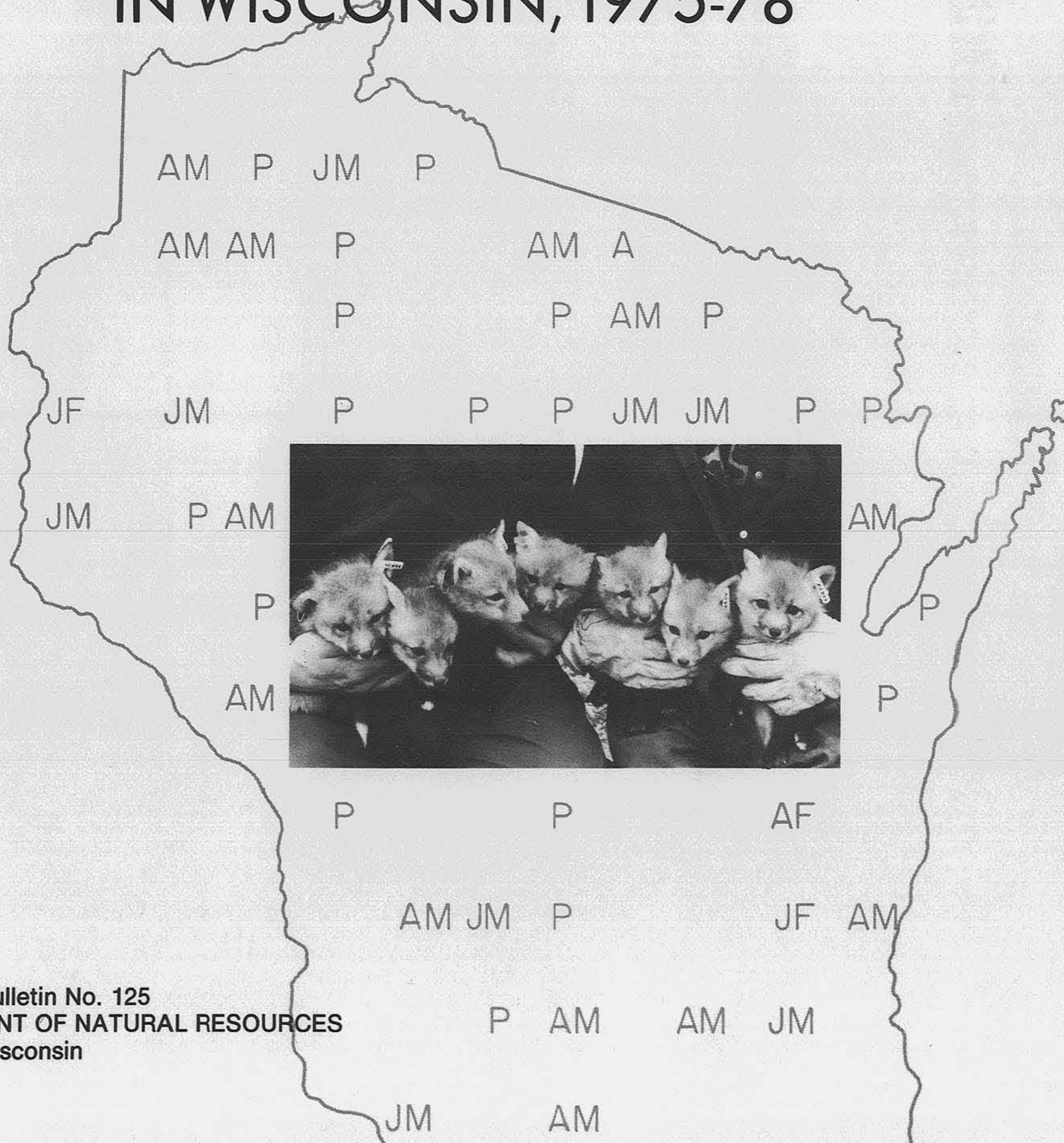
HARVEST, AGE STRUCTURE, SURVIVORSHIP, AND PRODUCTIVITY OF RED FOXES IN WISCONSIN, 1975-78



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ABSTRACT

Harvest, age structure, survivorship, and productivity of Wisconsin red foxes were examined from 1975 to 78. Two-hundred sixty-three questionnaire responses indicated that trappers drove less distance than hunters, but harvested 3 times the number of foxes during the fox season, partially because they spend more time afield. Fox hunters were most successful during January, while most foxes were trapped during November. Questionnaire data gathered from 363 licensed fur buyers suggested that red fox densities and the incidence of mange had declined during 1975-78.

Seventy-four percent of the 2,153 red foxes collected from 62 of the 71 counties in Wisconsin were juveniles. The sample of hunted and trapped foxes was segregated into 3 areas classified according to land use and habitat criteria. Sex ratios were significantly different only between trapped and hunted foxes collected in Area 1. Fifty-six to 58% of foxes collected in all 3 areas were males. The proportion of harvested adults in the sample increased from October to February.

Productivity estimates made during 1976-78 by examining 320 vixens statewide, resulted in (1) 6.9 embryos observed per female and (2) a mean juvenile placental scar count of 5.6 and an adult scar count of 5.4.

A population model integrating the data of Pils and Martin (1978) indicated that a stable population would develop over a 10-year period when hunting and trapping harvest was reduced by 45%.

Primary management considerations include a shortened, split, fox season. The shortened trapping portion of the season would run concurrently with the raccoon hunting and trapping season to reduce fox mortality.

Harvest, Age Structure, Survivorship, and Productivity of Red Foxes in Wisconsin, 1975-78

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INTRODUCTION

Historically, red foxes *(Vulpes vulpes)* have been one of the most important furbearers in Wisconsin in terms of monies generated by fur sales and recreation time afforded to hunters and trappers. The total pelt value of red foxes has ranked third behind muskrats *(Ondatra zibethicus)* and raccoons *(Procyon lotor)* since 1971-72 and accounted for $1.14 million in sales during 1977-78. Conversely, predation by red foxes has adversely affected some local Wisconsin ring-necked pheasant *(Phasianus colchicus)* populations (Gates 1971, Dumke and Pils 1973, Pils and Martin 1978). Other Wisconsin investigations have explored the relationship between red fox predation and pheasant densities, including Wagner et al. (1965) who concluded that some degree of population limitation by predation is within the realm of possibility. Richards and Hine (1953) collected information that would help in the evaluation of red fox management problems in Wisconsin, including population dynamics, food habits and analysis of the bounty system. Pils and Martin (1978) examined predator-prey relationships and gathered data concerning harvest levels, incidence of mange, age structure and reproductive performance from a sample of foxes collected in 6 southern Wisconsin counties; they concluded that this population was barely maintaining equilibrium because of intensive hunter-trapper exploitation. The current high pelt prices have heightened the demand for foxes, which could possibly depress populations to the point where productivity no longer balances mortality. However, these critical parameters are undefined for the statewide red fox population. Therefore, the primary objectives of the current study were to determine the age structure, incidence of mange, reproductive performance, survivorship, and harvest levels from a representative sample of Wisconsin red foxes collected from the 1975-76 through the 1977-78 fox seasons.

Management suggestions and population estimates have been formulated for arctic foxes *(Alopex lagopus)* in Northwest Territories, Canada (Macpherson 1969), river otters *(Lutra canadensis)* in Oregon (Tabor and Wight 1977), and bobcats *(Lynx rufus)* in Wyoming (Crowe 1975) using age and reproductive data. Red fox harvest data have been used to provide recommendations for hunting and trapping seasons (Andrews 1977, Sampson 1977). Storm et al. (1976) and Pils and Martin (1978) used age and reproductive data to estimate survivorship of local fox populations.

For years ecologists and mathematicians have been formulating models to study population dynamics (Preston 1973, Zarnoch et al. 1977). Until about 1965, the models involved only 1 or 2 parameters and had simplifying assumptions which taught us a lot about population phenomena but were not very realistic. The advent of inexpensive computing systems since 1965 has allowed for the development of more realistic models involving many interacting parameters. The speed of the computer has allowed us to solve problems which previously would have taken man-years to solve and hence were seldom attempted.

As one part of a study of the population dynamics of the red fox in Wisconsin, we decided to develop a computer simulation model to study some of the questions Pils and Martin (1978) had raised previously. A stochastic simulation model which allows ranges of values, permits a better understanding of the natural fluctuations in fox density than the deterministic (fixed value) model used earlier. It would also allow us to add new parameters, such as migration, which were difficult to use in a deterministic model. Finally, we could rapidly look at what would happen to the population if we changed the parameters of the population.

Therefore, by combining statewide information on estimated purchases, pelt values, and attitudes of fox hunters, trappers and fur buyers with computer simulations using Pils and Martin (1978) as a point of reference, a more meaningful portrayal of Wisconsin red fox population dynamics was possible. Collection and analysis of these types of data enhance the proper management of this valuable furbearer and game species.

STUDY AREA

An attempt was made to collect red fox carcasses from every Wisconsin county. Age and reproductive data were combined for foxes occupying similar habitats. The 140,318 km^2 of diverse habitat from which this sample was taken was segregated into 3 broad habitat types (Fig. 1) according to the land use and habitat criteria formulated by Hindall and Flint (1970):

Area 1 (59,333 km^2) - Twenty-four northern and central counties having more than 50% of their area in forested lands.

Area 2 (49,722 km^2) - Twenty-six western and central counties having more than 50% of their area in primary agricultural land with 15-49% of the area forested.

Area 3 (31,263 km^2) - Twenty-two southeastern counties having more than 50% of their area in productive to highly productive agricultural land and less than 15% of their area forested.

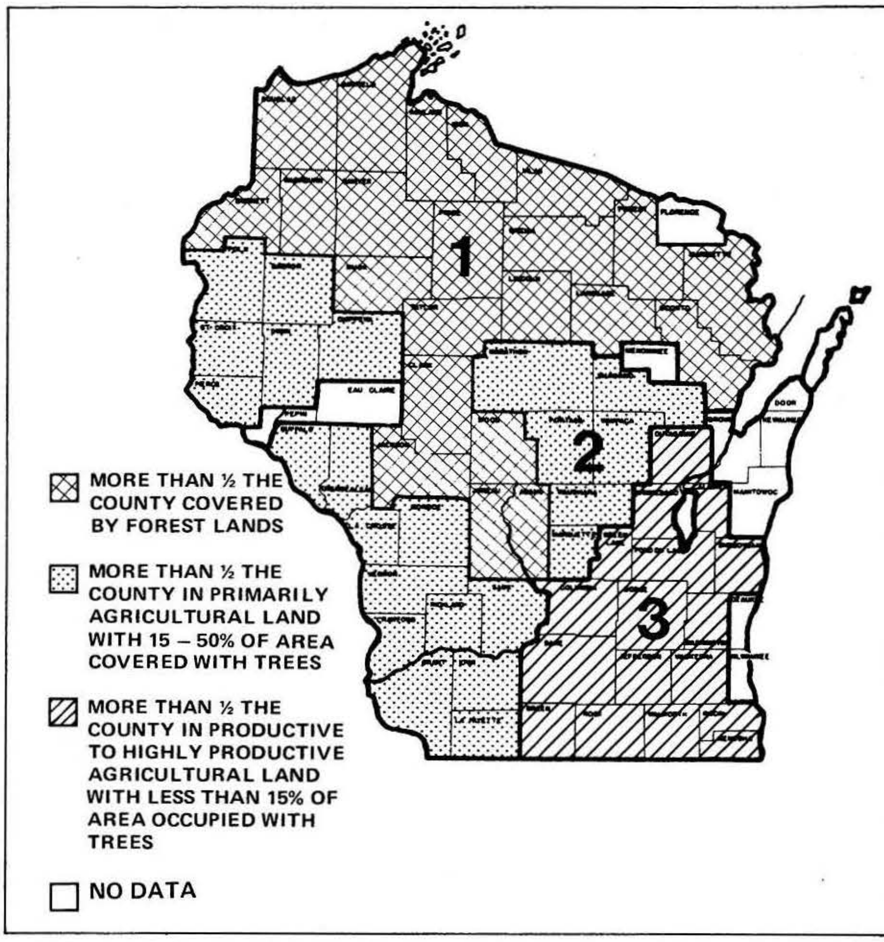

FIGURE 1. *The 3 study areas, based on percent forest and agricultural land, where data were collected for the current study.*

METHODS

CARCASS COLLECTION

Carcasses used for age and reproductive analysis were obtained by the following methods: (1) The Wisconsin Department of Natural Resources (DNR) Bureau of Research sent out requests to fox trappers, hunters and fur buyers who cooperated previously (Pils and Martin 1978) to donate carcasses for analysis; (2) DNR press releases were sent to newspapers and outdoors magazines throughout Wisconsin requesting carcasses, and (3) DNR District personnel contacted conservation clubs or similar groups concerning the collection of carcasses. Age, sex, and reproductive information was either obtained on the site by DNR personnel or portions of the carcasses such as upper mandibles or uteri were mailed or taken to the DNR research headquarters in Madison.

