

**The Status and Dynamics of the Bobcat Population in Virginia**

by

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(ABSTRACT)

Age and reproductive data from 67 bobcat carcasses and lower jaws were collected during the 1979-80 and 1980-81 trapping seasons. Sex and age data on 41 additional bobcats taken in the 1977-78 and 1978-79 trapping seasons were provided by the Virginia Commission of Game and Inland Fisheries.

The mean age from the 4-year pooled sample was  $2.83 \pm 0.24$  (S.E.) years, with 25% juveniles, maximum age 12 years, and sex ratio approximately 1:1.

Scent-station survey data did not parallel harvest records except in Region IV (Piedmont) where both were increasing. No correlation between bobcat pelt prices and harvest was established but bobcat harvest was correlated with prices of fox and raccoon pelts ( $r=0.87$  and  $0.81$  respectively,  $p \leq 0.10$ ). License sales were not correlated with bobcat harvests. Bobcat harvests were inversely related to precipitation in 3 regions and to snow and sleet in another region.

Mail survey responses indicated that most sportsmen (56%) believed bobcats to be increasing and 20% believed the population to be stable. The majority of Game Wardens (89.7%) reported that they thought the population to be stable or increasing. The survey indicated that 69.1% of the bobcats trapped are taken incidentally to trapping for other species. Taxidermists reported receiving 13-16% of the annual harvest. Survey responses from Game Wardens and tag records indicated that bobcats occur almost statewide. Northampton Counties and may be increasing their range.

Models based on population characteristics suggest that the population is at best stable and probably declining.

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## INTRODUCTION

The economic importance of the bobcat (Lynx rufus) has risen sharply over the last 3 decades. Progulske (1952) declared that the bobcat was considered to be of no importance as a fur or game species in Virginia in 1952 because it had little or no economic value. Many states offered bounties on bobcats which often was the only incentive to pursue them. Since the passage of the Endangered Species Act of 1973 and the Convention on International Trade in Endangered Species (CITES), international trade in pelts of spotted cats has focused on the lynx (Lynx canadensis) and the bobcat. This increased demand for pelts drove the price of bobcat pelts to a peak of \$400 in early 1980; concomitantly, there has been an increase in the number of pelts traded. The bobcat, as an economic species, has thus changed from a nuisance to a valuable resource.

Escalating exploitation of the bobcat has resulted in a widespread concern for its continued existence. Few, if any, states now view the bobcat as a nuisance species and most have given it the status of either a game animal or furbearer, thus offering some protection by limiting seasons, harvest, or both.

The pelts of most bobcats taken in the United States are exported to western Europe to be processed into garments. The U.S. Fish and Wildlife Service is empowered to control exports by issuance or denial of export permits for pelts. Decisions are made on a state-by-state basis from data supplied by state agencies and thus influence the U.S. market for bobcat pelts. Permits are denied when states fail to show that such export will not be detrimental to the population in the respective state. Recent litigation by Defenders of Wildlife has challenged the accuracy and validity of the information supplied by several states, underscoring the need for continued research upon which to base management decisions.

In view of the economic value of the bobcat, sound management programs are needed. The objectives of this investigation were: 1) To construct life tables for Virginia bobcats based on age and reproductive data gained in this study from trapper-supplied carcasses. 2) To determine the current status of Virginia's bobcat population by survey and analysis of harvest data. 3) To develop a model based on this information for Virginia's bobcat population.

## LITERATURE REVIEW

There have been few (6) studies of the bobcat in the mid-Atlantic states, and fewer still (2) in Virginia. The bobcat seems to have attracted more attention in New England and the western United States. This somewhat regional interest may be attributed to its reputation as a predator of deer in the northeast (Hamilton and Hunter, 1939) and a general antipathy toward wild carnivores in the west, where they are viewed as livestock predators (Young, 1958: 65; Evans and Pearson, 1980).

