990

Charleston, South Carolina

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FORWARD

The first National Wild Turkey Symposium was held in Memphis, Tennessee in 1959, and the second was held in Columbia, Missouri in 1970. Since then, Symposia have been held at 5-year intervals. Proceedings have been published for all of the Symposia, and except for the second, they are cited as a series. The second Symposium was published by the University of Missouri Press in 1973 and titled "Wild Turkey Management, Current Problems and Programs." Copies of all National Wild Turkey Symposia, including the second, can be obtained from the National Wild Turkey Federation, Edgefield, South Carolina.

The technical sessions at the sixth Symposium were enhanced by a trip to the Francis Marion National Forest to observe one of the oldest turkey management areas in the country and the devastation caused by Hurricane Hugo in September 1989. The FMNF Wildlife Preserve was established by Presidential Proclamation in 1948 and occupies about 19,000 ha of excellent wildlife habitat. The preserve has been managed cooperatively by the U.S. Forest Service and the South Carolina Wildlife and Marine Resources Department.

Part of the preserve, the Waterhorn Tract, is particularly significant to the history of wild turkey restoration. This area contains one of the purest strains of eastern wild turkey in the South, and it served as the source for restocking the Piedmont and mountains of South Carolina. It was also the area where H.L. "Duffy" Holbrook perfected the cannon-netting technique for capturing turkeys, and ushered in the modern era of turkey restoration. Much of the mature timber was blown down during Hurricane Hugo, but the turkeys seem to have taken the change in stride. We thank Duffy Holbrook, Jack Alcock, and the National Forest staff for an informative and enjoyable field trip.

Many people helped make the Symposium a success: Symposium Chairman John E. Frampton and Co-Chairman Dave Baumann; Conference Committee members Drenia Corley, Sharon Harsey, Bill Mahan, Debbie Owens, Tom Swayngham, Pete Swiderek, Donna Swygert, and Alvin Wright; Program Committee members Dave Baumann (Chairman), Sam Beasom, Jim Dickson, Bill Healy, James Earl Kennamer, Dick Kimmel, John Lewis, Terry Little, Curtis Taylor, Larry Vangilder, Ron Engel-Wilson, Jerry Wunz, and Bill Zeedyk. We thank the authors for their hard work, cooperation, and patience. All manuscript reviewers provided thorough, thoughtful, and courteous comments, making our job easier and improving the quality of the Proceedings. The Program Committee evaluated the preliminary abstracts and arranged the program. The Northeastern Forest Experiment Station and the University of Massachusetts, Department of Forestry and Wildlife Management, provided office support. The National Wild Turkey Federation is the publisher and distributor of the Proceedings, and we thank James Earl Kennamer and Mary C. Kennamer of NWTF for their advice and help.

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CURRENT STATUS AND DISTRIBUTION OF THE WILD TURKEY, 1989

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Abstract: The wild turkey *(Meleagris gallopavo)* population in the United States and Canada is estimated to be 3.5 million. That's about 1 million more than estimated in 1986 and about 3 million more than recorded by Henry Mosby at the first National Wild Turkey Symposium in 1959. When states that gave no estimate are accounted for, the total population approaches 4 million. Turkeys are found in every state except Alaska; 47 of the 49 states have huntable turkey populations. All 49 states with wild turkey populations plan to have a spring wild turkey hunting season by the year 1991. Restocking programs are complete in 12 states, and 16 other states predict completion by 1995. All suitable turkey habitat should be restocked by the year 2000.

The wild turkey is on a roll. The outlook is so positive that biologists predict all suitable wild turkey habitat will be stocked with wild-trapped birds of the appropriate subspecies by the year 2000.

According to H. S. Mosby, who spoke on the status and distribution of the wild turkey at the first National Wild Turkey Symposium in 1959, "...twenty years ago [1938] it was thought that the bird was doomed to extirpation" (Mosby 1959:1). Significant state and national legislation, including protection, increased interest by hunters/sportsmen, a concerted restocking effort by state wildlife agencies, combined with dramatic changes in wildlife management technology have made the difference in the comeback.

The 1930s were years of positive improvement in the field of wildlife management. Aldo Leopold wrote "Game Management" in 1933, the Cooperative Wildlife Research Units were established in 1935, President Franklin D. Roosevelt convened the first National Wildlife Conference (now known as the North American Wildlife Conference) in 1936, and the Pittman-Robertson Act was passed in 1937. Wild turkey populations during this period had retreated to areas not readily accessible to humans.

Since 1940 turkey populations and the area of occupied range have increased substantially (Mosby 1959, 1973, 1975; Bailey 1980; Kennamer 1986). State restoration programs, using birds caught from wild populations, are largely responsible for the re-establishment and expansion of the range of wild turkeys. We describe the distribution of wild turkeys in the United States in 1989. We also provide estimates of turkey populations, harvests, and numbers of hunters; information on methods used to estimate populations and harvest; and the status of state restoration programs. Additionally, we compare occupied range in 1979 and 1989, as well as 1979 predicted potential turkey population numbers with 1989 population estimates.

We sincerely thank the following members of the National Wild Turkey Federation (NWTF) Technical Committee who provided the respective state information: G. Widder, Alabama; R. Engel-Wilson, Arizona; R. Smith, Arkansas; J. Massie, California; R. Hoffman, Colorado; D. May, Connecticut; K. Reynolds, Delaware; N. Eichholz, Florida; R. Thackston, R. Simpson, and T. Holbrook, Georgia; T. Lum (representing R. Walker), Hawaii; T. Hemker, Idaho; J. Garvey, Illinois; S. Backs, Indiana; D. Jackson, Iowa; K. Sexson, Kansas; G. Wright, Kentucky; D. Timmer, Louisiana; P. Bozenhard, Maine; J. Sandt, Maryland; J. Cardoza, Massachusetts; J. Urbain, Michigan; G. Nelson, Minnesota; B. Herring and E. Hackett, Mississippi; L. Vangilder, Missouri; S. Knapp, Montana; K. Menzel, Nebraska; S. Stiver, Nevada; T. Walski, New Hampshire; B. Eriksen, New Jersey; D. Sutcliffe, New Mexico; D. Austin, New York; M. Seamster, North Carolina; L. Tripp, North Dakota; L. Culbertson and B. Stoll, Ohio; R. Smith and R. Masters, Oklahoma; K. Durbin, Oregon; G.

Wunz and B. Drake, Pennsylvania; J. Chadwick, Rhode Island; D. Baumann, South Carolina; L. Rice, South Dakota; J. Murrey, Tennessee; D. Wilson and J. Campo, Texas; J. Roberson, Utah; S. Darling, Vermont; G. Norman, Virginia; D. Blatt, Washington; C. Taylor, West Virginia; E. Frank, Wisconsin; and H. Harju, Wyoming.

METHODS

Data were obtained from members of the NWTF Technical Committee. The NWTF Technical Committee is made up of biologists responsible for wild turkey programs from each state. Since the formation of the technical committee, this group of biologists has been the source of information concerning the wild turkey in the various states (Kennamer 1986).

In fall 1989 committee members completed questionnaires about the status of turkeys in their states and provided state maps showing the distribution of turkeys at the county level. The information was traced from the individual state maps to form a composite national map. The NWTF has compiled information provided by the committee members to determine the nationwide status of the wild turkey.

RESULTS

Distribution

Wild turkeys are found in every state except Alaska, including 10 states outside the ancestral range, or, turkeys in 49 states compared to 37 states in 1959. The map (Fig. 1) indicates the distribution of the wild turkey by subspecies, including hybrid populations. Significant changes have occurred since the distribution map was compiled by Bailey (1980). Further changes were indicated by Kennamer (1986) as states increased their restoration and stocking programs.

Bailey (1980) compiled data on 36 states, which indicated 505,565 square miles of occupied range. In Kennamer (1986) 45 states indicated occupied range had increased to about 542,000 square miles. Data collected in 1989 estimate the occupied range at 553,000 square miles in 44 states. Occupied range has increased in 30 states over previous figures. The greatest expansions have taken place in 21 states, most notably Georgia, Illinois, Indiana, Maine, Michigan, Minnesota, New Jersey, New York, North Dakota, Ohio, Tennessee, Vermont, Wisconsin, and Wyoming (Table 1).

Rhode Island and Delaware were the last 2 states within the historic range to re-establish turkey populations. The last state in historic range to re-establish a spring wild turkey season is Delaware, which will reopen in 1991.

Populations

There are an estimated 3.5 million wild turkeys in the United States and Canada, 43 states and 3 provinces reporting (Table 2). That's 3 million more than the population estimate for 37 states reported at the first Symposium (Mosby 1959). The estimate is almost 1 million more wild turkeys than estimated in "Guide to the American Wild Turkey" (Kennamer 1986).

Bailey (1980) included "population potential" in his data compiled on the 4 hunted subspecies. He said that 29 states estimated their total population potential at 2.2 million, about 0.4 million higher than the 1979 population of 1.8 million. Figures compiled from 49 states in 1989 indicate most states have surpassed their predicted potential (Table 3). Eighteen states showed at least a 13% growth in 1989 population estimates over Bailey's (1980) predicted population potential.

This is the first time that estimates for the Gould's turkey *(M. g. mexicana)* have been included in the overall figures presented at a national symposium. Their numbers are under 200, and the subspecies is not hunted in the United States.

Over 15 states reported significant population growth compared with the 1986 figures. Iowa, Michigan, North Dakota, South Carolina, and Wisconsin are notable for their increases. Oklahoma and Virginia are the only states indicating population declines (Table 4).

Forty-two states have systematic ways of making population estimates. Some states use more than 1 technique to arrive at wild turkey population estimates, and 6 states do not make population estimates (Table 5).

Fig. 1. Occupied range of wild turkeys in the United States, 1989 (none in Alaska).

Table 1. Comparison of occupied range (square miles[a]) of wild turkeys in the U. S. between 1979 and 1989.

State	Source: Bailey 1980	Source: Kennamer 1986	Source: This report 1989
Alabama	32,000	31,250	~35,000
Arizona	9,900	7,180	7,180
Arkansas	25,000	27,000	22,301
California	13,000	16,000	9,000
Colorado	6,800	<15,000	12,000
Connecticut	5,000	2,800	3,300
Delaware	[b]	75	200
Florida	Unknown	35,000	26,500
Georgia	8,000	17,200	22,000-23,000
Hawaii	90,000 *[sic]*	200	Unknown
Idaho	1,400	Unknown	Unknown
Illinois	500	1,300	2,500
Indiana	2,000	2,500-3,000	10,000
Iowa	1,200	1,800	2,196
Kansas	20,500	4,830	Unknown
Kentucky	10,000	2,000	~8,000
Louisiana	8,500	10,000	15,000
Maine	40	580	750
Maryland	1,200	1,300	1,400
Massachusetts	1,100	2,375	3,300
Michigan	5,000	5,000	22,047
Minnesota	500	2,118	3,500
Mississippi	26,000	Unknown	33,750
Missouri	20,100	22,000	21,581[c]
Montana	5,100	10,000	5,000
Nebraska	2,100	1,200	1,200
Nevada	120	Unknown	200
New Hampshire	1,000	2,000	3,120
New Jersey	180	1,900	2,300
New Mexico	[b]	14,904	15,000
New York	20,000	28,000-30,000	46,408
North Carolina	5,500	10,680	12,000
North Dakota	800	1,000	11,000
Ohio	1,600	3,300	6,280
Oklahoma	1,000	44,800	24,800
Oregon	2,000	5,100	Unknown
Pennsylvania	15,000[c]	25,000	25,000
Rhode Island	0	350-400	350-400
South Carolina	6,200	12,000-14,000	16,000-18,000
South Dakota	3,500	5,500	5,800
Tennessee	2,100	9,000	13,082
Texas	134,200	125,000	Unknown
Utah	[b]	1,000	2,000
Vermont	3,000	5,700	6,750
Virginia	1,800	Unknown	23,589
Washington	2,500	Unknown	5,000
West Virginia	10,000	18,500	22,884
Wisconsin	125	4,000	23,000
Wyoming	[b]	2,500	18,358
Total square miles	505,565	538,942-542,992	550,626-553,676

[a]To convert square miles to square kilometers, multiply by 2.5901.
[b]State did not indicate any occupied range.
[c]Woodlands only.

Table 2. Population estimates of the wild turkey in the U.S. and Canada determined by state agency and province wild turkey project leaders, 1989.

State	Estimate	Subspecies[a]
Alabama	>350,000	Eastern
Arizona	No estimate	Merriam's
	<50	Gould's
Arkansas	100,000	Eastern
California	400	Merriam's
	100,000	Hybrid
Colorado	No estimate	Merriam's
	<1,500	Rio Grande
Connecticut	6,000	Eastern
Delaware	600	Eastern
Florida	75,000	Florida
	25,000	Intergrade
Georgia	325,000	Eastern
Hawaii	No estimate	Rio Grande
Idaho	<100	Eastern
	300	Rio Grande
	3,000	Merriam's
Illinois	35,000	Eastern
Indiana	30,000	Eastern
Iowa	>100,000	Eastern
Kansas	No estimate	Rio Grande
		Eastern
		Hybrid
Kentucky	>20,000	Eastern
Louisiana	35,000	Eastern
Maine	500-700	Eastern
Maryland	10,000	Eastern
Massachusetts	8,000-10,000	Eastern
Michigan	60,000	Eastern
Minnesota	18,000	Eastern
Mississippi	>350,000	Eastern
Missouri	350,000-400,000	Eastern
Montana	No estimate	Eastern
		Merriam's
Nebraska	15,000	Merriam's
	15,000	Hybrid
	100	Eastern
	100	Rio Grande
Nevada	800	Rio Grande
	<100	Merriam's
New Hampshire	2,500	Eastern
New Jersey	5,000-5,500	Eastern
New Mexico	1,000	Rio Grande
	28,900	Merriam's
	100	Gould's
New York	>65,000	Eastern
North Carolina	20,000	Eastern
North Dakota	11,000	Eastern
	2,000	Merriam's
	1,000	Hybrid
Ohio	32,000	Eastern
Oklahoma	>16,000	Eastern
	50,000	Rio Grande
	35-50	Merriam's
Oregon	No estimate	Eastern
		Rio Grande
		Merriam's
Pennsylvania	160,000-175,000	Eastern
Rhode Island	500-600	Eastern
South Carolina	70,000-80,000	Eastern
South Dakota	1,000	Rio Grande
	28,000	Merriam's
	1,000	Hybrid
Tennessee	60,000	Eastern
Texas	579,012	Rio Grande
	3,000	Eastern
Utah	<500	Rio Grande
	<1,500	Merriam's
Vermont	12,000-15,000	Eastern
Virginia	75,000	Eastern
Washington	400	Eastern
	2,500	Rio Grande
	1,800	Merriam's
	300	Hybrid
West Virginia	80,000	Eastern
Wisconsin	60,000	Eastern
Wyoming	15,000-20,000	Merriam's
	150	Hybrid
U.S. total	**3,420,747-3,506,562**	
Canada		
Alberta	>700	Merriam's
Manitoba	2,000	Merriam's
Ontario	6,845	Eastern
Canada total	9,545	
Grand total	**3,430,292-3,516,107**	

[a]Eastern *(Meleagris gallopavo silvestris)*, Merriam's *(M. g. merriami)*, Gould's *(M. g. mexicana)*, Rio Grande *(M. g. intermedia)*, Florida *(M. g. osceola)*, intergrade *(M. g. osceola* x *silvestris)*.

Table 3. Potential wild turkey population numbers as estimated in 1979, estimates of wild turkey numbers in 1989, and the comparison between the two.

State	1979[a]	1989	Comparison
Alabama	250,000	>350,000	Over
Arizona	18,000	No estimate	Unknown
Arkansas	200,000	100,000	Below
California	43,000	100,400	Over
Colorado	15,000	No estimate	Unknown
Connecticut	7,000	6,000	Below
Delaware	b	600	Unknown
Florida	b	100,000	Unknown
Georgia	40,000	325,000	Over
Hawaii	5,000	No estimate	Unknown
Idaho	2,000	3,400	Over
Illinois	10,000	35,000	Over
Indiana	10,000	30,000	Over
Iowa	30,000	>100,000	Over
Kansas	20,000	No estimate	Unknown
Kentucky	50,000	>20,000	Below
Louisiana	50,000	35,000	Below
Maine	500	500-700	Even
Maryland	b	10,000	Unknown
Massachusetts	b	8,000-10,000	Unknown
Michigan	10,000	60,000	Over
Minnesota	8,000	18,000	Over
Mississippi	250,000	>350,000	Over
Missouri	200,000	350,000-400,000	Over
Montana	b	No estimate	Unknown
Nebraska	50	30,200	Over
Nevada	300	900	Over
New Hampshire	7,000	2,500	Below
New Jersey	5,000	5,000-5,500	Even
New Mexico	b	30,000	Unknown
New York	50,000	>65,000	Over
North Carolina	12,000	20,000	Over
North Dakota	6,000	14,000	Over
Ohio	7,500	32,000	Over
Oklahoma	b	66,050	Unknown
Oregon	1,000	No estimate	Unknown
Pennsylvania	120,000	160,000-175,000	Over
Rhode Island	b	500-600	Unknown
South Carolina	35,000	70,000-80,000	Over
South Dakota	16,500	30,000	Over
Tennessee	24,000	60,000	Over
Texas	580,000	582,000	Over
Utah	1,000	<2,000	Over
Vermont	12,000	12,000-15,000	Even
Virginia	100,000	75,000	Below
Washington	3,000	5,000	Over
West Virginia	45,000	80,000	Over
Wisconsin	15,000	60,000	Over
Wyoming	b	15,150-20,150	Unknown
Totals	2,258,850	3,419,200-3,505,000	

[a]From Bailey (1980).
[b]No figures for these states were included in the 1979 estimates.

Table 4. Individual state wild turkey population estimates between 1986 and 1989 with significant changes in populations indicated.

State	1986 estimate[a]	1989 estimate	Change
Alabama	350,000	>350,000	Stable
Arizona	14,000	≥50 Gould's	Stable[b]
Arkansas	75,000-100,000	100,000	Up 25,000
California	100,000	100,400	Up 400
Colorado	10,300-10,400	≤1,500 Rio Grande	Stable[b]
Connecticut	4,000	6,000	Up 2,000
Delaware	200	600	Up 400
Florida	70,000	100,000	Up 30,000
Georgia	150,000	325,000	Up 175,000
Hawaii	6,000	No estimate	Unknown
Idaho	No estimate	3,400	Unknown
Illinois	15,000	35,000	Up 20,000
Indiana	3,000-5,000	30,000	Up 25,000-27,000
Iowa	>40,000	>100,000	Up 60,000
Kansas	45,000	No estimate	Unknown
Kentucky	13,000	>20,000	Up 7,000
Louisiana	18,000	35,000	Up 17,000
Maine	700	500-700	Stable
Maryland	5,000-6,000	10,000	Up 4,000-5,000
Massachusetts	5,000	8,000-10,000	Up 3,000-5,000
Michigan	13,000-15,000	60,000	Up 45,000-47,000
Minnesota	4,000-5,000	18,000	Up 13,000-14,000
Mississippi	>350,000	>350,000	Stable
Missouri	200,000	350,000-400,000	Up 150,000-200,000
Montana	No estimate	No estimate	Stable
Nebraska	25,000	30,200	Up 5,200
Nevada	200	900	Up 700
New Hampshire	1,500-2,000	2,500	Up 500-1,000
New Jersey	>4,500	5,000-5,500	Up 500-1,000
New Mexico	28,040	30,000	Up 1,960
New York	50,000-60,000	>65,000	Up 5,000-15,000
North Carolina	14,000	20,000	Up 6,000
North Dakota	12,000	14,000	Up 2,000
Ohio	>15,000	32,000	Up 16,200
Oklahoma	90,000	66,035-66,050	Down 23,965-23,950
Oregon	No estimate	No estimate	Stable
Pennsylvania	100,000-150,000	160,000-175,000	Up 25,000-60,000
Rhode Island	500-750	500-600	Stable-down 150
South Carolina	30,000	70,000-80,000	Up 40,000-50,000
South Dakota	20,000	30,000	Up 10,000
Tennessee	30,000	60,000	Up 30,000
Texas	300,000-500,000	582,012	Up 82,012-282,012
Utah	<1,000	<2,000	Up 1,000
Vermont	12,000-15,000	12,000-15,000	Stable
Virginia	188,000	75,000	Down 113,000
Washington	2,000	>5,000	Up >3,000
West Virginia	50,000	80,000	Up 30,000
Wisconsin	15,000	60,000	Up 45,000
Wyoming	10,000	15,150-20,150	Up 5,150-10,150
Totals[c]	2,490,740-2,785,590	3,420,747-3,506,562	

[a]Figures based on estimates in Kennamer (1986).
[b]Figures do not reflect population changes for the Merriam's subspecies for which no 1989 estimates were given.
[c]Figures do not reflect any Canadian province turkey populations.

Table 5. Methods used by state agency wild turkey project leaders to estimate wild turkey populations.

State	Population estimation methods
Alabama	Mail survey, brood count survey, county by county visual estimate by biologists.
Arizona	No standardized census in use.
Arkansas	Spring harvest and summer brood survey, stocking evaluations.
California	Local estimations based on occupied range.
Colorado	None.
Connecticut	Public sighting reports, estimates from harvest and survey data.
Delaware	Spring gobbler surveys, general observations by division personnel and public.
Florida	Extrapolation from harvest.
Georgia	Hunter success, brood counts, field personnel estimates.
Hawaii	None.
Idaho	None.
Illinois	Landowner brood survey, hunter success rates, sightings by successful deer hunters during gun season, field personnel estimates.
Indiana	Gobbling counts, hunter success, observation reports.
Iowa	Winter track counts on selected areas, winter concentrations, hunter success, brood counts, field personnel estimates, bag and tag returns.
Kansas	Trend indicator--archery deer hunter survey, rural mail carriers, harvest, turkey hunter report.
Kentucky	Brood survey, harvest data.
Louisiana	Field personnel estimates.
Maine	None at present.
Maryland	Gobbler counts, spring; brood observations, summer; and track counts, winter.
Massachusetts	No census methods employed--population estimate is subjective based on extent of occupied range.
Michigan	Actual winter count and estimated reproduction.
Minnesota	Deer hunter survey, landowner post card survey, registration stations, department sightings, etc.
Mississippi	Not available.
Missouri	Harvest data, hunter success, summer brood survey.
Montana	Monitor individual winter flocks, spring aerial surveys.
Nebraska	Summer brood routes (production indices); winter flock counts.
Nevada	Winter flock count and summer/fall counts.
New Hampshire	Sightings from landowners and hunters; observation/recording of fall/winter flocks; a sample of summer brood production.
New Jersey	Summer brood survey.
New Mexico	Brood counts, field personnel observations, hunter success.
New York	No census conducted. (Population estimates derived from known densities in research and other areas extrapolated by total amount of woodland in state.)
North Carolina	Brood counts, field personnel estimates, winter concentrations, landowner estimates, hunter estimates, bag and tag returns, hunter success, statewide observations, 5-year range and density mapping, mail surveys, gobbling counts.
Ohio	Spring gobbling census; turkey observation reports from cooperators; snow track counts for deer and turkey; analysis of harvest data.
Oklahoma	Summer brood survey and winter flock count.
Oregon	Random observation, hunter reports and reports from other agency personnel, winter concentrations, average complete brood size.
Pennsylvania	Brood counts, fall baiting census, winter track count, reported harvest and small game take harvest survey.
Rhode Island	Field observations, winter concentrations, brood counts.
South Carolina	Brood counts, field personnel estimates, landowner estimates, bag and tag returns.
Tennessee	Harvest survey--mandatory check station and tagging; summer brood survey.
Texas	Rio Grande-hen/poult count, roadside count, winter roost count and gobbler count; eastern-landowner/sportsmen observation cards, rural route post-card survey.
Utah	Brood counts, field personnel estimates, hunter estimates, hunter success.
Vermont	Field personnel estimates, bag and tag returns, wing collections.
Virginia	Mandatory check stations provide harvest data that are used as index to population.
Washington	Gobbling routes, brood surveys, sight frequency, landowner/public contacts, hunter reports, questionnaires.
West Virginia	Harvest trends, brood counts, wingtip data, mast survey.
Wisconsin	Population, density and distribution estimation based upon harvest registration data together with assumed 10% spring population exploitation rate of zones open to hunting; deer hunter survey, new release area observations.
Wyoming	Gobbling routes, brood surveys, sight frequency, landowner/public contacts, hunter reports, questionnaires.
Canada	
Alberta	Landowner survey and public sighting report.
Manitoba	Total count by volunteer members of Wild Gobblers Association of Manitoba.
Ontario	Observation cards, aerial surveys, indirect indices.

Hunting

Forty-seven states had spring turkey hunting seasons in 1990; exceptions were Delaware and Nevada. Twenty years ago Mosby (1973) predicted, "... it is entirely possible that a huntable population may be established in every state of the Union, except Alaska." That prediction will come true in 1991.

Delaware plans to open spring gobbler season in 1991, and Nevada has scheduled its Rio Grande *(M. g. intermedia)* population for a limited permit hunt in 1991. If these events occur, all 49 states with wild turkey populations would have a spring season in 1991 compared with 20 states with spring seasons in 1959. Correspondingly, turkey hunter numbers have increased for both spring and fall seasons from 1987 to 1989. All but 6 states indicate an upward or at least stable trend in the number of turkey hunters (Table 6).

According to state records, over 300,000 wild turkeys were harvested in the most recent spring and about 200,000 birds were taken in the latest fall season. By comparison, the U.S. Fish and Wildlife Service Big-Game Inventory conducted in 1952 (Mosby 1973) showed an annual harvest of just over 47,000 birds. By 1968 that figure had increased to over 128,000 birds compared with over 500,000 birds taken annually by 1989. Harvest data are reported in the majority of states through mail surveys (26 states) and check stations (27 states) (Table 7).

Restoration

Most restocking of the wild turkey should be completed by 2000. Restocking programs are complete in 12 states, and 16 states should have their restocking complete by 1995. Other states have made no projections as to completion dates at this time (Table 8).

DISCUSSION

The wild turkey has made a comeback and shown wildlife managers and researchers it is adaptable and can be restocked to its original range and introduced to suitable habitat outside its former range.

But how far can the wild turkey spread into the snow belt? How do silviculture practices affect the wild turkey? Is there a risk for a spread of disease from the domestic poultry industry litter? Can disease testing be simplified? How do logging and wildfires affect turkey populations? What kind of hunting opportunities exist considering turkey population dynamics, hunter satisfaction, and landowner tolerances? The NWTF, in cooperation with state agencies and individuals, is funding studies to answer these and other questions. Even though populations have exceeded expectations, there are still aspects of wild turkey ecology and population dynamics that are poorly understood. The challenge of the 1990s will be to complete the restoration of wild turkeys into all suitable habitats and to manage those populations to their potential.

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Table 6. Total number (reported) of wild turkey hunters by state for spring and fall seasons between 1987 and 1989, as well as the current trend in hunter numbers.

State[a]	Spring	Fall	Current trend
Alabama	38,521	9,312	Down
Arizona	3,683	10,425	Up
Arkansas	50,000	15,000	Up
California	22,840 spring and fall combined		Up 31%
Colorado	4,500-6,000	1,500-2,000	Stable
Connecticut	2,575	1,380[b]	Up
Florida	Unknown	Unknown	Unknown
Georgia	65,000	No season	Up
Hawaii	No season	Unknown	Unknown
Idaho	4,200	No season	Up
Illinois	13,848	4,700	Up
Indiana[c]	6,000	No season	Unknown
Iowa	17,904	8,876	Up
Kansas	13,581	2,037	Up
Kentucky	7,000	500	Up
Louisiana	16,000	No season	Up
Maine	500 max	No season	Up
Maryland	12,400	10,400	Up
Massachusetts	12,453	No season	Up
Michigan	30,000 quota	5,900 quota	Up
Minnesota[c]	3,821 permits	No season	Up
Mississippi	Unknown	Unknown	Up
Missouri	92,914	~50,000	Down
Montana	2,000	5,000	Up
Nebraska	8,206	7,066	Up
New Hampshire	1,200	300[b]	Up
New Jersey	3,700	No season	Up
New Mexico	6,200	2,970	Up
New York	58,495	47,207	Up
North Carolina	20,000	No season	Up
North Dakota[c]	753	5,098	Up
Ohio	24,740	No season	Up
Oklahoma	19,729	13,821	Stable
Oregon	2,623	No season	Down
Pennsylvania	206,000	282,000	Down
Rhode Island	300 max	No season	Down
South Carolina	35,591	10,235	Up
South Dakota	5,500	6,500	Up
Tennessee	27,000	8,000	Up
Texas	86,228	124,206	Up
Utah	450	No season	Up
Vermont	5,000	8,000	Up
Virginia	61,428	113,461	Down
Washington	800 spring and fall combined		Up
West Virginia	50,000	49,000	Up
Wisconsin	33,000	7,260	Up
Wyoming	3,587	1,483	Up
Totals	1,065,450-1,066,950	698,576-699,076	

[a]Delaware and Nevada currently have no turkey season. Delaware plans to open a spring season in 1991; Nevada hopes to have a season for Rio Grande turkey in 1991.
[b]Represents seasons restricted to archery hunting.
[c]Hunting open to residents only during all or part of reporting period.

Table 7. Fall and spring wild turkey harvests by state, 1987-89.

State[a]	Fall	Year	Spring	Year	Method of determination
Alabama	6,972	1988	43,718	1989	Check stations, mail survey
Arizona	1,462	1988	618	1989	Mail survey
Arkansas	1,184	1989	8,283	1989	Check stations, tags
California	8,760	1988	combined	1988	Mail survey
Colorado	355	1988	603	1989	Mail survey
Connecticut	7[b]	1989	459	1989	Mail survey
Florida	22,375	1989	16,000+	1988	Check stations on some wildlife management areas, statewide hunter survey
Georgia	NA		25,000	?	Check stations, mail survey
Hawaii	Unknown		Unknown		Check stations
Idaho	NA		228	1989	Random phone survey of tag holders
Illinois	728	1989	2,381	1989	Check stations
Indiana	NA		1,359	1989	Check stations, mail survey
Iowa	4,427	1988	6,796	1989	Mail survey
Kansas	814	1988	4,898	1989	Mail survey
Kentucky	20[b]	1989	1,000	1989	Check stations, tags
Louisiana	NA		6,000	1989	Mail survey
Maine	NA		19	1989	Check stations
Maryland	302	1989	962	1989	Tags
Massachusetts	NA		780	1989	Mandatory check stations
Michigan	6,195	1989	837	1988	Check stations, mail survey
Minnesota	NA		930	1989	Check stations
Mississippi	965	1987	59,241	1987	Mail survey
Missouri	21,885	1989	35,618	1989	Check stations, transport tags
Montana	1,500	1989	500	1989	Mail survey
Nebraska	4,000	1989	4,270	1989	Mail survey with wing
New Hampshire	11[b]	1989	142	1989	Tags, check stations
New Jersey	NA		445	1989	Check stations
New Mexico	1,392	1988	2,122	1988	Mail survey
New York	6,891	1988	13,681	1989	Tags-reported take, mail survey w/leg (fall only)
North Carolina	NA		1,274	1989	Tags
North Dakota	3,607	1988	502	1989	Check stations, mail survey w/wing
Ohio	NA		3,171	1989	Check stations
Oklahoma	3,339	1988	7,953	1988	Check stations for eastern turkey counties, phone survey statewide
Oregon	NA		313	1989	Mail survey, phone follow-up
Pennsylvania	40,000 average		17,500 average		Mandatory harvest report
Rhode Island	NA		9	1989	Check stations
South Carolina	792	1988	7,651	1989	Check stations, tags, mail survey
South Dakota	4,000	1988	3,000	1988	Mail survey, Hunter Report Card
Tennessee	41[b]	1989	2,770	1989	Check stations, tags
Texas	38,710	1988	52,935	1988	Mail survey
Utah	NA		66	1988	Mail survey
Vermont	700-1,000	1988	700-800	1989	Check stations, mandatory reporting
Virginia	10,623	1989	7,411	1989	Check stations, tags w/wing mandatory
Washington	4	1989	61	1989	Check stations, tags, mail survey, mandatory report
West Virginia	2,939	1988	7,207	1989	Check stations, mail survey w/wing, NWTF & Wildl. Resour. Div. Gobbler Survey
Wisconsin	1,570	1989	4,406	1989	Mandatory registration in check station, mail survey
Wyoming	1,045	1988	1,108	1988	Mail survey with leg
Total harvest	193,235-193,535		356,807-361,907		

[a]Delaware will open its first spring season in 1991; Nevada hopes to open a limited Rio Grande season in 1991.
[b]Archery only harvest.

Table 8. Summary of the beginning dates of state wild turkey restoration programs, completion dates or expected completion dates.

State	Year begun	Year ended	Expected end
Alabama	1942		Soon
Arizona	Early 1940s		1995
Arkansas	1930s[a]	Unknown	
	1950		Not determined
California	1908		Not determined
Colorado	1980		1991
Connecticut	1975	1987	
Delaware	1984		1995
Florida	1942	1970	
Georgia	1954[a]	1964	
	1972		1990-1991
Hawaii	Early 1960s	1960s	
Idaho	1925	1946	
	1952		Not determined
Illinois	1959		1995
Indiana	1956		1994
Iowa		1965	1990
Kansas	1962		1995
Kentucky	1978		1995
Louisiana	1962		1995
Maine	1977		1992
Maryland	1966		1991
Massachusetts	1972		1992
Michigan	1954		1998
Minnesota	1960s		Not determined
Mississippi	1954		1994
Missouri	1953	1979	
Montana	1954		Almost complete
Nebraska	1959	1983	
Nevada	1960	1963	
	1986		1992
New Hampshire	1969		1995
New Jersey	1977		1990
New Mexico	1930		Not determined
New York	1959	1986	
North Carolina	1950s		1995
North Dakota	1950s		Not determined
Ohio	1952		Not determined
Oklahoma: Eastern	1912[a]	1963	
Rio Grande	1948		Not determined
Eastern	1971		Not determined
Oregon: Merriam's	1960s		Not determined
Rio Grande	1984		Not determined
Pennsylvania	1956[a]	1985	
Rhode Island	1980		Not determined
South Carolina	1951	1958	
	1976		1995
South Dakota	1948		Not determined
Tennessee	1951		Not determined
Texas: Rio Grande	1924	1950	
Eastern	1941[a]	1978	
Eastern	1959	1976	
Florida	1959	1964	
Hybrids	1965	1978	
Eastern	1979		Not determined
Utah		1925	Unknown
	1936[a]	1941	
	1952		Not determined
Vermont	1973	1984	
Virginia	1929	1988	
Washington	1913[a]	Unknown	
Merriam's	1960	1988	
Rio Grande, Eastern	1984		Not determined
West Virginia	1950	1989	
Wisconsin	1954[a]	1957	
	1976		1993
Wyoming	1935	1984	

[a]Represents early restoration efforts using game-farm birds.

WILD TURKEY NESTING ECOLOGY ON THE FRANCIS MARION NATIONAL FOREST

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Abstract: A nesting ecology study was conducted during 1981-84 on a well-established population of eastern wild turkeys *(Meleagris gallopavo silvestris)* on a section of the Francis Marion National Forest in South Carolina. Seasonal surveys indicated population densities and reproduction were declining in the Francis Marion while increasing elsewhere in the state. We sought to determine the relationship between nest site selection and timber types and stand characteristics. Fifty-five hens were trapped, equipped with telemetry packages, and released on site. Movements were monitored to determine nesting activity. Forest types, stand age, years since last prescribed burn, nesting success, and distance of nests to various type U.S. Forest Service roads were determined. Turkeys preferred to nest in young ($\leq$10-year-old) clearcuts or seed-tree cuts and in mixed stands. Only 63.8% of adult hens nested and no juvenile hens nested. Fifty-five percent of the nesting hens were successful. Clutch size averaged 10.03 eggs; 87% of the eggs in successful nests hatched. Turkeys avoided nesting near roads open for vehicular traffic. The study supported the importance of pine-hardwood management, stand regeneration, prescribed burning, and road closure in a turkey management program.

This research was part of an extensive study of the population dynamics on one of the purest strains of eastern wild turkey in South Carolina. It is also the oldest continually managed wild turkey flock in the state and was the source for the successful restoration of turkeys in the Piedmont and mountains of South Carolina. The purpose of this study was to identify possible limiting factors on nesting success and to determine how silvicultural practices employed on the Francis Marion affected turkey nesting. Our objective was to capture and radio-instrument turkey hens before each nesting season to determine nesting and renesting activity and site selection.

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STUDY AREA

The study area comprises 18,940 ha and is located in Berkeley and Charleston counties near McClellanville, South Carolina, and encompasses the Waterhorn and portions of the adjacent Northampton Hunt Unit (HU) of the Francis Marion National Forest. Included were inholdings owned by timber companies and individuals.

The Waterhorn HU is significant historically because it was designated by presidential proclamation as a wild turkey refuge in May 1948 (Holbrook 1952). A hog-proof fence was constructed around 6,883 ha of the Waterhorn during the early 1950s. Since then the area has been managed intensively for wild turkeys; surplus turkeys were used for restocking. Project personnel estimated a population of 800-900 birds on the 6,883-ha refuge in 1952 (Holbrook 1952).

Forest cover types on the area were: loblolly pine *(Pinus taeda*, 6,747 ha, 35.6%), longleaf pine *(P. palustris*, 3,901 ha, 20.6%), other pine (271 ha, 1.4%), mixed pine-hardwood or hardwood-pine (765 ha, 4.1%), bald cypress-water tupelo *(Taxodium distichum-Nyssa aquatica*, 2,496 ha, 13.2%), sweet gumwateroak-willow oak (*Liquidambar styraciflua-Quercus nigra-Q. phellos*, 141 ha, 6.0%), sweet bay-water tupelo-red maple (*Magnolia virginiana-N. aquatica-Acer rubrum*, 816 ha, 4.3%), other hardwoods (primarily oaks, 526 ha, 2.7%), regenerated areas (1,261 ha, 6.7%), wildlife openings (68 ha, 0.4%) and other (primarily marsh, 948 ha, 5.0%).

A high percentage (49%) of the older timber (>70 years old) was composed of the bald cypress-water tupelo forest type, which was often flooded, and made up 13% of the study area. Silvicultural practices for pine stands included clearcutting and planting, or seed-tree cutting with natural regeneration. Natural regeneration of hardwood sites occurred after clearcutting. Prescribed burning was common in the upland pine types.

A small tidal stream ran through the middle of the study area and many dikes and ditches associated with early rice culture were present.

The study area has a number of Forest Service roads including approximately 61 km of rock-surfaced roads, 42 km of logging roads, 27 km of improved ditched dirt roads, and 15 km of paved roads. Many of the logging roads provide access to the 142 (68 ha) wildlife openings on the area.

METHODS

We used rocket-projected netting fired over sites prebaited with whole corn to capture hens during January, February, and early March 1981-84 (Austin 1965, Dill 1969). Captured hens were weighed, aged, banded, and fitted with a solar- or battery-powered transmitter. Transmitters were attached to a harness made of nylon-covered rubber tubing. A motion-sensing feature of the transmitters allowed interpretation of turkey activity.

After release hens were located $\geq$3 days/week at various hours until 1 August of each year. Locations were determined as described by Cochran and Lord (1963). Dates were recorded when the activity sensor indicated periods of inactivity and when radio locations became clustered signifying nesting.

Nest sites were located initially by flushing hens from nests after they had been incubating continuously for at least 15 days. When it became apparent that birds abandoned their nests after being flushed, we marked the general location of the nest with flagging and located it after the eggs hatched or the hen abandoned the nest.

After eggs hatched, we recorded clutch size; number of eggs hatched; distance to nearest road, wildlife opening, ditch or skid trail; last controlled burn; and overstory vegetation characteristics including basal area (BA). Basal area was determined using a BA factor 10 prism. With the nest as the center point, a 50-m plot was surveyed around the nest to determine forest cover type. Forest Service cover type guidelines were used to determine the forest type of the area surrounding each nest and for each timber stand on the area. Stands in which $\geq$70% of the dominant and codominant trees were either pine or hardwoods were classified as a pure stand. Stands in which 51-69% of the trees in the dominant and codominant positions were either hardwoods or pines were classified as mixed stands.

Preference for forest cover type and stand age class was analyzed using methods derived by Neu et al. (1974). If a hen's activity monitor failed to operate over a period of 3 days, she was located and, if dead, examined for causes of death.

RESULTS

Nesting Habitat

We located 28 nests of radio-equipped hens, and Forest Service personnel or hunters found 9 nests. Of the 37 nests, 15 (40%) were in mixed stands, 11 (30%) in pine stands, and 10 (27%) in seed-tree cuts or in clearcuts $\leq$10 years old. One nest was found in a 13-year-old pine stand that had been destroyed by wildfire. Nests were often in small patches of pine-hardwood within larger stands that were typed as pine, or near stand edges where pine-hardwood was more prevalent. Basal area for pine-hardwood and pine species surrounding nest sites averaged 17.1 and 22.6 m^2/ha, respectively.

Forest types were not used for nesting in proportion to their availability ($P \leq 0.10$) (Table 1). Hens preferred regenerating stands ($\leq$10 years old) and mixed stands. Pure stands of pine and hardwood were avoided. Stand age also had an effect on nest site selection ($P \leq 0.10$) (Table 1). The statistical analysis was limited to 35 nests located on Forest Service property where all stand-age data were available. Stands in the 0- to 10-year age class were preferred for nesting while stands >70 years were avoided. Hens selected stands in other age classes randomly with no statistical indication of preference or avoidance.

Sixteen nests (43%) were closer to a closed road than to any other type of road or opening, while 13 were closer to an open road. Eight nests were located closer to a wildlife opening than to a road. There was a higher nesting frequency along roads closed to vehicular traffic than along roads that were open ($X^2 = 6.635$, 1 df, $P < 0.01$) (Table 2). Five nests were within 20 m of a closed road and 11 were within 50 m. Three nests were within 50 m of an open road. Vehicular traffic on closed roads was restricted to maintenance of roads or openings and other forestry and wildlife management activities. Seven nests (19%) were within 10 m of a fire line or skid trail. All rock, improved-dirt, and paved roads on the area were open during the study.

Prescribed burning was a management practice commonly used by the Forest Service on the study area. Burning history was evaluated for 29 nest sites for which burning data were available. Eleven nests (38%) were in stands that had been burned within the previous 12 months (Fig. 1). These nests were generally in small pockets excluded from the burn because of dampness or topography. Nine nests (31%) were found in areas that had been burned 1-2 years before nest initiation. Forest Service personnel burned an average of 1,347 ha on the study area during 1977-83 (range 557-2,187 ha).

Table 1. Use and availability of forest cover types and stand age classes by nesting wild turkey hens on the Francis Marion National Forest, S. C., 1981-84.

Forest characteristic	Total area (ha)[a]	% availability	% use	Preference[b]
Forest type				
Pine	10,919	57.7	29.7	−
Hardwood	4,979	26.3	0.0	−
Regeneration ≤10 years old	1,261	6.6	27.0	+
Mixed	765	4.0	40.5	+
Other	1,016	5.4	2.8	±
Age class, years				
0-10	1,026	10.7	28.6	+
11-30	1,341	14.0	14.2	±
31-50	1,812	18.9	8.6	±
51-70	3,039	31.7	40.0	±
>70	2,363	24.7	8.6	−

[a]Thirty-five of the nests were on Forest Service property where all ages were known. All nests were included in the forest type analysis.

[b]Significant avoidance (−), preferrence (+), and randomness (±) ($P \leq 0.10$).

Table 2. Chi-square test of turkey nests in relation to roads on the Francis Marion National Forest, S.C., 1981-84.

Road type	Observed	Expected	Contribution to X^2
Open (103.08 km)	13	20.6	2.80
Closed (41.52 km)	16	8.4	6.88
Total	29	29.0	9.68[a]

[a]$X^2 = 6.635$; 1 df; $P < 0.01$.

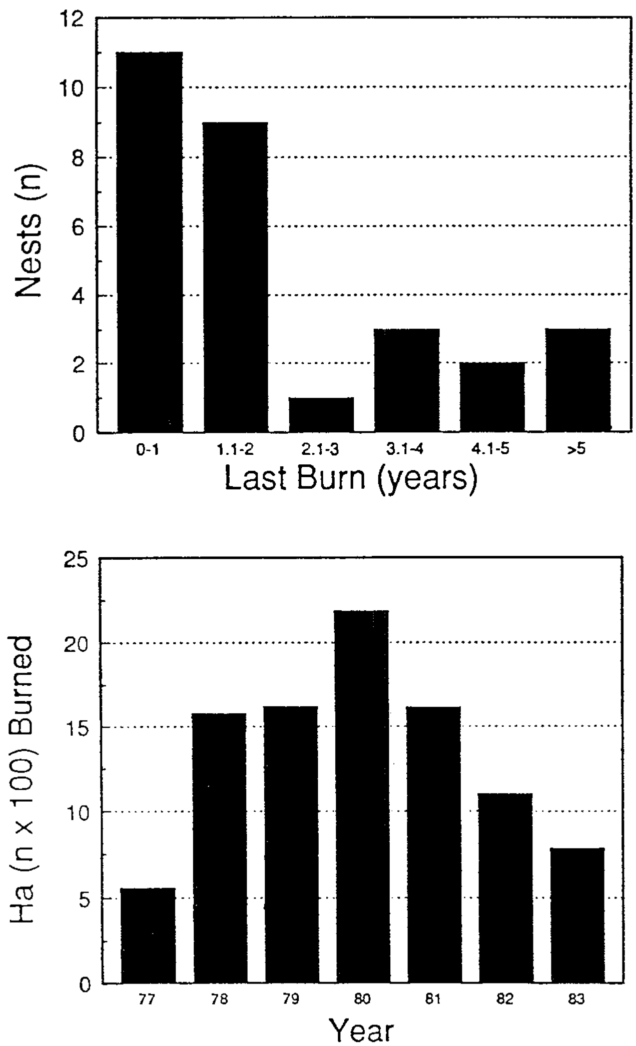

Fig. 1. Number of turkey nests by year since last prescribed burn, and area (ha) burned 1977-83 on the Francis Marion National Forest, S.C.

Nest Success

During 1982, 6 of 11 adult hens nested, and 2 hens renested. In 1983, 6 of 11 adult hens nested, 1 hen renested; and in 1984, 11 of 14 adult hens nested and 1 hen renested. Only 4 of 17 hens (23%) renested after their nests were destroyed or abandoned. Five radio-equipped hens were monitored for 2 or more seasons. The 1981 nesting data were not included in these calculations because information was not available through the entire nesting season. The nesting rate for adult hens nesting at least once ranged from 54.5% to 78.6% and averaged 63.8%. None of the 12 juvenile hens nested during the study.

During 1982-84 instrumented adult hens produced a total of 27 nests. Seven nests were abandoned due to human disturbance from project activities. Of the 20 remaining nests, 11 (55%) resulted in poults, 6 (30%) were destroyed by predators (1 nesting hen was killed by a bobcat *[Lynx rufus]*), 2 (10%) were flooded, and 1 (5%) was abandoned for unknown reasons. Only 1 (11%) hen returned to her nest after being flushed by humans. She was only 2 days from hatching and successfully hatched her brood.

Clutch size averaged 10.03 eggs; 87% of the eggs in successful nests hatched. Four of the 11 (36%) successful nests hatched between 1 June and 15 June; 2 nests (18%) hatched during each of the following periods: 16-31 May, 16-30 June, and 1-15 July. One nest (9%) hatched between 1 May and 15 May. Renesting attempts (4) were unsuccessful. Two second nests were depredated, 1 was flooded, and 1 was abandoned due to human disturbance.

DISCUSSION

We found that only 63.8% of the adult hens attempted to nest and observed no nesting by juvenile hens. In Florida, 64.1% of adult hens and 51.5% of juvenile hens were known to nest (Williams et al. 1971). Hillestad (1973) observed that 4 of 10 juvenile hens nested during his Alabama study.

Nesting hens would not tolerate human disturbance; only 1 (11%) of 8 hens returned to her nest after being flushed. Williams et al. (1971) reported that 7 of 11 hens (64%) abandoned their nests after being flushed from their nests by investigators. Bidwell et al. (1985) reported that human disturbance caused most nest losses (61%, 8 of 13) in his Oklahoma study. As turkey hunters and other resource users increase on the Francis Marion National Forest, the disturbance and abandonment of nests could significantly affect turkey production.

Second nesting attempts on the Francis Marion were uncommon; only 23% of the adult hens renested. In Florida, 14.3% of juvenile hens and 29.4% of adult hens renested after the loss of the first nest (Williams et al. 1971).

Study findings clearly indicated that Francis Marion turkeys would benefit from a mixed stand management strategy. Forty percent of the nests were found in areas where the regenerated by clearcutting or shelterwood cutting. Pine and hardwood regeneration areas were well distributed throughout the area and averaged 16.4 ha and 6.3 ha, respectively. In mature pine stands, prescribed burning and commercial thinning were conducted on 6-year and 10-year rotations, respectively.

METHODS

We captured turkeys during January-March and July-August 1984-88, by cannon-netting (Bailey 1976) or drugging with alpha-chloralose (Williams 1966). Hens were aged (Larson and Taber 1980), weighed, and marked with numbered aluminum leg bands and black patagial wing tags (Knowlton et al. 1964). Radio transmitters (Wildlife Materials, Inc., Carbondale, Ill.) were placed "backpack" style on captured hens (Everett et al. 1978). Hens were released at the capture site.

Telemetry readings were taken daily during the nesting season (1 Mar-30 Jun) to determine date of initial incubation. Incubation was assumed when a hen was at the same location for 2 consecutive days. After about 14 days of incubation, we recorded compass bearings toward the nest at several reference points, approximately 50 m from the nest, to locate the nest site after hatching or abandonment.

Nest Habitat Preference and Success Rates

Nest habitat preferences were determined by comparing the nest site habitat type with available habitat using a 2-sample test for equality of percentages (Leopold 1986). Available habitat for nesting was determined by calculating the area of each habitat type within a hen's prenesting home range. Habitat types were classified as: (1) mature pine: stands >10 years old and dominated by pine species, (2) bottomland hardwoods: stands >10 years old and dominated by hardwood species, (3) regeneration areas: stands $\leq$10 years old, and (4) fields. We determined prenesting home ranges by connecting the outer points of plotted telemetry locations from 1 March to the date of incubation initiation on a geoinformation system prepared for TWMA (Songer 1987). We combined the area of each habitat type within the prenesting home range for each hen to determine the total available habitat for nesting hens.

Habitat preferences were determined for: (1) habitat type, (2) period of time since prescribed burning within pine stands, (3) regeneration area type (hardwood, pine), and (4) age of regeneration area. Nest success rates were determined by dividing the number of successful nests by total nests for each habitat type. Success rates were determined for forested (mature pine and bottomland hardwoods) and nonforested (regeneration areas and fields) habitats.

Nest Site Characteristics

We measured 20 habitat characteristics at each nest. A 1-m^2 hoop was centered 46 cm (approximate height of a nesting hen) above the nest to estimate the percentage of vegetative cover directly over the nesting hen. A 1.8-m tall density board was placed 4.6 m away from the nest at the 4 cardinal directions to estimate lateral screening cover. We looked at the board from 46 cm above the nest and estimated the percentage of each 0.3-m level of the board that was obscured by vegetation. Vegetative life forms at the nest site (within the 1-m^2 hoop) were classified as brush, vine, grass, or forb. Average dbh for trees $\geq$10.2 cm dbh and percent canopy cover were estimated for a 10.7-m diameter plot surrounding the nest site. Basal area was calculated with a 10-factor prism. Nesting attempt, nest fate, edge type, number of edges, distance to closest edge, and number of habitat types seen from the nest site were recorded. We classified edges as natural (created by a change in habitats) or man-made (created by fire lane, logging trail, or road). Macro-habitat was defined as forested (mature pine and bottomland hardwoods) or non-forested (regeneration areas and fields).

Significance tests compared mean values of all site characteristics for successful and unsuccessful nests. Linear discriminant analysis was performed to identify variables most important to nest success. Analyses were conducted using SPSS-PC+ (SPSS, Inc. 1988) at $P = 0.05$ level of significance.

RESULTS

We located 44 nests from transmitter-equipped hens during 1984-88. Six nests, located on private land off the study area, were excluded from the habitat preference analysis

(Table 1). Two nests that were abandoned after we flushed the hen were excluded from the analyses of success rates (Table 4) and nest site characteristics (Table 5). Data were combined for all years.

Nest Habitat Preference and Success Rates

Mature pine and bottomland hardwood stands comprised 43.6% and 43.4% of available prenesting habitat, respectively (Table 1). Mature pine stands contained the most nests (18) and seemed to be used according to availability (P = 0.739). Regeneration areas made up only 12.5% of available habitat but contained 14 (36.8%) nests, indicating preference (P = 0.014). Bottomland hardwood stands were avoided by nesting hens (P = 0.001), and fields apparently were used in proportion to their availability (P = 0.226).

Preference/avoidance was not detected (P > 0.3) for nesting use of pine stands based on the time since the last prescribed burn (Table 2). At least 1 nest was located in stands burned the same year as nesting through stands burned up to 6 years prior to nesting.

Hens that nested in regeneration areas preferred 2-year-old stands (P = 0.035) and avoided stands >4 years old (P = 0.048) (Table 3). No preference/avoidance was detected (P = 0.539) for regeneration type (hardwood vs. pine).

Nest sites located in bottomland hardwood stands had the greatest success rate (75.0%), but the rate was based on a sample of 4 nests (Table 4). Mature pine stands contained 18 nests and had a 66.7% success rate. Nest success in pine and hardwood regeneration areas was 45.4% and 0.0%, respectively. All nests located in fields (n = 3) were unsuccessful. Combined nest success in forested habitats (68.2%) was significantly greater (P = 0.049) than in nonforested areas (25.0%). Nest success rates should only be used for comparison between habitat types. Actual nesting success would be lower than rates shown because nests destroyed or abandoned early during incubation could not be located and were excluded from the analysis.

Nest Site Characteristics

We compared 22 unsuccessful nests with 20 successful nests (Table 5). Successful nests had less lateral screening cover in the 0.3- to 0.6-m zone, were closer to roads, and were located near more edges (P < 0.05). Successful nests were usually in forested habitats, and unsuccessful nests were usually in nonforested habitats (P < 0.05).

Linear discriminant analysis selected distance to edge, edge type, presence of forbs at the nest, and presence of grasses at the nest as variables that predicted nest outcome. These variables correctly classified 76% of the nests. Type of edge (r = 0.739) and distance to edge (r = 0.418) had the highest correlations with the discriminant function and were the most important variables in predicting nest outcome. Nests were more successful as distance to edge decreased and when located near a man-made edge instead of a natural edge. Presence of forbs (r = 0.29) and grasses (r = 0.03) at the nest site were included in the function to allow the analysis to correctly predict the success of nests located in bottomland hardwoods.

Table 1. Habitat use by nesting transmitter-equipped wild turkey hens, Tallahala Wildlife Management Area, Mississippi, 1984-88.

Habitat type	Area		Nests observed		P-value
	ha	%	n	%	
Pine	5,259	43.6	18	47.4	0.739
Hardwoods	5,239	43.4	4	10.5	0.001*
Regeneration	1,507	12.5	14	36.8	0.014*
Field	66	0.6	2	5.3	0.226
Total	12,071		38		

* Significant ($P \leq 0.05$).

Table 2. Habitat use of pine stands according to time since prescribed burning for nesting transmitter-equipped wild turkey hens, Tallahala Wildlife Management Area, Mississippi, 1984-88.

	Area		Nests observed		
Time (years)	ha	%	*n*	%	*P*-value*
0	783	15.6	2	11.1	0.691
1	526	10.5	1	5.6	0.589
2	467	9.3	2	11.1	0.858
3	183	3.6	2	11.1	0.389
4	818	16.3	1	5.6	0.304
5	784	15.7	4	22.2	0.619
6+	1,444	28.9	6	33.3	0.776
Total	5,005		18		

* None were significantly different from expected.

Table 3. Habitat use of regeneration areas by nesting transmitter-equipped wild turkey hens, Tallahala Wildlife Management Area, Mississippi, 1984-88.

	Area		Nests observed		
Age (years)	ha	%	*n*	%	*P*-value
Not planted	231	15.3	1	7.1	0.491
0	248	16.4	1	7.1	0.445
1	191	12.7	3	21.4	0.540
2	61	4.0	5	35.7	0.035*
3	228	15.1	3	21.4	0.666
4	177	11.7	1	7.1	0.667
5+	372	24.6	0	0.0	0.048*
Total	1,507		14		

* Significant ($P \leq 0.05$).

Table 4. Nesting success by habitat type for transmitter-equipped wild turkey hens, Tallahala Wildlife Management Area, Mississippi, 1984-88.

	Nests	
Nest habitat	*n*	% successful
Bottomland hardwoods	4	75.0
Pine	18	66.7
Pine regeneration	11	45.4
Hardwood regeneration	6	0.0
Fields	3	0.0
Total	42	47.6
Forested	22	68.2
Nonforested	20	25.0
Total	42	47.6

Table 5. Site characteristics of successful and unsuccessful nests for transmitter-equipped wild turkey hens, Tallahala Wildlife Management Area, Mississippi, 1984-88.

Characteristics	Unsuccessful nests (n=22)	Successful nests (n=20)	P-value
Nesting attempt[a]	1.2	1.1	0.54
% overhead cover	61.2	60.6	0.95
Density board (% coverage)			
0.0-0.3 m	94.6	87.8	0.09
0.3-0.6 m	85.2	71.8	0.05*
0.6-0.9 m	71.4	58.5	0.14
0.9-1.2 m	61.8	50.6	0.22
1.2-1.5 m	54.7	49.4	0.57
1.5-1.8 m	52.1	47.1	0.59
Distance to edge (m)	12.1	7.8	0.11
Edge type[b]	0.5	0.8	0.01*
Number of edges	1.7	2.2	0.03*
Basal area (m^2/ha)	36.8	68.2	0.06
Average dbh (cm)	5.1	8.0	0.17
% canopy cover	20.5	37.5	0.06
Macro-habitat type[c]	0.6	0.3	0.03*
Number of habitat types	2.0	1.8	0.43
Vegetational structure at nest site[d]			
Brush	1.0	1.0	0.95
Vine	0.5	0.6	0.36
Grass	0.1	0.2	0.90
Forb	0.0	0.2	0.26

[a]First attempt = 1, second attempt = 2.
[b]Natural edge = 0, man-made edge = 1.
[c]Forested habitat = 0, nonforested = 1.
[d]Absent (0) or present (1) at nest site.
* Significant ($P \leq 0.05$).

DISCUSSION

Hens preferred to nest in regeneration areas and avoided bottomland hardwoods. Regeneration areas had an abundance of ground cover and a high density of woody vegetation. Understory vegetation provided the type, amount, and distribution of cover most suitable to nesting hens. Bottomland hardwood stands were frequently flooded causing an open understory with a low stratum of vegetation dominated by forbs and grasses. This forest type generally lacked the woody vegetation to provide suitable nesting cover. Mature pine stands contained the majority of nests and were used in proportion to their availability. Shrubs and vines dominated the understory of pine stands and provided patchy areas of cover used by nesting hens. Fields comprised <1% of available habitat, were used in proportion to their availability, and therefore were not an important nesting habitat. Other studies have shown nesting preferences for recently cut-over loblolly pine, shortleaf pine *(P. echinata)* and sweetgum (Hillestad 1973), forest openings (Porter 1978), powerline rights-of-way (Everett et al. 1981), fields (Speake et al. 1975), and 6-month- to 44-year-old pine plantations (Exum et al. 1987).

No preference/avoidance for nesting was detected for time since burning in mature pine stands. Stands generally burned unevenly leaving a patchy distribution of vegetation that provided suitable nest cover. Because no preference was detected, a shorter burning rotation may increase the quality of pine stands as year-round turkey habitat without adversely affecting nest site selection. Stoddard (1963) thought nesting hens preferred brushy clumps in open woodlands that escaped fire for 2-5 years. Hens selected recently burned areas in Georgia (Hon et al. 1978) but preferred sites that had not been recently burned in Alabama (Exum et al. 1987).

Hens nesting in regeneration areas preferred 2-year-old stands and avoided stands >4 years old. Two-year-old stands provided excellent nesting cover while vegetation in stands >4 years old was apparently too dense for use by nesting hens. Delaying site preparation for 1 or 2 years in pine regeneration areas may increase the number of years hens use these areas for nesting. Hens did not show a preference for regeneration area type (pine or hardwood). Although significance was not detected, hens used hardwood regeneration areas more than expected. Nesting in hardwood regeneration areas may have been influenced by their close proximity to bottomland hardwoods, which were determined to be the preferred brood habitat on TWMA (Phalen 1986). Delaying site preparation is not recommended for hardwood regeneration areas because of the low nest success in this habitat type.

Nests in forested habitats had significantly higher success rates than nests in nonforested habitats. High predator populations may have been responsible for the low nest success rate in nonforested habitats. Previous studies found that young pine plantations supported high populations of prey (Atkeson and Johnson 1979, Perkins and Hurst 1988) and predators (Baker and Brooks 1981). Nonforested habitats probably supported higher predator populations and were smaller in size than forested habitats. Therefore, a predator would have a greater probability of detecting a nest in nonforested habitats, resulting in lower success rates for this habitat type.

Nest sites were characterized by having an average of 60% overhead cover and 90% lateral screening cover at the 0.3- to 0.6-m height and gradually decreasing to 50% cover at the 1.6- to 1.8-m level. Hardwood reproduction, shrubs, and vines provided the vegetational structure that hens used for nesting cover. Nest sites were located an average of 10 m from an edge. Edges were created by gravel roads, logging trails, firebreaks, and changes in habitats. Previous studies found similar nest site characteristics (Williams et al. 1968, Hon et al. 1978, Martin 1984, Lazarus and Porter 1985, Exum et al. 1987, Holbrook et al. 1987).

Successful nests had lower lateral screening cover at all height levels with significantly lower cover at 0.3- to 0.6-m level. This result was probably a function of macro-habitat type instead of an optimum amount of cover because successful nests were generally located in forested habitats, and these stands have less ground and understory cover than regeneration areas.

Edges appeared to influence nest outcome. Successful nests were generally located <10 m from more than 1 man-made edge. Close proximity of edges may have provided hens with travel lanes to a variety of resources and decreased the time the hen was away from the nest. Limited time off the nest may reduce scent trails and decrease the chance of predation. Further research should be conducted to determine if creating edges in pine habitats would enhance productivity through increased nest success.

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CHRONOLOGY OF GOBBLING AND NESTING ACTIVITIES OF MERRIAM'S WILD TURKEYS

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Abstract: Gobbling activity of adult and subadult Merriam's wild turkeys *(Meleagris gallopavo merriami)* was studied in southcentral Colorado and northcentral New Mexico in 1986, 1988, and 1989. Gobbling was monitored in relation to time of day, roosting behavior, presence of hens, and timing of nesting events and spring hunting. Mean dates for onset of incubation were 14 May 1989, 18 May 1986, and 21 May 1988. Peak of incubation occurred between 16 and 25 May, after the spring hunting season. Gobbling was sporadic and differed among individuals. Adult males gobbled more ($P = 0.007$) in the morning (AM) than evening (PM), more ($P = 0.003$ for AM, $P = 0.006$ for PM) on than off the roost, more ($P = 0.016$) in the absence than presence of hens, and more during than before ($P = 0.01$) or after ($P = 0.034$) the hunting season. Two peaks of gobbling were identified. The second peak (11-20 May) approximated the peak of incubation. Subadult males seldom gobbled; 77% of all gobbling by subadults occurred in the absence of adult males. Data from this study support a late April opening date for the spring hunting season.

Management strategies for setting biologically sound spring seasons for wild turkeys involve knowing when peaks of gobbling and onset of incubation occur (Bailey and Rinell 1967, Bevill 1975). Properly timed seasons afford maximum protection of hens and optimize opportunities for hunter success (Miller 1984). Few investigations of Merriam's wild turkeys have provided quantitative data on timing of gobbling (Scott and Boeker 1972) or nesting (Lockwood and Sutcliffe 1985) events. Consequently, seasons have been set more on tradition than biological evidence (Kennamer 1986).

In 1986, 1988, and 1989, I monitored gobbling and nesting activities of Merriam's turkeys in southcentral Colorado and northcentral New Mexico. Gobbling was quantified in relation to age of bird, time of day, roosting behavior, presence or absence of hens, timing of incubation, and timing of the spring hunting season. My objectives were to identify peaks in gobbling activity, conditions influencing gobbling, and duration of gobbling.

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STUDY AREA

Trapping was confined to Longs Canyon and 2 tributary canyons, Sowbelly and Martinez, approximately 17 km southwest of Trinidad, Colorado in Las Animas County. From here, radio-marked birds ranged over 448 km^2 of surrounding areas during the breeding season. This area was bounded by I-25 on the east, Lorencito Canyon on the west, Colorado Highway 12 on the north, and the Canadian River in New Mexico on the south.

This topographically diverse area varied in elevation from 1,800 to 2,600 m and was intersected by 4 large canyons >30 km in length, each with numerous side canyons and adjacent smaller canyons. Major vegetation types included pinyon pine-juniper *(Pinus edulis-Juniperus* spp.), mountain shrub, and ponderosa pine *(P. ponderosa)*. The mountain shrub type was dominated by Gambel oak *(Quercus gambelii)*, which extended into the pinyon-juniper and ponderosa pine types. Douglas-fir *(Pseudotsuga menziesii)* and white fir *(Abies concolor)* occurred in association with ponderosa pine primarily on north slopes. Over 95% of the area was privately owned. Human activity was minimal. Use of private lands was limited to cattle grazing, some logging, and recreation.

METHODS

Turkeys were baited with oat hay and corn, and livetrapped with drop nets or cannon nets during February and March 1986, 1988, and 1989. No birds were trapped in 1987. Captured birds were classified to age and sex (Hoffman 1962), and banded with serially numbered aluminum leg bands. Numbered and color-coded (by year) Allflex livestock eartags were attached to the patagium. Ages were recorded as subadult (8-10 months) or adult (>18 months). One hundred forty-seven birds (16 adult males, 10 subadult males, 101 adult females, 20 subadult females) were equipped with lithium battery powered transmitters (Models HLPB 2750 and 2120-LD, Wildlife Materials, Carbondale, Ill.) attached with a poncho collar (Amstrup 1980) or tail-clip (Bray and Corner 1972). The poncho radio package weighed <40 gm, the tail-clip package <35 gm. Tracking was conducted from the ground using a 3-element Yagi antenna and Telonics TR-2 receiver. All locations were verified by visual observation and recorded to nearest 50 m as Universal Transverse Mercator coordinates. Two aerial searches were conducted each year between late April and late May for birds not found during ground searches. Birds found during aerial searches were subsequently located from the ground.

Flocks containing instrumented birds were monitored a minimum of 3 times/week beginning in late February to determine onset of gobbling and period of flock dispersal. Locations of radio-marked hens following flock break-up varied depending on how far they moved from wintering to breeding areas. Birds moving longer distances were located less frequently because they required more search time to find. During May, hens were located once every 3-5 days to minimize disturbance. All nests were located after incubation had begun. Nest sites were circled and flagged from >30 m away. Some nests were visually observable from this distance. Others were monitored but not approached for 30 days unless the radio-signal indicated the hen was gone. Nest sites were visited almost daily as the anticipated hatch date approached.

Onset of incubation was estimated by back-dating 28 days (Bailey and Rinell 1967) from the date of hatch. Most hens were located often enough just before and during the early stages of incubation to approximate within 3 days of when they started incubating. Unsuccessful hens located on nests during later stages of incubation were excluded from the analyses. Differences among years for mean dates of initiation of incubation were tested using ANOVA.

Gobbling indices were conducted 1 April to 15 June and categorized as preseason (~1-15 Apr), season (~16 Apr-15 May), and post-season (~16 May-15 Jun). Opening and closing dates of the hunting season varied by 3 days over the study period. I attempted to conduct 3 valid indices/week/time period (AM and PM). A gobbling index was considered valid if (1) positive identification was made of the instrumented bird that was gobbling, (2) the bird was not disturbed before or during the index, (3) the time the bird left (AM index) or went (PM index) to roost was known, (4) the index included time on and off the roost, and (5) it was known whether the bird was alone, or associated with other males and/or females.

An index lasted 1 hour from ½ hour before to ½ hour after sunrise (AM index) or sunset (PM index). The 1-hour period was divided into time spent on and off the roost and whether females were present or absent. Roosting times were determined by observing or hearing the birds fly to or from the roost. Presence of hens was ascertained from sightings or calls heard during the index or by locating and observing the birds after the index. In the case of simultaneous gobbling bouts, it was assumed the instrumented male was participating. Gobbles of subadult males were incomplete and higher pitched than gobbles of adults.

Radio-marked males were monitored on a rotating basis with the initial order being randomly selected. If, for example, male A could not be located on the day it was to be monitored, then the next male (B) on the list was indexed. Priority was then given to finding male A and doing an index on male A during the time period male B was supposed to be indexed. This order was adhered to as best possible. Some males were indexed less than others, however, because they were more difficult to find on a regular basis. For AM indices, the male was located on the roost the evening before. Males selected for a PM index were located at least 1 hour before sunset.

Gobbling data were totaled for each radio-marked male for each category of comparison (i.e., on and off the roost, hens present and hens absent, AM and PM, etc.) and converted to gobbles/hour. For example, if 200 gobbles (150 on and 50 off roost; 20 total gobbles during preseason) were recorded during 12 AM indices (720 min) on male A, 4 each during the preseason, season, and postseason totaling 252 minutes on and 468 minutes off the roost, then the preseason AM gobbling rate for male A was calculated as total gobbles recorded during the 4 preseason AM indices (20) divided by total minutes of observation (240) times 60 = 5 gobbles/hour. The on-roost AM gobbling rate was calculated as total gobbles on the roost (150) divided by total minutes of observation on the roost (252) times 60 = 36 gobbles/hour.

The Wilcoxon signed rank test was used to test the null hypothesis of no difference in gobbling on and off the roost, and in the presence or absence of hens. The same procedure was used to compare gobbling rates during the preseason, season, and postseason, and before, during, and after the peak period of incubation. Control of the overall error rate for these comparisons was maintained by use of the Bonferroni inequality. Gobbling of adults between years (1986 and 1989) was compared using the Mann-Whitney Wilcoxon test.

RESULTS

Nesting

Mean date for onset of incubation differed marginally (P = 0.103) among years, being earlier in 1989 (14 May, n = 12) than in 1986 (18 May, n = 14) and 1988 (21 May, n = 22). Earliest and latest dates for initiation of incubation of first nest attempts were 6 May and 8 June, respectively. Fifty-six percent (27/48) of the hens started incubation after the spring hunting season; another 35% (17/48) started the last week of the hunting season. The peak period for onset of incubation was 16-25 May.

Gobbling

Adults.--I obtained 203 valid indices on 12 different males in 1986 (99 indices on 7 males) and 1989 (104 indices on 5 males). Gobbling rates did not differ between years for AM (P = 0.687) or PM (P = 0.591) comparisons. Gobbling was first heard on 11 March and continued through 15 June when the gobbling indices were terminated. Radio-marked males were heard gobbling 2,830 times during 120 of 133 (90%) morning indices and 384 times during 43 of 70 (61%) evening indices.

On a daily basis, gobbling was extremely sporadic. Even during the peaks of gobbling, under ideal conditions, there were indices when no gobbling was heard. Some males gobbled consistently more than others. The typical pattern for an adult male was to gobble more (P = 0.007) in the AM than PM, more on than off the roost for both AM (P = 0.003) and PM (P = 0.006) comparisons, more (P = 0.016) in the absence than presence of hens, and more during than before (P = 0.01) or after (P = 0.034) the hunting season (Table 1). Gobbling did not differ (P = 0.60) between preincubation and incubation periods, but occurred less frequently during postincubation than during either preincubation (P = 0.015) or incubation (P = 0.012).

Two distinct peaks of gobbling were evident in 1986 (Fig. 1). The peaks were less pronounced in 1989, although the second peak in 1989 occurred at the same time as in 1986. Both second peaks of gobbling approximated the peak of incubation and occurred after the hunting season.

Subadults.--I obtained 85 valid indices on 8 different subadult males in 1988. Subadults were first heard gobbling on 15 April and last heard on 3 June. Only 62 gobbles were recorded between 1 April and 15 June, including 60 in the morning and 2 in the evening. No gobbling was recorded during 37 of 50 (74%) morning and 33 of 35 (94%) evening indices. The number of AM gobbles per index (n = 13) when subadults did gobble ranged from 1 to 27 (median = 1 gobble/hr).

Subadults gobbled at a slightly higher (P = 0.076) rate on than off the roost (Table 1). Only 2 AM gobbles were heard during 16 indices when hens were absent and 58 during 34 indices when hens were present. Seventy-seven percent (46/60) of all AM gobbling occurred in the absence of adult males.

Subadults appeared to gobble more during incubation than preincubation (Table 1); however, because of variation in gobbling among individuals, the difference was not

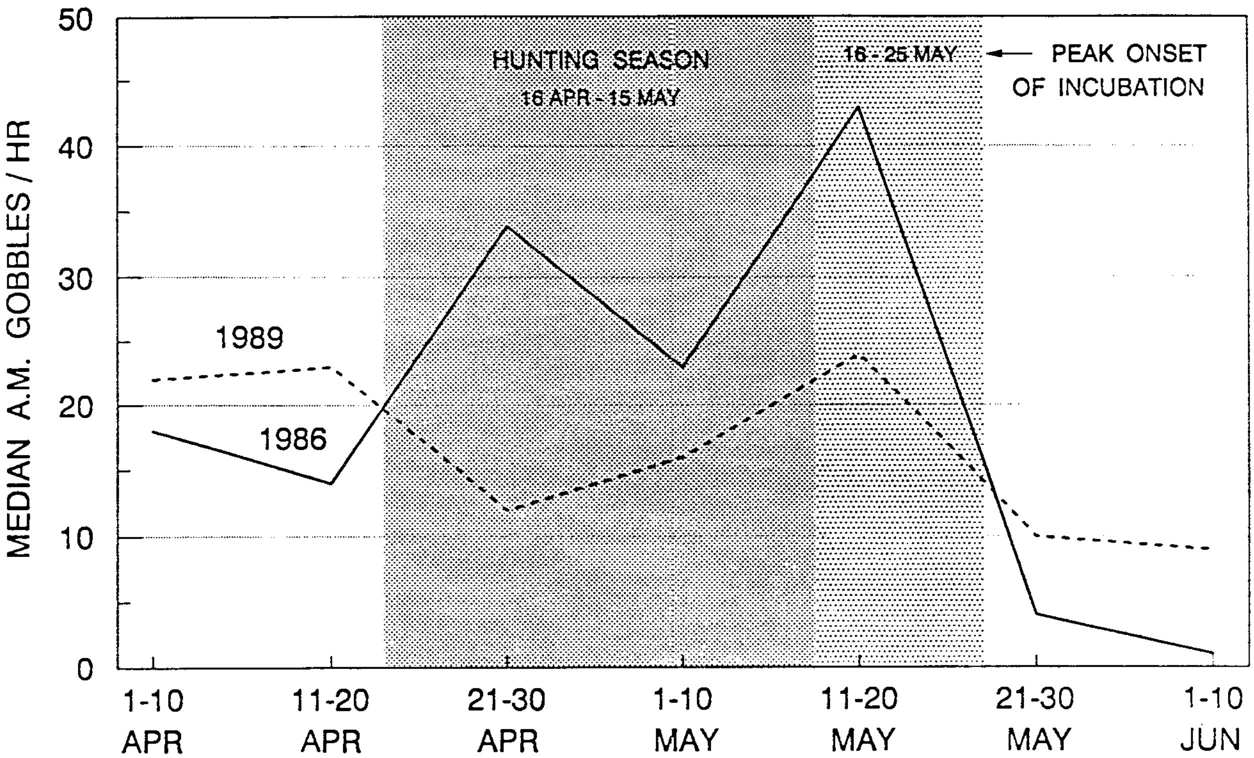

Fig. 1. Chronologic distribution of gobbling activity of adult male Merriam's wild turkeys in Colorado and New Mexico.

Table 1. Gobbling rate (gobbles/hour) of adult (n = 12) and subadult (n = 8) Merriam's wild turkeys in relation to time of day, roosting status, presence or absence of hens, and timing of incubation, and spring hunting season.

	Subadults			Adults		
Category	n[a]	Median	Range	n	Median	Range
Time of day						
AM	50	1.0	0.4-2.5	133	23.9	2.1- 44.8
PM	35	0.1	0.0-0.2	70	5.3	0.0- 24.7
Roosting status						
AM on	1,309	1.3	0.6-2.6	3,153	38.7	3.9-114.8
AM off	1,691	0.9	0.3-2.5	4,827	10.7	0.8- 29.3
PM on	1,012	0.0	0.0-0.1	1,586	12.3	0.0- 43.2
PM off	1,088	0.0	0.0-0.1	2,614	0.4	0.0- 23.8
Hens[b]						
Present	34	1.3	0.4-4.0	53	12.0	2.8- 34.0
Absent	16	0.0	0.0-0.7	46	29.2	1.4- 56.0
Timing of incubation[b]						
Preincubation	27	0.2	0.1-5.6	74	29.7	1.4- 53.7
Incubation	18	2.0	0.0-2.8	38	23.2	0.7- 88.0
Postincubation	5	[c]	[c]	21	2.0	0.0- 30.0
Timing of hunting season[b]						
Preseason	18	0.3	0.0-0.6	38	11.5	0.0- 52.1
Season	21	0.8	0.4-4.5	50	34.5	2.0- 77.0
Postseason	11	1.7	0.0-3.3	45	10.0	0.0- 38.6

[a]Total indices conducted except for roosting activity, which is expressed as total minutes of observation (i.e., AM min. on + AM min. off ÷ 60 = total AM indices).
[b]Based on AM indices only.
[c]Inadequate sample of indices per bird to compute a median and range.

significant ($P = 0.69$). Four of 8 subadult males gobbled more during the preincubation period and 4 gobbled more during incubation. Only 5 indices were conducted during postincubation, precluding comparisons with other periods. Gobbling also appeared to increase progressively from the preseason, through the season, and into the postseason (Table 1), but again, because of individual variation, no comparisons were significant ($P = 0.076$, 0.222, and 0.688 for preseason vs. season, preseason vs. postseason, and season vs. postseason, respectively). Four males gobbled most during the postseason. The other 4 males did not gobble in the postseason, but instead gobbled most in the preseason (3) and season (1).

DISCUSSION

Lockwood and Sutcliffe (1985) estimated the median incubation date for Merriam's wild turkeys in southeastern New Mexico to be 20 May. In central Arizona, Scott and Boeker (1972) reported the peak of hatch occurred around 15 June; backdating 28 days places the peak of incubation around 19 May. Nest initiation dates in South Dakota ranged from 20 April to 13 June (Wertz and Flake 1988). The corresponding incubation dates were 15 May and 8 July. No distinction was made between first and second nest attempts. Hatching dates for 15 nests in Oregon occurred over an 8-day period from 28 May to 4 June (Lutz and Crawford 1987). Incubation dates for these nests ranged from 2 to 8 May and were similar to dates reported by Mackey (1982) in Washington. Unpublished data from northern Arizona (H. G. Shaw, Ariz. Game and Fish Dep.) and southeastern Montana (J. E. Gobielle, Mont. State Univ.) indicated most hens started incubation in early May and late May, respectively. The Montana data may have included second nest attempts. Jonas (1966), in contradiction to Gobielle's data, reported incubation in southeastern Montana started in late April-early May. Jonas (1966) derived incubation dates indirectly from hatching dates assigned to poults visually aged in the field or from harvest samples of poults that were aged based on primary measurement techniques developed for eastern wild turkeys *(M. g. silvestris)* (Knoder 1959). This approach produced an inflated estimate of age and consequently an earlier estimate for onset of incubation.

I found the peak of incubation (16-25 May) in southcentral Colorado and northcentral New Mexico approximated (±2 weeks) dates reported from elsewhere within the native and expanded range of the Merriam's wild turkey. This relative uniformity among states suggests that photoperiod ultimately controls nesting. Photoperiod best explained the synchrony of turkey nesting in Vermont (Wallin 1983). Spring weather has a secondary influence on timing of nesting as evidenced by earlier nesting in 1989 compared with 1986 and 1988. Vangilder et al. (1987) attributed annual variations in nesting chronology to spring temperatures. However, there appears to be a period, regardless of weather, before which hens will not initiate nesting. In my study and the study in southeastern New Mexico (Lockwood and Sutcliffe 1985), no hens started incubation before 6 May despite annual differences in spring weather conditions. Late April seems to be the earliest Merriam's wild turkeys initiate incubation.

The median date for onset of incubation by Rio Grande wild turkeys *(M. g. intermedia)* in northeastern Colorado in 1986 was 6 May (Schmutz and Braun 1989). The median date of incubation on my study area in 1986 was 18 May, almost 2 weeks later. Rio Grandes were incubating as early as 21 April. Phenological differences between study areas were at least partially responsible for the advanced nesting in northeastern Colorado, but behavioral or physiological differences between subspecies also may have attributed to earlier nesting by Rio Grandes.

In Minnesota, the primary peak of gobbling associated with mating was consistent among years and occurred during the third and fourth weeks of April (Porter and Ludwig 1980). A secondary peak of shorter duration occurred in mid-May. Gobbling was heard throughout the monitoring period from 1 April to 17 June. Bevill (1975) documented a similar pattern of gobbling activity in South Carolina, except the primary (mid-Apr) and secondary (late Apr) peaks were earlier. Dates when gobbling was first and last heard ranged from 1 March to 10 July (Bevill 1973). Gobbling activity in Alabama peaked during the first and last weeks of April and ceased by mid-June (Davis 1969). The chronology of gobbling activities in Colorado and New Mexico most closely resembled the patterns observed in Minnesota.

Methods used to monitor and quantify gobbling have differed among studies, making comparisons difficult. Bevill (1973, 1975) recorded AM gobbling from fixed stations. He monitored both general and individual gobbling behaviors. Most other studies (Donohoe and Martinson 1963, Scott and Boeker 1972, Porter and Ludwig 1980) focused on general gobbling behavior and generated data from morning call-count routes. Davis (1969) used a combination of call-count routes and fixed stations to study general gobbling behavior. I conducted AM and PM gobbling indices on individuals. The location of the index depended upon where the bird roosted.

Wide daily variations in gobbling activity were apparent in all studies. When individuals were studied, it was apparent some males called more prolifically than others. Weather conditions accounted for some of this variation (Davis 1969, Bevill 1973), as did progression of the breeding season, and especially onset of incubation. I found that gobbling increased on the roost and in the absence of hens. None of the aforementioned studies specifically assessed gobbling in the presence or absence of hens. If gobbling serves to attract females (Bailey 1967:105), then gobbling should intensify in the absence of hens, which it did. But, males still gobbled in the presence of hens and did not always gobble in their absence, suggesting gobbling may function in other ways besides attracting females.

Gobbling was most consistently heard during the morning when males were still on the roost. Bevill (1975) recorded his highest counts during the 20 minutes preceding sunrise. In 89 days of monitoring, he heard $\geq$1 gobble on 53 (60%) mornings between 10 and 20 minutes before sunrise. I heard gobbling 73% of the time during the same interval. Bevill's (1973) study further indicated that adult eastern wild turkeys gobbled more than subadults. Converting his data to gobbles/hour revealed that adults gobbled an average of 62 gobbles/hour and subadults 13 gobbles/hour. Both age classes of eastern wild turkeys gobbled more than their respective age class of Merriams.

Bevill's (1973, 1975) data were collected from an unhunted population and may not reflect the true gobbling characteristics of eastern wild turkeys. He reported sporadic gobbling patterns for all his stations on hunted areas. He excluded these data from the analyses. Davis (1969) also had difficulty interpreting gobbling data collected on hunted areas. His comparisons were complicated by the use of different methods of monitoring gobbling on hunted (fixed stations) and unhunted (call count routes) areas. Although questionable, evidence from his study indicated that gobbling was more sporadic and occurred less frequently on hunted areas. This may be a normal response to hunting pressure. Males monitored on my study area were subjected to low hunting pressure and may have gobbled more than males on more heavily hunted areas.

MANAGEMENT IMPLICATIONS

The spring hunting season in Colorado currently opens in mid-April and closes in mid-May. These dates bracket the incubation period of Rio Grandes, and the peak of laying and beginning of incubation by Merriams. Most Merriams start incubating after the season closes. Thus, the current season structure is ideal for Rio Grandes, whereas a late-April to late-May season would be better for Merriams. Because Rio Grandes occur primarily in eastern Colorado and Merriams in western Colorado, with minimal overlap in ranges, seasons could be structured to open and close on different dates corresponding to peak incubation periods of the 2 subspecies.

The gobbling data supported the nesting data in terms of the justification for a later hunting season. Currently, the hunting season overlaps with the primary peak of gobbling and misses or includes only a portion of the secondary peak. Opening and closing the season 2 weeks later would minimize disturbance during peak of mating, bracket the peak of incubation, and include the second peak of gobbling.