Adult red foxes were separated from juveniles by measuring the enamel line distance of canine teeth (Allen 1974). Suspected adult fox mandibles bearing premolar teeth were sawed off and boiled in water for 30 minutes; premolar teeth were then pulled out and were sent to the histological lab at the University of Wisconsin - Stevens Point for slide preparation. Thirty-seven percent of the collection was further separated into age classes by year, using counts of cementum annuli from premolars (Monson et al. 1973).

Fox ages were classified by Hanson's (1963) criteria: "(1) juveniles are less than fully grown animals; (2) subadults are essentially fully grown, but the majority of their cohort have not completed their first breeding season; (3) adults are fully grown and the majority of their cohort have completed 1 or more breeding seasons."

Productivity was determined by counts of placental scars (Englund 1970:19) taken from uteri that were not chemically treated. Reproductive data were collected only during 1976-77 and 1977-78.

Harvest variables such as county, year, month, sex, how taken, and age class by year were analyzed at the University of Wisconsin-Madison Academic Computer Center, using the STATJOB System and the Program CROSSTAB2. Unless otherwise

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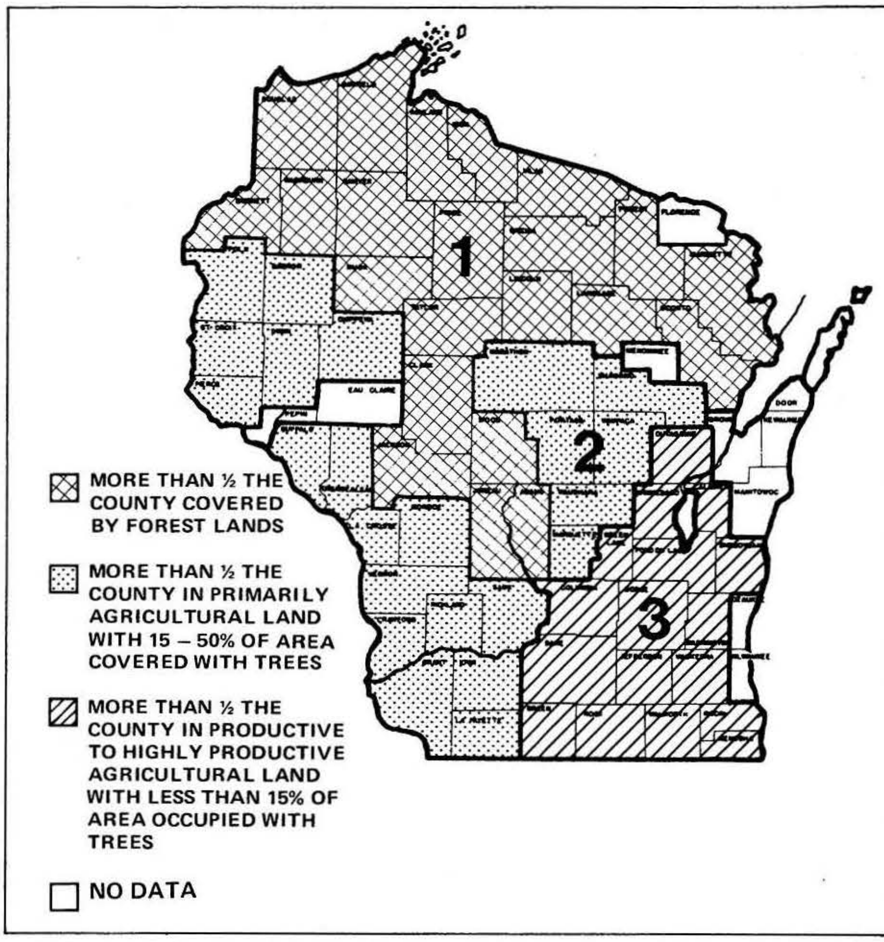

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RED FOX MODEL

Background. Several methods have been used to estimate canine survivorship including the Chapman and Robson (1960) equation used by Storm et al. (1976), life equations employed by Nellis and Keith (1976), and a population matrix utilized by Pils and Martin (1978). A red fox population model similar to one developed by Zarnoch et al. (1977) was used to estimate survivorship of Wisconsin red foxes employing data from the current study, Pils and Martin (1978), and Zarnoch et al. (1977). We chose the Zarnoch et al. (1977) model because it employed the maximum number of components crucial to the estimation of survivorship, including sex and age composition, litter size, types of mortality, and dispersal. The sex ratio at birth and ecological longevity were also included in the model.

The model simulates a square region which is divided into 961 territiories (Fig. 2). The region is subdivided into a central wildlife area (WA) with 121 territories and an outer border area 10 territories wide. All territories are assumed to have identical ecological characteristics. This is neither biologically realistic nor necessary from a programming standpoint. It was adopted, as were the assumptions given below, because (1) we do not know what are realistic values for them, and (2) even if we did, using some set of values would restrict the applicability of the results.

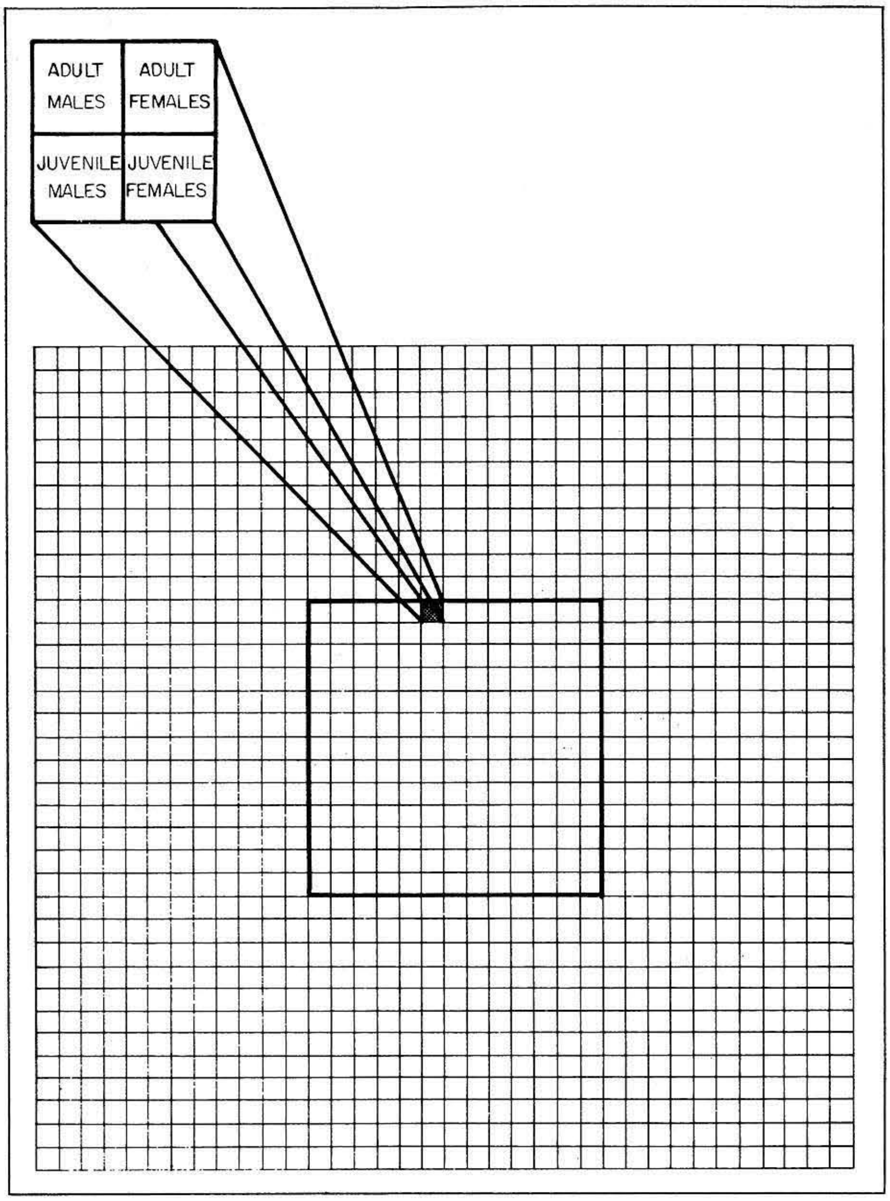

FIGURE 2. *Diagram of home ranges used in model. Each square represents a home range. The expanded square shows the four possible sex-"age" combinations found in each territory. The dark inner border delineates the 11 x 11 research area which the program reports on.*

The program was written in the BASIC computer language to run at the University of Wisconsin's Madison Academic Computing Center. The logical flow of the program is shown in Figures 3 and 4. The program prompts the values of the population parameters and the number of years to be simulated (1 to 20 years). Each year begins in "spring" with the birth of young. Mortality may occur in "summer" and "fall" and dispersal and pair formation occurs in "winter".

Reproduction. Young are born in spring only in territories occupied by a male and female. The probability of pregnancy occurring is age specific and is one of the input parameters. A restriction is placed on this in that the last age class (9) has a zero probability of becoming pregnant (i.e., nonreproductive or sterile). The size of the litter is selected at random with the probability of values of 1 through 12 being input values. Litter size is modelled as being independent of the age or previous experience of the female. The sex ratio in the litter is a constant, requested at the start of the simulation.

Mortality. Three identifiable types of mortality can occur following the spring reproduction. The summer mortality represents the casual mortality from accidents and disease. In the fall, hunting and trapping (2 separate causes) occur. It is possible to have only 1 general cause of mortality if desired. (If so, this takes place in summer.) Regardless, each type is sex and age specific and is input at the beginning of the simulation. All of the age class 9 individuals die in the current year. These mortality rates are not biologically realistic in that they are (1) constant for a simulation, (2) not density dependent, and (3) not dependent on the specific territory occupied.

Dispersal. In the "winter", after all mortality has occurred, the simulated animals disperse. Here, 5 parameters describe the process. First, the probability that an individual disperses is sex and age dependent. Second, the distance it migrates (from 1 to 11 territories) is only sex dependent. Third, the direction in which it moves is the same for all individuals and is limited to one of four directions, i.e., northwest, northeast, etc., with the probability of each set at the start of

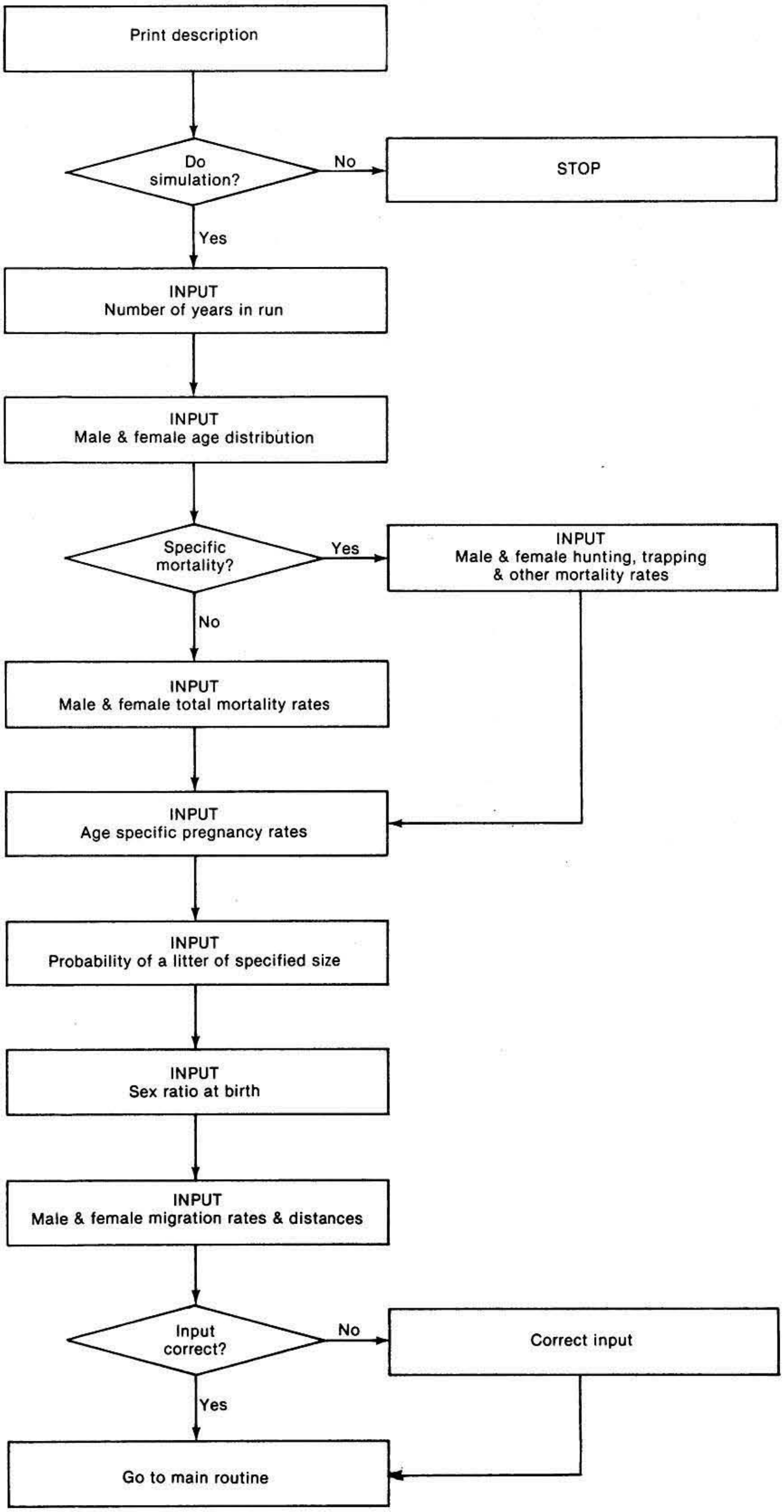

FIGURE 3. *Flow chart of input section of model showing population parameters needed.*

the simulation. These three parameters are asked for at the start of the simulation, unlike the remainder.