### Population Status

Bobcat population trends have been investigated principally in the western states where predator control activities have been underway for many years and harvest records have been maintained. Indices of population trends have been generated by a number of techniques which are applicable to or used for other species. The most common methods used in estimating coyote (Canis latrans) populations were discussed by Linhart and Knowlton (1975), who stated that scent-stations surveys were most likely to produce reliable and easily counted responses. Scent-

station surveys have been used in the western states (Knowlton and Tzilkowski, 1979) and in Georgia (Hon, 1979). Nunley (1978) and Crowe (1975b) used harvest data from federal animal damage control programs to assess population trends, since extensive records were kept and the effort was not subject to fluctuation under the influence of fur prices. Harvest variations were therefore considered to reflect changes in abundance. Knowlton and Tzilkowski (1979) did not consider recent indications of a decline of population levels to be cause for alarm but rather a decline from an unusually high population level, which Nunley (1978) noted and attributed to the indirect effect of intensive coyote control efforts during the 1950's and 1960's. Hensley and Fisher (1976) suggested that a sympatric predator could assume the role of a removed species, which is consistent with Nunley's (1978) proposal that bobcats may have increased when a principal competitor, the coyote, was reduced by control programs and bobcats have subsequently declined because of increased competition resulting from the cessation of the widespread coyote control activities.

### Reproduction

Various aspects of the reproductive biology of bobcats

have been investigated but some questions still remain unanswered. Males are generally considered to be fertile throughout the year (Duke, 19544; Asdell, 1964:488; Fritts and Sealander, 1978a), however Crowe (1974, 1975a) presented evidence which indicated that male bobcats may undergo testicular regression and reduction or cessation of spermatogenesis during the summer, and he postulated that climatic or geographic differences in reproductive phenomena may occur. Females have been found to be in breeding condition as early as November (Blankenship and Swank, 1979) and as late as August (Mehrer, 1975). Fritts and Sealander (1978a) implied that breeding may be possible throughout the year in Arkansas, with most bobcats breeding from December to March.

Female bobcats were reported to reach puberty by their first winter (at about 6 months of age) but some may not become pregnant (Fritts and Sealander, 1978a) although no reasons for this failure to become pregnant were offered by the authors. Males evidently are not capable of breeding as less than 1 year of age (Crowe, 1974, 1975a; Fritts and Sealander, 1978a). Both sexes may remain sexually active until death (Crowe, 1974). Pollack (1950) suggested that

bobcats are not polyestrous, but Crowe (1974, 1975a) and Duke (1949, 1954) reported evidence that they ovulate more than once per breeding season if not impregnated during their first estrus. Duke (1949) stated that no positive evidence existed as to whether ovulation in bobcats is spontaneous or induced. Perry (1971) argued that ovulation is induced but Progulske (1952) and Fritts and Sealander (1978a) agreed that it is likely to be spontaneous. Gestation periods of 50 days (Gashwiler, et al., 1961) to 70 days (Crowe, 1975a) have been reported. These differences may be related to the difficulty of establishing the exact dates of conception and parturition. The duration of estrus and the length of the estrus cycle are reportedly about 8 and 45 days respectively, (Mehrer, 1975). Reported litter sizes range from 1 to 8 kittens. Mean litter sizes of 2 (Pollack, 1950) to 3.5 (Gashwiler, et al., 1961) have been noted, determined from counts of embryos and/or placental scars, and observations of kittens.

### Mortality

Harvest aside, the causes and rates of bobcat mortality are not well understood. The usual life span of bobcats has been estimated to range from 7 years (Progulske, 1952) to 12

years (Crowe, 1974) in the wild. Natural mortality is thought to be relatively low (Bailey, 1974; Crowe, 1975b) and higher in juveniles than in adults; this difference may be related to disease or parasitism (Pollack, 1951b; Progulske, 1952), difficulty in capturing prey (Crowe, 1975b; Wassmer, D. 1981, pers. comm.) or poor population survey data. Trapping and hunting were thought by Crowe (1975b) to be the principal sources of bobcat mortality and that rising interest in such activities as hound hunting and predator calling could result in an increased annual kill. Weinstein (1977), discussing lynx cycles, theorized that apparent fluctuations in lynx populations derived from harvest records might be caused by changes in trapping intensity when trappers had more time to trap for lynx. Similar changes in trapping intensity could play a role in fluctuations of bobcat harvests.