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RELATIONSHIP OF WILD TURKEY POPULATIONS TO CLEARINGS CREATED FOR BROOD HABITAT IN OAK FORESTS IN PENNSYLVANIA

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Abstract: During a 20-year period, the relationship of wild turkeys *(Meleagris gallopavo silvestris)* to forest clearings was studied in 2 78-km^2 study areas in central Pennsylvania that normally support low density turkey populations. After 5 years of collecting baseline data on both areas, 20 small clearings were created on 1 area while the second area served as a control. At 10 and 12 years, 50 clearings were made on half of the second area. A third area (52 km^2) was included in the study as a replication for a 19-year period. After 4 years, 18 roadside strip clearings were made on half of this area; at 10 years, 14 semi-secluded clearings were made on the other half. The clearings were limed, fertilized, and seeded to legumes and grasses. Turkey populations were monitored annually by a baiting census in late summer and by counting turkeys from tracks in the snow. Hunter pressure and distribution were recorded on 2 of the areas. Data from surveillance cameras and radio-marked hens during the summer and from periodic searches for droppings showed turkey broods were attracted to and used clearings throughout the summer. Turkey populations on 2 areas appeared to increase in response to the clearings. The lack of a similarly positive response on the third area could have been due to greater human disturbance that negatively influenced the summer census data. The results emphasized the need for secluded brood habitats in greater amounts than those resulting from present forest management practices.

The literature has been replete with observational and circumstantial evidence indicating the importance of forest clearings for maximum wild turkey production (Mosby and Handley 1943, Wheeler 1948, Stoddard 1963, Holbrook and Lewis 1967, Hillstead and Speake 1970, Davis 1976, Healy 1985). A result has been the creation and maintenance of over 12,000 ha of herbaceous openings in 23 states by 1965 (Larson 1969). Since then the increase in logging and energy developments has provided even more opportunities for clearings in extensively forested areas.

A large increase of turkeys on an intensively managed area in western Virginia, where law enforcement protection also had been increased, was attributed mainly to the clearings that were created (McGinnis and Ripley 1962). Bailey and Rinell (1967) questioned the absolute need for clearings by eastern turkeys, but conceded clearings provided more abundant invertebrate and vegetation foods, particularly for poults, than would be available in forests. Markley (1967:221) also pointed out, "Although turkeys do make considerable use of clearings when they are available, it has not been demonstrated that creation of clearings results in a population increase." The objective of my study was to determine if creating herbaceous clearings in forests where this habitat component is scarce or lacking could enhance wild turkey production and increase turkey densities.

I am grateful for the major contributions to this study by R. Rossman, F. Rice, J. Slowikowski, and particularly by R. Potts and A. Ross. The study was partially funded by the National Wild Turkey Federation and its Pennsylvania chapter, and physically supported by the Pennsylvania State Bureau of Forestry.

STUDY AREAS

The main criteria for study areas were public land, few or no existing clearings, and low turkey densities. The study was conducted on 3 study areas. Two were 78-km^2 areas 8 km apart in northern Mifflin and Huntingdon Counties, with rugged mountain terrain and vegetation composition typical of southcentral Pennsylvania's Ridge and Valley Province. These parallel mountains and valleys, which lie in a southwest-northeast plane, range from 250 to 730 m in elevation. Mixed oak forests with ericaceous understories of mountain laurel *(Kalmia latifolia)*, huckleberry *(Gaylussacia* spp.*)*, and blueberry *(Vaccinium* spp.*)* predominated. Most of the valley bottoms and some lower slopes were forested with mixed stands of hardwoods, white pine *(Pinus strobus)*, and hemlock *(Tsuga canadensis)* with occasional dense stands of rhododendron *(Rhododendron maximum)* in the understory. The areas had been subjected to 60 years of browsing by deer *(Odocoileus virginianus)* (Christy and Sutton 1929), and understories were limited to old-aged relic specimens, or to extensive stands of ericaceous shrubs that are less palatable to deer. Soils were mostly the infertile stoney and sandy loams of the Hazelton-Laidig-Buchannon associations. Smaller amounts of Berks-Weikert association soils were found in the narrow upland valley bottoms and secondary ridges, in some places adjoining the fertile limestone soils of the intensively farmed Kishacoquillas Valley.

Each study area was composed of 2 parallel valleys and their adjacent ridges. About 25% of the edges of both areas bordered on the farms of the Kishacoquillas Valley. The remainder of the areas bordered extensive unbroken forests and terrain similar to the study areas. Other than the field edges and the clearings created for this study, few forest openings existed within either study area (Ross and Wunz 1990). A 20-m-wide gas transmission line right-of-way was the only break in the forest on the Seven Mountains study area (7M). Parts of both valleys in the Strong Mountain study area (SM) contained small remnants of reverting pastures and hay fields, considered somewhat better as turkey habitat. Most of these reverting fields were located on privately owned tracts, which comprised 26% of the SM area. The remaining 74% was state forestland, whereas 91% of the 7M area was state-owned.

Human access was greater on 7M where the terrain was less rugged and 88 km of roads were open to vehicles, compared with 78 km of roads on SM. At the beginning of study in 1968, cottages and hunting cabins in the SM area totaled 80, compared with 90 in 7M. During the study, the number of cabins remained essentially unchanged on 7M and in the 16-km-long Treaster Valley of the SM area, due to a moratorium on leasing cabin sites on state forestlands. In the Havice Valley part of SM, where 90% of the lower slopes and bottomland was privately owned, cabins increased from 40 to 93 in this 8-km-long valley during the 9-year period from 1975-1984. Off-road recreational vehicles were frequently driven on both areas during the latter half of the study period.

The third study area (SGL 88), 51 km south of these areas and also in the Ridge and Valley Province, was 52 km^2 of habitat types similar to those of SM and 7M. This 3.2-km-wide area of forest straddled the Tuscarora Mountain for 16 km, bordered farmland on both sides, and surrounded a 24-km^2 portion of state game lands (public hunting area No. 88). A 100-m-wide powerline right-of-way divided this study area into west and east halves. The mountain sides of the entire SGL 88 area and the top of the west half were forested mostly with large-pole and saw-log stands of oak. The top on the eastern half was mainly a small-pole stage forest with moderate to dense ericaceous understories, the result of fires and poor soils. Access was restricted by a gated road that traversed the length of SGL 88 along the summit of the mountain ridge in a southwest-northeast direction. Off-road vehicles were banned.

METHODS

After gathering baseline data on turkey populations on SM and 7M for 5 years, clearings would be created on the SM area and 7M would serve as a control area for the second 5-year period to measure any benefits to the turkey population that may have resulted from the treatments on SM. Assuming that the SM population would have responded (if at all) during the second 5-year period, the study would be replicated by establishing clearings at year 10 on 7M, after which SM would serve as the control.

The study began in 1968 and 20 clearings were made in 1972 and 1973 on SM that ranged in size from 0.01 to 1.0 ha ($\bar{x}$ = 0.3 ha). In 1977 and 1979, 50 clearings ($\bar{x}$ = 0.2 ha) were created on half of 7M to simulate the size, spacing, and density of log-landing type clearings that would normally be created from logging operations by the end of a 100-year rotation. This concentration on 7M resulted in a density of 1 clearing per 0.8 km^2, spaced an average of 0.5 km apart. The created clearings occupied 0.13% of 7M, or 0.26% of the half of the area on which they were concentrated. Clearings were more widely spaced on SM, occupying only 0.08% of the area (about 0.15% of Treaster Valley where most were located) at a density of 1 per 3.9 km^2 and 1.0 km apart.

The study plan was similar on the SGL 88 replication area where clearings were to be created first on the west half while the east half served as a control. Later their roles would be switched after clearings were created on the east half.

In 1972 and 1973, 18 long and narrow clearings were made that bordered 6.4 km of the 8.2-km access road on the west half of SGL 88. The 20-m-wide cleared strips totaled 8.1 ha, representing 0.3% of the west half of SGL 88. In 1980, 14 clearings of a more compact shape were completed on the east half, most of which were 50-100 m from the access road and hidden from view by vegetation. Spaced about 0.5 km apart, they were 0.2-0.4 ha in size and totaled 3.6 ha, which was 0.14% of the east half of SGL 88.

Most clearings on the study areas were created by bulldozing pole timber stands, except for 10 clearings on SM that were enlarged from log landings of earlier timber sales. The sites were limed, fertilized, and seeded to various legumes and grasses, as described in Wunz (1984, 1987). The most common and long-lasting mixtures seeded were birdsfoot trefoil with tall fescue, orchard grass, blue grass, or red fescue. Crown vetch was also sowed in the SGL 88 roadside strip clearings. No maintenance, other than mowing or herbicides in a few small experimental plots, was done to the SM or 7M clearings after they were established. The SGL 88 clearings were mowed periodically to control invading sweet birch *(Betula lenta)* and black locust *(Robinia pseudoacacia)*.

Turkey populations were monitored during the late summer for a 20-year period (1968-1987) on SM and 7M and for 19 years on SGL 88 (1971-1989). Flocks were lured with small grain as bait on trails leading to established sites along standardized routes where they could be counted by sighting, by 8-mm surveillance cameras, or by estimating their numbers from the amount of scratchings or droppings at the bait sites. During winter, observers on foot or snowmobile counted turkeys from snow tracks over established routes. The standardized route system, although weighted to winter ranges, also covered all habitat types and was considered nearly a complete census of all turkeys present. Complete coverage of the study areas was not possible with the baiting census method, and although a large proportion of the flocks present were lured to the bait sites, this method was considered an index of the population.

Radio telemetry, surveillance cameras, and periodic (not routine) inspections for turkey sign were used to determine use of clearings. In 1974, 1975, and 1984-1988, 33 of 66 radio-tagged hens on SM and 7M provided habitat use data. Hunting pressure was monitored by counting hunters during peak hunting days. Estimates of fall turkey harvest were attempted and found unreliable. Population trends were analyzed by correlation analysis; *t*-tests were used to compare means.

RESULTS

Clearing Use

Turkey sign, mostly droppings, was found in nearly all clearings during the study. Physical evidence of turkey use was least in the fall and winter months, except during years of mast shortages when turkeys fed on grass and forb seeds in the clearings. Use increased during spring and by summer as many as 56% of the clearings were used, especially by broods. Nearly all (96%) of the droppings found in clearings in August contained seeds from grass species growing in the clearings.

During the 300 days that surveillance cameras were operated during 1986-88 at most of the clearings on SM and 7M, turkey broods were filmed in 14 clearings a total of 24 times. Broods visited the sites 1-2 times daily, mostly between 0700-0930 and 1300-1930. Radio-tagged hens with broods that used clearings usually frequented more than one. One brood, monitored during the latter half of the summer period, used at least 8 clearings, 4 frequently.

Seventy-nine of 446 (18%) radio locations of hens with broods occupying summer home ranges that included at least 1 clearing were within 100 m of a clearing, although the combined area within these perimeters (3.14 ha each) amounted to 3% of only the portions of the areas that contained clearings. Considering all radio locations, regardless of the hens' home range, 11% were within 100 m of a clearing. Hens with broods used clearings mostly in the early summer period (before 15 Jul). Some broods used clearings through late summer (after 15 Jul) to feed on insects and grass seed, although their main foods at that time seemed to be blueberries and huckleberries.

Clearings used most by turkey broods had moderate stands of grass or trefoil, borders of shrubs or low overhead canopy cover, and were remote or well screened from roads. Turkeys seldom used 18 clearings on 7M after they were invaded by moderate to dense stands of sweet fern shrubs *(Comptonia peregrina)* late in the study.

Turkey Census and Populations

The summer baiting survey revealed that turkeys responded most readily to small grain bait during late August and early September after blueberry and huckleberry crops had waned and before hard mast and other forms of soft mast were available. The baiting census routes covered about 75% of each area, and finding that 67% of the radio-tagged birds were enticed to bait stations suggested that about 50% of the populations were being counted.

During the first half (10 years) of the study there was considerable agreement between turkey population trends indicated by summer and winter census methods within the SM (r = 0.76, $P < 0.005$) and 7M ($r = 0.88$, $P < 0.0005$) study areas. During the latter half they often fluctuated independently of one another (r = 0.06, $P > 0.4$; $r = -0.21$, $P < 0.4$). Population trends were also similar between study areas during the first 10 years, but dissimilar thereafter (Figs. 1, 2). Counts of turkeys on SM varied from 0.22 to 2.17/km^2 in the summer and 0.28 to 1.37/km^2 in the winter census. Counts on 7M ranged from 0.10 to 1.83/km^2 and 0.14 to 1.51/km^2, respectively.

These fluctuations, as much as 3-fold from year to year, made comparisons between treated and control areas difficult. For example, comparing the 5-year periods before and after clearings were created on SM with the same 2 periods on the 7M control area where clearings were not yet made, summer (baiting) counts of turkeys had increased similarly on both areas (39%, 31%). Winter track counts also increased on SM (32%), but decreased on 7M (−8%) during these 2 periods. Comparing the 10-year time periods before and after treatments on 7M with SM as a control area, the summer census revealed similar decreases (−14%, −13%) in counts on both areas. Winter counts showed slight decreases (−6%, −1%).

Considering the study areas individually (without controls) and comparing pre- and post-treatment time periods, both summer and winter census counts of turkeys indicated respective increases of 39% and 32% in the 5-year

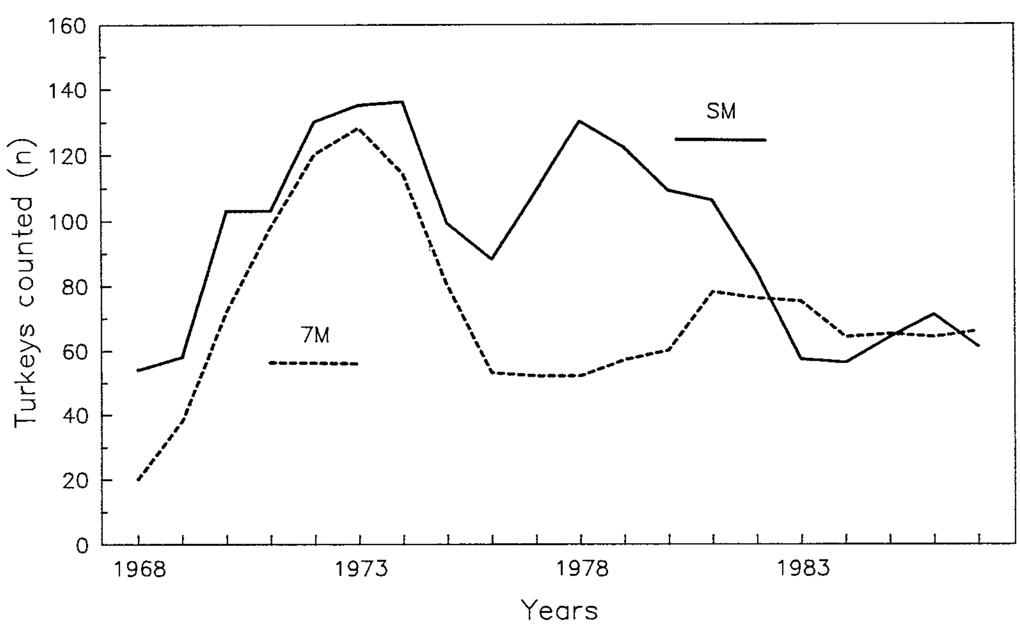

Fig. 1. Turkey population trends indicated by summer baiting census on Strong Mountain and Seven Mountain areas (3 years' moving averages). Summer census during first 10-year period $r = 0.57$, $P < 0.05$, and last 10-year period $r = -0.03$, $P > 0.4$ (r and P values based on individual year's data, not on 3-year moving average).

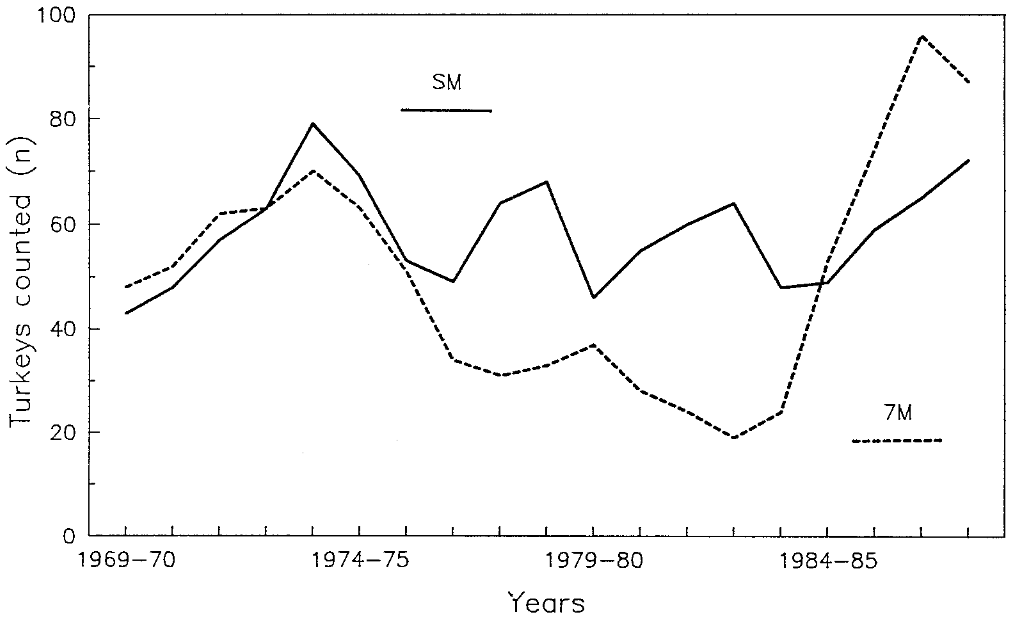

Fig. 2. Turkey population trends indicated by winter track counts on Strong Mountain and Seven Mountain areas (3 years' moving averages). Winter census during first 10-year period $r = 0.41, P < 0.25$, and last 10-year period $r = 0.20, P > 0.4$ (r and P values based on individual year's data, not on 3-year moving average.

period (38% and 24% in the 10-year period) of study that followed the establishment of the clearings on SM. During the last 5 years of the total 20-year study period, the summer and winter counts on SM had decreased by −49% and −12%, respectively, from the previous 10-year period, seemingly a result of the extensive cottage developments that had occupied some of the best brood and winter ranges on SM. During the entire period after clearings were created on SM the counts increased by 15% and 21%. Comparing the 2 10-year pre- and post-treatment periods on 7M, summer and winter counts decreased (-14%, −6%).

Separating the census data on each study area into halves with and without clearings generally indicated that more turkeys were inhabiting the parts of the areas with clearings and fewer were found on the parts that were without clearings. Summer and winter counts were greater (23% [$P < 0.001$] and 42% [$P < 0.0005$], respectively) during the 15-year period after clearings were created on part of SM. On the part without clearings, summer counts were essentially unchanged (6%), while winter counts decreased (−23%). During the 10-year period after clearings were made on half of 7M, summer counts changed little (-5%) while winter counts showed a substantial increase (35%). On the part of 7M without clearings both counts decreased (−27%, −47%).

On SGL 88, both summer and winter counts during the first 13 years of study showed greater turkey populations on the western half (Table 1). The summer baiting survey, conducted along the access road that traversed the top of the mountain ridge, showed broods were present on the west half in all but 1 of 13 years, whereas broods were found only during 3 years in the east half where turkey habitat was considered inferior. After the roadside clearings were made on the west half, the summer census did not show an increase in poults and hens during the following 15 years ($P < 0.001$). Counts of broods on the east half remained low until the last 6 years of study when a 12-fold increase occurred ($P < 0.0005$). Although clearings on the east half had grown sufficiently by 1981 to entice turkeys, broods did not use these areas consistently until after 1983. The winter census of the entire forested area of SGL 88 indicated the turkey population of the eastern half had more than doubled (127%) after 1983, while that of the western half was essentially unchanged (Table 1).

Table 1. Turkey hens and poults counted during the summer baiting census, 1971-89, and turkeys found during winter census, 1972-88, on SGL 88 study area, Pennsylvania.

Census period		West half $\bar{x}$	West half SD	East half $\bar{x}$	East half SD
Summer	1971-73	21.2	11.1	4.0[a]	6.9
	1974-78	17.0	15.4	2.4[a]	5.4
	1979-83	10.8	7.9	2.2	4.9
	1984-89	12.3	8.8	27.1	8.2
Winter	1972-83	33.4	33.6	24.8	25.3
	1984-88	36.2	42.2	56.4	38.7

[a]Pre-treated.

DISCUSSION

Although some turkey hens successfully raised broods in oak forests where herbaceous vegetation was scarce (Ross and Wunz 1990), this study indicated broods were attracted to and often used most of the clearings created for their benefit. Turkeys used clearings as feeding sites throughout the summer, but particularly in early summer for insects and green vegetation. Turkey use was noticeably greater in the late summer, and fall periods during years of poor blueberry, huckleberry, and hard mast crops.

Determining if these clearings were actually increasing turkey densities on the SM and 7M study areas, however, was complicated by uncontrollable variables. During the first 10 years of study, population trends indicated by the winter and summer census methods were similar for both study areas; but during the latter 10 years, a severe gypsy moth *(Lymantria dispar)* infestation, cabin developments, fuelwood cutting, and changes in fall hunting pressure had affected the census results. The summer census was more likely to be negatively affected by human disturbance from firewood cutting or cottage developments, because these activities were conducted on or near roads.

Fuelwood cutting had increased greatly during the late 1970s and early 1980s as a result of increased fuel oil prices and availability of oak trees killed by gypsy moth infestations. Both winter and summer census counts averaged 22% less in years following poor acorn crops, some of which resulted from gypsy moth defoliation. The infestations and fuelwood cutting were most extensive on 7M. Also, fall hunting pressure had increased from the first to the second half of the study by 24% on 7M, compared with 9% on SM. These factors appeared to have less effect on SM than the increase (133%) in cottage developments that usurped much of the brood and winter ranges in 1 of the 2 main valleys of SM.

To lessen the influence of these adverse variables that negated comparisons between SM and 7M as treated vs. control areas, data from pre- and post-treatment time periods were compared for each area separately. Numbers of turkeys increased substantially for a 10-year period after clearings were made on SM, until increased human disturbance from cottage developments caused loss of habitat, reducing the census counts during the latter years of the study.

The lack of a similar positive response to the clearings on 7M could be blamed on gypsy moth defoliation, increased hunting pressure, and disturbance from fuelwood cutting and management and research activities, all of which were more intense on this area during the 1980s. During the last 4 years of the study, however, the winter census indicated a substantial increase of turkeys on 7M. During 3 of these 4 years, marking the only occurrences since the study began, the winter counts on both areas were greater (3-97%) than those of the previous summer, appearing to reflect the increasing influence of these adverse factors on the summer census.

Additional comparisons made by separating each study area into halves with and without clearings generally showed turkey counts had increased after clearings were created, while the same number of or fewer birds were found on the halves without clearings. This suggested that the clearings were attracting turkeys, or possibly causing an increase in their numbers during a period when turkey populations were generally in a decreasing trend.

On SGL 88, both summer and winter census data were consistent in indicating turkey use, and populations had increased significantly on the east half of the study area on which semi-secluded clearings had been made. The fact that hens with broods were enticed to clearings made on mountain top sites in poor turkey habitat has substantial management implications because traditional lowland brood ranges are being lost to other land-use developments.

The comparative clarity with which SGL 88 data could be interpreted further exemplified the need for the control of variables, mainly those related to human disturbance that were not controlled on SM or 7M. On SGL 88 fuel-wood cutting by the public was banned and management work during the summer brood-rearing period was avoided. The gated road on top of the mountain and private lands flanking both sides of this study area greatly reduced year-round human disturbance and hunting pressure.

The reasons turkey broods did not respond positively to the clearings on the western half of SGL 88 seemed to be the invasion of dense vegetation (tree and shrub regeneration at first and crown vetch later), and greater possibilities of disturbance in these roadside strip clearings from humans and predators. Avian predators were commonly seen perched in these elongated clearings, which offered a large viewing area.

In summary, turkey populations on SGL 88, and to a lesser extent on SM, appeared improved by clearings, which occupied only 0.13% of the area. A similar response was not apparent on 7M, however, where twice this amount was in clearings. There was evidence that greater disturbance on 7M may have negatively influenced summer census data. The clearings on 7M were created purposely to simulate the spacing, size, and amount of permanent herbaceous openings that would have resulted from log landings under present forest management practices in this region by the end of a 100-year rotation period. The actual result of only 0.3% in clearings suggested the goal of at least 3% (>10 times the amount on 7M) specified in most management plans may be unrealistic to attain in practice, but perhaps necessary before significant benefits to wild turkey production would be apparent in most extensively forested areas where existing or natural brood habitat is scarce.

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HABITATS USED BY WILD TURKEY HENS DURING THE SUMMER IN OAK FORESTS IN PENNSYLVANIA

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Abstract: We studied the habitats used by 33 radio-marked eastern wild turkey *(Meleagris gallopavo silvestris)* hens during 7 summer seasons in the mixed oak *(Quercus* spp.*)* forests of the Ridge and Valley physiographic Province of southcentral Pennsylvania where conventional brood habitat of herbaceous vegetation is scarce. Normally, this area supported low-density turkey populations. The summer season was divided into early (May through 15 Jul) and late (16 Jul through Sep) brood-rearing periods. Turkey hens successfully raised broods in forests where natural clearings were rare. During early summer, most broods used lowland habitats where herbaceous plant stands existed in the forests. By late summer, most broods shifted to upland sites to feed on fruits of blueberry *(Vaccinium* spp.*)* and huckleberry *(Gaylussacia* spp.*)*. Hens without broods were typically found in upland habitats throughout the summer ($P < 0.001$). Most radio locations of hens were in forest stands where conifers were an important component. Encouraging some conifer stands in oak forests with dense shrub understories could have practical management implications.

Ordinarily, wild turkey hens with broods in oak forests frequent habitats with herbaceous ground vegetation of grass and forbs (Hillestad and Speak 1971, Pack et al. 1980, Healy 1985). In the extensive oak forests of central and southcentral Pennsylvania, however, broods have been seen inhabiting extensive forest areas where this conventional brood habitat of herbaceous vegetation is scarce and instead ground cover is mostly of ericaceous shrubs. Our objective was to determine the use of natural or existing habitat types by turkey broods in this environment. This study was done in conjunction with an evaluation of the influence of forest clearings on turkey populations (Wunz 1990).

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STUDY AREA

The study area consisted of 2 78-km^2 tracts, as described by Wunz (1990), in the Ridge and Valley Province of southcentral Pennsylvania. Both tracts were similar in terrain and vegetation and resembled about 75,000 km^2 of habitat types in the northeastern states and in the Appalachians. Agricultural land bordered on 25% of each study area. Topography of each area consisted of bottom areas and lower slopes (240-370 m), mountain benches and upper slopes (371-550 m), and mountain tops (551-730 m).

Bottom areas were typically dominated by eastern hemlock *(Tsuga canadensis)*, red oak *(Quercus rubra)*, white oak *(Q. alba)* and tulip poplar *(Liriodendron tulipifera)*. Common species in the mid-story were white pine *(Pinus strobus)*, witch hazel *(Hamamelis virginiana)*, and red maple *(Acer rubrum)*; understories were usually rhododendron *(Rhododendron maximum)* and mountain laurel *(Kalmia latifolia)*. Hay-scented *(Dennstaedtia punctilobula)* and New York *(Thelypteris noveboracensis)* ferns were the most prevalent ground covers. Some sedges *(Carex* spp.*)* and panic grasses *(Panicum* spp.*)* also occurred.

Lower slope areas were commonly dominated by red oak, white oak, and white pine. Typical species in the mid-story were white pine, red maple, and flowering dogwood *(Cornus florida)*, and mountain laurel in the understory. Ground cover included hay-scented and New York ferns and some panic grasses.

Mountain benches were usually forested in chestnut oak *(Q. prinus)* and red oak, with blackgum *(Nyssa sylvatica)* and red maple as the typical mid-story species. The most common understories were mountain laurel, blueberry, and huckleberry. Herbaceous ground cover was virtually nonexistent.

Upper slope overstories were predominantly chestnut oak, red oak, and black birch *(Betula lenta)*; mid-stories were red maple and blackgum. Understories of upper slopes were commonly dense stands of mountain laurel, blueberry, and huckleberry. Herbaceous cover was rare.

Mountain top overstories were typically chestnut oak; red maple and blackgum were common in the mid-story. The understory was composed almost entirely of blueberry, huckleberry, and mountain laurel, usually in dense stands. Herbaceous vegetation was limited to occasional sparse stands of panic grasses along roadsides.

METHODS

We used rocket-net boxes developed by Wunz (1974) to capture wild turkeys during February and March 1974, 1975, and 1984 to 1988. Classification of adults and subadults was based on contour of the spread tail (Godin 1960) and primary feather number 10 (Petrides 1942). Each turkey was marked with an aluminum patagial tag and leg band. All hens were fitted with radio harnesses built by A. Hayden and F. Rice.

In 1974 and 1975, a portable, homemade receiver assembled by H. Palmer was used to follow turkeys. After 1984, we used a portable Telonics receiver with either a 2-element hand-held Yagi antenna or, most often, a 4-element vehicle-mounted Yagi antenna. Three bearings were taken within a 10-minute period to triangulate each radio location of a hen. Usually hens were tracked 5 days per week from 0700 to 2000. Visual observations of radio marked hens were used as additional locations. Each location was plotted on a 7.5-minute USGS topographic map. Hens were followed through the entire brood-rearing period, which for this analysis, was divided into an early season (May through 15 Jul) and a late period (16 Jul through Sep).

We compared habitat characteristics at sites used by hens with those at 150 randomly chosen points on each study area. Random points were selected from the mercator coordinates on USGS topographic maps using a BASIC program, and were used to calculate the area of each habitat type. Because the 2 study areas were very similar in habitat type (Table 1), we combined both areas for the analyses.

Each hen location and random point was visited and 16 variables were evaluated. Most were categorical variables, and we assigned values after examining an area of about 25-m radius around the point. Categorical variables included aspect: north, south; topographic positions: bottomland, lower slope, mountain bench, upper slope, mountain top; land-use type: farm, reverting field, management clearing, road, natural clearing, forest; habitat cover type: open savannah, conifer, mixed oak, oak-conifer, cove hardwoods, chestnut oak, red maple, agriculture; and dbh categories. Vegetation densities were ocularly estimated (Hays et al. 1981) by 5% classes for overstory (all overhead cover), midstory, woody ground cover, and herbaceous ground cover. We measured distance from the site to the nearest water source, farm field, management clearing, road, and hunting cabin from USGS topographic maps. We estimated basal area using a Cruz-All angle gauge by Forestry Suppliers, Inc. A visibility index was calculated by sighting through holes in a staff at approximate eye level of a hen (70 cm) in the 4 cardinal compass bearings and averaging the distances to which vision was unimpeded by vegetation, undulation in terrain, or other obstructions.

Table 1. Habitat types for each study area (%) in southcentral Pennsylvania.

Habitat type	Strong Mountain	Seven Mountain
Bottomland (white oak-hemlock)	17	17
Lower slope (red oak-white pine)	15	13
Mountain bench (mixed oak)	2	2
Upper slope (chestnut, red oak-birch)	54	56
Mountain top (chestnut oak)	12	13

Comparisons were made between adult and subadult hens with and without broods, and with random points. Hens were visually observed at least twice during the brood-rearing period to determine if they had broods: once during the beginning of the early brood-rearing period and once near the end of the late brood-reading period. Analyses were made using Mann-Whitney tests to compare means and chi-square goodness-of-fit tests (Neu et al. 1974, Byers et al., 1984) to compare habitat use with availability and test for significance ($P \leq 0.05$).

RESULTS

Radio failure, predation, and poaching reduced the 66 instrumented hens to 33, 19 with broods and 14 without broods (Table 2), that could be monitored to determine habitat preferences.

Hens with Broods

Use vs. availability.--During the early brood-rearing period, hens with broods chose habitats with a more dense tree canopy (P = 0.046), more dense herbaceous ground cover (P < 0.001), and less dense woody ground cover (P = 0.015) than was available (Table 3). The visibility index was greater (P = 0.026) than expected. Hens with broods preferred bottomlands and lower slopes (P < 0.001) (Table 4). In these areas, hens most often were in conifer and oak/conifer stands (P < 0.0001). Broods were found close to management clearings (P < 0.001), which were located in a variety of widely distributed sites. However, broods also were found closer to water (P = 0.013), farm fields (P < 0.001), and hunting cabins (P < 0.001), which were usually concentrated in the bottom and lower slope areas.

Table 2. Turkey hens *(n)* with and without broods and locations *(n)* for the early (May-15 Jul) and late (16 Jul-Sep) brood-rearing periods in southcentral Pennsylvania.

Hens with broods				Hens without broods			
Early period		Late period		Early period		Late period	
Hens	Locations	Hens	Locations	Hens	Locations	Hens	Locations
19	265	17	174	14	173	14	164

Table 3. Mean values for habitat characteristics measured at sites used by hens with broods, hens without broods, and random locations in southcentral Pennsylvania.

		Hens with broods		Hens without broods	
Habitat characteristic	Random sites $n = 300$	Early $n = 265$	Late $n = 174$	Early $n = 173$	Late $n = 164$
Basal area, feet^2/acre	109	107	102	120*	109
Overstory canopy, %	68	72*	73	70	74
Midstory canopy, %	25	29	33*	30*	35*
Woody ground cover, %	45	36*	47	36*	53*
Herb. ground cover, %	6	13*	8	14*	4
dbh, cm	11.1	10.7	10.6	11.2	9.9
Visibility index, m	22.3	24.2*	20.7	24.0	17.0
Distance (m) to nearest:					
Water	339	301*	344	339	413*
Farm field	494	458*	467*	453*	491
Management clearing	467	418*	435*	418*	429*
Road	327	328	293	366*	339
Hunting cabin	439	408*	429	413*	477*

*Differs from random sites, Mann-Whitney test, $P \leq 0.05$.

Table 4. Habitat availability (%) and use (%) by hens during early and late brooding periods in southcentral Pennsylvania. Habitat use is based on 439 locations of 19 hens with broods and 337 locations of 14 hens without broods. Availability is based on 300 random sites.

		Use[a]			
		Hens with broods		Hens without broods	
Habitat type	Availability	Early	Late	Early	Late
Bottomland	17	19	4−	13	2−
Lower slope	14	37+	13	17+	7−
Mountain bench	2	6+	12+	8−	20+
Upper slope	55	32−	44−	52	56
Mountain top	12	6−	27+	10	15+

[a] + indicates more than expected, − indicates less than expected, Chi-square tests, $P < 0.05$.

In the late brood-rearing period, hens with broods preferred mountain benches and tops ($P < 0.001$). Hens preferred the areas which were forested primarily with chestnut oak and conifer stands ($P < 0.001$). Most of these stands were understocked, but a mid-story of red maple and blackgum increased the total tree canopy density on the sites most used by broods ($P = 0.007$). Understory ground covers were used in similar proportions as they occurred. Broods were found closer to management clearings ($P = 0.009$) more than expected, but not as much as during the early summer.

Hens With Broods: Adults vs. Subadults

Adult and subadult hens with broods used bottoms and lower slopes in similar proportions during the early brood-rearing period. In late summer, some adult hens continued to use the lowland habitats, whereas most of the adults and subadults shifted ranges to upland sites ($P < 0.001$). For the entire summer, adult hens preferred south-facing slopes while subadults used north-facing slopes (early, $P < 0.001$; late, $P = 0.005$). In early summer, adults were found closer to water ($P = 0.05$), farm fields ($P < 0.001$), and roads ($P < 0.001$). Subadults were more often found closer to management clearings ($P < 0.001$).

Hens Without Broods

Use vs. availability.--In the early summer period, 14 hens without broods used mountain benches and lower slopes ($P < 0.001$), and chestnut oak and conifer stands ($P < 0.001$) more than expected. Most stands used were understocked, but had a dense mid-story ($P = 0.002$). Hens chose understories with less shrub cover ($P = 0.009$) and more herbaceous ground cover ($P < 0.001$) than available. The sites chosen by these hens were usually closer to the management clearings ($P < 0.001$), farm fields ($P < 0.001$), and hunting cabins ($P = 0.005$), and farther from roads ($P = 0.023$) than expected.

In late summer hens without broods used mountain benches and tops ($P < 0.001$), and chestnut oak and conifer stands ($P < 0.0001$) more than expected. Forests used were understocked stands with dense mid-stories ($P < 0.001$) and shrub understories ($P = 0.025$) primarily of blueberry and huckleberry. Hens ranged closer to management clearings ($P = 0.007$), but farther from water ($P < 0.001$) and hunting cabins ($P < 0.001$) than the random points indicated.

DISCUSSION

We found that turkey hens successfully raised broods in forests where relic or natural clearings were rare. In early summer, most broods were found in lowland habitats where local stands of herbaceous plants grew in oak (mostly white) and conifer (mostly hemlock) forests. Cursory observations of droppings showed hens and poults were feeding on insects and green vegetation. By late summer, most of these broods migrated to upland sites, apparently attracted by ripening blueberries and huckleberries; droppings of birds at upland sites were composed almost entirely of remnants of these fruits. Pack et al. (1980) reported similar findings. Some broods, however, were raised entirely on these upland sites of chestnut oak with ericaceous shrub understories and scarce herbaceous vegetation. Why a greater proportion of subadults raised broods in these upland sites is unknown. However, it may be speculated that turkeys are territorial in that adult hens with broods won't tolerate subadult hens with broods.

Broods were often close to farm fields and hunting cabins because most broods frequented lowland forest sites where farm fields and most hunting cabins are located. Broods were generally near the management clearings throughout the summer.

Broods using uplands were seldom multiple, probably because insects are not abundant enough to provide sustenance for large numbers of poults. The exceptions were 2 occasions when large, multiple broods were found on the edge of gypsy moth *(Lymantria dispar)* larval infestations, and 1 occasion when a large hatch of 17-year cicadas *(Tibicen linnei)* erupted.

Hens without broods were found in slightly different habitats than hens with broods. Broodless hens tended to use upland sites during the entire summer, seldom venturing into valley bottoms; they preferred areas with less shrub cover and more herbaceous vegetation, including management clearings.

Although conifers were relatively scarce on the study area, particularly on upland sites, hens with and without broods were usually found in forest stands in which conifers were an important component. A plausible reason for this preference may be the denser canopy, which conifers provide, shades out the thick stands of ericaceous shrubs, allowing the birds greater freedom of movement. This finding implies that encouraging some conifer stands in oak forests of this kind could have practical management implications.

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EFFECTS OF PRESCRIBED BURNING ON WILD TURKEY HABITAT PREFERENCE AND NEST SITE SELECTION IN SOUTH GEORGIA

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Abstract: Habitat preferences and nest site selections of 37 radio-instrumented eastern wild turkeys *(Meleagris gallopavo silvestris)* were studied for 2 years on a southern Georgia area with a long history of prescribed burning. "Green-ups" stimulated by burning in December to February were avoided by turkeys during winter, but pine-hardwood, hardwoods, and fields of waste corn or cool-season grasses were used. Forest openings were preferred in spring of both years. Old-field pine plantations were preferred the first spring after planting but avoided the second spring. Freshly burned pinelands were preferred in spring 1988 but avoided the following spring when burn area extent was much larger. Annually burned pinelands were used more ($P < 0.05$) post-burn than pre-burn. Pine uplands left unburned for 1-3 years were avoided for general travel range but were highly preferred ($P < 0.01$) nesting habitat. Seventeen of 23 (74%) nests were in these "roughs" averaging 2.7 ha. Site-specific burning plans should be tailored to best suit local conditions.

Woods burning to attract game animals in the southeastern U.S. dates back to the time of the Indians and our pioneer ancestors (Komarek 1984). Herbert Stoddard was probably the first to recognize fire as a wild turkey management tool; he wrote that "...wild turkey management, at least in the deep South, may include a certain amount of use of properly controlled fire on the upland pine types to aid in maintaining proper food and cover condition ... and to provide fresh green feed for the birds" (Stoddard 1936:3). By the early 1960s he believed controlled fire to be "an almost indispensable tool for use in practical wild turkey management in the southeastern coastal plain" (Stoddard 1963:26).

Burning is known to cause an earlier green-up (Lemon 1967) and result in more nutritious forage (Lay 1957). The value of late winter-early spring green vegetation to turkeys has been well documented (Stoddard 1936, 1963; Wheeler 1948; Holbrook 1973; Exum et al. 1987). Dickson et al. (1978) believed that green forage resulting from winter burning could sometimes substitute for oak mast as winter food of primary importance. Understory fruit production, important as turkey food, is greatest 2-3 years after burning (Johnson and Landers 1978), and turkeys often nest in areas spared from fire for a few years (Stoddard 1963, Hon et al. 1978, Exum et al. 1987). Many authors have recommended burning on a 2- to 5-year rotation for turkey management (Stoddard 1963, Speake et al. 1975*a*, Hurst 1978). A recent study in southern Alabama, however, found turkeys generally preferred pinelands burned within 1-2 years (Exum et al. 1987). Despite recent advances in knowledge of controlled burning, there are deficiencies in knowledge regarding influences of burning on wild turkeys (Hurst 1981).

The purpose of this study was to quantify the attractiveness to turkeys of freshly greening-up prescribed burns in winter and spring, as well as habitat preference and nest site selection in an area of extensive annual burning. These data were collected as part of a larger ongoing study on wild turkey habitat management in fire-type pine forests being conducted cooperatively between Tall Timbers Research Station and the Alabama Cooperative Fish and Wildlife Research Unit.

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[1]Cooperators: U.S. Fish and Wildlife Service, Game and Fish Division of the Alabama Department of Conservation and Natural Resources, Wildlife Management Institute, Auburn University (Alabama Agricultural Experiment Station, Department of Fisheries and Allied Aquacultures, Department of Zoology and Wildlife Science).

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STUDY AREA

The study area is approximately 5,000 ha centered around Pebble Hill Plantation in Thomas and Grady Counties, Georgia. Hunting plantation properties make up 90% of the study area. The other 10% consists of a large dairy farm, paper company land, and scattered private home places. This part of the Coastal Plain is dominated by the Greenville-Magnolia soil association, and because of the rolling topography and relatively fertile red clay soil, is known as the Tallahassee Red Hills (Brueckheimer 1979).

The habitat now consists primarily of old-field loblolly *(Pinus taeda)* and shortleaf pine *(P. echinata)* with scattered longleaf pine *(P. palustris)* and some remnant stands of longleaf pine and wiregrass *(Aristida stricta)*. Interspersed throughout these uplands are hardwood stands, locally referred to as "hammocks," primarily in low-lying areas where fire rarely penetrates. These diverse stands commonly include American beech *(Fagus grandifolia)*, southern magnolia *(Magnolia grandiflora)*, spruce pine *(P. glabra)*, sweetgum *(Liquidambar styraciflua)*, various oaks *(Quercus* spp.*)*, hickory *(Carya* spp.*)*, yellow poplar *(Liriodendron tulipifera)*, sweet bay *(M. virginiana)*, and red bay *(Persea borbonia)*. Also scattered throughout the area are swamps, locally referred to as "heads" or "bays," with overstories of gum *(Nyssa* spp.*)* and/or cypress *(Taxodium* spp.*)*. There is a long history of prescribed burning in the area; most uplands are burned annually to maintain park-like pine stands for quail *(Colinus virginianus)* management and hunting. Small, scattered fields are usually planted to winter greenery such as wheat and oats, or annual grain crops for quail feed.

METHODS

Turkeys were captured in late winter each year with alpha-chloralose-treated corn (Williams 1966), leg banded, outfitted with solar-powered radio transmitters (Everett et al. 1978), and released near the capture site. Gobblers were additionally outfitted with patagial wing tags as described by Knowlton et al. (1964). We located turkeys by triangulation using a hand-held directional Yagi antenna, and by sightings of wing-tagged birds. Locations were plotted on topographic maps delineated into habitat types. Guidelines for telemetric accuracy were those used by Exum (1987) in a similar study. We attempted to locate hens daily between release and onset of incubation, and gobblers 2 times weekly. Tracking days were delineated into 3 time blocks (morning, mid-day, afternoon), each time block receiving approximately equal numbers of total locations.

In 1988 prescribed burning was begun in March on the entire study area and continued until early May. In the 1988-89 season burning was conducted on Pebble Hill from December to April. Surrounding properties were burned following the traditional pattern beginning in March. A fresh burn was considered one ≤ 2 months old. Spring was considered to be the period of 15 March-31 May for both years, which coincides with the majority of fresh burns in the area.

Chi-square analysis of preferences was performed for all seasons to determine whether habitats were used differently from their availability, and to determine if there was a difference between years. Seasonal habitat preferences were determined by setting up a family of 90% confidence intervals around the number of telemetry locations in a given habitat as described by Neu et al. (1974). These limits were compared with the expected value based on habitat availability. We used PREFER program (Great Lakes Fisheries Laboratory, U.S. Fish and Wildlife Service, Ann Arbor, MI 48105), which employs methods described by Johnson (1980), to rank preferred habitats, and the multiple-comparison procedure of Waller and Duncan (1969) to compare preference rankings. We used a preference index described by Ivlev (1961) as an additional measure of relative preference for each season. This index ranked habitats on a scale from +1 (most preferred) to −1 (least preferred). A paired *t*-test was used to determine if the percentage of turkey locations in fire-maintained pinelands differed between pre- and post-burn.

Upon onset of incubation, nests were located and marked at a distance as described by Everett et al. (1980), then monitored daily to determine their fate. Data were collected on habitat type, tree basal area, distance to nearest edge, time since last burn and size of rough area (where pertinent), and the 4 most abundant plants in the immediate area. *T*-tests were used to determine if differences existed in any of these variables between successful and unsuccessful nests. Nests were considered successful if any eggs hatched. The method described by Neu et al. (1974) was used to determine preference for nesting habitat.

The study area was divided into 9 habitat categories according to cover type, age, prescribed burning frequency, and silvicultural treatment: mature hardwoods and swamps, pine-hardwood, fields, annually burned pinelands, unburned natural pinelands, natural pinelands unburned for 1-3 years or "roughs," pine plantations $\leq$5 years old, pine plantations >5 years old, and grazed woods. Habitat availability was defined as that area within the boundaries of the outermost telemetry locations and thus was not necessarily the same both years. We used a planimeter to measure the area of each habitat type. The 2 most available habitats were hardwood (33% in 1988 and 28% in 1989) and annually burned pineland (20% in 1988 and 35% in 1989). Yearly availability of the other habitats were pine-hardwood (4% in 1988 and 2% in 1989), fields (15% in 1988 and 11% in 1989), unburned natural pineland (11% in 1988 and 4% in 1989), 1- to 3-year rough (8% in 1988 and 7% in 1989), pine plantations $\leq$5 years old (3% in 1988 and 10% in 1989), pine plantations >5 years old (4% in 1988 and 2% in 1989), and grazed woods (2% in 1988 and 1% in 1989).

RESULTS

We recorded 539 locations for 37 turkeys (26 hens and 11 gobblers). The first year's (1988) sample consisted of 9 hens and 5 gobblers, the second year's 21 hens and 8 gobblers. Gobblers accounted for 33% of the locations, hens 77%. Observed habitat use differed ($P < 0.05$) from expected use for all seasons and between years. Table 1 shows the number of observed locations versus the number of expected telemetry locations based on habitat availability for each season. Ivlev's (1961) preference index is presented in Fig. 1.

Preferred winter habitats were pine-hardwood and hardwood (Table 1). The PREFER program ranked pine-hardwood significantly ($P < 0.05$) above hardwood. Fields and pine plantations >5 years were used in proportion to their availability while all other types were avoided. Winter preference index rankings above zero were pine-hardwood, hardwood and fields in that order (Fig. 1).

Table 1. Seasonal habitat use by wild turkeys in Thomas and Grady Counties, Georgia.

	Jan-Mar 1989			Mar-May 1988			Mar-May 1989		
Habitat type	Observed locations	Expected locations	Use[a]	Observed locations	Expected locations	Use	Observed locations	Expected locations	Use
Hardwood	51	28	P	71	76		88	60	P
Pine-hardwood	16	3	P	5	9		6	5	
Fields	18	13		43	36		70	24	P
Annually burned pine	2	23	A	65	46	P	32	77	A
Unburned pine	1	9	A	20	26		5	9	
Rough (1-3 yrs)	0	7		4	18	A	2	16	A
Planted pine ($\leq$5 yrs)	0	4		22	7	P	9	22	A
Planted pine (>5 yrs)	1	2		2	9	A	3	4	
Grazed woods	0	2		0	5		20	20	

[a]P indicates habitat type used more than expected (preferred) and A indicates habitat type use less than expected (avoided). All others used in proportion to their availability. Chi-square test, $P < 0.10$.

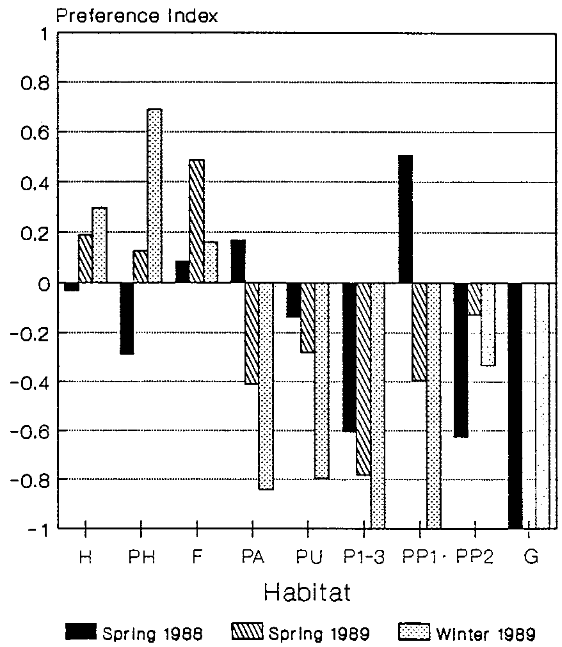

Fig. 1. Ivlev's (1961) preference index for habitat types available to wild turkeys in Thomas and Grady Counties, Georgia, March 1988-May 1989. H = hardwood, PH = pine-hardwood, F = field, PA = annually burned pinelands, PU = unburned pinelands, P1-3 = 1- to 3-year rough, PP1 = pine plantations $\leq$5 years old, PP2 = pine plantations >5 years old, G = grazed woods.

In spring 1988, pine plantations $\leq$5 years old and freshly burned pinelands were preferred ($P < 0.10$) (Table 1). PREFER indicated very young pine plantations were significantly more preferred ($P < 0.05$) than burned pinelands. The hardwood, pine-hardwood, field, and unburned pineland types were used in proportion to their availability, while the 1- to 3-year rough, pine plantation >5 years, and grazed woods were avoided. The preference index ranked pine plantations $\leq$5 years, annually burned pinelands, and fields above zero in that order (Fig. 1).

The second spring (1989), hardwood and fields were preferred types (Table 1). Fields were ranked ahead of hardwoods but not significantly so ($P > 0.05$). Pine-hardwood, unburned pinelands, pine plantations >5 years, and grazed woods were used in proportion to their availability, while annually burned pinelands, 1- to 3-year rough, and pine plantations $\leq$5 years were avoided. Although not preferred, fire-maintained pine uplands were used more ($P < 0.05$) post-burn than pre-burn. The preference index ranked fields, hardwood, and pine-hardwood above zero in that order (Fig. 1).

Twenty-three nest sites were located: 17 in 1- to 3-year roughs, 3 in hardwoods, 1 in pine-hardwood, 1 in annually burned pines, and 1 in 5-year-old planted pines (Table 2). One- to 3-year roughs in the pinelands were the preferred nesting cover, containing 74% of the nests. Eight of the 17 nests in the preferred type were in areas not burned for 1 year, 6 were in areas not burned for 2 years, and only 3 were in areas not burned for 3 years. The average size of unburned areas where nest sites were found was 2.7 ha, ranging from 0.04 to 16.2 ha. Patches of unburned cover within stands burned that year accounted for 8 of the 17 nests in 1- to 3-year roughs. Tree basal area averaged 8.5 m^2/ha for all nest sites. Average distance to the closest edge was 25.4 m and ranged from 4.6 to 59.5 m. The closest edge to a nest site was a travel lane (road or firebreak) on 9 occasions, an opening on 7, a fresh burn on 6, and a cypress bay on 1. The most common plants at nest sites were hardwood sprouts, blackberry (*Rubus* spp.), broomsedge (*Andropogon* spp.), and greenbrier (*Smilax* spp.), in that order. Other plants commonly encountered were wax myrtle (*Myrica cerifera*), muscadine (*Vitis* spp.), and bracken fern (*Pteridium aquilinum*). No significant differences existed between successful and unsuccessful nests for any of the variables tested. Nesting success was 48% for both years.

Table 2. Nest habitat types selected by radio-instrumented wild turkey hens in Thomas and Grady Counties, Georgia 1988-1989.

Habitat type	Nests *n*	Nests %	Availability of habitat type (% of area)
Hardwood	3	13.0	27.3
Pine-hardwood	1	4.3	2.1
Annually burned pine	1	4.3	35.3
Rough (1-3 years)	17	73.9*	7.2
Planted pine ($\leq$5 years)	1	4.3	9.8

*Preferred at $P < 0.01$ level of significance.

DISCUSSION

Winter habitats shown to be important to wild turkeys were pine-hardwood, hardwood, and fields. The high use of pine-hardwood was most likely due to the abundance of dogwood (*Cornus florida*) fruit in this type at a time of poor oak mast production in the hardwood hammocks. Barwick and Speake (1973) found dogwood fruit to be the number 1 winter food item in a year of oak mast failure in the Piedmont of Alabama. Other authors have reported dogwood midstories as important components of turkey habitat. Hardwood stands received extensive use during the winter season. The diversity of overstory and midstory tree species in these stands ensures at least some mast availability in most years. Fields also received considerable use during winter. They were almost exclusively fields of waste corn or cool-season greenery. Such fields have long been considered important to turkeys (Wheeler 1948, Stoddard 1963). No turkey locations were recorded on freshly greening-up winter burns in January or February. Turkeys apparently obtained any necessary winter greenery from fields rather than from fresh burns.

Forest openings in the form of fields, pastures, or very young pine plantations were a preferred habitat during both springs. This is consistent with findings of many other researchers (Wheeler 1948, Lewis 1964, Speake et al. 1975*b*). In 1988 old-field pine plantations in their first year were the preferred opening type, but these plantations were avoided during their second growing season. These areas had been harrowed and were in a very open condition the first spring, but by the second, a tall, rank growth of vegetation had accumulated, apparently making them unattractive to turkeys. In 1989 fallow corn fields and pastures were the preferred opening types. Two small, intensively site-prepared, first-year pine plantations also received heavy use.

Freshly burned pinelands were preferred the first spring when this type comprised 20% of the study area, but were avoided the second spring when 35% of the area was in fresh burns. The size of the study area nearly doubled the second year; the new area consisted of large expanses of open pine woodlands containing a small percentage of hardwoods and fields. Subsequently, the percentage of locations in burned pinelands decreased, while the percentage of locations in fields and hardwood increased. Turkey activity throughout the study was generally concentrated around large areas of well-developed hardwood hammocks. This suggests the importance of interspersion of habitat types and the reluctance of turkeys to use large expanses of open pinelands without security cover nearby. The annually burned pinelands also received considerable use the second spring but were not shown to be preferred, probably due to the large increase in the availability of this type. On several occasions turkeys moved into previously unused areas where a fresh burn was greening-up, and it was not unusual to see turkeys on fresh burns. The fresh green vegetation and open conditions make these areas suitable for gobbling, strutting, and feeding areas. These areas seem to be used more, however, when interspersed with hardwood hammocks and other habitat types.

Natural pine uplands left unburned for 1-3 years were avoided both springs by non-nesting turkeys. The long history of winter prescribed burning has led to the development of a dense groundcover that includes many hardwood sprouts with well-developed root systems. This groundcover, along with the long growing season, abundant rainfall, open canopy, and relatively fertile soil, causes rapid regrowth of vegetation after burning. Most unburned areas appear to be too thick for turkey travel range after 1 growing season and definitely so after 2 growing seasons.

One large area classified as unburned natural pinelands received considerable use during both springs. Five small fields scattered throughout this area that were heavily used by turkeys are believed primarily responsible for this use. Although classified as unburned, this stand was actually burned annually until 7-8 years before this study began. The stand has apparently opened up enough at turkey level so that turkeys were not deterred from using the area.

The preference for 1- to 3-year roughs for nesting is similar to the findings of Everett et al. (1981) where 1- to 3-year roughs after mowing were a highly preferred nesting habitat in northern Alabama. Exum et al. (1987) found 89% of the nest sites in an area of sandy soils in southern Alabama in vegetation unburned for 3 or more years, and only 11% in areas burned within 2 years. On our study area 82% of the nests in the preferred type were in vegetation burned within 2 years and only 18% in vegetation unburned for 3 or more years. This difference likely reflects the influence of soil type on growth rate of woody cover, together with influences by overstory density and burning history. One renest in June was in an area that had been clean burned only 3 months previously. This was apparently sufficient time for the vegetation to grow back to meet the cover requirements of that hen. Our findings of nearly half (47%) the nests in the preferred type to be in unburned patches of vegetation surrounded by freshly burned areas supports the findings of Hon et al. (1978) where 4 of 16 nests in saw palmetto *(Serenoa repens)* habitat were in small unburned clumps.

Although not analyzed statistically in comparison with random sites, our finding of the average distance from nest sites to the closest edge of 25.4 m agrees with the findings of Speake et al. (1975*b*), Hon et al. (1978), Exum et al. (1987), and others who found turkeys had a tendency to nest near edges.

MANAGEMENT IMPLICATIONS

In the fire-maintained pinelands of the Tallahassee Red Hills Region, both hardwoods and pine-hardwoods are important components of turkey habitat. Until more is known about the effects on turkeys of burning in hardwoods, we recommend hardwoods be protected from fire. Burning in pine-hardwoods, if necessary to keep them open at turkey level, should be done in a way that protects the hardwood component at midstory and canopy levels. Large expanses of open pinelands may be made more attractive to turkeys by keeping fire out of portions of them to allow development of mature hardwoods. Our data and observations indicate that in this area 7-8 years is sufficient time for these stands to open up at turkey level; however, this will vary depending on site conditions. Most pine uplands should be burned annually to maintain open conditions for general travel range while being careful to leave well-distributed blocks of nesting cover. More data are needed on the effects that distance to edges and size of cover blocks have on nest success before management recommendations can be made. Stoddard's (1963) recommendation of burning spots well distributed over the terrain instead of burning large compartments every 2 or 3 years should be heeded.

The strong preference for roughs in pinelands for nesting should be a clue to managers to avoid burning and mowing these areas during the nesting season. We know of 7 nests that were disrupted during this study because of late burning, brush mowing, or timber cutting operations during the nesting season. The peak onset of incubation both years was 25 April. Three hens had begun laying by the last week of March and 1/3 of all hens had begun by the first week of April. Therefore, broadscale burning should be finished as early as possible and certainly by the end of March. Summer burning or mowing for brush control, where necessary for long-term maintenance of turkey range in the pinelands, should be postponed until after the nesting season.

Turkeys highly preferred forest openings and fields in spring, and also used them in winter. A variety of seasonal crops should be used in these areas to ensure the turkeys' needs are met year-round. Use of young pine plantations could be extended by planting on a wide enough spacing to allow mowing between the rows to keep them in an open condition.

Comparison of our area with other areas in the Southeast reveals that generalized burning recommendations should be avoided. Because of differences in soil type, climate, species composition, overstory density, and land-use history, burning regimes suitable to 1 area may be totally unsuitable in another. Attention should be paid to what McGlincy (1985:24-25) called the "turkey stratum," defined as the zone in which "a bird fulfills its daily food requirements, finds concealment, escape cover, and protection from the elements." Site-specific burning plans should be developed to best provide for seasonal turkey needs.

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WILD TURKEY USE OF DAIRY FARM-TIMBERLAND HABITATS IN SOUTHEASTERN LOUISIANA

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Abstract: Little is known about behavior and ecology of different age and sex groups of the eastern wild turkey *(Meleagris gallopavo silvestris)* in domestic pine forests. During March 1983-May 1985, 4,321 telemetry locations were recorded in 11 of 14 available habitats. Females used a greater variety of habitats and averaged larger daily movements during all seasons than males did. Except during spring, when subadult females moved greater distances than adults, subadults and adults had similar daily movement patterns. Old pine (53.8%) and hardwoods (17.1%) received the greatest overall use; old pine was a preferred habitat of males during all seasons and was preferred by females during winter and summer. Seasonal habitat use differed among age and sex groups; and within age-sex classes, differences in habitat use occurred among seasons. Habitat use was influenced more by sex than age; the greatest disparity occurred during spring when males concentrated their activity in old pine stands (76.3%) while females apportioned use among hardwoods (19.5%), intermediate pine (30.7%), and old pine (24.7%). These data support the conclusion that life-history needs of male and female eastern wild turkeys can be met in different habitat types. Further, the high degree of landscape diversity created by an interspersion of different age-class pine timberland, hardwood streamside buffers, and farmland probably facilitates habitat segregation between sexes and may reduce the potential for intersexual competition, especially during the nesting season.

Many mixed pine-hardwood stands of the southeastern U.S. have been converted to even-aged loblolly pine *(Pinus taeda)* plantations (Smith 1981). Conversion of hardwoods to pine plantations has been implicated as a major influence on the quality of turkey habitat (Stoddard 1963, Markley 1967, Shaffer and Gwynn 1967, Bailey 1980, Exum et al. 1987). Certainly, the dramatic alteration of natural vegetation following European settlement will affect the distribution and abundance of future eastern wild turkey populations (Bailey 1980).

The habitat requirements of the eastern wild turkey in the Coastal Plain have not been quantified (Hurst 1981). A few studies have described habitat use within intensively managed pine timberlands (Kennamer et al. 1980*a,b*; Smith and Teitelbaum 1986; Exum et al. 1987), but little information related to age- and sex-specific behavior and ecology is available. Moreover, the influence of landscape diversity virtually has been ignored. Distribution and proportion of forest openings presumably affects habitat quality (Stoddard 1963, Speake et al. 1975, Dickson et al. 1978). Yet the role of agriculture as a determinant of dispersion and quality of forest openings remains unclear.

The purpose of this paper is to examine the habitat use and movements of different age and sex eastern wild turkeys in a landscape of domestic pine forest and dairy farmland on the southern Coastal Plain. Our objectives include testing the following null hypotheses: age and sex groups display similar daily movement patterns, and within an age-sex class, movements are similar among seasons; seasonal habitat use is similar among age and sex groups, and within an age-sex class, habitat use is similar among seasons; seasonal habitat use by age and sex groups is proportional to habitat avilability.

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STUDY AREA

The study area encompassed 5,241 ha; 4,953 ha were in southeastern Louisiana and included portions of R6E,T1S and R5E,T1S in St. Helena Parish, and a portion of R7E,T1S in Tangipahoa Parish. The remaining 288 ha were in R6E,T1N, Amite County, Miss. Boundaries were established by constructing the smallest convex polygon that included the peripheral locations of all radio-marked turkeys.

Commercial timberlands comprised 57% (2,998 ha) of the study area. These lands were managed primarily for loblolly pine production by International Paper Co., Inc. (2,581 ha), Crown-Zellerbach, Inc. (404 ha), and Rex Timber, Inc. (13 ha). About 42% (2,184 ha) of the area consisted of dairy and beef cattle pastures and nonindustrial hardwood and pine woodlands. Roads, buildings, ponds, and other unsuitable habitat made up the remaining 45 ha.

The study area was divided into 14 habitat categories according to age, vegetation structure, plant species, and agricultural or silvicultural treatment:

Clearcut (2.6%) - an area cleared and prepared for regeneration but not yet planted.

Two-year pine plantation (0.5%) - an area clearcut and planted with loblolly pine seedlings 2 years before data collection.

Three-year pine plantation (<0.1%) - an area clearcut and planted with loblolly pine seedlings 3 years before data collection.

Four-year pine plantation (1.6%) - an area clearcut and planted with loblolly pine seedlings 4 years before data collection.

Five-year pine plantation (0.7%) - an area clearcut and planted with loblolly pine seedlings 5 years before data collection.

Young pine plantation (19.4%) - an area clearcut and planted with loblolly pine and/or slash pine *(P. elliotti)* seedlings 6-10 years before data collection.

Intermediate pine plantation (9.1%) - an area clearcut and planted with loblolly pine seedlings 11-20 years before data collection.

Old pine plantation (39.2%) - a stand containing either, or any combination of, slash, loblolly, or longleaf pine *(P. palustris)* that was planted or naturally regenerated >20 years before data collection.

Hardwoods (8.7%) - a stand with >75% hardwood basal area and trees averaging >36 cm dbh.

Mixed pine-hardwood (0.3%) - a stand with 25-75% hardwood basal area or 25-75% pine basal area with stems averaging >15 years of age.

Deciduous thicket (0.7%) - a stand consisting of >75% basal area of deciduous shrubs, and trees <10 years old.

Improved pasture (15.7%) - pasture managed for grazing or hay production and mowed or grazed within 1 year before data collection.

Unimproved pasture (0.4%) - pasture left fallow for 1-5 years before data collection.

Agriculture fields (0.3%) - lands planted to row crops or other harvestable commercial crop including food plots.

Age categories of pine plantations were established according to the prevailing prescription schedule, i.e., pre-commercial thinning or prescribed burning of a stand, as determined from landowners. Lambert (1986) and Teitelbaum (1986) provide a more detailed description of the habitats and corresponding land-use practices.

METHODS

Turkeys were captured with a cannon net (Austin 1965, Austin et al. 1972). Age and sex were determined (Williams 1961, 1981), after which each bird was marked with a numbered, aluminum leg band (National Band and Tag Co., Newport, Ky.), and a colored ribbon or ALLFLEX livestock ear tag (Vet Brand, Inc., Torrance, Calif.) in the patagium. Turkeys were fitted with radio-transmitters with motion sensors (L2B5 backpack configuration, Telonics, Mesa, Ariz.) and released at the capture site.

To avoid capture-related biases, we began recording data 2 weeks after release. Each turkey was located at least 3 times weekly; nesting hens were monitored daily. A systematic, rotating sampling schedule was employed so that each bird was located during each of 5 (Teitelbaum 1986) or 7 (Lambert 1986) daily activity periods for all seasons, throughout the study period. Observations were recorded on individual aerial photographs (scale 1:80,000); a master grid and aerial photo system provided x and y coordinates. Date, time, group size and composition, habitat type, habitat types within 50 m of the primary habitat category (Smith and Teitelbaum 1986), and activity were recorded. Locations of radio-marked birds were assumed to be independent observations of habitat use. In this paper subadult refers to a bird during its first year.

Total area of each habitat type was estimated from aerial photographs with a Bruning randomized dot grid (Forbes 1961); the relative proportion of each habitat type within the study area was used as an estimate of its availability. Multiple contingency table analyses of frequency of use determined whether overall habitat use by turkeys was according to availability and whether seasonal habitat use differed among age and sex groups. Comparisons of habitat use to availability determined preference (Neu et al. 1974, Byers et al. 1984).

Average daily distance traveled (i.e., straight-line distance between 2 consecutive locations recorded within 24 hours) was computed with a FORTRAN program (Teitelbaum 1986). Analysis of variance determined if average daily movements differed among seasons and between age and sex groups; a Tukey multiple comparison test (Zar 1984) determined which seasons differed. Chi-square multiple contingency table analyses determined whether differences existed in habitat use between age and sex groups or among seasons; partial Chi-square analyses determined where differences in habitat use occurred. A probability of <0.05 was accepted as statistical justification for rejecting the null hypothesis. In this paper preference and avoidance are statistical terms to reflect habitat use that was significantly greater than or less than that expected according to habitat availability (Neu et al. 1974).

RESULTS

Four subadult males were captured 9 March 1983, and 5 subadult males and 5 subadult females were captured 7 October 1983; all turkeys (except when mortality or transmitter failure occurred) were monitored through 25 May 1984. On 11 March 1984, 8 subadult females and 3 adult females were captured; 5 subadult females and 1 adult female were captured 9 September 1984. These birds were monitored through 27 May 1985.

Movements.--We obtained 4,321 locations of radio-marked birds from 26 March 1983 through 27 May 1985. The time interval of locations used to calculate daily movements ranged from 17 to 24 hours and did not differ ($X^2 = 3.78$, $P > 0.25$, Kruskal-Wallis ANOVA, Zar 1984:178) among age and sex groups. Average daily movement was independent ($r_s = 0.325$, $P > 0.20$, Spearman rank correlation analysis, Zar 1984) of sample size. An adult male traveled the greatest straight-line distance (7.6 km) in 1 day. Seasonal estimates of average daily movements for adults (male and female) were: fall, 225.8 m; winter, 265.7 m; spring, 413.1 m; summer, 217.5 m. Corresponding estimates for subadults were 307.2 m, 249.7 m, and 349.6 m; a summer estimate could not be computed because of insufficient data. Among males, mean daily movements were similar between age classes but differed ($P < 0.05$) among seasons, the longest and shortest forays occurring during spring and summer, respectively.

Fall, winter, spring, and summer average daily movements for adult females were 423.0 m, 456.6 m, 307.1 m, and 230.2 m, respectively. Corresponding estimates for subadult females were 339.8 m, 532.9 m, and 378.3 m; subadult summer estimates could not be determined. Adult ($x = 268.1$ m) and subadult ($x = 417.7$ m) females differed ($P < 0.05$) in the length of their daily excursions during nesting, but behaved similarly during the remainder of the year. Average daily movements of both subadult and adult females were larger ($P < 0.05$) during winter than movements of subadult and adult males.

Habitat use.--The most frequently used habitat was old pine (53.8%); unimproved pasture (0.2%) received the least use. Hardwoods (17.1%), intermediate pine (11.7%), mixed pine-hardwood (6.7%), and improved pasture (6.7%) received most of the remaining use; agriculture, 4- and 5-year pine, young pine plantation, deciduous thicket, and unimproved pasture each received $\leq$1% of the overall use during the study. For subsequent analyses of seasonal habitat use, observations recorded in 4-year or 5-year pine plantations were combined into a single habitat category, 4+5-year plantation.

Overall, subadult males were recorded in 6 habitat types. Old pine was preferred during fall, winter, and spring (Table 1). Mixed pine-hardwood was preferred by subadult males during fall and spring, but used in proportion to its availability during winter; hardwoods were used proportionally throughout the study. Young pine plantation was avoided during spring and was not used during fall and winter. Also, improved pasture received little use by subadult males except during winter when it represented nearly 25% of total habitat use.

Although we obtained data for adult males during all seasons, they were recorded in only 4 habitat types: old pine, hardwoods, mixed pine-hardwood, and improved pasture (Table 2). Old pine was preferred throughout the study. During summer and fall, adult males also preferred mixed pine-hardwoods. In the spring, mixed pine-hardwoods were used proportionally, but received no use during winter. Except for summer, hardwoods were used proportionally throughout the year. Improved pastures and hardwoods were avoided during summer; improved pasture received no use during the fall. For the remainder of the year, however, adult males used improved pastures as expected (Table 2).

Despite an absence of data for the summer, subadult females used more habitat types (11) than any other age-sex group (Table 3). They preferred old pine and hardwoods during fall and hardwoods during winter; old pine received proportional use during winter. Mixed pine-hardwood and intermediate pine also received greater than expected use during fall and winter, respectively (Table 3). In the spring, however, subadult females shifted their use from old pine stands and hardwoods to 4+5-year plantations and agricultural fields. Intermediate pine continued to receive greater than expected use whereas use of mixed pine-hardwood increased over winter. Agriculture and 4+5-year plantation were both preferred during the spring while old pine stands were avoided and hardwoods received proportional use. The remaining habitat types received little or no use by subadult females (Table 3).

Adult females were recorded in 10 habitat types (Table 4). Hardwood was the most consistently used habitat type. Mixed pine-hardwood received significantly greater than expected use during fall, winter, and spring; intermediate pine and hardwoods were preferred by adult females during spring and fall. Agricultural fields and 4+5-year pine also received greater than expected use during fall and spring, respectively. Use of young regenerating stands (i.e., 4+5-year pine) was limited to spring, whereas use of agricultural habitat occurred mostly during the fall. In the summer and winter adult females used old pine stands almost exclusively; otherwise, old pine stands were avoided (fall and spring).

Table 1. Seasonal habitat availability (%), use (%), and selection[a] ($P < 0.05$) for subadult male eastern wild turkeys in southeastern Louisiana, March 1983-May 1985 (k is the number of radio-marked turkeys, n is the number of observations recorded on 5,241 ha).

		Fall (k = 5)		Winter (k = 4)		Spring (k = 7)	
Habitat	Availability	Use	Selection	Use	Selection	Use	Selection
Young pine	19.4	0	N	0	N	2.7	−
Old pine	39.2	65.6	+	64.1	+	76.5	+
Hardwoods	8.7	15.0	o	12.8	o	7.8	o
Mixed pine-hardwoods	0.3	11.9	+	0.8	o	5.1	+
Deciduous thicket	0.7	0	N	0	N	0.4	o
Improved pasture	15.7	7.5	−	22.2	o	7.5	−
		n = 160		n = 117		n = 550	

[a]Proportional use (o), significant avoidance (−), and preference (+); N indicates that statistical evaluation was not possible, i.e., no observations were recorded within habitat type.

Table 2. Seasonal habitat availability (%), use (%), and selection[a] ($P < 0.05$) for adult male eastern wild turkeys in southeastern Louisiana, March 1983-May 1985 (k is the number of radio-marked turkeys, n is the number of observations recorded on 5,241 ha).

Habitat	Availability	Fall (k = 4) Use	Fall Selection	Winter (k = 4) Use	Winter Selection	Spring (k = 2) Use	Spring Selection	Summer (k = 4) Use	Summer Selection
Young pine	19.4	0	N	0	N	0	N	0	N
Old pine	39.2	74.9	+	76.7	+	71.9	+	83.5	+
Hardwoods	8.7	11.6	o	11.1	o	9.4	o	2.3	–
Mixed pine-hardwoods	0.3	13.5	+	0	N	3.1	o	1.8	+
Deciduous thicket	0.7	0	N	0	N	0	N	0	N
Improved pasture	15.7	0	N	12.2	o	15.6	o	12.5	–
		n = 414		n = 90		n = 32		n = 883	

[a]Proportional use (o), significant avoidance (–), and preference (+); N indicates that statistical evaluation was not possible, i.e., no observations were recorded within habitat type.

Table 3. Seasonal habitat availability (%), use (%), and selection[a] ($P < 0.05$) for subadult female eastern wild turkeys in southeastern Louisiana, March 1983-May 1985 (k is the number of radio-marked turkeys, n is the number of observations recorded on 5,241 ha).

Habitat	Availability	Fall (k = 8) Use	Fall Selection	Winter (k = 6) Use	Winter Selection	Spring (k = 13) Use	Spring Selection
Young pine	19.4	2.2	–	0	N	0.6	–
Old pine	39.2	47.8	+	36.2	o	27.0	–
Hardwoods	8.7	25.0	+	33.3	+	13.3	o
Mixed pine-hardwoods	0.3	11.2	+	1.9	o	4.4	+
Deciduous thicket	0.7	0	N	0.5	o	0.6	o
Improved pasture	15.7	6.0	–	6.7	–	3.2	–
4+5-year pine plantation[b]	2.3	0.4	–	1.4	o	9.9	+
Intermediate pine	9.1	5.2	–	19.0	+	34.3	+
Agriculture	0.3	2.2	o	1.0	o	4.1	+
Unimproved pasture	0.4	0	N	0	N	2.5	o
		n = 268		n = 210		n = 315	

[a]Proportional use (o), significant avoidance (–), and preference (+); N indicates that statistical evaluation was not possible, i.e., no locations were recorded in habitat type.

[b]4+5-year pine plantation is a combined habitat category including observations recorded in 4-year or 5-year pine plantations.

Habitat use by subadult and adult males was similar during winter ($X^2 = 4.89, P = 0.180$) and spring ($X^2 = 2.33, P = 0.507$), but differed in the fall ($X^2 = 34.30, P < 0.001$). A partial Chi-square analysis (Zar 1984) indicated that this disparity was primarily due to a difference in the use of improved pasture ($X^2 = 31.64, P < 0.001$). In fall, subadult males were recorded in improved pastures in 7.5% of their locations while adult males did not use this habitat.

Subadult and adult females differed in their frequency of occurrence among habitat types during all seasons for which we had data for both age groups: fall ($X^2 = 39.55, P < 0.001$); winter ($X^2 = 84.57, P < 0.001$); and spring ($X^2 = 39.17, P < 0.001$). Partial Chi-square analyses indicated that there were differences in use of old pine ($X^2 = 13.70, P < 0.001$), hardwoods ($X^2 = 9.57, P < 0.005$), and improved pasture ($X^2 = 8.77, P < 0.005$) during the fall. For example, old pine and improved pasture comprised 47.8% and 6.0% of subadult female observations but only 30.1% and 1.7% of adult female locations, respectively. Use of hardwoods during the fall, however, was greater by adults (39.1%) than subadults (25.0%).

Table 4. Seasonal habitat availability (%), use (%), and selection[a] ($P < 0.05$) for adult female eastern wild turkeys in southeastern Louisiana, March 1983-May 1985 (k is the number of radio-marked turkeys, n is the number of observations recorded on 5,241 ha).

		Fall ($k = 8$)		Winter ($k = 7$)		Spring ($k = 6$)		Summer ($k = 8$)	
Habitat	Availability	Use	Selection	Use	Selection	Use	Selection	Use	Selection
Young pine	19.4	1.0	−	0	N	0	N	0	N
Old pine	39.2	30.1	−	64.9	+	21.8	−	76.7	+
Hardwoods	8.7	39.1	+	11.9	o	27.6	+	11.1	o
Mixed pine-hardwoods	0.3	7.8	+	17.9	+	7.9	+	0	N
Deciduous thicket	0.7	0.7	o	0	N	2.1	o	0	N
Improved pasture	15.7	1.7	−	5.2	−	2.9	−	12.2	o
4+5-year pine plantation[b]	2.3	0	N	0	N	11.3	+	0	N
Intermediate pine	9.1	17.0	+	0	N	25.9	+	0	N
Agriculture	0.3	2.7	+	0	N	0.4	o	0	N
Unimproved pasture	0.4	0	N	0	N	0	N	0	N
		$n = 412$		$n = 134$		$n = 239$		$n = 90$	

[a]Proportional use (o), significant avoidance (−), and preference (+); N indicates that statistical evaluation was not possible, i.e., no locations were recorded in habitat type.
[b]4+5-year pine plantation is a combined habitat category including observations recorded in 4-year or 5-year pine plantations.

During winter, subadult and adult females differed in their use of old pine ($X^2 = 14.16$, $P < 0.001$), hardwoods ($X^2 = 15.04$, $P < 0.001$), mixed pine-hardwood ($X^2 = 25.68$, $P < 0.001$), and intermediate pine ($X^2 = 25.57$, $P < 0.001$). Adults used old pine in 64.9% of their winter locations while subadults used old pine 36.2% of the time. Adults also used mixed pine-hardwood more often (17.9%) than subadults (1.9%). Hardwoods and intermediate pine comprised 33.3% and 19% of subadult female locations, respectively; adults, however, were in hardwoods only 11.9% of the time and were not located in intermediate pine during winter.

A difference in use of hardwoods continued on into the spring ($X^2 = 14.28$, $P < 0.001$), but the pattern changed dramatically. Adults more than doubled their use of hardwoods (27.6%) while subadult females significantly reduced their use of this habitat (13.3%). Also, agriculture and unimproved pasture comprised 4.1% and 2.5% of subadult locations during spring, respectively, but received little or no use by adult females.

Males and females used habitat types differently throughout the year ($X^2 = 899.66$, $P < 0.001$). During the fall, both males and females used old pine stands more than any other habitat type, but male use was nearly twice that of females (72.3% for males, 37.1% for females). Hardwoods also received heavy use by females (33.5%) and males (12.5%), as did mixed pine-hardwood stands (13.1% of male and 9.1% of female observations). Males were not observed in young pine, agricultural fields, or intermediate pine in the fall; corresponding female use was 1.5%, 2.5% and 12.4%.

During winter, males displayed a much higher frequency of use of old pine (69.5%) and improved pasture (17.9%) than females (25.5% and 6.2%, respectively). Hardwoods were used more by females (32.9%) than males (12.1%). Males were not recorded in intermediate pine or agriculture, but these habitat types represented 28.2% and 2.2% of female winter locations, respectively.

In spring, males also concentrated their activity in old pine stands (76.3%), whereas females apportioned use somewhat equitably among old pine (24.7%), intermediate pine (30.6%), and hardwoods (19.4%). Males were not observed in intermediate pine, and their use of hardwoods (7.9%) was less than half that of females. Conversely, males used improved pastures (7.9%) more than twice as often as females. Agriculture fields and unimproved pasture received no use from males and little use from females (2.5% and 1.8%, respectively).

Neither sex used regenerating stands frequently. Males were absent from 4+5-year pine stands whereas 2.6% of their spring locations occurred in young pine. Corresponding use by females was 10.4% and 0.4%.

Habitat use by males and females was most similar during summer when they differed only in the use of hardwoods (X^2 = 20.92, P < 0.001). Males reduced their use of hardwoods (2.3%) and increased their use of improved pasture (12.5%) over the spring; most of their use, however, continued in old pine stands. Similarly, females reduced their use of hardwoods (11.1%) while increasing their use of improved pasture (12.2%); their use of old pine during summer (76.7%) was comparable to that of males (83.5%).

DISCUSSION

Two critical assumptions of our analyses were that habitat abundance was a good estimate of habitat availability, and that habitats within the study area were equally available to all the radio-marked birds. Large forest openings, for example, are not completely available to several wildlife species because of a predisposition to avoid large, open areas where escape cover is not readily available (Johnson 1980). In these circumstances, abundance overestimates habitat availability and the relative importance of such habitats is underestimated. Wild turkeys in southeastern Louisiana concentrated their use in or near smaller ($\bar{x}$ = 7.2 ha) than available dairy pastures (Smith and Teitelbaum 1986). We suspect a similar bias exists in our analyses of large forest openings or fields in this paper.

Also, assuming that all habitat types in a large study area are equally available to the resident turkey population is probably unrealistic, especially when the proportions represented by the various habitat types are not equally distributed over the landscape. Moreover, conventional protocol for assessing wildlife habitat use requires that the radio-marked turkeys are treated as members of a population rather than as individual birds. We determine the total number of observations recorded in a habitat type by all radio-marked birds rather than compare use by each bird to corresponding habitat-type proportions within its home range. The implications of this approach are two-fold: first, it tends to emphasize "average" or population use and disregard individual variation among birds; and second, spurious conclusions will be inferred when the relative abundance of habitat types in a single bird's home range (or members of an age-sex class) differs from corresponding estimates derived for the entire study population. Thus, some of the variation related to habitat use among age-sex classes may have been due to error associated with estimating availability, or a result of spatial (rather than habitat) segregation by corresponding age-sex groups.

Previous studies of wild turkey movements and home range suggested a significant influence of forest composition (Speake et al. 1975, Davis 1976, Smith and Teitelbaum 1986, Wigley et al. 1986) and habitat structure (Wigley et al. 1986). Generally, stand characteristics that were associated with young pine regeneration resulted in increased movement and home range size (Wigley et al. 1986). Sex and age of wild turkeys also influenced movement and the manner in which birds used available habitat (Wigley et al. 1985, Smith and Teitelbaum 1986).

In this study, movement patterns were also influenced by age, sex, and season, and were probably related to specific life-history events. Much of the disparity in daily movement patterns between age classes was related to dispersal of juveniles from the capture site, and movements during spring that were presumably associated with nesting. Three subadult females left resident home ranges in January and established new ranges 5.7 km from the capture site; a fourth dispersed 5.3 km. Also, we observed significantly greater daily forays by subadult females during spring, a time when young hens are actively searching for suitable nest sites (Hon et al. 1979). The larger daily movements in this study, and larger center of activity and home range reported by Smith et al. (1989), support the conclusion that young hens may be forced to look for suitable nesting sites outside the traditional range of older hens. Indeed, subadult and adult hens used different habitats during nesting (Smith and Teitelbaum 1986).

Males in this study averaged smaller daily movements than females, yet Smith et al. (1989) reported larger home ranges for males. This suggests that males (especially adults) use their home range differently than females, making shorter but presumably more frequent forays into different portions of the available habitat. Wigley et al. (1986) reported widely spaced centers of intense activity for wild turkeys in the Ouachita Mountains. This behavior presumably represented an adaptive strategy that enabled turkeys to benefit from familiarity with areas of intense use, but provided a means of taking advantage of resources distributed throughout the individual's annual range (Wigley et al. 1986). Habitat use in this study varied among seasons and was influenced by sex and age. Wigley et al. (1985) also reported significant variation in habitat use among seasons and among age-sex groups for turkeys in the Ouachita Mountains. The similarity of both studies ends there however, as adult females in their study were the most selective. Conversely, adult (and subadult) females in our study seemed to be more generalized in their selection of habitats. Adult females in this study used 10 of 14 habitat types, whereas older males were located in only 4 types; and during most seasons, adult males used old pine and hardwoods almost exclusively.

As suggested earlier, dairy farm pastures were important to all sex and age groups, receiving consistent use throughout the year. Although improved pastures were not implicated as preferred habitat (and even evaluated as avoided), dairy farms were at the center of activity of all home ranges, and improved pasture was 1 of 4 core habitats consistently used by wild turkeys (Smith and Teitelbaum 1986). Also, in northwestern Alabama improved grazed pastures were used consistently year-round by wild turkey hens and were the preferred brooding habitat of successful hens (Everett et al. 1985).

Wild turkeys benefit from forest openings and edge (Smith and Teitelbaum 1986), especially during spring (Speake et al. 1975, Holbrook et al. 1987). Surprisingly, however, eastern wild turkeys show a greater tolerance to small, fragmented habitats than previously recognized (Wunz 1985), and fare better in fragmented, highly diverse landscapes than in large, contiguous tracts of mature forests. Wild turkey use of ecotones and success in small forested patches within highly agricultural landscapes have been greater than expected (Wunz 1985, Smith and Teitelbaum 1986). Given the opportunity to select different size habitat patches, wild turkeys avoided larger stands (Wigley et al. 1985).