The fourth parameter concerns the timing of dispersal. All adult movement occurs before any juvenile dispersal. The last parameter concerns displacement of one individual by another. No individual can be displaced from its territory except that an adult will displace juveniles. If a territory has a litter of juveniles in it and following the adult dispersal it has only 1 or 0 adults, 1 juvenile of the missing sex will remain in it. Lastly, all other juveniles disperse.

In order to carry out these rules, the program begins in the center territory (row 16, column 16). A random number between 0 and 1 was generated and compared to the probability of migrating for the age class of the adult male present (if any). If it was less than this value, he was removed from the territory and placed in a list of migrators. This process continued in concentric squares until all 961 territories were checked for migrating adult males. A random distance and quadrant were chosen for the first male in the list. Within the quadrant at the specified distance are a number of possible territories. One was chosen at random. If there was no male present, the migrator was assigned to the territory. If 1 were present, the process of getting a new territory was repeated using this occupied territory. Thus an individual migrator could leave his territory and return to it the same winter. If a male migrated to an area outside of the 961 territories in the program he was lost from the system completely. After all the males were either assigned territories or lost, the same process was gone through for the adult females. Juvenile males and juvenile females were handled similarly except that all migrated except as noted in the rules above. After all individuals have migrated the year ends and the next begins.

Output. The program's output reflects only what happens within the WA. It is as if there was a perfect census operation within the WA and no knowledge at all about the remaining area.

An example of the output from the model is shown in Figure 5. The basic output consists of a detailed look at the last generation of the simulation and a summary of all generations. The detail shows the distribution of distances migrated within the WA plus the number lost (i.e. migrated outside of the WA) and gained (i.e. migrated into the WA from the surrounding border area). This is followed by a picture of the 121 territories in the WA showing the sex-age combinations in each. Then the

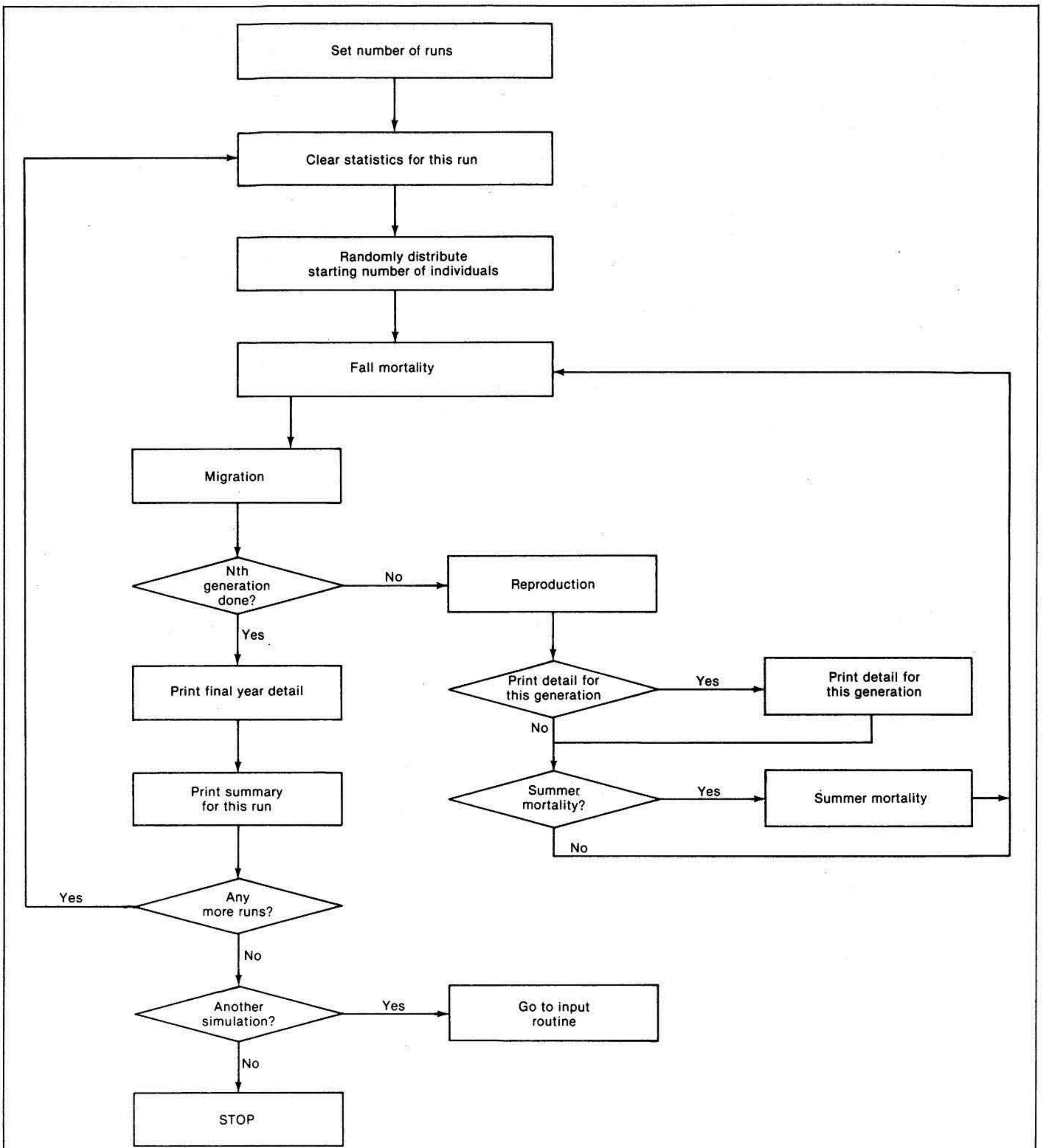

FIGURE 4. *Flow chart of main section of model.*

spring age distribution for males and females and the numbers of these that died during the year are given along with the number of females that reproduced. Finally the proportions of the adults that migrated in each direction are given. This detail can optionally be printed for each generation in the simulation if desired.

The summary of all generations gives the number alive in spring (Spring), the number dying in the year (Dying), the number migrating within the WA (No.), the average number of territories they migrated through (Dist.), the number lost (Lost) and gained (Gain) for both males and females. The number of reproducing females is also given (Reproducing).

The program can simulate a maximum of 20 generations. A number of runs using the same input parameters can be made by simply specifying the number. After all runs are made for a set of parameter values, the program allows for 1 or more of these parameters to be changed without affecting the parameters which are to remain constant.

Generation 10	Distance Migrated										Loss	Gain
	1	2	3	4	5	6	7	8	9	10		
Adult Female	3	7	6	4	0	0	0	0	0	0	16	13
Adult Male	6	12	6	11	0	3	0	0	0	0	32	42
Juvenile Female	0	3	2	0	0	0	0	0	0	0	3	6
Juvenile Male	0	2	3	4	1	0	0	0	0	0	10	7

AM	AM	P	JM	P		P				
	AM	AM	P			AM	AM		AF	
			P			P	AM	P		
JF	JM		P		P	P	JM	JM	P	P
JM	P	AM	AM	AF		P		AM	JM	AM
P		P	AM	JM	JM	P	AF	JF		P
AM		AM	JM		P	P		AM	P	P
		AM	P			P			AF	
	P	JM		AM	JM	P			JF	AM
AM		AM			P	AM		AM	JM	
			JM			AM				

AGE	-------------FEMALES --------------------			-------MALES ------	
	LIVE	REPRODUCTION	DEAD	LIVE	DEAD
1	29	0	13	19	4
2	17	7	1	31	1
3	8	3	1	15	1
4	6	3	0	12	1
5	4	1	0	8	0
6	3	0	0	6	1
7	0	0	0	2	0
8	2	0	2	0	0
9	0	0	0	0	0

MIGRATING DIRECTION

NORTHWEST	NORTHEAST	SOUTHEAST	SOUTHWEST
31	35	20	12

	---------------------FEMALES ----------------------							-----------------------MALES --------------------------					
			---------MIGRATING ---------				REPRO-			---------MIGRATING ---------			
YEAR	SPRING	DYING	NO.	DIST.	LOST	GAIN	DUCING	SPRING	DYING	NO.	DIST.	LOST	GAIN
1	199	60	61	2	57	40	0	199	19	70	3	81	96
2	150	46	58	2	39	41	41	149	21	72	2	70	82
3	146	39	55	2	40	35	41	145	23	63	2	65	61
4	147	43	51	2	39	30	37	138	24	71	2	52	55
5	147	54	45	2	33	36	40	147	25	62	2	62	53
6	115	43	41	2	27	29	29	127	18	71	2	49	41
7	91	32	32	2	19	22	23	119	18	59	2	51	49
8	94	27	39	3	18	14	26	115	15	60	2	44	47
9	84	30	26	2	20	17	19	102	9	55	2	42	38
10	69	17	25	2	19	11	14	93	8	48	3	42	35

FIGURE 5. *Status of all adult male (AM), adult female (AF), juvenile male (JM) and juvenile female (JF) foxes that dispersed throughout the 11 x 11 research area for the 10th simulated generation, and a summary of all 10 simulated generations.*

Questionnaires

Hunter-Trapper Questionnaire. Names and addresses of previously contacted hunters and trappers (Pils and Martin 1978), as well as Wisconsin fox hunting clubs and Wisconsin Trapping Association members were randomly selected from their respective directories. Questionnaires similar to those used in North Dakota (S. Allen No. Dak. Game and Fish Dep., pers. comm.) were then sent to prospective participants (Append. A).

Fur Buyer Questionnaire. A questionnaire concerning pelt purchases, harvest, incidence of mange, and estimates of red fox population trends (Append. B) was also sent to all licensed Wisconsin fur buyers.

Summer Wildlife Inquiry. The DNR Technical Services Section sends this questionnaire to selected rural residents throughout the state in mid-August (Thompson and Moulton 1981). Nonrespondents are continuously culled which has reduced the original list from 5,000 in 1962 to 1,600 in 1978. This level is still considered adequate for statewide estimates. Residents were asked the following fox questions: (1) Have you seen any FOXES on your farm since May 1?; (2) Do you know of any FOX LITTERS raised on your farm this year?; (3) How many litters did you see on your farm? Questions (1) and (2) were summarized from 1962-78 to serve as a further index of statewide red fox abundance.

RESULTS AND DISCUSSION

HARVEST MECHANICS

Hunter-Trapper Questionnaire

Sportsmen questionnaires can serve as a method for gathering a variety of useful harvest information as well as activities and attitudes of hunters and trappers. Heberlein and Laybourne (1978) used an extensive mailed questionnaire to obtain detailed data on deer hunter behavior in Wisconsin. Klessig and Hale (1972) utilized a 7-page survey mailed to a sample of 1,500 Wisconsin resident hunters to obtain information on the characteristics, activities, and attitudes of Wisconsin hunters. Eight of 10 hunters favored the control of fox numbers and most agreed that bounties should be used as incentives for this purpose (Klessig and Hale 1972). But subsequent Wisconsin red fox research has indicated the fallacies of that conclusion (Pils and Martin 1978). Trego and Kruckenberg (1975) used questionnaires to profile North Dakota fox hunter and trapper participation patterns. Southern Wisconsin residents and statewide fur buyers were surveyed by Pils and Martin (1978) to ascertain fox densities, harvest information, and months that foxes were harvested.