#### Disease and Parasitism

Progulske (1952) reported finding no evidence of disease in any of the bobcats which he examined, but noted a single report of a rabid bobcat. Several others reported rabies in bobcats (Marx and Swink, 1963; Sikes, 1970; Carey and McLean, 1978). Pollack (1951b) said that it may occur, but that epizootics were unlikely.

Endoparasites appear to be common in bobcats. Progulske (1952) found 87% of specimens examined infested with 1 or more helminth species, and noted that 2 captive kittens which died were heavily parasitized. Lungworms (Troglostrongylus wilsoni) were found by Sarmiento and Stough (1956) in 16 of 64 bobcats from Virginia and North Carolina. Others have demonstrated that most bobcats had parasites in the digestive tract, some of which could cause serious debility from loss of blood or damage to the mucosa (Mitchell and Beason, 1974; Pence, et al., 1978), or possibly by tract obstruction (Manville, 1958). The effects of heavy parasite infestation are likely to be more severe in young animals since blood loss to hookworms (Ancylostoma spp.) has been reported to be as much as 0.12 ml./worm/day (Mitchell and Beason, 1974); this may represent an important factor in juvenile mortality (Progulske, 1952). Geographic differences in endoparasite species found in bobcats (Little, et al., 1971) may stem from differences in the distribution of intermediate hosts preyed on by bobcats.

### Age

Determination of age presents some problems in wild carnivores as little work has been done on known-age

animals. A variety of methods have been proposed, but most require some degree of injury to the animal. Conley and Jenkins (1969) reviewed several commonly used techniques, and reported that analysis of tooth cementum annuli was the most accurate. Epiphysial closure in the long bones was investigated in raccoons (Procyon lotor) (Petrides, 1959) and in foxes (Vulpes fulva) (Reilly and Curran, 1961), and found to be useful for identifying juveniles, but exact age could not be established without knowledge of the age at which ossification of the epiphysis occurred (Conley and Jenkins, 1969). Skull measurements and skull characteristics of bobcats have been found to be effective in separating kittens, young adults, and adults (those over 2 years old) (Conley and Jenkins, 1969). Tooth wear has been considered to reflect relative age, but may be complicated by differential rates of wear or growth in animals whose teeth continue to erupt as has been claimed to occur in coyotes (Nellis, et al., 1978). Eye lens weight has also been suggested for aging bobcats, but the requirement for immediate removal and preservation and the adverse effect of freezing make this technique unsuitable in most circumstances (Conley and Jenkins, 1969). The presence of permanent canine teeth may indicate a certain minimum age

but is of little value unless the time of eruption of these teeth is known and has little variance.

Analysis of the cementum annuli in tooth root sections is the most widely accepted method of aging carnivores, but difficulties may arise from close or uneven deposition of annuli (Mahan, 1979). Crowe (1975a) found that annuli appear to be deposited in late winter or early spring, starting with the second winter, and suggested that a possible relationship existed between reproductive activity, with its attendant endocrine activity, and cementum deposition. Bobcats in or entering their first winter are identifiable by the absence of annuli and an open apical root foramen in the canine teeth (Crowe, 1975a; Matson, 1980, pers. comm.). Mahan (1979) offered a simple means of assigning bobcats to age classes of 0-1 year, 1-2 years, and over 2 years, by measurement of the canine pulp cavity and comparing the ratio of pulp cavity diameter to tooth diameter which she used to standardize the measurement.