We believe that the benefits accrued wild turkey populations inhabiting farmland-timberland landscapes are not limited to just the influence of increased edge. The mosaic landscape created by recent silivicultural and agricultural practices presents the eastern wild turkey with greater beta habitat diversity (*sensu* Whittaker 1960) and thus affords more opportunities for temporal as well as spatial habitat partitioning. Different age and sex wild turkeys can apparently meet life history needs in different habitat types (Wigley et al. 1985). The greater interspersion of forests and openings probably facilitates more efficient use of resources (Wigley et al. 1985). Moreover, when resources are limited, sex- and age-specific habitat preferences can reduce the potential for intraspecifc competition. Recall, male and female turkeys in this study displayed the greatest difference in habitat selection during spring, a time when resources and energy are at a premium.

Earlier studies of habitat use concluded that eastern wild turkeys prefer mature forests with an interperion of forest openings (Lewis 1964, Holbrook 1973, Kennamer et al. 1980*a*). Until recently, short-rotation pine plantations were regarded as unsuitable habitat for eastern wild turkeys, or at least not capable of supporting huntable populations (Stoddard 1963, Holbrook 1973, Mosby 1974, Davis 1976). This study supports an increasingly apparent generalization regarding wild turkey life history and management in the Southeast: eastern wild turkeys are more adaptable than previously recognized (Exum et al. 1987), can use a broad array of habitat types, and with adequate protection from poaching can produce huntable populations in a variety of landscape configurations, even those with significant human disturbance (Wunz 1985), substantial agricultural development and use (Clark 1985), and a high percentage of short-rotation pine plantations (Holbrook et al. 1985, Smith and Teitelbaum 1986, Exum et al. 1987).

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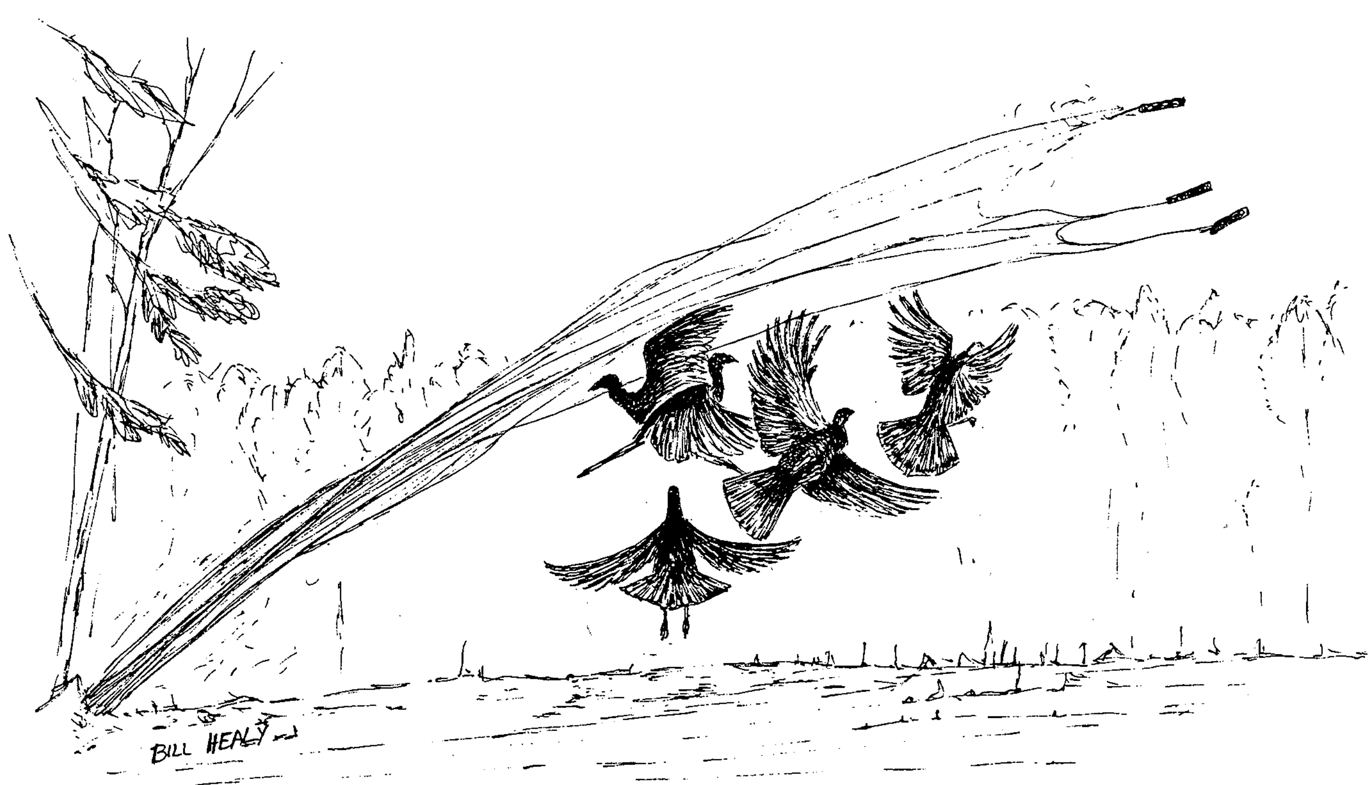

USE OF LOBLOLLY PINE PLANTATIONS BY WILD TURKEY HENS IN EAST-CENTRAL MISSISSIPPI

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Abstract: Conversion of mature pine-hardwood forests to intensively managed loblolly pine *(Pinus taeda)* plantations has caused concern that wild turkeys *(Meleagris gallopavo)* would not use the plantations. We determined habitat use by 55 wild turkey hens by telemetry from March 1986 through February 1988 in Kemper County, Miss. The study area (20,200 ha) consisted of pine plantations (45%), mixed forest (27%), hardwood forest (16%), and nonforest (11%) habitats. Most (69%) plantations were midrotation-aged (13-19 years old). Average seasonal home ranges (minimum convex) varied from 394 to 872 ha. About 50% of telemetry locations were in plantations, and hens used 85% of the plantations in the study area equal to or greater than expected ($P < 0.05$). Hens ($n = 16$) that reached the incubation stage nested in plantations ($\bar{x} = 17$ years old) that had been commercially thinned ($\bar{x} = 4$ years ago) and control burned ($\bar{x} = 4$ years ago). Most (81%) telemetry locations of hens with broods were also in plantations ($\bar{x} = 16$ years old) that had been commercially thinned ($\bar{x} = 4$ years ago) and burned ($\bar{x} = 3$ years ago). Of 98 field observations of hens with broods, 95% were associated with plantations. Discriminant analysis identified spur roads in or adjacent to plantations as an important factor related to turkey use of plantations.

Effects of large scale and intensive pine plantation management on wildlife in the southeastern U.S. have been discussed (McDowell 1954, Stoddard 1963). Several authors expressed concerns about responses of wild turkey populations to large-block, short-rotation, even-aged pine plantation management (Markley 1967, Schaffer and Gwynn 1967, Davis 1976). Only recently has research focused on the importance of plantation management to turkeys (Kennamer et al. 1980, Holbrook et al. 1985, Wigley et al. 1985, Exum et al. 1987).

As southern pine-hardwood forests are converted to plantations, it is critical to understand the response of wild turkeys to these habitat changes. To make effective decisions, forest and wildlife managers need information on turkey use of plantations and effects of silvicultural treatments in plantations on turkeys. Objectives of this study were to (1) determine habitat use by turkey hens in intensively managed plantations, (2) determine home ranges of turkey hens in plantations, and (3) describe hen use of plantations that received different silvicultural practices.

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STUDY AREA

The study area was in east-central (Kemper County) Mississippi in the Interior Flatwoods land resource area (Pettry 1977). Cutting sawtimber from the mature pine-hardwood forests began in 1912 and continued until the late 1930s, when the timber supply was exhausted. Another timber company acquired 33,995 ha of this land in 1941 and used a selective cutting method to regenerate a second-growth forest. In 1967, Weyerhaeuser Company purchased these lands and began converting mature pine-hardwood forests to intensively managed loblolly pine plantations (Smith 1988).

The original study area (core area) consisted of 9,700 ha of which 66% were in plantations, 21% in mixed forest, 9% in hardwoods, and 4% in nonforest habitats. Average plantation age was 13 years (0-19) and plantation size averaged about 100 ha (65-202 ha). Weyerhaeuser owned 77% of this area. The study area was later expanded to include lands surrounding the core area that radio-equipped turkeys used. The expanded study area (20,200 ha) included Weyerhaeuser lands, privately owned pine plantations, pastures, fields, and a large area of mature hardwood-pine and bottomland hardwood forests, and fields (soybean) along the Sucarnoochee Creek flood plain. Percentages of habitat types of the expanded area were pine plantations (45.2%), mixed forest (27.4%), hardwood forest (16.3%), and nonforest (11.1%). Weyerhaeuser ownership comprised 57% of the expanded area. Strips of mature hardwood forest, streamside management zones (SMZ) of various widths (20-100+ m) occurred within and adjacent to plantations and were scattered throughout the area.

Following clearcutting and mechanical site preparation, plantations were established by hand-planting genetically superior loblolly pine seedlings. Hardwood brush control was accomplished by applying herbicides at plantation age 3-4 years, and many plantations were fertilized with urea (181 kg/ha) at age 8-10 years. Most plantations were pre-commercially thinned from an average of 1,483 to 741 trees/ha at age 7-9 years. Commercial thinning from 741 to 445 trees/ha occurred at age 15-16 years. Controlled burning of plantations began at age 9-10 years and should occur at a 3- to 5-year interval. A second commercial thinning is planned and then a final harvest cut will occur at age 25-30 years. Average site index for loblolly pine is 19.8 m (65 ft) at age 25 years.

Several all-weather roads traversed the area, and Weyerhaeuser gated spur roads extended into most plantations. Spur roads were unimproved and were covered by herbaceous vegetation. Some roadsides were disked in early fall and planted to wheat and rye grass by hunting clubs.

METHODS

Wild turkeys were captured in the core area by cannon-netting on spur roads in plantations during January-March and July-August 1986 and 1987. Hens were fitted with transmitters ("backpack style") and released at capture sites.

We used a hand-held 3-element Yagi antenna and a TRX-1000S receiver (Wildlife Materials, Inc.) to locate turkeys by triangulation from 116 permanent telemetry stations established on roads throughout the area (Cochran and Lord 1963). To minimize error, we attempted to take bearings from 2 telemetry stations nearest the turkey. The dense road system permitted us to get close; most bearings were taken <0.6 km from the turkeys. Time intervals between consecutive locations were generally <5 minutes and many were between 2 and 3 minutes. Angles <25 degrees and >155 degrees were generally not accepted. Some angles >155 were accepted because the turkey was on the edge of a road between 2 stations on the road.

Each turkey was located 3 times/day, 3 days/week throughout winter, spring, and summer; and 2 times/day, 3 days/week in the fall. The order in which hens were located was frequently changed and monitoring generally occurred in morning (0700-1000), mid-day (1100-1400), and afternoon (1500-1800). Accuracy tests were performed.

Nesting hens were monitored several times each day. Hens with poults were located 3 times/day, morning, mid-day, and afternoon, for 14 consecutive days post-hatch. Ancillary observations of turkeys and associated habitat type(s) were recorded.

Weyerhaeuser stand histories and inventory data files were used to characterize its lands into 4 major habitat types: pine plantation, mixed forest, mature hardwood forest, and nonforest. Other lands were classified into the same types based on aerial photographs and ground surveys.

A base map containing all stands in the core area and expanded area was digitized from Weyerhaeuser stand maps and aerial photographs. All stands were assigned unique identifiers that corresponded to Weyerhaeuser stand numbers, histories, and conditions.

Turkey habitat use and home ranges were analyzed by season: spring (Mar-May), summer

(Jun-Aug), fall (Sep-Nov), and winter (Dec-Feb). A 2-sample test for equality of percentages (Zar 1984)) was used to compare (P = 0.05) turkey use of habitats to random expected use of habitats in the expanded study area. A line was drawn around the entire expanded study area to arrive at available habitats. This area included telemetry fixes and home ranges for all turkeys.

Minimum convex polygon method (Mohr 1947) and 80% harmonic mean transformations (Dixon and Chapman 1980) were used to calculate home ranges for turkeys with >25 locations per season.

A discriminant function analysis was used to determine if pine plantations that were used or not used by turkeys had distinctive silvicultural characteristics (Smith 1988). Prior to using discriminant analysis a correlation analysis was performed on all variables to eliminate intercorrelation between variables (Afifi and Clark 1984:246-284).

RESULTS

We took 7,353 locations on 55 turkey hens during the 24-month period (Mar 1986-Feb 1988). Number of locations and length of time individual turkeys were monitored varied. Telemetry accuracy tests, performed by the 2 observers who collected most (79%) of the data, produced mean estimated error polygons of 0.26 ha.

Seasonal home ranges.--We calculated 106 seasonal home ranges (Table 1). Average home ranges calculated by minimum convex method in 1986 ranged from 394 ha in summer to 611 ha in the fall (Table 2). In 1987 home range size varied from 419 ha in fall to 718 ha in spring. Home range sizes were decreased by over 50% using the harmonic mean method versus the minimum convex polygon method.

Nesting effort.--Four (25%) of the radio-equipped hens reached incubation stage in 1986, and 17 (71%) in 1987. Hatching success was 0% for 1986 and 46% for 1987. All nests were located in pine plantations. All hens except 1 selected 17- to 19-year-old pine plantations that had been commercially thinned and control burned in the past 6 years. One hen nested in a 9-year-old plantation.

Brood habitat use and home range.--Brood habitat information was obtained for 5 hens with broods $\leq$14 days old. Broods used pine plantations (81.2%), mixed forest (17.5%), and hardwood forest (1.3%). Habitat-type use was as expected (P > 0.05). Pine plantations used by hens with broods were 5-19 years old ($\bar{x}$ = 16), had been commercially thinned within 0-6 years ($\bar{x}$ = 4); and had been control burned within 0-6 years ($\bar{x}$ = 3).

We made 98 ancillary observations of broods, hens with poults, during the 2 years. Broods were associated with pine plantations (94.9%), hardwood forest (4.1%), and mixed forest (1%). No broods were seen in nonforested habitats.

Brood home ranges (n = 5) during 2 weeks post-hatch ranged from 50 to 169 ha ($\bar{x}$ = 102 ha). Movements from nest sites to brood range averaged <0.5 km. Six plantations used by brooding hens were also used for nesting, although 3 of these were used less than expected for brooding.

Table 1. Numbers of radio-equipped wild turkey hens used for habitat and home range analysis in Kemper County, Miss., 1986-88.

Year[a]	Season	Turkeys used for habitat analysis	Locations (n)	Turkeys used for home range analysis
1986	Spring	6	352	5
	Summer	8	218	2
	Fall	12	420	9
	Winter	11	537	8
1987	Spring	21	1,030	18
	Summer	23	865	11
	Fall	29	1,603	29
	Winter	29	1,659	24

[a]1986: March 1986-February 1987; 1987: March 1987-February 1988.

Table 2. Average seasonal home ranges (ha) for wild turkey hens in Kemper County, Miss., 1986-1988.

Year[a]	Season	Minimum convex $\bar{x}$	Minimum convex SD	80% harmonic $\bar{x}$	80% harmonic SD
1986	Spring	413	316	186	134
	Summer	394	221	50	13
	Fall	611	282	243	96
	Winter	515	287	202	107
1987	Spring	718	1,069	262	307
	Summer	872	819	405	425
	Fall	419	298	188	109
	Winter	470	405	211	143

[a]1986: March 1986-February 1987; 1987: March 1987-February 1988.

Habitat use.--In 1986 hens used pine plantations more than expected during fall and winter, and less than expected in summer ($P <$ 0.05) (Table 3). In 1987, plantations were used more than expected for all seasons except winter, when plantations were used less than expected. Hardwood forests, including SMZs, were used more than expected in all seasons except summer. Mixed forests were used less than expected for all seasons. Nonforest habitats were used less than expected in all seasons except winter when they were used more than expected.

In 1986 and 1987 some hens moved from pine plantations in late fall to the Sucarnoochee Creek bottom; they moved back into plantations in early spring. During the 2 winters, 36% (1986) and 56% (1987) of radio-equipped hens were found in the Sucarnoochee Creek area.

Pine plantation use and treatments.--Binomial comparisions (Zar 1984:395-397) of percentage use of pine plantations, by seasons, identified most pine plantations (85%, n = 464) as being used equal to or greater than expected (P = 0.05).

All pine plantations in the core study area that were used less than expected or were not used at all (group 1, 119 plantations) were pooled and compared with pooled pine plantations used equal to or greater than expected (group 2, 142 plantations) for discriminant analysis. We chose variables representing stand characteristics for spring 1987 because they represented conditions of the middle of the study period. We used Mahalanobis (Klecka 1988:55) distance as the test criterion for group discrimination.

The discriminant function correctly classified 79.0% for group 1 and 50.7% for group 2 (P < 0.05). Variables that entered the stepwise selection included roads (does a spur road border or transect the pine plantation), fertilization (number of years since the plantation had been fertilized), and hardwood control (number of years since hardwood

Table 3. Use of habitat types by radio-equipped wild turkey hens in Kemper County, Mississippi, 1986-1988.

Year	Season[b]	n locations	Habitat types[a] (% locations) NF	PP	MF	HF
1986	Spring	352	0.0	60.8	23.9	15.3
	Summer	218	0.0	24.3–[c]	67.9+	7.8+
	Fall	420	5.5–	57.1+	18.8	18.6
	Winter	537	6.5–	46.7+	21.0	25.7
1987	Spring	1,030	5.8–	56.2+	12.2–	25.7+
	Summer	865	3.5–	73.6+	16.5–	6.4–
	Fall	1,603	10.4–	49.8+	9.5–	30.3+
	Winter	1,659	18.1+	35.7–	14.7–	31.5+

[a]NF = nonforest, PP = pine plantation, MF = mixed forest, HF = hardwood forest.
[b]Spring (Mar-May), Summer (Jun-Aug), Fall (Sep-Nov), Winter (Dec-Feb).
[c]+ used greater than availability, – used less than availability (P < 0.05).

control with herbicides). The remaining variables did not significantly improve ($P > 0.05$) the model. Hardwood control was strongly correlated ($r = 0.850$) with fertilization. The pooled within-groups correlation matrix revealed that commercial thinning had the second highest correlation ($r = 0.812$) with fertilization. Commercially thinned also had an F value of 10.05 ($P < 0.0017$) second only to roads ($F = 10.06, P < 0.0017$).

Ancillary observations.--We recorded 570 observations of individual or flocks of wild turkeys. Most observations were made during the summer (43%) and the least in fall (13%) and winter (13%). Only 9 observations were recorded in December 1986 and 1987. Habitat types associated with turkey observations, pooled throughout the study period, were pine plantations (88.5%), mixed forest (2.9%), hardwood forest (3.4%), and nonforest (5.2%). Large flocks of turkeys ($\geq$30), some of which had transmitters, were often observed in soybean fields in the Sucarnoochee Creek bottom during both winters.

DISCUSSION

Wildlife biologists have been concerned that wild turkeys would not use large-block, even-aged, short-rotation pine plantations. Our telemetry study documented wild turkey hen use of intensively managed plantations. In addition, over 88% of ancillary observations were of turkeys associated with plantations. All turkeys were captured on spur roads in plantations. Hens used plantations more than expected in most seasons.

Hens used plantations more than expected in the winter of 1986 when there was a poor acorn crop, but used plantations less than expected in winter of 1987 when there was a large acorn crop. Some hens left the plantations in the winter and used a large creek bottom hardwood tract and associated soybean fields, but returned to the plantations in late winter. Movement of turkeys to river bottom forests has been reported (Dalke et al. 1946).

All nest attempts and most brood ranges were in pine plantations. Some hens attempted to rear their broods in the same plantations used for nesting. Most (95%) observations of hens with broods were associated with plantations.

Plantations used by turkey hens for nesting, brood rearing, and foraging were mostly midrotation-aged, 13-18 years old. These plantations had been commercially thinned once and control burned at least once. Vegetative conditions in the plantations were not measured; however, we believe the burning and thinning improved understory plant conditions for turkeys (Hurst and Warren 1982). The pine plantation canopy was opened by reducing pine stocking, which allowed increased growth of herbaceous plants and soft mast-producing vines, both important turkey food sources. In addition, commercial thinning operations, which removed all trees in every fourth row, created travel lanes and seemed to increase abundance of forage and seed and soft mast-producing plants.

Why turkeys used certain plantations was difficult to determine because most of the plantations were used equal to or more than expected, and they had received similar silvicultural treatments, thus yielding uniform conditions. These factors may explain why only 50.7% of plantations used equal to or more than expected were correctly classified by the discriminant function equation. Discriminant analysis identified spur roads in plantations as being an important factor. These roads and shoulders were about 20 m wide and were covered with native vegetation; some roadsides were planted to food (wheat, rye grass) plots by deer hunters. Spur roads were gated, locked, and posted. The roads provided travel corridors and food, such as green forage, grass seeds, blackberries (*Rubus* spp.), and insects (Kennamer et al. 1980, Exum et al. 1987). Turkeys seemed to frequent roads after a rain. Deer hunting from spur roads was intense from October through mid-January and probably decreased turkey use of roads during this period.

Discriminant analysis identified control of hardwood brush and fertilization as important factors. We believe these practices, performed over 9 years before the study began, do not have any biological relation to turkey use of plantations. Most plantations in the core area received the treatments. Vegetative responses to these treatments have been obscured by pre-commercial and commercial thinning, and control burning once or twice.

Hens used over 84% of the plantations equal to or more than expected. Most (69.3%)

plantations in the core area were >12 years old, and only 18.3% of the plantations were in the 3- to 10-year-old age class. Most older plantations had been thinned and burned at least once. Exum et al. (1987) and Smith and Teitelbaum (1986) reported greater than expected use of plantations >10 years old.

MANAGEMENT IMPLICATIONS

Turkey hens used intensively managed loblolly pine plantations. In fact, the most important phase of the wild turkey life cycle, the reproductive phase, occurred in pine plantations. Most plantations were 13-19 years old, and the important silvicultural practices seemed to be contol burning and commercial thinning. A burning and thinning rotation most favorable to turkey habitat has not been established but we can assume the earlier the better. Supplemental food in deer food plots may have improved the plantations for turkeys. The fact that all the study area is leased to hunting clubs and posted probably aids the turkey by decreasing poaching. High road spacing, about 1 road/0.5 km, is part of intensive pine plantation management, and roads were identified as important to turkey use of plantations. All roads should be gated, locked, and posted to control human access. Roads can be an asset (travel, food) to turkey habitat. Roadsides must be managed to prevent dominance by hardwood brush and volunteer pine trees.

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HOME RANGES, MOVEMENTS, AND HABITAT USE OF WILD TURKEY HENS IN NORTHERN MISSOURI

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Abstract: We studied home ranges, movements, and habitat use of wild turkey *(Meleagris gallopavo silvestris)* hens in northern Missouri to better understand habitat use patterns in the woodland-agriculture regions of the Midwest. The mean annual home range size was 779.9 ha (SE = 101.7), and seasonal home ranges were significantly smaller. Shifts in seasonal home ranges appeared to be related to food availability. The most pronounced differences in habitat use occurred in winter and were food related. Dispersal from wintering areas began in mid-March. Dispersal distances averaged <1.4 km, but movements of up to 11.5 km were noted. Most dispersals were completed in <2 days. Old field habitats were used extensively for nesting. Hens with broods used grassland habitats more frequently than did hens without broods. Mean distance of all brood locations to pasture during the summer was 119 m compared with 275 m for broodless hens. A 50:50 mix of mast-producing woodlands and open land appears to provide ideal turkey habitat. No less than 15% of the open land should be in row crops, and it is important that stands of mast-producing trees border some of the cropland.

The first release of wild trapped eastern wild turkeys in agricultural portions of the midwestern United States occurred in Adair County, Missouri, in winter 1961. The release was termed "experimental" because information available at that time suggested wild turkeys could not survive in areas with limited woodlands and severe winter weather. The success of the release in Adair County, and other early efforts to restore wild turkeys in agricultural habitats, precipitated the establishment of restoration programs throughout the agricultural portions of the Midwest. Most of the efforts occurred in the mid-1970s and early 1980s.

Densities of eastern wild turkeys are reported to exceed 30 birds/km^2 of commercial woodland in portions of the Midwest (Hanson 1984, Lewis and Kurzejeski 1984). The presence of row crop agriculture is thought to be a major factor in the maintenance of these high-density populations (Kurzejeski et al. 1987). Access to agricultural fields in winter in portions of the eastern wild turkey range in Minnesota has been suggested to affect survival (Porter et al. 1980) and reproductive effort (Porter et al. 1983). Although the importance of cultivated lands to wild turkeys is well documented, little information is published on habitat use patterns of wild turkeys in woodland-agriculture regions of the Midwest. In this paper we document habitat use, home ranges, and movements of wild turkey hens in northern Missouri during 1981-82.

E. A. Keyser, J. S. Fleming, B. J. Otten, D. J. Newswanger, and K. C. Ehlers assisted with the study. E. R. Jayne, C. J. Scriven, M. E. Wade, C. Turner, and many others provided access to their private lands, which was essential in conducting this study. G. S. Olson and S. L. Sheriff assisted with data analyses. Partial funding for this study was provided by the Missouri and local chapters of the National Wild Turkey Federation, and by the Federal Aid to Wildlife Restoration Act, under Pittman-Robertson Project W-13-R. The Wildlife Research secretarial staff typed drafts of this manuscript. L. D. Vangilder reviewed the manuscript.

STUDY AREA

The 52-km^2 study area is on private lands about 8 km west of Kirksville in Adair County, Missouri. Forty-six percent of the study area is in woodland, and 16% in row-crop agriculture, primarily soybeans and corn. Pasture and hayland cover 24% of the lands. Open lands not used for pasture or hayland (14%) and dominated by herbaceous plants were classified as old fields.

The topography is rolling with elevations ranging from 226 to 297 m. Bottomlands adjacent to the Chariton River, which bisects the study area, are primarily used for row cropping. Upland portions of the area are a mosaic of pasture and woodland. Most woodland is dominated by trees classified as large poles and small sawlogs (>10.2 and <40.6 cm dbh). About 25% of the woodland is moderately grazed.

METHODS

We used cannon-nets to capture wild turkey hens during 2 winters (1980-81, 1981-82). Each hen was aged (subadult or adult), instrumented, and released at the capture site. We attached a 140-g radio package operating on 164-165 MHz band, using a back-pack harness. The radio package was powered by a lithium battery with an expected life of 12 months. We located hens 3-5 days/week using 2 intersecting bearings obtained with a hand-held 4-element Yagi antenna. Compass bearings separated by $\geq 60°$ and $\leq 120°$, and accumulated within 10 minutes, were counted as locations. When necessary, we used fixed-wing aircraft to locate birds. We collected locations between 0600 and 1800 hours. Because we did not stratify our telemetry sample throughout the diurnal period we assumed time of day did not affect habitat use or movements.

We used aerial photographs and ground surveys to develop digitized cover maps from which we determined the habitat type of each location. Habitat use and home ranges were determined for 5 periods: winter (1 Jan-14 Mar), spring (15 Mar-31 May), summer (1 Jun-31 Aug), fall (1 Sep-30 Nov), and what we defined as the winter flocking period (1-31 Dec). We selected these intervals based on elements we thought may influence seasonal habitat use. We also examined habitat use and home ranges of hens with and without broods from the date of hatch through the end of the summer period.

We used TELEM (Koeln 1980) to calculate home range and movement statistics. Home ranges were estimated using the modified minimum area method (Harvey and Barbour 1965). Only birds with ≥ 10 locations/month were used in the analyses. Habitat use was expressed as the proportion of locations in each habitat type during a specified time period. Differences in the proportion of locations in each habitat type among seasons, and between years, were examined with Chi-square tests. Because of the large sample size of radio locations and their potential to affect the analyses, we established a conservative level of $P \leq 0.01$ for these tests.

Differences in home range sizes between seasons and years were tested with *t*-tests after data were subjected to arc sine transformations. Because of our small sample of subadult hens, we did not examine age-related differences in habitat use or home range, and data from both age classes were combined in the analyses.

We calculated the distance from the geometric center of the winter home range of each hen to the location of the first nest to determine mean distance moved from winter range to nesting cover. We measured the distance from telemetry locations to each individual cover type and to the nearest change in cover type (habitat edge) to evaluate the association of hens with and without broods with different habitats. Differences in mean values of these parameters were tested with *t*-tests.

RESULTS

Annual home range size (n = 12) varied from 365 to 2,299 ha. The mean annual home range size was 779.9 ha (SE = 101.7). Within annual home ranges areas of intensive use were evident. No differences were detected in seasonal home range size within or between years (Table 1). Spring and summer home ranges averaged 100.8 ha (SE = 18.9) and 174.7 ha (SE = 20.8), respectively. Fall and winter home range sizes were similar, averaging 148.9 ha (SE = 27.9) and 98.0 ha (SE = 15.8). Because duration of the winter flocking period (31 days) was shorter, we omitted it from the seasonal comparisons. We detected differences in habitat use (X^2 = 27.39, 9 df, P < 0.001) among seasons and between years; therefore, data were not combined.

The greatest seasonal variation in the proportion of locations in each cover type between years occurred in winter (Table 2). The most pronounced difference (X^2 = 32.2, 3 df, P < 0.001) in winter habitat use was in the proportion of locations in croplands. In 1981, 34% of all locations (n = 231) were in

Table 1. Seasonal home ranges (ha) for radio-tagged hen turkeys in Adair County, Missouri, 1981-1982.

	1981			1982			Cumulative		
Season	n^a	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE
Winter	7	141.2	28.0	6	84.4	17.6	13	98.0	15.8
Spring	16	99.8	18.9	18	106.5	31.9	34	100.4	18.9
Summer: Hens w/broods[b]							6	118.7	27.3
Hens w/o broods							16	175.6	30.3
All hens	14	185.4	24.9	10	158.1	41.1	24	174.7	20.8
Fall	14	198.8	40.5	9	79.5	19.9	23	148.9	27.9
Winter flocking	12	25.6	4.9	6	48.8	5.8	18	35.7	5.3

[a]Number of individual hens.
[b]Brood period = hatch date-31 Aug.

Table 2. Distribution (%) of 3,216 telemetry locations of wild turkey hens by season, year, and habitat type in Adair County, Missouri, 1981-1982.

			Habitat type			
Season	Year	n locations	Woodland	Pasture	Cropland	Old field
Summer	1981	927	58.6	26.1	5.2	10.0
	1982	584	61.5	22.4	3.3	12.8
Fall	1981	669	68.0	16.0	5.2	10.8
	1982	276	68.5	8.3	3.6	19.6
Winter	1981	106	45.3	6.6	34.0	14.2
	1982	125	60.0	6.4	5.6	28.0
Spring	1981	203	68.5	18.2	6.9	6.4
	1982	326	67.5	9.5	2.5	20.6

croplands whereas only 6% of locations were in this cover type in 1982. Use of old fields and woodland also varied between years. Woodland use ranged from 45% to 60% and locations in old field varied from 14% to 28%.

Distance moved from the geometric center of the winter home range to the location of a hen's first nest (n = 23) averaged 1.4 km. One hen moved 11.5 km from winter range to a nest location. Of 40 nests, 65% (26) were in old field habitats, 23% (9) in woodland, 10% (4) in pasture, and 3% (1) in cropland (winter wheat). Spring habitat use varied between years (X^2 = 29.9, 3 df, P < 0.001), the major difference being the proportion of locations (range 6-21%) in old fields (Table 2). Over 65% of locations (n = 529) were in woodland, and use of this cover type was greater than in winter, particularly in 1981.

Summer habitat use was based on 1,511 locations of 23 hens. Differences between years were not significant (X^2 = 7.9, 3 df, P = 0.47). Pasture was used more in summer than in other seasons, accounting for 22 and 26% of locations in 1981 and 1982, respectively (Table 2). Almost 60% of summer locations were in woodlands, and old field use ranged from 10 to 13% of locations. Crop fields accounted for <5% of locations.

Hens with broods (n = 475) and without broods (n = 864) used habitats differently during summer (X^2 = 33.9, 3 df, P < 0.001). Because sample sizes of hens with broods were small, data for both years were combined. Hens with broods were located more often in pasture (28%) than hens without broods (16%) (Table 3). Similarly, broodless hens were found in woodland habitats 67% of the time compared with 56% for hens with broods. Mean distance from all brood locations to pasture was 119 m (SE = 21) compared with 275 m (SE = 63) for broodless hens (t = 2.35, P = 0.03). Broods were not located closer to crop fields (699 ± 165 m) and habitat edges (43 ± 8 m) in comparison with broodless hens (1,070 ± 176 m and 67 ± 10 m, respectively).

Fall habitat use differed between years (X^2 = 20.6, 3 df, P < 0.001). The majority of locations (n = 945) were in woodland, and use of this type was greater than in summer (Table 2).

Table 3. Distribution (%) by habitat type of telemetry locations of wild turkey hens with and without broods in Adair County, Missouri, 1981-82.

Hens[a]	*n* locations	Habitat type			
		Woodland	Pasture	Cropland	Old field
With broods	475	55.6	28.1	7.2	9.1
Without broods	864	66.9	16.0	4.4	12.7

[a]Period = hatch date-31 Aug.

Use of pasture varied from 16% of locations in 1981 to 8% in 1982. Use of old fields also varied from 11 to 20% between respective years.

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Our findings support the contention voiced by many authors that available food resources frequently determine wild turkey home range and habitat use (Mosby and Handley 1943, Wheeler 1948, Porter et al. 1983). Annual home range size of hens in our study exceeded that reported in telemetry studies from southeastern Minnesota (Porter 1978). Within our annual home range, however, areas of seasonal use were similar in size to those in Minnesota (Porter 1978), Alabama (Speake et al. 1975), and southern Iowa (Crim 1981).

Seasonal home ranges appeared to be directly related to food availability with winter food needs exerting the greatest impact on movement and habitat use patterns. Extensive use of croplands as overwinter food sources has been well documented within midwestern wild turkey populations (Little 1980, Porter et al. 1980, Crim 1981). During 1980-81, a year of marginal acorn production, turkeys in our study area were observed to travel up to 4.8 km to winter in areas containing row crops. Sixteen percent of the study area was composed of row crops; however, most of the tilled acreage was located in the Chariton river bottoms. Observations from fixed-wing aircraft and telemetry locations indicated that in years when mast was scarce, virtually all turkeys in the 52-km^2 study area moved to the river bottoms. The only exceptions were occasional small groups of adult males that wintered in the woodland areas. If croplands had been more evenly dispersed throughout the study area, it is questionable whether similar movements would have been observed. In southern Minnesota, snow limited the ability of turkeys to move to food sources (Porter et al. 1983). Wild turkeys within our study area moved to wintering areas by early December, and because average snow depth on our study area is less than that in southeastern Minnesota, movements during winter did not appear to be restricted.

When turkeys congregated in the river bottoms, distinct shifts in areas of intensive use were evident. We believe the shifts were not caused by changes in food availability. Certain fields were used intensively more than once during the winter, indicating that food had not been depleted. It seems that disturbance of flocks, either by humans or predators, often was the cause for these movements. Most winter flock movements did not exceed 0.5 km; however, the presence of mature timber adjacent to croplands seemed to govern the selection of all the intensively used wintering areas. Croplands not bordered by mature timber stands were seldom used. Porter et al. (1980) and Crim (1981) alluded to the importance of woodland/cropland associations as wintering areas. During severe winter weather turkeys would fly from the roost to the croplands to feed most of the day, then fly to the roost at night, thereby reducing the need to travel during periods of deep snow and severe cold. About 20% of the cropland edge in our study area was bordered by mature timber stands >8 ha in size, and these characteristics were typical of sites used in winter. The only other factor affecting the selection of intensive use areas was the management of the adjoining croplands after harvest. Regardless of the amount of woodland along field edges, fall plowed fields received no use, but chisel plowed and moderately grazed fields were used if adjacent to timber stands >8 ha in size.

Although croplands undoubtedly play a major role in the maintenance of wild turkey populations in northern Missouri, our data on winter habitat use depict row crops as being a secondary food when sufficient acorn production occurs. In the winter of 1981-82 when mast was abundant, flocks did not move from the fall home range to wintering areas in the river bottoms. This supports Korschgen's (1967) contention that when food is abundant, seasonal movements are reduced, and consequently the range over which a turkey travels is governed by food supplies. Similarly, Ellis and Lewis (1967) reported that winter movements in southern Missouri were controlled by the location of food supplies.

Winter habitat needs seemed to exert the greatest influence on turkey movements. Our data, however, did not show winter foods acted in a limiting capacity. Little (1980), in a discussion of Iowa turkey habitat, suggested that if carrying capacity is a measure of habitat quality, then mixed farmland/forest habitats are of superior quality. Our data on population density strongly suggested that a 50:50 mix of mast-producing woodland and open lands approached the most ideal turkey habitat. Within a management unit we recommend that no less than 15% should be in row crops. In our latitude, it does not seem that cropland must be well dispersed as suggested by Porter et al. (1980), but some stands of mature trees should border the field. The remainder of the open-land component should be in old fields in varying degrees of succession and pasture lands. In our study area, pasture lands were especially important to hens with broods, which is consistent with the findings of other researchers (Ellis and Lewis 1967, Speake et al. 1975, Porter 1980). Old fields received use during all seasons and also seemed important as nesting areas. Based on the proportions of this cover type within our study area, we recommend that a management area include 15% old fields. Though we did not attempt to construct an index of habitat diversity within the study area, we should mention that, with the exceptions of croplands, cover types on the area were moderately interspersed. We concur with the recommendations of Porter (1980) and Crim (1981) that a diverse patchwork of habitat types may be important in maintaining high turkey population densities.

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ECOLOGY AND MANAGEMENT OF GOULD'S TURKEYS IN SOUTHWESTERN NEW MEXICO

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Abstract: Gould's turkeys *(Meleagris gallopavo mexicana)* in New Mexico continue to increase in abundance from a low of 16 in 1983 to an estimated 75 in 1989. Range expansion has increased from 3,600 ha in 1983 to 13,000 ha in 1988. Roost sites have increased from 16 in 1983 to 31 in 1988. Winter weight averaged 5.42 kg (SE = 0.5) for 7 adult females, 9.84 kg (SE = 0.3) for 3 adult males, 5.60 kg (SE = 0.3) for 3 immature males; and 1 immature female weighed 4.09 kg. A radio-equipped hen laid 9 eggs, hatched 7, and 3 poults survived to maturity. Four poults were lost during their first 2 weeks after hatching. The nest site was in the Emory oak, beargrass, sideoats grama habitat type. The microsite was at the base of a yucca *(Yucca schottii)* under an Emory oak *(Quercus emoryi)* tree. The overstory canopy and horizontal density of vegetation was higher than that in the surrounding area. The mean hatching date from 1982 to 1988 was 20 June. The spring and summer home ranges for 2 radio-equipped adult hens were 48 and 90.5 ha. The fall and annual home range sizes were 908 and 3,686 ha. Three habitat types that made up 4.5% of the area used by turkeys accounted for 71.5% of all observations. Key habitat types need to be protected from excessive grazing and other disturbances.

The objectives of our research have been to (1) determine status, distribution, and abundance of Gould's turkeys in the Peloncillo Mountains, Coronado National Forest, New Mexico; (2) describe food habits; (3) describe occupied habitats and key habitat components; (4) monitor movements and determine activity patterns; (5) determine main limiting factors and suggest management practices.

The New Mexico population is at the extreme northern edge of Gould's turkey range, which extends southward into Chihuahua, Mexico. Details of the past history of the species in New Mexico have been described by Schemnitz and Zeedyk (1982).

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STUDY AREA

The study area consists of the Peloncillo Mountain block of the Coronado National Forest, Douglas Ranger District in extreme southwestern New Mexico and southeastern Arizona. The Peloncillo Mountains, with elevations to 2,020 m, run through the area along a north-south axis. The Peloncillos are one of a series of ranges in the Mexican Highlands section of the Basin and Range Physiographic Province (Wilson 1962). They extend from near the Mexican border northward 110 km along the New Mexico-Arizona line.

The study area is the largest contiguous block of occupied Gould's habitat under public ownership in the U.S. The Coronado National Forest was established in 1916. Commercial use

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of the study area is restricted primarily to grazing. Nine U.S. Forest Service permittees graze cattle on the area. There has never been a commercial timber sale on the area, although postwood and fuelwood harvesting has been allowed in the past. Dead and down wood can be collected in certain areas with a permit, but illegal fuelwood cutting often occurs. Beargrass *(Nolina microcarpa)* harvesting also is allowed in certain areas.

The eastern half of the study area is characterized by rolling hills and wide drainages with gentle to moderate slopes. The western half is steeper, with deep canyons and rocky outcrops. Soils are primarily classified in the Rough Broken Land-Rock Land Lehmans association (Cox 1973). These are shallow, poorly developed soils, typically with a yellowish-red stony loam surface layer and a reddish-brown clay sub-soil.

METHODS

The Gould's turkey is listed as a Group II Endangered Species by the state of New Mexico. Under state regulations for listed species, reseachers were not permitted to mark, band, or handle the Gould's turkey in New Mexico. Due to an increase in population size (Willging 1987), we were given permission to capture and radio-collar 4 adult hens, and place patagial wing markers and leg bands on these hens and any other turkeys subsequently captured (not to exceed 16 total). A drop net with a modified Kansas drop-net trigger and a 3-mortar rocket-net similar to that described by Day et al. (1980) were used to capture turkeys. After turkeys were trapped, they were aged, sexed, and weighed; measurements of wing spread, wing cord, total length, tail length, tarsus, middle toe, leg diameter, spur diameter, spur length, and beard length were taken; coloration was noted; and leg bands and patagial wing markers (Knowlton et al. 1964) were placed on the turkeys. Four adult hens were captured and equipped with 170-gm, pulsed signal transmitters with mortality sensor (Telonics model MOD-400). The transmitters were mounted on the birds' backs with leather straps tied around the base of the wings. A Telonics model TR-2 biomedical telemetry receiver with multi-element antenna was used for tracking.

We used 5 to 8 Minolta model XL-610 super 8-mm movie cameras with built-in intervalometers to monitor turkey activity during the summers of 1985-1989. Six Telonics external intervalometers were used to set the exposure interval to 1 frame/5 minutes, and 2 light-sensitive switches were used to turn the cameras off at night. Cameras and intervalometers were housed in modified steel 50-calibre ammunition boxes; attached to trees, snags, or posts; and focused on areas where turkey activity was expected, such as a watering site or feeding area.

The first 5-10 frames of each roll of film were used to film a card that recorded the film roll number, location, date, exact time of start, interval length, and weather conditions. When developed, each frame was examined with a Craig portable 8-mm film editor. An observation was defined as 1 or more turkeys appearing on 1 or more film frames separated by at least 30 minutes from any other such appearance. When possible, turkeys were classified by sex and age from features readily apparent on film. When visible, patagial wing markers aided recognition of individual turkeys of known age and sex.

The total number of observations and the percentage of film rolls containing observations were compared to determine population trends. Also, the number of turkeys seen simultaneously at different camera sets, and large flocks seen on single film frames, were used to determine an absolute population minimum.

Nesting and Brood-Rearing Habitat

We used radio-equipped hens to locate nests. Localized movements beginning in May were assumed to indicate nest initiation (Porter 1978). When triangulation indicated no movement for 3 consecutive days, we assumed the hen was incubating and determined a relative nest location. To prevent disturbance of the hen, we flagged a circle about 50 m in diameter around the nest site. We located the nest when daily monitoring indicated incubation was terminated. We determined clutch size and the number of poults hatched by examining egg shells and unhatched eggs in the nest.

Nest Site Description

The nest site was classified according to habitat type following the procedures of Moir (1979) and (Willging 1987). Nest sites were sampled with a reconnaissance method to measure vegetative composition and cover (Pfister and Arno 1980). Measurements were taken on a 375-m^2 circular plot centered on the nest. Four radii (10.6 m) were measured out from plot center.

Trees within the plot were identified to species and tallied in 5.2-cm diameter classes. Overhead canopy cover at plot center was measured with a spherical densiometer (Lemmon 1956) as modified by Strickler (1959), and basal area (BA) was measured with a variable plot 2.3-m^2/ha (10^2-ft./acre) prism. Cover estimates for shrubs, grasses, and forbs were made to the nearest 5% for major or dominant species and 1% for infrequent or minor species. Plant species that occurred in the vicinity but not within the plot were recorded as present. The percent coverage of bare rock or soil, forest litter, and down wood was recorded. The circular boundary line could be visually projected from 1 flag to the next. Distances to nearest opening, water, and road were determined by pacing or from U.S. Forest Service maps. We used a "Suunto" clinometer to measure slope, and determined aspect from compass bearings. The number of cattle feces within a plot was recorded as an indicator of livestock use.

We evaluated concealment value provided by vegetation around the nest by using a 2.5-m horizontal density board as described by Wight (1938) and modified by Nudds (1977). Concealment cover was evaluated at 0.5-m intervals from ground level to 2.5 m. We observed the density board from a distance of 15 m at 90° intervals around the nest. The first direction was randomly chosen, and the 4 readings were averaged for each 0.5-m vertical interval.

At the end of each 15-m transect, we paced another 25 m and measured canopy cover, BA, and horizontal density. These measurements were compared with those from the nest site to determine which habitat factors were important.

Poult Survival and Brood Rearing Habitat

Poult survival was estimated by counting broods weekly from date of hatching until broods were about 3 months old. Poults were aged according to Nixon (1962). Brood habitats were determined by locating radio-equipped hens at least once/day during these 3 months. Areas used by broods also were determined from sightings of broods with hens that did not have radio transmitters. Only those sites where the hen and brood were observed feeding or seen repeatedly were considered brood-rearing sites. We used reconnaissance plots to measure habitat parameters at brood sites.

Home Range and Habitat Preference

We determined home range by the minimum convex ploygon method described by Mohr (1947) and Odum and Kuenzler (1955). Home range area was measured with a compensating polar planimeter. Home ranges were determined for spring (1 Feb-30 Apr), summer (1 May-20 Sep), and fall (21 Sep-30 Nov). The seasonal home ranges were then combined for yearly home range. Ranges were calculated for turkeys that had been located more than 5 times/season.

Habitat types within the 20,436-ha core turkey use area were mapped by Willging (1987). Use was determined by the frequency of observations within each habitat type. Habitat preference was determined by a method described by Neu et al. (1974).

Field Observations

We used standardized forms to record observations of turkeys or turkey sign. All of the major watersheds in the study area were surveyed at least once during summer and once during fall. During the summer dry season, all potential watering sites were surveyed at least once. All observations were numbered and plotted on a map. Local ranchers, Sheriff's Department, and U.S. Border Patrol Officers were contacted regularly to collect any observations they had made. Self-addressed, stamped envelopes containing observation forms were left with the above personnel to facilitate the recording of subsequent observations. The Peloncillo Mountains receive a number of visitors each year whose activities include hunting, fishing, camping, backpacking, fuelwood cutting, bird-watching, and reptile and rock collecting. Whenever these visitors were encountered, they were interviewed and given observation forms and self-addressed, stamped envelopes. Systematic effort was made to survey deer hunters each November. At least 1 field worker was in the study area during each deer hunt. All hunters encountered were informed of the project, interviewed, and given forms and envelopes. If a hunting camp was unoccupied, a letter explaining the project, forms, and envelopes were left on the vehicle's windshield.

Gobbler and Roost Surveys

Surveys of breeding males were conducted in the spring of 1987, 1988, and 1989. A computer technique developed for this project allows recognition of individual male turkeys based solely on recordings of their gobbles (Dahlquist et al. 1990). By comparing recorded gobbles, we were able to determine a minimum number of breeding males in the study area.

Most of the roost sites in the study area have been documented in the past. Therefore, we conducted a systematic survey of all known roost sites during the last week of each month, June through November 1988. Each site was classified as heavily, moderately, lightly, or not used based on the amount of sign beneath the trees. If the site was used for >6 "turkey nights," it was classified as heavily used, where 1 turkey night is equivalent to 1 turkey staying at that roost for 1 night. If the roost site was used for 4-6 turkey nights, it was classified as moderately used. If it was used for 1-3 turkeys nights, it was classified as lightly used, and if no sign was found it was classified as not used. All feathers and droppings were removed from beneath the trees after each survey to avoid recounting old sign.

A continued effort was made to locate new roost sites and new roost trees at established sites. Potential areas (stands of large pine or oak) were frequently investigated. Newly found roost trees were marked with numbered aluminum tags. Using procedures of Husch et al. (1972) and Hays et al. (1981), we recorded height, dbh, age, crown class, BA, slope, aspect, and height of lowest limb for each new roost tree at each site. We used a spherical densiometer (Strickler 1959) to determine overhead canopy cover. The distance and direction to other roosts in the vicinity also were recorded.

Potential Limiting Factors

Predation.--Because the radio transmitters on the 4 adult hens were equipped with a mortality signal, we could locate hens within 24 hours after death. When this occurred, the site was thoroughly surveyed to attempt to determine the cause of death. All remains were collected and photographs were taken. We used the same procedure when we found evidence of predation on turkeys not equipped with transmitters.

All predator observations were recorded. Any active predator dens and raptor nests were visited to search for turkey remains. Predator scats and raptor pellets were also collected when possible and analyzed for turkey remains.

Competition.--The Gould's turkey has many potential competitors in the study area including cattle, feral hogs, peccary *(Tayassu tajacu)*, and deer *(Odocoileus hemionus crooki* and *O. virginianus couesi)*. The numbers and activities of these competitors were recorded particularly at stock tanks and in riparian habitats. Competitor observations also were recorded by time-interval cameras.

Human use.--Use of the study area by humans was recorded for each month of the field season. Whenever we encountered people in the forest, we made them aware of the turkeys' endangered status, and asked them not to disturb the turkeys.

Hybridization.--A free-ranging flock of hybrid Gould's x domestic turkeys is owned by a rancher in Guadalupe Canyon at the southern end of the study area. Because of their mobility, the hybrids pose a serious threat to the genetic purity of the wild Gould's turkey. Disease transmission is also a potential threat. We visited the ranch periodically, and recorded number, sex, age, and any coloration differences of the hybrid turkeys.

RESULTS AND DISCUSSION

Taxonomy and Population Status

We captured, measured, weighed, and described 14 Gould's turkeys (Table 1). The coloration of turkeys captured was consistent within sex and age classes, and with the descriptions provided by Aldrich (1967). The most significant differences from the other subspecies of wild turkeys were the very light, almost pure white tips of tail feathers, upper tail coverts, and lower back and rump feathers. This characteristic of Gould's turkeys has been reported by Ridgway and Friedmann (1946), Lee (1959), Aldrich (1967), and Rea (1980).

Our measurements differed from those reported by Aldrich (1967). Of the turkeys we captured, the wing cord, tail, and middle toe without claw measurements were larger, and the tarsus measurements were smaller for adult males and adult females when compared with Aldrich's results (Table 2). The differences could be due to variation between local populations and the small sample sizes. Aldrich collected his samples in Durango, Mexico, over 600 km south of our study area. Additional samples will be needed to substantiate our results. There are no adequate weight descriptions of Gould's turkey in the literature. Our results indicate the average winter weight of 7 adult females was 5.42 kg (SE = 0.5); 3 adult males weighed 9.84 kg (SE = 0.3), 3 immature males weighed 5.6 kg (SE = 0.3), and an immature female weighed 4.09 kg.

Recent Gould's turkey research in New Mexico was begun in 1982 by Potter et al. (1985). Initial populations were as low as 12 birds, but have increased annually to 75 turkeys in 1988 (Table 3). Adult males have increased from 1 in 1983 to 18 in 1988. Gould's turkey range has increased from 3,600 ha in 1983 to 7,200 ha in 1986 and 13,000 ha in 1988 (Fig. 1). A flock of 24 turkeys, the largest documented Gould's winter flock in the United States, was seen 26 February 1988. Annual precipitation was above average each year, 1982-1988, and 27% above the long-term average. This above-normal rainfall contributed to lush vegetation and may partially explain the population increase.

Table 1. Weight (gm) and measurements (cm) of Gould's turkeys captured in Coronado National Forest January through March 1988.

Age and sex[a]	Weight	Total length	Wing spread	Wing cord	Tail length	Tarsus	Middle toe	Leg dia.	Spur length	Spur dia.	Beard length
A F	4,994	101.0	138.5	46.0	41.0	13.3	8.0	1.1			
A F	5,675	104.2	148.6	48.0	43.0	13.8	8.5	1.1			
A F	5,902	105.5	138.2	46.6	44.7	12.5	8.0	1.0			
A F	5,902	103.0	131.0	47.0	42.0	13.0	8.1	1.0			
A F	4,994	105.0	134.5	47.0	43.0	13.8	7.4	1.0			
A F	4,994	89.5	110.5	42.0	46.0	12.0	7.6	1.0			
A F	5,448	90.0	112.3	43.0	47.0	12.4	8.0	1.0			
A M	9,988	124.0	164.0	57.0	46.5	15.0	9.2	1.5	2.4	1.4	27.0
A M	9,534	120.0	154.0	55.0	46.0	15.5	9.5	1.3	1.9	1.4	26.2
A M	9,988	120.5	172.0	56.2	46.0	16.5	10.0	1.4	2.2	1.3	28.0
I M	5,902	119.0	128.0	50.0	37.0	15.8	9.5	1.3	0.5	0.7	8.0
I M	5,448	106.0	139.0	47.5	39.5	15.0	9.5	1.1	0.5	0.5	2.5
I M	5,448	108.0	134.0	48.5	39.0	15.0	9.0	1.0	0.1	0.1	2.5
I F	4,086	86.7		42.0	39.0	12.5	7.5	0.8			

[a]F = female, M = male, A = adult, I = immature.

Table 2. Comparison of physical characteristics (cm) of adult male and adult female Gould's turkeys collected in Durango, Mexico with turkeys captured in New Mexico.

Characteristic	Adult male		Adult female	
	Durango (n=9)[a]	New Mexico (n=3)	Durango (n=11)[a]	New Mexico (n=7)
Wing cord	49.0-54.5 (51.9)[b]	55.0-57.0 (56.1)	40.2-44.8 (42.)	42.0-48.0 (45.7)
Tail	37.0-43.7 (40.3)	46.0-46.5 (46.2)	31.8-36.2 (33.5)	41.0-47.0 (43.8)
Tarsus	16.4-18.2 (17.4)	15.0-16.5 (15.7)	13.2-14.9 (13.8)	13.0-13.8 (13.3)
Middle toe	8.4- 9.4 (8.8)	9.2-10.0 (9.6)	6.8- 7.6 (7.1)	7.4- 8.5 (7.9)

[a]From Aldrich (1967).
[b]Mean measurement in parentheses.

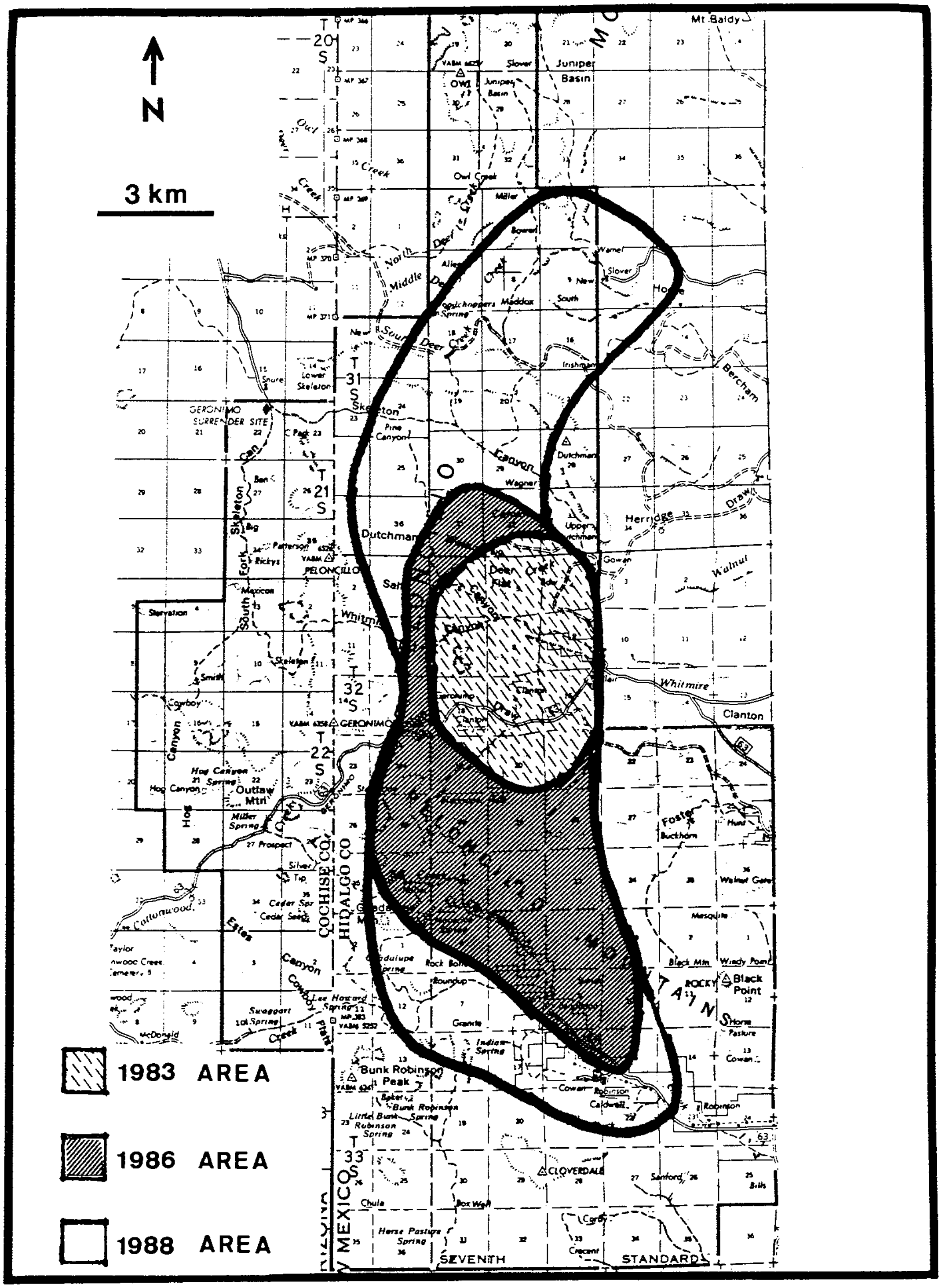

Fig. 1. Portion of study area, Peloncillo Mountains, N.M., occupied by turkeys in 1983, 1986, and 1988.

Table 3. Known population numbers and structure, 1983, and estimated population numbers and structure, 1985 through 1988 of Gould's turkeys in Peloncillo Mountains, New Mexico.

Age and sex	1983	1985	1986	1988
Adult male	1	9	10	18
Adult female	2	4	5	14
Subadult	3	6	13	9
Poult	6	16	17	34
Totals	12	35	45	75

Habitat types.--Potter et al. (1985) described the main habitat of Gould's turkey as the Madrean Evergreen Woodland community dominated by oaks, pines, and juniper, with beargrass, manzanita, and grasses in the understory. Willging (1987) further refined the vegetative characteristics of the study area into 8 habitat types (Table 4); 4 types comprised 92% of the study area (Table 5).

Nesting and nest habitat.--Four adult hens received radio transmitters. Two hens were killed by mountain lions *(Felis concolor)* prior to the breeding season. One of the 2 remaining hens nested and produced a brood. The first day of incubation was 26 May, and the eggs hatched on 22 June. Hatching dates from 1982-1988 were in June (mean 20 June) (Table 6). Seven of the 9 eggs in the clutch hatched. The remaining 2 eggs were eaten by a predator before we examined the nest, so it is unknown if they were infertile or if the embryos died before hatching. The nest consisted of a slight depression in the oak leaves, and it was 34 cm in length and 28 cm in width.

The nest was located in the Emory oak-beargrass-sideoats grama (see Table 4 for scientific names) habitat type, which comprises 32% of the core turkey use area. The area did receive light grazing use, but no cattle were present during nesting. The nest was located under an Emory oak tree at the base of a yucca on a moderately steep slope (47%) with a northeast aspect. The overstory canopy cover at the nest (97%) was higher than that of the

Table 4. Gould's habitat type characteristics (means from reconnaissance plots) in Peloncillo Mountains, New Mexico, 1987.

Habitat type	Slope[a]	BA (m^2/ha)	Shrub cover (%)	Grass cover (%)	Forb cover (%)
Emory oak, beargrass, sideoats grama *(Quercus emoryi, Nolina microcarpa, Bouteloua curtipendula)*	L-M	1.0	7.8	37.6	8.8
Pinyon pine, Toumey oak, bull muhly *(Pinus discolor, Q. toumeyi, Muhlenbergia emersleyi)*	M-S	1.0	9.3	22.3	1.6
Pinyon pine, pinyon ricegrass *(Pinus discolor, Piptochaetium fimbriatum)*	M	17.0	6.2	9.5	1.0
Chihuahua pine, silverleaf oak *(Pinus leiophylla, Q. hypoleucoides)*	L-M	14.0	14.7	18.3	3.8
Emory oak, canyon grape *(Q. emoryi, Vitis arizonica)*	L	14.0	18.5	24.0	5.9
Toumey oak, manzanita *(Q. toumeyi, Arctostaphylos pungens)*	M-S	0.0	55.0	5.0	1.0
Blue grama, sideoats grama *(B. gracilis, B. curtipendula)*	L	0.0	11.6	47.3	8.8
Arizona white oak, bull muhly *(Q. arizonica, Muhlenbergia emersleyi)*	M	3.4	18.3	55.0	9.2

[a]Most characteristic slope: L = level, M = moderate, S = steep.

Table 5. Comparison of habitat availability with habitat use by Gould's turkey hens with broods, June-September 1988 in the Peloncillo Mountains, New Mexico.

Habitat type	Availability ha	Availability %	Use (*n* locations) Observed	Use (*n* locations) Expected
Bull muhly, pinyon pine, Toumey oak	6,805	33.0	0*	38
Sideoats grama, Emory oak, beargrass	6,580	32.0	19	37
Blue grama, sideoats grama	3,263	16.0	17	18
Pinyon pine, pinyon ricegrass	2,174	11.0	1*	38
Toumey oak, manzanita	712	3.5	0	4
Arizona white oak, bull muhly	522	2.6	31*	3
Chihuahua pine, silverleaf oak	223	1.1	0	1
Emory oak, canyon grape	157	0.8	50*	1
Total	20,436	100.0		

*Significant at $P \leq 0.10$.

surrounding area (10%). There was no significant difference in BA at the nest site (2 m^2/ha) when compared with the area surrounding the nest (1.5 m^2/ha). The concealment cover at the nest was considerably greater than in the area surrounding the nest at the 0- to 0.5-m, and 2- to 2.5-m height intervals. The nest was located 0.2 km from a permanent water source, 0.8 km from a road, and 0.4 km from an opening. The nest was 1.8 km southeast of the capture site. A ranch house was not visible from the nest site, but we could hear voices and machinery noises coming from the ranch while at the nest site.

If the nest found in this study is representative of Gould's nests, the nesting requirements of Gould's turkeys are similar to those of other subspecies. This nest occurred on a moderately steep slope (47%). Mackey (1982) and Goerndt (1983) found that Merriam's turkeys *(M. g. merriami)* also nested on steep slopes (46% and 36%, respectively). The Gould's turkey nest was at the base of a large yucca plant. Mosby and Handley (1943), Ligon (1946), and Williams (1981) also noted that turkeys nested at the base of large trees or behind downed logs. In our study, canopy cover was almost complete (97%) over the nest. Hon et al. (1978), Mackey (1982), and Goerndt (1983) reported overhead cover that ranged from 50 to 90%, and Lazarus and Porter (1985) associated overhead cover with 80% of successful nests. We also found that the horizontal cover (0-0.5 m) around the nest was very dense, and Jones (1981), Goerndt (1983), Lazarus and Porter (1985), and Lutz and Crawford (1987) all found this to be the case.

Table 6. Gould's turkey hatching dates in the Peloncillo Mountains, New Mexico, 1982-88.

Year	Hatching date	Source
1982	2-17 June	Schemnitz & Zeedyk (1982)
1983	23 June	Potter (1984)
1985	21-28 June	Willging (1987)
1986	19 June	Willging (1987)
1987	24 June	Schemnitz & Pinto (1987)
1988	22 June	This study
Mean	20 June	

Poult survival and brood-rearing habitat.--Past researchers in this study area have had difficulty making regular observations of the same brood throughout the summer and fall. Therefore, only 1 estimate of poult survival has been made for this population. Potter et al. (1985) reported 100% survival for a brood of 6 poults in 1983. We made weekly observations of 1 brood through summer and fall 1988. There was 100% survival of 7 poults for the first week after hatching (22-29 Jun). During the second week post-hatching, 4 poults died of unknown causes. The remaining 3 poults survived at least until late November. On 21 September 1988, the radio-tagged hen and 3 poults joined a flock with 12 poults and 3 adult hens. The 15 poults in this multiple brood survived through 22 November 1988. This was the last observation of this flock due to failure of radio transmitters.

Overall survival rate for the poults was 43%; all of the losses occurred during the first 2 weeks after hatching. Other investigators also have reported high poult mortality in the first weeks post-hatching (Glidden and Austin 1975, Goerndt 1983, Lockwood and Sutcliffe 1985, Lutz and Crawford 1987). Usually the overall survival rate for poults is somewhat lower than that reported in our study. Bryant (1974), Glidden and Austin (1980), Jones (1981), Mackey (1982), Goerndt (1983), and Metzler and Speake (1985) found a poult survival rate below 25%. Porter (1980) found a 45% poult survival rate in an expanding turkey population in Minnesota, similar to our 43% survival rate. If this is an accurate survival rate for this Gould's turkey population, it is another indication of an expanding population.

We made 115 telemetry locations for the female with the brood. Poult age during the period monitored was 1-90 days. Seven reconnaissance plots were recorded. The habitat types used most frequently by the broods were the Emory oak-canyon grape and Arizona white oak-bull muhly (Table 5). These 2 habitat types provided over 70% of the observations, but they comprised only 3.4% of the total area. Six of the 7 reconnaissance plots were in these 2 habitat types (4 plots in Emory oak-canyon grape and 2 in Arizona white oak-bull muhly). Because both habitat types were selected by the turkeys, the vegetative measurements from them were combined.

Grass was a major component in the plots and covered an average of 30% (SE = 8.3) of all plots (Table 7). Common grasses included *Piptochaetium fimbriatum, Eragrostis intermedia, Bouteloua gracilis,* and *B. curtipendula. Andropogon cirratum, Aristida orcuttiana, Muhlenbergia emersleyi,* and *B. hirsuta* also were present. Forbs were a significant component of the ground cover with an average of 25.8% (SE = 8.6) on the plots. *Artemisia ludoviciana, Verbena wrightii, Phaseolus* sp., and *Penstemon* sp. were common. *Verbesina rothrockii, Desmanthus* sp., *Erigeron* sp., *Solidago wrightii,* and *Haplopappus gracilis* were occasional. Shrubs accounted for an average of 16.2% (SE =11.0) of area in plots. The shrub component included *Rhus trilobata, Vitis arizonica, Fallugia paradoxa, Arctostaphylos pungens,* and *Acacia constricta*. Emery oak and Arizona white oak were the dominant trees, and BA averaged 3.5 m^2/ha (SE = 2.2). The percent canopy cover varied from 0 to 32% with an average of 8.7% (SE = 12.9).

All of the brood-rearing reconnaissance plots were on level terrain, and only along canyon bottoms with intermittent streams. Due to the large component of grasses, forbs, and shrubs in these areas, the vegetation density was highest near the ground.

Table 7. Average values for habitat parameters measured in 6 reconnaissance plots at brood-rearing sites, Peloncillo Mountains, New Mexico, 1988.

Habitat characteristic	Mean	SE
BA (m^2/ha)	3.5	2.2
Canopy cover (%)	8.7	12.9
Canopy height (m)	7.2	3.2
N trees 0-5 cm dbh	5.7	4.2
N trees >5 cm dbh	3.7	2.6
Shrubs (%)	16.2	11.0
Grasses (%)	30.0	8.3
Forbs (%)	25.8	8.6
Soil/rock (%)	6.5	4.2
Litter (%)	11.8	8.8
Down wood (%)	3.3	5.2
Cattle feces (*n*)	15.3	17.9

Willging (1987) found "extremely heavy cattle use" in these habitat types; cattle feces averaged 35/375 m^2 in reconnaissance plots. Our reconnaissance plots of the same areas averaged 15.3 cow feces/375 m^2 (SE =7.7), which suggests that broods select micro-habitats that receive less cattle use. Grazing may be both beneficial (Stoddard 1963, Hillestad and Speake 1970) and detrimental to turkey brood habitat, but beneficial instances are rare.

Roost sites.--Potter et al. (1985) reported 16 roost sites in 1983. The number of active roost sites has increased to 31 in 1988. Similarly, the number of trees per roost increased from 3 trees/site in 1983 to 5.4 roost trees/roost site in 1988. Trees at 26 of the roost sites (84%) were Chihuahua pine. Emory oaks were used at 5 roost sites (16.1%). Other tree species used less frequently included sycamore *(Platanus wrightii)*, Fremont cottonwood *(Populus fremonti)*, and Arizona walnut *(Juglans major)*.

Roost sites have been documented in 13 (68%) of 19 Chihuahua pine stands in the study area. The Chihuahua pine-silverleaf oak habitat comprised 1.1% of the study area.

Home Range and Seasonal Movements

Home range.--We calculated home range for 2 adult hens, 1 of which produced a brood. These hens used the same general areas during spring and fall although they were not always located together. During summer, both hens used different areas, but much of their range overlapped. Toward the end of summer, they were often located together. The turkeys used 3 distinct ranges: 1 in spring, 1 in summer, and 1 in fall.

Seasonal home range size varied greatly. In spring, the 2 hens used a very small area (48 ha). Spring and summer home range for nesting hens averaged 150 ha in Alabama (Hillestad 1973), and 450 ha in the Southeast (Speake et al. 1975).

During summer, the home range we calculated remained relatively small and was located 3.5 km from the spring area. The hen that did not produce a brood used a 78-ha area, while the hen with the brood used a 103-ha area. Ligon (1946) stated that turkey home range size depends on suitability of available resources, especially food supply. The more nearly the habitat approximates optimum conditions, the smaller the home range will be. We believe this only partially explains the small seasonal home range used by the Gould's turkeys. The area used by the turkeys was good quality habitat as described in habitat preference, but it was very limited in size. The area surrounding the high quality habitat was much less desirable, and as a consequence the turkeys were restricted to a smaller area.

The turkeys' fall home range was much larger (908 ha) and was 12.7 km from the summer home range. This move took place in <5 days, and the reason for the move is unknown. Field examinations of droppings showed a change in diet in September and October. During summer, droppings consisted mostly of grasses, forbs, and insects, but by October they consisted almost entirely of pinyon nuts *(Pinus discolor)*. We suspect that this factor may have contributed to these movement patterns.

The yearly home range was determined by calculating the area that encompassed the 3 seasonal ranges. We determined the annual home range to be 3,686 ha, which is large when compared with the yearly home ranges others have calculated. Porter (1977) reported an average annual home range of 65 ha in Minnesota. In contrast, Ellis and Lewis (1967) reported a large average annual home range of 448 ha in Missouri. Lewis (1963), Barwick and Speake (1973), and Davis (1973) all reported averages within the 48- to 65-ha range. The reason Gould's turkeys have such a large home range is the patchy habitat. The turkeys must travel several miles to get from 1 area of quality habitat to another. Consequently, the Gould's annual home range is large, but <33% of the total range is consistently used by the turkeys.

Seasonal movements.--Potter (1984) and Willging (1987) suggested that this population of Gould's turkey did not exhibit seasonal movements or migrations. We found that seasonal movements did occur. The Gould's turkeys moved 3.5 km between their spring and summer ranges and 12.7 km between their summer and fall ranges. Bailey and Rinell (1967) reported that Merriam's and Rio Grande *(M. g. intermedia)* turkeys both exhibit seasonal movements. They reported that during the winter turkeys may move up to 80 km to avoid deep snow or find areas with an abundance of food. Because the Peloncillo Mountains do not have high elevation, snowfall is not the reason for these seasonal movements. The seasonal food habits of the Gould's turkeys seemed to change in this study. Potter et al. (1985) also found seasonal changes in food habits for this same population in 1983. We suspect that as the turkeys' diets change, the turkeys may change habitats to maximize their foraging efficiency. For example, in the summer turkeys concentrate their feeding efforts on succulent plants and insects; during the fall and winter they concentrate on mast (Korschgen 1967). In the Peloncillo Mountains, certain areas may have high concentrations of edible plants and insects but very low mast production, so the turkeys may move to an area that does produce mast. Typically these changes in diet occur seasonally so the turkeys' movements also occur seasonally. There were also areas, Big Lake and Whitmire Canyon, that received use throughout the year. Turkeys were able to stay in these areas continuously because they had access to habitats that contained all the necessary food requirements along with permanent water and roosting sites. Further research should be conducted to determine if these movements occur every year at approximately the same time. Also, additional food habits research should be conducted to determine if food abundance is the key factor causing these seasonal movements.

MANAGEMENT IMPLICATIONS

We believe that the riparian habitats in the Peloncillo Mountains are critical to the turkeys' survival. They contain the majority of the feeding, roosting, and brood-rearing sites, as well as travel lanes for the turkeys. We suggest that the bulk of the management effort should be spent protecting and enhancing these areas.

Due to the low precipitation in the area, permanent water sources should be established in these riparian habitats. The New Mexico Chapter of the National Wild Turkey Federation in cooperation with the U. S. Forest Service built 2 rock-header dams in the area, but additional ones are needed. These dams are designed to seep slowly to provide succulent vegetation below the dam as well as a permanent water supply.

The Chihuahua pine-silverleaf oak habitat comprises only 1.1% of the total area, yet it includes most of the suitable roosting sites. With plantings of sycamore and cottonwood, we could increase diversity and create new roost sites. These plantings should be done near the established permanent water sources to provide cover around them. The permanent water would also increase the trees' chance of survival in this arid environment.

Finally, seasonal reductions or total exclusion of livestock, and experimental controlled burns might be tried to rejuvenate degraded riparian habitats in the area.

The threat of hybridization to the main Gould's population was described by Potter et al. (1985). Progress has been made in curtailing this hybrid turkey population and needs to be continued. The landowner has been persuaded to destroy some of the hybrid birds. The landowner might be persuaded to kill the entire flock if the turkeys could be replaced with wild Gould's, and we strongly suggest this action.

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WILD TURKEY USE OF STREAMSIDE MANAGEMENT ZONES IN LOBLOLLY PINE PLANTATIONS

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Abstract: Documentation of wild turkey *(Meleagris gallopavo)* use of streamside management zones (SMZs) in short-rotation pine plantations is inadequate. Turkey use of narrow (30-45 m), medium (84-104 m), and wide (170-179 m) SMZs in midrotation-aged (13-19 years old) loblolly pine *(Pinus taeda)* plantations was studied using telemetry in Kemper County, Mississippi, 1986-1988. We recorded 14,809 locations on 108 turkeys during 2.5 years. Hen use of SMZs and adjacent areas was greater than expected in 20 of 30 possible cases (10 seasons x 3 SMZ widths), as expected in 9 cases, and less than expected in 1 case. Gobbler use of SMZs and adjacent areas was greater than expected in 14 cases, as expected in 13 cases, and less than expected in 3 cases. Turkey sign (droppings, feathers, tracks) was significantly less in 3 narrow SMZs than in 3 medium and 3 wide SMZs from October 1987 through September 1988. We believe that the greater-than-expected use of SMZs documents the importance of SMZs in pine plantations for wild turkeys.

Forest industry is converting mature mixed pine-hardwood forests to short-rotation pine plantations, which might decrease habitat suitability for turkeys (Stoddard 1963, Mosby 1975, Davis 1976, Bailey 1980). The importance of retaining areas of mature hardwood forest with mast-producing trees, usually oaks *(Quercus* spp.*)*, in pine plantations has been stressed (Speake et al. 1975). When clearcutting, some companies leave strips of mature hardwood forest--streamside management zones (SMZs)--along creeks and rivers for esthetics, protection of water quality, and enhancement of wildlife habitat. Use and importance of SMZs to the wild turkey have not been documented (Dickson 1989). This study was conducted to determine seasonal use of SMZs by turkeys, and relate turkey use to SMZ width and vegetative conditions.

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STUDY AREA

The study area was in the Interior Flatwoods land resource area of Kemper County, Mississippi (Pettry 1977). Weyerhaeuser Company purchased a large tract in 1967 and converted most of the mature pine-hardwood forest to intensively managed, short-rotation (25-30 years), even-aged loblolly pine plantations (Smith 1988, Burk 1989).

The original study area (core area) consisted of 9,700 ha, and pine plantations occupied 66% of the area. Other habitats were mixed forest (21%), SMZs (9%), and non-forest (4%). The core area was enlarged to include all habitats used by radio-equipped turkeys (20,200 ha), and included pine plantations (45.2%), mixed forest (27.4%), SMZs and hardwood forests (16.3%), and non-forest (11.1%). Topography is nearly flat, 0 to 3% slope. A large complex of bottomland hardwood forests and agricultural fields (Sucarnoochee Creek bottom) bordered the southern part of the study area.

SMZs from 0.4 to 5.6 km long were distributed within pine plantations and throughout the core area. SMZ width ranged from 30-45 m (narrow), to 84-104 m (medium), to 170-179 m (wide). Wide SMZs had a permanent creek within them while medium and narrow SMZs contained either permanent or ephemeral creeks. Dominant trees in SMZs were oaks, sweetgum *(Liquidambar styraciflua)* and hickories *(Carya* spp.*)*, and average tree age was about 75 years (Burk 1989).

METHODS

Wild turkeys were captured by cannon-net on Weyerhaeuser spur roads in pine plantations in the core area during July-August 1986 and 1987, and January-March 1986, 1987, and 1988. A "backpack" style transmitter was placed on each turkey, which was then released at the capture site.

Permanent telemetry stations (n = 116) were established on roads throughout the area, as needed, to get as close to radio-equipped turkeys as possible. Turkey locations were determined by triangulation (Cochran and Lord 1963) from 2 stations nearest the turkey. Angles <25 degrees or >155 degrees were generally not accepted. Some angles >155 were accepted because the turkey was on the edge of a road between 2 stations on the road. A maximum 12-minute time limit between consecutive fixes was used; however, most intervals were <5 minutes and many were only 2-3 minutes. A hand-held 3-element directional Yagi antenna and a TRX-1000S (Wildlife Materials, Inc.) receiver were used for telemetry. Accuracy tests were conducted for personnel who conducted the majority (79%) of the telemetry.

All turkeys were located 3 times/day and 3 days/week throughout winter (Dec-Feb), spring (Mar-May), and summer (Jun-Aug), and 2 times/day, 3 days/week in the fall (Sep-Nov). Telemetry was conducted so that individual turkeys were not located at the same time each day.

Telemetry data were separated into individual dBASE files by turkey, sex, and season. Point files (x and y coordinates) were created in Mississippi State Planer Coordinates (MSPC), by the program TBASE, Mississippi Remote Sensing Center (MRSC). TBASE is a modified TELEM program (Koeln 1980).

A base map containing all SMZs (by width class), bottomland hardwood forests, and hardwood dominated forests was digitized from Weyerhaeuser stand maps set in MSPC. We realized that using telemetry locations to determine turkey use of SMZs would have accuracy problems. Therefore, program PROX was used to generate 5 proximity bands that projected out from each SMZ. Band width (51 m) was the length of a side of the error polygon (0.26 ha^2) calculated from accuracy tests. The bands, including the SMZ itself, were numbered 0-5 from inside to outside. Turkey telemetry locations were compared with random locations in each of the bands and were assigned ratings of greater than, equal to, or less than, according to the amount of turkey use each received. If the zero band (SMZ) was used greater than expected, that particular SMZ was assigned that rating. If the zero band (SMZ) did not have a greater-than-expected rating, then the rating assigned would be based on the majority (SMZ plus 5 bands) rating for the 6 bands. In the majority of cases, most of the bands had the same rating.

Turkey point files were used to compute percentage use for each SMZ and its associated proximity bands stratified by turkey, sex, and season. Random points were generated by RASPLOT to calculate relative availability for each SMZ. Turkey locations were then compared with random locations using a 2-sample test for equality of percentages (α = 0.05) (Marcum and Loftsgaarden 1980) to determine if turkey use of SMZs and SMZ bands was equal to expected, less than expected, or greater than expected compared with availability.

Nine SMZs, 3 of each width class, were systematically searched for turkey sign (droppings, feathers, tracks) monthly, October 1987 through September 1988. Searches were conducted in 0.1-ha plots spanning the entire width of an SMZ. Plots were randomly located in a 0.8-km long section of an SMZ. SMZs had similar midrotation-aged pine plantations on both sides. Amount of turkey sign was totaled for each SMZ by month and then was converted to stabilize the variance by the formula: Arcsin (SQRT (x + 3/8)), where x was the percentage of turkey sign. A 3 x 12 factorial design (SAS

1985) was used to test whether turkey sign differed by month and SMZ width.

Vegetative conditions (basal area, dbh, stems/ha, and percent canopy cover) for the canopy, subcanopy, midstory, and understory layers in the 9 SMZs were determined on nested plots (Dickson and Huntley 1987) in summer 1988. The canopy included all dominant trees, whereas the subcanopy included intermediate and codominant trees. The understory layer included all trees and shrubs 0.6-3.7 m tall, and the midstory layer included all trees >3.7 m but less than the subcanopy layer. Vegetative conditions (percent cover, stem density, species composition) in the herbaceous layer (plants <45.7 cm tall) were sampled twice/season from November 1987 through September 1988 (Burk 1989).

RESULTS

We located 108 turkeys 14,809 times from March 1986 through July 1988 (Table 1). Hen use of SMZs and associated bands was greater than expected ($P < 0.05$) in 20 of the 30 possible cases (10 seasons x 3 SMZ widths), equal to expected in 9 cases, and less than expected in 1 case, winter 1987-88 (Table 2). Hen use of other hardwood forests and the Sucarnoochee Creek bottom was greater than expected in 6 cases, equal to expected in 3 cases, and less than expected in 11 of 20 cases. Hen use of other hardwood forests and Sucarnoochee Creek bottom was greater than expected most often in fall and winter.

Gobbler use of SMZs was greater than expected in 14 cases, equal to expected in 13 cases, and less than expected in 3 cases. Use less than expected occurred in spring or summer. Gobbler use of other hardwood forests and the Sucarnoochee Creek bottom was greater than expected in 4 cases, equal to expected in 3 cases, and less than expected in 13 cases. Gobbler use of the Sucarnoochee Creek bottom was greater than expected in fall, winter, and spring of 1986-87, but was less than expected in all other seasons. Hens used all widths of SMZs greater than or equal to expected in 29 of 30 cases; in 1 case use was less than expected in a wide SMZ. Gobblers used all widths greater than or equal to expected in 27 of 30 cases, and less than expected in 3 cases, in wide SMZs.

Turkey sign was significantly less ($P < 0.05$) in narrow SMZs than in medium and wide SMZs. Sign in medium and wide SMZs was similar ($P > 0.05$). Turkey sign was greater ($P < 0.05$) in October 1987 than any other month. December, November, February, and January had the next highest amounts of turkey sign, respectively, but were not different ($P > 0.05$) from other months. No significant ($P > 0.05$) interaction of widths and months was found.

No radio-equipped hen nested in an SMZ. Hens with broods ($n = 14$) <2 weeks old did not use SMZs as brood habitat. Hens with older broods ($n = 14$) used SMZs as expected. There was no difference in turkey use of pine plantations versus SMZs as roost sites.

Table 1. Radio-equipped turkeys monitored for use of streamside management zones in Kemper County, Mississippi, 1986-88.

		Turkeys (n)		Locations (n)	
Year	Season	Male	Female	Male	Female
1986	Spring	7	6	296	352
	Summer	4	8	150	218
	Fall	4	12	144	420
	Winter	6	11	93	537
1987	Spring	7	21	256	1,030
	Summer	3	23	90	865
	Fall	3	29	56	1,603
	Winter	2	29	71	1,659
1988	Spring	12	46	1,118	4,280
	Summer	6	29	226	1,345

Table 2. Radio-equipped turkey use of streamside management zones (SMZs) by sex and season in Kemper County, Mississippi, 1986-88.

		SMZ width				
Sex	Season[a]/year	Narrow (30-45 m)	Medium (84-104 m)	Wide (170-179 m)	OH[b]	SCB[c]
Male	Spring/86	>[d]	>	=	<	<
	Summer/86	=	>	<	<	<
	Fall/86	=	>	=	<	>
	Winter/86-87	=	=	=	=	>
	Spring/87	=	>	<	>	>
	Summer/87	=	>	<	<	<
	Fall/87	=	>	=	=	<
	Winter/87-88	>	>	=	=	<
	Spring/88	>	>	>	<	<
	Summer/88	>	>	=	<	<
Female	Spring/86	=	=	>	<	<
	Summer/86	=	=	>	=	<
	Fall/86	=	>	>	<	>
	Winter/86-87	>	>	>	>	>
	Spring/87	>	>	>	<	>
	Summer/87	>	>	=	<	=
	Fall/87	>	>	=	>	<
	Winter/87-88	=	>	<	=	>
	Spring/88	>	>	>	<	<
	Summer/88	>	>	=	<	<

[a]Spring, Mar-May; summer, Jun-Aug; fall, Sep-Nov; winter, Dec-Feb.
[b]Other hardwood forests.
[c]Sucarnoochee Creek bottom (soybean fields and hardwood forests).
[d]> greater than expected use, < less than expected use, = equal to expected use ($P < 0.05$).

Table 3. Average basal area (BA), diameter at breast height (dbh), stems/ha (S/ha), and percent overhead cover (% OC) for the canopy layer of 9 streamside management zones (SMZs) in Kemper County, Mississippi, 1988.