We recognize that harvest as reported through the hunter-trapper or fur buyer questionnaires and as revealed by the model represents an estimate of the relative monthly distribution of the known losses to the fox population, primarily during the fox season, when animals can be legally obtained and sold as pelts. Pils and Martin (1978) determined that trapping and hunting constituted the major source of annual mortality for southern Wisconsin foxes. Although losses from hunting and trapping are limited to only 5 months out of the year, they are of primary importance in an analysis of annual mortality.

The 378 questionnaires produced 263 responses (70% return) including 31 individuals that both hunted and trapped (Table 1). The Wisconsin Trappers Association membership was larger and more accessible than the combined constituency of all fox hunting clubs; therefore more trappers were available for questionning. Trappers returned questionnaires at a higher rate than did hunters.

Although trappers drove fewer kilometers per season, they took 3 times as many foxes and spent considerably more time afield than did hunters (Table 2). However, more mangy foxes

TABLE 1. *Classification of the 263 responses to the hunter-trapper questionnaires, 1975-78.*

Years	Hunter	Trapper	Hunter and Trapper	No Activity*
1975-76	0	20	5	3
1976-77	22	69	14	14
1977-78	16	58	12	30
TOTALS	38	147	31	47

*Included returns with no information, or hunters and/or trappers returning questionnaires indicating no field activity for the year.

TABLE 2. *Summary of 263 harvest questionnaires from Wisconsin red fox hunters and trappers.*

Harvest Data	Fox Trappers	Fox Hunters
Mean number foxes taken/season	10.5	3.4
Mean number days spent in field/season	35.9	20.1
Mean number kilometers driven/day	40.3	46.3
Percent mangy foxes taken/season	3.6*	5.5**

*63 trapper replies
**42 hunter replies

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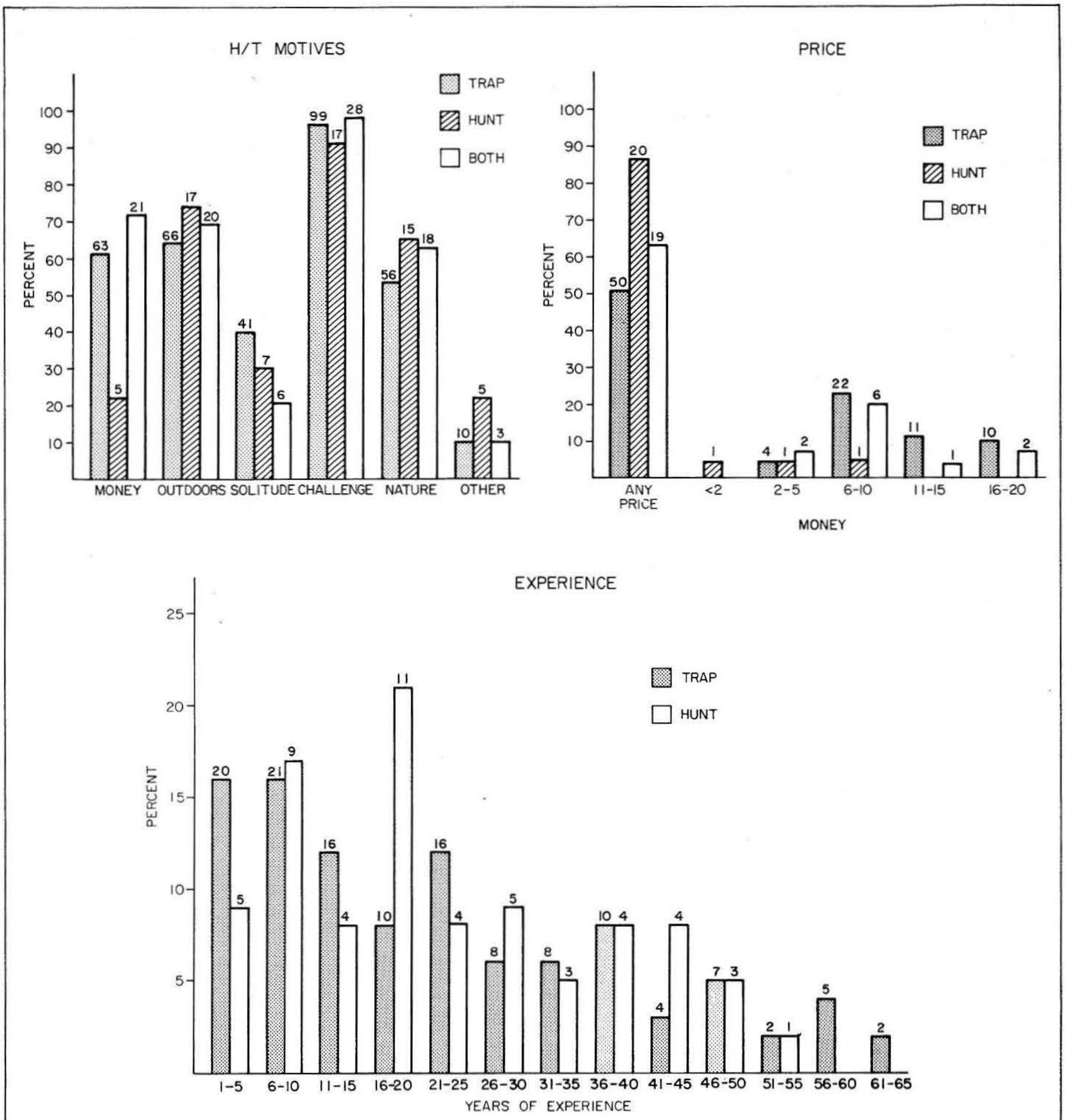

FIGURE 6. *Results of replies from questionnaires sent to fox hunters and trappers, 1976-78. The number above the bar refers to sample size.*

were shot each season than were trapped.

Hunting-Trapping Motives and Experience. Respondents answered questions concerning the reasons why they trapped or hunted, which provided some psychological perspective to these activities. In all instances, multiple answers were given to questions 1c and 1d (Append. A). Hunters and trappers went afield primarily to enjoy the challenge, to get outdoors and to enjoy nature (Fig. 6). Earning money was important to 72% of those participants who both trapped and hunted, while 3 times as many respondents trapped rather than hunted in order to earn money, a fact suggested by Trego and Kruckenberg (1975) and Pils and Martin (1978:46). Thirty percent of the fox hunters queried pursued foxes in order to find solitude. This apparent desire for solitude seemed to contradict our observations that group hunting is the most common technique for shooting foxes in Wisconsin. Klessig and Hale (1972:14) found that the majority of predator hunters said that they pursued foxes in order to enjoy nature. Other reasons given for harvesting foxes included testing of trapping lures, controlling fox numbers, and harvesting surplus foxes.

When asked how low fur prices would have to decline before hunters or trappers would give up their efforts, all groups overwhelmingly replied that they would pursue foxes regardless of price (Fig. 6). Trego and Kruckenberg (1975) received a similar response from North Dakota hunters and trappers; however, they found a high correlation between numbers of fox hunters and trappers and average annual pelt prices over a 6-year period. Wisconsin data also seem to reflect this finding. Most fox trappers questioned had 1-10 years of trapping experience (Fig. 6) which corresponded with the period (1968-78) in which average pelt prices increased more rapidly than in any other decade in Wisconsin fur history (Table 3). On the other hand, most hunters polled (72%) had 16-20 years experience, which would suggest less of an interest in earning money (Fig. 6). Many of the respondents had considerable field experience; 36% of the trappers and 37% of the hunters questioned had trapped for more than 25 years. Seven percent of those polled had trapped for more than a half-century (Fig. 6).

Months of Harvest. Foxes were hunted most heavily during January, followed by December and February (Fig. 7). Snow accumulation, usually at a peak during January, is a critical factor for spotting and tracking foxes (Pils and Martin 1978:22). Foxes shot during October and November in southern Wisconsin may have been harvested incidentally to hunting for pheasants and for deer (Pils and Martin 1978:24).

Fox trappers were most successful during November (Fig. 7), when more foxes were available. Trapping conditions were also better during the earlier months of the season before the advent of extreme temperatures, ice and snow. Fall red fox dispersal starts during October in southern Wisconsin (Pils and Martin 1978:18) Extensive fall movements following the mid-October fox season opening possibly increased the numbers of fox-trap encounters as compared to the later months.

TABLE 3. *Wisconsin red fox fur values and estimated purchases, 1968-78.*

Year	Fur Value ($)	Adjusted* Value ($)	Number of Estimated Purchases	Total Pelt Value ($)
1968-69	8.03	7.31	35,989	288,991
1969-70	6.43	5.53	34,818	223,880
1970-71	6.57	5.42	29,960	196,837
1971-72	10.65	8.50	26,373	280,872
1972-73	20.65	15.51	25,386	524,221
Mean ± S.E.	10.47 ± 2.66	8.45 ± 1.86	30,505 ± 2148	302,960
1973-74	28.06	19.00	33,766	947,474
1974-75	23.61	14.65	25,662	605,880
1975-76	40.79	23.92	23,364	953,018
1976-77	54.25	29.89	25,340	1,374,669
1977-78	52.70	26.79	21,607	1,138,740
Mean ± S.E.	39.88 ± 1.68	22.85 ± 2.72	25,948 ± 2087	1,003,956

*Formulated by Pils and Martin (1978:45)

Fur Buyer Questionnaire

The 366 licensed Wisconsin fur buyer replies (Append. B) during 1975-78 indicated that 69% of the red foxes purchased were trapped (Table 4). According to the Hunter-Trapper Questionnaire (Fig. 7), 90% were trapped. The majority of the Hunter-Trapper Questionnaire respondents were trappers (Table 2), which probably biased the sample in favor of trapping. Mangy foxes constituted 4.4% of all foxes brought in to fur dealers during 1975-78, a figure comparable to the 3.6% mangy foxes reported taken by trappers and the 5.5% mangy foxes reported killed by hunters (Table 2). In addition, most fur buyers reported a decline in the incidence of foxes with mange during each survey year from 1975-76 to 1977-78.

According to the fur buyer survey, total harvest was greatest during December (30%) followed closely by November (28%, Fig. 8). The trapper-dominated Hunter-Trapper Questionnaires suggested that November (45%) and October (26%) were the primary months of red fox harvest (Fig. 8).

Pils and Martin (1978:7,28) found local and regional declines in southern Wisconsin red fox densities during 1972-75. Similarly, Wisconsin fur buyers also estimated lower fox numbers from 1974-75 to 1975-76 (Pils and Martin 1978:25) and felt that Wisconsin fox densities continued to decline through 1977-78.

TABLE 4. *Results of red fox statewide questionnaires from Wisconsin fur buyers, 1975-76 through 1977-78.*

Harvest Data	Red Foxes Number	Red Foxes Percent
Type		
Trap	32,941	69
Hunt	12,710	27
Other	1,961	4
TOTAL	47,612	100
Month		
October	4,840	11
November	12,854	28
December	13,522	30
January	9,344	21
February	4,340	9
March*	294	1
Total Kill	45,194	100
Total Replies	366	55

*Some fur buyers indicated March harvest although the season closed at the end of February.

AGE AND SEX COMPOSITION

Ages were determined for 2,153 red foxes collected in 62 of the 72 Wisconsin counties (Fig. 1). The age distribution of red foxes collected in each of the 3 study areas was similar. Juveniles comprised 74% of all red foxes examined (Table 5). Approximately 90% of the foxes inspected consisted of juveniles through age 3. The highest percentage of juveniles (76%) was found in Area 2. Sex was determined from 2,105 of the foxes in the sample; males constituted the bulk of the juvenile sample (Fig. 9).