### Habitat

Habitat preferences seem to be somewhat varied, consistent only in an apparent preference for undisturbed or inaccessible areas. Progulské (1952: 24-27) found that in

Virginia the bobcat occurred mostly in the mountainous counties with an isolated group in the Dismal Swamp. Thick understory growth seems to be preferred for cover as well as dense swamy terrain (Pollack, 1951b). McCord (1974) found definite use of roads and trails, which he attributed to energy conservation in deep snow. Hall and Newson (1976) in Louisiana, and Marshall and Jenkins (1966) in South Carolina reported that bobcats displayed a tendency to hunt along the edges of roads, railroads, and other cleared areas.

#### Range and Movement

The home range and movement of bobcats has been studied by radiotelemetry (Marshall and Jenkins, 1966; Bailey, 1974; Hall and Newson, 1976), snow tracking (Pollack, 1951b; McCord, 1974), and by tag/recapture (Robinson and Grand, 1958). Pollack (1951b) reported travels of 2 to 5 miles per night. Daily movements of 2 miles (Bailey, 1974) to 3.5 miles (Marshall and Jenkins, 1966) have been recorded. Robinson and Grand (1958) found the mean recovery distance of ear-tagged bobcats to be 4.1 miles with a maximum of 23 miles. Harestad and Bunnell (1979) constructed a mathematical model for home ranges of carnivores as a function of body weight. They reported that their results in

modeling bobcat home range was consistent with the results of a radio-telemetry study by Hall and Newsom (1976) in which the average summer home range was 494.1 ha for males and 97.1 for females. The dimensions of home ranges have been found to change, particularly in the case of females, whose movements tend to be reduced during breeding season (Korschgen, 1957; Crowe, 1974). Home ranges of males may overlap, while those of females do not (Marshall and Jenkins, 1966), the opposite of the pattern in the lynx (Mech, 1980).

### Food Habits

Bobcats appear to feed principally on lagomorphs and small mammals. Ellis and Schennitz (1958) found that rabbits occurred in 60% of the stomachs that they examined in Oklahoma. Kitchings and Story (1979) reported that cottontail rabbits (Sylvilagus floridanus) and pine voles (Microtus pinetorum) occurred in 70% and 40% respectively of their Tennessee scat samples in fall and winter, while in spring and summer rabbits occurred in 67% of the samples and pine voles occurred in 28%. Buttrey (1979) found that in Tennessee, rodents and small game mammals made up 57% of the contents of digestive tracts and scats in fall and winter and 61% in spring and summer. They noted that voles occurred in 22.4% of their samples, most often the pine vole.

Westfall (1956) found rodents in 70% of the digestive tracts of bobcats in Maine. Progulske found gray squirrels (Sciurus carolinensis) in 31.6% of the digestive tracts of Virginia bobcats and in 28.9% of the scats examined while cottontail rabbits were found in 31.6% of the tracts and 54.6% of the scats. Berg (1979) reported that the snowshoe hare (Lepus americanus) as the major food item of bobcats in Minnesota (40% occurrence) and that porcupines (Erithizon dorsatum) occurred in 12% of the stomachs examined.

Deer have often been mentioned in the literature of bobcat food habits. Landry (1979) stated that while deer seemed to be an important food resource, there remains a question of whether deer are obtained as prey or carrion. Some authors have expressed the opinion that deer eaten by bobcats may represent mostly carrion or hunter-wounded deer (Pollack, 1951a; Petraborg and Gunvalson, 1962; Fritts and Sealander, 1978b). Other researchers have suggested that predation on deer (if it occurs) may be seasonal, i.e., during fawning time (Beason and Moore, 1977) or harsh winter weather with deep snow (Petraborg and Gunvalson, 1961; McCord, 1974). Progulske (1952) found deer in 3 of 53 scats collected in spring and summer, and in 10 of 71 scats collected during the fall and winter in Virginia. In fall and winter, stomach and intestine contents were examined and

deer remains were present in 42% of the intestines and 25% of the stomachs examined from cats taken in Virginia. Latham (1950) noted deer in the stomach contents of bobcats taken in winter in the northeastern U.S., and Davis and Haugen (1957) reported finding deer in bobcats killed between May and August.