SMZ width	No.	BA (m^2/ha)	dbh (cm)	S/ha (*n*)	% OC
Narrow (30-45 m)	1	7.3	36.3	32.4	37.5
	2	12.2	35.8	48.7	38.8
	3	9.3	29.5	59.5	38.0
	Avg.	9.6	33.8[a]	47.0	38.1
Medium (84-104 m)	1	14.4	35.3	58.8	50.0
	2	16.6	41.4	49.5	50.8
	3	19.1	33.8	85.5	52.5
	Avg.	16.6	36.8[a]	64.6	51.1
Wide (170-179 m)	1	19.5	44.4	50.5	48.6
	2	21.2	43.9	67.4	56.7
	3	14.6	51.3	29.0	56.1
	Avg.	18.4	46.7[b]	49.0	53.8

[a,b]Means with same letter are not significantly different ($P > 0.05$).

Wide SMZs had higher average basal area (BA) and percent overhead cover, and significantly greater ($P < 0.05$) average dbh in the canopy layer than medium and narrow SMZs had (Table 3). BA, stems/ha, percent cover, dbh, and species composition in the subcanopy layer were similar. Narrow SMZs had a higher percent cover in the understory layer than wide SMZs had (62% vs. 34%, $P <$ 0.05). Stems/ha, percent overhead cover, and species composition were similar ($P > 0.05$) for the midstory layer. In the herbaceous layer, stems/ha and percent overhead cover were higher ($P < 0.05$) in narrow SMZs than in medium and wide SMZs in all 4 seasons. For example, in the spring mean stems/ha was 141,505 and cover was 54% in narrow SMZs while mean stems/ha was 60,770 and cover was 26% in wide SMZs (Burk 1989).

DISCUSSION

Our data demonstrate the importance of SMZs (and associated bands) to turkeys because hens used SMZs of all widths equal to or greater than expected in 29 of 30 possible cases (widths x seasons), and only once, winter 1987-88, was use less than expected. Gobblers used SMZs of all widths equal to or greater than expected in 27 of 30 cases. Turkeys apparently used SMZs for traveling, roosting, feeding, loafing, and perhaps as "cool" areas in the hot, humid summer months. SMZs were not used for nesting or as early brood range.

Emphasis was constantly focused on minimizing bias and error associated with telemetry (Springer 1979). Many locations from well-dispersed telemetry stations, on a dense road system, and in an area with flat topography increased accuracy. Most locations were on turkeys only several hundred meters from the road, and many locations were even closer. Heezen and Tester (1967) recommended angles close to 90° to minimize error. Angles of 90° were not necessary when turkeys were near roads and telemetry stations.

Individual pine plantations were large (avg. 100 ha) enabling turkey locations to be accurately placed in plantations. Relative to plantations, SMZs were small, narrow strips, 30-179 m wide, which presented a problem with accurately placing turkeys in or near SMZs. The proximity (PROX) program was developed to estimate accurately turkey use of SMZs and adjacent bands. We believe that accepting turkey locations in or near SMZs as turkey use of SMZs was biologically sound.

High use of narrow SMZs by radio-equipped turkeys but low amounts of turkey sign in the 3 narrow SMZs was probably due to differences in sampling methods. Data from radio-equipped turkeys included the entire study area and sign data were obtained from only 3 narrow SMZs within midrotation-aged pine plantations. Parts of some narrow SMZs seemed to be used when favorable conditions in adjacent stands allowed turkeys access.

Structural differences in creeks in SMZs may have caused differences in turkey use between medium and wide SMZs. Medium SMZ 2 was used more than any other SMZ, except wide SMZ 2. Medium SMZ 2 did not contain a creek but was a flat drainage area. Wide SMZ 2 contained a large, permanent, steep-banked creek, but it was along the southern boundary of the SMZ. Wide SMZs 1 and 3 contained steep-banked, permanent creeks that wound from SMZ border to border. This undulating pattern created a series of small islands instead of an easily traveled corridor (Gherken 1975, Holbrook et al. 1985). Turkeys did use wide SMZs 1 and 3, but use was much lower than in wide SMZ 2 during months when water in the creek was deep. Permanent creeks also had dense vegetation at their bank edges, due to an opening in the canopy and available moisture (Burk 1989). We believe that creek pattern and vegetative conditions at creek edges affected turkey use of some SMZs.

Wide and medium SMZs generally had more and larger mast-producing trees than narrow SMZs had. Also, the herbaceous layer was not as dense in wide and medium SMZs. Sunlight penetrated from both sides of narrow SMZs and increased vegetative density in the herbaceous layer.

Importance of SMZs to turkey population density remains to be determined. Forest managers, however, should plan for establishment of medium to wide SMZs.

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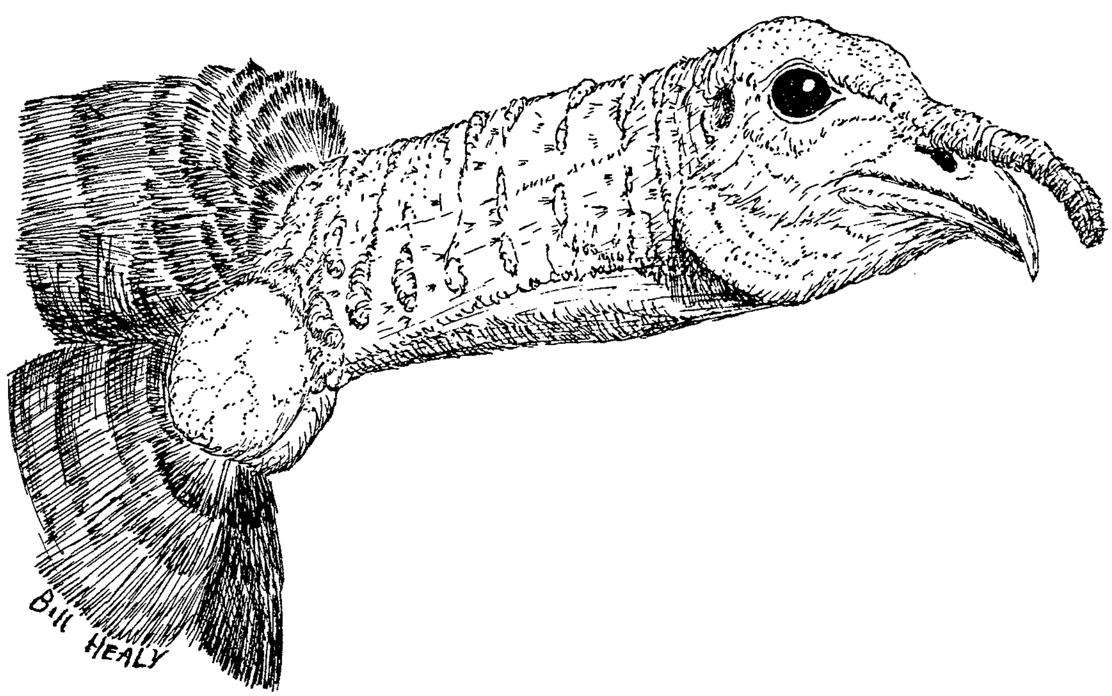

OAK AND FLOWERING DOGWOOD FRUIT PRODUCTION FOR EASTERN WILD TURKEYS

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Abstract: Fruits of oak *(Quercus* spp.*)* and flowering dogwood *(Cornus florida)* are important foods for wild turkeys *(Meleagris gallopavo silvestris)* throughout eastern deciduous forests. To understand wild turkey ecology better and to manage forest habitat for wild turkeys, fruit production data for oaks and dogwood are needed. Annual fruit production was measured for 19 years in 4 hardwood habitat types in the Ozark Highlands of northern Arkansas. Mean annual acorn production ranged from 23 to 168 kg/ha, and mean annual dogwood fruit production ranged from 1.3 to 8.5 kg/ha for the habitat types. Annual production of acorns and flowering dogwood fruit was erratic in all stands. In each habitat type, acorn production was minimal (0-22 kg/ha) in 5 of the 19 years and profuse in 9 years. The extreme year-to-year variation and minimal production of oak and flowering dogwood fruit some years point to the importance of managing for diverse wild turkey habitat with a diversity of food sources.

Eastern wild turkeys evolved over thousands of years in association with mature forests, and according to accounts of early explorers in North America, were very abundant in mature forests in pre-colonial times (Mosby and Handley 1943). Early prescriptions for optimum habitat called for at least 50% of turkey range in mature forest with at least half of the forested area in hardwoods, preferably oaks (Mosby and Handley 1943). Oaks are favored because they are common in most eastern U.S. forests, because acorns are a high-energy wildlife food (Short 1976), and because studies have consistently shown that acorns are a turkey food of major importance. Regarding eastern wild turkey foods, Korschgen (1967) concluded that acorns from the many species of oaks indigenous to the eastern United States were the most important food. In a summary of 7 studies analyzing over 800 turkeys, acorns were the number 1 food, comprising from 4 to 45% of crop and stomach food volumes. In a summary of dropping analysis studies in the eastern deciduous forests (7 studies, n = 9,874 birds), acorns again were the most important food (Korshgen 1967).

Acorns are consumed by turkeys as they become available in the fall, and increase in importance in winter as the availability of other foods decreases. In a summary of 8 winter food habits studies (n > 8,000 turkeys), acorns comprised almost half of the foods consumed, providing more than 3 times as much food as the next most important item (Korschgen 1967). Acorns remained the primary food through spring, but declined to less than 5% in summer as consumption of insects, herbaceous material, and grass seed increased.

Fruits of flowering dogwood are the second most important food of eastern wild turkeys (Korschgen 1967). Turkeys relish the fruits during fall and winter, after frost.

Because oak and flowering dogwood fruit are so important to wild turkeys and many other species (Martin et al. 1951), production data are needed for a better understanding of wild turkey ecology and for effective management of forest habitat for wildlife. The objective of this study was to quantify production of acorn and flowering dogwood fruit in 4 forest types in northern Arkansas.

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METHODS

Oak and dogwood fruit production was sampled in 4 vegetation types over about a 5-km^2 area in the Sylamore Experimental Forest in the Ozark Highlands of northern Arkansas (Rogers et al., in press). The vegetation types were (1) upland white oak-black oak-northern red oak (WO-BO-NRO), (2) streambottom WO-BO-NRO, (3) shortleaf pine-oak (SLP-O), and (4) eastern red cedar (ER) (Eyre 1980).

The upland WO-BO-NRO type, which was dominated by white oak *(Q. alba)*, black oak *(Q. velutina)*, and northern red oak *(Q. rubra)*, occurred on north and east exposures of ridgetops and upper slopes (Segelquist and Green 1968). Mean basal area of mast-producing size trees (>25 cm dbh) was 8.5 m^2/ha about midway through the 19-year study. The SLP-O type occurred on dry south and west facing slopes. Shortleaf pine *(Pinus echinata)* dominated with a scattering of oaks and other hardwoods. Mean basal area of mast-producing size trees was 9.1 m^2/ha. Eastern red cedar *(Juniperus virginianus)* typified the ER type, but were small and scattered. Oaks were the dominant trees on the dry sites with shallow soils. Mean basal area for trees >25 cm dbh for the type was 6.7 m^2/ha. The streambottom WO-BO-NRO type occurred in narrow stream bottoms and lower slopes. White oak, sweetgum *(Liquidambar styraciflua)*, northern red oak, and other hardwoods predominated. Mean basal area of mast-producing size trees was 9.9 m^2/ha.

Mast production was sampled annually from 1959 through 1977 at randomly selected points from 348 208-liter open-top barrels (0.25 m^2 each). Sample points were stratified by vegetation type; 152 barrels were placed in the upland WO-BO-NRO type, 102 in the upland SLP-O type, 46 in the ER type, and 48 in the streambottom WO-BO-NRO type. Barrels were not placed at sample points that did not fall under trees, and those sample points were assigned 0 values. Barrels were turned upright in late summer each year and allowed to catch rainwater prior to mast drop. Holes were punched in each barrel at about 0.3 m from the bottom to allow excess water to drain out. Water accumulating in the barrels helped protect acorns from depredation and decay. A stick was placed in each barrel protruding out the top so that rodents that fell into the barrels could escape. Sound fruits in the barrels were counted, dried, and weighed early each spring and oven-dry yields per hectare were calculated.

RESULTS

Mean acorn production was higher in the upland WO-BO-NRO stand (168 kg/ha) and the SLP-O stand (100 kg/ha) than in the streambottom WO-BO-NRO (34 kg/ha) or the sparsely timbered ER stands (23 kg/ha) (Table 1). Also, acorn yield differed between vegetation

Table 1. Oak and flowering dogwood fruit production (kg/ha) in the Ozark Highlands of northern Arkansas.

	Stand							
	Upland white oak-black oak-northern red oak		Shortleaf pine-oak		Eastern red cedar		Streambottom white oak-black oak-northern red oak	
Year	Oak	Dogwood	Oak	Dogwood	Oak	Dogwood	Oak	Dogwood
1959	144.6	11.9	90.6	10.3	3.2	0.0	0.0	6.4
1960	637.5	16.0	436.8	16.4	10.8	0.2	122.8	0.0
1961	124.2	30.6	52.2	21.4	5.9	0.0	109.9	50.7
1962	51.6	4.1	35.4	4.8	0.6	0.0	0.0	3.2
1963	16.9	6.4	8.2	5.8	0.0	2.8	16.6	5.3
1964	21.5	0.0	8.0	0.1	9.3	0.3	23.2	0.0
1965	336.0	5.7	212.1	1.8	76.5	0.4	52.0	0.3
1966	51.2	0.0	32.7	0.0	12.7	0.0	6.8	0.0
1967	494.7	11.4	243.3	9.0	84.8	0.1	92.7	3.4
1968	6.6	0.2	3.2	0.2	0.0	0.0	0.0	0.0
1969	68.3	3.4	49.6	5.6	16.6	0.0	11.3	1.3
1970	20.7	0.4	9.2	0.0	0.0	0.0	0.0	0.0
1971	260.1	1.0	163.4	0.8	0.0	0.0	20.6	0.0
1972	97.2	2.7	49.4	2.7	19.8	1.9	25.5	0.3
1973	45.2	2.7	22.1	8.2	15.7	3.0	44.5	3.0
1974	510.6	4.4	209.8	1.0	138.2	0.0	62.0	0.0
1975	5.4	9.1	0.9	3.0	0.0	7.4	0.0	0.0
1976	334.4	45.0	154.8	13.1	37.7	2.4	26.7	13.9
1977	220.0	2.4	198.2	8.5	42.0	3.9	19.6	0.0
Mean	168.0	8.5	99.5	6.4	23.0	1.3	34.4	5.0

types in relation to oak stocking. Acorn yield in kg/ha per m^2 basal area of oaks more than 25 cm dbh was much lower in the ER glade (5.6) than the other 3 types (12.0 to 15.4). Soils in cedar glades were shallow and dry, and oak vigor was probably lower there than on the other more productive sites.

Annual acorn production fluctuated drastically in all types. In each type there was very little or no production in 5 of the 19 years: no production in the ER and streambottom WO-BO-NRO types, less than 10 kg/ha in the SLP-O type, and less than 22 kg/ha in the upland WO-BO-NRO type. Three of these 5 years of minimal acorn production coincided for all vegetation types. Conversely, mast production was profuse in 7 to 9 years with the upland WO-BO-NRO and SLP-O types producing over 120 kg/ha each.

Yields of dogwood fruit were lower but followed a similar pattern. Annual yields were higher for the upland WO-BO-NRO (8.5 kg/ha), SLP-O (6.4 kg/ha), and streambottom hardwoods (5.0 kg/ha), than for the ER glades (1.3 kg/ha). Annual yields fluctuated drastically; in the forest type with the highest yield, upland WO-BO-NRO, production exceeded 10 kg/ha in 5 years and was ≤ 1 kg/ha in 5 years. Two of the 5 years of lowest production coincided with acorn failures.

DISCUSSION

Many other species of vertebrates and invertebrates consume acorns before and after they fall to the ground. Downs (1949) reported that by the time acorns fell to the ground only about half were sound, 24% had been at least partially consumed by squirrels and birds, and 30% by insect larvae. Cypert and Webster (1948) estimated that about 12% of acorns in trees were removed, that 5-14% eaten by birds before they fell, and that about 5% of those on the ground were consumed during each 24-hour period. Goodrum et al. (1971) found that in years of low production acorns disappeared soon after falling.

Individual trees seem to have different innate capacities to produce acorns; some are consistently good producers and some poor (Christisen and Korschgen 1955, Goodrum et al. 1971). On areas intensively managed for acorn production, consistent mast producers can be protected from harvest, and poor producers can be cut. Cut trees and leave trees could be selected in the fall when acorn production is easily evaluated.

Other than innate abilities of individual trees, acorn production is usually related to crown size and dominance, but not to bole diameter growth (Downs 1949, Christisen and Korschgen 1955, Goodrum et al. 1971, U.S. Forest Service 1981). Trees with bigger, more exposed crowns tend to produce more acorns. Most oak species are intermediate in space and light tolerance. Silvicultural practices, such as harvests or thinnings, that give good mast producers or potential producers more crown space and light should result in higher acorn production. Also, how natural succession, erratic perturbations such as tornadoes, or insects and diseases such as gypsy moth defoliation of oak stands or dogwood anthracnose will affect stands, should be considered in long-range planning for turkey habitat (Dickson 1986).

Flowering dogwood grows well in partial light (Blair 1982), but flowers and fruits best in full sunlight (Halls 1973). Partial cuts that admit more midstory sunlight should increase dogwood fruit production.

Initial acorn production for most oak species occurs at about 20-25 years (about 25 cm dbh) (Table 2) (Goodrum et al. 1971, U.S. Forest Service 1981). But dwarf species, such as bear oak *(Q. ilicifolia)*, and some smaller species such as post oak *(Q. stellata)* and bluejack oak *(Q. incana)*, produce when small (Tables 2, 3).

For most species optimum acorn production age is from about 50 to 125 years (U.S. Forest Service 1981), depending on tree and stand factors such as vigor and competition. Maximum age of production is generally thought to be about 200 years, but this is quite variable and poorly defined. Optimum tree size for acorn production for most species is from about 30 to about 65 cm, but is smaller for post oak and bluejack oak (Table 3).

Table 2. Fruiting habits of oaks and flowering dogwood in the southeast.[a]

Species	Initial mast production Age	Initial mast production dbh (cm)	Optimum mast production Age	Optimum mast production dbh (cm)	Maximum age of mast production (pathological)	Remarks
OAKS						
Bear *(Quercus ilicifolia)*	2					Seldom fail
Black *(Q. velutina)*	20	15-20	40-80	25-76	100	
Blackjack *(Q. marilandica)*		15-20	10-24			
Bur *(Q. macrocarpa)*	35		75-150		400	Some production yearly
Cherrybark *(Q. falcata* var *pagodaefolia)*	25		50-80			Seldom fail
Chestnut *(Q. prinus)*	20	15-20	50-100	30-61	150	Fail every other year
Chapmans *(Q. chapmanii)*	2	3				
Laurel *(Q. laurifolia)*	15		25-?			Seldom fail
Live *(Q. virginiana)*						Seldom fail
Northern red *(Q. rubra)*	25	25	50-125	36-71	200	
Nuttal *(Q. nuttallii)*	20					Some production yearly
Overcup *(Q. lyrata)*	25					
Pin *(Q. palustris)*	15		25-80			
Post *(Q. stellata)*	25	15	50-150	20-51	250	
Bluejack *(Q. incana)*		5		10-20		
Scarlet *(Q. coccinea)*	20	15-20	50-125	25-71	150	
Shumard *(Q. shumardii)*	25		50-?			Some production yearly
Southern red *(Q. falcata)*	25	25	50-75	51-76+	125	
Swamp chestnut *(Q. michauxii)*	25		40-?			Some production yearly
Swamp white *(Q. bicolor)*	35		75-200		300	Some production yearly
Turkey *(Q. laevis)*			25-?	13-20		Fail about every third year
Water *(Q. nigra)*	20	25-30	50-125	36-76	175	Seldom fail
White *(Q. alba)*	20	20-25	50-200	36-76	300	Fail every other year
Willow *(Q. phellos)*	20	20-25	30-100	36-61	125	
FLOWERING DOGWOOD *(Cornus florida)*	4	5		10-20		Trees ≥10 cm seldom fail

[a]From U.S. Forest Service (1981).

Mast production for the 4 vegetation types in Arkansas was generally similar to yields in other regions. In a Louisiana stand dominated by upland hardwoods, mean yield for 8 years was 87 kg/ha (Collins 1961). In a southern Appalachian oak stand with a history of heavy cutting annual mast production ranged from about 112 to 180 kg/ha (Downs 1949). In a hypothetical Missouri oak stand with 50 seed-bearing trees per hectare, average annual production was only 22 kg during the 6-year study (Christisen and Korschgen 1955).

These long-term data from 4 different habitats demonstrate that oak and dogwood fruit production is erratic. There was minimal acorn yield 20-25% of the years, and abundant production in about 1/3 to 1/2 of the years in these different vegetation types. This extreme

Table 3. Expected air-dry acorn yields (kg/m^2 of basal area) by species and diameter class of oaks.[a]

DBH (cm)	Chestnut	White	Post	Northern red	Southern red	Scarlet	Black	Water	Blackjack	Bluejack
10			5.9							29.8
15			14.2							31.7
20			14.6						4.4	28.8
25	8.8	6.3	13.7	3.4	2.9	22.0	9.8	3.9	11.2	24.9
30	18.1	9.3	12.2	13.7	4.9	23.9	10.7	12.7	14.2	
36	22.0	12.2	11.2	24.4	6.8	24.9	10.2	16.6	14.6	
41	22.0	15.1	10.2	34.6	9.8	27.8	9.8	24.9	16.1	
46	22.0	23.1	9.3	39.0	13.2	32.7	9.3	19.5	13.2	
51	19.5	23.4	8.8	35.1	17.6	33.2	8.8	19.5	13.2	
56	18.1	21.0	8.3	31.7	22.4	32.2	8.3	19.0	12.7	
61	15.6	19.5		23.9	28.3	27.8	8.3	18.5		
66	13.7	17.6		18.1	31.7	24.4	7.8			
71	12.2	14.6		14.2		21.0	7.3			
76	10.7	12.2		9.8		18.1	6.8			

[a]From U.S. Forest Service (1981).

variability has been noted in other geographic areas. In a loblolly pine-hardwood stand in eastern Texas, fruit production was low and variable (Halls and Boyd 1982). Annual acorn production ranged from 0 to 20 kg/ha. There was no measured acorn production in 1 year, and annual production surpassed 10 kg/ha during 3 of 15 years. There was no measured dogwood fruit production in 2 years, <1 kg/ha in each of 6 years, and 1-5 kg/ha in each of 6 years. In another study, from 17 to 100% of dogwoods growing in the open produced fruit each year (Halls 1973). Variable acorn production also has been observed in the southern Appalachian Mountains (Downs 1949), the Ozark Mountains of Missouri (Christisen and Korschgen 1955), and in Louisiana (Collins 1961, Goodrum et al. 1971).

Wild turkey range should be managed for habitat and stand diversity favoring key food producers to provide for varying seasonal needs and to compensate for erratic food production, which is minimal during some years. Openings in forested habitat are important sources of forbs, grass seed, and insects (Hurst and Dickson, in press); and small blocks of agricultural land can provide supplemental foods. Silvicultural practices that produce between- and within-stand diversity and favor key food producers will provide good wild turkey habitat. Temporary food shortages in 1 vegetation type may be compensated for by production in another type, and within-stand variety can ensure that some food will be available even if certain species fail to produce. In this study, white oaks produced no acorns during 3 years and only 1.3 kg/ha during another year, while red oaks produced 44-125 kg/ha in each of those years. In another year, red oaks produced <0.5 kg/ha, but white oaks 144 kg/ha. Because red oak acorns develop over 2 years and white oak in 1 year, severe spring freezes that kill flowers and limit white oak acorns the subsequent fall would limit red oak acorns the second fall. Red and white oak acorns also differ in palatability and nutritional value. Fox squirrels *(Sciurus niger)* preferred acorns of white oaks over red oaks (Short 1976). White oak acorns also had higher metabolizable energy and apparent palatability for ruffed grouse *(Bonasa umbellus)* than red oak acorns (Servello and Kirkpatrick 1989).

CONCLUSIONS

Oak and flowering dogwood fruit are very important foods of eastern wild turkeys throughout the eastern deciduous forests. Annual production is highly variable and minimal some years. Land management practices that provide habitat diversity, promote healthy and varied deciduous forests, and favor key food producers enhance wild turkey habitat.

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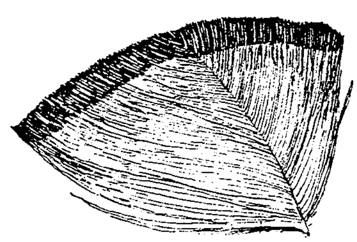

WILD TURKEY AND ROAD RELATIONSHIPS ON A VIRGINIA NATIONAL FOREST

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Abstract: We studied the response of wild turkeys *(Meleagris gallopavo silvestris)* to roads and road use on the George Washington National Forest, Virginia. Radio-equipped wild turkeys used the area within 150 m of state roads less than expected ($P < 0.05$). Turkeys were seen crossing state roads only in locations where the road was bordered by woods or fields <80 m wide. Turkey use of the area surrounding U.S. Forest Service roads was not strongly correlated with road use. Seasonal habitat preferences seemed to dictate turkey use of the surrounding area more than road use levels. Turkey mortality was not closely related to road type or road use levels.

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

Little is known about the effects of roads on turkey populations. Michael (1978) found that only 1% of all turkey sign along a West Virginia highway was within 160 m of the highway. Adams and Geis (1981) did not find any turkeys within 400 m of interstate highways or county roads. Wright and Speake (1975) found that areas of high human activity remove certain zones of unspecified width around them from regular use by turkeys. According to Bailey and Rinell (1968), the best turkey populations occur on areas with <2.5 km of open road per 1,000 ha.

According to Bailey and Rinell (1968), public access due to a high density of roads and trails may increase the turkey harvest to levels dangerous to sustained populations. Holbrook and Vaughan (1985*b*) reported that turkeys found dead in Virginia during hunting season died closer to roads than turkeys found dead at other times of the year and concluded that the extensive open road system (13.8 km/1,000 ha) in their study area played an important role in the numbers of turkeys killed by hunters and the percentage of kill lost as cripples.

Forest roads can be beneficial to wild turkeys. In heavily forested areas, roads provide openings that turkeys may use for nesting, dusting, loafing, or feeding (Mosby and Handley 1943, Leedy 1975). It is not unusual for wild turkey nests to be within 15 m of little-traveled roads (Mosby and Handley 1943, Williams 1981, Porter et al. 1983, Speake and Metzler 1985). Gobblers sometimes use roads as strutting areas in the spring and some roads are important sources of grit. The planting of old logging roads to grasses and other wildlife food plants is a desirable wild turkey management practice (Mosby and Handley 1943).

Roads are an integral part of forest management on most national forests. On the George Washington National Forest (GWNF), roads provide access for treating individual forest units, compartments, and stands. According to the 1986 GWNF Final Land and Resource Management Plan, the current road system was judged inadequate to manage the forest resources (U.S. Dep. Agriculture 1986). During the first 10-year period, 919 km of roads were planned for construction or reconstruction. Approximately 90% of the roads constructed would have been closed to public

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vehicle access after the resource activity was completed. Because of unresolved public appeals, the plan was remanded to the GWNF in 1989 to be rewritten.

One of the research needs listed in the plan was to determine the effects of roads and road management policies on wildlife species during all stages of their life cycles. The wild turkey was the first chosen to be studied because it was an important Virginia game species and one thought to be sensitive to environmental alterations. The objectives of this study were to measure wild turkeys' response to road types throughout the year; determine how vehicular road use influences wild turkey area use; and determine if turkey mortality is influenced by road type and road use levels.

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

STUDY AREA

The study area was southwest of Deerfield in the Deerfield Ranger District of the GWNF, Virginia. Portions of Bath, Augusta, and Rockbridge counties were encompassed by the boundary. The 15,727-ha study area included Walker Mountain, Sideling Hill, Little Mill Mountain, and Chestnut Ridge. The study area is part of the Ridge and Valley physiographic province (Kozak 1970). Seventy percent of the study area was national forest. The adjacent valley land was, with few exceptions, privately owned cattle farms. The study area was 66% hardwood forests, 16% mixed pine-hardwood forests, 10% fields, 5% regeneration areas, and 3% pine forests. The dominant forest cover-type was oak-hickory pole and sawtimber.

Study area roads were divided into 6 groups (Fig. 1): (A) state blacktop roads (32.8 km), (B) state gravel roads (26.5 km), (C) Forest Service roads open all year (15.2 km), (D) Forest Service roads open seasonally (22.6 km), (E) reseeded Forest Service roads (38.2 km), and (F) woods roads and trails (unknown km). Type C roads were gravel roads designed for a low volume of traffic. Type D roads were gated normally but were opened seasonally for hunting or commercial resource activities. Type E roads

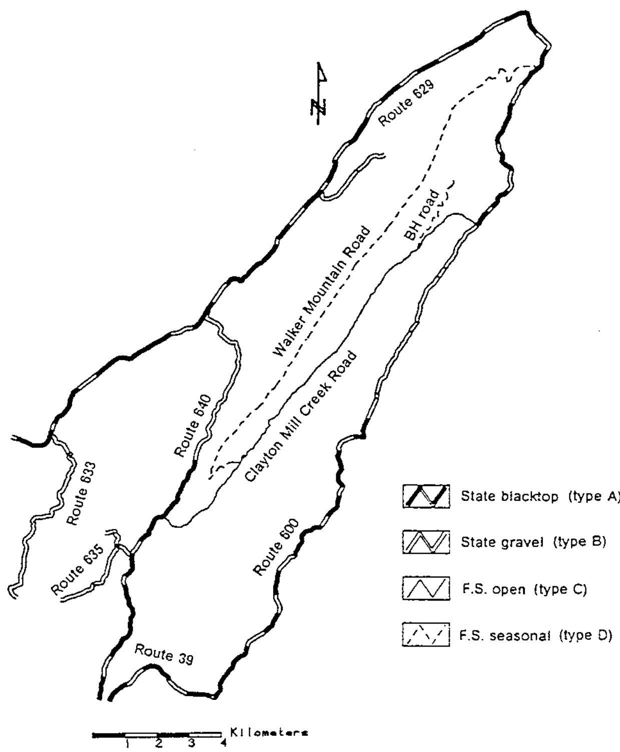

Fig. 1. Four road types on the Deerfield Study area, George Washington National Forest, Va., 1985-87.

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

METHODS

The study extended from September 1985 through August 1987. Each year was divided into 4 seasons: spring (Mar-May), summer (Jun-Aug), fall (Sep-Nov), and winter (Dec-Feb). Wild turkeys were trapped during the fall and winter each year with alpha-chloralose-laced bait or a cannon net. For the former, cracked corn was moistened with water and mixed at the rate of 2 g alpha-chloralose per 0.25 L of bait (Williams 1966, Holbrook and Vaughan 1985*a*). Adults and juveniles were captured with the same drug dosage. Two piles of bait (0.13 L each) were set out for each turkey thought to be using the site. Narcotized turkeys were kept in specially designed boxes until they fully recovered from the drug

(Williams et al. 1966, Austin et al. 1975). Each turkey was removed from its box at 4-hour intervals to exercise its legs and give it water. Corn was removed surgically from the crop of any turkey that appeared to have been overdosed on the drug (Williams 1966).

Age (adult and juvenile) and weight were determined for all captured turkeys. Sex was determined for all adults and juveniles past their post-juvenile molt. Each turkey was marked with Virginia Department of Game and Inland Fisheries (VDGIF) aluminum leg bands (National Band Co., size 24) and patagial wing tags (Allflex cattle or pig ear tags). Selected turkeys were equipped with 75-g radio transmitters (Telonics, Inc.) painted brown to blend with turkey plumage. Transmitters were attached with a nylon, overbraided backpack harness. Juveniles weighing <2.25 kg were not equipped with transmitters. When they appeared to be recovered from the drug, all turkeys were released close to their capture site.

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

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

We attempted to locate each radio-marked turkey at least 5 times/week. Radio-marked turkeys were located visually if they remained in 1 location for more than 2 days. We used the UTM grid system to plot visual locations of live and dead radio-marked turkeys. Cause of death was determined if possible. Radio-marked turkeys shot legally during hunting season usually were turned in at local check stations. Information was requested from hunters about kill location, date, and time of day killed. A $25 reward was given for returned transmitters and a $10 reward was given for returned leg bands. We used program MICROMORT (Heisey and Fuller 1985) to calculate estimates of annual and monthly survival. Turkeys dying from probable trap-related injuries were not included in the analysis. Survival was calculated by sex for the 2 years pooled.

Instrumented hens that were located in the same place for several consecutive days in the spring were presumed to be nesting. Nests were located by circling the nesting hens at 25-50 m and taking compass bearings at points around the circle. The nest and egg shells were visually located after the clutch had been hatched or abandoned (Everett et al. 1980). A nest was considered successful if any poults hatched.

Data sets were formed by combining all radio-marked turkey locations within the study area except those suspected of dying from trap related injuries. Data sets were sorted by season, sex, or time of day. To minimize dependence between observations, we randomly chose only 1 location/turkey/day to be included in each data set. If turkeys were traveling in groups, only 1 location/group was used.

We used USGS topographic maps (1:24,000), U.S. Forest Service maps and stand information, and VDGIF aerial slides to construct a study area cover map. The USGS topographic maps were enlarged (1:12,000) and printed as 1 map on transparent mylar. We used a Kargl reflecting projector to transfer U.S. Forest Service maps to the mylar map. The aerial slides then were projected through the mylar map at the proper scale, and features were traced onto the mylar. Infrared and natural color slides were taken during leaf-off periods to facilitate mapping roads. Five broad habitats were delineated on the cover map.

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

We calculated home ranges with TELEM (Koeln 1980) using the 100% minimum convex polygon method (Mohr 1947). All locations obtained per turkey were used in determining home ranges. Individual home ranges and a composite home range of all turkeys were overlaid on the road map to obtain the length (m) of road types A, B, C, and D within each home range. The percentages of each road type found within an individual home range were obtained by dividing the length of each road type by the combined lengths of road types A, B, C, and D within the home range. The Wilcoxon Rank Sum (2-sample) and Kruskal Wallis tests were used to test for differences in road type percentages between the individual home ranges and the composite home range.

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

Using the buffer command of PC ARC/INFO, we created 3 150-m zones around each type A, B, C, and D road in the study area (Fig. 2). Fourteen zones were created including zone intersections and areas >450 m from any road. The composite home range of all radio-marked turkeys was used as the study area boundary. Radio-marked turkey location maps were overlaid on the road-zone map to obtain the percentage of radio-marked turkey locations in each zone and the study area. The percentage of turkey locations in each zone was compared with percentage expected, testing the hypothesis that turkeys use the zones in proportion to availability, using the Chi-square

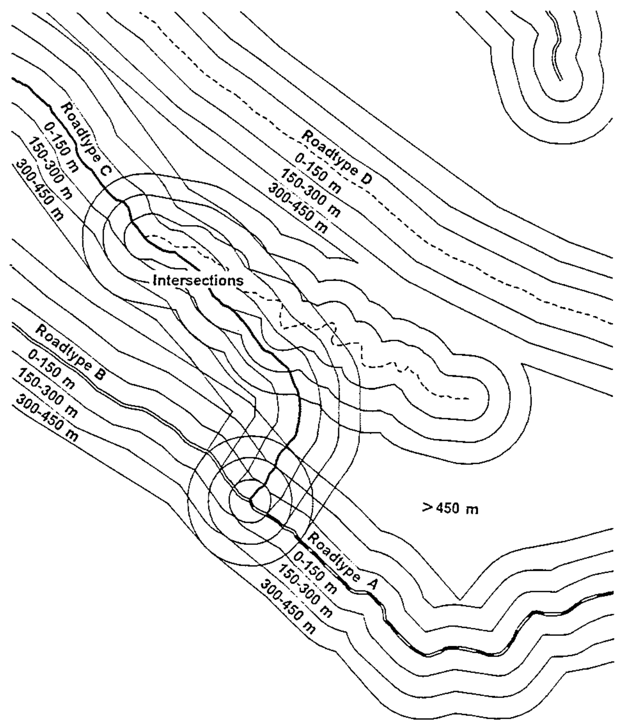

Fig. 2. A section of the zones created around road types A, B, C, and D in the Deerfield study area, George Washington National Forest, Va., 1985-87.

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

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

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

RESULTS AND DISCUSSION

Sixty-four wild turkeys were trapped at 11 trap sites during 15 trapping attempts. Five turkeys were recaptured the second year. Sites were baited throughout the study area but most (64%) of the successful trap sites were located on the southeast sides of Walker Mountain and Sideling Hill. Although successful trap sites were not located randomly in the study area, spring dispersal resulted in the redistribution of radio-marked turkeys over most of the area.

Forty turkeys were equipped with transmitters over a 2-year period. The maximum number of radio-equipped turkeys on the study area at 1 time was 20. We collected 4,100 turkey locations during the study. Trapping efforts and poor weather conditions limited the amount of location data collected during the winter. The standard deviation of bearing error calculated from the practice transmitters was 7.5 degrees. The mean absolute error between radio-determined and actual locations was 170 m. The absolute errors ranged from 5 m to 466 m. The mean distance-to-road error was 96 m. The distance-to-road error was always less than or equal to the corresponding absolute error.

The Virginia Department of Transportation (VDT) counted traffic on type A and B roads once each year, usually in the spring. Traffic on type A and B roads averaged 115 and 63 cars/day, respectively. A short segment of type A road (State Route 39) on the southern border of the study area averaged 1,670 cars/day. Traffic on the only type C road on the study area ranged from 2 to 123 cars/day. Traffic on type D roads ranged from 0 to 60 cars/day. Type D roads were open to the general public only during fall hunting seasons (late Sep-Dec). Traffic was heaviest during the 2 weeks of deer rifle season.

We obtained survival data from 38 of 40 different turkeys released with transmitters during the 2 years of the study. Overall annual survival rate was 37%. Females had an annual survival rate of 35%, and males 39%. Females had a 48% harvest mortality rate and a 17% mortality rate due to unknown causes. Males had a 24% harvest mortality rate and a 37% mortality rate due to unknown causes. All turkeys known to be shot were killed during turkey hunting seasons. Eighty-seven percent of male and 100% of female turkeys found dead of unknown causes died in months with open hunting seasons.

Twenty-five percent of turkeys shot were within 150 m of a type A, B, C, or D road. Forty-two percent were shot >450 m from a road. All turkeys (n = 7) that died of unknown causes died >150 m from a road. Distances from roads to locations of all dead turkeys were not different (P > 0.05) from expected. Distances from carcass to road for shot turkeys and turkeys dying of other causes were similiar (P > 0.05). Instrumented turkeys shot in fall hunting season were shot closer to open roads ($\bar{x}$ = 388 m, n = 9) than turkeys shot during spring gobbler season ($\bar{x}$ = 677 m, n = 3).

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

Distances from nests (n = 9) to roads (type A, B, C, or D) and random points were similiar (P > 0.05). Forty-five percent of nests were located >450 m from a road. Eleven percent were within 150 m of a road. Twenty-two percent of all nests were within 150 m of a type E (reseeded) road. Proximity to woods roads and trails (type F) was not analyzed. Openings and road-edges were not used as nest sites as frequently as reported in other studies (Speake et al. 1975, Williams 1981, Speake and Metzler 1985).

Distances from turkeys and random points to the nearest road (type A, B, C, or D) were not different (P > 0.05) but turkeys used the area within 150 m of road types A and B less than expected ($P < 0.05$) annually (Tables 1, 2). The percentage of type B road found within individual home ranges and the composite home range was similiar ($P > 0.05$); however, individual home ranges had less of type A road ($P < 0.05$) than the composite home range. Turkeys were seen crossing types A and B roads, but only in locations where the road was bordered by woods or fields <80 m wide.

Avoidance of the area within 150 m of types A and B roads appears to be caused by the synergistic interaction of road use and surrounding habitat. The 150-m zone around type A and type B roads contained 55% and 35% fields, respectively. Eichholz and Marchinton (1975) found that constructed topographic features such as improved pastures, roads, and large agricultural clearings acted as barriers to turkeys. Turkeys in their study area were never located beyond a wooded area bordered by a 243-ha pasture and highway. Raybourne (1968) reported that turkeys readily crossed clearcut areas not greater than 137-183 m wide but did not penetrate beyond 46-69 m if clearcuts were >274 m wide. Florida turkeys seldom ranged farther than 91 m from cypress woods, and palmetto prairies restricted movements (Williams et al. 1974). Oxley et al. (1974) found road clearance (the distance from forest to road edge) to be the most important element inhibiting movements of forest mammals across roads.

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

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

Van Der Zande et al. (1980) found that there was a definite threshold value of a stimulus beyond which a bird will react by avoidance. Madsen (1985) found that geese would feed undisturbed in fields only at >200-300 m from a road. This distance increased with greater traffic levels. The area 300-450 m away from road type A was used more than expected ($P < 0.05$) annually. Use of the area 300-450 m away from type B road was not different ($P < 0.05$) from expected. These zones contained 26-28% fields. Several turkey groups, located in fields in these zones, were observed for reactions to passing vehicles. The sound of an approaching vehicle would usually cause a turkey to raise its head, but only large trucks occasionally would cause flight. Turkeys may have become used to seeing traffic at a distance on type A or B roads because most vehicles rarely slowed or stopped. Burbridge and Neff (1975) found that vehicles moving rapidly on roads were less disturbing than vehicles moving slowly, although less often, on rougher roads. Wright and Speake (1975) observed that turkeys at Land Between the Lakes would feed in large fields with a tractor 500 m away. Apparently the avoidance threshold in large fields near type A or B roads lies between 0 and 300 m from the road.

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

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

Turkeys used the area 150-450 m away from type C road less than expected ($P < 0.05$) annually (Table 1). Distances from turkeys to type C road were not correlated with road use. The percentage of type C road found within individual home ranges and the composite home range was similiar ($P > 0.05$). Because

Table 1. Road-zone use (%) vs. road-zone availability (%) for wild turkeys on the George Washington National Forest near Deerfield, Virginia 1985-87. (See Figs. 1, 2 for road types.)

Road type	Zone (m)	Available	All year Used	All year Pref[a]	Fall Used	Fall Pref	Summer Used	Summer Pref	Spring Used	Spring Pref
A	0-150	6.5	3.0	–	4.0	0	2.0	–	2.4	–
A	150-300	6.5	7.0	0	9.5	0	5.0	0	5.7	0
A	300-450	6.7	9.6	+	12.9	+	10.0	+	5.0	0
B	0-150	5.4	1.7	–	0.5	–	6.0	0	3.1	0
B	150-300	5.0	4.0	0	2.0	–	4.0	0	7.3	0
B	300-450	4.9	4.0	0	4.0	0	2.6	–	8.1	0
C	0-150	4.3	3.7	0	5.7	0	2.7	0	2.9	0
C	150-300	3.9	2.0	–	1.7	–	2.4	0	2.9	0
C	300-450	3.7	2.0	–	0.5	–	1.8	–	3.6	0
D	0-150	2.5	0.8	–	0.0	0	0.8	–	1.6	0
D	150-300	2.3	2.0	0	0.5	–	3.0	0	3.1	0
D	300-450	2.2	1.5	0	1.0	0	2.0	0	1.3	0
	>450	37.0	47.0	+	48.0	+	52.0	+	39.0	0
Intersections		8.6	11.0	+	9.0	0	9.6	0	13.0	+
N locations			2,185		402		882		616	
X^2			270		98		163		73	

[a] + = used more than available, – = used less than available, 0 = use proportional to availability ($P < 0.05$).

turkeys avoided the 150- to 450-m zone rather than the 0- to 150-m zone, the results probably reflect habitat use rather than road or road-use effects.

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

Females used the area within 150 m of type C roads less than expected ($P < 0.05$) in summer (Table 2). Road use, which ranged from 0 to 11 vehicles/24 hours during summer, likely did not cause the hens to avoid the road. Another possible explanation is that good brood habitat was generally unavailable near the type C road except sections at either end of the road, which were included in the intersection zone. Hens may have used the 150-m zone less than expected in the summer because better brood range was available elsewhere.

Turkeys used the area within 150 m of type D road less than expected ($P < 0.05$) annually and in the summer (Table 1). Females used the 300- to 450-m zone around type D roads less than expected ($P < 0.05$) annually (Table 2). Two type D roads were included in the study area (Fig. 1). Walker Mountain road (18.7 km) followed a ridgetop, and Bettys Hill road (3.9 km) was on a southeast midslope. Speake and Metzler (1985) found that mountaintops in Alabama were not used as brood range because of little herbacious cover and few openings. Walker Mountain had few openings, most of which were on either end of the mountain and included in the intersection zone category rather than the type C or D road zones. Hens tended to move to private land after nesting probably because of lack of good brood habitat on Forest Service land. Bettys Hill road area received heavy use in the winter and early spring, but winter location data were not plentiful enough to analyze. Annual data sets contained primarily spring, summer, and fall locations.

Table 2. Road-zone use (%) vs. road-zone availability (%) for female wild turkeys on the George Washington National Forest near Deerfield, Virginia 1985-87. (See Figs. 1, 2 for road types.)

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

[a] + = used more than available, – = used less than available, 0 = use proportional to availability ($P < 0.05$).

The area >450 m from any type A, B, C, or D road was used more than expected annually, in the fall, and in the spring ($P < 0.05$). The intersection zone was used more than expected annually and in the spring ($P < 0.05$). Males used the intersection zone less than expected in the summer ($P > 0.05$) (Table 3). Intersection zones occurred primarily where 2 road types met. Engineers build road intersections in areas with low slopes, which typically have good timber site indexes (Trimble and Weitzman 1956, U.S. Dep. Agriculture 1987). Turkeys may have been using intersection zones because the habitat was better than that available on much of the study area.

The area within 150 m of type E roads was used more than expected in the summer and spring and less than expected in the fall. Males used the area less than expected ($P < 0.05$) in the winter. Insufficient winter location data were collected to analyze female use.

Other turkey studies have shown the importance of clearings seeded to grasses and legumes (Bailey and Rinell 1967, Ellis and Lewis 1967, Hillestad and Speake 1970, Blackburn et al. 1975, Speake et al. 1975, Hayden 1980). Seeded clearings provide an important source of food in the spring when other food sources have been depleted. Hens require a high-protein, high-calcium diet for egg-laying (Scott 1973, Healy 1981). Green forage and invertebrates are important in meeting these needs (Korschgen 1973). Insects are more abundant in fields and other clearings than in the forest (Wheeler 1948, Stoddard 1963, Martin and McGinnes 1975).

CONCLUSIONS

Turkeys' response to road types seemed to depend on road use, surrounding habitat, and season. Surrounding habitat and season became more important in determining turkey use of an area as traffic levels decreased. Turkeys never crossed a busy (1,670 vehicles/day) type A road regardless of the surrounding habitat or season. Type A and B roads with less traffic (63-115 vehicles/day) were crossed occasionally but only in locations where the surrounding habitat offered sufficient protection from disturbance. Type A and B roads bordered by wide fields acted as barriers to turkey movement.

Turkey use of the area surrounding Type C and D roads was not strongly correlated with road use, although areas >450 m from any road were preferred throughout most of the year. Seasonal habitat preferences seemed to dictate turkey use of the surrounding area more than road use levels. Lack of preferred habitat

Table 3. Road-zone use (%) vs. road-zone availability (%) for male wild turkeys on the George Washington National Forest near Deerfield, Virginia 1985-87. (See Figs. 1, 2 for road types.)

			All year		Spring		Summer	
Road type	Zone (m)	Available	Used	Pref[a]	Used	Pref	Used	Pref
A	0-150	6.5	3.7	–	3.0	–	1.8	–
A	150-300	6.5	7.8	0	5.6	0	3.7	0
A	300-450	6.7	11.0	+	6.6	0	14.4	+
B	0-150	5.4	1.1	–	2.8	0	1.2	0
B	150-300	5.0	3.1	0	6.6	0	2.1	0
B	300-450	4.9	4.1	0	8.3	0	2.8	0
C	0-150	4.3	2.9	0	3.8	0	3.7	0
C	150-300	3.9	1.7	–	2.8	0	1.5	–
C	300-450	3.7	2.2	–	3.5	0	2.8	0
D	0-150	2.5	0.9	–	2.10	0.9	0	
D	150-300	2.3	3.1	0	3.80	5.5	0	
D	300-450	2.2	1.7	0	1.40	4.0	0	
	>450	37.0	49.7	+	38.0	0	51.0	+
Intersections		8.6	7.0	0	12.0	+	4.6	–
N locations			1,145		288		326	
X^2			195		30		116	

[a] + = used more than available, – = used less than available, 0 = use proportional to availability ($P < 0.05$).

probably caused turkeys to use the area less than expected in the summer when traffic levels were relatively low (0-11 vehicles/day). Turkeys used type C and D roads and surrounding habitat more in the spring than during any other season analyzed.

Turkey mortality did not seem to be closely related to road type or road use levels. Turkeys were not dying or being shot close to roads although turkeys shot in spring were farther from open roads than those shot in fall when more roads were open to public use. Poaching along open roads did not seem to be a significant source of mortality in the study area.

This study was conducted on a small area with a small sample size of each road type. Traffic levels did not vary enough throughout the year to test adequately for correlation between road use and turkey distance from roads. Correlation efforts were further confounded because peak road use occurred during hunting season when turkeys could have been disturbed by hunters walking through the forest. Future road studies should be conducted in a larger area with a greater variety of roads and road use.

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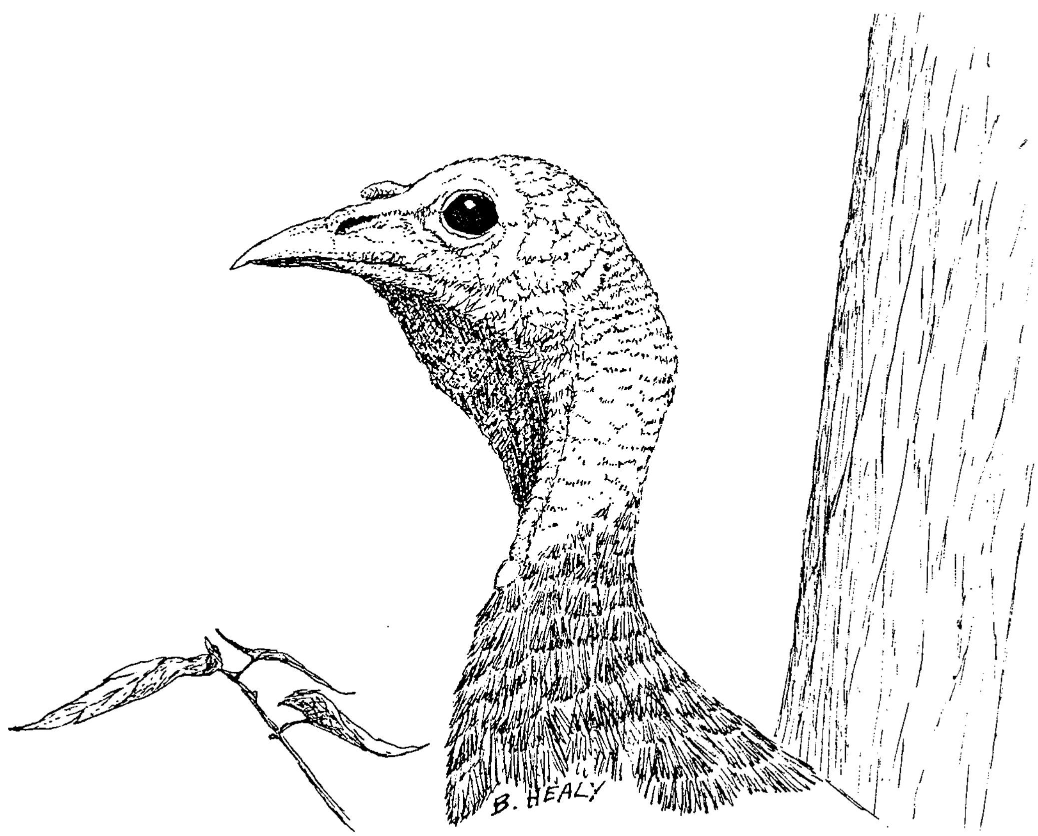

APPLICATION OF POPULATION MODELING TECHNIQUES TO WILD TURKEY MANAGEMENT

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Abstract: Although population modeling techniques have been available for decades, the advent of the personal computer makes them readily accessible to the biologist. Computerized population models enable us to gain a clearer understanding of ecological relationships and of management alternatives. This paper compares 2 distinct styles of computer modeling: detailed models that incorporate highly specific aspects of life history, and general models that rely on a few parameters to integrate life history processes. Both deterministic and stochastic approaches to modeling populations are reviewed. Selection of the modeling style and approach requires a clear understanding of the objective of the modeling exercise, the data resources, and the environment within which management must operate. Mechanistic models are important where the intent is to gain a deeper understanding of the interaction among various conditions affecting population change. General models are most useful where the objective is to predict future populations. A stochastic approach to modeling is valuable where broad environmental fluctuation affects reproduction or survival, and is especially helpful where turkey *(Meleagris gallopavo)* populations are small and risk assessment is desired in planning management strategies. General models are shown to be superior to mechanistic models in most management situations. We assert that population modeling will be an essential tool in meeting the management challenges in the next several decades.

As wildlife biologists or managers, we are frequently confronted with people who disagree with our ideas about habitat or harvest management regimes. The questions they ask are often difficult to answer. For instance, do the benefits of mitigation efforts required in a reservoir development plan merit the cost? What difference will habitat management make in terms of the actual number of turkeys available to a spring hunt? What is the risk associated with an increase in the bag limits during a fall harvest? Population modeling is a powerful way of addressing these questions.

In our experience, many biologists and managers are reluctant to trust models. Biologists and managers are uncertain about how modeling really works, are put off by the jargon, perceive models as requiring highly detailed data sets, or worry that models require too many assumptions. Unfortunately, there is no single paper that summarizes the essence of modeling in terms easily understood by the uninitiated. Our intent is to provide such a summary related to modeling wild turkey populations. We focus special attention on guidelines for the application of modeling in management of the wild turkey. We explore 3 aspects of modeling in a management context:

1. Approaches to modeling - mechanistic models and general models.
2. Application of deterministic and stochastic models.
3. Specifications for data necessary to modeling.

All models are abstractions of the physical and biological processes that cause change in populations. They enable us to predict population change from a variety of biological and physical factors. Informally, we all use models every time we make decisions regarding the ecology or management of the wild turkey because our knowledge is incomplete: our decisions almost always rest on estimates and assumptions. More formal models are written out in an objective and quantitative fashion. This process forces us to be explicit about what's important, what we know, and what we assume. Ultimately, models allow us to predict how a population will change, and understand the biological basis for these changes.

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MECHANISTIC MODELS

Mechanistic models incorporate details of the natural history of the wild turkey, such as seasonal survival rates and nesting success. The population size at some time in the future, most often next year, is calculated by adding the number of new individuals entering the population and subtracting those that leave. In most cases, those entering the population are young that have hatched, and those leaving the population have died.

There are 2 keys to modeling. The first is establishing clear definitions. What is our population? Is it all the birds in the southeastern quarter of the state, or a county, or a management zone? If our intent is to predict the population size after the harvest in the management zone, we need to begin with the population in that zone for the calculation to work out correctly.

A very simple mechanistic model might be written as:

$$N_1 = (N_0 \times P) + (N_0 \times F) \quad (1)$$

where

N_0 is the population size present at the beginning of the time interval, $T(0)$,

P is the proportion of individuals that survive and are present in the population at the beginning of the next time interval, $T(1)$,

N_1 is the population size at the beginning of the next time interval,

F is the number of young that hatch and survive, and are present at $T(1)$ per adult in the population at $T(0)$.

The interval time between $T(0)$ and $T(1)$ is 1 year, and our intent is to predict the population next year (Table 1). Note that survival (P) is defined carefully. An individual must not only survive from $T(0)$ to $T(1)$, but must also remain in the area (thus, as defined here, P incorporates emigration). If a bird leaves the management zone, we must consider it no longer a part of the population inhabiting the zone. Recruitment (F) integrates the number hatched and the proportion that survive to be present in the population at $T(1)$.

Table 1. Sample calculation of a simple population model incorporating annual survival (P) and recruitment of young (F) to project change in abundance (N) from 1 time period to the next.

$$N_1 = (N_0 \times P) + (N_0 \times F)$$
$$N_0 = 100$$
$$P = 0.50$$
$$F = 3.0$$
$$N_1 = (100 \times 0.5) + (100 \times 3.0)$$
$$N_1 = 350$$

A more realistic mechanistic model incorporates the differences in survival between males and females. It also recognizes survival through distinct seasons, for instance, the fall harvest and winter periods.

$$H_1 = (H_0 \times P_1 \times P_2) + (H_0 \times F_1) \quad (2)$$

where

H_0 is number of hens at $T(0)$,

P_1 is proportion surviving fall harvest,

P_2 is proportion surviving the winter,

F_1 is number of female young recruited per female at $T(0)$.

$$G_1 = (G_0 \times P_3 \times P_4) + (H_0 \times F_2) \quad (3)$$

where

G_0 is the number of gobblers at $T(0)$,

P_3 is the proportion of males surviving spring harvest,

P_4 is the proportion of males surviving the fall harvest.

Note that the number of new males added to the population at $T(1)$ is dependent of the number of females and the survival rate (F_2) of poult-juvenile males from nesting to the following spring. The total population at $T(1)$ is thus:

$$N_1 = H_1 + G_1. \quad (4)$$

TIME LINES

The second key to modeling is keeping the sequence of events in order. Most of the confusion in formulating models is alleviated with a good, clear time line that relates all life history events resulting in additions to and subtractions from the population to the time of census. For instance, the time interval in our model may begin just before nesting each year (Fig. 1). We call this our *time of census* because, even though we may never actually go into the field to census the population, we have some fix on the population size.

Alternatively, our time of census may not coincide with the time of reproduction, and the model becomes more complex. If our time of census is just before fall harvest, the values input to the model include an estimate of the number of females (obtained in the fall) and the number of poults per female (obtained in the following summer). Simply multiplying total number of hens by nesting success and poult survival would not provide an accurate estimate of recruitment. To be correct, the recruitment component must allow for loss of females between the time of census and nesting. This is done by including survival values of the adult females in the recruitment component (see Fig. 2 and Table 2).

Table 2. Sample calculation of recruitment when time of census and time of reproduction do not coincide, and where seasonal survival rates are incorporated.

$$H_1 = (H_0 \times P_1 \times P_2) + (H_0 \times P_1 \times P_2 \times S \times E \times P_3)$$

H_0 is females pre-harvest in the fall	200
S proportion of hens nesting successfully	0.6
P_1 is probability of surviving the fall harvest	0.8
P_2 is probability of surviving the winter	0.7
E is number of eggs hatching to female poults	6
P_3 is survival of poults through the summer	0.5

$$\begin{aligned} H_1 &= (200 \times 0.8 \times 0.7) + (200 \times 0.8 \times 0.7 \times 0.6 \times 6 \times 0.5) \\ &= 112 + 201 \\ &= 313 \end{aligned}$$

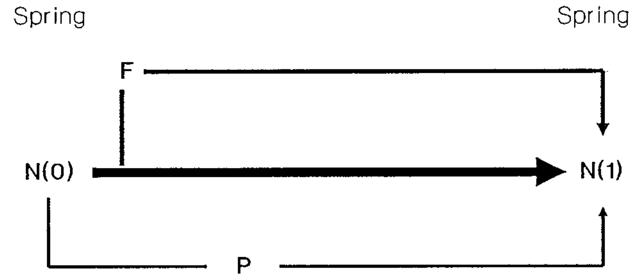

Fig. 1. Time line for population model showing time of census in spring, just before nesting. N is numbers of hens and gobblers, combined; P is probability of survival, F is recruitment of young to T(1).

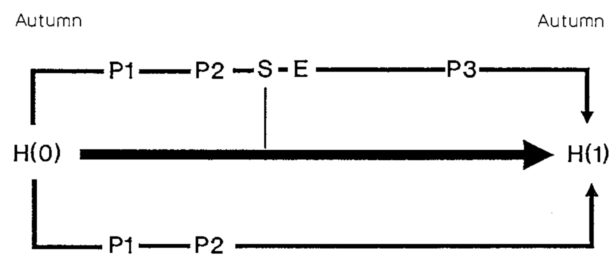

Fig. 2. Time line for population model showing time of census in fall, just before harvest. H is number of hens, P's are probabilities of survival, S is probability a female will nest successfully, and E is average number of eggs/nest.

MODELING AGE-SPECIFIC SURVIVAL

Another layer of complexity is added when we consider age-structured populations. For wild turkeys, studies have documented differences in the nesting rates and nest success rates of yearling versus adult hens. Suppose that we have information suggesting that young are more vulnerable in a fall harvest than adults and incur higher mortality during the winter. This is incorporated using a new set of equations, one each for young and adults.

$$YH_1 = YH_0 \times P_4 \times P_5 \tag{5}$$

$$AH_1 = AH_0 \times P_1 \times P_2 \tag{6}$$

where

YH is number of young of the year hens,
AH is number of adult hens,
P variables are individual survival rates.

Note that the first of these 2 equations calculates the proportion of young of the year (*already present* at our first time of census, $T(0)$) that survive to $T(1)$. The calculation of recruitment requires an estimate of the number of young females that will be alive to nest. This means we have to account for the fall harvest and winter mortality, and estimate the number present in the population just before harvest at $T(1)$. Thus, P_4 and P_5 are included to account for fall hunting and winter survival in the juvenile birds, and to distinguish them from those of adults.

These modifications can be made with adult males and with more specific age-related survival rates. Most models begin with a simple form and grow to be more complex as we add more specificity to accommodate desires for more realism.

INITIALIZING MODEL VARIABLES

With the time line and mathematical relationships formulated, we can insert values for each variable. In the jargon of modelers, this is called variable initialization. Suppose that we have a reliable estimate of 100 birds for the current population size. We need an estimate of the proportion of these adults that will survive. We also need an estimate of the number of poults that are hatched and survive. Initial values inserted into the model can be hard data, guesses by experienced biologists or managers, or estimates from the literature (e.g., Table 3). The model can then be run and we can evaluate the degree to which the output matches our experience. The values inserted in the model are then adjusted through several runs until both the input and output meet our expectations (e.g., Suchy et al. 1990).

PROGRAMMING MODELS

Computers possess 2 distinct characteristics that allow efficient use of models. Once they are programmed, they can calculate population projections in a matter of seconds. Modeling tends to be a process of trial and error because we adjust the values input to the program to accommodate various assumptions. Therefore, rapid turn-around time is crucial. Second, if programmed correctly and variable values are input accurately, the computer makes no computational errors.

There are 3 major processes a computer program must perform: input, calculation, and output. In most programs, a majority of the computer codes is associated with input and output. Input commands enable the user to specify the numerical values for each of the parameters of the model. Output commands allow the user to view the results, defining the content and format of the display. The calculation is generally a few lines of code.

A variety of programming languages are available on desktop computers. Two of the most common are BASIC and PASCAL. The code for projecting populations using Eq. (2) is relatively simple (App. A). Both programs prompt the user for input values for the variables and are thus interactive. Both are easily understandable. The difference between languages is that PASCAL requires about 50% more lines of code than BASIC. Some programmers favor PASCAL, however, because it allows compartmentalization of the major processes (i.e., input, output, calculation), which facilitates finding and correcting errors. This becomes important as programs grow larger and more complex.

SENSITIVITY ANALYSIS

Once a program is written and corrected for errors the next step is sensitivity analysis. Simply stated, this involves systematically varying the values input for each variable to answer 2 questions: which variable has the greatest influence on population change, and what are the levels of each variable below which the population declines.

This is illustrated by using the following equations to predict population changes. The time of census is fall, pre-harvest.

$$H_1 = H_0 \times P_1 \times P_2 \times E \times S \times P_3 + H_0 \times P_1 \times P_2 \quad (7)$$

$$G_1 = H_0 \times P_1 \times P_2 \times E \times S \times P_3 + G_0 \times P_4 \times P_5 \quad (8)$$

$$N_1 = H_1 + G_1 \quad (9)$$

where

H and G are numbers of Hens and Gobblers, respectively,
P_1 is hen survival through the fall harvest,
P_2 is hen survival through the winter,
P_3 is poult survival through the summer,

Table 3. Estimates of survival and reproductive rates for wild turkeys that could be used as initial values for variables in a mechanistic population model. Values are those reported explicitly or are derived from data presented in the corresponding reference.

Variable	Estimate	Reference
	Reproduction and Recruitment of Young	
Adult nesting rate	0.83-0.94	Glidden and Austin 1975
	0.57-1.0	Everett et al. 1980
	0.9	Porter et al. 1983
Juvenile nesting rate	1.0	Glidden and Austin 1975
	0.71-1.0	Everett et al. 1980
Adult hatching rate	0.2-0.41	Glidden and Austin 1975
	0.33-0.75	Everett et al. 1980
	0.6	Little and Varland 1981
	0.62	Porter et al. 1983
Juvenile hatching rate	0.33-0.57	Glidden and Austin 1975
	0.60-0.67	Everett et al. 1980
Adult renest rate	0.75	Glidden and Austin 1975
	0.25	Everett et al. 1980
	0.60	Porter et al. 1983
Juvenile renest rate	0.40	Glidden and Austin 1975
Poult survival to 4 weeks	0.20	Glidden and Austin 1975
	0.0-0.27	Everett et al. 1980
	0.47	Porter et al. 1983
	0.1-0.64	Metzler and Speake 1985
Poult survival 4-12 weeks	0.89-1.0	Porter et al. 1983
	0.94	Speake et al. 1985
	Survival of Juveniles and Adults	
Female survival - nesting (All age classes)	0.9-0.93	Glidden and Austin 1975
	0.7	Porter 1978
	0.81	Everett et al. 1980
	0.55	Speake 1980
	0.83-1.0	Porter et al. 1983
	0.77	Kurzejeski et al. 1987
Female survival - fall harvest (All age classes)	0.65	Hayden and Wunz 1975
	0.78	Kurzejeski et al. 1987
Male survival - spring harvest (All age classes)	0.57	Lewis and Kelley 1973
	0.65	Everett et al. 1980
Male survival - fall	0.65	Hayden and Wunz 1975
Adult survival - summer	0.91-1.0	Porter et al. 1983
	0.87	Kurzejeski et al. 1987
Juvenile survival - winter	0.37-0.75	Austin and DeGraff 1975
	0.4	Hayden and Wunz 1975
Adult survival - winter	0.37-0.75	Austin and DeGraff 1975
	0.4	Hayden and Wunz 1975
	0.35-0.90	Porter et al. 1983
	0.83	Kurzejeski et al. 1987

P_4 is gobbler survival through the fall harvest,
P_5 is gobbler survival through the spring,
E is the average number of eggs/nest,
S is the probability of a hen nesting successfully.

Assuming:

1. Survival of young and adults through hunting seasons is the same.
2. Mortality of hens through spring and summer is negligible.

Incremental changes in the values for survival shows that the model is much more sensitive to mortality among females than males (Table 3). A reduction in male survival from 80% to 60% during a fall season (holding female survival constant at 80%) yields a net difference in the population of 1,325 birds after 10 years of growth. The same reduction in female survival (holding male survival at 80%) produces a net change of 24,369 birds at 10 years. That the model is not sensitive to mortality among males is as we would expect, and thus increases our confidence in the model. The magnitude of the decline in population growth with harvest of females is more instructive.

Testing the limits of the model involves modifying the estimates to attempt to project population growth for best-case and worst-case scenarios. For example, the first set of values in Table 4 might be considered the best-case scenario. Annual survival of females is 64%, nesting success rates are 80%, and poult survival is 50%. In this situation, the population is doubling each year. If we reduce annual survival of females to 48% through increased fall harvest, the population still grows, but at a much slower rate. A fall harvest of about 60% causes the population to decline.

DETERMINISTIC VERSUS STOCHASTIC MODELS

So far, all of the models have been *deterministic*. That is, there was 1 unique prediction for each combination of input values. There is, however, considerable variation around life-history events of the wild turkey, especially from 1 year to the next. Because of the myriad influences on turkey populations throughout an annual cycle, precise prediction of actual events is often not possible. Managers often must set the fall harvest season 8 months ahead and are faced with some uncertainty about size of that fall population. The solution to this is generally to set harvest at a conservative level. But, what's conservative? For example, should management be designed to harvest around the long-term mean population size, or be predicated on the worst-case scenario, such as population abundance given poor brood survival?

One approach to gaining confidence in setting harvest levels is to allow some random fluctuations in our model inputs. For example, brood survivorship varies between 0 and 64% (Table 3) and is difficult to predict because it is highly dependent on weather (Healy and Nenno 1985). *Stochastic* models allow incorporation of random variation in the population projections. The program is adjusted so that each time it is run, the computer selects a different value for brood survival bounded between 0 and 60%. By running the model many times, we can get an idea of how a population is likely to respond to a pre-determined fall harvest rate, even with the unpredictable brood survival rates (Fig. 3). Good stochastic models do not arbitrarily select the "random" value for each variable, but draw on known probability distributions (e.g., normal), based on samples taken from populations. Thus, stochastic models often correspond more closely with actual experience.

Stochastic models are especially helpful in assessing risks. They provide results that can be used to formulate probability statements such as: "our modeled population fell below the desired level 30% of the time at the end of 10 years" (Fig. 4). This approach thus provides a quantitative means for evaluating the potential of a new management direction.

GENERAL PREDICTIVE MODELS

Population growth rate, positive or negative, is the result of all the detailed events that occur in the annual life cycle of the wild turkey. Indeed with just 2 pieces of information, population size and growth rate, we can model just about any management scenario for a wild turkey population. This type of model requires only some knowledge of population size at 2 or more periods of time. A very simple model that incorporates estimates of population size and growth rate is:

$$N_1 = N_0\lambda \tag{10}$$

$$\lambda = N_1/N_0 = e^r \tag{11}$$

where

λ is the finite rate of growth,

N_1 is the population size in the second year,

N_0 is the population size in the first year,

e is the Napierian logarithm,

r is the instantaneous growth rate.

Table 4. Sensitivity analysis for a model of wild turkey population growth assessing the relative importance of hen survival through the fall harvest (P_1) and poult survival through the summer (P_3). The initial population for each simulation is 10 females and 10 males.[a]

Simulation	P_1	P_2	P_3	P_4	P_5	E	S	Population Yr 10
1	0.8	0.5	0.8	0.8	0.8	11	0.8	25,961
2				0.7				25,232
3				0.6				24,636
4	0.7			0.5				7,067
5	0.6							1,592
6	0.5							280

[a]P_1 is hen survival through the fall harvest
P_2 is hen survival through the winter
P_3 is poult survival through the summer
P_4 is gobbler survival through the fall harvest
P_5 is gobbler survival through the spring
E is the average number of eggs/nest
S is the probability of a hen nesting successfully.

Assuming: Survival of young and adults through hunting seasons is the same. Mortality of hens through spring and summer is negligible.

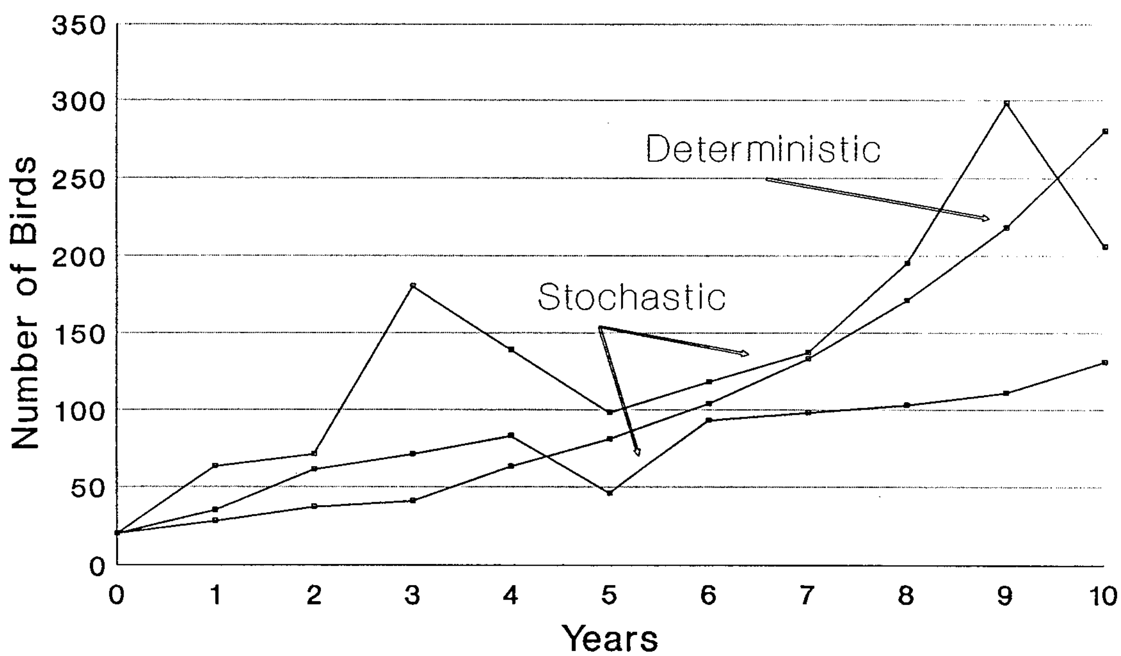

Fig. 3. Results of modeling population change showing stochastic modeling in which hen survival through the fall was 50% and 60%, respectively, and brood survival varied randomly between 0 and 1.0. The deterministic model assumes 50% hen survival through fall harvest and 50% brood survival. The proportion of females nesting, female survival through nesting, and male survival during fall and spring are all set at 80%; clutch size is set at 11 eggs.

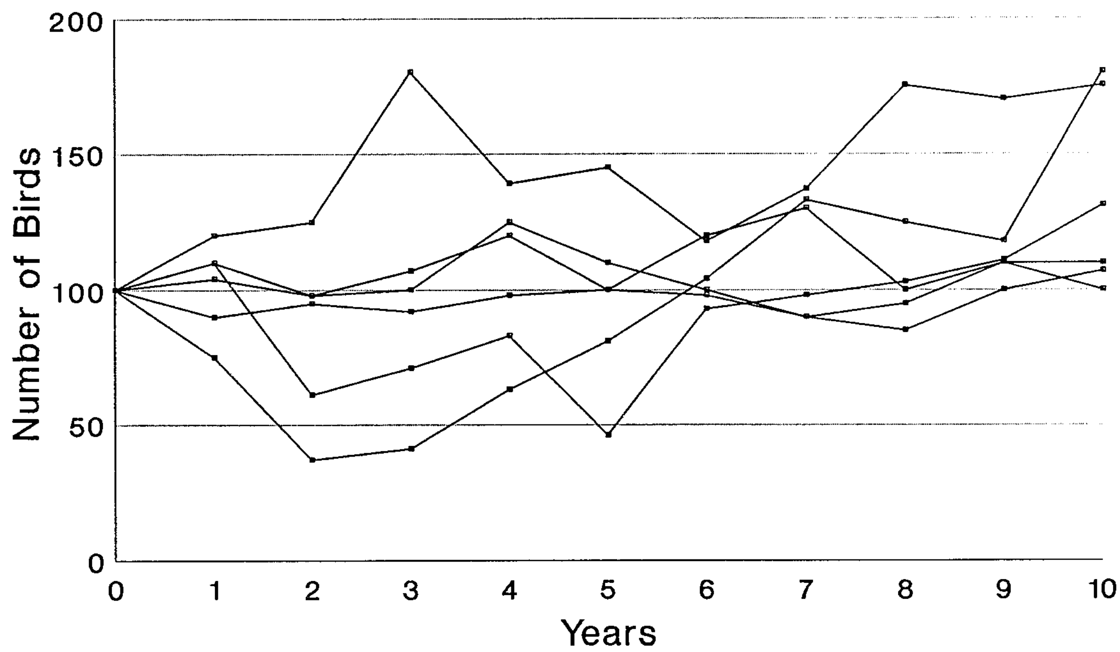

Fig. 4. Results of population modeling where a stochastic approach was used to assess the probability that a 20% fall harvest of females would cause the population to decline below 50 birds, given uncertain, variable brood production.

GUIDELINES FOR MANAGERS

Given there are a variety of options for applying modeling to management, the questions become more focused:

1. When should we apply detailed mechanistic models, and when should we stick with general models?
2. When should we consider stochastic models?
3. What data do we really need to make effective use of models?

Detailed mechanistic models are used most commonly to strengthen our understanding of the basic biology of the wild turkey, but they can be very useful for management as well. Because of their detail, these models can be used to identify the events in the annual life cycle that have the greatest effect on population change. For instance, in Minnesota, Porter et al. (1983) showed that winter food supply could affect both overwinter survival and subsequent nesting success. Incorporating estimates for these variables into a detailed model suggested that habitat management to secure winter food resources in the form of standing corn is critical to long-term maintenance of populations in the Upper Mississippi Valley. This modeling effort resulted in a management program to purchase standing corn near wintering areas as a food resource during severe weather. Suchy et al. (1990) use a mechanistic model to simulate harvest programs and assess the effect of harvest on wild turkeys in Iowa.

There are drawbacks to using detailed models for wild turkey population management, however. First, such models require a lot of information. Short of major investments in field studies, it is difficult to obtain data of sufficient detail, specific to a given locale. Second, estimates for each variable are computed from statistical samples. Variances associated with estimates of model inputs, when strung together in a complicated model, tend to inflate proportionally (multiplicatively), not additively. Frequently, the confidence intervals around model predictions are so large that any reasonable manager is forced to conclude that a good guess is just as valid.

General models, on the other hand, are useful where the primary objective is prediction of population growth. If we can estimate the increment of growth in the population, we can readily set harvest regulations to crop this increment and maintain a relatively constant population size. Indeed, breeding population size and subsequent recruitment form the foundation of most harvest management theory (Caughley 1977, McCullough 1979). Porter et al. (1990) use these parameters to evaluate the effect of harvest on wild turkey populations in New York.

Under what circumstances would a stochastic model be a better representation than a deterministic model? While opinions vary, stochastic models are best used in directing management when uncertainty in prediction is a primary concern. Where populations exist in environments that fluctuate widely, such as the Upper Mississippi Valley (Porter 1978) or South Texas (Beasom and Pattee 1980), stochastic models can be insightful. For small populations (e.g., transplants), stochastic models are almost a necessity. Chance plays a significant role in determining the dynamics of these populations. Stochastic models provide information on the boundaries within which populations could be expected to vary, and the probability of transplant failure.

DATA FOR MANAGEMENT

Caughley (1977) points out that the aims of population management are few and specific:

1. to enhance the rate of growth and density of a small or declining population,
2. to exploit an established population and remove from it a sustained yield, and
3. to lower the rate of growth of a population to stabilize or reduce its density.

Many managers are unaware of the utility of population data routinely collected by most agencies in addressing these objectives. Perhaps the most common data are harvest statistics: annual harvest tallies by sex and age; carcass measurements; hunter effort by town, county, or management unit; population surveys; and biological specimens. Unfortunately, we often discount these data, assuming that inherent biases negate application of the data. Biased data are not useless, they are simply constrained. Some biases can even be removed through statistical treatment, while others may not really affect the inferences drawn from the analyses.

Discussion of all commonly collected data is beyond the scope of this paper, but we will address those data that are most commonly collected and that can help us build more general, predictive models. Two variables are of primary interest: abundance and rate of growth.

Abundance

Most managers can afford neither the time nor the financial cost of obtaining large-scale estimates of population density. Such absolute estimates are seldom needed, however; indices to population abundance are cheaper and, statistically, more precise (Caughley 1977, Eberhardt and Siniff 1977). One candidate for use as an index includes total harvest if effort is consistent between years. Effort is seldom consistent, however, and harvest data often do not fit a normal statistical distribution, making difficult the application of parametric analysis techniques. Gefell (1990) found that effort-based indices of abundance (e.g., time-to-first-kill during the opening week) can provide a statistically valid index. In some cases it is possible to calibrate the index with an independent estimate of absolute abundance and then convert the relative measure (index) to density. Caughley (1977) gives several examples of commonly used indices and possible functional relationships to true abundance.

Rate of Growth

The rate of growth reveals more about a population than the speed with which it increases in size (Caughley and Birch 1971, Caughley 1977). The most common method for estimating rate of growth is to estimate population size in 2 consecutive years and calculate the rate of growth (λ) as:

$$\lambda = N_{t+1}/N_t = e^r.$$

N_{t+1} and N_t can be estimated from either absolute count or index measures obtained from harvest data as described above. Perhaps a more useful approach to estimating growth rate is to regress $\log_e$ abundance, as measured over a period of years, on time. If the trend is linear (i.e., rate of growth is constant) the slope of the line is the average rate of growth per year (Caughley and Birch 1971, Caughley 1977).

Another rate of growth (r_s) is computed from age-specific values of survival and reproduction. This rate, referred to as "demographic vigor" (Caughley 1977), is the one at which the population would grow if average survival and reproduction were to remain constant through time. By assuming constant vital rates, r_s is calculated in a way that removes the influence of unbalanced age structures (see Caughley 1977 for details). This is particularly useful with turkey populations because many exhibit boom and bust recruitment, and thus commonly have large gaps in the population age structure.

For example, most turkey populations in northern latitudes show moderate to large fluctuations from year to year. It would be useful to know whether fluctuations in r are due mostly to age-specific survival and reproduction in adults, versus boom and bust juvenile recruitment. By calculating demographic vigor and an observed rate of growth over a 5-year period, one can determine by inspection which component is most important (Caughley 1977). If unbalanced age structures are not important, then r will be approximately equal to r_S.

The weak link in the population is either adult survival or reproduction. While r is easily computed, r_s is more difficult to compute because it requires age-specific values of reproduction and survival (Caughley 1977). Data sufficient for the construction of a table of age-specific reproductive rates may be obtained from a variety of sources without much concern for bias as long as all age classes are adequately sampled. A table of age-specific survival rates is not as easily obtained, however. Hunter harvested samples are generally biased, especially in sexually dimorphic species such as the turkey. While biased age compositions cannot be used to construct survival rates, there are tests for detecting hunter selectivity (e.g., Caughley 1966), and some methods for correcting biases are available.

The elegance of using a simple index of abundance combined with general models of growth rates is appealing in a management context for the wild turkey. Not only do the variables involved provide a concise summary of population welfare, but they also allow analyses of the influence of habitat and harvest with minimal data.

With a little more sophistication, regression analyses of rates of growth and habitat, weather, and harvests can produce predictive equations that can guide management decision-making. These equations can be thought of as empirically derived deterministic models. These models can be made stochastic by incorporating the residual error around the regression (Grant 1986, Caughley et al. 1987).

RECAPITULATION

Though brief, this overview of population modeling captures the essence of the approaches and computer applications in wildlife management today. With some guidelines, a novice can learn enough programming commands to get a simple model running in an hour. Models cannot replace good judgement in management, but they provide a more rigorous structure for decision-making and allow a quantitative assessment of the risks. Further, the almost instantaneous turn-around time between running a program and seeing results allows a biologist to experiment with different ideas and evaluate these ideas without field trials. Perhaps most important, models can provide a new avenue for communicating. In the past 30 years, the wildlife biologists and managers have been extremely effective at restoring the wild turkey to its historic range. Efforts to understand the ecology of this species have provided a rich resource of information and resulted in superb habitat and harvest management programs. In the next 30 years, wild turkey management will face 2 new challenges: a society in which the values of the wild turkey hunter are not commonly understood or accepted, and a society seeking to intensify agricultural use of the land and expand residential development. Meeting those challenges will require a much more comprehensive synthesis of the data and experience acquired in the past 3 decades, and a more effective approach to communicating this information.

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Appendix A. Sample programs to project population change written in BASIC and PASCAL programming languages for IBM and compatible microcomputers.

<u>Programing in BASIC 3.0</u>

```
10 REM PROGRAM TO MODEL POPULATION GROWTH USING BASIC
20 CLS:KEY OFF: SCREEN 0,0,0
30 REM *******INPUT STATEMENTS*******
40 PRINT "How many years do you want to calculate population growth?"
50 INPUT J
60 PRINT "What is the number of turkeys, initially?"
70 INPUT N0
80 PRINT "What is the average number of poults/hen in August?"
90 INPUT F
100 PRINT "What is the average percent survival of adults through the year (0-100%)?"
110 INPUT P
120 CLS
130 REM *******CALCULATION STATEMENTS*******
140 P = P * 0.01
150 FOR YEARS 1 TO J
160 N1 = (N0 * F) + (N0 * P)
170 REM *******OUTPUT STATEMENTS*******
```

```
180 PRINT "The population is predicted to be:"
190 PRINT "Year  ";J, "Birds  ";N1
200 N0 = N1
210 NEXT J
220 END
```

Programing in PASCAL 5

```
Program Population Calculation;
uses crt; {In Turbo Pascal 3 this line would be unnecessary}
var j,yrs:integer;
    n0,f,n1,p:real;
Procedure Input;
begin;
    clrscr;
    write ('How many years? ');
    readln (j);
    write ('What is the number of turkeys? ');
    readln (n0);
    write ('What's the mean number of poults/adult in Aug.? '); readln (f);
    write ('What's the mean % survival of adults/year? ');
    readln (p);
    clrscr;
    p := p*0.01;
end;
Procedure Calculate;
begin;
    n1:=0;
    n1 := (n0*f)+(n0*p);
    n0 := 0;
end;
Procedure Output;
begin;
    writeln ('The population is predicted to be:');
    writeln ('Year ',yrs);
    writeln;
    writeln (n1:1:2,' birds');
    writeln;
    writeln;
end;
begin;
input;
for yrs := 1 to j do
    begin;
        calculate;
        output;
        n0 := n1;
    end;
end.
```

EFFECTS OF FALL EITHER-SEX HUNTING ON SURVIVAL IN AN IOWA WILD TURKEY POPULATION

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Abstract: Recently restored populations of eastern wild turkeys *(Meleagris gallopavo silvestris)* are thriving in smaller, more fragmented habitats in Iowa than are typical of most eastern turkey range. Fall either-sex hunting has the potential to decrease turkey survival and subsequent population levels unless hunting mortality replaces or is compensated for by some other mortality factor. Effects of either-sex fall hunting could be greater in fragmented habitats if turkeys are more vulnerable to hunters. Survival rates of adult male (AM), adult female (AF), juvenile male (JM) and juvenile female (JF) turkeys were estimated using radio-telemetry before and after fall hunting was initiated. Before the advent of fall hunting, annual survival rates were 40-49% for males and 63-64% for hens. Spring hunting and predation during nesting/brood rearing were the major mortality factors. After fall hunting was allowed, annual survival rates declined 21-23% for AM, JM, and JF, and 6% for AF. Fall hunting mortality was additive to existing mortality factors for 3 of 4 age-sex groups and was the primary cause for the lower annual survival. Turkey populations varied directly with annual variations in poult production, but did not respond as quickly or completely to good production after fall hunting was allowed. Fall either-sex hunting mortality that exceeds 10% of the population should be viewed as potentially decreasing annual turkey survival unless other factors are known to compensate for the additional loss of birds.