Several authors, including Layne and McKeon (1956), Sheldon (1949:236), and Storm et al. (1976:24), have compared sex ratios of juvenile and adult red foxes to an assumed 50:50 sex ratio at conception. At the Waterloo dens, we found a juvenile sex ratio of 49 males:51 females (Pils and Martin 1978). In the present study, the statewide and regional sex ratio data were not statistically compared to this 49:51 sex ratio because of the unknown bias associated with the preponderance of trapped foxes in the

TABLE 5. *Comparative age structure of 2,153 foxes killed in the 3 land use and cover areas of Wisconsin, 1975-78.*

Area	Age	Type of Harvest: Trapped	Hunted	Unknown	Total
1	J	265	42	29	
	1	59	8	6	
	2	25	9	2	
	3	17	1	1	
	4	7	2	0	
	5	5	0	0	
	6	0	0	0	
	7	4	0	0	
Total		382	62	38	
Percent					
juv.		69	68	76	
ad. (1-7)		31	32	24	
2	J	501	183	54	
	1	70	24	2	
	2	39	19	6	
	3	25	9	2	
	4	9	7	0	
	5	5	5	0	
	6	4	3	0	
	7	1	1	1	
	8	3	2	0	
Total		657	253	65	
Percent					
juv.		76	72	83	
ad. (1-8)		24	28	17	
3	J	388	131	3	
	1	58	30	1	
	2	28	15	0	
	3	15	0	0	
	4	10	1	1	
	5	2	0	0	
	6	0	0	0	
	7	1	1	0	
	8	0	1	0	
	9	1	0	0	
Total		503	188	5	
Percent					
juv.		77	70	60	
ad. (1-9)		23	30	40	
State Total		1,542	503	108	2,153
Percent					
juv.		75	71	80	74
ad. (1-9)		25	29	20	26

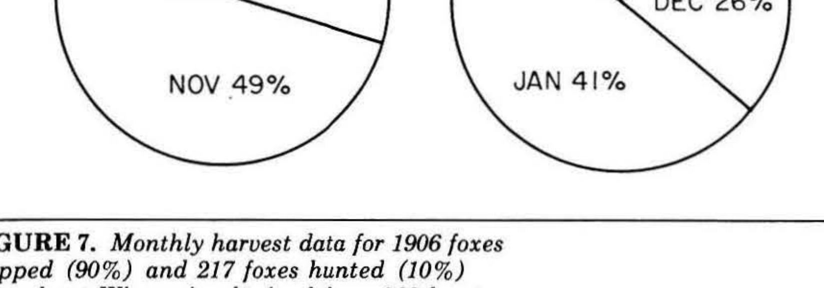

FIGURE 7. *Monthly harvest data for 1906 foxes trapped (90%) and 217 foxes hunted (10%) throughout Wisconsin obtained from 263 hunter-trapper questionnaires, 1975-78.*

sample. However, a majority (57%) of trapped and hunted foxes gathered in all 3 collection areas were males. We also compared sex ratios between trapped and hunted foxes (Table 6); a significant difference was found only in Area 1.

The reason for the prevalence of males in the sample remains largely unknown. Storm et al. (1976:24) believed that males suffered higher mortality because of their longer movements. Conversely, if our juvenile sex ratio at the Waterloo dens was also typical of statewide ratios, vixens may have suffered higher pre-October mortality (of unknown causes) than males, resulting in more males being available for hunters and trappers at the onset of the fox season.

More juvenile males were taken by trappers while more adult males were taken by hunters (Table 7). Statistical comparisons were not made between areas due to small sample sizes. Statewide trapped juvenile and adult foxes exhibited significantly different sex ratios (Table 7). The proportion of adults increased from October to February because of two factors: (1) more juveniles than adults were available to hunters and trappers in October; (2) juveniles were more susceptible to hunting and trapping mortality and were taken at a higher rate earlier in the season, thus a higher proportion of adults appeared in the sample as the season progressed. In all months except February greater proportions of adult females, as compared to adult males, were trapped (Fig. 10). Conversely, males constituted the greatest proportion of adults shot from December through February.

PRODUCTIVITY

Three-hundred twenty vixens were examined for embryos and placental scars during 1976-78. We found an average of 6.9 embryos/vixen as compared to 6.4 embryos/female noted for 17 vixens collected in southern Wisconsin (Pils and Martin 1978:13) and 6.8 fetuses/female for 82 vixens examined in Illinois and Iowa (Storm et al. 1976:23). Because only 12 pregnant vixens were available for embryo counts, our estimates of litter size were based on placental scar counts (Fig. 11).

Sixty-five percent of the sample represented yearlings without placental scars. Englund (1970) discussed the problems inherent in using scar counts as an index of productivity. Chi square analyses were used to test for the effect of age on pregnancy rate (number of vixens with placental

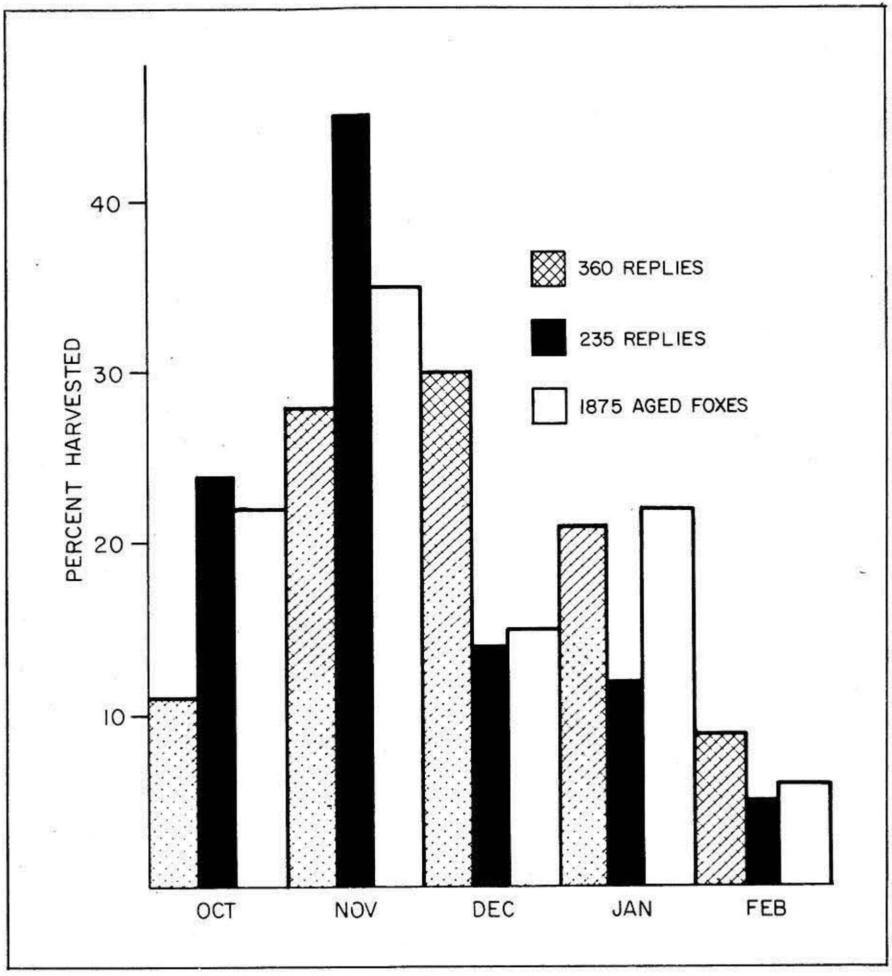

FIGURE 8. *Comparative statewide monthly harvest of foxes as determined by (1) fur buyer survey (1975-78), (2) hunter-trapper questionnaire (1976-78), and (3) aging data (1976-78).*

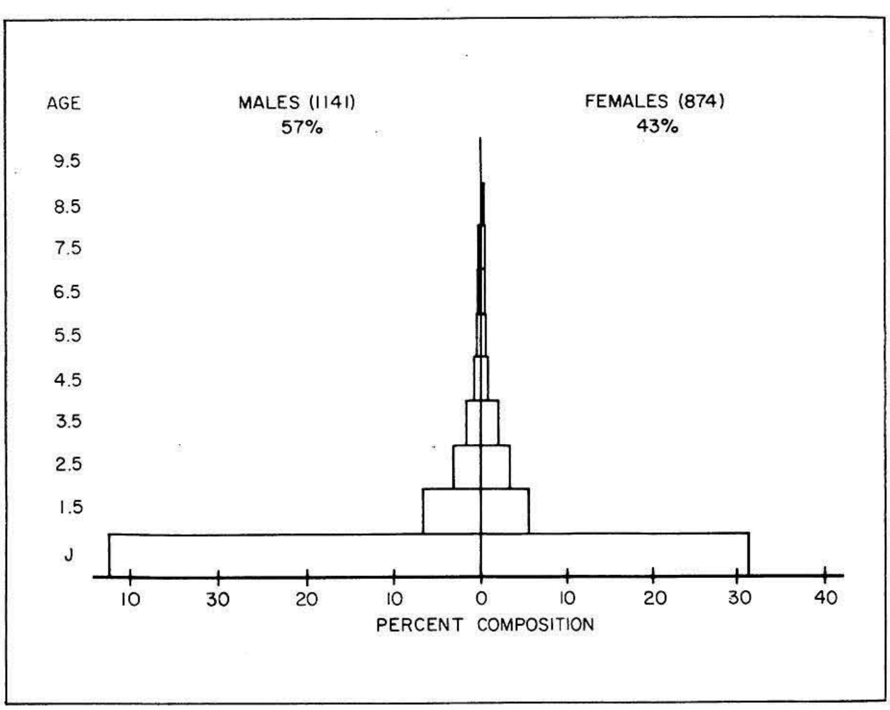

FIGURE 9. *Composite age-sex frequency distribution for 2,015 Wisconsin red foxes aged, 1975-78.*

scars). Mean litter sizes for both yearlings and adults increased from Area 1 to Area 3 (Fig. 11), but were not significantly different. Mean litter size ranged from 5.3 in Area 1 to 5.9 in Area 3; average adult litter size increased from 4.2 in Area 1 to 6.3 in Area 3. Since all three area values overlapped, differences in litter size could not be solely attributed to changes in latitude. Previous research concerning red fox litter sizes has not established any positive relationship between numbers of young produced and latitude. Schofield (1958) felt that the significant differences observed in red fox litter size between northern, central and southern Michigan were primarily due to the environmental capacity of the fox range and compensatory reproduction by more severely exploited southern Michigan foxes which produced the largest litter sizes. However, Layne and McKeon (1956) found the largest litter sizes in central, rather than northern or southern New York. Lord (1960) concluded that litter size appeared to be inversely related to the density of breeding populations of foxes, which, in Michigan, was dependent on human predation. Our highest litter sizes were found in Area 3, a region of heavy hunting and trapping pressure, high soil fertility, intensive land use and high prey base (Pils and Martin 1978:34) or high carrying capacity, which agreed with Schofield's (1958) conclusions. Land use is less intense and human population densities are lower in Area 2 than in Area 3. Therefore, it was not possible to specifically implicate fox population density as a factor regulating subsequent litter size in Wisconsin red foxes.

SURVIVORSHIP

Background

Few previous studies have attempted to age large samples of hunted and trapped carnivores in order to explore survivorship. Smirnov (1964) aged Russian arctic foxes and constructed dynamic life tables in order to determine abundance. Macpherson (1969) aged 951 Canadian arctic foxes, counted placental scars from 118 vixens, and estimated litter size by observing numbers of whelps from 50 weaned litters. These data were used to build life tables which suggested that over half of a year class dies before weaning, half the remainder perishes in the next year and less than 10% of the cohort survives to the second year. Crowe (1975) obtained age and productivity data from 161 Wyoming bobcats to determine age-specific reproduction and mortality and past population fluctuations. The population status of western Oregon otters was estimated from a population model (Henny et al. 1970) that included estimates of survival and recruitment obtained from aging and examining 113 females.

Storm et al. (1976) and Pils and Martin (1978) estimated survival and mortality based on returns of tagged red foxes. However, little previous documentation of fox population dynamics has been made employing age and productivity data obtained from samples of harvested red foxes. Allen (No. Dak. Game and Fish Dep., pers. comm.) is currently investigating age and sex-specific survival rates from red foxes harvested in North Dakota from 1971-77. An estimate of survival using a collection of shot and trapped foxes, is defective because of several inherent biases. Since the sample was obtained primarily from hunters and trappers of varying ability, harvest success was uneven throughout Wisconsin; therefore all populations were not equally exploited. Foxes also were not harvested uniformly throughout the state; rather the majority were taken where hunting and trapping conditions were optimal. The degree of cooperation between Wisconsin fur dealers and DNR personnel also varied. As a result, large numbers of carcasses were obtained from some areas while few or none were collected elsewhere. Most importantly, the collection was probably not representative of the actual age distribution of the statewide population. Rather, the 2,153 carcasses collected during the study represented the age distribution of red foxes that were trappable and huntable. These foxes were predominantly juveniles (Table 5) with little experience in avoiding trappers and hunters (Pils and Martin 1978:29). If these limitations associated with the collection of age data are recognized, a more meaningful appraisal of the subsequent survivorship estimates is possible.