The ability of bobcats to kill prey as large as deer may be questioned. Ewer (1973) suggested that it may not normally be possible, but Hamilton and Hunter (1939) stated that a large bobcat may be able to do so, particularly in deep snow. These authors pointed out that some of the bobcats they examined weighed over 30 pounds. Young (1928: 77-91) reported the killing of deer by bobcats and attempts on bedded deer were reported by McCord (1974).

The presence of plant material in bobcat food habit studies has been reported by Landry (1979), Marshall and Jenkins (1966), McCord (1974), and Ellis and Schemnitz (1958). The latter work suggested that plant material may come from the stomach contents of prey species. Landry (1979) stated that grass was found often enough to be considered a food item. However, Miller and Speake (1978) found no vegetation in bobcats that had been shot and suggested that the plant materials found in the digestive

tracts of their trapped specimens was ingested while the animal was held by a trap.

## SECTION I. STATE POPULATION CHARACTERISTICS

### Materials and Methods

The age distribution, sex ratio, and reproductive capacity (Appendix 1) of Virginia's bobcat population were investigated as a basis for their use in models. These data were taken principally from carcass examination.

Bobcat carcasses were solicited from sportsmen, fur buyers, and taxidermists during the 1979-80 and 1980-81 hunting and trapping seasons. A \$2 reward for each bobcat carcass was offered by the Virginia Commission of Game and Inland Fisheries (VCGIF) in the 1979-80 season and raised to \$3 in the 1980-81 season. The collection of carcasses was announced in the National Trappers Association paper, "Virginia Wildlife", the "Federation Record" of the Virginia Wildlife Federation, outdoor columns in the Roanoke, Richmond, and Norfolk area press, and by notices sent to fur buyers by the VCGIF. These announcements included (1) instructions for preservation of the carcasses, (2) names and telephone numbers of personnel to call to arrange pickup, (3) requests for data on date and county of capture, and (4) the name and address of the donor. The Virginia Trappers Association was informed of the program and this author and a colleague made personal contact with

taxidermists and fur buyers across the state and in adjacent counties of North Carolina and West Virginia.

Carcasses received during the 1979-80 and 1980-81 trapping seasons were stored in a freezer pending post-mortem examination. Each carcass was tagged with an identifying number and all information provided by the donor was entered on a data sheet bearing a matching identifying number. Sex was recorded as reported by the donor and confirmed at post-mortem examination. Age data, from the 1977-78 and 1978-79 trapping seasons, was determined using teeth from the lower jaws and sex from donors' reports of sex, which were supplied by the VCGIF (VCGIF, 1979b; J.V. Gwynn, VCGIF. 1980. Pers comm.).

The ages of the bobcats collected were determined by analysis of cementum annuli in the lower canine teeth. The heads or lower jaws were boiled for 20 to 30 minutes to loosen the teeth and the lower canine teeth were extracted with pliers. The teeth were preserved in 10% formalin in individual vials with appropriate labels pending further processing. When a sufficient number of teeth (10-15) had been accumulated, the root portion was removed at approximately the gum line. Tooth roots were decalcified in 5% nitric acid for 5 days, and neutralized by flushing under running water for 2 hours, then dehydrated with ethanol,

cleared with methyl salicylate, and infiltrated with "Paraplast" according to the procedure in Table 1, following methods of Brain (1966: 85-112, 171-172). The infiltrated tooth roots were then embedded in "Paraplast" for sectioning.

Table 1. Schedule for clearing and wax infiltration of tooth roots from bobcats collected in Virginia during the 1979-80 and 1980-81 trapping seasons.