The Iowa Department of Natural Resources (IDNR) began restoring eastern wild turkeys in the mid-1960s in the face of considerable skepticism that Iowa's remnant, fragmented forests could ever support viable turkey populations (Klonglan et al. 1970). The first limited spring gobblers-only season was held in 1974, and has since spread statewide as huntable populations have developed wherever turkeys have been released. Hunter success rates exceeding 25% and observations of large turkey flocks led to the conclusion by the mid-1970s that these supposed marginal habitats were supporting high turkey densities, commonly exceeding 20 turkeys/km^2 of commercial forest land (Little 1980). Similar results have been reported from other states in the Midwest with interspersed forest and agricultural land (Donohoe 1985, Kurzejeski et al. 1987).

A study was begun in 1977 to seek explanation for this unexpected success. The study's objectives were to monitor turkey population levels, habitat use, survival, productivity, and hunter harvest on Stephens State Forest (SSF), an area with high turkey densities typical of Iowa's best wild turkey habitat. The rationale for selecting SSF was that information gleaned from this "best" turkey area could be used to develop management prescriptions for other regions in Iowa.

Preliminary modeling of telemetry-generated annual survival and productiity estimates for 1977-81 indicated that simulated turkey population estimates were consistent with annual fluctuations observed on SSF. Modeling indicated that this population could withstand an additional fall harvest of 5-10% of the hens and 15-28% of the males without affecting future population levels or age and sex structure depending on whether the effects of fall hunting were additive or compensatory (Suchy et al. 1983). Results of the modeling were used to overcome objections that either-sex hunts would again eliminate wild turkeys from Iowa, because unrestricted hunting was thought to be a cause of their original extirpation (Little 1980).

Regulated fall either-sex hunts were begun in southern Iowa in 1981. License quotas were established to allow a harvest of approximately 3 turkeys/km^2 of forest, or 10% of a hypothetical regional population of 30 turkeys/km^2, a conservative estimate for southern Iowa at that time. Seasons were 14 days long during the last half of October. The SSF study area was considered a "worst case" test of the effects of fall hunting because its status as a public hunting area and its proximity to a large urban population in Des Moines (80 km) could lead to intense hunting pressure and high harvest rates.

The objectives of this paper are to compare age- and sex-specific seasonal and annual wild turkey survival rates and seasonal survival patterns before and after fall hunting was introduced. Suchy et al. (1990) discussed the overall effects of fall hunting on turkey population levels, on age and sex structure, and on spring hunting.

The field work was coordinated and conducted by L. Crim, G. Crim, W. Suchy, J. Telleen, and D. White. W. Bunger, M. Conner, K. Craft, B. Ehresman, M. Ehresman, B. Fistler, M. Griffin, T. Haindfield, A. Hancock, R. Hendrickson, M. Jansen, J. Layton, R. Munkel, B. Ohde, M. Olsen, T. Rossberg, J. Strotman, C. Sweeney, D. Towers, and G. Zenner assisted in turkey trapping and data collection. W. Clark, W. Fuller, and J. Hasbrouck of Iowa State University provided advice on data analyses. The study was funded by Iowa hunting license revenue, Pittman-Robertson Federal Aid Project W-115-R, and donations from the Iowa state and local chapters of the National Wild Turkey Federation.

STUDY AREA AND METHODS

The 2,200-ha study area includes SSF and surrounding private farmland that is part of a highly interrupted 40-km-long band of timber lying between the Chariton River and Whitebreast Creek drainages. SSF was first stocked with eastern wild turkeys in 1968 and was thought to have stable winter populations in excess of 30 turkeys/km^2 of forest when the study was begun. The study area consists of a 50:50 mosaic of oak-hickory timber and agricultural openings of diverse shapes and sizes. Timber is primarily in pole stage, and grazing is common on private lands. Relatively little of the study area is >800 m from a road or trail, making it easily accessible to hunters. Regulated spring hunting seasons were held throughout the study.

Turkeys were captured with rocket nets from late summer through winter and fitted with AVM module H-SB2 radio backpack packages weighing approximately 140 g. Instrumented birds were monitored weekly from a vehicle-mounted telemetry system modified from Hallberg et al. (1974). When successive triangulations or radio signal variations indicated a bird was stationary, the turkey was approached with a hand-held antenna receiver to determine its status. Evidence at the kill site was used to determine the cause of death. Birds that survived <14 days post-instrumentation were excluded from the data set because of potential capture injury or stress.

Annual productivity estimates were obtained by remotely monitoring hens daily in April-June. Stationary hens were approached in a manner similar to that for suspected dead turkeys, but were not flushed from the nest. A circle was marked with flagging at a radius of at least 15 m, depending on cover density, from the suspected nest, and the hen was monitored remotely until she was detected permanently off the nest. The nest was then located and egg-shells counted to determine the number of young hatched. The number of poults hatched per radioed hen was used as an index to annual productivity.

Survival estimates were based on 447 radio-tagged turkeys that were monitored during the years before (Oct 1977-Sep 1981) and after (Oct 1981-Sep 1986) fall hunting was introduced. We used MICROMORT (Heisey and Fuller 1985) to estimate daily, seasonal, and annual survival rates for 4 age-sex classes: AM, AF, JM, and JF. MICROMORT uses a generalized Mayfield method for estimating unbiased cause-specific mortality rates based on the number of days a radio-tagged bird was monitored (Mayfield 1961, 1975; Trent and Rongstad 1974).

To assess the effect of fall hunting on survival, the annual survival rate was regressed on an intercept and dummy variable that contrast a fall season and no fall season. Variables were scaled by their standard errors. We obtained a standard error (SE) for 1980 JF that had an estimated SE of 0 by using the 2 adjacent years and weighting by radio-days. The regression should produce a mean square error of about 1 if there is no annual variation in survival rates in addition to measurement error. This was the case only for AF. Hence, a components of variance technique was used to adjust the yearly standard errors. The variables were rescaled by these adjusted standard errors, and the regression coefficients and their standard errors were re-estimated.

Harvest and hunter effort estimates were based on postcard surveys of a random sample of licensed hunters in the hunting zone. A voluntary check station was run during each fall and spring hunting season to determine the age and sex composition of harvested marked and unmarked birds. Turkey hunters received an explanation of the research project with their license and received a reward for each banded or radio-tagged turkey brought to the check station. Check station notices were also placed on all unattended vehicles on SSF each day of the hunting season. As a result, about 75% of the estimated harvest was checked annually.

We used track counts made each winter (Jan-Mar) to estimate turkey populations. Thirteen permanent transects designed to put an observer within 0.4 km of all points on SSF during a 2-hour period were marked on topographic maps. All transects were walked concurrently beginning 2 hours after sunrise on days with 5-15 cm of overnight snowfall. For all turkey tracks intercepting the transect, observers determined the sex (if possible), and recorded number of tracks, time tracks were intercepted, and direction of travel. Sex-time-direction information was used to eliminate obvious duplicates. Annual counts were adjusted to 1 January to eliminate bias caused by winter mortality. Adjusted counts were derived by dividing the observed number of tracks by the mortality rate of radio-tagged turkeys observed since 1 January in that year. We believe this to be a minimum estimate of the winter turkey population in SSF. We were never able to repeat counts in the same year to determine the precision of the estimate because suitable snow conditions occurred rarely. Inadequate snowfall prevented counts from being made in 1979 and 1981.

RESULTS

Fall Harvest Statistics

As expected, hunting pressure at SSF was intense. An average of 14.1 hunters/km^2 of forest hunted at least 1 day on the study area annually (Table 1). Success rates for turkey hunters averaged 31%, producing an average harvest of 4.3 turkeys/km^2. Success rates ranged from 41% to 27%. The interaction between hunter numbers and success rates produced a harvest that was greatest the first year, then declined.

Demographic data for harvested turkeys were based on examination of 76% of the estimated 369 turkeys taken in 1981-85 (Table 1). Age-sex ratios in the composite 5-year sample were unbalanced (X^2 = 7.64, 3 df, P < 0.05) with more adults than expected among females, and fewer juveniles than expected among males. Annual variability was high and juvenile:adult hen ratios varied significantly between years (P < 0.1). The fewest juveniles were shot in 1981. The first year of fall hunting accounted for nearly half the adult hens and a third of the adult males taken in all 5 years.

Table 1. Fall harvest statistics from the Stephens State Forest Study Area, Iowa, 1981-85.

Harvest statistics	1981	1982	1983	1984	1985	Total	Mean
Hunter density[a]	15.1	20.2	12.6	11.8	10.7		14.1
Success rate[b]	0.41	0.27	0.27	0.30	0.28		0.31
Harvest density[a]	6.2	5.4	3.4	3.6	3.1		4.3
Harvest[c]	106	92	58	61	52	369	
Juvenile males[d]	6	12	13	17	12	60	
Adult males	32	8	11	10	8	69	
Juvenile females	6	16	16	20	5	63	
Adult females	41	15	13	10	10	89	
Total	85	51	53	57	35	281	
% checked[e]	80.1	55.4	91.4	93.4	67.3		76.1
Juveniles:Adult Female	0.29	1.87	2.23	3.70	1.70		1.38

[a]Number/km^2 of forest land (commercial and noncommercial).
[b]Proportion of hunters that bagged a turkey.
[c]Determined from mail surveys.
[d]Determined from check station.
[e]Proportion of the estimated harvest brought to a voluntary check station.

Increasing numbers of juveniles and fewer adults were then taken each year until 1985.

The effect of high harvest densities on turkey populations was apparently buffered by the high turkey densities on the study area. Average mortality rates due to fall hunting for the 5 years were about 21% for AM, 13% for JM, 8% for AF, and 24% for JF (Table 2). Hunting mortality rates for AF were nearly twice as high in the first year as any other year (0.209), and declined to <0.10 in 3 of the remaining 4 years. Sample sizes were too small to determine annual mortality rates reliably for other age-sex classes.

Annual changes in harvest data were closely related to changes in the demographics of turkey flocks and total turkey numbers on the study area (Fig. 1). Track counts indicate turkey populations peaked in the winter of 1979-80, declined through 1983, and then recovered somewhat in 1984-86. This trend followed changes in productivity of radio-equipped hens, particularly before the introduction of fall hunting. The productivity index (poults:hen) increased from 1978 to 1979, declined and remained low through 1983, then recovered to high levels by 1985, suggesting that winter turkey numbers were at least partly explained by the success of the previous reproductive season. The population did not recover to the peak levels seen in 1980 after fall hunting was introduced, however, even though productivity levels were as high or higher than that observed in earlier years.

Poor production of poults in the year fall hunting was initiated (1981) was associated with a low juvenile:adult female ratio in the check station samples and a relativly high AF mortality rate due to hunting (Fig. 1). Juvenile:adult female ratios increased and AF mortality rates decreased as productivity and total turkey numbers improved, at least through 1985.

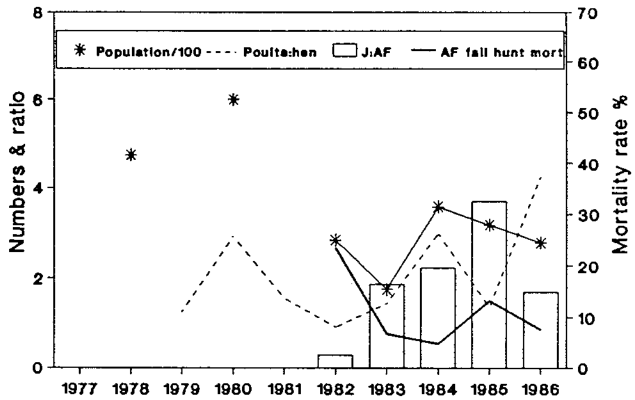

Fig. 1. Relationship between annual wild turkey productivity, adult hen mortality, and population levels on Stephens State Forest, Iowa, 1978-86. Winter population estimates are keyed to production and harvest data from the previous summer-fall (e.g., winter track counts for 1982 are aligned with the productivity index for 1981 and AF mortality rates and J:AF ratios for the fall-hunting season of 1981).

Survival Rates

The effects of fall hunting on turkey survival appeared to be substantial when annual survival rates were examined (Table 3). Average annual survival rates declined for all age-sex classes after fall hunting was introduced: 21-23% for AM, JM, and JF, and a relatively low 6% for AF. To determine if nonhunting mortality might be responsible for the decline in annual survival, we examined survival patterns for each age-sex class. Table 3 lists seasonal interval survival rates for each age-sex class in the years before fall hunting (1977-80) and after fall hunting was introduced (1981-86).

Prior to fall hunting, survival through the fall and winter of adult turkeys of both sexes was high--96% for AM and 91% for AF (Fall-Winter survival rates are the product of the individual seasonal rates). Most AM died during

Table 2. Mayfield mortality rates due to fall hunting of radio-equipped wild turkeys at Stephens State Forest, Iowa, 1981-85.

Age and sex	1981	1982	1983	1984	1985	Mean
Juvenile male	0.163	0	0	0.446	0.080	0.125
Adult male	0	0	0.317	0	0.107	0.209
Juvenile hen	0.208	0.524	0.086	0.391	0	0.253
Adult hen	0.234	0.068	0.048	0.132	0.076	0.087

Table 3. Interval and annual survival rates for radio-tagged wild turkeys at Stephens State Forest before (1977-80) and after (1981-86) fall hunting was initiated.

Period, age-sex class	1977-80	1981-86	t-value	P[a]
Fall hunting, 17-31 Oct				
Juvenile male	0.894 (190/1)[b]	0.875 (480/10)	0.09	0.46
Adult male	1.000 (526/0)	0.791 (377/5)	2.71	0.01
Juvenile female	0.963 (586/1)	0.747 (551/18)	2.26	0.03
Adult female	0.990 (2,244/2)	0.913 (1,482/16)	2.60	0.02
Fall, 1-31 Nov				
Juvenile male	0.894 (335/2)	0.948 (1,654/13)	−0.40	0.70
Adult male	1.000 (504/0)	1.000 (1,365/0)		
Juvenile female	0.866 (589/3)	0.931 (1,930/4)	−1.41	0.20
Adult female	0.990 (2,253/1)	0.980 (5,475/4)	0.60	0.57
Winter, 1 Dec-14 Apr				
Juvenile male	0.817 (2,987/5)	0.728 (3,769/10)	0.55	0.60
Adult male	0.964 (3,292/1)	0.861 (4,277/5)	1.51	0.17
Juvenile female	0.890 (5,744/6)	0.724 (4,597/13)	1.25	0.25
Adult female	0.919 (12,815/11)	0.950 (15,713/7)	−0.72	0.49
Spring hunting, 15 Apr-13 May				
Juvenile male	0.714 (423/6)	0.696 (566/9)	0.10	0.46
Adult male	0.642 (505/9)	0.496 (653/17)	1.02	0.17
Juvenile female	0.900 (1,517/8)	0.884 (988/5)	0.19	0.43
Adult female	0.926 (2,652/8)	0.920 (3,364/14)	0.16	0.44
Summer, 14 May-16 Oct				
Juvenile male	1.000 (1,553/0)	0.862 (2,475/3)	1.59	0.16
Adult male	0.897 (2,276/2)	0.848 (2,494/3)	0.52	0.62
Juvenile female	0.933 (5,319/3)	0.917 (4,460/3)	0.28	0.79
Adult female	0.837 (11,494/17)	0.833 (14,305/19)	0.09	0.93
ANNUAL[c]				
Juvenile male	0.399 (5,428/14)	0.169 (8,949/45)	1.72	0.07
Adult male	0.493 (7,103/12)	0.281 (9,166/30)	1.54	0.08
Juvenile female	0.644 (13,755/21)	0.434 (12,526/38)	1.27	0.12
Adult female	0.639 (31,458/39)	0.576 (40,339/60)	1.72	0.07

[a]One-tailed test used for fall hunting, spring hunting and Annual rates.
[b]Radio-days of exposure pooled over years/total deaths.
[c]The annual rate does not equal the product of the interval rates because pooling was done on annual rates but not interval rates.

spring hunting season (mean mortality = 36%), and few AM died during any other season (mean non-spring hunting season mortality = 14%). Therefore, 86% of the AM that survived the spring hunting season were alive to start the next spring season. Few AF died during the spring hunt (primarily illegal kills of unbearded hens), but their major mortality period was during the spring and summer and was associated with nesting and brood-rearing activities.

A significant decline ($P < 0.02$) in survival of both sexes of adults occurred during the fall hunt, but was greater for AM. There was some indication that survival of AM declined in the winter and spring hunting seasons after the introduction of fall hunting (spring hunters apparently took a larger proportion of AM as study area populations declined). No statistically significant differences were detected for survival rates of AM or AF in seasons other than fall hunting season.

Juveniles had different survival patterns from adults. JM had the lowest fall-winter survival rate (0.73) before fall hunting, and the addition of a fall hunting season produced only a small decline (0.69) in survival during this period. JM had slightly higher survival during the spring hunting season and summer than did AM. JF had a similar fall-winter survival rate as JM prior to fall hunting (0.77) but had the greatest decline in survival due to hunting of any age-sex class.

Except for juveniles there was no substantial nonhunting mortality of turkeys during the fall that fall-hunting mortality could replace. There was also no increase in survival of any age-sex class during any other season to offset losses due to fall hunting.

DISCUSSION

The unusually high turkey densities found on our study area and the absence of comparable survival data from other long-term studies may lead to speculation about the applicability of our results to other regions within eastern wild turkey range. Turkey densities reported from most of the eastern United States seldom exceed 3.9/km^2 (Kennamer 1986), a fraction of that observed on our study area. Midwestern states in general, however, do support excellent turkey populations where restoration programs are complete (Donohoe 1985, Kurzejeski et al. 1987).

Available data suggest that the survival rates and patterns we observed before the initiation of fall hunting were not unusual. Annual survival rates were >50% for adult turkeys. Spring hunting caused the greatest mortality in males, and a combination of illegal spring hunting and predation during nesting/brood-rearing activities caused most hen deaths. Juveniles of both sexes were exposed to heavier predation during the fall than adults were, and to legal and illegal hunting-related mortality during the spring-hunting season, but annual survival rates were not greatly different for juveniles and adults of either sex. Everett et al. (1980), Kimmel and Kurzejeski (1985), and Vander Haegen et al. (1988) reported similar annual or seasonal mortality rates, patterns, or causes of death for radio-tagged eastern turkeys in Alabama, Missouri, and Massachusetts, respectively. Swank et al. (1985) reported similar results for Rio Grande turkeys *(M. g. intermedia)* in Texas.

The ease of public access to the study area produced hunter densities 8-23 times greater than those recorded on other public or private turkey habitats in southern Iowa (IDNR, unpubl. data). As a result the average harvest level of 4.3 turkeys/km^2 was greater than the average total turkey population reported from most of eastern turkey range (Kennamer 1986). This harvest produced low-to-moderate hunting mortality rates, <24%, because of high turkey densities at SSF. These mortality rates were slightly higher than the theoretically allowable rates suggested by Suchy et al. (1983) based on survival and productivity data from the years before fall hunting was allowed.

Annual hunting mortality rates and their effect on various age-sex classes depended on annual recruitment of young turkeys and apparently differential vulnerability to fall hunting between age-sex classes. In years of good production, numerically superior juveniles buffered the effect of fall hunting on adults. In years of poor production hunters maintained relatively high success rates but took mostly adult turkeys. This ability to harvest adults in years when juveniles are scarce may be an artifact of high turkey densities and the fragmented nature of midwestern turkey habitats.

Adult males and JF seemed to be the most susceptible to fall hunting, and AF the least susceptible. Small samples of radio-tagged AM may have biased their harvest rate, but several hunting parties did report hunting exclusively for gobblers in check station interviews. Adult females were taken in large numbers only following years of poor production; AM were selectively taken each year. Apparently, turkey densities were high enough that even reclusive AM were unable to escape the intense hunting pressure. The fall-to-spring survival rates we observed for AM suggest that fall hunting may reduce the number of gobblers available to spring hunters, i.e., most AM shot in the fall would otherwise be alive the following spring.

The differing harvest levels between AF and JF is probably a result of inexperience on the part of juveniles and the techniques used by fall hunters. When a brood is flushed during a fall hunt, juveniles return to the caller while the AF stands and calls her brood and is not as susceptible to being shot. In a wing-shooting situation the probability of selecting the adult out of a flushing brood is low. Juveniles could also be slower than AF to react to danger.

The reason for differing harvest rates of JM and JF were not as clear. Telemetry data indicated JF were the most socially dependent age-sex class and stayed with the brood hens through fall and winter. JM were already leaving brood flocks by mid-October and traveled in smaller groups usually independent of larger hen flocks. Hunters may have found the larger hen flocks more easily, and JF may return more readily to a calling hunter than JM would because of their greater dependence on the brood hen. JM are also larger than JF by mid-October and may be selected by hunters on that basis.

Fall hunting would not affect turkey populations if fall hunting mortality is compensatory; that is, if there is a compensating increase in survival during other periods of the year to offset fall hunting, or if birds shot by fall hunters would have died anyway to some other agent. Neither of these situations existed during this study. Average annual survival rates for all age-sex classes declined after fall hunting was introduced. Regardless of age-sex, survival outside of hunting seasons was high. There was little opportunity in adult survival rates for compensating increases in survival to offset fall hunting mortality. There was room for some compensation in fall-winter survival of juveniles, but it did not occur. Fall hunting mortality was additive to other mortality factors that were already occurring, primarily predation and spring hunting. This implies that fall hunting may affect future turkey populations. Shooting adult turkeys in poor production years may reduce the number of hens available to nest, as well as reduce gobbler numbers available to hunters. A reduction in hens could reduce recruitment and total turkey numbers further and prolong the recovery from poor production than would have occurred without fall hunting. See Suchy et al. (1990) for a further discussion.

We are not saying that all hunting mortality on wild turkeys is necessarily additive. There was a substantial legal harvest of males and low illegal take of hens during spring hunting season before the introduction of fall hunting. These losses may have been compensating for mortality due to natural causes that would have occurred anyway. The effect of additional hunting-induced mortality during the fall was not offset by declines in spring mortality, however, indicating that the combined effects of spring and fall hunting were additive.

We suggest that where fall hunting mortality rates are >10%, they should be viewed as potentially reducing survival of wild turkeys. The exception would be where a natural mortality agent is known to take a large percentage of the population such as periodic winter starvation of turkeys in northern turkey ranges (Porter et al. 1983). A decrease in survival does not necessarily mean fewer turkeys, because productivity and other factors are involved in determining turkey population levels. We believe a management strategy aimed at maintaining moderate-to-high turkey densities and good numbers of gobbling turkeys in the spring should allow only conservative fall harvests unless the specific dynamics of a turkey population are known.

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TURKEY SIGHTINGS BY HUNTERS OF ANTLERLESS DEER AS AN INDEX TO WILD TURKEY ABUNDANCE IN MINNESOTA

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Abstract: Wild turkey *(Meleagris gallopavo)* sightings by hunters of antlerless deer provide an effective indicator of annual fluctuations in wild turkey abundance in Minnesota. During fall 1987 and 1988, we surveyed a random sample of antlerless-deer hunters within Minnesota's wild turkey range. Differences in mean number of turkeys seen per day were used to detect population changes between geographical areas within a year and between years within an area. Estimates of wild turkey population densities by wildlife personnel in fall 1987 were correlated with mean number of turkeys seen per hunter per day ($r = 0.94$, $n = 28$, $P = 0.0001$) and with percentage of hunters seeing turkeys ($r = 0.93$, $n = 28$, $P = 0.0001$). A survey of antlerless-deer hunters can give management personnel the ability to detect 10-15% changes in turkeys seen per hunter per day at a relatively low cost.

The ability to monitor wild turkey distribution and abundance is important for turkey management programs. No single wild turkey population survey technique is universally accepted (Mosby 1967, Jahn 1973, Menzel 1975, Hanson and Jackson 1988). Biologists have experimented with wild turkey survey techniques with varied degrees of success. Several methods have been used within single wild turkey management programs (Kennamer 1986).

Observations by wild turkey hunters have been used to survey turkey populations (Kennamer 1986). Many states, including Minnesota, have used informal reports from turkey hunters as an indication of population status. Although such information can be useful on a localized basis, annual trends in abundance and distribution cannot be determined because standardization is lacking and information is circumstantial. Also, monitoring turkey numbers is often critical but not possible in areas without hunting seasons because populations are not yet well established.

In Missouri, Lewis (1980) asked firearm deer hunters in fall to report number of turkeys observed. For hunter observations collected from 1964 to 1978, he reported that number of birds seen and percentage of hunters seeing turkeys were correlated with the following spring harvest. Percentage of hunters seeing turkeys showed a stronger relationship ($r = 0.947$) with spring harvest than number of turkeys seen.

Garver (1986) in Illinois initiated a survey of turkey sightings by deer hunters in 1978. Successful firearm deer hunters were interviewed at check stations. Locations of turkey sightings were recorded to determine range expansion. Garver (1986) indicated that percentage of hunters seeing turkeys was more sensitive to changes in turkey numbers than number of birds seen.

The popularity of white-tailed deer *(Odocoileus virginianus)* hunting and the similarity of deer and turkey habitat place deer hunters within most potential turkey range. Because distribution of antlerless-deer hunters is relatively even over antlerless-deer permit areas (PA) in Minnesota, wild turkey observations made by antlerless-deer hunters can be an effective indicator of wild turkey abundance and distribution. The technique can be improved if hunters are randomly selected and the amount of effort (time spent in the field) is included in observation information. Our objectives were to test a wild turkey survey of antlerless-deer hunters in Minnesota to provide an index to Minnesota's wild turkey abundance.

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METHODS

We surveyed by mail a random sample of 4,410 deer hunters who received antlerless-deer permits for 1 of 28 PAs ranging from 158 to 3,424 km^2 in size (Minn. Dep. Nat. Resour. 1988) within Minnesota's wild turkey range during 1987 and 1988 (Table 1, Fig. 1). Hunters were asked the number of days they hunted deer, location hunted most often, and number and location of wild turkeys observed (App. A). Location was recorded as the distance and direction from the nearest town.

Table 1. Antlerless-deer permit areas, number of permits available by year, and wild turkey survey sample size, Minnesota, 1987-88.

Antlerless-deer permit area	Antlerless-deer permits available 1987	1988	Survey sample size[a]
226	1,500	1,100	250
235	150	150	100
236	1,100	1,000	100
337	600	600	200
338	800	700	200
339	700	1,000	200
341	2,000	1,900	200
342	1,000	1,200	150
343	2,000	2,000	180
344	1,100	1,000	150
345	1,300	1,100	180
346	2,000	2,000	200
347	1,100	1,100	110
348	1,200	1,000	110
349	2,300	1,900	230
418	700	650	200
419	750	750	200
430	1,400	1,100	200
431	500	400	200
445	1,000	1,000	250
459	300	500	100
461	400	400	100
462	600	700	100
463	200	300	100
464	300	400	100
465	300	300	100
466	600	500	100
467	500	400	100
Total			4,410[a]

[a]Permit area 236 not sampled in 1988. Total sample size in 1988 was 4,310.

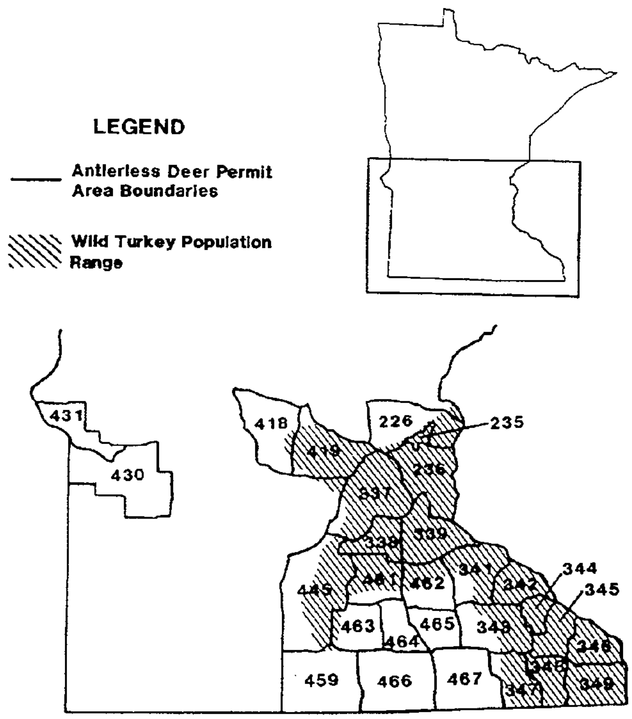

Fig. 1. Antlerless-deer permit areas used for survey of wild turkey sightings by antlerless-deer hunters, Minnesota, 1987-1988.

The survey was mailed 1 week before the opening of the deer hunting season. Three additional surveys were mailed to non-respondents at 2-week intervals after the deer hunting season. The fourth mailing included a warning regarding state legislation requiring hunters to complete and return questionnaires.

If respondents indicated they hunted a fraction of a day, the number was rounded up to the whole day. If a range was given for the number of turkeys seen, the median value rounded to the nearest whole number was recorded. If a range with no upper limit (50+) was given for number of turkeys seen, the lower limit was recorded. Surveys with missing data or errors were eliminated from the data set.

We calculated 3 population indices for each PA: mean number of turkeys seen per hunter per day (TPD), percentage of hunters seeing turkeys (PST), and mean number of turkeys seen per hunter per day excluding observations by individuals seeing no birds (TPD-X0).

We interviewed 360 antlerless-deer hunters in person (111 in 1987 and 249 in 1988) to determine hunting patterns and clarity of survey questions. We selected areas where large numbers of hunters could be interviewed in 10 PAs representing high turkey populations or recent transplants. Antlerless-deer hunters were asked to complete a survey identical to the mail survey (App. A). In addition, each hunter was asked: (1) if any of the questions were unclear, (2) the greatest distance they would hunt between 2 locations during the course of the season, and (3) if at any time during the season they anticipated hunting outside the PA for which they held an antlerless-deer permit (legal if antlered deer were hunted in the same deer hunting zone [indicated by first digit of PA]). If hunters were uncertain about hunting outside the PA, their response was treated as if they indicated that they would hunt outside the PA.

To test the results of a survey of wild turkey sightings by antlerless-deer hunters, we surveyed 78 wildlife professionals by mail asking each to provide wild turkey density estimates (number of birds/mile^2) in fall 1987 for PAs within their work area. Sixty individuals provided estimates for 1 or more PAs. The mean density estimate for each PA was compared with TPD and PST. Density estimates by wildlife personnel were collected before the deer hunter survey information was released. Density estimates were used because no other information pertaining to wild turkey population estimates was available in Minnesota.

TPD by individuals grouped by response period, by total number of days hunted, and by PA within years were compared using the general linear model (GLM) for ANOVA on mean ranks of TPD. Analysis was performed by deer hunting zone when testing for differences in TPD by days hunting because each zone differs in number of days available to hunt. If differences were detected, Tukey's studentized range test was used to identify the groupings that were different. Differences in TPD within PAs between years were tested by Student's *t*-test performed on the mean ranks of TPD. Statistical tests were performed using SAS software (SAS Inst. Inc. 1985).

Coefficient of variation from Student's *t*-test performed on mean ranks of TPD from fall 1987 to 1988 was used to determine sample size needed for each PA (Sokal and Rohlf 1969). Sample sizes necessary to detect 10-25% changes in TPD were determined.

RESULTS

The return rate for the postcard survey was 84.7% in 1987 (n = 3,737) and 87.9% in 1988 (n = 3,787). Return rates for each mailing ranged from 26.4 to 41.4% with a mean of 36.4%. The third mailing produced lowest return rates both years.

TPD was tested for differences by response period to address potential bias. Hunters grouped by response period did not show differences in TPD (1987, F = 1.59, 3,608 df, P = 0.09; 1988, F = 1.25, 3,652 df, P = 0.25).

Significant changes in TPD between years were reported in 44% of the PAs sampled (Table 2). There was an increasing trend in TPD from 1987 to 1988. All but 1 of the significant changes in TPD that were detected were increases.

Significant differences in TPD were detected between PAs within years (1987, F = 29.42, 3,608 df, $P < 0.01$; 1988, F = 44.07, 3,652 df, $P < 0.01$). TPD in PAs 347, 348, and 349 in 1987 and PAs 348 and 349 in 1988 were significantly higher than all other PAs within the respective years (Table 2, Fig. 1).

Sample size required for future analysis increases curvilinearly as desired sensitivity increases (Table 3). To detect a 10% change in TPD, the required sample size would be approximately 4 times the sample size required to detect a 20% change in TPD.

TPD in fall 1987 was positively correlated with density estimates made by wildlife personnel (r = 0.94, n = 28, $P < 0.01$). PST in fall 1987 (Table 4) was positively correlated with wild turkey density estimates by wildlife personnel (r = 0.93, n = 27, $P < 0.01$).

To investigate the possibility of bias involved with number of days hunting deer, TPD was tested for differences by number of days hunting. Differences in TPD were detected in 50% of the cases (1987, zone 3, F = 2.96, 1,684 df, $P < 0.01$; 1988, zone 2, F = 2.36, 300 df, P = 0.02; 1988, zone 3, F = 2.50, 1,751 df, P = 0.02).

Five percent (19) of hunters interviewed reported they had hunted or intended to hunt

Table 2. Survey of wild turkey sightings by Minnesota antlerless-deer hunters. Comparison of mean number of turkeys seen per hunter per day (TPD) by year, Minnesota, 1987-88.

Antlerless-deer permit area	TPD (SE) 1987	TPD (SE) 1988	Probability of Type I error
226	0.05 (0.02)	0.15 (0.04)	0.02 **
235	0.07 (0.03)	0.18 (0.05)	0.02 **
236[a]	0.01 (0.01)		
337	0.13 (0.05)	0.35 (0.09)	0.02 **
338	0.28 (0.09)	0.73 (0.25)	0.02 **
339	0.92 (0.31)	0.95 (0.20)	N.S.[b]
341	0.74 (0.28)	0.97 (0.18)	0.07 *
342	0.27 (0.09)	0.44 (0.11)	N.S.
343	0.27 (0.10)	1.25 (0.34)	<0.01 ***
344	0.79 (0.18)	1.25 (0.19)	<0.01 ***
345	0.94 (0.20)	2.96 (0.70)	<0.01 ***
346	2.04 (0.54)	3.87 (0.72)	<0.01 ***
347	1.68 (0.31)	2.56 (0.54)	N.S.
348	2.81 (0.82)	4.17 (0.72)	0.01 **
349	3.64 (0.50)	5.66 (0.79)	0.02 **
418	0.09 (0.04)	0.16 (0.08)	N.S.
419	0.23 (0.11)	0.24 (0.07)	N.S.
430	0.13 (0.08)	0.10 (0.06)	N.S.
431	0.28 (0.11)	0.31 (0.19)	N.S.
445	0.67 (0.20)	1.06 (0.27)	0.03 **
459	0.33 (0.26)	0.08 (0.05)	N.S.
461	0.24 (0.14)	0.06 (0.04)	N.S.
462	0.25 (0.09)	0.14 (0.06)	N.S.
463	0.03 (0.02)	0.02 (0.01)	N.S.
464	0.03 (0.02)	0.00 (0.00)	0.05 *
465	0.14 (0.07)	0.08 (0.05)	N.S.
466	0.10 (0.07)	0.31 (0.15)	N.S.
467	0.06 (0.05)	0.06 (0.04)	N.S.

[a]Permit area 236 not sampled in 1988.
[b]Not significant.
* 0.10 significance. ** 0.05 significance. *** 0.01 significance.

outside the PA for which they received an antlerless-deer permit. The distance moved while hunting deer averaged 5.8 miles (9.3 km) (range 1-65 miles [1.6-104.6 km]). Over 70% moved <5 miles (8.0 km). Over 90% moved <15 miles (24.1 km). Three percent (12) of hunters interviewed indicated a problem with clarity of questions on the survey. Ten of the individuals who had difficulty with question clarity found the question asking location information unclear (App. A).

DISCUSSION

We derived 3 population indices from number of turkeys seen and number of days hunting deer by antlerless-deer hunters: TPD, TPD-X0, and PST. PST (Table 4), assuming even distribution of hunters, should provide information on turkey distribution. Higher PST would be indicative of a more widely distributed turkey population. TPD-X0 (Table 5) should indicate turkey abundance in areas where turkeys are seen. Higher TPD-X0 would be indicative of higher turkey populations in areas where turkeys are present.

In areas of recent transplants (such as PA 337 and 419 in Table 4), PST is very low because wild turkey distribution is low. Unless overall sample size is extremely large, the number of hunters seeing turkeys will be small. TPD-X0 would not be a practical indicator for these areas. Population information for these areas is needed to evaluate the success of transplants. Because distribution of wild turkeys in many parts of Minnesota is characterized by pockets of turkeys within extensive areas where turkeys are not present, TPD-X0 does not seem to be a practical indicator for Minnesota.

Table 3. Sample sizes for survey of wild turkey sightings by antlerless-deer hunters at a significance level of 0.05, Minnesota.

Antlerless-deer	1989 permits	Sample size to detect a change of:			
permit area	available	10%	15%	20%	25%
226	350	166	74	42	27
235	150	289	129	72	46
337	500	262	116	65	42
338	200	328	146	82	52
339	900	500	222	125	80
341	1,900	473	210	118	76
342	1,300	427	190	107	68
343	1,500	415	185	104	66
344	1,100	678	301	169	108
345	1,000	643	286	161	103
346	2,600	660	293	165	106
347	1,100	764	340	191	122
348	1,300	808	359	202	129
349	2,200	808	359	202	129
418	650	155	69	39	25
419	750	237	105	59	38
430	1,000	73	32	18	12
431	400	109	49	27	17
445	650	346	154	87	55
459	600	106	47	27	17
461	300	150	67	38	24
462	600	260	116	65	42
463	100	72	32	18	12
464	300	58	26	15	9
465	150	120	53	30	19
466	600	170	76	43	27
467	400	102	46	26	16

TPD (Table 2) should represent some combination of wild turkey distribution and abundance. TPD should be effective for indicating abundance for areas where TPD-X0 is not practical.

The survey form was easily understood by hunters. Only 2 of the hunters interviewed (<1%) had a problem with questions pertaining to number of days hunting and number of turkeys observed (App. A). Questions dealing with location were most difficult for hunters.

Our methodology considered potential biases involved with a survey of wild turkey sightings by antlerless-deer hunters. A large number of antlerless-deer hunters are available from which to select a random sample. A minimal number of repeat participants each year minimizes a decline in response rate over the years due to a decrease in interest.

Lack of change in TPD as a function of response time indicates lack of bias due to non-response. Repeated mailings may not be desired. If time is a concern and cost is prohibitive, increasing initial sample size and using 2 mailings should give similar results and allow survey results to be available a month earlier, reducing labor costs. However, if availability of antlerless-deer hunters is limited (Table 1, PA 235), additional mailings may be necessary to gain an adequate sample.

Bias involved with number of days hunting is minimal. Although differences in TPD are detected by GLM ANOVA, Tukey's range test fails to detect meaningful differences between TPD by total number of days hunting.

Bias due to hunter location does not seem to be a contributing factor to variation in TPD. Our field interviews suggest that most hunters pursue deer within a relatively small area and that a very small percentage actually hunt outside their PA. Although hunters tend to pursue deer in the PA for which they possess an antlerless-deer permit, the question asking location of turkeys observed is useful in refining the locations of large flocks.

Table 4. Survey of wild turkey sightings by antlerless-deer hunters. Percentage of hunters seeing turkeys (PST), Minnesota, 1987-88.

Antlerless-deer permit area	PST 1987	PST 1988
226	4.0	9.6
235	6.3	19.3
236[a]	2.5	
337	7.1	15.5
338	10.0	19.7
339	26.5	22.8
341	19.4	26.9
342	16.8	23.1
343	12.0	29.0
344	31.7	52.0
345	31.0	43.1
346	31.9	46.8
347	50.5	47.8
348	52.8	73.3
349	55.3	67.0
418	6.5	6.2
419	9.3	10.8
430	3.6	2.2
431	4.6	4.1
445	12.0	19.5
459	3.8	4.5
461	7.1	4.9
462	11.6	10.5
463	3.3	2.3
464	4.5	0.0
465	5.9	3.7
466	5.8	8.0
467	3.4	4.7

[a]Permit area 236 not sampled in 1988.

Table 5. Survey of wild turkey sightings by antlerless-deer hunters, mean number of turkeys seen per hunter per day excluding observations by individuals seeing no birds (TPD-X0), Minnesota, 1987-88.

Antlerless-deer permit area	TPD-X0(SE) 1987	TPD-X0(SE) 1988
226	1.16(0.43)	1.58(0.32)
235	1.06(0.33)	0.92(0.17)
236[a]	0.30(0.10)	
337	1.89(0.50)	2.25(0.43)
338	2.77(0.65)	3.71(1.13)
339	3.46(1.08)	4.18(0.64)
341	3.80(1.31)	3.63(0.52)
342	1.61(0.39)	1.91(0.36)
343	2.28(0.67)	4.31(1.02)
344	2.50(0.47)	2.40(0.30)
345	3.03(0.54)	6.87(1.51)
346	6.41(1.52)	8.28(1.38)
347	3.33(0.51)	5.35(0.96)
348	5.32(1.46)	5.70(0.92)
349	6.58(0.79)	8.45(1.10)
418	1.39(0.38)	2.57(1.15)
419	2.48(1.08)	2.19(0.46)
430	3.58(1.84)	4.38(1.65)
431	6.06(1.29)	7.54(3.87)
445	5.62(1.37)	5.45(1.20)
459	8.50(5.89)	1.77(0.75)
461	3.35(1.56)	1.31(0.62)
462	2.12(0.47)	1.36(0.41)
463	0.83(0.33)	0.75(0.50)
464	0.75(0.14)	0.00(0.00)
465	2.30(0.85)	2.08(0.92)
466	1.70(1.09)	3.82(1.39)
467	1.83(1.33)	1.38(0.72)

[a]Permit area 236 not sampled in 1988.

The ability of a survey to detect annual fluctuations in animal numbers is the purpose for conducting a survey. There were increases in TPD from 1987 to 1988 in nearly all PAs where turkey populations were hunted in spring 1988 (PAs 343, 345, 346, 347, 348, and 349 in southeastern Minnesota [Fig. 1, Table 2]). Wild turkey management personnel made the decision to open or reopen spring gobbler hunting seasons within portions of PAs 226, 235, 341, 344, and 445 in 1989 (Fig. 1).

In winter 1986, wild turkeys were released in PAs 337 and 338 (Fig. 1). Increases in TPD in these areas from 1987 to 1988 (Table 2) indicate population growth and expansion that wildlife personnel also believe are occurring.

The correlation between density estimates by wildlife professionals and both TPD and PST suggests that TPD and PST reflect wild turkey abundance and distribution. We do not and cannot predict actual turkey densities. More information is needed to determine the relationship between actual turkey density and TPD and PST from a survey of turkey sightings by antlerless-deer hunters.

Sample size determination is dependent on 2 factors: amount of change that is desired to detect, and number of antlerless-deer permits available. In some areas in Minnesota, number of antlerless-deer permits available becomes a limiting factor for sensitivity of a survey of wild turkey sightings by antlerless-deer hunters (Table 3). For example, PA 235 (Table 3) is limited to the ability to detect a 15% change in TPD.

MANAGEMENT IMPLICATIONS

A survey of wild turkey sightings by antlerless-deer hunters is relatively inexpensive, requires a minimal amount of labor, and can generate information on wild turkey abundance. The total costs to run the survey for a sample of 4,410 hunters for 4 mailings can be as low as $3,500 (Welsh 1990). Gobble count routes (previously used in Minnesota to monitor turkey populations) conducted over the same area would cost approximately $5,600, requiring more than 70 worker-days by a large number of personnel. We were interested in finding an alternative technique because quality of data resulting from gobble counts is questionable and labor expenditure is high. Minnesota Department of Natural Resources adopted a survey of wild turkey sightings by antlerless-deer hunters in 1989.

A survey of wild turkey sightings by antlerless-deer hunters provides a cost-effective alternative to route-oriented survey methods for monitoring fluctuations in wild turkey numbers. One individual can conduct the survey in an office. Labor expenditure is high for route-oriented survey methods where a large number of routes must be driven within a specific time frame.

A survey of wild turkey sightings by antlerless-deer hunters is an effective alternative to surveys where voluntary landowner cooperation is required. In Iowa, wild turkeys are surveyed by landowner-sighting survey, and over the years landowner interest has declined and individuals responded less often (T. Little, pers. commun.). In a survey of wild turkey sightings by antlerless-deer hunters, a random sample is drawn from a large pool of deer hunters and annual repetition of individuals surveyed is avoided. Therefore, response rate remains relatively constant.

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Appendix A. Postcard questionnaire for survey of wild turkey sightings by antlerless-deer hunters, Minnesota, 1987-88.

Dear Minnesota White-tailed Deer Hunter:

You have been randomly selected from all firearm deer license buyers within areas of Minnesota which may contain wild turkeys to help us evaluate the present status of our wild turkey population. We need this information to determine wild turkey population trends.

On the attached questionnaire, please indicate the number of days you hunted for deer with a firearm this year; the town nearest the area you hunted the most, and the distance and direction from that town; the total number of turkeys seen; and the location, as completed above, of the turkey sighting. This questionnaire is postage-paid, just tear along the perforation and drop it in a mailbox.

<u>It is imortant that you complete and return this questionnaire even if you did not see any wild turkeys or did not hunt during the 1988 firearm Deer Season.</u>

Thank you for your cooperation,

Farmland Wildlife Populations and Research Group
Division of Fish & Wildlife
Department of Natural Resources

. . . .

TURKEY SIGHTING QUESTIONNAIRE

Please complete the following for the 1988 Firearm Deer Season:

Number of Days Hunting Deer:__________

Location where you hunted the MOST:

__________Miles______________Of________________
(#) (direction) (nearest town)

How many WILD TURKEYS did YOU see during this year's firearm deer season?______________

Location where Turkeys were seen:

__________Miles______________Of________________
(#) (direction) (nearest town)

Comments:

CRITERIA AND GUIDELINES FOR WILD TURKEY RELEASE PRIORITIES IN INDIANA

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Abstract: Habitat criteria based on the theoretical potential to support self-sustaining wild turkey *(Meleagris gallopavo silvestris)* populations serve as a more objective guide for determining restoration priorities. We derived criteria from literature sources, examination of restoration projects in other states, and the results of >30 years of wild turkey restoration efforts in Indiana. Wild turkey populations have been restored in both "traditional" and "marginal" habitat types. We reported harvest results relative to 3 levels of habitat quality. Wild turkey population growth and dispersal have been influenced primarily by land use, human population levels, and physiography. Restoration problems related to habitat fragmentation, population isolation, inbreeding depression, and founder effects were incorporated into guidelines for supplemental and interplanting releases in existing populations. Criteria are applicable to other wild turkey restoration projects, especially in the Midwest.

Since the 1950s eastern states have restored the eastern wild turkey through much of its original range where suitable habitat exists. Indiana's restoration began in 1956 following a path similar to other states (Wise 1973, Machan 1986). Restoration efforts accelerated rapidly in 1980 with almost 90% of the total birds (n = 1,923; 127 sites) released during the last decade. Wild turkeys now exist in >50 of Indiana's 92 counties with estimated spring densities ranging from <0.4 to >10 birds/km^2 (<1 to >25 birds/mile^2) or approximately 30,000 birds over 30,000 km^2 of statewide range. Spring hunting began in 1970 and hunting is currently allowed in 39 counties covering 13,424 km^2. The 1989 spring season harvest was 0.2 gobblers/km^2 (range 0-1.0) of huntable range (0.4 gobblers/km^2 forest land; range 0-2.1) with a mean hunter success of 22%.

Personnel responsible for wild turkey restoration needed biological criteria to develop release area priorities as the restoration program accelerated and habitats of more marginal quality were considered. Selection of suitable release areas became increasingly difficult compared with previous years when restoration had focused primarily on large public forests >40 km^2. Management decisions came under increased public scrutiny as interest grew. This became especially evident when areas of population voids within existing turkey hunting range were evaluated along with opportunities to establish populations in more marginal habitats. Once developed, criteria for release areas would also help other agency personnel and the public better understand how restoration priorities were determined.

The purpose of this paper is to discuss the development of the criteria for selecting wild turkey releases and describe their application in determining restoration priorities. Turkey harvests and population densities (winter/spring; pre-breeding season) are reported as the number of birds/km^2 of huntable or occupied range and as the number of birds/km^2 of forest land within the range to allow comparisons with those reported elsewhere (e.g., Hewitt 1967, Lewis 1980, Little 1980).

The restoration of wild turkeys in Indiana is the result of the collective effort and dedication of many wildlife research and management personnel. This paper resulted from those efforts, and several individuals contributed ideas. Funds were received through the Pittman-Robertson Federal Aid to Wildlife Restoration, Wildlife Research Project W-26-R, and the Forest Wildlife Project W-27-D Indiana. Several conservation clubs including the Indiana Chapter of the National Wild Turkey Federation supported various aspects of the restoration effort.

INDIANA LAND USE

Forest land comprises only 23% of the total land area (93,717 km^2) of Indiana with most located in the southern half of the state. Commercial timberland comprises 85% of the forest land. Predominate forest types are oak-hickory (33%), maple-beech (23%), and elm-ash-soft maple (19%) (Hansen 1987), and most forest land is mature sawtimber (Leatherberry 1987). Agricultural land comprises 65% of the total land area and is primarily in row crop (corn and soybeans) cultivation followed by livestock production (cattle and hogs) (Indiana Planning Services Agency 1979). Physiography, topography, soils, vegetation, and climate vary across the state with 12 defined natural regions (Homoya et al. 1985). Urban and industrial developments constitute about 9% of the land with 13 major metropolitan areas (>100,000 people). Human density averages 60 persons/km^2, ranging from 10 to 768/km^2 on a county basis, and 51% are considered rural residents (Indiana Department of Natural Resources 1984, Flemming 1989). Rural road densities in counties average 0.8 km/km^2, ranging from 0.5 to 1.7 km/km^2. Water bodies and wetlands constitute <2% of the geographical area. Rivers and streams are interconnected and well dispersed across the state.

DEVELOPMENT OF CRITERIA FOR NEW RANGE ESTABLISHMENT

Habitat criteria for Indiana's restoration were initially developed by gleaning information from literature and biologists from other states. Technical information was coalesced with personnel experience from >30 years of turkey restoration history in Indiana. Current wild turkey management philosophy recognizes that quality turkey habitat exists in both forest and agricultural matrices (Schroeder 1985). Indiana possesses both types of habitat, and restoration criteria were designed to reflect the different proportions of forest to agriculture encountered across the Indiana landscape. Habitat assessments for wild turkey restoration focus primarily on the amount, distribution, and spatial configurations (heterogeneity) of land use components (e.g., forest, agriculture, water, and human development). Nomenclature from Kurzejeski and Lewis (1985) and Bowen and Burgess (1981) describing forest cover patterns were integrated into different levels of criteria describing turkey habitat quality (Figs. 1, 2).

Level I Criteria

Level I criteria (Table 1) for establishing new populations describes "optimum" turkey habitat in both forest (NR-Ia) and agricultural (NR-Ib) matrices similar to Schroeder (1985). Adequate winter food sources and quality brood cover are relatively assured in both types of habitat. Corridors for population range expansion, dispersal, and interchange exist. Estimated probability for success of restoration is high (>90%).

"Established" turkey populations (Little 1980) in counties containing primarily Level I habitat produced mean annual harvests during 1987-89 of 0.33 gobblers/km^2 (range 0.16-0.72) of range or 0.72 gobblers/km^2 (range 0.26-2.08) of forest land. Assuming spring gobbler harvests represent 10% of the winter (pre-breeding) population (Mosby 1968, Lewis 1980), estimated mean winter populations are 3.3 birds/km^2 of range or 7.2 birds/km^2 of forest land. These population densities are less than but within the range for similar habitats in Iowa and Missouri (Little 1980, Kurzejeski and Lewis 1985). Most of the Indiana's Level I populations are <10 years old and still growing. Based on Missouri's experience, new turkey populations can be expected to grow for $\leq$20 years depending on the amount of habitat and the number of releases made in an area (L. D. Vangilder, pers. commun.). All major blocks of Level I habitat in Indiana are stocked.

Level II Criteria

Level II (NR-IIa and NR-IIb) criteria (Table 1) describe less than optimum turkey range. Lack of quality brood cover (e.g., Healy 1985, Metzler and Speake 1985) is the primary limiting factor in NR-IIa habitats. Annual winter food availability (primarily hard mast) is not consistent because of poor forest composition or lack of seral diversity. Areas involved are often public forests and normally have potential to be elevated to NR-Ia through habitat management.

NR-IIb criteria describes less than optimum habitat in agricultural areas where forest cover has diminished. Connective habitat corridors are reduced and winter food supplies

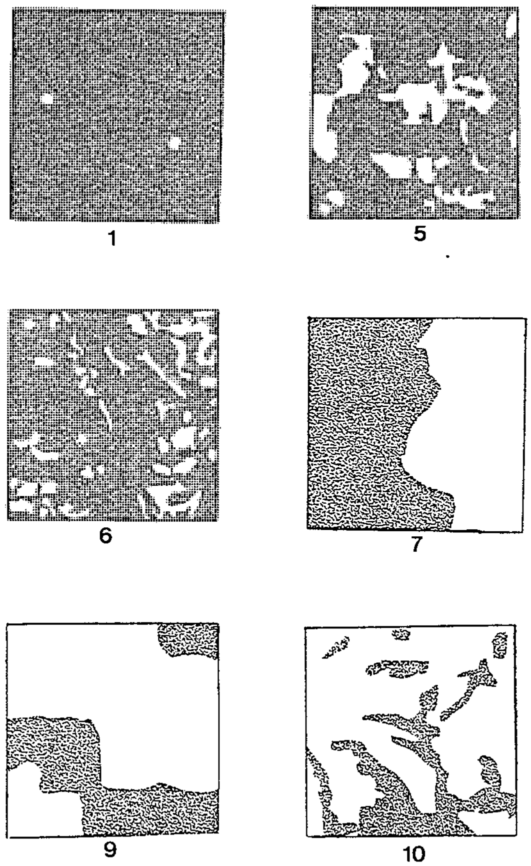

Fig. 1. Missouri interspersion patterns (MIP) (Kurzejeski and Lewis 1985). Darkened areas = forest land; white areas = openland. Each block represents 400-500 ha (R. Kirkman, pers. commun.).

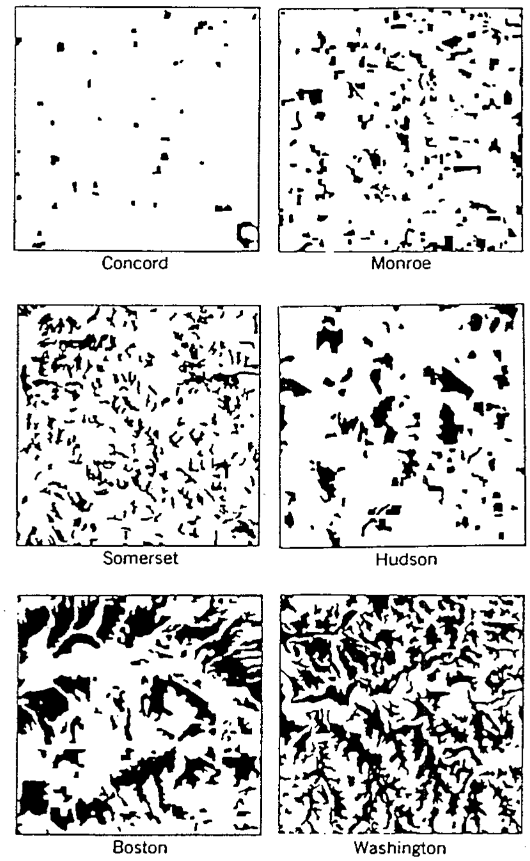

Fig. 2. Forest cover patches from 6 Ohio landscapes (from Bowen and Burgess 1981). Darkened areas = forest land; white areas = openland. Each block is 10 km^2.

can potentially be limited because of poor forest composition and increased levels of fall plowing in agricultural fields. The amount of quality brood habitat is inversely related to the intensity of agriculture practices. Potential disturbance factors related primarily to human development are greater than Level I.

NR-IIb habitats frequently are landscape peninsulas extending from large blocks of Level I habitat and may become inhabited by turkeys through natural dispersal from established populations in the Level I habitat. Interconnection to larger "continental" populations is important to many wildlife species (MacClintock et al. 1977, Harris 1984). Habitat interconnections and corridors have been referred to as "turkey trots" (Harris 1983:380). Holbrook et al. (1987) described the value of "leave strips" as corridors to ensure turkey recruitment between areas of intense pine management. Densities of turkey populations attempting to colonize long, narrow extensions of habitat may diminish towards terminal extremes or where barriers exist. These situations may necessitate that peninsulas of NR-IIb habitat be restocked separately from larger established populations.

Estimated probability for restoration success in Level II habitats is good (>70%), although the initial population response (growth) is generally slower than in Level I range. Established turkey populations in counties containing primarily Level II habitat have produced mean annual harvests during 1987-89 of 0.08 gobblers/km^2 (range 0.04-0.14) of range or 0.21 gobblers/km^2 (range 0.09-0.55) of forest land. Estimated winter populations are 0.8 birds/km^2 of range or 2.1 birds/km^2 of forest-land. Many NR-IIb populations are ≤ 5 years old and continued growth is expected. NR-IIa populations are generally some of the oldest releases (>15 years) and would be expected to increase if habitat quality were enhanced through management. All major blocks of Level II habitat in Indiana are stocked.

Level III Criteria

Level III (NR-III) habitats (Table 1) are the poorest habitats currently considered for restoration. All habitat factors are limiting. Human populations can be extremely high due to urbanization or low as in intensely farmed regions of the state. In many cases the amount of success is limited or uncertain. Restoration success in NR-III habitats increases when these areas are in proximity to Level I or Level II habitats to allow frequent emigration from established populations. Little (1980) indicated similar occurrences in Iowa.

Hunting opportunity currently exists in only 2 areas of Level III habitat, and harvest data are limited because most populations are ≤5 years old. Turkey populations in counties containing primarily NR-III habitat have produced mean annual harvests of <0.01 gobblers/km^2 (range 0-0.02) of range or 0.02 gobblers/km^2 (range 0-0.03) of forest land (1988-89). Estimated winter populations are 0.1 birds/km^2 of range or 0.2 birds/km^2 of forest land. Some areas of NR-III habitat have not contributed to the harvest in 2 years although populations are still present.

Table 1. Criteria for wild turkey restoration in Indiana. (See Figs. 1, 2 for patterns mentioned.)

NEW RANGE ESTABLISHMENT

- Areas currently unoccupied by wild turkeys
- Each release receives 11 hens:4 adult gobblers; or 2 juvenile gobblers/adult gobbler up to 4 juvenile gobblers.
- Release areas considered on a scale ≥25-50 km^2.
- Releases generally 8-16 km apart or 1 release/50+ km^2.

Level I "NR-I" (Optimum)

(a) Forest cover 80±10% (hard/soft mast-producing types preferred, 60-70% >40 years old, 20-30% in shrub/brush seral stages, minimal grazing); openland 15±5%; meadow, pasture, or hayfields (grass/forb/legumes, not intensely grazed or mowed) well interspersed and moderately interconnected throughout forest cover (MIP #5,6 patterns; Kurzejeski and Lewis 1985). Barriers to population expansion minimal or nonexistent. Human development <10%; <12 people and <0.8 km rural roads/km^2.

or (b) Forest cover 50±10% (similar forest type and seral composition), dendritic forest cover or very interconnected with wide strip corridors (Washington, Boston patterns; Bowen and Burgess 1981); cropland (row crops) 25-35% with <35% fall plowing; and meadow or pasture 10-15% (similar qualifications as above). Human development <10%; <18 people and <0.8 km rural roads/km^2.

Level II "NR-II" (less than optimum)

(a) Forest cover ≥95% (general lack of seral diversity); openland (<5%) poorly interspersed; forest/openland interface often abrupt and narrowly defined (MIP #1,7 patterns); openland often intensely cultivated, grazed, or in human development. Potential brood habitat very limited and poor quality. Frequently characterized by ridge (forest) and valley (agriculture) topography or insular public forest lands. Human development <10%; <12 people and <0.8 km rural roads/km^2.

or (b) Forest cover 20-40% (some diversity of seral stages); fairly contiguous forest distribution with strip and line corridors (Somerset, Hudson, MIP # 9,10 patterns); openland (40-70%) often intensely cultivated, grazed, or in human development; moderate (40-70%) fall plowing. Human development ≤20%; <25 people and <0.8 km rural roads/km^2.

Level III "NR-III" (Poor)

Forest cover 8-<20% (seral diversity poor, mast types low) and in blocky, patchy, insular, or very thin dendritic patterns; potential travel corridors thin, broken, or absent (Concord, Monroe patterns); openland (≥70%) often intensely cultivated, grazed, or in human development; fall plowing >70%. Intense agriculture >65% (human development <10%) or high human development >25%; >30 people and >1 km rural roads/km^2.

GUIDELINES FOR SUPPLEMENTAL AND INTERPLANTING RELEASES

"Block stockings" of several release sites in a general restoration area was a restoration strategy devised to speed up population dispersal in areas of widely scattered timber stands (Little 1980). Block stockings were incorporated into Indiana's wild turkey restoration program in 1980 when more birds became available through interstate trade agreements. The quick success of block stockings in NR-Ib habitats stimulated biologists to re-examine the success history of previous releases made in apparently good habitats (NR-Ia or NR-IIa) that did not support expected population levels. These older (10->15 years) populations never expanded or dispersed successfully into adjacent NR-Ib habitats, as in Iowa (Little 1980), even though there was much opportunity to do so.

Early releases often used few birds (<12) and only a single release was made in fairly large areas (Wise 1973). Restocked areas were separated by considerable distances often containing many barriers to interchange among populations. In several cases birds were captured from the same local population (deme), and birds may have been directly related (parents and progeny, or siblings). Releases showed some initial population growth for about 5 years but then declined to much lower levels than expected. Observations of turkeys or turkey sign (tracks, droppings, or feathers) in areas became incidental, sometimes less than a single observation per year. Estimated population densities were <0.4 turkeys/km^2 of range or 0.5 turkeys/km^2 of forest land. Habitat, poaching, and predation were not considered limiting factors. Biologists began to explore potential problems contemporarily related to "conservation biology" (Schonewald-Cox 1983, Soulé 1986).

One problem with restoring extirpated populations concerns the genetic aspects of managing small populations (Lovejoy 1978). When relatively few turkeys are used, especially directly related individuals, a "genetic bottleneck" is placed on a new population with significant implications for future population growth or existence (Corbin 1978). The potential adverse "founder effects" leading to "inbreeding depression" increase (Carson 1983, Ralls et al. 1986) and an "effective breeding population" may never be attained (Shaffer 1981, Ralls and Ballou 1983). Inbreeding depression results in a decrease in population size due to lower reproductive potential (fertility and fecundity decrease), decreased animal vigor, and increased susceptibility to perturbations of their environment (Lovejoy 1978, Schonewald-Cox 1983). A review of strategies for restoration of various species indicates that successful translocations released more animals than unsuccessful translocations, assuming habitat was not limiting (Griffith et al. 1989).

Because of their polygamous, harem breeding behavior and relative sensitivity to human disturbance barriers (Bailey 1967), wild turkeys may be more prone to inbreeding depression (Chesser 1983, Lacy 1987) and population isolation (Allendorf 1983, Liu and Godt 1983) than other wildlife species. Block stocking wild turkeys increases the size of the founder population and promotes an immediate, rapid population growth ensuring more genetic integrity than probable with a single release (Senner 1980). The interchange among several demes, initially separated, may be an effective strategy to counteract problems related to founder effects or population isolation (Ralls and Ballou 1983, Lacy 1987). Where natural interchange among populations does not occur, humans may have to transport individuals between populations (Chesser 1983).

Management strategies for preserving threatened species (Lovejoy 1977) and zoo populations (Ralls and Ballou 1983) provided a strong theoretical basis for developing guidelines for supplementing existing wild turkey populations or for making interplanting releases to minimize the potential genetic problems related to isolated populations (Table 2). Supplemental and Interplanting Type I (SI-I) releases used a full complement of birds normally used to establish populations in new range. Supplemental-Interplanting Type II (SI-II) releases were used where less corrective population management was needed. These releases primarily utilize excess hens that might otherwise be released at trap sites.

Our goal was to improve low densities (<0.4 birds/km^2) of wild turkeys in areas where habitat was considered to be good (Level I or II). Our objectives were to supplement existing populations or to fill in voids between populations (interplantings) by making releases in adjacent habitats the existing population had failed to colonize.

In 1983, we tested the possibility that additional releases into low-density turkey populations would result in higher population densities. A 1,700-km^2 area encompassing the Lost River Purchase Unit, Hoosier National Forest (Lost River) and the Crane Naval Weapon Support Center (Crane) were chosen (see Wise 1973, Backs et al. 1985 for locations). A single release had previously been made in Lost River (1968-69) and 2 small releases in Crane (1956, 1974-75). Forest cover was 80-85% and the habitat was primarily (70%) Level I with the rest in Level II. Both populations were initially successful after releases, supporting estimated populations of 200 birds each. Both areas served as trapping sources. Eventually populations declined and efforts to locate birds in the winter for trapping became futile. Lost River was open to hunting in 1973 and the annual mean harvest during 1979-83 did not exceed 0.03 gobbler/km^2 of hunting range (0.05/km^2 forest land). No birds were harvested in some areas in latter years.

We made 8 releases in Lost River in 1983, several near the perimeter of the Crane Base. Each release site included birds from different sources. Habitat quality in Lost River and Crane was probably slightly less than during 1969-74 due to advanced forest succession. New populations were subsequently evaluated (Backs et al. 1985), and the success was overwhelming. Turkeys were observed across the entire area and appeared to form 1 continuous population. The Lost River Area was included into the 1987 hunting range and supported annual mean harvests during 1987-89 of 0.17 gobbler/km^2 (0.29/km^2 forest land) with populations still increasing. Populations on Crane have responded similarly. Turkey densities on the 2 areas are among the highest in the state. Winter flocks of 15-30 birds are relatively common, and flocks of 50-100 birds are not rare. Both areas are used as trapping sources. Total annual removal from trapping and harvest is currently >200 birds for the combined areas.

A similar opportunity to rehabilitate an existing low density population existed in the Little Africa Purchase Unit, Hoosier National Forest (Little Africa). This area had previously been restocked over a 2-year period (1970-71) when birds available for restoration were scarce. The restocking was made with only 10 birds (7 were possibly related and 4 were juveniles). The main body of habitat was and still is NR-IIa

Table 2. Guidelines for supplemental or interplanting wild turkey releases in Indiana.

Area Identification Criteria ($\geq$1 apply)

- Areas (>40 km^2) with low turkey densities (0.4 birds/km^2) that are apparently not related to the quality or amount of habitat (i.e., habitat is not considered a limiting factor; NR-I or II type habitat).
- Existing population somewhat "insular."
- Less than expected densities may be related to population isolation; "inbreeding depression," "founder effect" (i.e., initial stocking <12 birds and birds directly related).
- Sufficient time (3-5 years) has elapsed for birds to become established from restocking or to successfully emigrate from established population to the area considered.

TYPE 1 "SI-I"

- Generally done where density of gobblers not known.
- Receives full complement of birds (11 hens:4 adult gobblers; or 2 juvenile gobblers substituted for each adult).
- May or may not be in existing hunting range (gobblers released in hunting range wing-marked).
- Releases made $\geq$8 km apart or 1 release per $\geq$50 km^2.

TYPE 2 "SI-II"

- Generally done where a few gobblers are present and usually in existing spring hunting range.
- Receives less than full complement of birds (8-10 hens), principally excess hens from in-state trapping efforts.
- Allows maximum benefit (use) of in-state trapping effort.

with several extensions in Level I or NR-IIb. The population never showed much growth based on observations and hunting results. Populations were estimated at <0.4 birds/km^2. In 1988, 1 release was made in Little Africa and 3 others within 12 km. Initial response after 2 breeding seasons greatly exceeds previous observations, and the population appears to be expanding into additional areas.

Observations from these 2 supplemental releases are by no means conclusive evidence supporting the theory behind SI-type releases, but they are not unique. Similar observations have been made in Washington (D. Blatt, pers. commun.) and Arkansas (R. A. Smith, pers. commun.). Controlled studies to gather empirical data and test theories related to genetic fitness in wild, free-ranging populations are difficult to conduct. Another plausible hypothesis is that supplemental birds are effective in offsetting some limiting threshold of natural predation or poaching. Natural predation and poaching are recognized as potential limiting factors especially if they occur soon after release, but in established populations they are generally accepted attrition (Markley 1967). We believed poaching or predation were not primary limiting factors when established populations declined. Two wild turkey populations studied by Miller (1983) both overcame 50% mortality following release and were open to hunting 4 years post-release. No harvest was recorded in the most disjunct population 7 years post-release while the harvest in the other population, with a connective travel corridor to a larger population, remains fairly stable. Sometimes observations of events in the field and theoretically based inferences have to suffice until more knowledge is obtained.

APPLICATION TO RESTORATION PROGRAM

Potential release areas in Indiana are generally considered on a scale of at least 25-50 km^2. Exceptions are smaller public areas (10 km^2) with wildlife management programs. When suitable habitat exists, areas >25 km^2 containing privately owned land are generally adequate (Little 1980, Lewis and Kurzejeski 1984) and can normally be inhabited by expanding turkey populations in $\geq$3 years (Little and Varland 1981, Backs et al. 1985).

Regional landscape assessments are normally made using U.S. Geological Survey (USGS) topographic (1:250,000) and corresponding Land Use and Land Cover (LUDA) maps (Anderson et al. 1976) highlighted to depict major land use types. LUDA maps provide regional land use information for Indiana, although forest cover estimates are slightly exaggerated when actual forest cover is <15% (Backs et al. 1989). Standard USGS topographic maps (1:24,000), various aerial photos (e.g., Soil Conservation Service), and occasional aerial flights (1,000-1,300 m above ground level) are used to verify regional map assessments. Flights are also useful to evaluate larger drainages (>200 km) or more expansive areas (>500 km^2) of potential range.

All information gathered is incorporated into the evaluation process. Criteria levels are conditioned by the amount of overall habitat involved, potential or current proximity to existing turkey populations or other proposed release sites, and potential limiting factors; e.g., critical seasonal flooding (e.g., Zwank et al. 1988), climatic factors, and barriers limiting or inhibiting turkey population expansion or interchange. Common barriers include heavily traveled road systems, human development, or large, intensely farmed agricultural areas.

Since 1979, a release normally consisted of at least 11 hens and 4 adult gobblers. Juvenile gobblers are occasionally substituted for adults at a rate of 2 juveniles/adult up to a total of 4 juveniles. The 15 birds per release is similar to the number commonly used by other states (Kennamer 1986). A release of this size is capable of substantial growth in suitable habitat (Little and Varland 1981) and producing an effective breeding population within 3-5 years. On each release, a concerted effort is made to release a mix of birds from different source populations and to complete a release in the same trapping season (Dec through Feb).

Block stockings were used when the extent of habitat warranted more than a single release. Priorities for block stockings were generally determined by the overall rating for the majority of sites involved (Little 1980). Individual release sites were generally 8-16 km apart or at a maximum density of 1 release in at least 50 km^2 of continuous blocks of habitat. The distance between release sites varied when travel or population expansion corridors were insufficient. Where barriers existed, releases were on both sides of the barrier 6-8 km apart. Longer distances (≤24 km) between releases were also possible where population expansion was expected to be linear along a limited drainage or habitat corridor. Release sites were often placed in proximity to convergence of drainage systems to facilitate rapid population expansion.

Releases are evaluated after at least 2-3 breeding seasons (Little 1980, Backs et al. 1985). Populations were considered established when observations indicated brood production, gobbling activity, and fall-winter flocks of 12-20 birds occurred consistently for 2-3 years over 75% of the potential habitat in the general area considered. This generally occurs in 2-3 years in Level I and II habitats assuming no major production losses (e.g., summer drought 1988). Level I and II populations are normally included into the spring hunting range after 3 or more breeding seasons post-release.

DISCUSSION

Wild turkey range in Indiana has been identified traditionally through a "personal opinion approach," (POA) (Seitz et. al. 1982). Biologists responsible for wild turkey restoration use their knowledge of wild turkey habitat needs from literature sources and personal experience to evaluate the potential of habitat in an area to support populations of wild turkeys. Although more objective and sophisticated approaches exist (Backs 1984), the POA is the only feasible method currently available for wild turkey restoration in Indiana (and other states). Established criteria facilitated a more objective POA and also integrated a form of "pattern recognition" where relative probabilities to support high verses low densities of wild turkeys are developed (Kurzejeski and Lewis 1985).

In the development stages, 2 categories of criteria became a necessity. Criteria for establishing populations in new range evolved primarily around the life requirements of wild turkeys and used ideas related to a landscape ecology perspective. Guidelines for supplemental and interplanting releases involved rehabilitating existing populations that, despite apparently good habitat, suffered from some type of population depression related to population isolation. Conceptually the Supplemental and Interplanting guidelines have a more theoretical basis related to conservation biology but show some evidence of successful management application in the field. The habitat criteria and the population management perspective are intertwined because the genetic health of a population often depends on its interconnections to other populations (Harris 1984, Harris and Kangas 1988).

The major thrust of Indiana's restoration effort should be completed within 2-3 years at the current rate of restocking. Additional restockings after this primary effort will be attempts to fill voids in existing populations (SI-I or SI-II releases) and lower quality habitats (i.e., <NR-III).

Wildlife management programs need to recognize that human development continually contributes to the temporal patterns of the landscape, which affect wildlife (Forman and Godron 1986). Established wild turkey populations could be transformed into insular populations by changing land use, necessitating some type of population maintenance strategy to ensure genetic viability. This may be potentially greater in Indiana than in some other states. Indiana has substantially higher human densities than Iowa or Missouri (Merz 1978) and a more developed highway system that dissects the state. Supplemental and Interplanting releases could potentially be "preventive maintenance" for maintaining higher densities in semi-isolated populations. In some instances, a single Supplemental or Interplanting release may produce greater numbers of turkeys and provide more recreation opportunity than several NR-III releases.

However, caution is necessary. The implementation of Supplemental and Interplanting stockings could become "Pandora's Box" if management decisions are not carefully evaluated. It is imperative that poor habitat quality is not a limiting factor before Supplemental or Interplanting stockings are considered (Griffith et al. 1989). Otherwise, Supplemental and Interplanting stockings could evolve into glorified "Put and Take" programs to satisfy constituencies rather than to solve biological problems of wild turkey restoration.

Restoration results in Indiana point to a bright future and have far exceeded some expectations. The mean hunting success in recent years (1987-89) has increased to 24% ($\bar{x}$ harvest = 0.12 gobblers/km^2 hunting range or

0.29 gobblers/km^2 forest land) with estimated winter populations of 1.2 birds/km^2 (2.9 birds/km^2 forest land). While these harvest levels and successes may be less than in other states, they compare favorably with a decade ago (1977-79) when hunter success was only 8% ($\bar{x}$ harvest = 0.01 gobblers/km^2 or 0.02 gobblers/km^2 forest land) with estimated winter populations of 0.1 birds/km^2 hunting range (0.2 birds/km^2 forest land). Several generations of citizens are now seeing wild turkeys for the first time in their lives in the state where only a generation ago wild turkeys did not exist.

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TELEMETRY DATA MANAGEMENT: A GIS-BASED APPROACH

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Abstract: We developed standard procedures for storing and managing telemetry data on microcomputers to facilitate analysis. Raw location and descriptive data for several wild turkey *(Meleagris gallopavo)* research projects were entered into microcomputers in a standard file format used by several commercially available database management programs. Computer programs were developed to allow easy transfer of these data between a standard database format and a standard geographic information system (GIS) data exchange format. Researchers analyzed the same data set in both tabular and visually geographic form, enhancing relationships that might otherwise take longer to recognize. Standard commercial software formats minimized the time required to exchange data among analysis programs, allowing the use of programs that suited researcher's individual needs and means.

Telemetry has become a widespread and proven wildlife research technique (Mech 1983). Capabilities in the space-use analysis of telemetry data have made meaningful advances in the past decade due to improved statistical software and geographic information systems. A GIS is a methodology--including hardware, software, and graphics--that encodes, analyzes, and displays multiple data layers derived from various sources. Analyses can be expressed in tabular or graphic form, and most important, in geographically coordinated mapping format (American Farm Trust 1985). Once telemetry data are collected, animal locations determined, and results placed in a suitable format, there are many opportunities for analysis. Researchers unwilling to seek a permanent solution to the temporary problem of data format conversions find that similar difficulties arise every time data are needed for analysis by statistical programs or GIS.

The proprietary data formats of most GISs make data exchange difficult, leading to the adoption of informal data exchange standards by the GIS community (Guptill 1988). We took advantage of these standards by formulating procedures for managing telemetry data from initial field collection to an intermediate form practical for both GIS and conventional statistical analysis methods. Our efforts focused on 2 objectives: (1) to develop procedures for managing telemetry data on IBM Personal Computer (PC) and compatible microcomputers, and (2) to develop procedures for integrating telemetry analysis with GIS.

We thank D. Smith, W. Palmer, and J. Burk for their contributions and constructive criticisms. We acknowledge the support of the Mississippi Remote Sensing Center (MRSC), W. F. Miller, Director, and the Mississippi Cooperative Wild Turkey Research Project. S. Jordan typed and edited the manuscript.

METHODS

Our first task was to select a suitable tabular database management system (DBMS). A DBMS is a program that stores, retrieves, and organizes collections of related information or data (Ashton-Tate, Inc. 1985). A database file is subdivided into individual entries called records. Each item of information within a record is called a field. For example, our databases of wild turkey telemetry data were subdivided into individual records for each telemetry fix or station location; in the raw telemetry database, fields existed for such information as wild turkey identification (ID) number, sex, date, time, station numbers, and bearings (Table 1). A unique set of fields that makes up a record is known as a structure and determines the contents of the entire dBase file.

Table 1. The dBase-compatible record for raw telemetry data files used for telemetry data storage at Mississippi Remote Sensing Center.

Field	Field name	Type	Width	Decimal
1	DATE	Date	8	0
2	OBS (observer)	Character	2	0
3	SEX	Character	1	0
4	ANIMAL (animal No.)	Character	3	0
5	TIME (of first azimuth)	Numeric	4	0
6	STA (station name)	Character	4	0
7	AZM (first azimuth)	Numeric	3	0
8	SIG (signal rating)[a]	Numeric	1	0
9	TIME2	Numeric	4	0
10	STA2	Character	4	0
11	AZM2	Numeric	3	0
12	SIG2	Numeric	1	0
13	ACT (activity code)[b]	Numeric	1	0
14	MISC (notes)	Memo	10	0
Total			50	

[a]Rated 1-5, weak to strong.
[b]Moving or not moving (motion switch on transmitter active or inactive).

Our choice for standard DBMS file format was the generic form of Ashton-Tate's dBase III+ (Ashton-Tate Inc. 1985). The dBase format (Versions I-IV) is the most universally used database format found on PC-compatible microcomputers. It is readable by a number of "workalike" DBMSs, such as Foxbase, Clipper, and Quicksilver. Users can choose among these DBMSs to decide which product best meets their needs and budget, while still using a compatible format. DBMSs are all relatively easy to use and inexpensive, with volumes of documentation and user guides available from manufacturers and others. These programs allow data in columnar format to be read directly from other files, have sophisticated data entry screens, and contain report writing facilities.

We next developed a standard record structure for each of our telemetry files. We had 3 basic record structures: station lists, raw telemetry data, and wild turkey locations (Tables 1-3). All data collected before standards were implemented were reformatted using the columnar reformatting capabilities of a word processing program (WordPerfect Corp. 1987). Ashton-Tate's dBase III+ was used to read the data from the reformatted text files directly into the standard raw telemetry record structure. All record structures contain only core information that can be read and written by any version of Ashton-Tate's dBase (I-IV) or its workalikes.

TeleBase (Wynn 1989*a*), a computer program based on TELEM (Koeln 1980), was written to calculate wild turkey locations using the 3 standard dBase telemetry record structures. The first file is a list of station numbers and their associated coordinates (Table 2). The coordinates can be any Cartesian *x,y* pair type, such as Universal Transverse Mercator (UTM) or state planar coordinates (SPCs). Station numbers are sorted as they are read into memory by the program to save search time.

The second file is the raw telemetry data associated with each triangulation (Table 1). Two stations are required to obtain each fix. The station numbers are read from raw telemetry data, and station locations are determined by searching for each station number in the stations file and reading its associated coordinates. The wild turkey number, sex, and activity code (motion switch in transmitter is active or inactive) are recorded along with its estimated location determined by triangulation between the 2 stations.

The third file (Table 3) contains wild turkey locations. If a fix is successfully obtained, its coordinates are written to this file, along with other data recorded in the raw telemetry file. If an error is encountered, it is flagged by writing

Table 2. The dBase-compatible record structure of station list file used for telemetry data storage at the Mississippi Remote Sensing Center.

Field	Field name	Type	Width	Decimal
1	STA_NO	Character	5	0
2	X_COOR	Numeric	10	3
3	Y_COOR	Numeric	10	3
Total			26	

Table 3. The dBase-compatible record structure for telemetry locations file used for telemetry data storage at Mississippi Remote Sensing Center.

Field	Field Name	Type	Width	Decimal
1	DATE	Date	8	0
2	SEX	Character	1	0
3	ANIMAL	Character	3	0
4	X_COOR	Numeric	8	0
5	Y_COOR	Numeric	8	0
6	ERR_TYPE[a]	Character	45	0
Total			74	

[a]The information in the ERR_TYPE field is a 1-sentence explanation of why a fix could not be obtained.

specific negative *x,y* coordinates to the locations file, along with a 1-sentence explanation of the reason for the error so it can be located in the raw telemetry file. Once errors in location data are edited or discarded, locations can be written by dBase commands to formats readable by an assortment of statistical analysis packages (e.g., SAS [1982], SPSS [1988]), or left in dBase format and manipulated using the dBase programming language.

We next chose a standard GIS file format to write tabular data for spatial analysis. Data represented in both tabular and spatial formats have the dual advantage of allowing researchers to observe spatial trends visually in a GIS and analyze the same data set statistically in an analysis package, speeding the process of finding outliers and examining trends. We selected AutoDesk's AutoCAD Drawing Interchange Format (DXF) Version 2.5 or later (AutoDesk, Inc. 1987) for a universal spatial data format.

DXF was developed by AutoDesk as a universal format for exchanging drawings, maps, or blueprints created with the company's AutoCAD computer-aided design (CAD) software. The parallel development of GIS and CAD has resulted in DXF's being a standard data exchange format among GISs. In a recent survey published by GIS World (1989) magazine, 25 different GISs, ranging in price from $300 to $80,000, can read or write DXF files. DXF is a text format, allowing data transfer between computers of any size or operating system.

TeleDXF (Wynn 1989*b*), a companion to TeleBase, was developed to allow the transfer of telemetry location data from dBase to DXF format. TeleDXF reads the location data (as described in Table 3) and converts wild turkey locations to AutoCAD DXF "point" data (Autodesk, Inc. 1987), which consist of pairs of *x,y* coordinates with associated text identifiers. During conversion, extreme coordinates for wild turkey locations are calculated, and a rectangle is drawn around all points as a geographic reference (Fig. 1). If loaded into AutoCAD or a GIS, data appear as a map of wild turkey location points with identifying numbers that correspond to their record numbers in the original dBase location file. The numbers are automatically scaled to be proportional in size to whatever computer display is being used when viewed.

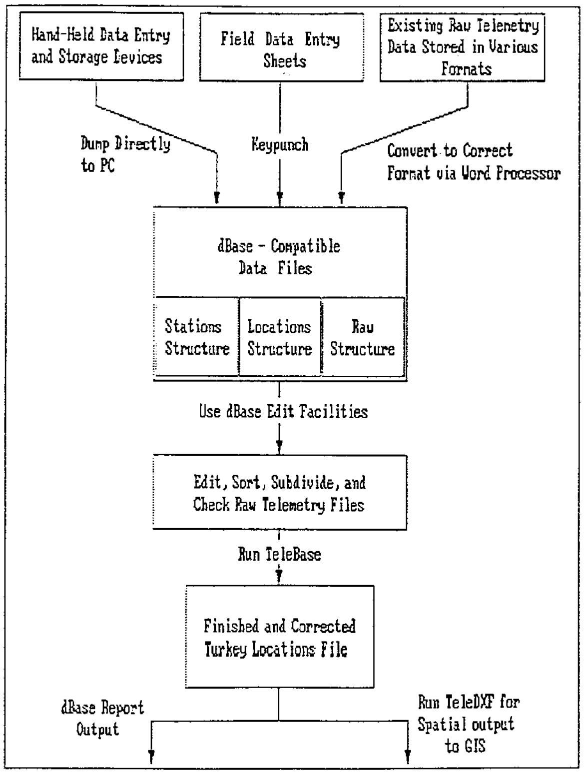

Fig. 1. Flowchart depicting the flow of raw telemetry data for field collection, through entry into the correct dBase format, and finally into finished turkey location data generated by TeleBase 1.0.