Zarnoch et al. (1977) postulated through computer simulation that when survivorship equaled 0.45, fox populations would stabilize. Pils and Martin (1978) determined that survivorship of tagged foxes in southern Wisconsin had steadily decreased during the period from 1973 to 1975, probably in an inverse relationship to increased pelt prices during the same period. Estimated survivorship varied from 0.25 in 1973 to 0.15 in 1975. Most importantly, these estimates were well fitted to the recovery data (Pils and Martin 1978:27). Storm et al. (1976:56) used the Chapman and Robson (1960) equation to determine survival rates of 0.17 for males and 0.19 for

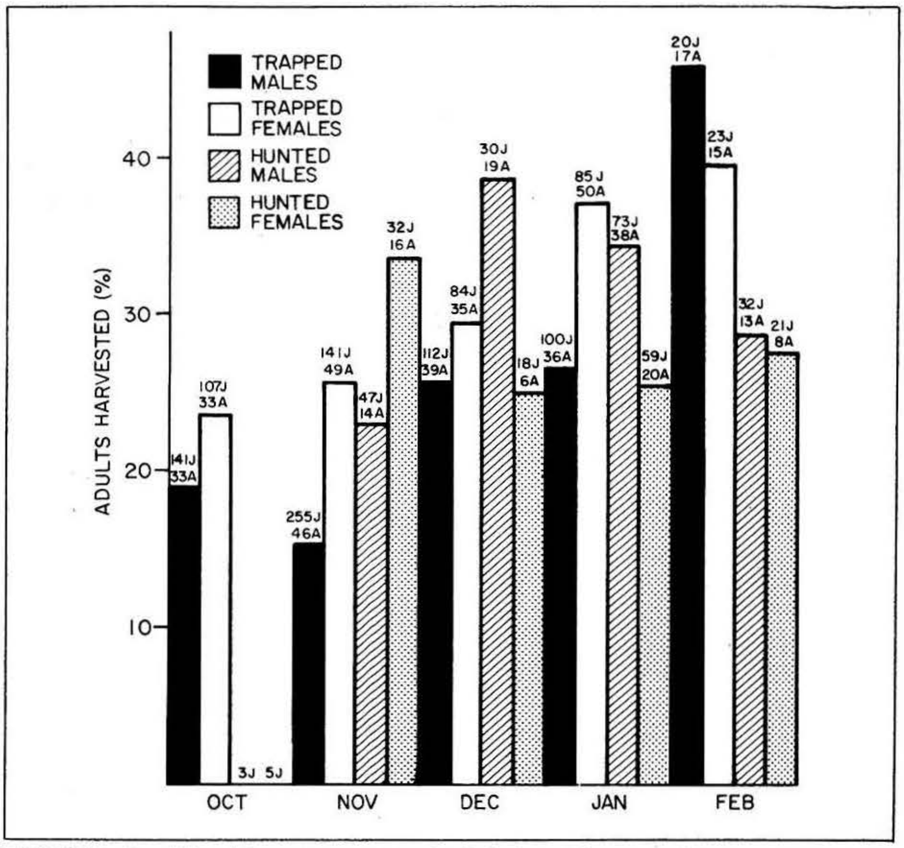

FIGURE 10. *Monthly percentages of adult foxes harvested in Wisconsin from 1975-78. The numbers above each bar represent the total harvest of juveniles (J) and adults (A) each month.*

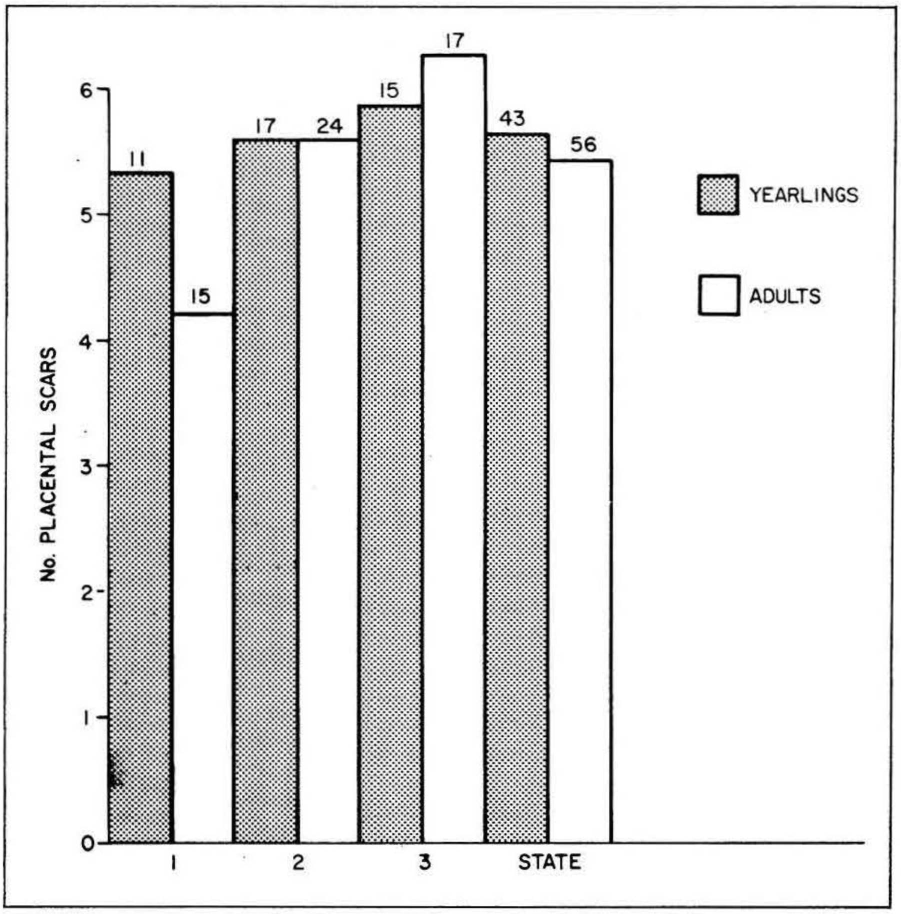

FIGURE 11. *Average number of placental scars found in yearling and adult red foxes collected in Wisconsin during 1976-78. The number above each bar indicates sample size.*

TABLE 6. *Binomial confidence limits on sex ratios of trapped and hunted foxes collected in each of the 3 study areas and Chi square tests of differences in sex ratios between trapped and hunted foxes.*

Area	Number Harvested			Percent	95%	Chi
	Males	Females	Total	Males	C.I.	Square
1						
Trapped	201	170	371	54.1	49.1-59.1	
Hunted	44	18	62	71.0	58.0-82.0	
Total	245	188	433	56.6	52.6-62.6	5.43*
2						
Trapped	348	279	627	55.5	51.5-59.5	
Hunted	144	107	251	57.4	51.0-64.2	
Total	492	386	878	56.0	52.7-59.3	0.18
3						
Trapped	280	200	480	58.3	53.8-62.7	
Hunted	106	80	186	57.0	49.8-64.1	
Total	386	280	666	58.0	54.2-61.7	0.05
Statewide						
Trapped	829	649	1478	56.1	53.5-58.6	
Hunted	294	205	499	58.9	54.4-63.2	
Total	1123	854	1977	56.8	54.6-59.0	1.10

*Significantly different, $P < 0.05$

TABLE 7. *A Chi square test of differences in sex ratios between juveniles and adult foxes hunted and trapped statewide.*

Age	Trapped Males			Hunted Males		
	Percent	No.	Chi Square	Percent	No.	Chi Square
Juveniles	58.4	1,105	8.89*	57.4	352	0.95
Adults	49.3	373		62.6	147	

*Significantly different, $P < 0.05$

TABLE 8. *Standard values for a simulated red fox population.*

Age	Number		Morality Rates: Females			Morality Rates: Males			Pregnancy	Proportion	Migrating
	Females	Males	Hunt	Trap	Other	Hunt	Trap	Other	Rate	Females	Males
1	267	365	0.35	0.35	0.20	0.30	0.35	0.25	0.86	1.0	0.769
2	47	60	0.12	0.62	0.06	0.22	0.46	0.12	0.92	0.3	0.21
3	27	30	0.18	0.46	0.06	0.23	0.36	0.11	0.92	0.3	0.21
4	17	15	0.16	0.49	0.05	0.16	0.44	0.10	0.92	0.3	0.21
5	8	8	0.27	0.38	0.05	0.09	0.50	0.11	0.92	0.3	0.21
6	3	3	0.24	0.40	0.06	0.17	0.42	0.11	0.92	0.3	0.21
7	1	1	0.0	0.64	0.06	0.45	0.15	0.10	0.92	0.3	0.21
8	1	2	0.0	0.64	0.06	0.24	0.36	0.10	0.92	0.3	0.21
9	1	1	0.21	0.43	0.36	0.3	0.3	0.4	0.00	0.3	0.21

Litter Size	Proportion	Distance	Proportion Females	Going Males	Direction	Proportion Migrating
1	0.0	1	0.23	0.01	NW	0.20
2	0.068	2	0.10	0.13	NE	0.45
3	0.102	3	0.08	0.01	SE	0.28
4	0.203	4	0.01	0.01	SW	0.07
5	0.237	5	0.13	0.03		
6	0.237	6	0.01	0.07		
7	0.085	7	0.08	0.03		
8	0.051	8	0.03	0.03		
9	0.017	9	0.03	0.07		
10	0.0	10	0.01	0.03		
11	0.0	11	0.29	0.58		
12	0.0					

TABLE 9. *Number of females in spring in typical simulations. The hunting and trapping mortality was changed between simulations from 100 to 55% of the standard rate.*

	Hunting and Trapping Mortality					
Generation	100%	90%	80%	75%	60%	55%
1	372	372	372	372	372	372
2	303	355	409	398	411	433
3	211	260	392	362	411	391
4	104	156	343	357	426	384
5	27	87	264	294	408	379
6	11	49	237	278	404	397
7	6	20	190	230	376	411
8	4	10	142	182	386	392
9	1	3	99	153	386	374
10	0	2	67	130	361	389

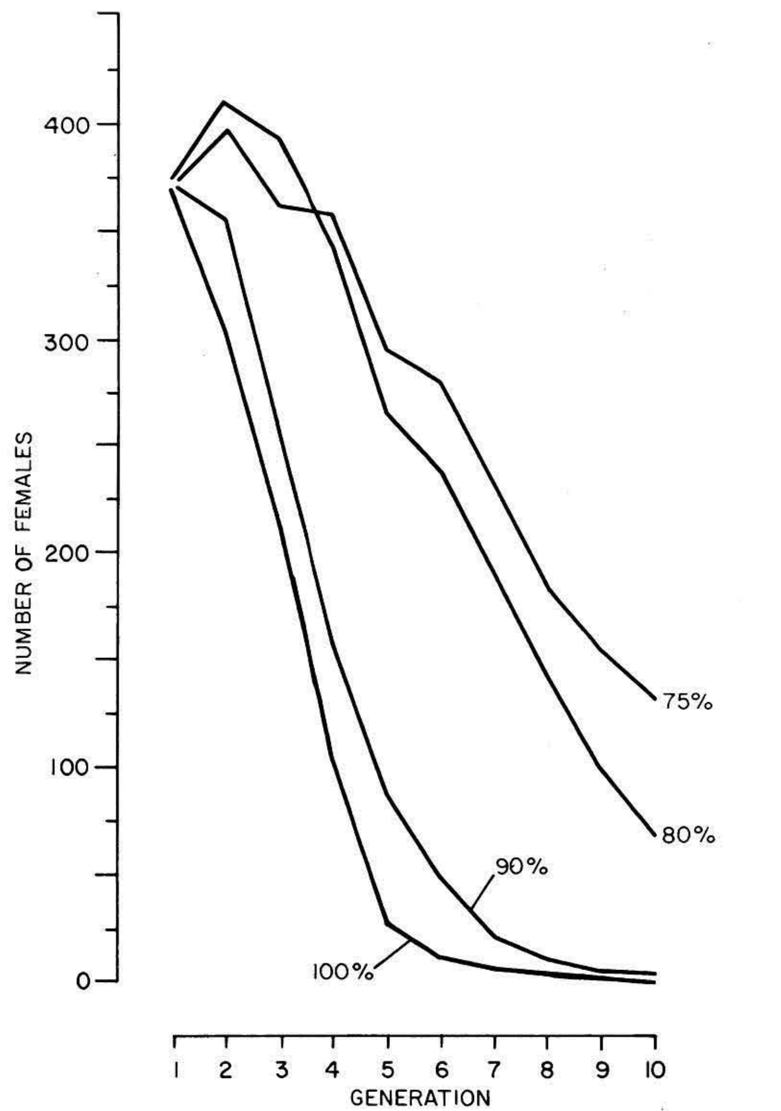

FIGURE 12. *Simulated red fox population on the wildlife area after 10 generations assuming hunting and trapping mortality ranging from 100 to 75%.*

females tagged in Illinois and Iowa from 1965-70, which would result in a declining population.

Red Fox Model

A simulation model can be used in a variety of ways to study characteristics of the population or parameters of the system being modeled. For instance, one can apply a single set of parameter values to the model and see what the result is. This set can then be modified until the output of the model stabilizes and/or reaches a specific value. The modeler could also vary the values of the parameters one at a time to find out which one (or set) produces the maximum variation in the model's output.

We were interested in looking at only one parameter, the hunting and trapping mortality throughout Wisconsin. This is a parameter which we can manipulate by regulating the lengths of the seasons, the time of the year in which the seasons are set, the methods permitted for hunting and trapping, and the bag limits. We are not certain of the specific factors affecting reproductive rates, so these would be much more difficult for us to actually manipulate but easy to vary in the model.