TIME	MEDIUM
1 hour	90% Ethanol
1 hour	Absolute Ethanol
1 hour	" "
1 hour	" "
.5 hour	Absolute Ethanol and pure Methyl salicylate, equal volumes
1 hour	Methyl salicylate
1 hour	Methyl salicylate
3 hours	Methyl salicylate and Paraplast, equal volumes
24 hours	Paraplast (3 changes within 24 to 48 hours)

Sectioning was done on a microtome (American Optical Co., Model 820) to a thickness of 10 to 14 microns. The sections were mounted on glass microscope slides with albumen and dried for 24 hours at 200+ degrees F. At least 5 sections were cut from each tooth, bracketing the lumen or root canal.

The mounted sections were stained following procedures recommended by Humason (1972:143, 239) (Table 2). After staining, they were rinsed with 2 changes of water and examined under 40X magnification for the presence of dark-staining bands or annuli.

All tooth section slides were examined and the number of annuli in each section was counted. The section having the greatest number of annuli present was used as the age-determining section, because these lines are deposited annually and using a section with less than the maximum number of lines present could underestimate the age. In cases where the annuli were indistinct or there appeared to be 2 or more closely parallel lines, magnification was increased to 100X. Where 2 lines could not be clearly distinguished under 100X, they were scored as a single broad line. Ages were assigned using the criteria set forth by Crowe (1972) and Johnson, et al. (1981).

**Table 2. Staining schedule for bobcat tooth sections.  
From Humason, 1972.**

<b>TIME</b>	<b>MEDIUM</b>
10 minutes	Xylene
10 minutes	Xylene
5 minutes	Absolute ethanol
3 minutes	90% ethanol
3 minutes	70% ethanol
3 minutes	50% ethanol
20 minutes	Giensa stain

The data from this study were tested in the population model proposed by Crowe (1975b). The parameters used were sex ratio=1:1, litter size=2.27, age structure from the pooled data, and the running mean harvest figures. The year class frequencies were smoothed by regression based on the equation  $\log Y = a + bX$ , where  $X$ =age and  $Y$ =the frequency in that year class. The resultant regression was then used to produce adjusted frequencies within each year class, and age-specific survivorship  $S$  was calculated from the adjusted frequencies as  $S = N(x+1)/N(x)$ , where  $N(x+1)$ =the number in age class  $(x+1)$ , and  $N(x)$ = the number in age class  $(x)$ . Lambda, the finite rate of increase, was calculated from the running mean harvest data as  $P(t)/P(t-1)$ , where  $P(t)$ =the population at time  $(t)$ , and  $P(t-1)$ = the population at time  $(t-1)$ . Additionally, a life-table for Virginia bobcats was constructed from these data.

### Results

The results of the analyses of tooth sections for bobcats collected in 1979-80 and 1980-81 are shown in Table 3. Mean ages were calculated for each of the 4 years and compared by the Student-Newman-Keuls (SNK) test (Sokal and Rolf, 1969: 242). The mean age of males and females were calculated separately for each of the 4 years and compared by SNK test. The mean ages did not differ significantly

between years at the 0.05 probability level so the data were combined and mean ages were calculated from the pooled sample. The mean age, drawn from the pooled data, was  $3.20 \pm 0.36$  (S.E.) years for females and  $2.45 \pm 0.32$  years for males. The mean age for both sexes combined was  $2.83 \pm 0.24$  years. Of 120 bobcats aged, 30 (25%) were juveniles (young of the year), comprised of 16 males and 14 females.

Table 3. Age distribution of 120 bobcats examined from the 1977-78 through 1980-81 trapping seasons, in Virginia.