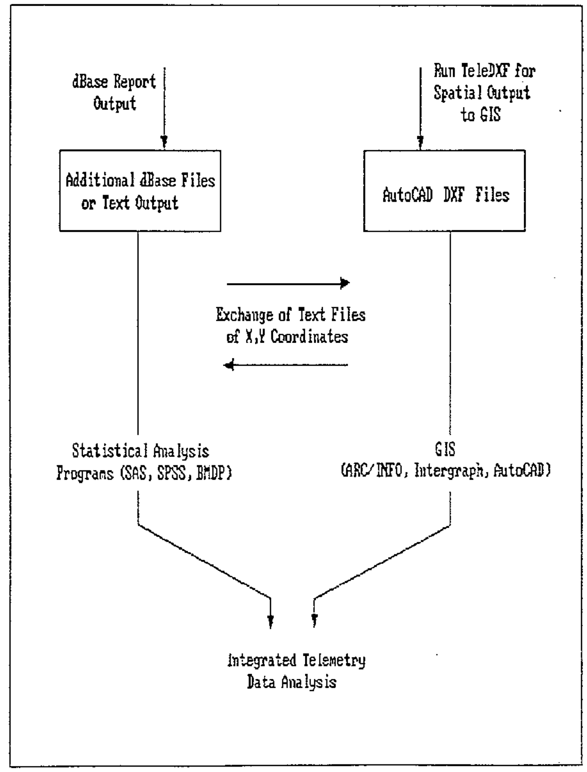

Fig. 2. Flowchart depicting the flow of telemetry locational data produced by TeleBase 1.0 into inputs and eventual output for both tabular (database) and GIS (spatial) analysis programs.

RESULTS AND DISCUSSION

The above procedures were used on 2 wild turkey research projects. All existing telemetry data were converted to the standard dBase format, and all new data were entered directly using custom dBase screen data entry forms. The dBase format allowed checking for errors, sorting, and movement within the data files, which consisted of over 16,000 actual telemetry locations. Analyses were performed on these data using SAS, MCPAAL (1986), and other statistical programs.

While work with telemetry locations was progressing, several data layers from 1 project's study area were digitized into a commercial GIS. The study was of wild turkey use of loblolly pine *(Pinus taeda)* plantations in Kemper County, Mississippi (Smith 1988, Burke 1989). The GIS database covered a map area of approximately 25 x 25 km, and contained over 700 individually coded forest stands. Stand data, such as type, age, and silvicultural management history, were also stored in dBase format. Map layers digitized included land cover type, forest stand and streamside management zone (SMZ) boundaries, surface hydrology, and roads.

Telemetry data were transfered from dBase format to several GIS formats, including ERDAS (ERDAS, Inc. 1988), AutoCAD, and ARC/INFO (ESRI 1989), using the TeleDXF conversion, and between GISs by their own conversions. Telemetry location data were used as layers in the GIS databases, allowing analysis of habitat use vs. availability, home range, use of SMZs, and distance and density of point locations to streams and roads. Geographic data allowed visual recognition of use trends, while the tabular data provided information for detailed interpretation of use trends and tests of significance.

In addition, random point locations were generated with a GIS to compare actual wild turkey use to expected use. These locations were output back to dBase format using output utilities, allowing the use of tabular statistical analysis programs with data generated independently within a GIS. Tabular and geographic systems support each other, making the transition between them less tedious and more efficient (Fig. 2).

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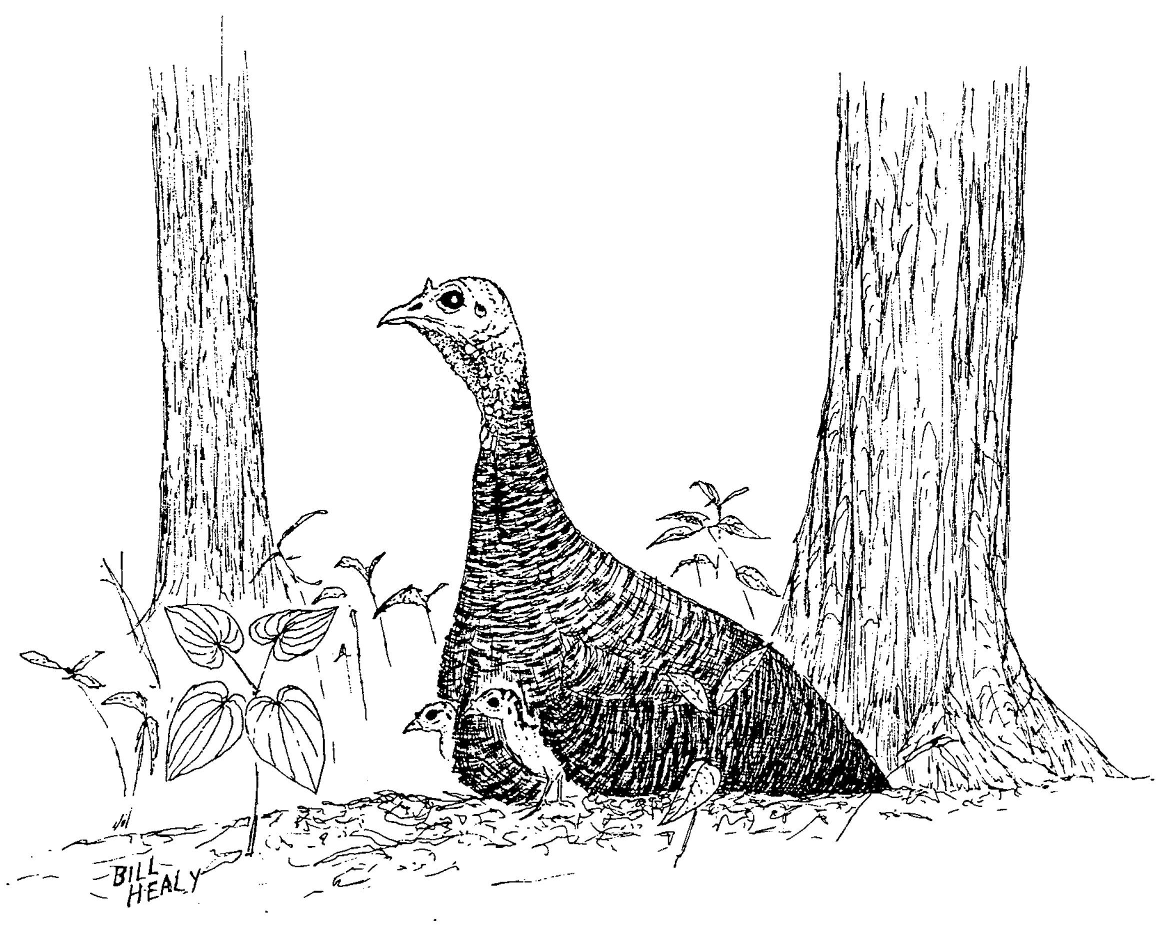

DISTINGUISHING INDIVIDUAL MALE WILD TURKEYS BY DISCRIMINATION OF VOCALIZATIONS

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Abstract: Collection of data for census and distribution of a state endangered subspecies of Gould's wild turkey *(Meleagris gallopavo mexicana)* has been a major problem. Because capture was not allowed, radio-telemetry or tagging techniques could not be used. Therefore, bioacoustical analysis was developed using sound equipment and personal computer to identify individual gobblers. Individual gobblers were identified during 1987-89. We can determine census and distribution data without using more costly observer teams. Subspecies differentiation between Merriam's *(M. g. merriami)*, Rio Grande *(M. g. intermedia)*, and Gould's was determined. We discovered that the initial portion of gobbles of 3 subspecies were of different frequencies.

The endangered Gould's wild turkey of New Mexico has been the subject of a joint research project by the New Mexico Wild Turkey Federation and the Fisheries and Wildlife Sciences Department of New Mexico State University since 1982. Because the bird is an endangered subspecies, data collection has been difficult, particularly with regard to census and distribution. Capture was not allowed and therefore usual procedures such as tagging and radio-telemetry were not possible.

Gobblers were tape recorded during the 1987-89 breeding seasons by calling them to within 100 m of the observer. The recording apparatus is described in Appendix A. The turkey gobble is a fixed action pattern given with equal intensity regardless of the motivational state of the gobbler (Schleidt 1968).

The computer readout is based on the correlation of individual gobblers compared with each other. Based on our study we have determined that individual gobblers have distinct spectrogram characteristics. These spectrograms are similar for the same gobbler recorded at different times and are dissimilar for different gobblers.

We appreciate the assistance of G. Flachs, R. Deitner; graduate students D. Figert, V. Pinto, R. Willging, D. York; and undergraduates R. Aaltonen, C. Dixon, and M. Foley. New Mexico State University Agriculture Experiment Station and New Mexico Wild Turkey Federation provided funding.

METHODS

Verner and Lehman (1982) had used voice print techniques with bald eagles *(Haliaeetus leucocephalus)*. A pilot study (Bushman 1986) was conducted to determine the feasibility of bioacoustical techniques. Bushman showed that individual turkey spectrograms could be visually differentiated. He further showed that by using a cross correlation technique, a computer could be programed to make the differentiation. Because the study was positive, a bioacoustic system was developed. Our system consists of audio recording equipment (App. A) for field use, a personal computer, and programs (App. B) for the laboratory.

Our tapes recorded in the field were analyzed in the laboratory with computer programs written by the authors. The programs were designed for data acquisition, spectrogram and oscillogram production, comparison of spectrograms, and data management. This paper explains how the system works and reviews the results obtained.

The date, time, weather conditions, direction and distance of the turkey, vegetation, and forest noises all need to be recorded and filed with the computer database. The field observer needs to be well acquainted with methods described by Kinsler (1982). All these factors affect the transmission of bird vocalizations, and detailed notes are essential for selecting calls for analysis and interpreting the results. Observers also must master the techniques used by the turkey hunter in pursuing the wary bird to call him in and to record his gobble in the field. In this respect the observer must become an expert turkey caller.

Our first program is commercial software and assists in the process of initial review and in the selection process of gobbles (LPCLAB program produced by Data Translation Inc., Marlboro, Mass.).

Our second program is Data Acquisition, which selects gobbles from the recorder tape, digitizes the selected gobble, and provides for data storage. The program is written so that any selected gobble is limited to a sampling rate of 5,370 samples (or numpts) per second. We have found this feature useful in the analysis process because of recognition of superimposed gobbles and extraneous field noises.

The third program produces spectrograms and oscillograms associated with each gobble. The spectrogram and oscillogram are used in comparing gobbles for identification of particular birds (Wiley and Richards 1982). The analysis of the spectrogram is summarized as a Discrete Fourier Series (DFS) whose coefficients are stored. The spectrogram is viewed as an image.

The DFS of individual gobbles are compared using an index of similarity that is a slight modification of the special correlation metric (Chatfield 1984). This measure is more sensitive to changes in pitch.

The fourth computer program pertains to Data Management. The data are stored with their description in the database. Each binary spectrogram is stored so that recent gobbles follow older gobbles. Trails of turkey gobbles are formed by comparing calls with the most recent data and with all previous data.

Information on computer programs and availability may be obtained from Dep. Fishery and Wildlife Sciences, Box 30003, Dep. 4901 (ATTN: S.D. Schemnitz), New Mexico State University, Las Cruces, NM 88003-0003.

RESULTS

Approximately 400 Gould's wild turkey calls were heard and recorded in 1987 through 1989. Seventy-four of these calls are identified by name and stored in the computer, and 35 were selected for analysis.

Twenty-eight calls were determined to be different birds while 7 were duplications of previously heard gobbles of different years. The extent of movements of identical birds from year to year ranged from 1.6 to 11.2 km.

The oscillograms and spectrograms of gobble recordings (Figs. 1, 2) are printed out by the computer system. The oscillogram (Fig. 1), although not used in the computer correlation of individual birds, is a useful tool for recognizing various amplitudes and time duration of gobble. The spectrogram (Fig. 2) is the basis for the computer correlation that analyzes about 5,000 points of data to compare 1 spectrogram with another (Bushman 1986). The number of frequency bands varies with individual birds and ranges between 2 and 4. The spectrogram (Fig. 2) has 2 distinct frequency segments.

The oscillograms and spectrograms of Figs. 3 and 4 visually demonstrate the comparison of the same bird and different birds. Note the correlation numbers of dissimilar birds and similar birds. Also note the marked sameness of the same bird recorded at different times but with different initial identification labels and those of different birds with their different identification labels. The 5% spectrogram is part of the computer programing, which eliminates all of the signal except a specified amplitude percentage. This process eliminates all but essential parts of the turkey call and gets rid of superfluous noises.

The computer correlation of 2 gobbles involves comparison of data points (Figs. 3, 4). If the same gobble is compared with itself, the correlation number is 1. If 2 different gobbles of the same bird are compared, the correlation number is somewhere between 0.41 and 1.0. If the gobbles of 2 different birds are compared, the number is between 0 and 0.41. The number 0.41 is changeable and is currently used by our system to separate the same bird gobbles from different bird gobbles. The number 0.41 is based on our experience in the field in recording known identical birds and different birds. Obviously, correlation numbers of around 0.4 are borderline, and correlation numbers near it should be evaluated carefully in line with observer comments.

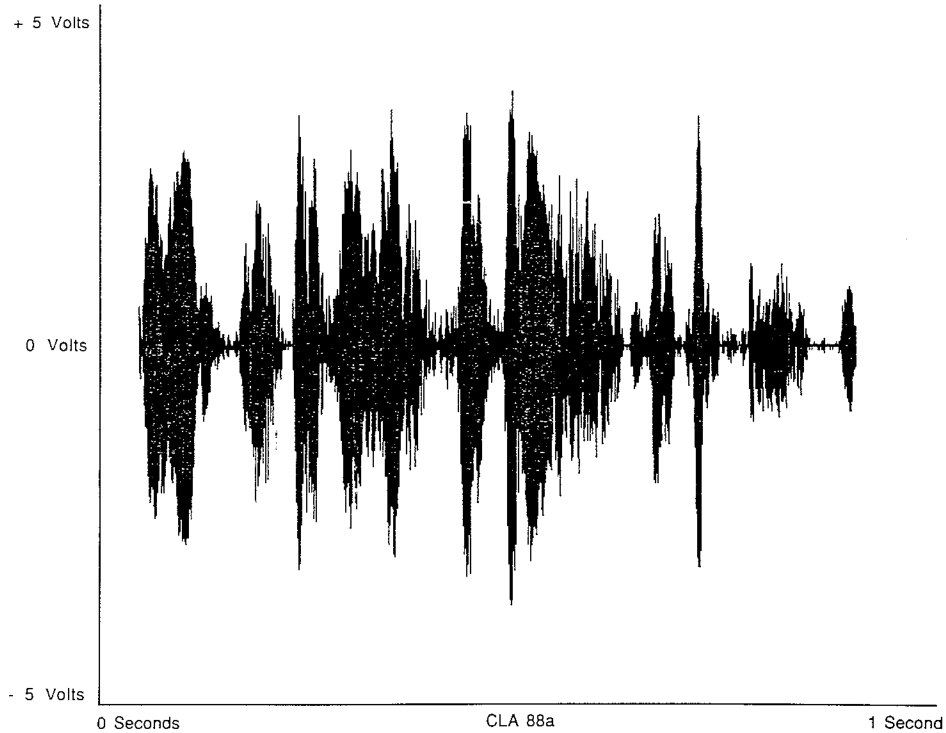


Fig. 1. Oscillogram of a selected turkey gobble (Whit 87b). Amplitude of signal is measured on the vertical axis in volts, the horizontal axis in time.

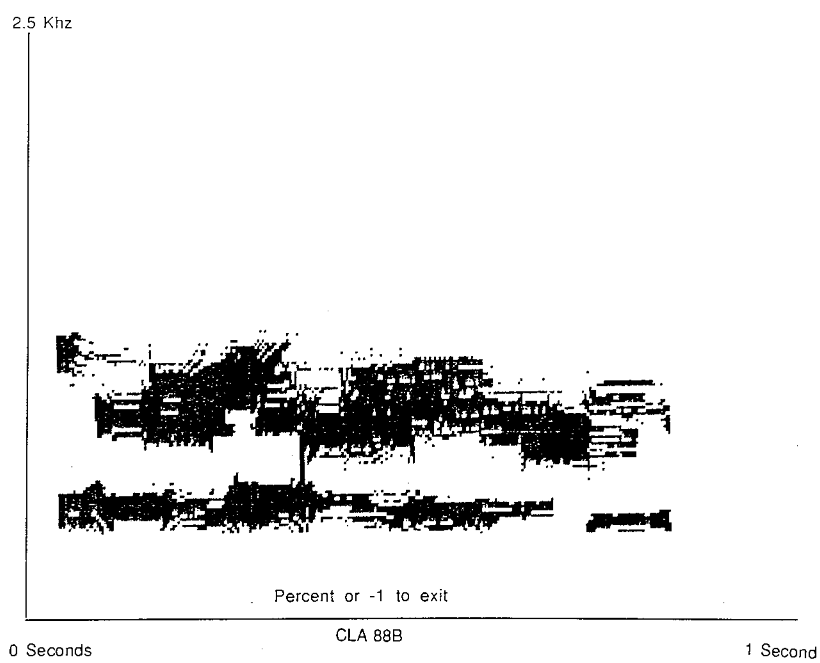
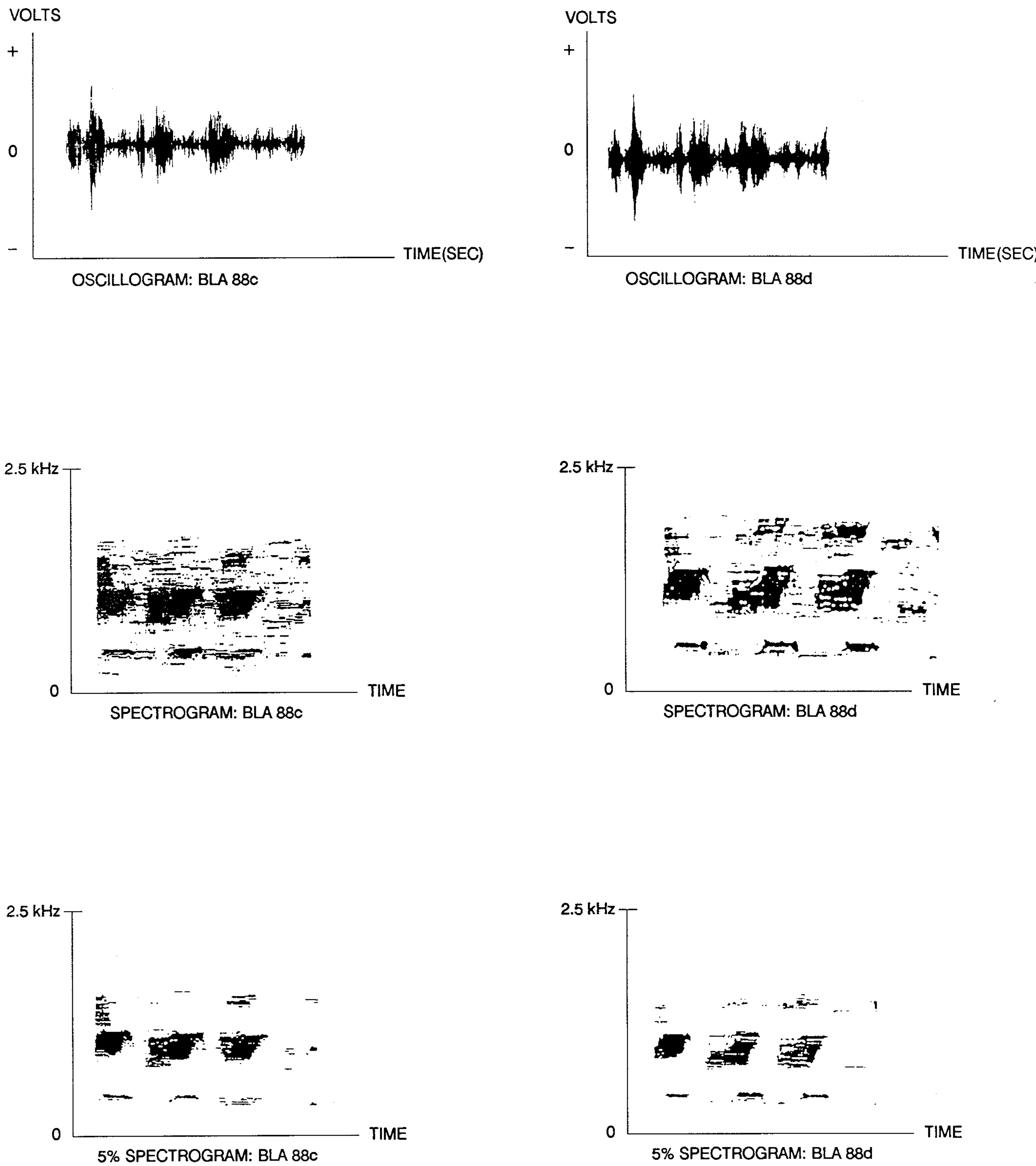
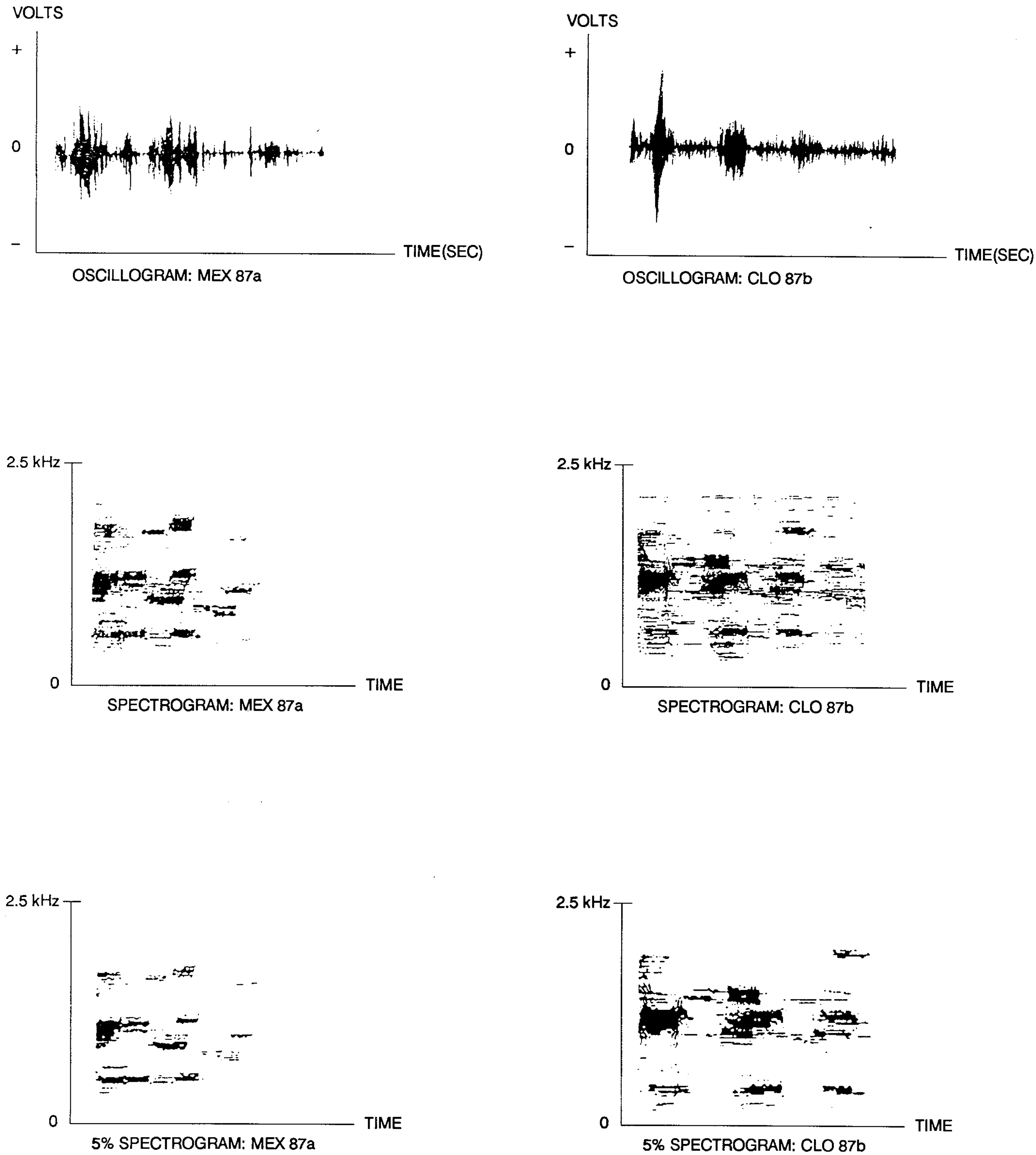


Fig. 2. Spectrogram of a turkey gobble. Diagram shows gobble to be in 2 frequency segments of about 0.5 kHz and 1 kHz.



Correlation Number 0.598584

Fig. 3. Comparison of spectrograms and oscillograms of the same turkey recorded gobbling at different times.



Correlation Number 0.347844

Fig. 4. Comparison of spectrograms and oscillograms of gobbles of different turkeys.

Subspecies were recognized by visiting known habitat areas of the Gould's, Merriam's, and Rio Grande turkeys. Recordings were made in each area and 6 samples of Merriam's, 15 of Gould's, and 11 of Rio Grande were plotted. We could demonstrate differences by comparing the initial average high portion of the spectrograms of several birds (note Fig. 2 for high initial segment). Figure 5 shows the frequency high of Merriam's averages about 1600 kHz, Gould's about 1300 kHz, and Rio Grande about 700 kHz. There was minimum overlapping between Merriam's and Gould's.

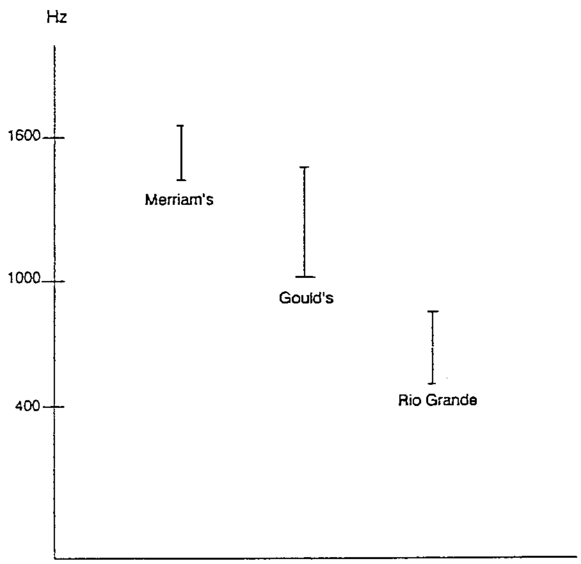


Fig. 5. Average frequency plots of initial portion of gobble of Merriam's, Gould's, and Rio Grande wild turkeys.

DISCUSSION

The system has proven itself an effective tool for research and wildlife management. We have been able to determine census data without actually seeing the gobblers. However, we have recently received permission to capture birds and with tagging we should be able to correlate sightings with recordings and develop a more definitive process of accurately determining any changes in gobbles from year to year.

Field observers should be familiar with fundamental acoustics (Kinsler 1982) and sound transmission and signal detection (Wiley and Richards 1982); be able to comment on possible effects of scattering (Givens et al. 1946), atmospheric absorption and reverberation (Richards and Wiley 1980), vegetation (Aylor 1971), and wind turbulence (Munn 1966, Stringer 1972).

Perhaps the most valuable contribution of the personal computer is in the data management program. This program permits the storage of data in an orderly way so that they can be readily retrieved and compared. This management technique allows the presence and movement of birds for yearly mating seasons to be chronicled and provides indications of population and distribution. Future use of the system may include identification of hens.

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Appendix A. Equipment and sources for recording and analyzing wild turkey calls.

Equipment components of the system are in 2 parts: those for field recording and those for laboratory analysis. A list of equipment and availability data follows:

1. Six "Bionic Ears" (directional microphones) with parabolic reflectors (Bionic Ear Co., Silver Springs, Ind.).
2. Six tripods fabricated from 3/4-inch PVC pipe.
3. Two specifically designed low-pass filters with a high side cutoff at 2500 cycles per second.
4. Four commercial stereo equalizers for multiple applications (Tandy Corporation).
5. Three X15 Fostex portable stereo recorders (Fostex Corporation of America, Norwalk, Calif.).
6. One 8-watt stereo amplifier (hand made).
7. One IBM PC compatible personal computer with 640 Kbyte memory.
8. One printer for PC.

Field Equipment.--The field equipment hookup consists of a directional, parabolic microphone connected through a low-pass filter to a stereo recorder that makes a permanent record of turkey calls on a cassette tape. The low-pass filter eliminates sounds above the frequency of the turkey call.

The stereo recorders are X15 Fostex models and are used both in the field and laboratory. The recorder can be used to record 2 tracks of the 4-track tapes simultaneously. Monitoring is done visually by observing an electronic display and audibly by earphones or loudspeaker. The microphone is a Bionic Ear attached to a parabolic reflector that increases the sensitivity by 17 times. Tripods were fabricated with PVC pipe, which are light and easily assembled. The low-pass filters were locally fabricated. The filter reduces high frequency forest sounds and reduces introduction of harmonics.

Laboratory equipment.--The laboratory equipment consists of a recorder, a locally made 8-watt stereo amplifier, speaker, and a COMPAQ portable computer with 640 k memory and equipped with a terminal board and a digitization board. A hard disk and printer are included.

Appendix B. Computer software for managing and analyzing data on turkey gobbles.

The computer programing (software) used for the system consists of 4 programs.

(a) The LPCLAB commercial routine, which can present up to 3 turkey calls simultaneously on the screen, measures amplitude and time duration, and compares calls occurring on tape for a 60-second period to assist the analyst in selecting signals for further analysis (Fig. 6).

(b) Three additional programs were written in "C" language using selected 1986, 1987, and 1988 calls as a basis. Selected calls for program development were known to be from either the same turkey or from different turkeys.

The first step for the analysis is the collection of data. Once the data are available, there needs to be a method for comparing gobbles, and to decide whether the calls represent the same turkey. To be useful, this capability must be teamed up with some data management capabilities. We developed software for all 3 of these areas.

Data acquisition.--The turkey gobbles are stored on audio cassette and must be digitized before any analysis can be performed. This first step is very important; a mistake here will render the results of the analysis invalid. One of the important parameters is the sampling rate. This rate must be chosen such that the signal is not aliased. Aliasing is a disorder that transforms frequencies higher than half the sampling frequency into lower frequencies. If aliasing were to occur, the resulting data would be useless. On some tapes, jay (*Aphelocoma* spp.) calls are audible, and frequencies as high as 8 kHz can be identified on a spectrum analyzer. These recordings must be sampled at 16,000 samples/second or more. Hardware limitations make 20,000 samples/second the safest choice.

Because turkey gobbles do not exhibit frequencies above 2.0 kHz, a third order elliptical filter is employed to eliminate all frequencies above 2.5 kHz. The signal is then decimated to 5,000 samples/second. These 2 steps reduce the amount of data for the average 1-second turkey gobble to 5,000 samples. A 80386-based personal computer can process these signals reasonably efficiently.

The operation of the data acquisition software requires the user to start the digitizer, play the tape, and stop the digitizer after a gobble has been heard. The software employs a circular buffer to remember that last 4 seconds of data. Next, the user is asked to locate the relevant portion of the oscillogram. Before the data are saved to disk, a description of the gobble must be entered. This description accompanies the data throughout the process and is only a part of the careful documentation effort that must be made for the results to be meaningful.

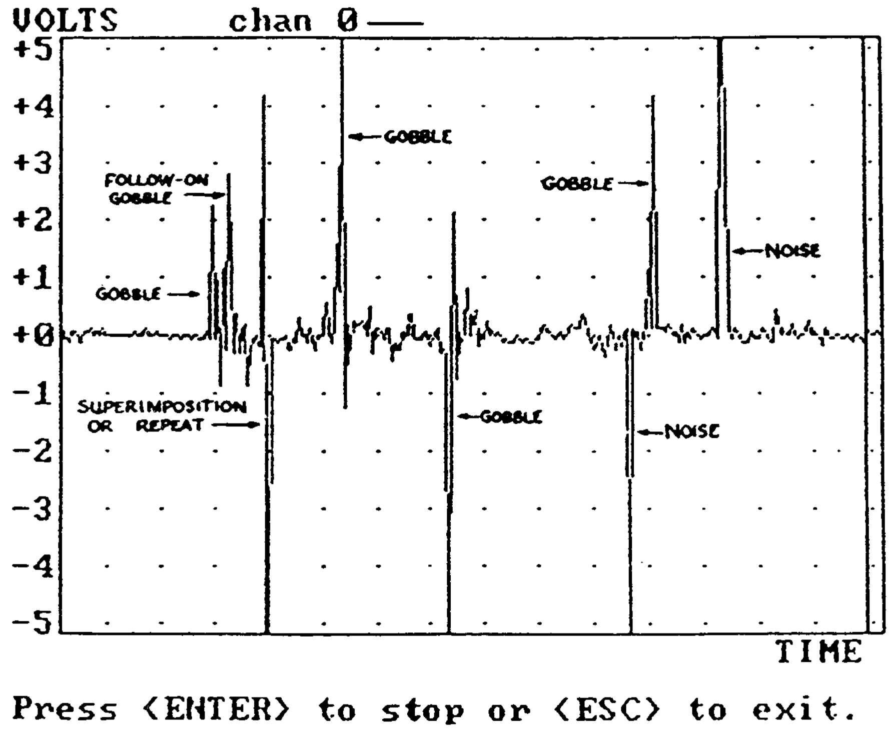

Fig. 6. This LPCLAB display shows a sequence of calls recorded for a 1-minute period. Note probable call doubling, follow-on gobble, and noise labels.

Spectrograms.--To identify turkeys by their gobbles, there must be some feature characteristic of an individual turkey. A spectrogram is a plot of frequency content over time and has been found useful in identifying human speakers. Common features between avian communication and human language has been demonstrated (Marler 1970).

To compute a spectrogram, start at the first sample and consider the next Nw samples as a window. Compute the Discrete Fourier Series (DFS) of the window and remember the magnitude of the frequency coefficients. Slide the window to the next sample and compute the DFS for the window. Repeat this process, sliding the window to the end of the data. Once the spectrogram is computed, it can be viewed as an image.

The essence of the spectrogram can be captured by converting it to a binary image. A pattern preserving the major features of a turkey's spectrogram can be generated by assigning the most intense 5% of the coefficients to the value 1 and all others to 0. Although minor features will be lost, most of the irrelevant forest disturbances also will be eliminated.

When the correlation between 2 spectrograms exceeds a certain threshold (our threshold is 0.41) the 2 gobbles will be judged to belong to the same turkey. This threshold is a critical factor in determining the probability of error. Unfortunately, there is no threshold that will simultaneously be greater than all autocorrelations between gobbles of different turkeys and less than the correlations between gobbles from the same turkey. All we can do is adjust the threshold so that the minimum probability of error (Smith 1978) is achieved.

Data management.--After the data are acquired, they must be stored in a database so that relationships between the gobbles can be stored and used. Each gobble's binary spectrogram is stored with its description in the database so that recent gobbles follow older gobbles. Once a gobble is entered into the database, trails of turkey sightings can be formed. These trails are formed by comparing, one by one, the most recently gathered data with all previous gobbles. Associations are made such that autocorrelation is maximized and exceeds a minimum threshold. The trails are maintained through the use of a doubly linked list. Adding a new gobble is a matter of daisy-chaining (linking) it onto the previous gobble.

The use of the linked list also allows the user to maintain the database easily. Occasionally, the investigator will disagree with the generated trails based upon experience and documentation taken at the time of the sighting. In this case, the operator must be allowed to alter the trails. In fact, the investigator may wish either to establish new associations or erase an existing pairing. Either task can be accomplished merely by adjusting the linking references.

EXPENDITURES FOR WILD TURKEY HUNTING

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Abstract: Following the 1988 spring turkey *(Meleagris gallopavo)* season in Missouri and the 1989 spring season in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia, survey questionnaires were mailed to randomly selected turkey hunters in their respective states. Two questions concerning expenditures during the spring season and annual household income were included on the survey. In addition, similar surveys were mailed to National Wild Turkey Federation members in South Carolina and West Virginia. Average expenditures by hunters ranged from \$92.45 (Missouri) to \$428.20 (South Carolina) for residents and \$140.77 (West Virginia) to \$704.20 (South Carolina) for nonresidents. Expanding these data further, total expenditures by all turkey hunters ranged from \$592,514.79 in Minnesota to \$40,839,645.00 in Pennsylvania with a mean of \$12,333,719.88. The highest percentage of respondents in each state had an annual total household income of \$25,000 to \$49,999. Average expenditures by National Wild Turkey Federation members in South Carolina and West Virginia were \$578.13 and \$259.11, respectively. The highest percentage of these hunters were in the \$25,000 to \$49,999 total household income category.

Wildlife-associated recreation (fishing, hunting, and nonconsumptive use) is an important form of outdoor recreation. In 1985, there were 46.4 million fishermen, 16.7 million hunters, and 134.7 million nonconsumptive wildlife users (U.S. Fish and Wildlife Service 1988). Total expenditures on wildlife-associated recreation was \$55.7 billion of which hunters spent \$10.1 billion (U.S. Fish and Wildlife Service 1988). The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation showed that 1.9 million hunters spent 14.9 million days hunting wild turkeys in 1985 (U.S. Fish and Wildlife Service 1988). This survey did not provide separate estimates of expenditures by wild turkey hunters.

As wild turkey populations increased through successful trapping and relocation of wild birds, the number of turkey hunters has increased. Trends in the number of wild turkey hunters are up in 40 of the 46 states that allow spring turkey hunting (Kennamer 1986). Knowledge of the effect that spring turkey hunters have on each state's economy is important because these data help justify reintroduction programs, research, population and habitat management, and habitat acquisition.

The purpose of this study is to provide information on expenditures by spring turkey hunters in 6 states.

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METHODS

Questionnaires were mailed to randomly selected resident and nonresident spring turkey hunting permittees following the 1988 spring season in Missouri (MO) and the 1989 season in Arizona (AZ), Minnesota (MN), Pennsylvania (PA), South Carolina (SC), and West Virginia (WV). Table 1 indicates numbers of hunters

Table 1. Number of hunters surveyed, number responding, response rate, and number of mailings by state for a survey of expenditures by spring wild turkey hunters, 1988 (MO) and 1989 (AZ, MN, PA, SC, WV).

State	Hunters surveyed	Respondents	% response	Mailings
Arizona	1,996	1,071	53.7	1
Minnesota	1,966	1,802	91.7	4
Missouri	6,700	5,041	75.2	3
Pennsylvania	2,997	599	20.0	1
South Carolina	2,643	476	18.0	1
West Virginia[a]	1,273	639	50.2	2

[a]Includes 100 hunters surveyed by telephone.

surveyed, number responding, response rate, and number of mailings for each state.

To provide uniformity, 2 questions regarding expenditures were taken from the 1988 Missouri survey and included on the 5 other participating state surveys. The first question asked for an estimate of expenditures incurred during the 1988 spring season in MO and the 1989 spring season in the other 5 states. The expenditures were divided into 10 categories: special hunting clothes, turkey calls, ammunition, new firearms, transportation (gas, oil, repairs), lodging (motel, cabin, campgrounds), food and drink (restaurants, groceries, snacks), rented/leased hunting land, taxidermy, other related items (camera film, boot grease, knives, etc.). The second question asked respondents to check the category best describing their total household income last year (<$10,000, $10,000-$14,999, $15,000-$24,999, $25,000-$49,999, ≥$50,000).

Mean expenditures for each of the 10 expense categories were calculated separately as well as for all categories combined. If a hunter did not report spending money in an expense category, a zero was listed for that category. To calculate total expenditures by all respondents for each category and for all categories combined the following formula was used:

Total expenditure for a category = A x B x C
where

A = Expenditure for a category
B = Proportion of respondents who hunted during the spring season
C = Number of permits or tags issued.

Means and standard errors were also calculated for each of the 10 expense categories only for respondents who said they spent money in a particular category. Thus, respondents who did not spend money in a particular category were excluded. For example, the mean amount spent in the guns category would be an estimate of what an individual hunter would pay for a gun.

In addition to the questionnaires mailed to spring turkey hunting permittees or tag recipients, a survey with the same questions was mailed to all NWTF members in SC and WV. Of 2,987 surveys mailed in SC, 831 responses were returned. In WV approximately 600 surveys were mailed and 210 returned. The results of these surveys were not included with the random sample of permittees but were analyzed separately.

Information on the total annual household income questions were computed by state; the NWTF surveys in SC and WV were analyzed separately. No effort was made to correct for nonresponse bias on any of the surveys.

RESULTS AND DISCUSSION

Missouri

Resident 1988 spring turkey hunters in MO spent the most money on transportation, followed by guns, food, clothing, and calls (Table 2). Nonresidents spent more money than residents in each of the 10 categories (Table 3). Nonresidents spent the most money on transportation, followed by food, guns, clothing, and lodging (Table 3). Because leasing land for spring turkey hunting is not prevalent in MO (Table 4), the least amount of money was spent on leases by both residents and nonresidents.

Average total expenditures (not including permit costs) were $92.45 and $290.18 for

Table 2. Average expenditure per resident turkey hunter during the 1988 spring season in Missouri and 1989 in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia (*n* respondents in parentheses). If a hunter spent money in at least 1 category, a value of zero was included for categories left blank.

	Missouri (3,928)		Arizona (876)		Minnesota (1,572)		Pennsylvania (519)		South Carolina (328)		West Virginia (515)	
Item	$\overline{x}$	SE	$\overline{x}$	SE	$\overline{x}$	SE	$\overline{x}$	SE	$\overline{x}$	SE	$\overline{x}$	SE
Clothing	$13.21	0.37	$13.88	1.00	$22.48	0.88	$26.31	7.78	$34.90	3.00	$14.97	1.32
Calls	7.34	0.13	9.56	0.46	14.35	0.33	10.38	1.96	21.80	2.30	7.85	0.56
Ammunition	6.13	0.10	6.96	0.30	6.53	0.17	7.87	2.70	18.40	4.10	6.34	0.86
Guns	16.73	1.13	17.15	3.09	15.07	1.94	41.06	30.57	55.20	8.80	30.48	4.44
Transportation	23.08	0.72	57.07	1.73	35.28	0.85	35.83	12.25	89.00	9.00	21.01	1.43
Lodging	2.07	0.22	6.45	0.88	17.21	0.84	11.43	17.35	7.70	2.20	3.85	0.77
Food	13.99	0.39	46.07	1.62	33.12	0.93	31.46	17.63	33.50	3.40	13.80	1.26
Land	2.49	0.47	.28	0.23	0.80	0.20	4.48	25.64	142.00	34.00	4.65	1.35
Taxidermy	2.72	0.38	6.02	1.23	9.26	1.08	4.20	11.11	6.20	2.20	0.54	0.31
Other items	4.69	0.35	9.85	0.57	12.29	2.00	7.68	5.68	19.50	5.00	8.08	2.45
Totals	$92.45	2.01	$173.29	5.81	$166.39	4.54	$180.70	50.81	$428.20	47.00	$111.57	8.26

Table 3. Average expenditure per nonresident turkey hunter during the 1988 spring season in Missouri and 1989 in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia[a] (*n* respondents in parentheses). If a hunter spent money in at least 1 category, a value of zero was included for categories left blank.

	Missouri (477)		Arizona (16)		South Carolina (64)		West Virginia (124)	
	$\overline{x}$	SE	$\overline{x}$	SE	$\overline{x}$	SE	$\overline{x}$	SE
Clothing	$ 28.68	1.90	$ 19.50	8.50	$109.00	60.00	$ 14.63	3.26
Calls	12.42	0.61	11.75	3.26	53.00	24.00	5.58	0.94
Ammunition	7.71	0.33	4.63	1.54	13.20	1.50	3.44	0.65
Guns	31.10	5.15			36.00	15.00	16.22	5.54
Transportation	90.15	5.11	93.69	19.21	126.00	16.00	20.60	2.99
Lodging	27.63	2.68	12.50	12.50	86.00	40.00	9.40	2.78
Food	61.47	2.68	64.38	9.97	84.00	13.00	23.08	3.62
Land	5.86	1.75			155.00	37.00	16.92	8.88
Taxidermy	9.78	1.97	14.38	14.38	20.10	8.60	0.36	0.36
Other items	14.37	1.18	61.81	44.78	21.90	4.80	29.05	15.37
Totals	$290.18	11.31	$282.64	49.34	$704.20	109.00	$140.77	27.70

[a]Two states excluded: Minnesota, no nonresidents; and Pennsylvania, insufficient sample.

Table 4. Percentage of resident and nonresident respondents who spent money on leasing of land for spring turkey hunting during the 1988 season in Missouri and the 1989 season in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia.

State	Resident	Nonresident
Missouri	2.4	3.6
Arizona	0.3	0.0
Minnesota	2.4	a
Pennsylvania	2.9	b
South Carolina	31.7	45.0
West Virginia	5.4	8.1

[a]No nonresidents.
[b]Insufficient sample.

residents and nonresidents, respectively (Tables 2, 3). The average total expenditure for residents and nonresidents combined was $113.86 (Table 5). Expanding these figures to all permit buyers who hunted (90,624), the total expenditure was $10,318,448.64, excluding permit costs (Table 6). Spring turkey hunting permit buyers in 1988 killed 30,184 turkeys; thus, each turkey killed resulted in an expenditure of $341.85.

Total expenditures by permit buyers underestimate total expenditures for spring turkey hunters because landowners may hunt on their land without purchasing a permit. These landowners could not be included in the survey because addresses were not available. Approximately 8,500 landowners (assuming their success rate was similar to permit buyers) killed 3,003 turkeys during the 1988 spring season.

In 1988, 87,987 resident and 6,314 nonresident spring turkey hunting permits were sold. Resident and nonresident permit costs were $8.00 and $55.00, respectively. Hunters, therefore, spent an additional $1,051,166 for permits.

The average expenditure for a particular category for only those who spent money in that category are shown in Tables 7 and 8. Residents spent the most money on taxidermy followed by guns, land leases, lodging, and clothing. Nonresidents also spent the most money on guns followed by land leases, taxidermy, lodging, and food.

Because economic industries are interrelated, money spent in 1 sector of the economy tends to multiply through other economic sectors. In MO, the overall multiplier for the amusement and recreation sector of the economy is 1.964 (Harmston 1977). Thus, to determine the total impact of spring turkey hunting on MO's economy, the total expenditure should be almost doubled. Considering expenditures for turkey hunting in MO, the $146,775 (Table 9) spent by the MO Department of Conservation on the wild turkey program in fiscal year 1988-89 was money well spent.

Most respondents had a household income between $25,000 and $49,999 (Table 10).

Arizona

Resident turkey hunters spent an average of $173.29 (Table 2) and nonresidents $282.64 (Table 3). Greatest expenditures by resident hunters were for transportation, followed by food, guns, clothing, and other items. Nonresidents spent the most on transportation, followed by food, other items, clothing, and taxidermy. Land leasing for turkey hunting was not prevalent in AZ (Table 4). Expenditures for residents and nonresidents combined averaged $175.27 (Table 5).

Total expenditures by 3,683 (3,617 resident, 66 nonresident) spring hunters amounted to $645,519.44 (Table 6). Spring hunters took 618 birds, resulting in an expenditure of $1,043.88 per bird. Resident and nonresident hunters spent an additional $135,889.00 for turkey tags, application fees, and licenses. The average expenditures for a particular category for only those hunters who spent money in that category are shown in Tables 7 and 8. Residents spent the most on guns, followed by taxidermy, land leasing, lodging, and transportation (Table 7). Nonresidents spent the most on taxidermy, followed by lodging, transportation, other items, and clothing (Table 8). The AZ Game and Fish Department expended approximately $43,000 (Table 9) on their wild turkey program during fiscal year 1988-89. The highest percentage of hunters had an annual household income in the $25,000 to $49,999 category (Table 10).

Table 5. Average expenditures per turkey hunters (resident and nonresident) combined during the 1988 spring season in Missouri and 1989 in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia (*n* respondents in parentheses). If a hunter spent money in at least 1 category, a value of zero was included for categories left blank.

Item	Missouri (3,928)		Arizona (892)		Minnesota (1,572)		Pennsylvania (519)		South Carolina (328)		West Virginia (515)	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Clothing	$ 14.90	0.40	$ 13.98	0.99	$ 22.48	0.88	$ 26.31	7.78	$ 47.00	10.00	$ 14.90	1.24
Calls	7.90	0.14	9.60	0.45	14.35	0.33	10.38	1.96	27.00	4.40	7.41	0.49
Ammunition	6.31	0.09	6.92	0.30	6.53	0.17	7.87	2.70	17.60	3.40	5.78	0.71
Guns	18.30	1.15	16.85	3.03	15.07	1.94	41.06	30.57	52.10	7.80	27.71	3.74
Transportation	30.33	0.90	57.73	1.94	35.28	0.85	35.83	12.25	95.00	8.00	21.22	1.29
Lodging	4.82	0.37	6.56	0.89	17.21	0.84	11.43	17.35	20.50	7.00	4.92	0.83
Food	19.13	0.50	46.40	1.60	33.12	0.93	31.46	17.63	41.70	3.70	15.60	1.25
Land	2.85	0.46	0.28	0.23	0.80	0.20	4.48	25.64	144.00	29.00	7.03	2.04
Taxidermy	3.46	0.40	6.17	1.29	9.26	1.08	4.20	11.11	8.50	2.30	0.51	0.26
Other items	5.86	0.34	10.78	1.24	12.29	2.00	7.68	5.68	19.90	4.30	12.15	3.59
Totals	$113.86	2.35	$175.27	5.79	$166.39	4.54	$180.70	50.81	$473.30	44.00	$117.24	8.55

Table 6. Total estimated expenditures by Missouri spring turkey hunters in 1988, and Arizona, Minnesota, and Pennsylvania, South Carolina, and West Virginia spring hunters in 1989 (*n* in parentheses).

Item	Missouri (90,624)	Arizona (3,683)	Minnesota (3,561)	Pennsylvania (226,008)	South Carolina (32,886)	West Virginia (51,534)
Clothing	$ 1,349,274.76	$ 51,488.37	$ 80,051.28	$ 5,946,270.48	$ 1,545,642.00	$ 767,856.60
Calls	716,155.10	35,356.80	51,100.35	2,345,963.04	887,922.00	381,866.94
Ammunition	571,524.45	25,486.36	23,253.33	1,778,682.96	578,793.60	297,866.52
Guns	1,648,329.66	62,058.55	53,664.27	9,279,888.48	1,713,360.60	1,427,730.00
Transportation	2,748,812.08	212,619.59	125,632.08	8,097,866.64	3,124,170.00	1,093,551.40
Lodging	436,451.73	24,160.48	61,284.81	2,583,271.44	674,163.00	253,541.28
Food	1,734,068.76	170,891.20	117,940.32	7,110,211.68	1,371,346.20	803,930.40
Land	258,043.15	1,031.24	2,848.80	1,012,515.84	4,735,584.00	362,284.02
Taxidermy	313,910.90	22,724.11	32,974.86	949,233.60	279,531.00	26,282.34
Other items	531,367.58	39,702.74	43,764.69	1,735,741.44	654,431.40	626,138.10
Totals[a]	$10,318,448.64	$645,119.44	$ 592,514.79	$40,839,645.60	$15,564,943.80	$ 6,041,047.61

[a]Totals are not equal to the sum of the categories because of rounding error.

Table 7. Expenditures by resident turkey hunters during the 1988 spring season in Missouri and 1989 in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia. Tabled values are only for hunters who said they spent money in a particular category. Respondents who did not spend money in a particular category were excluded.

Item	Missouri			Arizona			Minnesota			Pennsylvania			South Carolina			West Virginia		
	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n
Clothing	$31.81	0.67	1,631	$42.21	2.26	288	$40.36	1.29	879	$57.80	12.19	212	$ 55.50	4.2	206	$47.88	2.85	161
Calls	11.56	0.16	2,495	18.09	0.65	463	18.14	0.35	1,249	17.59	2.69	275	28.60	2.9	249	18.29	0.91	221
Ammunition	9.16	0.10	2,630	12.50	0.39	485	10.20	0.19	1,011	13.19	3.69	278	24.00	5.2	252	14.85	1.88	220
Guns	126.90	8.40	303	288.96	39.89	52	321.59	19.67	74	294.38	86.98	65	329.00	34.0	55	193.80	20.21	81
Transport.	27.25	0.83	3,327	61.87	1.78	808	38.90	0.89	1,432	47.30	14.86	353	96.10	9.6	304	41.30	2.18	262
Lodging	46.09	3.43	176	70.66	5.99	80	51.76	1.73	525	59.20	41.85	90	88.00	20.0	29	47.17	6.49	42
Food	27.45	0.63	2,002	55.82	1.75	723	42.29	1.05	1,234	53.90	24.37	272	45.40	4.3	242	36.82	2.65	193
Land	102.00	16.24	96	82.00	59.81	3	33.16	6.61	38	139.33	155.95	15	448.00	100.0	104	85.61	19.65	28
Taxidermy	138.69	11.70	77	155.18	18.34	34	120.72	9.28	121	178.14	79.97	11	136.00	33.0	15	31.11	15.65	9
Other items	17.34	1.20	1,063	20.78	1.02	390	25.99	4.18	746	24.68	10.77	145	49.00	12.0	131	31.28	9.23	133

Table 8. Expenditures by nonresident turkey hunters during the 1988 spring season in Missouri, and 1989 in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia[a]. Tabled values are only for hunters who said they spent money in a particular category. Respondents who did not spend money in a particular category were excluded.

Item	Missouri			Arizona			South Carolina			West Virginia		
	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n	$\bar{x}$	SE	n
Clothing	$ 52.22	2.69	262	$ 52.00	15.47	6	$179.00	97.0	39	$62.55	9.61	29
Calls	17.79	0.70	333	18.80	3.70	10	67.00	30.0	51	17.74	1.82	39
Ammunition	11.22	0.33	328	8.22	2.05	9	17.20	1.6	49	14.23	1.43	30
Guns	353.19	26.85	42				233.00	74.0	10	182.82	34.85	11
Transport.	93.68	5.24	459	99.93	19.43	15	132.00	17.0	61	57.08	4.24	48
Lodging	90.90	6.19	145	200.00		1	196.00	89.0	28	68.53	13.45	17
Food	69.31	2.80	423	73.57	8.89	14	99.00	84.4	54	58.41	6.50	49
Land	164.53	30.55	17				342.00	66.0	29	209.80	94.11	10
Taxidermy	150.52	15.46	31	230.00		1	214.20	38.5	6	45.00		1
Other Items	27.98	1.80	262	57.42	16.58	12	40.00	7.6	35	120.07	61.38	30

[a]Two states excluded: Minnesota, no nonresidents; and Pennsylvania, insufficient sample.

Table 9. Approximate expenditures by state agencies for wild turkey programs in fiscal year 1988-89.

State	Expenditures
Missouri	$146,775
Arizona	43,000
Minnesota	90,000
Pennsylvania	70,000
South Carolina	58,225
West Virginia	130,246

Minnesota

All 1989 spring turkey hunters in MN were residents because spring hunting is not open to nonresidents. The average 1989 Minnesota spring turkey hunter spent the greatest amount of money on transportation, followed by food, clothing, lodging, and guns (Table 2). The average total expenditure per turkey hunter was $166.39, excluding license costs (Table 2). Few respondents leased land for turkey hunting in MN (Table 4).

Total expenditures on spring turkey hunting in 1989 were $592,514.79 without license costs (Table 6). Hunters killed 930 birds, resulting in an expenditure of $637.11 per bird. License costs for each hunter in 1989 totaled $29.50, including a $3.00 application fee, $14.00 for a resident small game hunting license, and $12.50 for a spring turkey hunting permit. Expanding this cost for all applicants and successful applicants purchasing a license and permit results in an additional expenditure of $141,327.50.

Excluding individuals who did not report spending money in a particular category, the average MN spring turkey hunter spent the most on guns, followed by taxidermy, lodging, food, and clothing (Table 7). Transportation was the most common category of spending: 90.7% of respondents spent money in that category (Table 7). Leasing land for hunting and guns were the least common categories for spending: 2.4% and 4.7% of respondents, respectively, spent money in those categories (Table 7).

Approximately $90,000 (Table 9) was spent by the MN Department of Natural Resources on the wild turkey program during fiscal year 1988-89.

Table 10. Annual household income for all 1988 survey respondents in Missouri and 1989 respondents in Arizona, Minnesota, Pennsylvania, South Carolina, and West Virginia.

Income category	Missouri		Arizona		Minnesota		Pennsylvania		South Carolina		West Virginia	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
<$10,000	387	8.3	26	2.4	86	5.5	43	8.6	24	5.0	59	13.1
$10,000-14,999	582	12.5	37	3.5	101	6.5	64	12.9	27	5.7	62	13.7
$15,000-24,999	1,219	26.1	158	14.8	314	10.2	131	26.3	78	16.4	111	24.6
$25,000-49,999	1,848	39.6	454	42.4	758	48.7	202	40.6	196	41.2	169	37.5
≥$50,000	634	13.6	355	33.1	298	19.1	58	11.6	123	25.8	50	11.1

Table 11. Expenditures by resident 1989 spring turkey hunters in South Carolina and West Virginia who responded to a questionnaire mailed by the South Carolina and West Virginia Chapters of the National Wild Turkey Federation (*n* respondents in parentheses). If a hunter spent money in at least 1 category, a value of zero was included for categories left blank.

	South Carolina (733)		West Virginia (200)	
Item	$\bar{x}$	SE	$\bar{x}$	SE
Clothing	$ 51.00	2.10	$ 30.54	3.47
Calls	28.20	2.80	16.55	1.37
Ammunition	11.63	0.42	8.36	0.67
Guns	75.80	6.90	70.43	12.54
Transportation	99.80	4.60	58.95	4.48
Lodging	15.40	2.30	4.72	1.48
Food	49.70	2.80	28.74	2.87
Land	181.00	14.00	5.19	2.30
Taxidermy	19.60	2.60	8.86	2.95
Other items	46.00	10.00	24.17	9.00
Totals	$578.13	24.00	$259.11	22.37

More than 48% of MN spring turkey hunters surveyed reported an annual household income between $25,000 and $49,999 (Table 10).

Pennsylvania

Successful resident turkey hunters spent an average of $180.70 (Table 2). Only 4 nonresidents responded to the questionnaire and were not included. Greatest expenditures by PA hunters were for guns, followed by transportation, food, clothing, and lodging. Land leasing for turkey hunting was not important in PA (Table 4).

Expenditures by 226,008 spring hunters was $40,839,645.60 (Table 6). An estimated 18,500 turkeys were killed in the 1989 spring season, resulting in an expenditure of $2,207.55/bird taken. No special license or permit is required to hunt turkeys. For successful hunters who spent money in a particular category, the greatest expenditures were for guns, taxidermy, land leasing, lodging, and clothing (Table 7). The expenditure values for PA hunters may be biased upwards because only successful hunters were surveyed. In MO, successful hunters spent $12.31 more than unsuccessful hunters. During fiscal year 1988-89 the PA Game Commission spent close to $70,000 (Table 9) on their wild turkey program. The highest percentage of respondents had an annual household income in the $25,000 to $49,999 category (Table 10).

South Carolina

Resident turkey hunters in SC spent an average of $428.20 per hunter (Table 2) and nonresidents $704.20 (Table 3) during the 1989 spring season. Residents spent the most money on land leasing, followed by transportation, guns, clothing and food (Table 2). Nonresidents spent the most money on land leasing, followed by transportation, clothing, lodging, and food (Table 3). Leasing land for hunting is widespread in SC (Table 4); both resident and nonresident hunters expend the most amount of money in this category.

The average total expenditure for residents and nonresidents combined was $473.30 (Table 5). This figure is higher than for the other states cooperating in this study; however, SC has a long hunting season and liberal bag limit. The spring season varies from 31 to 46 days with a statewide limit of 2 gobblers per day and 5 per season. This provides a tremendous amount of turkey hunting opportunity, resulting in greater expenditures.

In SC, 92.4% of the respondents reported hunting turkeys during spring 1989. Expanding these data to all hunters issued tags, the total expenditure was $15,564,943.80, excluding license and permit costs (Table 6). Spring hunters harvested 7,651 turkeys, for an expenditure of $2,034.37 per bird. No special permits are required to hunt turkey in SC, and the mandatory turkey tags are issued free to individuals with a license and big-game permit.

Average expenditures by category for only those hunters spending money in that category are shown in Table 7 for residents and Table 8 for nonresidents. Residents spent the most money on leasing land, followed by guns, taxidermy, transportation, and lodging. Non-residents spent the most money on leasing land, followed by guns, taxidermy, lodging, and clothing. Nonresidents spent more than residents on clothing, calls, transportation, lodging, food, and taxidermy. The SC Wildlife and Marine Resources Department expended approximately $58,225 (Table 9) on its wild turkey program during fiscal year 1988-89. The highest percentage of respondents had an annual household income in the $25,000 to 49,999 category (Table 10).

Of the 831 respondents on the NWTF questionnaire, 733 reported spending money in 1989 (Table 11). All NWTF members for this survey were residents. Money spent by NWTF members was greater than for the other group surveyed; the average cooperator spent $578.13. Greatest expenditures were for land leasing, followed by transportation, guns, clothes, and food. We assume these individuals are avid turkey hunters, thus willing to spend more than the average hunter. Most (42.4%) of these hunters earned $25,000 to 49,999 in 1989 (Table 12).

Table 12. Annual household income for all National Wild Turkey Federation members responding to 1989 questionnaire in South Carolina and West Virginia.

	South Carolina		West Virginia	
Income category	*n*	%	*n*	%
<$10,000	15	2.0	7	3.3
$10,000-14,999	20	2.7	14	6.6
$15,000-24,999	106	14.4	41	19.5
$25,000-49,999	311	42.4	111	52.8
≥$50,000	266	36.2	37	17.6

West Virginia

Resident hunters spent an average of $111.57 (Table 2) and nonresidents $140.77 (Table 3). Resident hunters spent the most on guns, followed by transportation, clothing, and food, while nonresidents averaged spending the most on other items, food, transportation, and land leasing. Nonresidents spent more than residents for land leasing, lodging, and other items. Other-item costs may reflect license fees because nonresident hunters are required to purchase an additional $10.00 turkey stamp. This stamp is not required of resident hunters who purchase a sportsman's license, which includes the turkey-hunting stamp. Hunters not purchasing a sportsman's license must buy a basic hunting license ($11.00), conservation stamp ($3.00), and a $5.00 turkey stamp in order to hunt spring gobblers. Resident landowners hunting on their property are not required to purchase a license. Licenses are also not required of persons under 15 years old or of persons 65 years of age and older. Land leasing for turkey hunting was not prevalent in WV (Table 4).

Expenditures by resident and nonresident hunters combined averaged $117.24. The greatest single expenditure was for guns, followed by transportation, food, clothing, other items, and turkey calls (Table 5). The lowest expenditures were for taxidermy and lodging. Total expenditures for an estimated 51,534 spring gobbler hunters was $6,041,047.61; the most money was spent on guns and transportation (Table 6). Hunters harvested 7,245 spring gobblers in 1989, resulting in an expenditure of $833.82 per bird killed.

The average expenditures for a particular category for only those respondents reporting spending money in that category are shown in Tables 7 and 8. Residents spent most on guns, leased land, and clothing (Table 7), while nonresidents spent the greatest amounts on leased land, guns, other items, and lodging (Table 8). The most common expenditures by residents were for transportation, calls, ammunition, and food; for nonresidents, food, transportation, ammunition, and other items.

Least common for both groups was taxidermy, followed by leased land. Expenditures for leased land and guns were higher than for other categories; however, only a small percentage of hunters spent money on these items. In WV the Department of Natural Resources spent $130,246 (Table 9) on its wild turkey program in fiscal year 1988-89. Most hunters had a yearly household income of $25,000 to $49,999 (Table 10).

The mean total expenditure by 200 resident participants in the WV NWTF Spring Gobbler Survey was $259.11 (Table 11). Greatest expenditures were for guns, followed by transportation, clothing, and food. The lowest expenditures were for lodging and ammunition. The WV NWTF Spring Gobbler Survey has been conducted yearly since 1983. Economic information was collected from 1983 to 1986 prior to 1989. During the 4-year period total expenditures ranged from $134.33 in 1983 to $161.55 in 1984, with an average expenditure of $153.29 (Pack et al. 1983, Igo et al. 1984, Taylor et al. 1985, Sharp et al. 1986). The 1989 average total expenditure has increased 73% over the 4-year average. The average hunter had an annual household income of $25,000 to $49,999 (Table 12).

CONCLUSIONS

The total expenditure by spring turkey hunters in the 6 states was almost $74 million. The average total expenditures for the 6 states was $12,333,291.26. We assume that these states are representative of all 46 states that allow spring turkey hunting. Therefore, the total expenditure for spring turkey hunting in the United States in 1989 was over $567 million. The expenditure values generated by this study estimate only indirect benefits resulting from the impacts of these expenditures on each state's economy. Expenditure values under-estimate the true economic value of the wild turkey resource because they do not include direct benefits received by the resource user (the consumer surplus value) (Bishop 1987, Mo. Dep. Conserv. 1989). Expenditures by the 6 represented resource agencies for wild turkey projects averaged $89,707.66 during fiscal year 1988-89. Considering that total expenditures by hunters in these 6 states averaged in excess of $12 million, money spent on wild turkey management is money well spent. As wild turkey populations and hunter numbers increase, especially in those states with relatively new programs, total U.S. expenditures will no doubt continue to increase. The results of this study indicate that expenditures by spring turkey hunters are an important source of revenue at the national, state, and local levels.

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CHARACTERISTICS, ATTITUDES, AND PREFERENCES OF MISSOURI'S SPRING TURKEY HUNTERS

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Abstract: A questionnaire entitled "Turkey Hunting in Missouri" was sent to 7,000 randomly selected 1988 spring turkey hunting permit buyers to determine the characteristics, attitudes, and preferences of turkey hunters toward wild turkeys *(Meleagris gallopavo silvestris)*, turkey hunting, and turkey harvest management. The composite Missouri spring turkey hunter was male, 39 years old, had a rural or small-town background, and had hunted turkeys in Missouri in the spring for 7 years. Most hunters were satisfied with the quality of their 1988 spring season and experienced few problems with interference by other hunters (72.9%), all-terrain or off-road vehicles (88.8%), trespassing (80.5%), or free-ranging dogs (79.1%). Most respondents (74.6%) thought Missouri's spring season was about the right length and preferred the current 14-day season to a longer season if a longer season would mean a decrease in the proportion of adult gobblers in the harvest. Over 80% of the hunters derived great enjoyment from killing an adult gobbler while only about 25% derived great enjoyment from killing a juvenile gobbler. Missouri turkey hunters were concerned about being shot by another hunter and over 35% had been in a situation in which they believed they were in danger of being shot. Hunters opposed (82.3%) a mandatory hunter-orange requirement, however, and most did not use orange while turkey hunting.

The popularity of wild turkey hunting in Missouri has increased dramatically in the last 3 decades. In 1960, 698 hunters harvested 94 turkeys during Missouri's first modern spring turkey season. By contrast, during the 1988 spring season, almost 100,000 hunters harvested 33,187 birds. The tremendous increase in hunter numbers was partially due to an increase in occupied (huntable) range resulting from continuing restoration efforts. But since 1979, when the restoration effort was complete and all suitable habitat was occupied (about 54,390 km^2 of forest), hunter numbers have doubled. The high visibility and public awareness surrounding wild turkeys and turkey hunting, both in Missouri and nationally, have been a major reason for the continued increase in hunters. Despite the increase, turkey populations and hunter success rates in Missouri have remained high (L. D. Vangilder, unpubl. data). Continued publicity and high success rates will likely result in future increases in the number of spring turkey hunters.

The maintenance of high turkey population levels has been the most important factor in making harvest management decisions to date. The demands of the resource user, however, are also important and should be incorporated into population management decisions (Hendee and Potter 1971). The Missouri Department of Conservation (MDC) has conducted surveys designed to assess the attitudes of a variety of resource-user groups (Porath et al. 1980, Kirby et al. 1981, Sheriff et al. 1981), but little data were available concerning turkey hunters in Missouri or in any other state.

The purpose of this study was to determine the characteristics, attitudes, and preferences of spring turkey hunters in Missouri toward wild turkeys, turkey hunting, and turkey harvest management. Specific objectives were to determine (1) socio-economic characteristics of spring turkey hunters, (2) whether spring turkey hunters were satisfied with current opportunities to harvest a wild turkey, (3) whether turkey hunter densities were viewed as a problem, (4) hunter opinions about current regulations, (5) what elements contribute to a quality turkey hunting experience, and (6) spring turkey hunters' opinions about safety.

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METHODS

We used techniques described by Dillman (1978) to design a self-administered, mail-back questionnaire. After the 1987 season, a pilot questionnaire was sent to 231 spring turkey hunters who were members of the Missouri Chapter of the National Wild Turkey Federation or worked for MDC. A revised questionnaire entitled "Turkey Hunting in Missouri" was then sent to 7,000 randomly selected resident and nonresident 1988 spring turkey hunting permit buyers on 8 September 1988. Nonrespondents were sent 2 follow-up mailings. A questionnaire was deliverable to 6,700 of 7,000 permit buyers selected for the survey. We had received 5,041 usable responses (75.2%) when the survey was closed on 5 April 1989.

No study of nonrespondents was undertaken, so no evaluation of possible nonresponse bias can be offered. The percentages that follow do not include nonresponse to individual questions by those responding to the questionnaire.

RESULTS AND DISCUSSION

The Missouri Spring Turkey Hunter

A composite Missouri spring turkey hunter is male (98.1%), 39 ($\bar{x} \pm SE = 39.2 \pm 0.2, n = 4{,}984$) years old, has a rural or small-town background (84.6%), and has a total household income between $15,000 and $50,000 (65.7%). This person has hunted for 26 ($25.8 \pm 0.2, n = 4{,}966$) years but has hunted wild turkeys in the spring in Missouri for only 7 ($6.7 \pm 0.1, n = 4{,}932$) years and has killed 4 ($4.3 \pm 0.1, n = 4{,}781$) turkeys in the spring.

This hunter wears complete camouflage (at least coveralls or coat and pants and gloves, with either hat and face paint or a head net) (70.2%) and uses a turkey call (95.8%). The most frequent calls and combinations of calls used are a box call only (20.2%); a diaphragm and box call (18.7%); a diaphragm call only (15.9%); a diaphragm, box, and slate call (7.8%); and a slate call only (4.7%). The Missouri turkey hunter rarely or never uses an all-terrain vehicle (ATV) for spring hunting (88.1%).

1988 Spring Turkey Hunting Experiences

Most respondents to our survey hunted during the 1988 spring turkey season (96.1%). Only 59.2% of the respondents hunted during the 1987 fall firearms turkey season and only 36.3% hunted during the 1987 fall archery deer and turkey season.

Hunter success (killed at least 1 turkey) was 41.5% for the 1988 spring season, 51.9% for the 1987 fall firearms season, and 4.9% for the 1987 fall archery season. Success reported in this survey was higher than success calculated based on the number of turkeys registered at mandatory check stations and estimated hunter numbers (30.3%). This difference was probably the result of response bias (i.e., some respondents may have claimed to have killed more turkeys than they actually did).

Successful hunters were afield 6 days ($5.9 \pm 0.1, n = 1{,}947$) days whereas unsuccessful hunters were afield 5 days ($5.1 \pm 0.1, n = 2{,}739$) days. Successful hunters were more experienced than unsuccessful hunters (Table 1). Nonresidents were more successful (50.2%) than residents (40.5%).

Table 1. Hunting experience of respondents by whether they were successful during Missouri's 1988 spring turkey season.

	Successful				Unsuccessful			
Experience	$\bar{x}$	SE	Median	n	$\bar{x}$	SE	Median	n
Years hunted all game	27.1	0.3	25	1,954	24.4	0.3	21	2,738
Years hunted turkeys in Missouri during spring	8.4	0.1	7	1,931	5.7	0.1	4	2,720
Turkeys harvested during Missouri's spring season	7.3	0.2	5	1,862	2.3	0.1	0	2,687

Nearly 66% of the respondents hunted exclusively on private land, whereas only 14.5% hunted exclusively on public land (Table 2). The remaining 19.5% hunted on both public and private land. The percentage of respondents hunting on public land is disproportionate to land ownership in Missouri. Only about 7% of the land area in Missouri is publicly owned and not all of it can be hunted.

Most hunters (87.9%) had no difficulty in finding a place to hunt and traveled, on average, 112 km (112.0 ± 2.1, n = 4,758) one-way to the area they hunted most. The overall average was greatly influenced by nonresident hunters who traveled, on average, 520 km (519.8 ± 24.5, n = 493). By contrast, resident permit buyers traveled, on average, 64 km (64.4 ± 1.3, n = 4,245). The median distance traveled was 367 km for nonresidents and 24 km for residents.

Leasing of land for spring turkey hunting was uncommon. Only 2.8% of turkey hunters paid someone for the right to turkey hunt. Leasing was more common among nonresidents (4.0%) than among residents (2.7%). Respondents who leased land were more successful (51.2%) than those who did not lease land (41.4%).

Most hunters were satisfied with the quality of their 1988 spring turkey hunt. The 1988 spring season was rated excellent by 17.5%, good by 28.3%, and fair by 28.7% of the hunters. Only 23.0% rated the 1988 season as poor. The majority of spring turkey hunters had little or no problem with interference by other hunters, disturbance by ATVs or other off-road vehicles (ORVs), trespassing hunters, or free-ranging dogs (Table 3). Of the problems listed above, interference by other hunters was the greatest (26.5% of the respondents had somewhat of a problem or a great problem) encountered.

In West Virginia, 58% of the respondents to a volunteer survey reported hunter interference. ATVs were also viewed as a problem because 83% of the respondents said that ATVs should not be allowed on public land (West Virginia Spring Gobbler Survey 1988, unpubl. rep.).

Table 2. Percentage of 1988 spring turkey hunters who hunted on private, public, or combinations of private and public lands in Missouri.

Area hunted	Respondents %	Respondents n
Private land only	66.0	3,140
Public land only	14.5	689
Both private and public land	8.2	389
Private land only and public land only	8.4	398
Private land only and both	1.5	73
Public land only and both	0.6	28
Private land only, public land only, and both	0.8	38

Table 3. Perceived problems (%) with factors affecting the quality of the 1988 Missouri spring turkey hunting season.

Factor	Problem: Great	Some	Little	None	No opinion	Respondents (n)
Interference by other hunters	6.3	20.2	23.2	49.7	0.6	4,736
Disturbance by ATVs or ORVs	3.7	6.8	8.0	80.8	0.7	4,687
Trespassing hunters	4.8	11.4	11.2	69.3	3.3	4,672
Free-ranging dogs	6.3	12.8	10.2	68.9	1.8	4,690

Williams and Austin (1988) found that 74% of respondents to a survey of experienced Florida turkey hunters thought that low hunter densities were important for a quality turkey hunt. Too many hunters in the woods and seeing dogs in the woods were cited as degrading to a good turkey hunting experience.

Respondents hunting on private land only had less problem with interference than did those hunting on public land only or on a combination of private and public land (Table 4). The type of land hunted did not influence perceived problems with ATVs and free-ranging dogs (Table 4). Trespassing was, by definition, more of a problem on private land and on combinations of public and private land than on public land (Table 4). In Iowa, rates of interference by other hunters during the 1988 spring season ranged from 19.9 to 34.6%. Interference rates were also lower on private land (19.9%) than on public land (23.8%) (Jackson 1989).

Success was higher for respondents hunting on private land only (43.4%) than for respondents hunting on either public land only (34.6%) or on a combination of private and public land (41.1%). Hunter success in Iowa was also higher on private land (52.2%) than on public land (37.8%) (Jackson 1989).

On average, the 1988 spring turkey hunter encountered (saw or heard) 4 other hunters (3.9 ± 0.1, n = 4,663) (not including those in their party) while turkey hunting. The median number encountered was 2. Respondents hunting on public land only or on both public and private land saw more other hunters (6.4 ± 0.3, n = 668 and 6.1 ± 0.3, n = 885, respectively) than did those hunting on private land only (2.7 ± 0.1, n = 3,079).

To determine if seeing other hunters affected a hunter's rating of the 1988 spring season, we examined the percentage of successful and unsuccessful hunters that rated their season good or excellent and the number of other hunters seen. We did a similar analysis for the effects of interference by other hunters, interference by ATVs and ORVs, trespassing, and free-ranging dogs.

The percentage of hunters rating the 1988 season good or excellent declined as the number of hunters seen increased from 0 to 5 (Table 5). Satisfaction with the 1988 hunt also declined with increasing problems with interference by other hunters (Table 6). The effect of problems with ATVs, trespassing, and dogs on a hunter's rating of the season was not as clear, although the general trend was one of decreasing satisfaction with increasing problems (Table 6). In all cases successful hunters rated their season substantially higher than did unsuccessful hunters (Tables 5, 6).

Table 4. Perceived problems (%) with factors affecting the quality of the 1988 Missouri spring turkey hunting season by ownership of land hunted.

Land ownership	Problem				Don't know	Respondents (n)
	Great	Some	Little	None		
Interference by other hunters						
Private only	4.9	17.5	20.8	56.2	0.7	3,112
Public only	9.5	24.5	27.4	38.3	0.4	687
Combination	8.6	26.5	28.3	36.2	0.4	906
Interference by ATVs or ORVs						
Private only	3.0	5.2	6.6	84.4	0.8	3,078
Public only	5.4	9.1	10.4	74.8	0.3	682
Combination	4.8	10.0	11.3	73.5	0.5	898
Interference by trespassing hunters						
Private only	5.9	13.7	12.6	64.9	3.0	3,081
Public only	0.8	1.6	4.3	88.5	4.8	669
Combination	0.8	10.6	11.6	70.7	3.0	894
Interference by free-ranging dogs						
Private only	6.5	12.7	10.4	68.6	1.8	3,080
Public only	4.7	13.7	8.8	71.1	1.8	685
Combination	7.1	12.3	10.9	68.1	1.6	897

Table 5. Turkey hunters rating their 1988 spring season good or excellent by success and number of other hunters seen during the season in Missouri.

Number of other turkey hunters seen	Unsuccessful %	Unsuccessful *n*	Successful %	Successful *n*
0	33.1	728	75.5	429
1	31.6	301	68.1	166
2	31.7	476	69.7	340
3	29.2	271	67.8	211
4	26.0	235	66.5	167
5	20.7	164	63.9	144
$\geq$6	27.3	510	64.5	445

Table 6. Turkey hunters rating their 1988 season in Missouri good or excellent by success and interference by other hunters, by ATVs or ORVs, trespassing hunters, and free-ranging dogs.

Interference	Unsuccessful %	Unsuccessful *n*	Successful %	Successful *n*
Other hunters				
No problem	32.9	1,421	72.5	843
Little problem	29.1	556	68.5	524
Some problem	26.0	520	62.9	418
Great problem	18.6	188	58.4	101
ATVs or ORVs				
No problem	29.3	2,196	69.9	1,525
Little problem	32.4	210	70.4	159
Some problem	28.3	166	57.9	145
Great problem	30.3	89	66.3	80
Trespassing hunters				
No problem	30.6	1,923	69.9	1,265
Little problem	24.5	249	70.8	264
Some problem	27.1	280	66.5	242
Great problem	29.9	127	62.0	92
Free-ranging dogs				
No problem	30.3	1,885	71.0	1,288
Little problem	30.0	250	66.7	225
Some problem	27.4	339	69.0	248
Great problem	26.9	149	54.6	141

In Michigan, Hawn et al. (1987) also found an association between the number of other hunters encountered and the proportion of hunters rating their season good and very good.

Opinions About Spring Turkey Hunting in Missouri

A large majority (91.3%) of Missouri's spring turkey hunters thought there are enough turkeys to allow hunters ample opportunity to harvest a bird.

Hunters were divided when asked their opinion about peak gobbling activity in relation to season dates. Over 37% thought the season dates were just right for peak gobbling activity, 29.2% thought the season was too late, 16.8% thought the dates were too early, and 16.7% had no opinion.

The same question, but with regard to the 1988 season only, was also asked of another group of spring turkey hunters in a survey designed to determine hunting pressure (L.D. Vangilder and G.S. Olson, unpubl. data). In that survey, 26% of the respondents thought the season was just right for gobbling activity, 29% thought it was too early, 23% thought it was too late, and 22% had no opinion. Spring phenology and wild turkey breeding chronology were late in 1988, which resulted in a season opener that coincided with a lull in gobbling activity.

Most hunters (74.6%) indicated that Missouri's 14-day spring turkey season is about the right length whereas 20.6% thought it is too short. Just over 50% were in favor of some type of liberalization of the spring season (Table 7). However, when asked whether they would prefer the current 2-week, 1-bird/week season, which results in a high proportion of adult gobblers in the harvest, or a longer season and more liberal bag limit, which would result in a higher proportion of juvenile gobblers in the harvest, a large majority (77.2%) chose the current season.

Most hunters did not favor restrictions on the spring season (Table 7). The negative response to hunter's-choice seasons or a limit on the number of permits issued was not surprising considering that most respondents believe that there are many turkey hunters but that they are not a problem (55.7%). Only 18.4% thought that there were too many turkey hunters. The low percentage of respondents who had a great problem with interference, disturbance by ATVs or ORVs, and trespassing hunters (see Table 2) is also consistent with the negative response to limits on hunter numbers.

Because Missouri has a spring hunting tradition and the fall firearms season has been in effect only since 1978, we asked spring turkey hunters what effect they thought the fall firearms season had on spring turkey hunting. Only 6.1% of the respondents indicated that the fall season had a negative effect on spring turkey hunting.

Observing other wildlife, killing a gobbler, hunting with family and friends, seeing hens with gobblers, and teaching someone else to hunt were the top 5 conditions that contributed to a good turkey hunting experience (Table 8). Missouri turkey hunters would rather kill an adult gobbler (80.3% great enjoyment) than a juvenile (25.4% great enjoyment). This may help explain why hunters would rather have a 2-week season and 2-bird limit than a more liberal season.

Turkey Hunting Safety

The number of hunting accidents associated with spring turkey season has increased from none in 1960 to 29 in 1986. Most of these accidents (78.1%, n = 256; 1960-1988) were the result of the victim's being mistaken for game, and 93.3% were either mistaken-for-game or line-of-fire accidents.

About 67% of Missouri's spring hunters have been concerned about being shot by another hunter, and 35.5% have been in a situation in which they believed they were in danger of being shot. Concern for safety was higher for respondents hunting only on public land (72.8%) or a combination of private and public land (71.5%) than for those hunting exclusively on private land (65.8%). Similarly, 44.0 and 38.2% of the respondents hunting on a combination of private and public land and public land only, respectively, said they had been in a situation in which they were in danger of being shot, while only 32.7% hunting on private land only said they had been in such a situation.

Table 7. Opinions (%) of spring turkey hunters about liberalization of Missouri's spring turkey season; since 1979, Missouri's spring season has been 2 weeks (14 days) in length with a 1-bird/week bag limit.

Choice	Good idea	Not a good idea	No opinion	Respondents (n)
Liberalization				
Shoot 1 bird on 2 consecutive days	51.5	36.3	12.2	4,749
All-day hunting	52.7	35.2	12.1	4,855
Three-week season, 2-bird limit	55.0	34.3	10.7	4,888
Restriction				
Three-week season, 1-bird limit	10.2	79.7	10.1	4,798
Hunter's-choice season[a]	8.6	75.3	16.1	4,739
Limit permits issued	13.6	70.9	15.5	4,759

[a]Hunter selects portion of season to hunt but can't hunt entire season.

Table 8. Enjoyment by turkey hunters (%) of activities that may contribute to a good spring turkey hunting experience in Missouri.

Activity	Enjoyment: Great	Some	Little	None	No opinion	Respondents (*n*)
Observing other wildlife	83.1	14.3	1.5	0.6	0.5	4,884
Killing a gobbler	80.3	4.2	0.3	5.4	9.8	4,731
Hunting with friends and family	71.9	19.3	3.7	3.7	1.5	4,882
Seeing hens with gobblers	56.4	28.1	7.1	6.1	2.3	4,856
Teaching someone else to hunt	53.9	24.7	5.3	8.1	8.0	4,826
Preseason scouting	46.0	35.6	8.0	6.8	3.6	4,870
Camping	39.9	17.2	8.0	25.1	9.8	4,732
Calling turkeys for another hunter	32.7	21.8	7.4	25.9	12.1	4,761
Seeing spring wildflowers	31.5	36.0	18.5	10.4	3.6	4,796
Camouflaging yourself and equipment	31.3	37.5	17.3	10.3	3.7	4,809
Mushroom hunting	29.6	24.9	12.6	26.5	6.4	4,799
Preseason calling	26.3	27.0	13.3	26.7	6.7	4,784
Killing a juvenile gobbler	25.4	31.4	15.6	14.6	13.1	4,569
Hunting on public land	21.7	22.6	13.5	26.4	15.8	4,787
Photography	19.9	24.0	12.5	31.1	12.4	4,706
Cleaning a turkey	14.4	26.5	24.5	24.4	10.2	4,763
Shooting a turkey without calling it	11.3	22.8	23.8	31.3	10.8	4,779
Having the option to use a 10-gauge	10.0	7.3	7.1	52.7	23.0	4,787

In 1982, 370 volunteers participating in a study of the use of hunter orange during the Missouri spring turkey season were asked how often they had been concerned with their safety during past spring seasons. Almost half (44%) responded "never," 48% "on a couple of occasions," and 7% "often" (Witter et al. 1982). In a 1983 study of the use of a camouflage-orange vest during the spring season, 36.8% of the 517 volunteer participants said they had never felt unsafe, 53.2% said they had occasionally felt unsafe, and 10.1% said they had often felt unsafe (Mo. Dep. Conserv. 1983).