To use the model, we had to have estimates of the population parameters described in the previous section. The standard values used are listed in Table 8 and are derived from Pils and Martin (1978). There are two problems with applying the values directly to the model.

The first concerns the density (number) of individuals at the start of the simulation. Using our estimate of 10.73 km^2 for the size of a red fox territory, we could say that the model covers an area of 10,312 km^2 (961 x 10.73). Using the estimate of fox density from Pils and Martin (1978) we could then arrive at the number of foxes for the first generation. The problem here is that our model simulates an area with 961 identical territories, while the fox density value is from a diverse region which includes areas that are not fox habitat; therefore, this density, from the model's standpoint, is an underestimate.

Thus, we decided to fill the entire model area with adults and juveniles. We used the sex ratio and age structure data to calculate the values given in Table 8. These numbers correspond only to the Wildlife Area in the model. The program puts an equivalent number of individuals in the border area. This is not the maximum possible density which the model could generate, which is 121 adult males, 121

TABLE 10. *Red fox hunting and trapping harvest represented as a monthly percentage of total harvest in Wisconsin, 1976-78.*

Type of Harvest	Month of Harvest October	November	December	January	February	Total
Percent trapped monthly	25.6	37.1	14.8	18.3	4.2	100
Percent hunted monthly	1.4	26.9	17.3	40.4	13.9	100
Percent harvested monthly	22.1	35.6	15.2	21.5	5.6	100

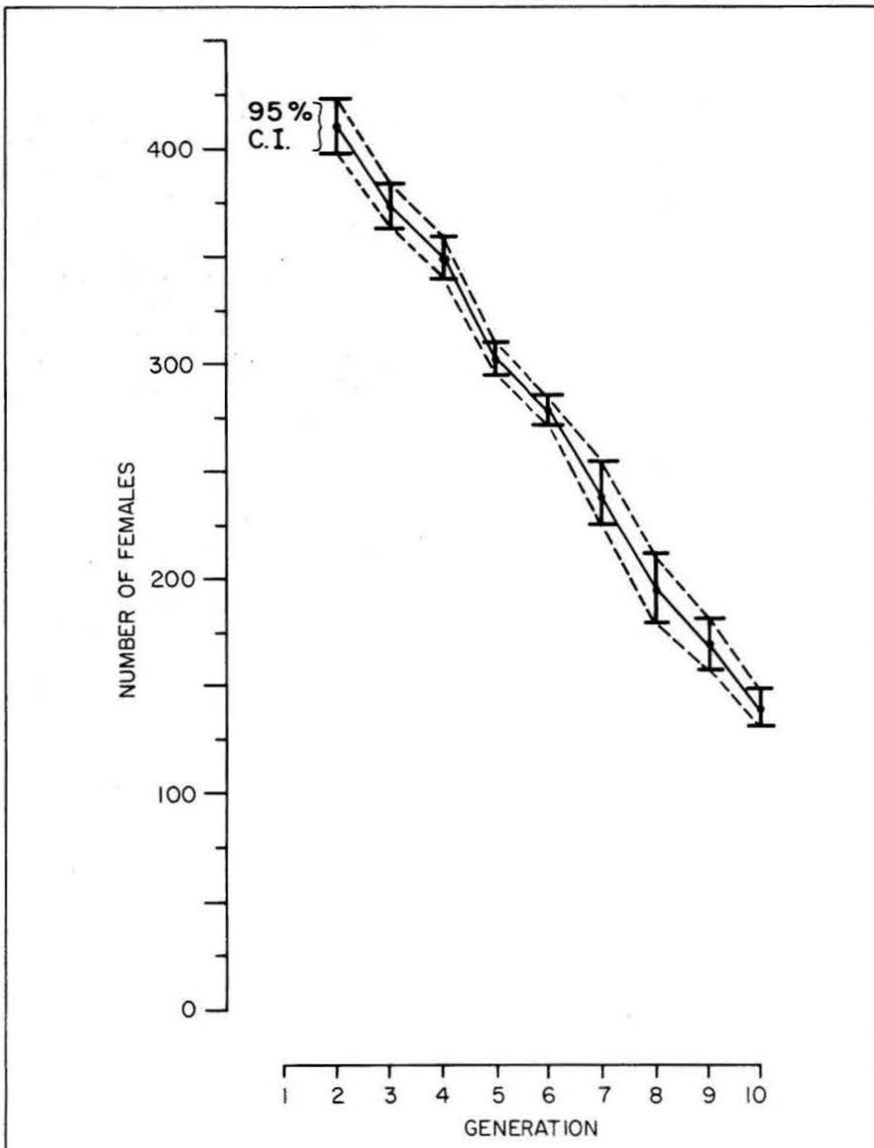

FIGURE 13. *Mean of 10 runs at 75% of the standard hunting and trapping mortality. The dotted lines represent 95% confidence intervals.*

adult females, and 1089 juveniles. Using this high density gives a better discrimination between simulations if the differences are small and, as in our case, the population is decreasing.

The other problem is the migration distances. These were translated from the distances in Pils and Martin (1978) to a number of territories using the size of a territory given above, with the assumption that they are square. The same problem of a uniform area being assumed for the model and a nonuniform one for parameter estimation exists. A further question of the distance function exists. We made no attempt to smooth this function. Consequently it is quite rough, as can be seen from Table 8. Further, an arbitrarily small probability of 0.01 was used in place of zero for some distances to facilitate programming.

We first performed the simulation using the standard parameter values and ran it for 20 simulated generations (Fig. 12 and Table 9). The population soon crashed and became extinct after 9 generations. This is similar to the results of the analysis in Pils and Martin (1978). Thus, the additional effect of migration on the population is not enough by itself to keep it extant.

Since we wanted to see what would happen when we decreased mortality (as represented by harvests), we then modified it to 90%, and finally 75% of the standard values for the hunting and trapping harvest. These simulations were only for 10 generations to maintain some conformity with the 100% results. According to Table 9 and Figure 12, the decrease in the harvest changes the rate of decline in the population.

For the 75% of the standard hunting and trapping mortality case, we made a total of 10 runs. The mean number per generation and its 95% confidence intervals are graphed in Figure 13 to illustrate the variation in the results for one set of parameter values.

We did experiment at values ranging from 100% to 25% of the standard hunting and trapping mortality rate. At 25% of the standard rate, the population became so large and the computer had so many individuals to handle, that the run could not be completed in a reasonable time and at a reasonable cost.

Eventually, we determined that 55% of the standard mortality (hunting and trapping) was the rate that produces a "stable" population. Just how realistic this rate is is unknown, because of the previously described limitations of the model. The parameter values are only estimates of the real values and may not be correct although they must necessarily be close.

Thus, we have demonstrated that, if the assumptions of the model are valid, the statewide fox population is declining. We could modify this decrease by cutting the rate of hunting and trapping mortality to 75% of the 1977 level. Many of the parameters used in the model are density dependent.

Consequently, we need to re-estimate them to obtain a better feeling of what happens to these parameters as the population density decreases. According to the model, we have time to accomplish this assessment by using a mortality rate of 75% of the 1977 hunting and trapping rate. Therefore, this decrease in the rate of harvest may not be so extreme that it would influence the rate of reproductive success.

MANAGEMENT CONSIDERATIONS

Pils and Martin (1978:47) listed the major management considerations for Wisconsin red foxes including a shortened, staggered season, mandatory pelt registration, and special trapping licenses. The 1977-78 red fox hunting and trapping season was shortened to the suggested 1 November to 31 January period. At the same time mean pelt prices jumped from $23.61 during 1974-75 to $52.70 in 1977-78 (Table 3). We feel that our earlier premise (Pils and Martin 1978:27) which suggested that survivorship was inversely related to rising pelt prices remains valid for the 1975-78 period. As prices increased during that time, numbers of estimated purchases remained relatively constant (Table 3). This sequence of events suggested that available foxes are being exploited to their limit. Our attempt to model Wisconsin fox populations during 1975-78 based on Zarnoch et al. (1977) verified this assertion by indicating that fox numbers are declining. When all the sources of harvest data from the present study were compared on a monthly basis (Fig. 10), November, December and January were the most important exploitation periods.

Although fox hunting and trapping seasons have been reduced by 43 days, staggering the seasons may offer further relief to the highly exploited Wisconsin fox populations. Iowa used split seasons during 1975-77, but returned to concurrent seasons due to law enforcement problems (Andrews 1977:15). The biggest problem concerned trappers taking foxes in traps (during the closed trapping season) that were supposedly set for other species, such as raccoons. The importance of curtailing the fox harvest by staggering hunting and trapping dates was clarified by determining the percentage of foxes killed per month. The relative importance of monthly fox harvest could then be determined. The 2 years of complete carcass collection (1976-78) were used to determine the monthly percentage of foxes trapped, hunted and harvested by both techniques (Table 10). Approximately 78% of the trapping mortality occurred during October, November and December. Since weather conditions are optimal for trapping in October (26% harvest) before severe weather conditions occur, a 1 November to 31 December trapping season could possibly benefit statewide fox populations. Similarly, 58% of the Wisconsin foxes collected were shot during December and January. Our past research has indicated that most fox hunting activities take place during these 2 months, regardless of the length of the season. However, Pils and Martin (1978:47) stated that foxes shot in November by pheasant and deer hunters accounted for 11% of the annual fox kill in southeastern Wisconsin. Therefore, the shift to a 1 December to 31 January hunting season may decrease the hunting pressure on red foxes. We recognize that survivorship of red foxes may be compensatory, that is foxes saved by the closed October season may be harvested later.

A longer term DNR survey has also indicated that populations are declining. The DNR Technical Services Section sent out 44,525 summer wildlife inquiries to rural Wisconsin residents during 1962-78 (Thompson and Moulton 1981). The inquiries consisted of observations of "foxes" and litters on farms and served as an independent index of statewide red fox abundance. We assumed that a large number of the observations were of red foxes, since these canids are much more common in Wisconsin than gray

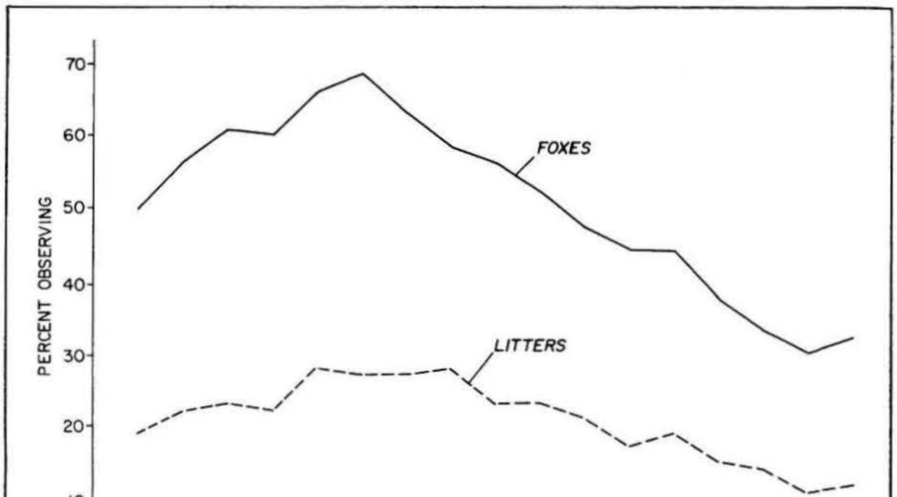

FIGURE 14. *Results of statewide summer fox inquiries for Wisconsin, 1962-78.*

Consequently, we need to re-estimate them to obtain a better feeling of what happens to these parameters as the population density decreases. According to the model, we have time to accomplish this assessment by using a mortality rate of 75% of the 1977 hunting and trapping rate. Therefore, this decrease in the rate of harvest may not be so extreme that it would influence the rate of reproductive success.

MANAGEMENT CONSIDERATIONS

Pils and Martin (1978:47) listed the major management considerations for Wisconsin red foxes including a shortened, staggered season, mandatory pelt registration, and special trapping licenses. The 1977-78 red fox hunting and trapping season was shortened to the suggested 1 November to 31 January period. At the same time mean pelt prices jumped from $23.61 during 1974-75 to $52.70 in 1977-78 (Table 3). We feel that our earlier premise (Pils and Martin 1978:27) which suggested that survivorship was inversely related to rising pelt prices remains valid for the 1975-78 period. As prices increased during that time, numbers of estimated purchases remained relatively constant (Table 3). This sequence of events suggested that available foxes are being exploited to their limit. Our attempt to model Wisconsin fox populations during 1975-78 based on Zarnoch et al. (1977) verified this assertion by indicating that fox numbers are declining. When all the sources of harvest data from the present study were compared on a monthly basis (Fig. 10), November, December and January were the most important exploitation periods.

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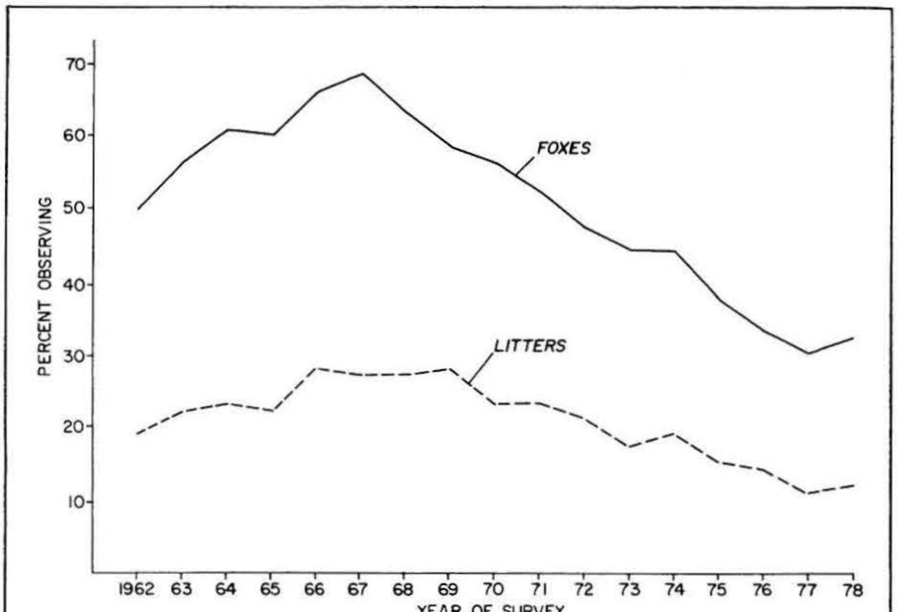

FIGURE 14. *Results of statewide summer fox inquiries for Wisconsin, 1962-78.*

foxes *(Urocyon cinereoargenteus)* (Petersen et al. 1977). Seventy-nine percent of all the inquiries were returned by rural residents, who observed the highest percentage (68) of foxes during 1967 (Fig. 14). Similar fox litter observation peaks occurred in 1966 and 1969, with litter observations declining thereafter (Fig. 14).

When red fox pelt prices were compared with percent yearly fox observations during 1962-78 (i.e., 1977-78 *pelt purchases* were compared to the 1978 observation year), no significant correlation was noted (r=0.12). However, a strong inverse correlation was noted between the percentage of foxes observed and average pelt prices (r = -0.92). This latter test agrees with our earlier conclusion that red fox survivorship in southern Wisconsin has decreased in an inverse relationship to *pelt prices* during the same period (Pils and Martin 1978:27). Therefore, our suggested seasonal changes represent a small step toward protecting a valuable furbearer and recreational resource. However, if red fox pelt prices decrease in the future, the split season may not be needed.

Our final management consideration concerns the questionnaires used to gather information from fur buyers (Append. B), fox hunters, and trappers (Append. A). Names and addresses of fur buyers, hunters, Wisconsin Trapping Association members, and various fox hunting club members could be obtained from current DNR records. Specific trapping information could be retrieved from trappers by survey, especially if a separate trapping license were created.* Questionnaires could then be sent to these fur buyers and sportsmen throughout the state annually in order to obtain information similar to the data recorded in this study. Results from these surveys could used to assess hunting and trapping pressure, harvest and population trends.

*This was initiated in Wisconsin in 1979.

SUMMARY

We investigated red fox harvest, age structure, survivorship (using a computer simulated population model) and productivity throughout most of Wisconsin during 1975-78.

A hunter-trapper questionnaire sent to 378 sportsmen was returned by 263 respondents. Trappers reported a higher average number of foxes taken per season (10.5) than did hunters (3.4). However, trappers spent an average of 35.9 days in the field per season as compared to 20.1 days for fox hunters. Trappers drove an average of 40.3 km per day during the season while hunters drove an average of 46.3 km per day. Both groups pursued their respective sports in order to "enjoy the challenge", "to get outdoors", and "to enjoy nature". However, more trappers went afield to make money than did hunters. January was the most heavily hunted month, when snowfall and spotting conditions were optimal, followed by December and February. Fox trappers were most successful during November, when more foxes were available.

Questionnaire replies from 366 licensed fur buyers indicated that 69% of the red foxes purchased were trapped. Mangy foxes comprised 4.4% of all foxes brought into fur dealers during our 3-year study period. Fur buyers also felt that fox populations had declined from 1974-75 to 1975-76.

Juveniles comprised 74% of the 2,153 red foxes collected in 62 of the 72 Wisconsin counties. More male juveniles were aged than were female juveniles. Significant differences in sex ratios were noted only in Area 1. Possible reasons for more males being collected were: (1) higher male mortality due to their longer movements, and (2) higher preseason vixen mortality resulting in higher numbers of males being available for the fall season.

Three hundred-twenty females were examined for embryo and placental scars from 1976-78. We found an average of 6.9 embryos/female for 12 vixens examined. Mean litter sizes based on placental scars, ranged from 5.3 in Area 1 to 5.9 in Area 3. Our highest litter counts were in Area 3, a region of heavy hunting and trapping pressure, high soil fertility, intensive land use and high prey base.

Our modeling efforts were centered on only one parameter, hunting and trapping mortality, and included data from the current study as well as supplementary information from previous southern Wisconsin red fox research. Initially red fox populations became extinct after 9 generations when exploited at a 90-100% hunting and trapping pressure. However, populations stabilized after 10 generations when hunting and trapping mortality was reduced by 45%.

Summer wildlife inquiries sent to rural Wisconsin residents from 1962-78 corroborate our questionnaire data by indicating a red fox population decline.

Suggested management considerations include creation of a 1 November to 31 December trapping season coupled with a 1 December to 31 January hunting season, which should reduce some fox mortality. However, if fox pelt prices decline in the future, these changes probably would not be needed. A final consideration would be the annual use of questionnaires similar to those used in this study, to obtain harvest and population trends and to assess hunting and trapping pressure. Creation of a separate trapping license would create an excellent source of potential trapper information.

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Our modeling efforts were centered on only one parameter, hunting and trapping mortality, and included data from the current study as well as supplementary information from previous southern Wisconsin red fox research. Initially red fox populations became extinct after 9 generations when exploited at a 90-100% hunting and trapping pressure. However, populations stabilized after 10 generations when hunting and trapping mortality was reduced by 45%.

Summer wildlife inquiries sent to rural Wisconsin residents from 1962-78 corroborate our questionnaire data by indicating a red fox population decline.

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APPENDIX A
Wisconsin Fox Hunter and Trapper Questionnaire

1976-77 FOX HUNTER AND TRAPPER QUESTIONNAIRE

Dear Fox Hunter and Trapper:

Enclosed is a questionnaire designed to summarize your 1976-77 fox hunting and trapping activities.

Please fill out this questionnaire to the best of your knowledge and mail it back as soon as possible. You are the only source we have for this information. The information is extremely important to us in properly managing red and gray foxes in Wisconsin for better hunting and trapping.

Thank you.

Charles M. Pils
Research Biologist

CMP:jh

Name of Hunter or Trapper ______________________

There are 3 sections to this questionnaire to be completed by: (1) fox hunters and trappers; (2) those hunting for fox and (3) fox trappers. Please go through the entire questionnaire and answer all questions as completely as possible.

1. QUESTIONS FOR ALL FOX HUNTERS AND TRAPPERS

   a. What year did you start trapping? ________

   b. What year did you start hunting? ________

   c. Why do you hunt or trap fox? (CHECK ALL THAT APPLY)

      ____to make money ____to get outdoors ____find solitude

      ____enjoy the challenge ____to enjoy nature ____other

   d. How low would fur prices have to go before you would give up your fox hunting or trapping efforts?

      ____less than $2/pelt ____$5-$10/pelt ____$15-$20/pelt

      ____$2-$5/pelt ____$10-$15/pelt

      ____Would hunt or trap regardless of the level of pelt prices?

2. FOX HUNTERS

   a. How many different days did you hunt foxes during the 1976-77 season? ______________ (include part of a day as a full day).

   b. What was the average number of miles you drove in a single day of fox hunting? ______________

   c. How many mangy fox did you harvest during the 1976-77 fox season? ________

   RED FOXES

   a. What was your total red fox harvest during the 1975-76 season? ________

   b. What was your total red fox harvest during the 1976-77 season? ________

   c. How many red foxes did you harvest while fox hunting during each month of the 1976-77 season? Oct.____ Nov.____ Dec.____ Jan.____ Feb.____

   d. Please list your 1976-77 red fox harvest by county of kill:

      1. County________ - Kill____ 3. County________ - Kill____

      2. County________ - Kill____ 4. County________ - Kill____

3. FOX TRAPPERS

   a. How many different days did you trap foxes during the 1976-77 season? ______________ (include part of a day as a full day).

   b. What was the average number of miles you drove in a single day of fox trapping? ______________

   c. How many mangy fox did you harvest during the 1976-77 fox season? ________

   RED FOXES

   a. What was your total red fox harvest during the 1975-76 season? ________

   b. What was your total red fox harvest during the 1976-77 season? ________

   c. How many red foxes did you harvest while fox trapping during each month of the 1976-77 season? Oct.____ Nov.____ Dec.____ Jan.____ Feb.____

   d. Please list your 1976-77 red fox harvest by county of kill:

      1. County________ - Kill____ 3. County________ - Kill____

      2. County________ - Kill____ 4. County________ - Kill____

   GRAY FOXES

   a. List the number(s) of gray foxes: (1976-77)

Shot	County	Trapped	County
________	________	________	________
________	________	________	________
________	________	________	________

APPENDIX B
Wisconsin Fur Buyer Questionnaire

1977-78 FUR BUYER QUESTIONNAIRE

The Wisconsin Department of Natural Resources is concerned about the numbers of foxes harvested in Wisconsin. Current high pelt prices have placed a great deal of pressure upon this valuable game species. Results from last year's survey accompanies this form. Thank you.

Charles M. Pils
Research Biologist

1. Approximate number of red fox bought from the public from the fall of 1977 to the spring of 1978 ________.

2. Of the red fox that you bought, approximately what number were taken by:

   ________ fox

   ________ fox hunters

   ________ other (car kills, bird hunters, etc.)

3. Of the red fox that you bought, approximately how many were killed during:

   ________ October 1977 ________ January 1978

   ________ November 1977 ________ February 1978

   ________ December 1977

4. Approximately how many mangy fox were brought into you this year? _____

   How does this compare to last year?

   ________ more ________ less ________ same

5. Do you think the red fox population is:

   ________ up ________ down ________ same as last year

Name of Fur-Buyer ______________________________

Address ______________________ County________ Zip ______

TABLE 1. Results of the 1976-77 Wisconsin fur buyers red fox statewide questionnaires.

Pelt Data	Red Foxes Number	Percent
Type of Harvest		
Trap	15,113	75
Fox Hunters	4,318	22
Other*	582	3
Month of Harvest		
October	1,828	10
November	5,563	31
December	5,852	32
January	3,570	20
February	1,320	7
Total Replies	122	55

*Car kills, bird hunters and unknown causes.

TABLE 2. Fur buyers estimates of red fox population levels and incidence of mange.

Mange and Population Statistics	Buyers Reporting Number	Percent
Incidence of Mange		
More than Previous Year	5	6
Less	54	65
Same	24	29
Fox Population Trend		
More than Previous Year	9	10
Less	53	58
Same	30	32
Total Replies	122	55**

**Percent of total fur buyers reporting.

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METRIC CONVERSION TABLE

Kilometers (km) x 0.6 = miles
Square kilometers (km^2) x 0.4 = square miles ($miles^2$)

ACKNOWLEDGEMENTS

We would like to thank the Wisconsin Trappers' Association for their extensive assistance in providing names and addresses of members to whom we sent mail questionnaires. WTA members also donated many of the carcasses used during our investigation. Our appreciation is also extended to several of the Wisconsin fur buyers, trappers and hunters who carefully recorded kill information that was given to us with their fox carcasses. Wisconsin DNR wildlife managers, wildlife technicians and other DNR personnel who collected fox skulls and carcasses are also acknowledged for performing an unpleasant but important task. Norbert Damaske, former Chief, DNR Game Farm and Shooting Preserves, expedited the distribution of the fur buyer survey by including it in his mailings.

Special thanks are due to Donald R. Thompson, Chief of DNR's Technical Services Section, for guiding the tabulation of our data through the program CROSTAB 2 and for providing statistical advice. John Cary, Staff Specialist for the University of Wisconsin-Madison also extended his statistical expertise to our project.

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