Only 44.2% of Missouri's spring turkey hunters have taken a hunter safety course. A voluntary hunter education course has been available since 1957 in Missouri, and mandatory hunter education (for hunters born on or after 1 Jan 1967) was instituted in 1988. Only 9.7% of the respondents were $\leq$20 years of age and were therefore required to be trained. The percentage of spring hunters who had received hunter safety training was only slightly lower than that of the general hunting public in Missouri in 1988 (46.2% of the 1988 small-game license buyers had received firearms or hunter safety training [G.S. Olson, unpubl. data]). Respondents who had received hunter safety training were more successful (44.9%) during the 1988 spring season than those who had not received hunter safety training (39.2%).

A turkey hunting safety seminar is also offered by MDC and the Missouri Chapter of the National Wild Turkey Federation, but only 12.0% of the respondents had attended such a seminar. Only 30.4% had attended a turkey hunting seminar of any kind. Respondents who said they had attended a seminar (MDC, private, or both) were more successful during the 1988 spring season than those who had not attended a seminar (Table 9).

About half (47.1%) of the respondents favored a mandatory hunter education course for all turkey hunters. This relatively high percentage reflects the concern among hunters about being shot. Over 53% of the respondents who said they were concerned about being shot favored mandatory turkey hunter education, whereas only 46.6% of those not concerned about being shot favored such a course.

Table 9. Hunter success (%) during Missouri's 1988 spring season by the type of seminar attended.

Seminar	Unsuccessful	Successful	Respondents (*n*)
None	62.5	37.5	3,214
Mo. Dep. Conserv.	46.5	53.5	563
Private	51.9	48.1	719
Both MDC and Private	42.4	57.6	158

The mandatory use of hunter orange has been suggested as a way to reduce turkey hunting accidents because it has been effective in reducing deer hunting accidents. Unlike deer, wild turkeys can probably see color and hunters obviously know it (Witter et al. 1982, Eriksen et al. 1985). Despite their concern for safety, 82.3% of Missouri's spring hunters opposed a mandatory hunter orange requirement for firearms turkey hunting.

The Missouri spring turkey hunting brochure (which all hunters, in theory, receive when they buy their permit) encourages the use of hunter orange while moving about or carrying a bird out of the woods. It also discourages waving or using a turkey call to alert approaching hunters and the use of a gobble call. However, the use of hunter orange was a relatively infrequent behavior and almost 48% of the respondents said they usually or always signal an approaching hunter by waving (Table 10). Only 12.6% of the respondents usually or always use a gobble call. Most hunters said they usually or always leave an area when they find another hunter already there, and most said they usually or always sit with their backs against a large tree (Table 10).

Hunters who said they wore orange at all times while turkey hunting were less successful than those who said they never wore orange. This difference persisted across all levels of turkey hunting experience (Table 11A). Hunters who said they always wore orange while moving about were also less successful than those who said they never wore orange while moving at all levels of experience except 3-5 years (Table 11B).

MDC conducted a study of volunteers who were asked to use a hunter-orange "alert band" (Witter et al. 1982) and a camouflage-orange vest (Mo. Dep. Conserv. 1983) during the 1982 and 1983 spring turkey seasons, respectively. In both years at least 50% of the participants who saw turkeys but were unsuccessful thought the orange item had an effect on their ability to harvest a gobbler. In the study of the camouflage-orange vest 61% of the successful hunters believed the vest had a negative effect on their ability to call gobblers into shooting range. In a study conducted in New Jersey and Virginia, hunters wearing blaze orange were less successful at calling in gobblers than were those who did not wear blaze orange (Eriksen et al. 1985).

Beginning in the 1987 spring season legal shot size was restricted to #4 or smaller (from BBs or smaller) to reduce the severity of accidents. Most hunters (78.9%) already used #4 shot or smaller before the restriction and therefore only 14.8% indicated that the shot-size restriction inhibited their ability to kill a turkey.

A hunter's failure to identify his target properly is responsible for mistaken-for-game accidents. With this fact in mind we asked what characteristics turkey hunters used to identify their target before they shoot. Only 2.6% of the respondents did not use the beard to identify a legal turkey. The remaining respondents used the beard alone or in combination with other characteristics to identify a legal turkey. The most common characters used were beard alone (13.3%); beard, strutting, body color, gobbling, head color, size, and response to calls (10.6%); beard, strutting, body color, gobbling, and head color (8.4%); and beard, strutting, body color, gobbling, head color, and response to calls (4.8%). Perhaps if a greater percentage of hunters used the beard alone to identify a legal turkey, the number of beardless hens killed and the number of mistaken-for-game accidents would be reduced.

Table 10. Frequency (%) of behaviors by hunters in Missouri that may influence the probability of being accidentally shot during spring turkey season.

Behavior	Frequency				Respondents
	Always	Usually	Occasionally	Never	(*n*)
Wear hunter orange at all times during hunt	3.9	3.2	10.7	82.2	4,912
Wear hunter orange while moving through woods	16.0	12.3	16.7	55.0	4,935
Wrap or have an item of hunter orange on a tree	3.9	5.6	15.4	75.1	4,887
Wrap orange around or conceal a dead turkey while transporting it	33.2	13.9	10.1	42.8	4,747
Leave the area if you find another hunter calling to a gobbler that you heard and went to	52.4	27.8	10.9	8.9	4,900
Sit with your back against a large tree	37.4	47.3	13.7	1.6	4,939
Move about while calling to a bird	4.1	11.7	42.6	41.6	4,916
Use a gobbler call	6.0	6.6	26.2	61.2	4,860
Wave to signal an approaching hunter	31.5	16.3	11.1	41.2	4,888
Use a turkey call to signal an approaching hunter	1.2	1.7	3.6	93.4	4,896
Hide in a blowdown or thick cover	9.1	23.0	37.1	30.7	4,869
Use a decoy	4.3	8.7	26.6	60.5	4,936

Table 11. Success during the 1988 spring turkey season in Missouri by years of turkey hunting experience and frequency with which hunters (A) wear blaze orange at all times while turkey hunting, and (B) wear blaze orange while moving from place to place.

Years of experience	Success[b]	Frequency of blaze orange wear[a]			
		Always	Usually	Occasionally	Never
A. At all times					
0-2	U	81.4 (48)	87.0 (40)	84.4 (108)	72.4 (679)
	S	18.6 (11)	13.0 (6)	15.6 (20)	27.6 (259)
3-5	U	69.6 (39)	65.4 (34)	68.6 (105)	62.0 (691)
	S	30.4 (17)	34.6 (18)	31.4 (48)	38.0 (423)
6-10	U	61.5 (16)	58.8 (10)	56.7 (72)	48.6 (478)
	S	38.5 (10)	41.2 (7)	43.3 (55)	51.4 (506)
≥11	U	52.9 (9)	36.4 (8)	40.2 (33)	39.4 (301)
	S	47.1 (8)	63.6 (14)	59.8 (49)	60.6 (462)
B. While moving					
0-2	U	84.1 (191)	79.9 (115)	73.6 (148)	70.4 (421)
	S	15.9 (36)	21.1 (29)	26.4 (53)	29.6 (177)
3-5	U	68.4 (173)	64.9 (111)	65.3 (156)	70.5 (433)
	S	31.6 (80)	35.1 (60)	34.7 (83)	29.5 (181)
6-10	U	60.0 (90)	58.2 (82)	50.7 (105)	45.9 (304)
	S	40.0 (60)	41.8 (59)	49.3 (102)	54.1 (359)
≥11	U	46.9 (46)	42.9 (42)	36.2 (46)	39.4 (225)
	S	53.1 (52)	57.1 (56)	63.8 (81)	60.6 (346)

[a]Percent of total respondents (*n* in parentheses) in same category of experience and frequency with which orange was worn.
[b]U = unsuccessful; S = successful.

CONCLUSIONS

Fifteen years ago, when the density of spring turkey hunters in Missouri was about 0.6 hunters/km^2 of forest, Madson (1975) warned that the quality of spring turkey hunting in Missouri and other states was decreasing because of increasing hunter numbers. Although hunter densities have tripled since 1975 to 1.8 hunters/km^2 of forest, <20% of Missouri's spring hunters thought there were too many turkey hunters. Most had little or no problem with interference by other hunters, ATVs or ORVs, and trespassing hunters. Spring turkey hunters were not in favor of regulations that would limit hunter densities.

Our results agree with the observation of Williams and Austin (1988) that many of the elements that contribute to a good turkey hunting experience are related to turkey population densities, whereas those elements that degrade the hunting experience are related to human activities. In Missouri, the increase in hunter numbers and the resulting decrease in turkey hunting quality that might have occurred has evidently been offset by a more rapid, 6-fold increase in turkey harvest (and densities) since 1975. Over 90% of the respondents believed there were enough turkeys in Missouri to allow ample opportunity to harvest a bird.

Missouri's harvest strategies are aimed at maintaining a high proportion of adults in the harvest. The 14-day spring season in Missouri is one of the shortest among the states with well-established turkey populations. The short season results in a high proportion of adult gobblers in the spring harvest (70%). Because our spring turkey hunters would much rather kill an adult gobbler than a juvenile, they are satisfied with our current spring season. Most respondents thought the season was about the right length, and most would rather have the current season than a longer season if it would mean a reduction in the proportion of adult gobblers in the harvest. L. D. Vangilder and T. G. Kulowiec (unpubl. data) have demonstrated, using a turkey population model, that if <30% of the male population is harvested during the spring season, the percentage of adult gobblers in the harvest will be >70%. When the spring harvest approaches 50% of the male population, the percentage of adult gobblers in the harvest drops to about 50%. Missouri hunters are willing to forego additional opportunity if the additional opportunity would result in a decrease in the quality of their spring turkey hunting experience. Safety was of concern to the majority of Missouri's spring turkey hunters. Few hunters (17.7%), however, favor hunter orange as a means to combat mistaken-for-game accidents. Most hunters would rather risk being shot than wear hunter orange because most feel that blaze orange will decrease their hunting success. A mandatory hunter-orange requirement might reduce the number of mistaken-for-game accidents. Our results, however, indicate that such a requirement would be unacceptable to the majority of spring turkey hunters and therefore, compliance could be extremely low. Thus, mistaken-for-game accidents will occur until all hunters learn to identify their target positively before they shoot. As the percentage of turkey hunters who have attended a hunter education class increases, the number of mistaken-for-game accidents may decrease. Continued emphasis on safety in turkey hunting brochures and in media coverage may also help alleviate the problem. Reducing hunter densities would not be an effective means of reducing the number of mistaken-for-game accidents because the number of accidents does not seem to depend on hunter densities (L.D. Vangilder and J.B. Lewis, unpubl. data).

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ATTITUDES, OPINIONS, AND CHARACTERISTICS OF A SELECT GROUP OF ARKANSAS SPRING TURKEY HUNTERS

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Abstract: To improve research efforts and turkey *(Meleagris gallopavo silvestris)* hunting in Arkansas, we surveyed turkey hunters on their attitudes, opinions, preferences, and activities regarding spring turkey hunting. A questionnaire with 35 questions was mailed to all Arkansas National Wild Turkey Federation (NWTF) members (789) after the 1988 spring turkey season. Results characterized the average Arkansas NWTF member as male, 45 years of age, with a rural background and approximately 16 years of spring turkey hunting experience. The most important reasons for spring turkey hunting were associated with the outdoor environment and natural experiences. About half of the hunters thought that turkey numbers in the areas they hunted in the spring of 1988 were adequate but believed there were too many hunters. Hunters rejected proposed season changes that would reduce legal hunting opportunity, and >88% would not support mandatory hunter-orange requirements. Highly favored proposals to improve spring turkey hunting included establishment of more walk-in turkey hunting and wilderness areas, and closure of low population areas for stocking. Respondents perceived the greatest threats to spring turkey hunting were illegal harvest, unsafe hunters, poor hunter behavior, and free-running dogs. Because respondents perceived legal and ethical problems as serious threats to spring turkey hunting, law enforcement and hunter education programs are important. Although NWTF members indicated some tolerance for program changes, tradition was still reflected in attitudes and opinions expressed. For this reason, a more aggressive information and education effort is warranted to achieve public support needed for a more progressive turkey management program in Arkansas.

The wild turkey was on the verge of extinction in Arkansas after the turn of the Century; only small populations existed in scattered, localized flocks (Holder 1951). Turkey numbers dwindled due to deterioation of turkey habitat, minimal reforestation, market hunting, overgrazing, and a total lack of protection (Gaines 1972). Efforts in restoring populations were largely unsuccessful during the 1920s and 1930s, and the statewide population was estimated at only 7,000 birds by 1946 (Holder 1951). A restoration program involving trapping and stocking of wild birds, protection, and regulated hunting allowed a tremendous comeback of wild turkey in the state (Kaffka 1979, Cartwright and Pledger 1986).

The statewide population estimate for the mid-1980s approached 100,000 turkeys, occupying more than 69,930 km^2 of range (Kennamer 1986). The wild turkey is a valuable resource in Arkansas for sport hunting and for its aesthetic appeal to the public. During 1985 an estimated 56,700 hunters ($\geq$16 years old) devoted 503,300 days to hunting turkey in Arkansas (U.S. Fish and Wildlife Service 1989).

Studies on wild turkeys in Arkansas have focused on distribution and relative abundance (Holder 1951, James and Preston 1959); trapping, stocking, and restoration efforts (Preston 1959, Rush 1973, James et al. 1983); habitat use (Wigley et al. 1985, 1986*a*; Nelson 1987); and home range (Wigley et al. 1986*b*). Studies have not been conducted on turkey hunter use or characteristics. Our study of a select group of spring turkey hunters was designed to determine socioeconomic and demographic characteristics; opinions, attitudes, and preferences involving management programs; activities and participation in spring hunting; and perceptions of threats to turkey hunting.

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METHODS

We developed a self-administered, mail-back questionnaire based on techniques described by Dillman (1978) and Filion (1980). In early summer 1988, names and mailing addresses of NWTF members residing in Arkansas were obtained from the NWTF headquarters in Edgefield, S.C. Each NWTF member was sent a cover letter and questionnaire. Of 789 questionnaires delivered, 663 (84.0%) were returned after 1 follow-up mailing, and 657 were classified as usable for analysis. Because of the high response rate, we did not send a third mailing to nonrespondents. Survey data were coded, put on computer tape, and sent to North Carolina State University's Institute of Statistics for analysis. We did not survey nonrespondents for evaluation of possible nonresponse bias. Percentages were adjusted for nonresponse to individual questions. Chi-square analysis was used to determine relationships between respondent characteristics and responses to specific survey questions. We inferred statistical significance when $P \leq 0.05$. A weighted factor ranking procedure based on sum of responses (Gilbert 1977) was used to compute values indicative of overall importance of responses to several multianswer questions (i.e., questions that require the respondent to rank a statement). A point value (i.e., 3, 2, 1, 0, etc.) was assigned to each level of response (i.e., of much importance, of some importance, not important, etc.). The point value of each response level was multiplied by the number of repondents who checked that level. The sum of the products (sum of values) was divided by the sample size (n) to determine a mean point value (i.e., the weighted factor rank). A statement's level of importance was determined through the use of an established range of values.

RESULTS

Socioeconomic Characteristics

A sketch of a spring turkey hunter in this survey shows a male, 45 ($\bar{x}$ = 44.91 ± 0.55 [SE]) years old with 16 ($\bar{x}$ = 15.79 ± 0.44) years of spring turkey hunting experience. The individual lives in an average household of 3 ($\bar{x}$ = 3.00 ± 0.05) people, earns ≥$45,000 annually, is employed as a white-collar worker, and has a rural background with a current residence that is urban (Table 1). Ages of turkey hunters ranged from 13 to 85. Seventy percent of respondents were 31-59 years old, 17.8% were 60 or older, and 12.2% were 30 or younger. Most respondents (65.0%) listed a rural background in their youth; however, slightly less than half (46.2%) listed a current rural residence.

Hunting Participation Characteristics

The turkey hunter.--Years of spring turkey hunting experience ranged from <1 to 60. Slightly over 18% of respondents listed ≤5 years of experience whereas 60.4% listed ≥11 years. More than two-thirds (68.8%) of respondents stated that 1 member of their household regularly hunted turkey during the spring season, whereas about half (50.3%) stated that household members did not regularly hunt turkey during the fall season.

More than half (59.1%) of respondents stated they did not travel out of Arkansas on a regular basis to hunt during spring. There was no difference in out-of-state or in-state hunting participation for young (≤30), middle-aged (31-59), or older (≥60) hunters (X^2 = 0.005, 2 df, P = 0.998). A higher percentage of young and middle-aged hunters in the Ouachita and Gulf Coastal Plain regions turkey hunted outside Arkansas during spring. The reverse was true for the Ozark Mountain region. Overall, a higher percentage of Delta hunters (52.5%) stated they went out of Arkansas to spring turkey hunt. Respondents listed Missouri, Mississippi, Oklahoma, and Alabama as the other states most often hunted. Ozark and Ouachita Mountain hunters tended to go to Missouri, whereas Delta and Gulf Coastal Plain hunters seemed to prefer Mississippi.

Table 1. Socioeconomic characteristics of Arkansas' spring turkey hunters, 1988.

Characteristics	Respondents *n*	%
Sex		
Male	650	99.7
Female	2	0.3
Age		
≤30	80	12.2
31-59	460	70.0
≥60	117	17.8
Family income		
<$10,000	12	1.9
10,000-14,999	30	5.0
15,000-24,999	95	15.7
25,000-34,999	127	21.0
35,000-44,999	113	18.6
≥$45,000	229	37.8
Occupation		
Blue collar	170	26.4
White collar	327	50.8
Student	5	0.8
Farmer	49	7.6
Retired	80	12.4
Military	4	0.6
Unemployed	0	0.0
Other	9	1.4
Current residence		
Rural	298	46.2
Urban	302	46.8
Other	45	7.0
Youth residence		
Rural	421	65.0
Urban	188	29.0
Other	39	6.0

Most respondents (87.9%) stated they normally take time off from work to hunt during Arkansas' spring season. In addition, 61.2% stated they had attended at least 1 turkey calling contest. Compared with other regions, a higher percentage of respondents (71.7%) who hunted in the Ouachita Mountain region stated they had attended at least 1 calling contest in the past.

The 1988 spring hunt.--A high percentage (89.3%) of respondents stated they turkey hunted during the 1988 spring season in Arkansas. Respondents reported harvesting 497 turkeys during 6,898 days afield. The mean number of days hunted/respondent and birds harvested/respondent was 10.50 ± 0.27 and 0.76 ± 0.04, respectively. Hunters were persistent in participation throughout the 4-week spring season. Most respondents (85.8%) hunted during the first week. The percentage dropped to 64.0% during the last week. Almost half (48.7%) of turkeys killed by respondents were taken during the first week and 68.2% were taken by the end of the second week. Only 15.1% of turkeys killed during the season were taken during the fourth week.

Montgomery County, in the Ouachita Mountain region, was listed as the county most often hunted. Three of the top 5 counties were within this region. Respondents spent 57.9% (4,126 days) of total hunting days on public lands. These hunters spent an average of 6.28 ± 0.26 days on public lands, and averaged 4.18 ± 0.23 days on private lands. Turkey hunters drove an average of 91.95 ± 3.39 km one-way to reach the area most often hunted.

A slightly higher percentage of respondents hunting in the Ouachita (55.3%) and Delta (55.4%) regions listed an urban residence. In contrast, a higher percentage hunting in the Ozark (52.5%) and Gulf Coastal Plain (59.1%) regions listed a rural residence. Respondents, regardless of rural or urban residence, spent a higher percentage of total hunting days on public lands in the Ouachita (77.1%) region compared with the Ozark (57.1%), Delta (21.3%), and Gulf Coastal Plain (49.1%) regions.

Most respondents (63.9%) spent ≥3 days preparing for the 1988 spring turkey season in activities such as scouting, preparing gear, and obtaining landowner permission. A small number (7.4%) spent a couple of hours or less, but 17.3% devoted >15 days to getting ready. We found that the time spent preparing for the season did not depend on years of hunting experence (X^2 = 24.681, 18 df, P = 0.134).

Most hunters (77.3%) stated they did not attempt to call turkeys for practice or photography during preseason scouting. Only 6.5% attempted to call 1 bird. Four hunters reported calling ≥20 birds and 1 attempted to call 25. Respondents tried to call 514 gobblers ($\bar{x}$ = 0.78 ± 0.09/hunter) during preseason scouting.

Hunters were asked to list the number of days hunted during morning hours, afternoon hours, and during both periods of the day. One half (50.0%) of total hunting days listed involved morning hunting only, 18.5% involved afternoon hunting only, and 31.5% involved hunting during both periods of the day.

An equal percentage of respondents (48.4%) thought turkey numbers in areas they hunted were either adequate or too low. On a regional basis, hunters in the Delta (64.4%) and Ozark Mountain (53.3%) regions thought turkey numbers were adequate, whereas those in the Ouachita (53.8%) and Gulf Coastal Plain (60.5%) regions believed turkey numbers were too low. The majority of hunters (53.3%) said there was an overabundance of turkey hunters in the area they hunted. Only in the Delta region did a substantial number (50.0%) think that hunter numbers were acceptable. In other regions, fewer than 35.0% indicated hunter numbers were reasonable.

Turkey Management and Hunting

Program evaluation.--Hunters rated Arkansas' turkey management program favorably. Most (95.5%) rated it at least "fair" and 73.4% judged it as "good" or "excellent." The 1988 spring season was 4 weeks long with a bag limit of 2/day and 2/season (3/day/season in all or parts of 10 counties). A majority (76.3%) supported the 4-week spring season length. Only 8.1% thought it was too short and 15.2% thought it was too long. Many hunters (48.8%) indicated the spring season opening date, 7-10 April since 1984, was acceptable. Few (7.5%) indicated it opened too early but many (41.6%) thought it opened too late. The highest percentage of respondents hunting in the Delta (62.4%) and Gulf Coastal Plain (49.1%) regions indicated the spring season opened too late. The highest percentage of respondents hunting in the Ozark (60.9%) and Ouachita (50.0%) regions said the opening date was acceptable.

Hunting pressure.--Spring season participation has been high on opening day for many years. Of the proposals suggested for reducing opening day pressure, hunters favored a Monday opening or any week-day opening. Respondents rejected options that precluded hunters from participating on opening day such as hunter quotas or hunter's choice season (Table 2).

Hunting safety.--Most respondents believed the greatest effect of too many turkey hunters afield was to reduce their chances of killing a turkey (Table 3). Fifty-six percent thought the number of hunters afield presented a safety hazard. A lower percentage (43.0%) in the Delta region indicated that hunters afield were

Table 2. Responses (%) to options for reducing opening day hunting pressure during the spring turkey season in Arkansas, 1988.

Option	Yes	No	Unsure
Monday opening	77.6	12.4	10.0
Any week-day opening	65.8	14.4	19.8
Hunter's choice season[a]	10.1	75.5	14.4
1 bird/hunter/day during 1st week of season	39.3	50.8	9.9
1 bird/hunter/day during entire season	30.4	60.8	8.8
Opening day hunter quota	5.5	83.3	11.2
Limit out-of-state hunters	40.5	44.7	14.8

[a]Hunter selects portion of season he wants to hunt, but would not be allowed to hunt the entire season.

a safety hazard. Hunters (88.2%) were against the required wearing of hunter orange during the spring turkey season. Even those who thought that unsafe hunters were a threat to spring hunting rejected mandatory wearing of hunter orange outer garments. In contrast, hunters supported (68.5%) restricting legal shot size to #4 or smaller.

Future program direction.--Hunters were given a choice of proposals for improving turkey hunting, population levels, and turkey distribution in the state (Table 4). Proposals highly favored by respondents included establishing more wilderness and walk-in hunting areas, closing low population areas, and stocking. There was also good support for vehicle-access control. Respondents rejected proposals to reduce hunting opportunity, such as shortening the spring season to 1 or 2 weeks, and to eliminate turkey calling contests. There was considerable support for strengthening trespass laws by those who hunted in the Delta region (83.0%) where public land is limited and most hunting occurs on private land.

Reasons for hunting.--NWTF members were asked to rate the importance of 19 possible reasons for spring turkey hunting. Hunters primarily sought to experience the outdoors and nature, socialize, harvest a turkey, and test skills (Table 5). Obtaining meat for the table was rated as somewhat important and seemed to be more important to younger hunters ($\leq$30, 70.0%) than to middle-aged (31-59, 55.6%) and older ($\geq$60, 41.2%) hunters.

Table 3. Responses (%) of Arkansas spring turkey hunters to statements about turkey hunter numbers, 1988.

Statement	Agree	Disagree	Unsure
A large number of hunters in the field reduces my chances for taking a turkey.	83.9	10.6	5.5
There are too many hunters in the areas I spring turkey hunt.	59.6	23.4	17.0
The number of hunters afield presents a hazard to my safety.	56.0	21.8	22.2
Because of the large number of hunters afield recently, I now enjoy spring turkey hunting less than in the past.	47.6	41.8	10.6

Table 4. Opinions of spring turkey hunters about proposals to improve turkey hunting, turkey population levels, and turkey distribution in Arkansas, 1988.

Proposals	n	Sum of values[a]	Mean[b]	%[c]
Yes (0.34 to 1.00)[d]				
Establish more walk-in turkey hunting areas	655	507	0.77	84.7
Establish more wilderness areas	656	494	0.75	84.6
Close low population areas and stock	650	487	0.75	82.2
Reduce access roads (public lands)	655	386	0.59	75.1
Close non-maintained roads to vehicles during spring season	652	302	0.46	69.3
Unsure (−0.33 to 0.33)				
Reduce spring season bag limit to 2 gobblers statewide	654	114	0.17	10.1
Strengthen trespass laws	653	113	0.17	15.9
Reduce areas open to fall hunting	650	63	0.10	11.5
Bag limit of 1 gobbler/day, 2/season	649	34	0.05	10.0
Bag limit of 1 gobbler/day, 1st week of season	649	−25	−0.04	9.9
Quota hunter permits on public lands	654	−126	−0.19	19.0
1/2 day hunting (morning only)	654	−188	−0.29	9.5
No (−1.00 to −0.34)				
Shorten spring season to 3 weeks	649	−220	−0.34	61.0
Split season opening between north and south Arkansas	646	−232	−0.36	58.4
Shorten spring season to 2 weeks	644	−404	−0.63	76.4
Eliminate turkey calling contests	655	−514	−0.78	83.8
Shorten spring season to 1 week	640	−529	−0.83	87.7

[a]Sum of values derived by procedures described by Gilbert (1977).
[b]Mean equals sum of values divided by sample size (n).
[c]Percent of responses that placed factor in category where listed.
[d]Range of values in which mean must fall to be placed in category.

Of 12 possible conditions influencing NWTF members to start spring turkey hunting, the 3 most important were: a friend who turkey hunts (26.8%), being invited by an experienced hunter (19.1%), and outdoor magazine articles (12.9%). Attending turkey calling contests was rated of little importance. Family tradition and friends and neighbors reporting sightings of turkeys ranked as somewhat important factors.

Enjoyment of hunting.--We examined factors that enhance or detract from the enjoyment of spring turkey hunting. Highly ranking enjoyment factors included hearing gobbling, calling turkeys, killing a turkey, and seeing turkey sign (Table 6). Important factors that detracted from enjoyment included wounding a turkey, poaching, and dogs in the turkey woods. Unimportant factors included turkey calling contests, access roads, and 4-wheel-drive vehicles.

Spring hunting threats.--Factors associated with legal and ethical problems ranked as great threats. These included poaching, unsafe hunters, killing hen turkeys, and poor hunter

Table 5. Importance of reasons to go spring turkey hunting in Arkansas, 1988.

Reason and importance	*n*	Sum of values[a]	Mean[b]	%[c]
Of much importance (2.26 to 3.00)[d]				
Get out of doors	655	1,845	2.82	85.5
Enjoy springtime environment	655	1,813	2.77	80.3
Feel close to nature	654	1,685	2.58	62.5
Learn about nature	652	1,573	2.41	48.9
Have a challenge in life	655	1,575	2.41	51.2
Be with friends	655	1,536	2.35	45.0
Kill a turkey	655	1,513	2.31	38.6
Test my hunting skill	654	1,498	2.29	43.0
Of some importance (1.51 to 2.25)				
Have excitement in my life	655	1,455	2.22	46.7
Be alone	655	1,379	2.11	54.5
Get exercise	655	1,369	2.09	58.6
Get away from city life	649	1,334	2.06	30.8
Get away from work	649	1,270	1.96	41.8
Be with family	649	1,243	1.92	37.8
Have stories to tell others	653	1,181	1.81	53.3
Obtain meat	652	1,033	1.58	49.2
Not important (0.76 to 1.50)				
Show others my hunting skills	653	937	1.44	56.1
Escape the family for a while	654	918	1.40	60.1
Satisfy hunting friends/family	654	777	1.19	78.4
Unsure (0.00 to 0.75)				

[a]Sum of values derived by procedures described by Gilbert (1977).
[b]Mean equals sum of values divided by sample size (*n*).
[c]Percent of responses that placed factor in category where listed.
[d]Range of values in which mean must fall to be placed in category.

behavior (Table 7). Free-running dogs and factors associated with land management were also ranked as important threats. Factors categorized as somewhat of a threat included clearcutting, too many hunters, coyotes *(Canis latrans frustror)*, politics, and city growth. Legal sport hunting, nonresident hunters, and armadillos *(Dasypus novemcinctus mexicanus)* were not considered threats.

Turkey habitat.--Hunters were presented a list of 20 habitat characteristics and asked to select the 5 most important to ideal turkey habitat. Items ranked in descending order of importance were: within 1/2 mile of water, more than 1/4 mile to open road, large pine and hardwood, open woods, and large and small pine and hardwood. Old fields tied for fifth place. Respondents who favored more wilderness areas and thought clearcutting was a threat listed "old fields" as one of the top 5 ranking items. Hunters in the Ozark and Delta regions listed "old fields" in the top 5 items. In addition, "less than 1/2 mile from food plots" was ranked as a top 5 item in the Delta region. Those hunting in the Ouachita and Gulf Coastal Plain regions substituted "large and small pine and hardwood" as a top 5 item, out-ranking "old fields" and "less than 1/2 mile from food plots." "Open woods" and "large pine and hardwood" did not make the top 5 items in the Delta region.

DISCUSSION

Results of this study indicate that NWTF members are generally older and have higher household incomes, more hunting experience, and higher hunting success rates than spring turkey hunters in general. A 1985 hunter survey in Arkansas indicated an average age of 39 years for spring turkey hunters and a harvest rate of 0.65 birds/hunter (Heller 1985). A 1988 survey of spring turkey hunters in Missouri indicated a household income of $25,000-$49,999, a hunter success rate of 41%, and an average of 6.7 years of turkey hunting

Table 6. Factors affecting enjoyment of spring turkey hunting in Arkansas, 1988.

Factor and importance	*n*	Sum of values[a]	Mean[b]	%[c]
Adds greatly to enjoyment (1.21 to 2.00)[d]				
High gobbling activity	651	1,260	1.94	95.1
Calling turkeys	652	1,220	1.87	91.4
Killing a turkey	647	1,022	1.58	64.9
Turkey sign	650	1,025	1.58	61.2
Familiar hunting area	650	982	1.51	60.8
Friends	645	953	1.48	58.6
Birds and other wildlife	647	934	1.44	62.6
Camping	646	852	1.32	54.0
Adds some to enjoyment (0.41 to 1.20)				
Family	642	744	1.16	29.0
Legal sport hunting	603	595	0.99	7.3
Photography	643	578	0.90	29.6
Long season	648	441	0.68	27.0
Neither adds or takes away (−0.39 to 0.40)				
Turkey calling contests	646	246	0.38	59.3
Access roads	650	−203	−0.31	23.2
4-wheel-drive vehicles	652	−230	−0.35	35.7
Takes away some from enjoyment (−1.19 to −0.40)				
Cold temperature	648	−282	−0.44	31.8
Rain	641	−279	−0.44	36.5
Hot temperature	644	−384	−0.60	37.3
Weekend season opening	650	−436	−0.67	19.4
Other hunters	641	−473	−0.74	42.8
Low gobbling activity	649	−606	−0.93	38.1
All-terrain vehicles	651	−629	−0.97	14.6
Takes away greatly from enjoyment (−2.00 to −1.20)				
Free-running dogs	654	−1,046	−1.60	74.0
Dogs chasing wildlife	653	−1,056	−1.62	78.0
Poaching	648	−1,130	−1.74	82.6
Wounding a turkey	647	−1,202	−1.86	89.6

[a]Sum of values derived by procedures described by Gilbert (1977).
[b]Mean equals sum of values divided by sample size (n).
[c]Percent of responses that placed factor in category where listed.
[d]Range of values in which mean must fall to be placed in category.

experience (Vangilder et al. 1990). A study in Virginia (Norman et al. 1988) indicated an average of 12.3 years of turkey hunting experience. Johansen et al. (1988) found that spring turkey hunters in West Virginia averaged 41 years of age and had almost 11 years of hunting experience.

Regions hunted by NWTF members reflected hunting use characteristics by urban versus rural respondents. The Delta region is predominately highly productive private land. High turkey populations exist primarily on private hunting club lands inside the Mississippi River levee. Many of the urban hunters attracted to the Delta region may be members of these private hunting clubs. Urban hunters are probably attracted to the Ouachita Mountain region because of extensive public land available within the 1.5-million-acre (607,500-ha) Ouachita National Forest. In addition, the region traditionally has maintained high turkey populations and high harvests, exceeding other regions until the late 1980s (R. Smith, AGFC, unpubl. data).

Lower participation by NWTF members in fall hunting versus spring hunting seems to reflect general trends in turkey hunting in states with a spring hunting tradition. A recent survey of spring turkey hunters in Missouri indicated 96% hunted during the spring; however, only 59% had hunted during the previous fall (Vangilder et al. 1990).

Table 7. Importance of perceived threats to spring turkey hunting in Arkansas, 1988.

Threats and importance	*n*	Sum of values[a]	Mean[b]	%[c]
Much of a threat (2.26 to 3.00)[d]				
Poaching	651	1,792	2.75	77.0
Unsafe hunters	651	1,694	2.60	64.7
Killing hen turkeys	652	1,673	2.57	65.8
Poor hunter behavior	654	1,665	2.55	58.0
Free-running dogs	654	1,602	2.45	57.3
Clearing forests	650	1,584	2.44	57.4
Too many roads	648	1,539	2.38	49.1
Vehicle access	653	1,501	2.30	38.6
Somewhat of a threat (1.51 to 2.25)				
Clearcutting	654	1,456	2.23	36.1
Too many hunters	652	1,432	2.20	58.4
Coyotes	653	1,405	2.15	53.8
Politics	645	1,309	2.03	42.6
City growth	651	1,235	1.90	50.5
Anti-hunters	649	1,229	1.89	38.1
Posting land	654	1,168	1.79	44.5
Not a threat (0.76 to 1.50)				
Armadillos	652	930	1.43	32.2
Building dams	649	892	1.37	42.8
Out-of-state hunters	652	884	1.36	50.5
Legal sport hunting	640	806	1.26	65.5
Unsure (0.00 to 0.75)				

[a]Sum of values derived by procedures described by Gilbert (1977).
[b]Mean equals sum of values divided by sample size (*n*).
[c]Percent of responses that placed factor in category where listed.
[d]Range of values in which mean must fall to be placed in category.

Turkey hunting is important to NWTF members as most hunted throughout Arkansas' 1988 4-week spring season. A majority spent several days preparing for the hunt, most took time off work to hunt, and a large number (40.9%) hunted out of state. A national survey of licensed hunters in 1985 revealed that 87% hunted only in their state of residence (U.S. Fish and Wildlife Service 1988). This high level of participation by NWTF members shows dedication, persistence, enjoyment of the sport, and successful management.

The importance of public land was evident as NWTF members spent more days afield hunting on public land than on private land. Respondents also favored hunting areas in Ouachita Mountain region counties, several of which are dominated by national forest lands. Arkansas is fortunate to have extensive federally and state-owned public land, especially in the Ouachita and Ozark Mountain regions. These lands also harbor the largest concentrations of turkey in the state (R. Smith, AGFC, unpubl. data).

Most NWTF members are highly experienced and understand the importance of not harassing turkeys before the spring season. Preseason calling makes the birds call-shy and more difficult to harvest. Hunters prefer morning hunting when turkey mating and gobbling activity are at a daily peak; however, many hunters persisted throughout the day. Arkansas has always allowed all-day spring turkey hunting.

Studies conducted in Ohio (Donohoe and McKibben 1973), Virginia (Norman et al. 1988), and West Virginia (Johansen et al. 1988) have shown that turkey-hunter crowding and interference can detract from a quality hunting experience, especially during a spring gobbler season. NWTF members voiced similar concern, especially in the highest turkey density regions. This issue must be addressed by managers in the future.

NWTF members generally are satisfied with Arkansas' turkey management program. Most of the respondents who thought the spring season opened too late hunted in the Delta and

Gulf Coastal Plain regions. This response level may be partly because phenological vegetation changes and diel temperatures increase earlier in spring in these regions than in mountainous regions. The first peak in gobbling (Bevill 1975) may occur slightly earlier, prompting hunters to hunt gobblers when they are most easily called but before hens are receptive to breeding. Data on turkey breeding activity in Arkansas (R. Smith, AGFC, unpubl. data) indicate little difference throughout the state.

Opinions on proposals to reduce opening day spring season pressure and improve spring turkey hunting were similar to those of Missouri hunters (Vangilder et al. 1990). Proposals that reduce or restrict hunting opportunity and bag limits, or preclude hunting on opening day of the season, were not considered acceptable. Hunters want to be in the turkey woods on opening day!

A highly favored proposal of concern to managers was the establishment of more wilderness areas. It is interesting that respondents who favored wilderness areas and who thought clearcutting was a threat rated old field habitat as one of the 5 most important items making up ideal turkey habitat. This suggests possible misconceptions about turkey ecology and points out the need for more education efforts regarding turkey habitat requirements and management. A high level of concern about vehicle-access control may have prompted NWTF members to support establishment of more wilderness areas to accomplish vehicle-access control on public lands. The issue must be addressed by all public land management agencies in the state. The AGFC is working closely with the U.S. Forest Service in establishing more walk-in turkey hunting areas. Efforts also are continuing to build viable flocks by closing low population areas for stocking.

Concerns about too many hunters interfering with each other's efforts to harvest a turkey apparently outweigh safety concerns of NWTF members. This was more evident in the Delta region where large tracts of private land exist, and hunter numbers are likely controlled, especially on hunting-club lands.

Hunters object to mandatory hunter-orange requirements because turkeys see color and hunters perceive that wearing bright colors would make turkeys more wary and more difficult to call within gun range. More research is warranted in this area as 14 turkey hunting accidents, including 2 fatalities, occurred in Arkansas during 1988 and spring 1989 (D. Reber, AGFC, pers. commun.). Support for shot restrictions is probably based on hunter safety reasons, but it also may be because most turkey hunters already use #4 shot or smaller. Seventy-nine percent of spring turkey hunters surveyed in Missouri stated they used #4 shot or smaller even before shot size was restricted in the state (Vangilder et al. 1990).

A quality outdoor experience is important to spring turkey hunters. More than 80% of Missouri hunters stated that observing wildlife produced great enjoyment (Vangilder et al. 1990). Similar attitudes among NWTF members in Arkansas indicate that strong consideration should be given to emphasizing quality experiences to improve hunter satisfaction and maintain program support.

Many believe the growing number of turkey calling contests to be a reason for the increase of turkey hunters. Our results lend little support for this premise. Being invited by a friend to turkey hunt seems to be the most common reason influencing individuals to start turkey hunting.

Factors producing great enjoyment while turkey hunting were associated with turkey behavior and characteristics. Maintaining or improving these enjoyment factors will require an increase in turkey numbers and maintenance of a high component of adult males in the turkey population.

NWTF members would welcome improvements in the ethical and behavioral traditions of some turkey hunters. Four of the most important threats listed for spring turkey hunting were related to illegal or improper behavior. Posting of land was rated as practically no threat. If hunters strive to maintain good relationships with private landowners, posting may not become a threat. A more aggressive effort in Arkansas' hunter education and STOP POACHING programs would be a positive step to reduce ethical problems and enhance responsible behavior. The problem of free-ranging dogs is not unique to Arkansas. Spring turkey hunters in Virginia (Norman et al. 1988) and West Virginia (Evans et al. 1987) reported the common occurrence of free-ranging dogs in areas they hunted. A solution to this problem can be developed only through cooperative efforts of land management agencies, landowners, and turkey hunters.

The importance of forest openings for improving turkey nesting and brood habitat has been well documented (Holbrook and Lewis 1967, Shaffer and Gwynn 1967, Martin and McGinnes 1975). Our results indicate that NWTF members are familiar with several important habitat components such as available water and large open woods. Habitats associated with nesting and brood range, such as proximity to food plots and clearcuts, were considered somewhat less important, however. Again, results indicate a need for a more concerted effort in educating turkey hunters about the wild turkey and its habitat needs.

A ranking of ideal turkey habitat components reflected general habitat conditions in the regions hunted. Old field and food plot components rated higher in the Ozarks and Delta regions where they are likely more common. More timber cutting, resulting in diverse stand ages, occurs in the Ouachita and Gulf Coastal Plain regions. In these regions the ranking of "large and small pine and hardwood" was higher.

This survey revealed a number of hunter interests and ideas in common with the AGFC. Although tolerance to change is indicated, which will help give the AGFC some flexibility in making difficult decisions on funding and regulation of hunting, traditional attitudes and opinions are still evident. The AGFC and the turkey hunter must work together in a spirit of cooperation to achieve the progress each desires. The AGFC must increase efforts in communication, law enforcement, and education, whereas turkey hunters must be receptive to change and new ideas. Arkansas turkey hunters must be willing to support professional, scientific efforts both financially and politically to improve their sport.

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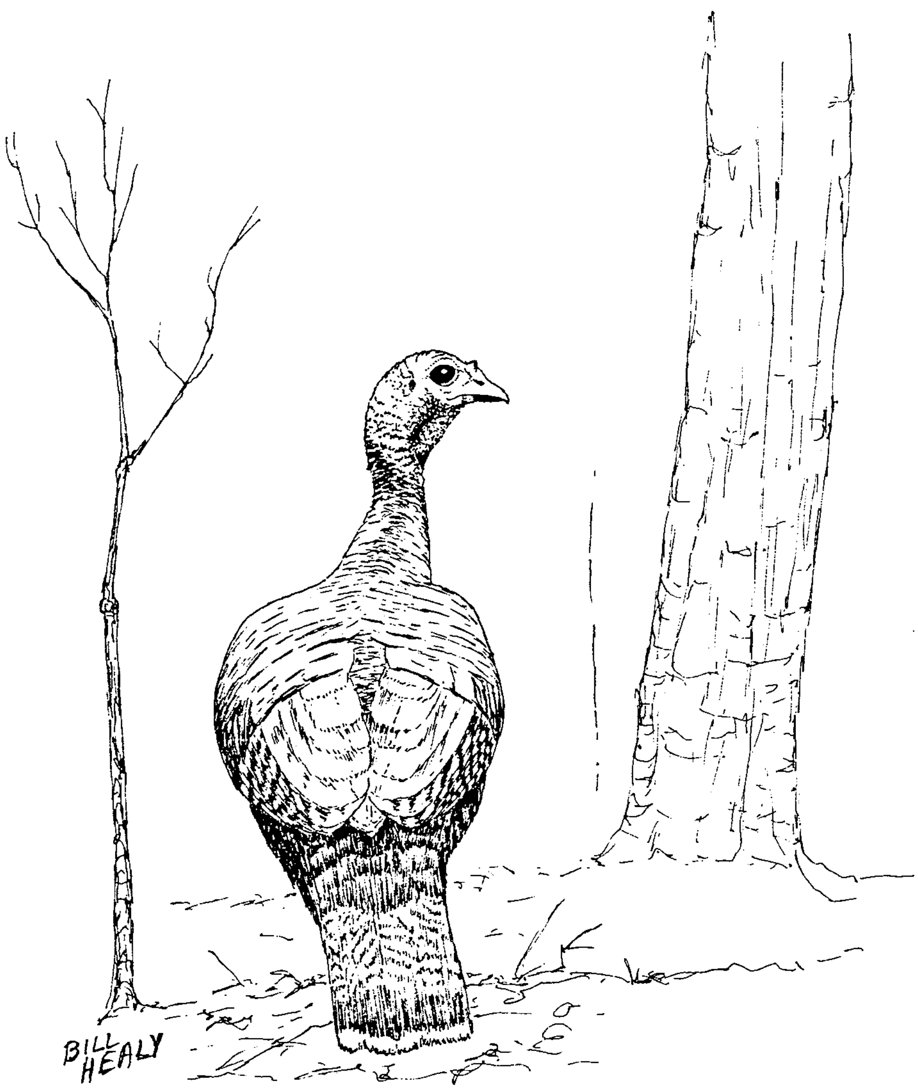

INFLUENCE OF HUNTER HARVEST ON THE POPULATION DYNAMICS OF WILD TURKEYS IN NEW YORK

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Abstract: Most wild turkey *(Meleagris gallopavo)* hunting programs are predicated on the hypothesis that harvests will not cause a decline in turkey populations. We tested this hypothesis by examining 50,000 hunter harvest and effort reports for the fall turkey hunting seasons of 1969 through 1981 in southern New York State. We used time-to-first-kill, an effort-based index, to measure relative population abundance. We used regression analysis to remove the variation in abundance attributable to land-use and weather conditions and then examine the influence of hunter effort in year Y on the abundance index in year $Y+1$. Hunter effort accounts for only 12% of the variation in both annual and long-term wild turkey abundance. Hunter success rates decline with hunter density and suggests that season length, rather than number of licenses, may be the most important consideration in regulating total harvest. Presence of snow on opening day has a positive effect on hunter success, but rainfall and temperature do not show a consistent influence. Data suggest density-dependent recruitment of young is at maximum at low levels of abundance. Populations of wild turkeys in New York appeared to be at 20-40% of ecological carrying capacity during most of 1969-81. We hypothesize that density-independent elements, and not hunter harvest, regulate the population in most years. Periodic synchrony of favorable conditions across all elements leads to rapid population growth, but in the highly variable environment of New York, this high abundance does not persist >1-2 years.

Biologists are increasingly challenged with questions about harvest of wild turkeys. Some groups would like to see more liberal seasons and others are concerned that the kill is already too high. The concern of the biologist or manager is for the vitality of the resource. Therefore we must be cognizant of the question: Can we overharvest turkeys? Implicit in this question is a value judgement. Harvest levels that prevent populations from achieving carrying capacity are viewed by some as excessive. Others may define overharvest as occurring only when it depresses the population to the point of risk of local extinction. Frequently, there is no consensus on which value system to apply. We suggest an objective phrasing of the question: Can harvest drive a population so low that recovery through reproduction is not possible within 1 year?

We explore classical harvest theory and evaluate its applicability to historical wild turkey populations in New York State. Drawing on data obtained during the 1970s, we attempt to measure the maximum rate of growth and to determine the abundance of turkey populations relative to the upper limit or ecological carrying capacity (Caughley 1979). Finally, we examine the hypothesis that hunter harvest is the dominant element affecting wild turkey abundance in New York State.

J. W. Glidden and D. E. Austin stimulated many of the ideas presented here. We are indebted to W. M. Healy and J. B. Lewis, who helped clarify the presentation of this material. The work was supported by the New York State Chapter of the National Wild Turkey Federation and the Grant-in-Aid programs of the National Wild Turkey Federation and National Rifle Association.

STUDY AREA AND METHODS

We used New York State's wild turkey harvest and hunter effort data from >300 townships in the southern part of the state (Fig. 1). This region is composed of hardwood forest

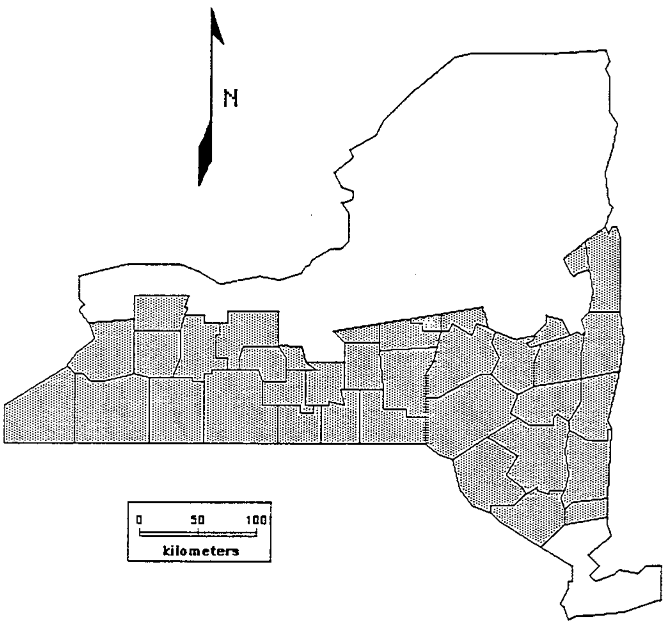

Fig. 1. Region of New York from which historical hunter effort, harvest, land-use, and weather data were obtained for analysis of the influence of hunter effort on abundance and growth rates of wild turkeys, 1969-81.

interspersed with agriculture. Forest comprises 15-85% ($\bar{x}$ = 38%) of each township; brushland, 0.4-37% ($\bar{x}$ = 24%); cropland, 0.1-43% ($\bar{x}$ = 24%) and noncultivated open land, 0.1-27% ($\bar{x}$ = 13%). Dairy is the dominant industry, and corn, clover, winter wheat, and oats are the most common crops.

Either-sex, 2-week-long fall harvests began in 1968, and from 1969 to 1981, harvest and effort data were collected from turkey hunters via mail-in report cards given to all hunters. The fall hunting season was conducted in conjunction with the traditional small-game season, and from 1969 to 1975, hunters could take 1 turkey on the small-game license. Beginning in 1975, hunters were required to purchase a $2.00 permit in addition to a small-game license and allowed to take 1 turkey. For purposes of the analysis, we assumed that the proportion of hunters pursuing turkeys (among all hunters in the field) was constant through the time period. Hunter densities during this period were approximately 2-5 hunters/km^2 of woodland (DeGraff and Austin 1975). Hunter reports are biased because successful permit-holders were more likely to respond voluntarily than unsuccessful hunters were. Responses to urges by mail were used to estimate the nonresponse bias and correct the harvest and effort data.

The corrected data were used to develop an index of relative population size. We explored traditional harvest-based techniques (e.g., total kill/unit area, change-in-ratio, harvest/effort) for estimating relative abundance. None produced values that met basic tests for accuracy or conformed to normal statistical distributions (Gefell 1990). Consequently, we developed an effort-based index. The conceptual foundation for this index is the relationship between time required to harvest a turkey and turkey abundance. The abundance index estimates the waiting time (number of hunter-days) before the first kill of the season in a given town. The reciprocal of hunter time-to-first-kill yields an index positively related to turkey density, meets basic accuracy tests, readily conforms to a standard statistical distribution (gamma), and provides a high degree of precision in analyses (Gefell 1990). Two examples of its calculation are:

	Area 1	Area 2
Hunter-days of effort opening day	200	200
Turkeys harvested opening day	20	5
Hunter time-to-first-kill	10	40
Abundance index	0.100	0.025

While the hunter effort is the same in both examples, the number of turkeys harvested is different. This difference is reflected directly in the abundance index, and we interpret values to mean the population in Area 1 is 4 times as abundant as compared with Area 2.

Testing for Influence of Hunter Effort on Abundance

To examine the effects of hunter harvest on population change, we used the abundance index as the response (dependent) variable in multiple regression analysis. Predictor (independent) variables were land use, weather, and hunter effort. Superficially, this analysis seems circular because we are using effort to generate the response variable, and then evaluating the influence of effort by casting it as a predictor variable.

The approach is not circular because, while there is a measure of effort on both sides of the equation, it is not the same measure. The analysis uses total hunter effort in the first year (Y) to predict the rate at which hunters will harvest turkeys (time-to-first-kill) in the subsequent year ($Y+1$). Thus, measures of effort are drawn from 2 different years. Further, Glidden (1980) has shown that our index of abundance is highly sensitive to the actual numbers of turkeys observed in late summer ($r = -0.89$).

Our hypothesis predicts that if hunting does affect abundance, the removal of turkeys due to effort in year Y should influence time-to-first-kill in years $Y+1$ and, perhaps, $Y+2$. More specifically, if hunter effort constitutes the dominant factor affecting population dynamics of turkeys, a majority of the variation in time-to-first-kill should be attributable to the effort in the previous year.

We anticipated that some variables may affect populations on an annual basis and others on a longer term. We also wanted to evaluate the effect of harvest on the rate of change in the population. Thus we ran 4 separate analyses, using each of 4 response variables derived from our index:

1. Annual Population Abundance
2. Annual Change in Abundance
3. Mean Population Abundance (1970-81)
4. Mean Change in Abundance (1970-81).

The analysis was conducted as a 2-step procedure. First, we statistically removed variation in abundance that could be attributed to land use and weather using multiple regression. Land-use data were obtained from New York's Land Use and Natural Resources Survey, completed in 1970, and variables used in this analysis were percentages of cultivated land, open (noncultivated) land, brushland (woody vegetation $\leq$9 m high), and woodland (woody vegetation >9 m high). Weather data were obtained from National Oceanic and Atmospheric Administration (NOAA) meteorological stations in each township. For purposes of this analysis, single-station data were assumed to be representative of the entire township. In simplified form, the regression formula appeared as:

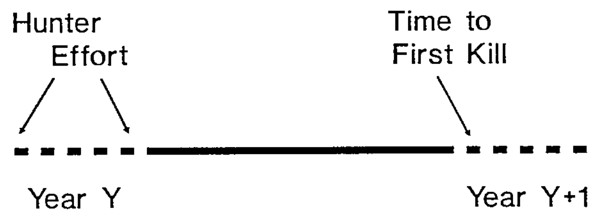

Fig. 2. The analysis tests the hypothesis that hunter effort in year Y influences wild turkey abundance in year $Y + 1$. Abundance in year $Y + 1$ is indexed by hunter time to first kill.

$$\text{Index of Abundance} = B_0 + B_1(\text{Land use}) + B_2(\text{Weather}) + e.$$

The residuals (e) from this regression contain the variability associated with hunter effort and other unmeasured variables (e.g., poaching, predation).

In the second step, the residuals were used as the response variable and regressed on hunter effort from the previous year. To reduce the confounding influence of turkeys learning to avoid hunters from early season experience, only first-week hunter-effort data were used (analysis showed a high correlation between hunter effort in the first week and total season, $r = 0.991$). Stepdown linear regression was used to evaluate the variability that could be attributed to fall hunter effort, to spring hunter effort, and to fall and spring hunter effort combined. We also examined potential curvilinear relationships using second-order terms for each of the dependent variables.

Testing for Density-Dependent Growth

The hypothesis that populations of wild turkeys display density-dependent growth was examined using the relationship between current population size and population growth in the subsequent year. Abundance indices were used to estimate growth rates (r), calculated as:

$$r = ln\ (N_t/N_{t-1})$$

where r is the instantaneous rate of growth,
ln is the Napierian logarithm,
N_t is the abundance in the current year,
N_{t-1} is the abundance in the previous year.

We predicted that if density-dependent growth mechanisms were operating, an inverse relationship between growth and relative abundance would be evident (Caughley and Birch 1971). Further, if this were the case, the Y-intercept would provide an estimate of the intrinsic rate of growth (r_m).

To further define the relationship between growth rates and abundance, a recruitment curve (increment of growth) was generated using data for 1969-81 from Cattaragus County, a county with a wide range of hunter effort.

RESULTS

Influence of Hunter Effort on Abundance

Sample sizes for all analyses were at least 50. Levels of hunter effort within a single township during 1 season ranged from 0 to 3,786 hunter-days during the first week and 0 to 7,800 hunter-days during the entire season.

Regression analyses show hunter effort accounts for a minor portion of the variation in abundance. After controlling for the influence of land use and weather, hunter effort accounts for approximately 12% of the variation in population abundance (Table 1). This influence is strongest for annual and long-term abundance, and seems to have little influence on growth rate (Table 2). Examination of the influence of hunter harvest on populations 2 years later shows no significant relationships.

Success rate (proportion of hunters killing a bird) is influenced by turkey abundance, hunter density, and weather. Within a season, there is good correspondence between total hunter effort and total harvest (r = 0.60). The number of birds harvested per unit effort declines in a curvilinear fashion with increasing hunter density (Fig. 3). Within-season effects of weather on fall harvest appear related primarily to precipitation. Increases in rainfall and the presence of snow, however, correlate directly with harvest-per-unit effort. Hunter success rates show no relationship to maximum or average daily temperature during the fall (Table 3).

Table 1. Coefficients of determination (r^2) derived from regressions of mean abundance of wild turkeys (1970-81) on land use, weather, and hunter effort in New York.

Variable	Sample size (n)	r^2	P
Land use	60	0.449	0.0179
Weather	77	0.139	0.0008
Hunter effort	210	0.125	0.0001

Table 2. Coefficients of determination (r^2) derived from regressions of measures of wild turkey abundance and growth rates on hunter effort (hunter-days in first week of fall season) in New York, 1969-81.

Variable	Sample size (n)	r^2	P
Annual abundance	775	0.1176	0.0001
Annual rate of change	768	0.0303	0.0006
$\bar{x}$ abundance (1970-81)	210	0.1247	0.0001
$\bar{x}$ rate of change (1970-81)	61	0.0464	0.9270

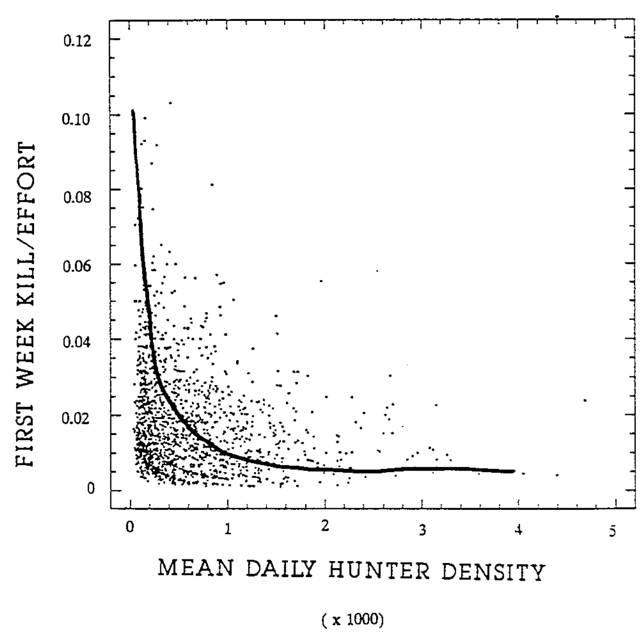

Fig. 3. Scatterplot of the relationship between average daily hunter density in a township and hunter success for the first week of fall wild turkey seasons in southern New York, 1969-81. Curve is drawn free-hand.

Table 3. Coefficients of determination (r^2) derived from regressions of hunter effort on intra-seasonal weather factors in New York, 1969-1981.

Variable	Sample size (n)	r^2	P
$\bar{x}$ maximum daily temp.	148	0.012	0.18
$\bar{x}$ daily temperature	147	0.004	0.38
$\bar{x}$ daily precipitation	155	0.053	0.01
$\bar{x}$ daily snow depth	157	0.058	0.01

Density-Dependent Growth

Regression analysis of growth rate in year $Y+1$ on abundance in year Y shows a strong inverse relationship and suggests density-dependent growth. Analysis of Cattaragus County data shows growth rate is strongly influenced by population abundance (r = 0.78) and that the relationship is curvilinear (Fig. 4). This translates to a recruitment curve that is skewed with a long tail to the right (Fig. 5). Maximum population growth occurs at densities of about 0-0.2 on our scale of relative abundance.

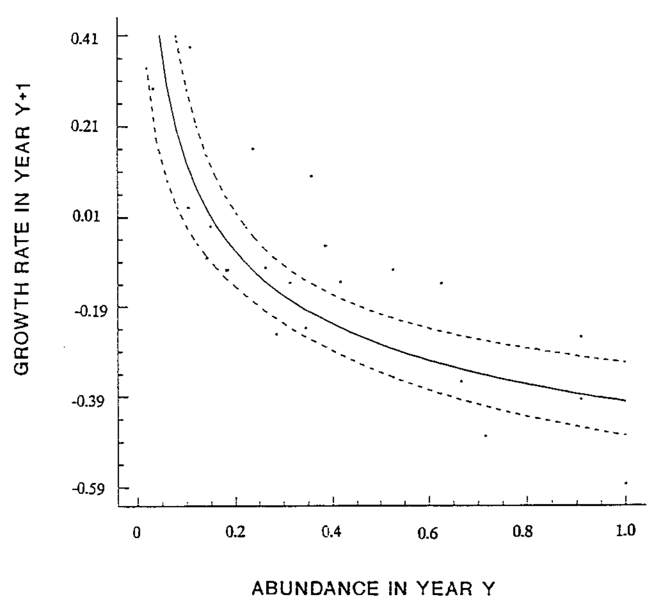

Fig. 4. Regression of population growth rate in year $Y+1$ on abundance in year Y for Cattaragus County, New York, 1981. Regression formula is $\hat{y} = aX^b$; $r^2 = 0.61$, $P < 0.0001$. Dotted lines represent upper and lower 95% confidence intervals. Growth rate is calculated as $r = ln\ (N_{Y+1}/N_Y)$.

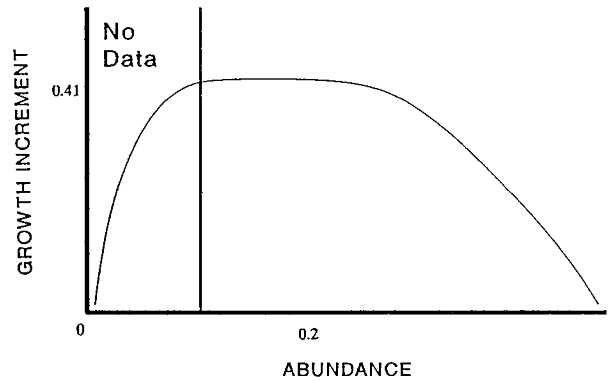

Fig. 5. Growth increment curve for Cattaragus County, New York, 1969-81. Abundance is scaled 0-1. Maximum population growth occurs at densities of about 0-0.2 on the scale of relative abundance.

DISCUSSION

Can we overharvest wild turkeys? The answer is certain: yes. It is likely that overharvest contributed to the extirpation of the bird throughout much of its range. More important, it is likely that the wild turkey, today, is vulnerable to overharvest. Much of the range to which the turkey has been restored is composed of dendritic or isolated block arrangements of forest cover (Backs and Eisfelder 1990), which are readily accessible by hunters. The more important questions are, what is the risk of overharvest, given current regulations; and what levels of control are likely to be most effective in adjusting harvest?

The ability of a population to sustain continuing harvest, or conversely the risk that it cannot, is predicated on classical population theory of density-dependent growth. Application of this theory to management in the context of maximum sustained yield has been explored for a variety of species (e.g., Gross 1969, Harwood 1981, McCullough 1981). Although maximum sustained yield has never been a goal in wild turkey management, understanding the limits to which wild turkey populations can sustain harvest is helpful in assessing the risk of overharvest.

In most populations, the number of new individuals added to the population (increment of growth) varies with the density of that population. The increment of growth reaches a maximum (I) and then declines to zero at ecological carrying capacity (K) (Fig. 6). The position of a population on the increment of growth curve is important to determining the level of harvest that can be sustained. According to theory, reducing population abundance with harvests on the right arm of the curve moves the population to a higher level of production, and thus the population compensates for the loss (Fig. 6). Harvests taken from a population on the left arm of the parabola, however, will result in reduced production. Continued removals at that level will cause the population to decline to extinction (e.g., McCullough 1979).

While the general model of density-dependent growth is a symmetrical curve with peak annual production at 50% of maximum population size, in reality the curves may be skewed (Fig. 6). A skew with a tail to the left indicates a harvest of a population on the right arm of the parabola will result in a dramatic increase in growth because peak production occurs at high levels of abundance. Should the population fall below relatively high abundance levels, it cannot sustain continued harvest. The long tail to the left, however, means a large difference between the abundance at peak production and extinction. This is likely to allow several years of continuing harvest, providing an opportunity for detection and adjustment of the harvest.

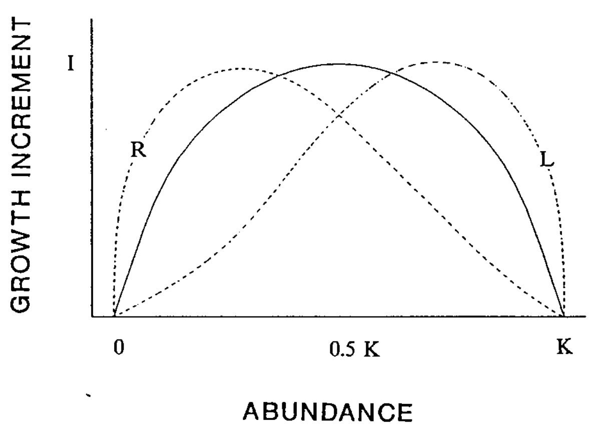

Fig. 6. Classical relationship between annual increment of growth and population density. Maximum annual production occurs at the peak (I) and is zero at ecological carrying capacity (K). Curve R shows maximum increments of growth occur when abundance is well below 50% of ecological carrying capacity. Curve L shows maximum growth increments occur at high abundance levels.

In contrast, a skew to the right means peak production occurs at relatively low densities. This allows the population to be harvested to very low levels with little risk of extinction (Fig. 6). In this case, the population compensates for harvest over a broad range of abundance levels. The danger is that if population abundance does fall to the left arm, there is little time to detect the problem and correct harvest management regimes.

Evidence of Density-Dependent Growth

Which model best characterizes the wild turkey? Fowler (1981) predicts that short-lived, rapidly reproducing species (such as the wild turkey) should display a right skew to the increment of growth curve. The results of our analysis of New York data support this. The relationship between growth rate and abundance is slightly curvilinear and concave upward. The analysis of statewide data shows substantial variance around the curve that we believe is attributable to differences in habitat quality (and thus ecological carrying capacity) among the various regions of the state. Minimizing this variation by examining a single county, Cattaragus, shows the right skew is a consistent pattern.

Influence of Harvest on Population Dynamics

Observations show that relative abundance is most frequently in the range of 0.2-0.4 on our scale of relative abundance (0-1.0). This suggests that turkey populations in New York are generally well below 50% of ecological carrying capacity. Is hunter harvest the primary factor holding populations in New York below carrying capacity on a continuing basis? We believe the answer is no.

There is no clear relationship between hunter effort in 1 year and abundance levels in the following year. Empirical analyses show hunter effort accounts for only 3% of annual variation in growth rate and 12% of the variation in abundance. The lack of any significant relationship between effort and population abundance in the second year indicates that time-lag effects are not important in the short term.

We hypothesize that the lack of a clear relationship between harvest and abundance is attributable to the reproductive potential of this species. Reproduction occurs between harvest in 1 year and the time of our estimate of abundance in the next, and can thus offset losses to harvest before the subsequent fall. The relative abundances of 0-0.2 are within the range where the increment of growth is at its maximum. Such inference suggests compensatory reproduction, but we can offer no data to evaluate this hypothesis.

We are left with an enigma: If harvest is not driving population change in wild turkeys, why do populations in New York tend to remain well below ecological carrying capacity? Why is high abundance rare? One hypothesis is that unrecorded kill is substantial and having a significant influence on population dynamics. Kimmel and Kurzejeski (1985) and Kurzejeski et al. (1987) suggest that illegal or inadvertent kill during the spring season may be frequent. This would have a dramatic effect on population growth because female losses during the spring are likely to occur after density-dependent growth responses are in place for the year.

An alternative hypothesis is that density-independent elements are of primary importance to population change in this environment. Horn's (1968) concept of the relative influence of independent elements provides a good model for New York (Fig. 7).

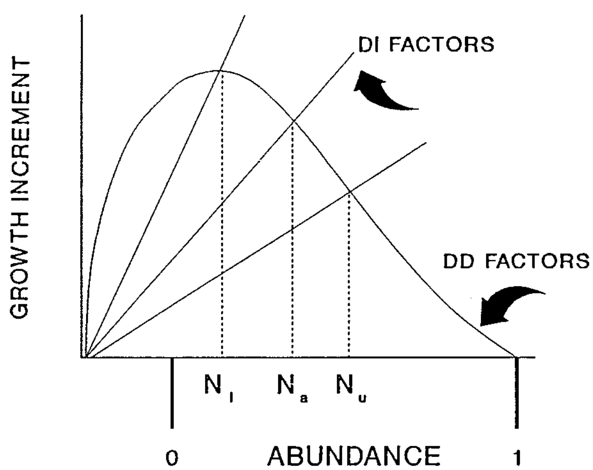

Fig. 7. Horn's (1968) concept of the relative influence of density-independent (*DI*) and density-dependent (*DD*) factors and the hypothesized model for New York. Variation in the effect of density-independent factors is depicted as lower (N_1) and upper (N_u) abundance levels. The range of 0-1 represents relative abundance as measured by time to first kill.

The range of relative abundances observed suggests a suite of density-independent elements define an average population size (N_a) with a broad variance (N_l to N_u). The periodic high abundances result from a coincidence of favorable weather, habitat, and other environmental conditions that allow explosive population growth. We suspect that subsequent variation in the effects of harvest reflects a complex phasing of hunter effort, hunter success rates, and weather patterns as they interact with density-dependent growth.

MANAGEMENT IMPLICATIONS

Given the growing popularity of turkey hunting, it is conceivable that hunter harvest might reach a level that could drive a population to the left arm of the growth increment curve. Managers can safeguard against this by manipulating 3 variables: total hunter effort (number of hunters), distribution of the effort in time, and the dispersion of effort, spatially. Decreasing hunter effort is the intuitive choice for decreasing harvest.

Our analyses suggest that number of licenses is not likely to have a great influence on harvest. The strong inverse relationship between hunter success and hunter density suggests that we can allow a large number of hunters in the field without great risk of overharvest. We suspect this is related to inter-hunter interference and, perhaps, rapid behavioral conditioning of turkeys that encounter hunters frequently.

An alternative management strategy is to adjust season length. If the number of hunters remains constant, but the season is shortened, hunter density will increase. Our analyses suggest that this will lower hunter success rate and thus decrease the total harvest. Conversely, spreading the same number of hunters over longer time spans or larger areas (of similar turkey density) should increase the harvest.

These findings provide direction for more intensive study of turkey harvest management programs. First, if our hypothesis is correct and there is a strong compensatory recruitment at low levels of abundance because of the skew of the growth increment curve, turkey populations in New York appear to be resilient to high levels of harvest over broad ranges of abundance. We need a better understanding of the potential compensatory nature of reproduction to be able to assess rigorously the risk of overharvest. Second, if as we hypothesize, population abundance in environments such as New York is largely determined by density-independent elements, management programs need to be tailored more closely to cope with the exceptionally poor years and take advantage of the exceptionally favorable years. We need to identify cues that will aid managers in anticipating the extreme conditions.

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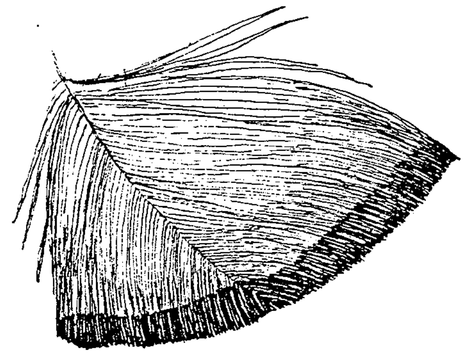

EVALUATION OF A POPULATION MODEL AS A MANAGEMENT TOOL IN IOWA

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Abstract: We evaluated the ability of a computer simulation model to project wild turkey *(Meleagris gallapavo silvestris)* numbers by determining if projections were correlated with winter counts of turkeys on a study area in south-central Iowa. Four different levels of model complexity were evaluated and all were positively correlated with the winter counts. Projections from the model using average survival rate estimates and year-specific fecundity estimates provided the best fit. The model was adopted for regional use by using survey data collected annually as an index to fecundity rates. The projections from these models are examined to demonstrate how they might be used to answer population management questions.

Computer simulations of wildlife populations have become an accepted management tool for many big game species (Walters 1972, Pojar 1977, Williams 1981). These computer models keep track of the size and structure of the simulated population through time. Managers use these models to ask "what if" questions about the effect of management strategies such as hunting on the population of interest. Even though these models are simplifications of reality, they generally require extensive data. Their data requirements usually are directly related to their complexity (Porter et al. 1990). Intuitively, we expect increased model complexity to yield increasingly realistic and accurate results. Theoretically, a wild turkey population model could include estimates of population size, age- and sex-specific seasonal and annual survival, age-specific fecundity; and the effects of weather, predators, and density-dependent phenomena on these parameters. Agencies charged with managing turkey populations often have only a few of these estimates available to them. Thus, given the available data, management models should be parsiminous and tractable to be of practical value.

Because of the lack of suitable data, few attempts have been made to model wild turkey populations. Porter et al. (1983) developed a model to emulate the effect of severe winters on turkeys in southern Minnesota. Kimmel and Kurzejeski (1985) used this model to project the effect of illegal hen loss on turkeys in Missouri. Suchy et al. (1983) simulated the potential effect of a fall hunting season in Iowa. The database used for their model was based upon the results of the first 4 years of a radio-telemetry study in southern Iowa. The study continued for another 4 years and provides additional information to develop and validate the model further. The effects of fall hunting on survival in this population were reported by Little et al. (1990).

The objective of this study was to determine how complex a model is needed to reflect adequately wild turkey population numbers recorded on the study area. The model with the best fit was then used to investigate 2 typical management situations. The first was to evaluate the effect that fall hunting had on the turkey population on the study area. The second was to illustrate how the model can be used to simulate regional populations using survey data collected annually for input.

We thank the personnel who diligently collected the field data for this project. We appreciate the help and suggestions provided by J. Kienzler and 2 anonymous reviewers. Funding for this project was provided by Iowa's sportsmen, the Iowa Chapter of the National Wild Turkey Federation, the National Wild Turkey Federation, and Iowa Federal Aid in Wildlife Restoration Project FW-115-R.

METHODS

The computer program TURKEY (Suchy et al. 1983) was modified to reflect the addition of a fall hunting season. The model, TURK4, begins with an initial population just prior to the spring hunting season (Fig. 1). The initial

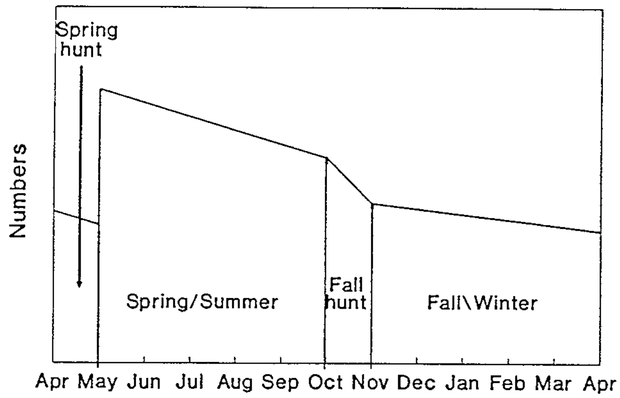

Fig. 1. One annual cycle in the population model TURK4.

numbers for all simulations of the study area population were: 119 juvenile females, 164 adult females, 120 juvenile males, and 76 adult males. The simulated year is divided into 4 segments, which correspond to the spring hunt, the spring-summer, the fall hunt, and the fall-winter periods. The initial population is subjected to sex- and age-specific survival rates for each period. Age-specific recruitment occurs after the spring hunt period. All periods except the spring-summer have only 2 age classes: juveniles ($\leq$1 year old) and adults (>1 year old). There are 3 age classes during the spring-summer: poults, juveniles, and adults. Harvest can be either specified explicitly or can be part of the period mortality rate. If the former method is chosen, harvest mortality is assumed to be additive (Little et al. 1990). Population size and structure is output prior to the fall and spring hunting periods each year.

Parameter Estimates

Values for variables in the model were estimated from data collected on 447 radio-tagged turkeys monitored during a study of wild turkey ecology in south-central Iowa from 1978 through 1986. The study area included about 8,300 ha of publicly owned state forest and 13,700 ha of surrounding privately owned land. See L. Crim (1981) and G. Crim (1981) for a more detailed description of the study area. The entire area has been open to spring gobbler-only hunting since 1974. A fall season for any-sex turkeys was initiated in 1981.

Fecundity rates used were the average number of poults hatched per radio-tagged female alive at the beginning of the spring hunting season. This date approximates the onset of reproductive activities. Separate rates were calculated for juvenile (n = 43) and adult (n = 120) females (Table 1). The sex ratio of poults hatched was assumed to be 50:50.

We calculated juvenile and adult survival rates used for the model for each period by using a generalized Mayfield technique to estimate unbiased cause-specific mortality (Heisey and Fuller 1985). The data were pooled to obtain better precision, when z-tests indicated no difference between juvenile and adult birds. See Little et al. (1990) for a more detailed explanation. For males, all years were pooled except 1978 and 1984. For females, data were pooled in 1978, 1979, 1983, 1984, and 1985.

Poult survival rates were estimated from bi-weekly flush counts of 74 radio-tagged females with broods. We used a regression technique with nested error structure to make the estimates because of these repeated observations (Fuller and Battese 1973). The technique estimated the percent alive (survival) after a given number of days (Table 2). Poults were difficult to count because they often scattered and hid ($\leq$3 weeks post-hatch) or ran away without flushing (>3 weeks). The effects of this behavior were compounded in years when many hens produced broods because many hens with poults banded together in flocks of 2 or more broods. These "gang broods" were unstable associations that were difficult to count because poults from different broods were indistinguishable. The later problem may have resulted in underestimating poult survival in 1979, 1982, 1983, and 1985 when many broods were produced.

Table 1. Fecundity rates used in the simulations. Rates were calculated from number of poults hatched per radio-tagged female alive at the beginning of April.

Year	Juveniles	Adults
1978-79	0.00	2.40
1979-80	1.60	3.60
1980-81	0.30	2.40
1981-82	0.70	1.20
1982-83	0.00	1.60
1983-84	1.30	3.40
1984-85	0.00	1.90
1985-86	4.60	4.00
Average	1.18	2.72

Table 2. Survival estimates used in the simulation models of wild turkey populations by age and sex class for 3 periods. Estimates were derived from a sample of 447 radio-tagged turkeys monitored from 1978 to 1986.

Year	Period[a]	Juvenile females	Adult females	Juvenile males	Adult males	Poults
1978-79	1	0.97	0.97	0.97	0.97	
	2	0.82	0.82	0.82	0.84	0.51
	3	0.73	0.78	0.41	1.00	
1979-80	1	0.75	0.96	1.00	0.27	
	2	1.00	0.75	1.00	0.62	0.23
	3	0.75	0.75	0.67	0.67	
1980-81	1	0.96	0.96	0.95	0.95	
	2	0.81	0.81	0.76	0.76	0.45
	3	1.00	0.83	0.68	0.68	
1981-82	1	1.00	0.98	0.95	0.95	
	2	1.00	0.88	0.76	0.76	0.41
	3	0.79	0.66	0.66	0.66	
1982-83	1	0.63	0.92	0.46	0.46	
	2	1.00	0.87	1.00	1.00	b
	3	0.70	0.70	0.49	0.49	
1983-84	1	0.95	0.95	0.91	0.91	
	2	0.78	0.78	0.60	0.60	0.28
	3	0.27	0.82	0.42	0.42	
1984-85	1	0.81	0.82	0.54	0.54	
	2	0.89	0.84	0.70	0.70	0.39
	3	0.61	0.61	0.10	0.72	
1985-86	1	0.97	0.97	0.87	0.53	
	2	0.79	0.79	0.86	0.83	0.37
	3	0.86	0.86	0.72	0.72	
Average	1	0.88	0.94	0.80	0.68	
	2	0.89	0.83	0.83	0.79	0.34
	3	0.71	0.75	0.52	0.67	

[a] 1 = spring hunt, 2 = spring-summer, 3 = fall hunt and fall-winter.
[b] Estimate was <0, substituted lowest estimate from other years = 0.23.

We estimated population numbers for the study area in winter by walking permanent transects and recording the number of individual birds or sets of tracks encountered. Counts were only conducted after fresh snowfall, and we assumed that no birds were missed or counted more than once. We conducted counts every year except 1979 and 1981, when snow conditions were not suitable.

Simulations

Initially, we ran 4 simulations using increasingly complex data sets. In the first simulation (S1) we held survival and fecundity rates constant throughout the simulation. We used the average fecundity ($\bar{F}$) and the average survival ($\bar{S}$) rates calculated over the period of the study. In the second simulation (S2) we used average survival rates but year-specific fecundity rates (F). In the third simulation (S3) we used average fecundity rates and year-specific survival rates (S). In the fourth simulation (S4) we used year-specific fecundity and survival rates (F,S).

Linear correlation analyses (Steel and Torrie 1980) were used to determine which simulation was best correlated with the winter track counts. Because all of the simulations start with the same initial size, a basic assumption of correlation analysis was violated. Thus, the first year is not included in the analyses. The resulting correlation coefficients are primarily for comparisons of fit, not statistical significance.

Because the poult survival estimates used for this model were considered the least reliable input estimate, they were chosen for use in a sensitivity analysis. The objective of this analysis was to determine to what extent changes in the values of this input affect model performance. We also determined if an improvement could be made in the fit of the projections to the winter counts.

We reran the initial simulation, which produced the projections that best fit the winter counts for the sensitivity analysis. This simulation (S5) used a poult survival rate of 44% for all years. This estimate was the mean rate for years when we believed gang-brooding least affected the accuracy of summer flush counts. We increased poult survival rates by the same amount (6%) for each of the next 3 simulations. Simulations S6, S7, and S8 used poult survival rates of 50%, 56%, and 62%, respectively. Although poult survival rates in the wild could be higher, we believed that this range was wide enough to evaluate the sensitivity of the model. Higher rates would simply produce projections with larger numbers.

We reran the simulations to determine what effect fall hunting may have had on the size and age composition of the population on the study area. Again, we used the combination of survival and fecundity rates that produced the projection that best fit the winter counts. For these simulations, however, we used average survival rate estimates from 1978 to 1980 for the first 3 years and 2 different sets of survival rates for the 1981 to 1986 period. The first set of survival estimates were made using radio-tagged birds lost to fall hunting, the second set excluded these birds (Table 3).

Finally, we ran simulations using the mean flock size reported on the summer brood survey for all of southern Iowa as an index to yearly fecundity rates (Table 4). We used mean flock

Table 3. Average survival rates, by age and sex class, used to simulate the effects of fall hunting on turkeys in south-central Iowa.

Year	Period[a]	Juvenile females	Adult females	Juvenile males	Adult males	Poults
1978-81	1	0.89	0.96	0.97	0.73	
	2	0.88	0.79	0.86	0.83	0.50[b]
	3	0.83	0.79	0.59	0.78	
1981-86	With fall hunting					
	1	0.88	0.92	0.71	0.66	
	2	0.90	0.85	0.82	0.66	0.50[b]
	3	0.66	0.73	0.49	0.61	
	Without fall hunting					
	1	0.88	0.92	0.71	0.66	
	2	0.90	0.85	0.82	0.66	0.50[b]
	3	0.76	0.84	0.54	0.71	

[a]1 = spring hunt, 2 = spring-summer, 3 = fall hunt and fall-winter.
[b]Used 0.50 from simulation S6, the projection that best fit the winter counts in the sensitivity analysis.

Table 4. Average flock size reported on the summer brood survey and the fecundity rate estimates calculated for the regional simulation.

Year	Average flock size	SD from mean	Fecundity rates from study: Juveniles	Fecundity rates from study: Adults	Fecundity rates used for regional simulation: Juveniles	Fecundity rates used for regional simulation: Adults
1978	10.7	−0.65	0.00	2.40	0.21	2.04
1979	13.1	0.97	1.60	3.60	2.63	3.75
1980	13.3	1.10	0.30	2.40	2.83	3.89
1981	10.7	−0.65	0.70	1.20	0.21	2.04
1982	9.3	−1.59	0.00	1.60	−1.20[a]	1.04
1983	11.3	−0.24	1.30	3.40	0.81	2.46
1984	11.5	−0.11	0.00	1.90	1.01	2.61
1985	14.3	1.78	4.60	4.00	3.83	4.60
1986	11.8	0.09	2.10	4.00	1.32	2.82
1987	12.2	0.36			1.72	3.10
1988	10.1	−1.05			−0.40[a]	1.61
Mean	11.66		1.18	2.72	1.18	2.72
SD	1.48		1.50	1.06	1.50	1.06

[a]Negative rates assumed = 0.

size because it was correlated with the fecundity estimates for adult females during the study (G.A. Hanson, unpubl. Pittman-Robertson rep.). We calculated the fecundity rates by first transforming the mean flock size to a standard normal distribution. Next we used the mean and standard deviation of the fecundity rates from the study to calculate a fecundity rate for each year (Steel and Torrie 1980). For example, in 1978 the average summer flock size was 0.65 standard deviations below the mean for the 1978-88 period. The fecundity rates for the regional simulation were then calculated so that they were 0.65 standard deviations below the mean fecundity rates recorded on the study area. We calculated separate estimates for juvenile and adult females. We compared the projection from this simulation with spring hunter success using correlation analysis.

We used this simulation to estimate the minimum population size in the southern region of Iowa. We chose the southern region because the majority of the spring and fall harvest takes place there. The minimum population estimate was derived by increasing the initial population until the fall harvest recorded for the southern region was less than 5% of the total fall population in any 1 year. A 5% harvest rate was about 1/4-1/2 that found on the study area (Little et al. 1990). Five percent should represent a hypothetically high harvest rate for the region, because hunter densities on the study area were 8-23 times greater than the average for the rest of the region. Thus, the population estimate derived from these simulations should be considered a conservative minimum.

RESULTS

Population projections from all 4 simulations were positively correlated with the track counts (Table 5). The S1 simulation $(\bar{S},\bar{F})$ produced a population that declined steadily at about 15% annually, compared with an average decline for the track counts of about 9% (Fig. 2). We used these S1 projections as a baseline for comparisons between projections because S1 reflects what happened on average during the study.

The projections from the S2 simulation $(\bar{S},F)$ provided the best fit to the track counts (Fig. 2). It was the only simulation that did not project a decline in 1984, when track counts increased dramatically from their lowest point. The projections from the S3 simulation $(S,\bar{F})$ provided the poorest fit to the winter counts (Fig. 3). As might be expected, the projections from the S4 simulation (S,F) were quite variable because both survival and fecundity rates varied annually (Fig. 4). S2 appears to provide the appropriate level of complexity given the available data. Thus, average survival and year-specific fecundity rates were used for the remaining simulations.

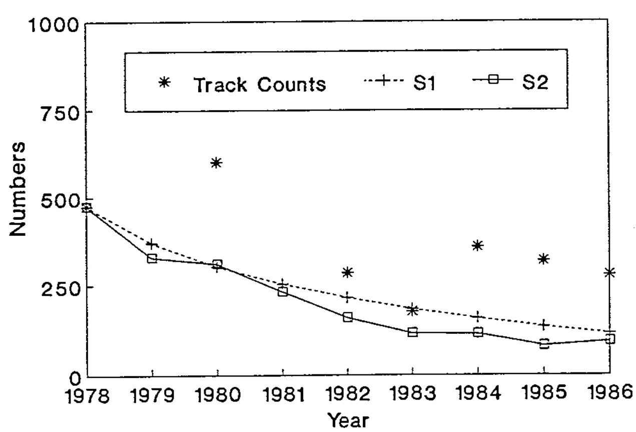

Fig. 2. A comparison of the projected number of turkeys on the study area before the spring hunting season from simulations S1 and S2 with the winter track counts recorded on the study area.

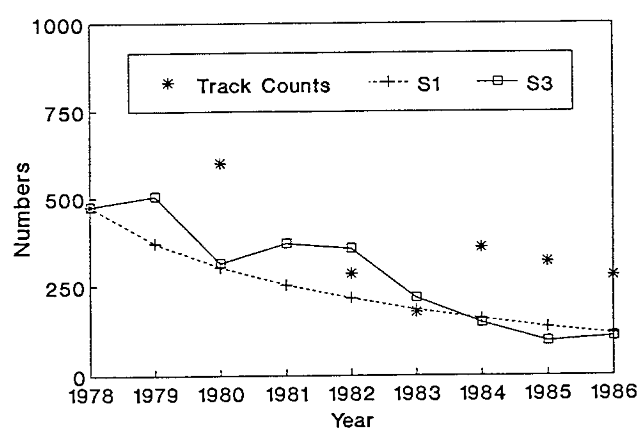

Fig. 3. A comparison of the projected number of turkeys on the study area before the spring season from simulation S3 with projections from S1 and the winter track counts.

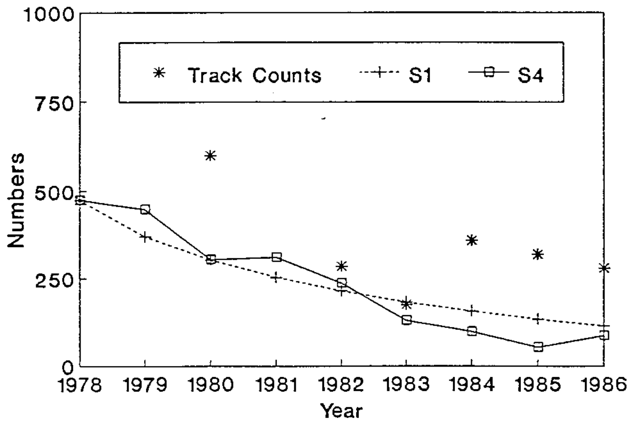

Fig. 4. A comparison of the projected number of turkeys on the study area before the spring season from simulation S4 with projections from S1 and the winter track counts.

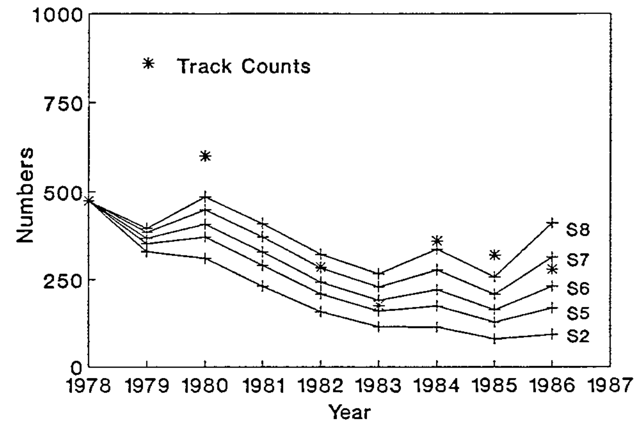

Fig. 5. A comparison of the projected number of turkeys on the study area before the spring season from simulation S2 with projections from S5 through S8.

Although S2 ($\bar{S}$,F) projections had the highest correlation with the winter counts, they remained well below the track counts from 1984 to 1986. Rerunning the S2 simulation with increased poult survival rates during the sensitivity analysis improved this fit (Fig. 5). Projections from simulations S5-S8 were consistent and fit the winter counts reasonably well (Table 5). The projections from S5, S6, and S7 were only slightly better correlated with the track counts than was S2. Thus, the model selected, S2, seems to be robust to parameter changes. Because S6 projections best fit the track counts, poult survival rates of 50% were used in all subsequent simulations.

Using the S6 model, we reran the simulations once with hunting mortality included in the fall survival rate estimates and once with survival rate estimates that excluded the fall hunting losses. Comparing these projections we see that fall hunting reduced the number of turkeys present each spring from the number that would have been expected without fall hunting (Fig. 6). The projections without fall hunting suggests turkey numbers would have rebounded by 1986 to about the average level recorded before fall hunting was allowed. The cumulative effect of 5 years of fall hunting, however, resulted in a projected population about 50% lower than this level.

Figures 7 and 8 show that fall hunting repressed the projected number of males more than females. The simulated number of males on the study area in 1986 would have been just 14% lower than the 1978-81 average without fall hunting. With fall hunting, the projected numbers of males on the study area in 1986 were 48% lower. Female projections were 12% higher than the 1978-81 average without fall hunting but 44% lower with fall hunting. The relative proportion of adults to juveniles present in the population each spring for both sexes was similar with and without fall hunting.

Table 5. Results of the correlation analyses (6 df) between the simulations and the winter counts.

Simulation	Survival and fecundity rates	Correlation coefficient	Probability Ho: $r = 0$
S1	$\underline{\bar{S}}\,\bar{F}$	0.70	0.12
S2	$\bar{S}\,\underline{F}$	0.84	0.04
S3	$S\,\bar{F}$	0.32	0.53
S4	$\underline{S}\,F$	0.62	0.19
S5	$\underline{\bar{S}}\,F$	0.86	0.03
S6	$\underline{\bar{S}}\,F$	0.87	0.02
S7	$\underline{\bar{S}}\,F$	0.85	0.03
S8	$\bar{S}\,F$	0.77	0.07

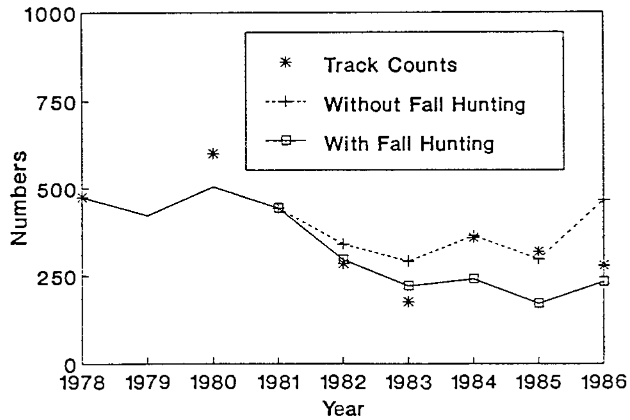

Fig. 6. A comparison of the projected number of turkeys on the study area before the spring hunting season from simulations with and without fall hunting and the winter track counts.

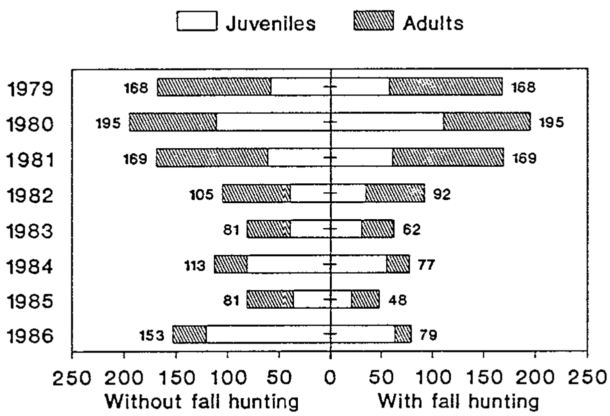

Fig. 7. A comparison of the projected numbers of juvenile and adult males on the study area from the simulations with and without losses due to fall hunting.

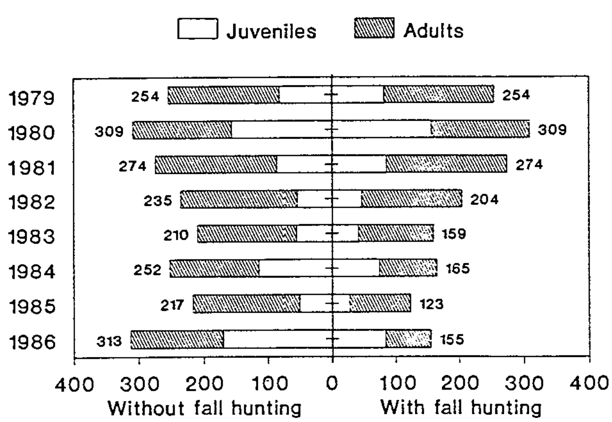

Fig. 8. A comparison of the projected numbers of juvenile and adult females on the study area from the simulations with and without losses due to fall hunting.

Figure 9 shows the estimated minimum number of turkeys present in southern Iowa from 1978 to 1988 with simulation S6 and the fecundity estimates derived from the summer turkey brood survey. An initial population of 24,000 turkeys increased to over 40,000 in 1981 and then declined in a similar fashion to projections for the study area through 1983. The regional projections then recovered to 37,000 turkeys in 1988, unlike study area projections that remained much lower. Spring hunter success rates were significantly correlated with this simulated population (r = 0.70, P = 0.025).

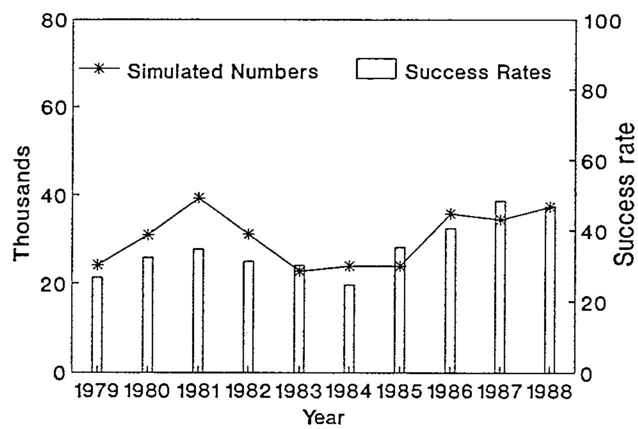

Fig. 9. A comparison of the projected number of turkeys in southern Iowa with hunter success rates in the spring. The fecundity rates used in the simulation were calculated from the mean flock size reported on the summer brood survey for the region.

DISCUSSION

Projections from the initial simulations (S1 and S2) that used the average survival rates fit the track counts better than those that used the year-specific estimates. This would suggest that the year-specific survival estimates may have been imprecise because of small sample sizes of radio-tagged turkeys for some age classes in some years and the difficulty in estimating poult survival. Because S1 and S2 used survival rates that did not vary from year to year, this also suggests that survival rates in the wild may have been fairly constant during the study.

Projections from both simulations that used the year-specific fecundity estimates (S2 and S4) fit the counts better than the projections from simulations using the average estimates. This suggests that the yearly variation in these rates may reflect changes in the actual population rates. It also implies that variations in productivity are more directly responsible for the observed population changes in wild turkey populations than are variations in survival.

All of the projections from S1-S4 failed to mimic the increases recorded in the track counts from 1978 to 1980 and in 1984. Although fecundity rate estimates for 1979 and 1984 were relatively high, poult survival estimates were low. As would be expected, the S3 and S4 projections declined because they used these year-specific survival rates. The S1 projections also declined while the S2 projections were more stable because the low survival rate estimates for these years were averaged with higher estimates for the other 6 years. Increasing poult survival rates during the sensitivity analysis would reduce or eliminate the effect of these low estimates in the simulations. Simulations S5-S8 used these higher rates, and the projected populations all increased to levels in 1980 and 1984 that more closely reflect the track counts recorded on the study area. This suggests that flush counts may substantially underestimate poult survival and that poult survival may have been relatively constant during the study. Because these simulations, S2, and S5-S8, all produce stable results, we believe the model is robust to input parameter changes. This is a very desirable trait for a management tool.

The simulations that evaluate the effect of fall hunting suggest that on small areas composed of public land with easy hunter access, fall turkey hunting might reduce turkey densities substantially, particularly the number of males. The fall hunting harvest rates that produced this effect were not obviously excessive: 21% for adult males, 11% for juvenile males, 14% for adult females, and 24% for juvenile females (Little et al. 1990). These harvest rates, however, were higher than the hypothetical allowable rates of 5% for females and 17% for males found by Suchy et al. (1983) when they assumed that hunting mortality was totally additive. Little et al. (1990) also reports that spring mortality of both sexes increased after the fall hunting season was initiated. This may have been due to lower turkey populations on the study area as well as increased spring hunting pressure. The combined effects of this additional hunting mortality seemed to be additive, which reduced the annual survival rates of all age and sex classes. Spring hunter success rates also declined during these years. Thus, fall hunting also may have affected spring hunter success.

The effect of fall hunting was undoubtedly magnified on the study area because hunter densities were much greater than over the surrounding region. Many additional elements might mitigate the effects shown in the simulations including immigration and density-dependent population responses. The latter were not detected at the harvest levels encountered (Little et al. 1990). Natural (nonhunting) mortality rates were low (Little et al. 1990), which leaves little room for any compensatory mechanisms to occur. Immigration from surrounding areas, however, is a plausible explanation of why the simulated populations remained somewhat below the winter counts. Many other factors should also be considered before extrapolating these results to other regions. These high survival and productivity rates may be due to a mild climate and the interspersion of crop fields and grasslands with forest land on the study area, which provide excellent winter and brood rearing habitat (G. Crim 1981, L. Crim 1981). This might not be true in regions where some natural mortality agent (such as winter starvation) takes a larger proportion of the population as reported by Porter (1983) on the northern fringes of the turkey range.

The regional simulations appear to hold much promise as a management tool. Data requirements to run this simulation include average survival rates, harvest, and a yearly index to fecundity. The latter 2 inputs are currently collected as part of Iowa's management activities. These simulations could be used to predict upcoming spring populations and the expected spring hunter success rates. Continued success at predicting the spring hunting season success rates would further validate this model.

CONCLUSION

A model of intermediate complexity using average survival and year-specific fecundity rates provided the best fit to recorded population numbers. The model appeared to be robust to changes in an input parameter estimate. Using this model, simulations indicate that spring turkey densities could be reduced substantially when fall hunting takes about 15-20% of the hens, ignoring any compensatory mechanisms. The model was easily adopted for use on a regional area by converting an index to productivity into fecundity estimates and produced projections that correlated well with spring hunter success rates. This model has much potential for use in making harvest recommendations.

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WILD TURKEY PRODUCTION, FALL AND SPRING HARVEST INTERACTIONS, AND RESPONSES TO HARVEST MANAGEMENT IN PENNSYLVANIA

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Abstract: Relationships between wild turkey *(Meleagris gallopavo silvestris)* production, spring and fall harvest, and management strategies to control fall harvest were evaluated. We examined 14 years of brood counts, and harvest information from postal questionnaires and from hunter report cards. Brood counts were more highly correlated with hunter report cards than with the postal survey. An inverse relationship between spring and fall harvests from the postal survey indicate a reduction in fall harvests may result in greater spring harvests. After a management area concept was adopted for setting fall hunting season length, based on the results of the previous summer's brood counts, fall harvest trends have closely correlated with those of the brood counts. A correlation between brood counts and annual harvest on one of the management regions, indicated these brood counts were also a valid index to turkey abundance and precursors of harvest on a regional basis. Longer fall seasons were negatively correlated with the following summer's brood counts. Poult:hen ratios were poor indicators of overall production. Brood counts of hens and poults are a reliable index of turkey population trends in Pennsylvania.

Evaluating methods to inventory wild turkey populations or their trends has been neglected. Mosby (1967) stated there was no reliable method to determine the total number of turkeys over a large area. Normal annual population fluctuations of 50% or more that commonly occur could also complicate determining population trends.

In addition to after-the-fact methods that measure harvest, either by mandatory reporting or by postal surveys involving hunters, the most widely used before-the-fact inventory is some form of "brood count." Procedures range from recording broods seen during routine field activities (Shultz and McDowell 1957, Wunz and Shope 1980) to counts run over specified routes and time periods (Beasom 1970, Shaw 1973, Menzel 1975, Bartush et al. 1985). The poult:hen ratios obtained from these surveys are the most common index for productivity.

Shaw (1973) concluded that standardized brood counts in Arizona may be a useful indicator of population trends for Merriam's turkeys *(M. g. merriami)*. In Nebraska, Menzel (1975) reported no relationship between poult:hen ratios of Merriam's turkeys and the subsequent fall harvest.

Pennsylvania seems to be the only state where brood census data are being used as a basis to manage fall harvests of turkeys, a necessity in a state where turkey hunters exceeded 400,000 in the late 1970s and early 1980s. The objective of this study was to evaluate brood counts as a population trend indicator, effects of harvesting on the population, and the relationship between brood counts and harvest.

We are grateful to W. Tzilkowski for his initial review of the procedures and manuscript.

METHODS

Pennsylvania Game Commission field officers have submitted records of turkey hens and poults that the officers and their deputies observed during routine duties and patrols during each June, July, and August since 1953. A post-hunt random mail survey of 3-4% of all hunters (>40,000) was started in 1971 to obtain harvest estimates of small game species and wild turkeys. Usable data for this evaluation were obtained from 1973 to 1987.

Harvest data were also obtained from report cards submitted by successful hunters for 10 years (1975, 1979, 1981-88) of fall hunts and 9 years (1980, 1982-89) for spring hunting. Although these report cards are mandatory, the compliance rate was calculated at 33% for fall hunters and 16% for spring hunters from 1987 data (R. Cogan, pers. commun.). The reason for the discrepancy in reporting rates is unknown.

In response to the relationship between brood counts and total annual harvests (indicated by the post-hunt mail survey, Wunz and Shope 1980), the Game Commission adopted a concept of 4 ecological regions in 1981 for setting fall hunting seasons based upon the preceding summer's turkey brood counts. Under the regional concept, a minimum-length season was set for each region, with the option to lengthen the season later if the brood counts justify an extension in any of the regions. In 1985, the number of regions was increased to 9. Each region covered all or parts of several counties similar in amount or composition of forest habitat, in potential to support turkeys, in road network for hunter access, and in human populations.

Brood count data were compared with harvest data by correlation analysis. For this analysis, annual harvest refers to the combined harvests of fall and the subsequent spring, both of which should be influenced by the brood production of the previous summer. Data from southcentral Pennsylvania (management region 7) were tested to determine if the brood counts were applicable as population indices to the smaller ecological regions. This region was chosen because of its long-established turkey population on fully occupied range and heavy hunting pressure that has the potential to overharvest the population during fall.

RESULTS AND DISCUSSION

Statewide annual harvests (fall and subsequent spring) estimated from the postal survey were correlated with hunter report card data ($r = 0.67$, $P < 0.10$). Both of these harvest inventory methods have followed trends indicated by the summer brood counts (Fig. 1). A significant correlation ($P < 0.05$) was found between brood counts and annual harvest estimated from the postal survey ($r = 0.64$, $P < 0.02$). A stronger relationship ($r = 0.81$, $P < 0.005$) existed between brood counts and hunter report card data (Fig. 1).

Considering only fall hunting, a significant correlation existed between postal survey and report card harvest data ($r = 0.64$, $P < 0.05$). The postal survey estimates tended to follow the previous summer's brood counts ($r = 0.46$, $P < 0.10$). A higher correlation existed between these brood counts and fall hunter report card data ($r = 0.60$, $P < 0.05$). In contrast, spring harvest data, either from mail surveys or hunter report cards, were not significantly correlated with the previous summer's brood counts ($r = 0.19$, $P > 0.3$ and $r = 0.51$, $P > 0.05$).

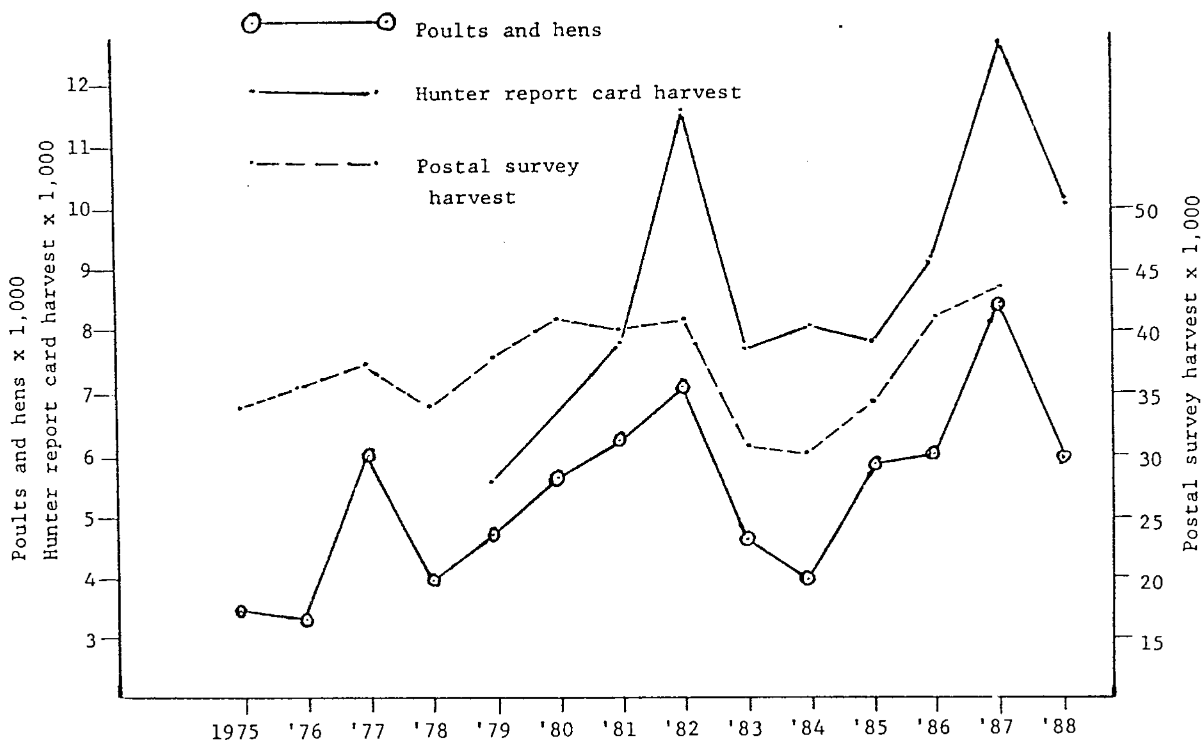

Fig. 1. Brood and harvest inventory data in Pennsylvania, 1975-88.

We found a significant inverse relationship ($r = -0.57$, $P < 0.05$) between fall and spring harvest estimates calculated from the mail survey. This relationship suggests that a high take of turkeys during the fall season may result in reduced spring harvest or a low take of turkeys during the fall could result in an increased spring harvest.

After adopting a management region concept in 1981 for setting fall hunting season length, fall harvest trends calculated from mail surveys have closely followed those of brood counts ($r = 0.78$, $P < 0.025$). Before 1981, there was no significant correlation ($r = 0.47$, $P > 0.10$). In comparing hunting and harvest data before and after 1981, the average annual harvests (fall and subsequent spring) computed from the postal survey have remained unchanged. Numbers of hunters have decreased at the same rate (18%) for both spring and fall seasons; yet fall harvest decreased by 7% whereas spring harvest increased by 18%. This finding suggested that controlling fall harvest on a management region basis had a positive effect on turkey populations and spring harvests.

Brood counts were highly correlated to subsequent annual harvests compiled from hunter report cards ($r = 0.88$, $P < 0.01$) in southcentral Pennsylvania (management region 7). This indicated brood counts were a valid index of turkey abundance and precursors of harvest on an ecological management region basis, as well as statewide.

Comparisons between fall season length and the following summer's brood counts in region 7 showed a significant negative correlation ($r = -0.51$, $P < 0.025$) (Table 1). This implied that lengthening the fall season resulted in a greater harvest, which reduced the following summer and fall turkey populations. Thus, restricting fall hunting season length may reduce harvests and allow populations to reach higher levels.

Perhaps a major reason that brood counts have not been found to be indicators of turkey populations in some states has been due to the emphasis on poult:hen ratios. Our analysis of Pennsylvania data showed a poor relationship of these ratios with subsequent fall harvests ($r = -0.07$, $P < 0.4$), suggesting they were not necessarily indicators of overall production. This result was probably because poult:hen ratios usually account only for the hens successful in raising broods. Menzel (1975) also found no relationship between poult:hen ratios and fall turkey harvest data. However, our analysis of the Nebraska data using total counts of hens and poults, instead of poult:hen ratios, revealed a significant correlation between brood counts and harvest ($r = 0.69$, $P < 0.02$).

Hunter report cards have proved to be a more reliable index of turkey harvest than the mail surveys, particularly in smaller management regions where data from mail surveys have been inadequate. Our analysis strongly suggested that brood counts of hens and poults have been a reliable index of turkey populations in Pennsylvania, regionally as well as statewide, despite not being standardized for effort over given routes or time periods.

Table 1. Influence of length of fall hunting seasons on the following summer's counts of hens and poults during a 20-year period, 1967-88, in southcentral Pennsylvania (management region 7).

Length of fall season (weeks)	Years	Poults and hens seen during the following summer $\bar{x}$	SD
2	8	1,443	502
3	9	1,130	430
4 & 5	3	839	393

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EFFORT, SUCCESS, AND CHARACTERISTICS OF SPRING TURKEY HUNTERS ON TALLAHALA WILDLIFE MANAGEMENT AREA, MISSISSIPPI

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Abstract: The increasing number of wild turkey *(Meleagris gallopavo)* hunters in Mississippi necessitates an understanding of the effect of hunter effort on harvest and hunter success rates relative to turkey population size. Hunter effort and success were studied for 6 spring gobblers-only hunting seasons on a public hunting area in Mississippi. An average of 32 gobblers was harvested and hunter effort averaged 502 hunter-days per year. Hunter success rate averaged 6.5%. An average of 25.8% of the pre-hunting season gobbler population was harvested. Hunter success rates were correlated with gobbler call counts ($P = 0.03$), but, only weakly correlated with population estimates ($r = 0.57$). Daily harvest and hunter effort were positively correlated ($P = 0.000$). Hunter success rates were inversely correlated with hunter effort ($P = 0.03$). There were more hunters on weekends ($P = 0.000$), and hunters on weekends had lower success rates ($P = 0.007$). Although 1 in 6 unique hunters harvested a turkey, fewer than 20% of hunters returned after their first year. Hunter effort did not decline in seasons with low gobbler populations or in years with low gobbling activity. The low return rate of hunters to Tallahala Wildlife Management Area and the inverse relationship between daily hunter effort and success per hunter may indicate that hunter density was too high for a quality hunting experience. Hunter density could be limited to increase hunter satisfaction.

Annual harvest of wild turkeys in Mississippi has increased steadily and was about 53,000 in 1986 (Steffen 1986). Hunting pressure increased from 8,694 hunter-days in 1951 to 381,077 in 1987 (Steffen 1987), and demand for turkey hunting is expected to exceed supply within 40 years on national forests in Mississippi (U.S. Forest Service 1987). Williams and Austin (1988) reported that experienced hunters considered sparse hunter density to be an important attribute of quality spring turkey hunting. Research on effects of hunter density on hunter success rate is limited, however. No significant relationship between hunter density and average success per hunter was found on a public hunting area in Florida where hunter density was controlled (Williams and Austin 1988). Several studies of turkey hunting reported a positive relationship between hunter effort and total harvest and some recommended increasing hunter-days (DeGraff and Austin 1975, Lewis 1975, Glidden 1980).

Most studies of spring gobbler harvests indicated that a conservative proportion of the population was removed (Gardner et al. 1972, Lewis and Kelly 1973, Lewis 1975, Everett et al. 1978, Weaver and Mosby 1979). Madson (1975) discussed the difficult position in which state wildlife agencies were placed when limiting hunter-days to promote quality hunting.

Objectives of this study were to determine relationships among hunter success rates, harvest, hunter effort, population size, and gobbling activity on an unrestricted public hunting area.

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STUDY AREA

The study area was the 14,140-ha still-hunting portion of the Tallahala Wildlife Management Area (TWMA), Strong River District, Beinville National Forest. TWMA is located 56 km west of Meridian, Mississippi, in Jasper, Scott, Smith, and Newton Counties. Topography is gently to moderately rolling hills. More than 95% of the area is forested. Mature pine (*Pinus* spp.) and pine-hardwood stands comprise 67% of the area. Loblolly pine (*P. taeda*) is the dominant species. Remaining stands are primarily hardwood-pine and bottomland hardwood. Pine is regenerated by clearcutting and planting, or by the seed-tree method. Prescribed burning of upland pine sites occurs at approximately 6-year intervals. Secondary roads are distributed throughout the study area. Gates on U.S Forest Service (USFS) roads were closed before and after spring turkey season to limit access during turkey nesting and brood rearing. Beginning in 1986, motorized vehicles were prohibited on some USFS roads during turkey season to reduce hunter interference (Steffen et al. 1988).

Two of the 6 years studied, winters of 1984-85 and 1987-88, were associated with mast crop failures (W. E. Smith, TWMA area manager, pers. commun.). Also, a severe drought occurred on TWMA from July 1987 to June 1988, during which rainfall was 37% below average for Jasper County, Mississippi (Seiss 1989).

METHODS

Spring turkey hunter effort and hunter success rates were studied from 1984 through 1989. Turkey season opened each year on the third Saturday in March and continued through the first day of May. Self-service permit stations (6) were located throughout TWMA. Hunters were required, by state law, to pick up and complete a permit (name, address, and date) and display the permit on their vehicle while hunting. Upon completion of the hunt, hunters were required to deposit their permit card at a permit station. Roads were patrolled by project personnel to promote compliance with permit-card regulations. Although no estimate of compliance was available, small samples suggested at least 85% of the hunters completed and returned permits. Hunter effort (number of hunter-days) was determined from the number of permit cards returned. *T*-tests were used to test for differences in hunter effort between weekends and weekdays.

Hunters were required to check-in harvested turkeys at TWMA headquarters. Gribben (1986) reported a 95% compliance rate with the mandatory check-in regulation on TWMA. Successful hunters were interviewed to determine location and time of harvest, hunter age and hunting experience, number of hunting trips taken per year, and number of hunters in the party. Although turkeys killed off the area were brought to TWMA headquarters, only those harvested on the area were counted in the total harvest and only successful hunters on TWMA were included in hunter characterization.

Data were analyzed using dBase (Ashton-Tate, Inc. 1985) and SPSS/PC+ (SPSS, Inc. 1988). Statistical tests follow Steel and Torrie (1980). The binomial test of 2 proportions was used to test for differences in hunter success rates. When >2 rates were being compared, the Chi-square test of homogeneity was used. All tests were conducted at the 0.05 level of significance.

To estimate harvest rates, turkeys were captured, tagged, and released during January through early March (Gribben 1986). Harvest rates were the percentage of tagged gobblers banded the year of recovery.

Gobbler call counts were conducted from 1 week before the hunting season to 1 week after the close of the season. Except for 1984 when 1 observer counted 1 route, 2 routes, totaling 18 listening stations, were conducted simultaneously 3 days/week. Listening stations were spaced at least 1.6 km apart. Counts were conducted during peak gobbling hours, 30 minutes before and after sunrise (Bevill 1975). Observers listened for 4 minutes at each station, recording the number of gobblers heard, their direction relative to the station, and the number of calls per gobbler. Counts were not conducted on days with heavy winds (>15 mph), heavy rain, or on weekends when hunter density was high. Days missed because of weather were rescheduled. *T*-tests were used to test for differences in call counts (number of gobblers heard/day) between years.

Gobbler population size was estimated using Buckland's modified Jolly/Seber method (Buckland 1980, Lint 1990).

RESULTS

Harvest rate and population size.--An average of 32.5 gobblers was captured each winter, ranging from 16 in 1984 to 53 in 1985. Of the 195 gobblers captured, 191 were released (Table 1). Population estimates averaged 91.8 gobblers, and declined from 123 (0.9 gobblers/km^2) in 1984 to 63 (0.4 gobblers/km^2) in 1989.

Total harvest averaged 32 (SD = 14.1) turkeys/year (0.2 turkeys/km^2) and ranged from 13 (0.1 turkeys/km^2) to 46 (0.3 turkeys/km^2). Harvest rates averaged 25.8% (15-40%). Most (92%) of the harvest occurred before noon.

Hunter effort and success.--Hunter effort averaged 502 (SD = 77.6) hunter-days/season and ranged from 406 to 594 (Table 2). Average number of unique hunters in each year was 210 (SD = 28.8). Nonresident hunters increased from 21 in 1984 to 63 in 1989. Average number of hunters per day was 11.9 (SD = 9.7) or about 1 hunter/12 km^2. Maximum hunter density was 1 hunter/2.5 km^2. Average hunter-days were greater (P = 0.000) on weekends ($\bar{x}$ = 17.24) than weekdays ($\bar{x}$ = 9.54). Hunter effort was greatest the first week of the season and gradually declined the rest of the season.

Hunter success rates for all years combined was 6.5%, and ranged from 2.2% (1989) to 9.7% (1984). Unique hunter success rates for all years was 17.1%, and ranged from 5.4% (1989) to 21.6% (1984). Nonresident hunters had a lower average success rate (P = 0.04) than residents did, 4.5% and 6.9%, respectively. Hunter success rates did not differ during the week (P = 0.94) or between Saturday and Sunday (P = 0.27); however, weekdays were associated with higher hunter success (P = 0.007).

Total harvest and total hunter effort showed no relationship (r = 0.092). Hunter effort and harvest, by week of season, were correlated (r = 0.989, P = 0.000). Daily hunter effort and harvest were correlated (r = 0.461, P = 0.000, n = 250).

Days on which no gobblers were harvested (0% hunter success) occurred when hunter effort ranged from 1 to 52 hunters/day. The presence of 0% hunter success days in the correlation analyses resulted in a near zero correlation coefficient between daily hunter effort and daily success (r = 0.04). Therefore, days were grouped by hunter effort into classes (<11, 11-20, 21-30, and >30 hunters/day) and an average success per class was determined (Table 3). Hunter success rates per class were inversely correlated with average hunter effort per class (r = -0.88, P = 0.12). The correlation was significant (r = -0.97, P = 0.03) between the average success per class and the $\log_{\ln}$ (average hunter effort/class). Because hunter success rates may be affected by gobbler density, a Chi-square test of homogeneity was used to determine if all years were equally represented in all classes of hunter effort. All years appeared to be equally represented in each class (X^2 = 7.08, P = 0.96).

Population size, gobbling activity, and hunter success.--We heard an average of 4 different gobblers per day for all years combined. Call counts (average number of gobblers heard per day) ranged from 0.9 in 1988 to 6.9 in 1986 (Table 4). Call counts were significantly correlated with hunter success rates (r = 0.86, P = 0.03), resident hunter success rates (r = 0.91, P = 0.01), and total harvest (r = 0.86, P = 0.03). Total hunter effort was not correlated with call counts (r = 0.02). Nonresident hunter effort, however, was inversely correlated with call counts (r = -0.85, P = 0.03).

Call counts were significantly lower in 1985 than in 1986 (P = 0.046) and significantly lower in 1988 (P = 0.001) than 1987, but not 1989 (P = 0.249).

Gobbler population size was not correlated with total harvest (r = 0.47, P = 0.35), total hunter success rates (r = 0.53, P = 0.28), or call counts (r = 0.57, P = 0.24).

Hunter characteristics.--A total of 887 unique turkey hunters hunted on TWMA from 1984 to 1989. An individual hunted an average of 3.4 times per hunting season (SD = 5.5) on TWMA. About 20% of the hunters returned to TWMA after their first season. Only 5 hunters used the area for 5 consecutive years. Successful hunters averaged 35.8 years old (SD = 12.6) and hunted in small groups or alone ($\bar{x}$ = 1.6, SD = 0.5). These hunters had hunted turkeys for an average of 10.6 years (SD = 9.6) and spent an average of 15.9 days hunting turkeys each season (SD = 9.8).

Table 1. Number of gobblers captured and released in winter capture periods, number of gobblers harvested, and number of tagged gobblers in the harvest, Tallahala Wildlife Management Area, Mississippi, 1984-89.[a]

Year	Captured in winter	Released in winter	Harvested[b]	Tagged in harvest
1984	16	14	59	3
1985	53	53	51	21
1986	40	40	58	16
1987	20	20	62	3
1988	40	37	29	7
1989	26	25	29	5
Total	195	191	288	55

[a]Data from Lint (1990).
[b]Includes birds harvested off study area.

Table 2. Hunter effort (*n* hunter-days) and hunter success (birds killed/total hunter-days) on Tallahala Wildlife Management Area, Mississippi, during spring turkey hunting seasons 1984-89.

	Hunter effort			Hunter success (%)		
Year	Resident	Nonresident	All	Resident	Nonresident	All
1984	438	34	476	9.1	17.7	9.7
1985	375	67	443	6.9	3.0	6.3
1986	428	69	497	8.9	4.3	8.2
1987	507	84	593	8.1	6.0	7.8
1988	275	130	406	4.7	4.6	4.9
1989	421	173	594	2.4	1.7	2.2
Avg.	407	93	502	6.9	4.5	6.5

Table 3. Average effort and success for spring turkey hunters on Tallahala Wildlife Management Area, Mississippi, when grouped into classes by daily effort, 1984-89.

Hunter/day class	Days (*n*)	Success rate[a]	Mean hunters/day	$\mathrm{Log}_{\ln}$ (mean hunters/day)
1-10	142	7.7	6.1	1.81
11-20	79	6.3	14.6	2.68
21-30	20	6.1	25.6	3.24
>30	9	5.5	48.1	3.88

[a]Birds killed by class/total hunter-days by class x 100.

Table 4. Gobbler population size (*n*), average number of gobbers heard/day, number of gobblers harvested, and proportion of tagged gobblers in the harvest on Tallahala Wildlife Management Area, Mississippi, during spring turkey hunting, 1984-89.

				Harvest rate[b]	
Year	Population	Heard/day	Harvested	$\bar{x}$	95% CI
1984	123	5.9	46	21.4	10.0-32.8
1985	121	4.0	28	39.6	32.8-46.4
1986	89	6.9	41	40.0	32.2-47.8
1987	78	4.3	46	15.0	6.8-23.2
1988	77	0.9	20	18.9	12.4-25.4
1989	63	1.4	13	20.0	11.8-28.2
Avg.	92	4.0	32	25.8	17.7-33.9

[a]Data from Lint (1990).
[b]Percentage of tagged gobblers banded the year of recovery.

DISCUSSION

Number of turkeys harvested per square kilometer was lower than that reported in other studies (Gardner et al. 1972, Everett et al. 1978). The turkey population on TWMA has declined since 1984 (Lint 1990), probably due to low recruitment since 1986 (Seiss 1989).

Harvest rates in this study were similar to other studies. A removal rate of 26% (not including crippling loss) is considered a conservative harvest (Weaver and Mosby 1979).

Gobbler call counts have been used to estimate relative abundance (Scott and Boeker 1972, Porter and Ludwig 1980). Porter and Ludwig (1980) found strong correlations between winter flock counts and spring counts based on maximum number of gobblers heard and average flock size. They also reported a strong correlation between predicted peak gobbling counts and hunter success. We found that hunter success rates were positively related to call counts. Hunters may have expended greater effort when gobblers were heard more frequently. Also, a calling gobbler may have increased the likelihood of a hunter-turkey interaction, especially during low population years.

Population estimates were only weakly correlated with call counts. We believe this was because call counts not only index gobbler populations, but gobbler condition as well. When acorn mast was scarce on TWMA, alternative food sources were limited. In 1988 the severe drought may have reduced food resources (green forage) further. Siess (1989) reported hens on TWMA began nest initiation later in 1985 and 1988. Gobbler weights in the 1988 harvest were low (W.E. Palmer, unpubl. data). Our results suggest that gobbler population indices based on call counts may falsely indicate population decline after winters with food shortages.

Although total hunter effort was not related to call counts, this result was probably due, in part, to annual increases in nonresident hunter effort, which was inversely correlated with hunter success rate, harvest, population estimates, and call counts. Our results indicate that nonresident hunter effort continues to increase despite a declining gobbler population and reduced harvest.

Studies have reported direct relationships between total hunter effort and harvests (DeGraff and Austin 1975, Williams and Austin 1988). Our results suggest that the relationship between hunter effort and harvest is direct within years, but not between years. This result may be due to changes in gobbler population condition and age structure, caused by low recruitment, between years. Older birds or birds in poorer condition may require more effort to harvest.

Williams and Austin (1988) in Florida, and Lewis (1975) in Missouri, found no relationship between hunter success rates and hunter effort. Our results indicate daily hunter success rates were inversely related to daily hunter effort, although this was only evident when days were grouped by hunter effort. This result was confounded by several variables. Fewer hunters may have hunted on days with poor hunting conditions (i.e., windy, raining, no gobbling activity). Further investigation revealed that when <5 hunters were hunting on TWMA, success rates were indeed low (3.6%). Also, 95% of the days with >30 hunters occurred within the first 14 days of the season. Perhaps hunters early in the season were, on average, less experienced. Gobblers early in the season may be less wary and therefore easier to harvest.

To clarify further the effect of daily hunter density on hunter success rates, future studies must control hunter density and should measure daily weather variables and gobbling activity.

It is conceivable that hunter success could be facilitated by increased hunter effort. Hunter success rates with spring hunting methods may be reduced, however, by competition among hunters attracted to calling gobblers, especially when relatively few gobblers are calling.

Of the 887 unique hunters on TWMA, 1 in 6 harvested a turkey. Over 80% of the hunters, however, did not return to TWMA to turkey hunt. Possibly hunter densities were greater than desirable for a quality hunting experience. Williams and Austin (1988) reported that the first criterion for a quality hunt, according to 74% of experienced turkey hunters surveyed, was low hunter densities.

On TWMA, increasing hunter effort will increase harvests while decreasing hunter success per hunter. As spring turkey hunting attracts more hunters, state wildlife agencies might maintain hunting quality on public hunting areas by reducing hunter interaction through controlling hunter effort. Competition among hunters may increase during low gobbler population years or when fewer gobblers are calling. Total hunter effort remained high even under these conditions. Therefore, quotas on hunter density should be modified with respect to population size and gobbler condition if hunter interference is to be reduced. Control of hunter effort may place state wildlife agencies in a difficult position because, biologically, spring harvests may be increased in some areas without detriment to turkey populations (Madson 1975). Spring turkey hunters, however, have reacted positively to regulations designed to reduce hunter density and increase hunter satisfaction (Steffen 1988, Williams and Austin 1988).

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MANDATORY LANDOWNER CONSENT AS A METHOD OF CONTROLLING WILD TURKEY HUNTER DENSITY AND HUNTER SUCCESS RATES

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Abstract: Ninety-five percent of Connecticut's 12,973.3 km^2 is in private ownership. The human population density of about 239/km^2 places a heavy demand by wild turkey *(Meleagris gallopavo silvestis)* hunters on the open space in private ownership and on the 344.5 km^2 of state land available for hunting. In an effort to keep private lands open to wild turkey hunting, we instituted a system of written mandatory landowner consent for turkey hunting at the onset of Connecticut's first modern-day turkey hunting season in 1981. After 9 years, the number of landowners permitting wild turkey hunting has increased by 308%. This trend is partially attributable to the expansion of huntable range since 1981. However, private land area open to turkey hunting has increased by 37.9% since 1987 while total huntable range remained stable. This landowner consent system has also controlled hunter density on private lands (1.5-2.3 hunters/km^2) keeping it lower than on state lands (2.2-3.2 hunters/km^2) where hunter density was controlled by lottery selection during the 1981-1987 period. Hunter success rates on private land ranged from 13.1 to 25.5%, about 3-5 times higher than on state land (2.4-6.4%).

Over 95% of Connecticut's 12,973.3 km^2 is privately owned. The 85,000 individuals who hunt in Connecticut annually place considerable pressure on the private landowner for the opportunity to hunt. In 1981, 82% of surveyed landowners in Connecticut indicated they allowed either no one or only friends to hunt on their land (Gallagher 1983). Many landowners who posted their land had a concern for safety and 56% had negative experiences with hunters. However, little anti-hunting and anti-hunter sentiment was expressed. Sixty-nine percent of respondents indicated they believed a small percentage of hunters ruin opportunities for the majority. "Many landowners indicated that if they could be assured bad experiences would not be repeated, they would be willing to re-open their land to a limited number of hunters. Seventy-nine percent indicated support for an outdoor ethics education program as a means of eliminating the type of behavior which causes land to be posted" (Gallagher 1983:a1). This 1981 survey showed that more landowners had hunters on their land without permission (81%) than had received requests for hunting (70%) (Gallagher 1983), indicating that landowners had little control over who was on their land. In response to the concerns documented by Gallagher's study, the Connecticut Department of Environmental Protection's Wildlife Bureau (DEP) instituted a mandatory hunter safety program and established a landowner consent system for wild turkey hunting on private land. Our purpose is to describe the wild turkey hunting permit system; examine the effects of the mandatory landowner consent system on turkey hunter density and success rates; and identify landowner relationships, hunter responses, and management advantages and limitations associated with the system.

METHODS

Permit System

The first modern wild turkey hunting season was established in Connecticut in the spring of 1981. A mandatory landowner consent system used for deer hunting since 1975 was modified for the first turkey season.

The permit system has been modified several times between 1981 and 1989, but 2 components remained consistent throughout this period. First, each hunter was required to submit a turkey hunting permit application, obtained from town halls or license vendors, to the DEP's license and revenue unit for either a state or private land turkey hunting permit. Second, all private land permit applications required the additional submission of a signed landowner consent form.

The consent form must be signed by the deed-listed landowner. The property address, legal land description, property acreage, hunter's signature, and authorization for choice of weapon must be included on each form. Currently, 1 copy is retained by the hunter and must be carried while hunting. The additional 2 copies are sent to DEP; one copy is retained on file and 1 copy is sent to the appropriate Conservation Officer. One consent form is required for each property hunted. A minimum of 1 form must be submitted with the permit application. Copies of additional consent forms can be submitted as permission is obtained.

From 1981 to 1984 hunters were required to return all 3 copies of the completed consent form. All forms were checked for completeness to ensure that these properties were located within the hunter's zone of application. In 1981, the number of consent forms issued per property was based on acreage (1 for the first 10.1 ha [25 acres] and 1 for each additional 20.2 ha [50 acres]). Sorting and filing consent forms by landowner ensured that these limits were not exceeded. The original copy of each consent form meeting these criteria was validated and returned to the hunter.

The restriction on number of consent forms issued per landowner (of greater than 10.1 ha) was lifted in 1982. In 1985 hunters were no longer restricted to 1 private-land hunting zone. These 2 changes abolished the need for close agency scrutiny and validation of each consent form. This action greatly reduced the administrative cost and time required by this system but retained the integrity, record trail, agency control, and advantages of a mandatory consent system. Landowners of fewer than 10.1 ha and their lineal descendants could hunt their own property (non-deed listed lineal descendants were required to submit a consent form) by applying for a free landowner permit. Landowners, however, could not issue a consent form on this acreage until 1988 when this restriction was also lifted.

All consent form data were tabulated at the close of each season. File copies of all forms were retained for 1 year.

Regulation Changes

In 1981, the core of Connecticut's turkey hunter permit system required hunters to select either a public land area or private land zone they wished to hunt. Four choices could be listed in the order of preference on the application, and applications were selected randomly by computer. This selection process was designed to limit turkey hunter densities to 1 hunter/40.5-60.7 ha (100-150 acres). Successful applicants were notified and asked to submit the license fee (when required) to obtain a permit. Hunters on private land were restricted to 1 zone and were required to include a signed landowner consent form in their zone of selection before a permit would be issued.

In succeeding years, this system was modified and regulations liberalized to adjust for changes in hunter pressure and distribution, expanded turkey range, and increased wild turkey densities (Table 1). As wild turkey densities and occupied range increased, incentives (longer season, no-zone restriction, no random drawing, 2-bird bag limit) were incorporated into regulations and permit system to encourage increased participation on private lands, thus creating a more even distribution in hunting pressure among state and private lands.

From 1981 to 1983 the number of private-land hunters applying to any 1 zone never reached the quota. Therefore, in 1984 private-land hunters were no longer required to enter the random selection process. They needed only to submit an application, a signed consent form from a landowner in the zone they wished to hunt, and the permit fee to the DEP's license and revenue unit (no application deadline was set).

In 1987 a 2-bird bag limit was instituted on private land. Five new hunting zones opened an additional 1,877.8 km^2 of huntable range and created a total of 1,272 state land opportunities.

In 1988, no lottery was required to hunt state land on the 10 state land zones that were consistently filled under quota. A new permit "State Land - No Lottery Required Permit" was needed to hunt this land. The season was the full 3 weeks in length and the bag limit remained at 1. No changes were made in the 1989 spring season.

Table 1. Changes made in the spring Connecticut turkey hunting regulations from 1981 to 1987.

Year	km^2 open	n zones open	State-land permits avail.	Private-land permits avail.	n applications	n permits issued (state & private)	Regulation changes
1981	1,813	5	284	716	3,938	428	• Two-week season. • Opening day on Saturday. • State & private land both in lottery. • State land quota 1/100 acres.
1982	1,813	5	284	716	2,676	574	• Same.
1983	3,626	8	750	1,350	1,684	888	• Three 1-week seasons on state land. • State-land quota 1/150 acres. • Opening day on Wednesday. • Private-land season extended to 3 weeks. • Added 3 zones. • First year for license fee.
1984	4,403	9	1,034	Unlimited	1,027	1,172	• Private land no longer in lottery. • Yale Forest open to hunting; treated as private land. • Added 1 zone.
1985	4,403	9	985	Unlimited	897	1,119	• Private land no longer restricted to 1 zone. • State land divided into 2 seasons instead of 3. • State land quota 1/100 acres.
1986	4,921	10	1,059	Unlimited	878	1,286	• Added 1 zone.
1987	6,799	15	1,272	Unlimited	929	1,557	• Two-bird bag on private land. • Added 4 zones. • Yale Forest treated as state land with same seasons and bag limits.
1988	6,799	15	630[a]	Unlimited	669	2,101	• No lottery on 10 state-land areas not filling quota. (These areas had 3-week season and 1-bird bag limit.)
1989	6,799	15	630[a]	Unlimited	691	2,575	• Same.

[a]Number of state land permits available were unlimited on 10 state land zones that historically were not filled to quota.

The extended season and uncontrolled hunter densities on state land zones not requiring a lottery changed a number of parameters discussed later in this paper. Therefore, when comparisons of parameters are made between the lottery and consent form system, only 1981-1987 data will be used. Data from 1988 and 1989 will be included when they do not influence the comparison.

Hunter Survey

Since 1981, a mandatory hunter survey card was attached to each permit issued. Each hunter was required to return this completed survey within 10 days of the season's end to be eligible for a hunting permit the following year. Survey questions were designed to document quantity and time of hunter effort, hunt quality in terms of number of turkeys seen and heard for each day hunted (Hawn et al. 1987), and total number of other hunters seen during the season. All parameters could be segregated by state or private land.

Mandatory Hunter Check Stations

All successful hunters were required to report to a designated check station. Sex, age, weight, and location of kill were recorded for each bird harvested. In 1984 and 1985, hunters were also interviewed to determine the level of hunter competition they were experiencing. Data could be segregated by state or private land.

RESULTS

The number of wild turkey hunters has increased consistently as the turkey population, huntable range, and hunting opportunity have increased. The addition of incentives for hunting on private land increased the proportion of hunters using private land from 38.6% in 1981 to 54.8% in 1989 (Tables 2, 3). Although the amount of private and state land available to turkey hunting was about the same (Tables 2, 3) before 1986, mean hunter density on private land (1.7 hunters/km^2) was less than that on state land (2.6 hunters/km^2). In 1987 (when a 2-bird bag limit was instituted on private land), the percentage of total hunters on private land (51.4%) exceeded that on state land (48.6%) for the first time.

Administration of the computer selection process required about 20 worker-days annually. By contrast, distribution, sorting, and analysis of consent forms required 3 worker-days annually. The consent system used no computer time and required 1 less mailing than the computer selection process. The cost of printing consent forms was the only expense incurred other than the the computer selection process.

Hunter success rates on state land have ranged from 2.4% in 1983 to a high of 6.4% in 1989 (Table 3). Hunter success on private land ranged from 13.1% to 25.5% (Table 2). The percentage of successful hunters taking a second bird since the 2-bird bag limit was established in 1987 has remained near the success rates for the first bird: 26.0%, in 1987, 21.4%, in 1988, and 27.1% in 1989.

New Jersey and Massachusetts are 2 northeastern states with turkey densities and huntable range comparable to Connecticut's. Both states control hunter densities through a computer selection process; however, they make no distinction between state and private land. Connecticut's turkey hunter success rates were consistently higher than those in New Jersey and Massachusetts from 1981-1989 (Table 4). Both states, however, recorded higher hunter numbers and harvests (R. Erickson 1989, pers. commun.; J. Cardoza 1989, pers. commun) than Connecticut's.

Hunter Surveys

During 1981 to 1987, 73.5% of all Connecticut hunters completed the mandatory hunter survey. Hunters using state land reported hearing and seeing fewer wild turkeys than hunters using private land (Table 5).

In 1986 and 1987, state-land hunters encountered an average of 2.4 other hunters over the course of the season. One-third (33.1%) did not encounter another hunter. Successful Connecticut turkey hunters in 1984 and 1985 saw an average of 0.34 other hunters during the season while 80.6% of all successful hunters did not see another hunter. Hunters on private land encountered an average of 1.5 other hunters throughout the seasons of 1986 and 1987, and 52.0% did not see another hunter.

Table 2. Area of private land open to hunting (km^2), numbers of landowners and hunters, density of hunters (n/km^2), percentage of hunters harvesting a turkey, and number of gobblers heard during Connecticut's spring turkey hunting seasons, 1981-89.

Year	Private land open to hunting	Landowners	Hunters	Consent forms/ hunter	Hunters/km^2	Successful hunters (%)	Gobblers heard/ hunter/trip
1981	110.1	191	165		1.5		1.0
1982	167.6	132	283	1.0	1.7	13.4	1.5
1983			337			13.1	1.8
1984	266.8	286	435	2.1	1.6	14.7	2.1
1985	237.8	229	469	1.3	2.0	21.3	2.6
1986	290.9	283	613	1.4	2.1	19.7	1.8
1987	346.8	433	800	1.9	2.3	25.5	2.1
1988	390.8	614	1,076	1.5	2.7	20.0	1.7
1989	478.4	780	1,411	1.6	2.9	21.5	1.6

Table 3. Area of state land open to hunting (km^2), number of hunters, density of hunters (n/km^2), and percentage of hunters harvesting a turkey during Connecticut's spring turkey hunting seasons, 1981-89.

Year	State land open to hunting	Hunters	Hunters/km^2	Successful hunters (%)	Gobblers heard/ hunter/trip
1981	114.7	263	2.3		1.4
1982	114.7	291	2.5	6.0	1.0
1983	173.3	551	3.2	2.4	0.7
1984	299.1	737	2.5	3.5	0.8
1985	299.1	650	2.2	4.0	1.0
1986	313.9	673	2.2	4.2	1.1
1987	344.2	757	2.2	5.4	1.0
1988[a]	344.2	1,025	3.0[b]	5.6	1.0
1989[a]	344.2	1,164	3.4[b]	6.4	1.0

[a]Data for both lottery and nonlottery zones are pooled.
[b]Hunters per km^2 increased when no lottery zones were instituted on under-utilized state land areas thus ceasing to limit hunter densities on 10 of 15 areas.

Table 4. Percentage of hunters harvesting a turkey, numbers of hunters, area open to hunting (km^2), turkey population size, and number of wild turkeys harvested in Connecticut, Massachusetts, and New Jersey during spring turkey hunting seasons during 1980-1989.

	Hunter success rates			Turkey hunting permit sales			Area open to hunting			State turkey pop.		Total birds harvested		
Year	Conn.	Mass.[a]	N.J.[b]	Conn.	Mass.[a]	N.J.[b]	Conn.	Mass.[a,c]	N.J.[b]	Conn.	N.J.[b]	Conn.	Mass.[a]	N.J.[b]
1980		6.7			1.076			3,250					72	
1981	4.9	6.0	7.8	428	2,261	900	1,813	3,250	648	2,000	1,000	21	136	71
1982	9.3	7.4	8.0	574	2,679	1,200	1,813	3,129	648	2,300	1,400	56	198	96
1983	6.4	6.8	6.6	888	2,685	2,000	3,626	3,129	1,166	3,000	2,500	57	184	132
1984	7.7	5.6	6.3	1,172	3,485	3,000	4,403	3,898	1,943	3,500	2,800	90	208	189
1985	11.3	6.1	7.3	1,119	5,054	3,000	4,403	3,898	3,108	4,000	3,500	126	308	220
1986	11.6	7.2	9.4	1,286	6,161	4,054	4,921	5,804	4,144	5,125	4,500	149	444	334
1987	15.7	5.7	9.6	1,557	8,221	3,865	6,799	6,167	4,662	5,500	4,280	298	471	356
1988	12.9	6.3	8.7	2,101	8,840	5,547	6,799	6,998	7,770	5,750	4,370	318	557	485
1989	14.6	6.3	8.1	2,575	12,453	5,400	6,799	6,998	7,252	6,000	4,618	459	780	445

[a]J. Cardoza (pers. commun.).
[b]R. Erickson (pers. commun.).
[c]km^2 open to hunting is actually km^2 of forest open to hunting.

Table 5. Number of eastern wild turkeys seen or heard by Connecticut spring wild turkey hunters on state and private land during 1981-1989 hunting seasons.

	Gobblers heard		Males seen		Females seen	
Year	State land	Private land	State land	Private land	State land	Private land
1981	1.4	1.0	0.4	0.5	0.3	0.5
1982	1.0	1.5	0.3	0.6	0.3	0.3
1983	0.7	1.8	0.2	0.8	0.2	0.5
1984	0.8	2.1	0.3	0.9	0.3	0.5
1985	1.0	2.6	0.3	1.3	0.3	1.2
1986	1.1	1.8	0.3	0.6	0.3	0.8
1987	1.0	2.1	0.3	0.9	0.2	0.5
1988	1.0	1.7	0.3	0.6	0.3	0.5
1989	1.0	1.6	0.3	0.7	0.3	0.7

Results of the 1981 to 1987 hunter survey indicate that the typical hunter using state land had 2.2 years experience and spent 2.8 days hunting, 4.6 hours per hunting trip, and 11.3 hours scouting. Only 23.9% had previously harvested a turkey and 32.5% had never hunted wild turkeys before. Calling devices were used by 87.7% of state land hunters, 67.9% had attended a seminar, and 17.8% had hunted in other states.

The hunter on private land typically had 3.3 years experience and spent 3.3 days hunting, 4.4 hours per hunting trip, and 9.3 hours scouting. Nearly half (45.7%) of the hunters using private land had harvested a turkey but 22.3% had never hunted before. Most (93.9%) private-land hunters used calling devices, 59% had attended a seminar, and 27.1% had hunted in other states.

Despite longer private-land seasons, hunters on state land in 1983-1986 averaged only 0.9 fewer days afield/season than hunters on private land (3.5 days/season). Private-land hunting pressure was spread more evenly throughout the season than on state land (Table 6). However, a higher percentage of Saturday hunting pressure occurred on private land (30.2%) than on state land (24.0%).

Table 6. Mean distribution of hunting pressure (% of total hunter days) by week[a] on state and private lands throughout the 1983-1987 Connecticut spring wild turkey hunting seasons.

	Week			
Land	1	2	3	Saturday
State	51.3	30.0	17.7	24.0
Private	46.5	28.3	23.9	30.2
Total	48.8	29.0	21.1	27.0

[a]Week is Wednesday-Tuesday (including Saturdays). No Sunday hunting is permitted in Connecticut.

DISCUSSION

Hunter Distribution

Hunter emphasis shifted from state to private land between 1981 and 1989 (Tables 2, 3). In 1987 the percentage of total hunters using private land (51.4%) exceeded that on state land (48.6%) for the first time, and has continued annually. The trend is partially in response to increased incentives offered to the private-land hunter by way of longer, less restricted seasons, with higher bag limits. This shift in pressure achieved the desired result as it more evenly distributed the hunters and harvest, modified overcrowding on state land, placed hunters in the best habitat, improved the quality of the individual hunting experience, and ultimately increased harvest and improved success rates.

The future growth potential for wild turkey hunting in Connecticut lies on private land. Prior to 1988, new parcels of state land were regularly opened to wild turkey hunting. The area of state land available to spring turkey hunting generally exceeded what was available on private land. From 1987 to 1989, the state land area open to wild turkey hunting has remained constant (Table 3). The amount of private acreage open to hunting, however, has increased by 37.9% and now exceeds state land availability. Areas with potential for inclusion in huntable range contain relatively little public land. Therefore, most additional turkey hunting opportunities lie on private lands.

Hunter Density

The consent form system has resulted in hunter densities on private lands that are similar to or lower than hunter densities on state land (which are controlled by a random selection process with a quota of 1 hunter/40.5-60.7 ha) (Tables 2, 3). In addition, hunting pressure on private land (% of total hunters/week) was more equally distributed between the second and third week of the season, and more activity took place on Saturdays than on state land (Table 6). Hunters on state land concentrate their efforts as early in the season as possible. When one considers that hunters selected for state land had to concentrate all of their activities in the period assigned, this trend becomes even more pronounced.

The preference for weekday and early season hunts on state land may be influenced by the hunter competition experienced in these areas and the possible interference that can result (Madson 1975). Hunters on state land had a higher probability (66.9%) of encountering another hunter than hunters on private land (48%). The mean number of other hunters encountered on state land during the entire season was also higher (2.4) than on private land (1.5). Therefore, hunters on private land are less affected by hunter competition and tend to hunt more on Saturdays and distribute their efforts throughout the entire season. The number of other hunters encountered on both state and private land, however, was lower than that reported in Michigan (1.8 other hunters/day) (Hawn et al. 1987).

Hunter Success Rates

Wild turkey hunter success rates were considerably higher on private land (13.1-25.5%) than on state land (2.4-6.4%) in all years (Tables 2, 3). Less hunter competition on private land seems to be one factor influencing success rates (Hawn et al. 1987, Porter 1990). Check station data between 1984 and 1985 indicate that most successful hunters (80.6%) did not encounter another hunter during the season. The mean number of other hunters encountered by successful hunters was also very low (0.34). Therefore, the higher percentage of hunters on private land not experiencing competition (52%) relative to hunters on state land (33.1%) contributes to higher success rates on private land.

Private-land hunters saw more wild turkeys ($\bar{x}$ = 0.6 female and 0.8 male) and heard more gobblers ($\bar{x}$ = 1.8) per hunting trip than did state-land hunters ($\bar{x}$ = 0.3 female seen, 0.3 male seen, and 1.0 gobbler heard) during the 1981-1987 spring wild turkey hunting season (Table 5). The greater number of wild turkey males heard and seen on private land obviously increased harvest opportunities. The number of gobblers heard/hunt was similar to that in southern counties of West Virginia (2 gobblers/hunt) (Pack and Plaugher 1985) and was higher than that reported in Michigan (1.3 gobblers/hunt) (Hawn et al. 1987). The higher number of birds encountered on private land may have been partially influenced by lower hunter densities. However, increased habitat diversity (pastures, hay fields, small grain fields), and alternative food supply (waste grain, silage, and manure) available on private lands created higher quality wild turkey habitat than found on most state land areas and may have supported a higher density of wild turkeys. Therefore, lower hunter density, less hunter interference, more evenly distributed hunting pressure throughout the season, and better habitat quality on private lands positively influence the success rates on these areas.

Landowner Relationships

The number of hunters on private land and number of landowners permitting access for turkey hunting have increased steadily (>308% from 1981 to 1989) as wild turkey range expanded and densities increased (Table 2). Some landowners permitted access as soon as the wild turkey season was open in their area. Other landowners were reluctant to permit access until they perceived that the turkey population on their property was adequate to support a harvest. In some instances, landowners denied access to their properties in years when they believed wild turkey numbers were depressed on their lands. In other instances, landowners placed restrictions on the hunting method that could be practiced (archery or shotgun) or restricted the number of birds that could be harvested (i.e., 1 bird/hunter, although the bag limit was 2). Therefore, landowners often were controlling hunter numbers, distribution, and harvest based on local wild turkey population densities.

The mandatory landowner consent system gave landowners control of access to their property for wild turkey hunting. The landowners, in turn, controlled wild turkey hunter densities at levels comparable to or lower than the computer selection process did. In addition, landowners appeared to respond to changes in local wild turkey population densities thus influencing hunter distribution and harvest at a local level.

The number of consent forms obtained per hunter remained stable (1.0-2.1) from 1981 to 1989 (Table 2). The number of landowners permitting access increased as hunter numbers increased. This suggests that landowners not previously permitting access were being asked by new hunters for permission to hunt on private land. This supports our observations of cooperative relationships often formed between landowners and hunters granted access to their property. Hunters having permission to hunt on private land in Connecticut experienced the highest success rates in the Northeast, had longer seasons than on state land, and since 1987 had a 2-bird bag limit. To maintain this privilege, hunters often gave Christmas presents, shared game, offered services (e.g., help with farm chores, rebuilding stone walls, or habitat management projects), and established friendships with landowners granting them access to their land for wild turkey hunting. In return hunters often encouraged landowners to restrict access by other hunters to these properties; in effect, this relationship resembled a "membership" arrangement.

Hunter Responses

Wild turkey hunters on private land from 1981 to 1987 averaged 1.1 more years of turkey hunting experience than hunters on state land. There were 10.2% fewer first-time turkey hunters on private land, and an additional 21.8% had previously harvested a wild turkey. This suggests that as hunters become more experienced and dedicated to the sport, they are more likely to respond to increased incentives and expend the effort necessary to obtain and sustain access to private land.

The higher success rates on private land under the landowner consent system can be attributed to lower hunter density and hunter competition, more birds seen and heard (partially due to better habitat quality), and higher hunter skill levels. Private-land hunters also spent less time advance-season scouting, which may indicate their familiarity with the area; hunting on "home range" may have also contributed to their success (Thomas et al. 1973).

Advantages

The mandatory landowner consent system had 3 distinct advantages that saved time and expense compared with Connecticut's computer selection process. Seventeen worker-days were saved annually, no computer time was required, and 1 less mailing to all hunters was needed to complete the permitting process. The cost of printing consent forms was the only expense other than the computer selection system.

The mandatory landowner consent system gave private landowners control of access to their property for wild turkey hunting and maintained hunter densities comparable to or lower than those generated by our random selection process. Consent forms aided law enforcement officials in making clear determinations of legal vs. illegal access and apprised them of the magnitude and location of hunting pressure even before the season began. This system produced accurate records of trends in private land availability for wild turkey hunter access and locations of hunter concentration, which was available to guide harvest management decisions. Finally, this system fostered landowner-hunter interactions that developed into positive, cooperative relationships.

New Jersey, Massachusetts, and Connecticut initiated a wild turkey hunting season in 1980-81, and used a random selection process by computer to control hunter density. In Connecticut, however, the lottery selection process only applied to state land. Hunter density on private land was controlled by the mandatory landowner consent system. Under this system, hunter success rates were consistently higher than in the other northeastern states with comparable wild turkey populations and huntable range (Table 4).

Limitations

In New Jersey and Massachusetts, a hunter selected by the computer selection process could hunt state land or non-posted private land. Posted private land (and in N.J., all agricultural land) required landowner consent (written in Mass.; verbal in N.J.). In Connecticut, written landowner consent was required on all private lands, posted or not.

Connecticut hunters often experienced difficulty in obtaining hunting access to corporate lands for wild turkey hunting. Finding the authorized individual to sign such a form, along with with legal concerns, effectively closed to wild turkey hunters lands available for small game hunting. (Corporate and absentee landowners who do not oppose hunting on their property leave them unposted. Although landowner permission is encouraged, Connecticut law permits hunting for all species except white-tailed deer and wild turkey on non-posted lands without written consent).

Hunters encountered similar obstacles when seeking written consent for lands in absentee ownership. Absentee landowners were more difficult to reach and sometimes were reluctant to sign a form with which they were unfamiliar. These difficulties with corporate- and absentee-owned lands reduced huntable acreage, which may explain why the number of turkey hunters in Connecticut was less than 1/2-1/5 those recorded in New Jersey and Massachusetts, respectively, even though these states had comparable huntable range (Table 4). The lower hunter numbers ultimately resulted in lower turkey harvests in Connecticut despite higher hunter success rates. Therefore, the quality of the hunting experience has been preserved on private lands through the use of limiting the number of hunters that could participate. This tradeoff was suggested by others for consideration over 15 years ago (Madson 1975, Potter et al. 1973). In today's society with increasing hunter numbers and stable or decreasing available land, the ultimatum of whether to manage for quantity of hunting experiences or to restrict participation to manage for the quality of each experience becomes even more pertinent. This dilemma will undoubtedly be faced by wild turkey managers in the future throughout the wild turkey's range. Perhaps it is possible to strike some compromise as suggested by Hendee (1974:108) who stated, "Diversity of opportunity - not adherence to one stereotype - is the way to provide better quality for more hunters."

The primary purpose of the mandatory private landowner consent system is to give private landowners control of access to their property for hunting. If a primary state management objective is to maximize harvest and participation (number of hunters), states considering a mandatory landowner consent requirement should consider a modification of Connecticut's system. Such a provision should consider the privacy, legal concerns, and management objectives of the landowner; require as little effort on the part of the absentee and corporate landowner as possible; and provide for access to lands in which corporate and absentee landowners do not oppose hunting.

CONCLUSION

Although Connecticut's mandatory landowner consent policy has restricted the access of sportsmen to turkey habitat on private lands, it has not prevented access. It has provided a mechanism whereby landowners can control access to their property for wild turkey hunting. Tradition indicates that, in the absence of such control, landowners may react by posting their property. In Connecticut, use of the private-land consent system has resulted in a steady increase of private land availability. This is a function of sportsmen recognizing that the best turkey hunting opportunities and turkey habitat are on private lands and then seeking out landowners for the necessary written consent. This meeting allows sportsmen to educate landowners about turkey hunting and to foster positive, cooperative relationships, which may not occur if the public has unrestricted access to private land. The consent form policy has resulted in a quality hunting experience on private land, based upon high success rates and low hunter competition.

The written consent requirement will undoubtedly prevent Connecticut from achieving a level of maximum sustainable harvest statewide. Some private landowners are unwilling or unavailable to sign consent forms, while others may be overly restrictive. However, in a small state that has limited open space, high hunter pressure, increasing hunter numbers, and an increasing loss of private land to development, this policy seems to be the best option towards achieving the Connecticut's turkey management goal: to provide a safe, high quality hunting experience on as much private and public land as possible.

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SYMPOSIUM SUMMARY: LOOKING TOWARD 2000

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Abstract: National Wild Turkey Symposia have been an important means of communication among biologists. Proceedings of the 6 Symposia contain over 160 papers, more than any other source of technical literature. The Symposia provide a record of turkey *(Meleagris gallopavo)* restoration and the development of concepts about habitat requirements. Research in the next decade should focus on developing a unified theory of habitat use and a better understanding of population dynamics. Trap-and-transfer programs will continue to be important for population restoration, and they will become important for managing existing populations. Recent theoretical advances are being applied to restoration and management programs. The number of turkey hunters has grown dramatically; it is estimated that turkey hunters spent about $567 million in 1989. The popularity of turkey hunting and innovations in hunting equipment will challenge hunter education programs. State agencies will emphasize safe, quality hunting rather than maximum sustained harvest. The greatest challenge will be communicating management goals to a largely urban population. Managing turkey populations and hunters will be easy in comparison.

The first National Wild Turkey Symposium was sponsored by the Southeastern Section of The Wildlife Society through its Forest Game Committee and held in Memphis, Tennessee, in February 1959. The second Symposium was held in Columbia, Missouri, in 1970 and since then Symposia have been held at 5-year intervals. Proceedings of the first 5 National Symposia include 138 technical papers, and these Proceedings contain 29. From 1959 through 1989 *The Journal of Wildlife Management* included 65 articles about wild turkey, and the *Wildlife Society Bulletin* (started in 1973) contained 9. There are other important sources, but the Proceedings of the National Wild Turkey Symposia clearly contain a large part of the technical literature about wild turkeys.

In reviewing the 6 Symposia Proceedings one can trace the restoration of the species and the careers of those who pioneered turkey research, management, and restoration. The steady expansion of wild turkey range and the reoccupation of most historic range in North America is described by Mosby (1959, 1973, 1975), Bailey (1980), and Kennamer and Kennamer (1990). The dramatic increase in turkey populations and range expansion during the past 30 years has been accompanied by a corresponding increase in our understanding of turkey ecology and habitat requirements. Lambert et al. (1990) describe this change in understanding: "... eastern wild turkey are more adaptable than previously recognized ..., can use a broad array of habitat types, and with adequate protection from poaching can produce huntable populations in a variety of landscape configurations, even those with significant human disturbance, substantial agricultural development ..., and a high percentage of short-rotation pine plantations ...."

My objective is to contemplate future trends in research and management based on a review of this symposium and past National Wild Turkey Symposia. I will also share my views of potential challenges to successful wild turkey management.

I thank my wife and co-editor, Georgette Healy, the authors, the reviewers, and the Symposium planning committee (p. ii).

RESEARCH NEEDS

We need to synthesize the large amount of data on turkey habitat, home range, and movements into a generalized theory of habitat use. The end product of that synthesis should be models that can be used to direct management and assess the value of any landscape for wild turkeys. Eleven papers in this symposium describe habitat use, but only 1 provides a habitat suitability model. Comparisons of habitat use with availability have shown us what habitat types turkeys use at particular times and places. Most of these studies describe vegetation or other attributes of individual habitat types, but few studies relate habitat characteristics to specific population levels, behavior, and physiological needs of turkeys.

Measurements of the quantity and quality of food available for turkeys in specific habitat types are uncommon (but see Martin and McGinnes 1975, Dickson 1990). Yet, these measures of within-habitat-type characteristics are essential to developing a general theory of habitat suitability.

Generalized habitat models are essential to communicate effectively the needs of wild turkeys to land managers and to maintain our credibility with the public. About 10 years ago I tried to describe the habitat requirements of wild turkeys in the southeastern mountains (Healy 1981). That effort was useful (Schroeder 1985), but it did not go far enough. Today we have better descriptions of how and when turkeys use the habitat types available to them. Unfortunately, structure and energy content of most habitat types have not been fully described. That tedious and time-consuming work should receive high priority. I recommend that a considerable portion of our research energies be directed at quantifying habit type characteristics and developing regional models of habitat suitability.

We need more information about the dynamics of wild turkey populations (Little et al. 1990, Porter et al. 1990*a*). Turkey populations are difficult to study because they occur at low densities (1-5/km^2) over large areas (100-1,000 km^2). Wunz (1990) pointed out the difficulty of maintaining control during long-term, large-scale studies.

Radio telemetry will probably remain the primary tool for obtaining data on survival, reproduction, and causes of mortality. Unfortunately, radio telemetry techniques are not well suited to estimating population size, and obtaining adequate samples to estimate demographic parameters is expensive and labor intensive. Our ability to obtain demographic data from birds killed by hunters is limited by lack of techniques for aging birds older than 2.5 years and estimating reproduction from reproductive tracts. Intensive population studies may be too expensive for individual states. Perhaps it is time for interstate cooperative research--that approach certainly worked with restoration.

MANAGEMENT OPPORTUNITIES

Habitat

I think direct habitat management will remain a small part of most state agency programs. States will continue to emphasize population management because most turkey habitat occurs on private land, and turkey populations are expanding in most states.

The good news is that a little habitat management can have a large effect. Schemnitz et al. (1990) report that Gould's turkeys *(M. g. mexicana)*, an endangered subspecies in New Mexico, have annual home ranges of over 3,600 ha, but spend 71% of the time around riparian habitat types that constitute 4.5% of the range. Protecting and enhancing key riparian habitats will do much to ensure the success of these Gould's populations. In Pennsylvania, Wunz (1990) found that turkey *(M. g. silvestris)* populations increased in 1 extensive tract of public forest when less than 1% of the area was converted to wildlife clearings. Wunz (1990) suggests that a clearing program involving 3% of the area might be adequate. In intensively managed loblolly pine *(Pinus taeda)* forests, streamside management zones were important to turkeys in all seasons (Burk et al. 1990). Streamside management zones occupied 9% of the landscape, and were important for maintaining turkey populations where 66% of the land was occupied by pine plantations. Populations can be enhanced and conflicts with other resources can be minimized by focusing our efforts on key habitat types.

Cooperative efforts between conservation organizations and public agencies provide the most exciting opportunities for habitat management. The Making Tracks Program, a partnership among the U. S. Forest Service, the National Wild Turkey Federation, and state wildlife agencies has the potential to enhance 28 million acres (113,217 km^2) of turkey habitat on national forest land in 35 states. The Making Tracks Program should serve as a model for cooperative efforts on state and industrial forest lands.

The habitat available to wild turkeys should remain relatively constant during the next decade. Forestland area declined relatively little in any region since 1950 (Oliver 1986). The South has experienced the fastest rate of forest land loss in the nation; commercial timberland in the South declined from 196.8 million acres (79.6 million ha) in 1962 to 182.3 million acres (73.7 million ha) in 1985 (Boyce et al. 1986). The southern region also has the most intensive forest management in the nation, and pine plantations occupy about 14% of the forest area. Despite these changes the proportion and total area of upland hardwood and oak-pine forest increased in the South from 1962 to 1985 (Boyce et al. 1986). In the next decade, loss of forest land and farm land will be a local problem, but it should not threaten regional turkey populations.

Population Management

Trap-and-transfer programs will continue to be the cornerstone of population restoration, and the technology will become important for managing existing populations. Despite the success in restoring turkey populations during the past 30 years, important regional and local areas of suitable habitat remain unoccupied (Kennamer and Kennamer 1990). Further, Backs and Eisfelder (1990) have shown the value of transplanting to revitalizing low density populations in good habitat and maintaining isolated populations. Backs and Eisfelder (1990) seem to be the first to have applied concepts derived from island biogeography and conservation biology to the management of an abundant species. Their recommendations will be particularly useful to states that are finishing their restoration efforts and attempting to manage populations in the face of changing land-use patterns.

Management of hunting and protection from poaching will be the other major population management activities. I think the emphasis will be on quality hunting experiences rather than maximum sustainable yield. We know enough about turkey populations to provide reasonable hunting opportunities and maintain abundant turkey populations (Little et al. 1990, Porter et al. 1990*b*, Suchy et al. 1990).

Providing safe, quality hunting experiences will be a challenge. Success, satisfaction, and safety are interconnected elements in turkey hunting that seem to be negatively correlated with the density of turkey hunters (Cartwright and Smith 1990, Miller and May 1990, Vangilder et al. 1990). About 26% of spring turkey hunters in Missouri reported that interference by other hunters was a problem; even successful hunters reported satisfaction levels declined as the number of other hunters encountered increased (Vangilder et al. 1990).

Turkey hunters are concerned about safety. More than 35% of spring turkey hunters in Missouri reported being in a situation in which they believed they were in danger of being shot (Vangilder et al. 1990). Despite their concerns few hunters were in favor of mandatory requirements for wearing blaze orange or restrictions that would limit the numbers of hunters (Vangilder et al. 1990). Arkansas turkey hunters shared similar attitudes (Cartwright and Smith 1990).

The popularity of turkey hunting will stress our regulatory and hunter education systems. In the past 30 years the number of turkey hunters in Missouri has increased from about 700 to almost 100,000 (Vangilder et al. 1990). These hunters spent more than $10 million in 1988, not including permits and licenses (Baumann et al. 1990). It has been projected that nationwide turkey hunters spent about $567 million in 1989 (Baumann et al. 1990).

Many new devices and technical innovations have been offered to the growing market of turkey hunters. Turkey hunting equipment now includes 10-gauge shotguns, magnum shells, custom chokes, buffered copper-coated shot, calls, decoys, and camouflage accessories of all types. Used responsibly most of these devices increase the probability of a quick kill and reduce the probability of wounding birds. But, when used unethically or illegally some of these devices increase the risk of hunting accidents. I do not wish to condemn any of these devices or offend anyone who uses them. I use some myself. But I must share the concern I felt while in the woods, watching a young man dressed in street clothes and wearing white socks stalk my hunting partner! Popularity produces competition. We clearly have a hard task ahead in producing responsible and ethical hunters.

CHALLENGES

The greatest challenge of the next decade will be communicating natural resource management goals to the public. We will deal with an increasingly urbanized population with greatly reduced understanding of natural systems (Hendee 1989). "Between 1950 and 1980, the urban population of the United States increased over 65%, from 97 to 167 million people, while the rural population increased less than 10%, from 54 to 59 million people" (Oliver 1986:34).

Public interest in the environment has increased during the past 30 years. But, few people have hands-on experience with or basic understanding of the ecosystems that support their lives. Concepts of natural succession and population dynamics that form the background for many decisions by resource managers are generally not public knowledge. There seems to be a widespread perception that hunting and timber harvest exclude other uses of forest land. The idea that proper resource management can enhance noncommodity values is not widely accepted.

For the most part, those who have been involved with turkey restoration and management have also been hunters. Today, the National Wild Turkey Federation and state wildlife agencies are key partners with the U.S. Forest Service in the Making Tracks Program, an innovative cooperative effort to manage turkey habitat on U.S. Forest Service lands. Many wildlife species benefit from this program, and enthusiasm for the Making Tracks approach has had a positive effect on funding for all wildlife management activities on national forest lands.

I suspect that few nonhunters realize that ecosystems large and diverse enough to support wild turkeys also produce a tremendous array of other benefits. Or, that turkey habitat management, such as protecting riparian habitats in the arid Southwest and leaving hardwood corridors along streams in the South, can protect ecosystems and benefit a much larger wildlife community.

There is a growing intolerance of hunting and wildlife management. Organizations that oppose hunting promote the idea that hunting is detrimental to all wildlife because wildlife management practices harm species that are not hunted and disrupt "natural" ecosystems (see Satchell 1990). That generalization is false. Sportsmen and wildlife managers have had a primary role in protecting ecosystems and wildlife communities in this country.

Lack of common experience is a formidable obstacle to communication. In August 1982, I was photographing at Spruce Knob, West Virginia, when a family approached the observation tower. The 2 preschool-aged children paused to pick and eat blueberries growing along the path. When the father saw what they were doing, he rushed back and pulled the berries out of the younger child's mouth! He warned the children that they did not know what the berries were and that they might be poisonous. I believe the children knew exactly what they were eating and tried to tell the parents, but they seemed embarrassed and hurried away. It is sad to think that anyone could come to a place like Spruce Knob and yet know so little about what was there. It is more disturbing to think that the man who was afraid of fresh blueberries may be typical of much of the public. How do we explain turkey hunting to someone who finds all his food wrapped in heat-shrink plastic and sitting on a grocery shelf?

I am convinced that we will sustain our life style and the ecosystems around us only through careful planning and active management. But I am not sure the urban public believes resource managers can produce commodities while protecting the environment. We need to promote a greater understanding of ecosystem and management processes. I hope in the process that we can gain greater acceptance of hunting and other traditional resource uses. The communication challenge will involve personal commitment. We cannot rely on agency programs and information specialists. We need to be active in several conservation organizations--not just the National Wild Turkey Federation and our professional societies. Concerned citizens are eager to learn what resource managers know, and we need to share generously our field skills and technical knowledge with them.

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