AGE	77-78		78-79		79-80		80-81		TOTAL	TOTAL
	M	F	M	F	M	F	M	F	MALE	FEMALE
<1	3	3	3	2	5	4	5	5	16	14
1	5	2	6	1	7	4	2	3	20	10
2	1	-	1	-	1	4	6	5	9	9
3	-	-	2	3	3	4	2	4	7	11
4	-	-	-	2	-	1	-	2	-	5
5	2	-	1	1	-	1	-	3	3	5
6	-	-	1	-	-	1	-	-	1	1
7	-	-	-	-	2	-	-	-	2	-
8	-	-	-	-	-	1	-	-	-	1
9	-	-	-	1	-	-	-	-	-	1
10	-	-	-	-	-	-	-	1	-	1
11	-	-	-	-	-	-	1	1	1	1
12	-	-	1	-	-	-	-	1	1	1
<b>SUM</b>	<b>11</b>	<b>5</b>	<b>15</b>	<b>10</b>	<b>18</b>	<b>20</b>	<b>16</b>	<b>25</b>	<b>60</b>	<b>60</b>

graph

followed  
4 yr

### Sex and Age Distribution

The sex ratio was calculated for each of the 4 years and for the pooled sample. The sex ratio for the pooled data was 1:1. The age distribution is shown in Table 3 and the sex ratios for each of the 4 years are shown in Table 4. Of 120 bobcats aged, 96 (80%) were 4 years old or younger with 30 (25%) less than 1 year old. No males were found in year classes 8 through 10, but 2 were 11 and 12 years old respectively. Females were represented in all but the 7th year class. In the pooled sample, 6 specimens (5%) were 9 years or older. Sexing errors by donors were noted in 2 cases and corrected in the data presented.

Table 4. Sex ratios (M:F) of bobats aged by tooth annuli analysis from 1977-78 through 1980-81. Data for 1977-78 and 1978-79 were provided by the VCGIF.

	1977-78		1978-79		1979-80		1980-81		POOLED	
	M	F	M	F	M	F	M	F	M	F
JUVENILES	1	1	1.5	1	1.25	1	1	1	1.14	1
ADULTS	4	1	1.5	1	0.81	1	0.55	1	0.96	1
TOTAL	2.2	1	1.5	1	0.9	1	0.64	1	1	1

When age class frequencies were smoothed by regression, the resultant equation was  $\log Y = 1.4181 - 0.1303X$  ( $r^2 = 0.79$ ), where  $X$  = age and  $Y$  = the number of animals in age class  $X$ . Adjusted frequencies were derived from this equation and a model of the population following Crowe (1975b) was constructed. The proportionate survivorship varied from a minimum of 0.50 for 10 year olds to a maximum of 1.00 for 9, 11, and 12 year olds with a mean of 0.76 (Table 5). The mean value of  $\Lambda$  derived from this model was 1.14. This value was used to determine juvenile survivorship, which was found to be 0.33.

Table 5. Age structures from the 4 years pooled data (Np), the pooled data smoothed by regression (Ns), and the age-specific survivorship (S) calculated from the smoothed age structure following Crowe (1975b). Mean survivorship (Smean) was calculated as the geometric mean of survivorship. Mx=the number of female kittens per female of age x.

AGE	Np	Ns	S	Mx
0	30	26	----	0.00
1	30	20	0.77	1.00
2	18	14	0.70	1.25
3	18	11	0.78	0.93
4	5	8	0.73	
5	8	6	0.75	
6	2	4	0.66	
7	2	3	0.75	
8	1	2	0.66	1.24 <sup>1</sup>
9	1	2	1.00	
10	1	1	0.50	
11	1	1	1.00	
12	1	1	1.00	

-----  
Smean=0.76

<sup>1</sup> Mean number of females per female age 4 or over.

### Discussion

Sex ratios, necessary for estimating potential reproductive performance in a population, could not be used alone in determining population trends. These ratios do not reflect recruitment or population changes, but only ratios in the harvest which may be the result of other factors (Downing, 1981). Sex ratios strongly favoring males are unfavorable as excess males use resources (prey and range) without a corresponding addition to recruitment. Such a ratio was noted in the harvest of the 1977-78 trapping season but appeared to have been balanced out by a more favorable ratio in the 1978-79 harvest (Table 4). The reason for the high preponderance of adult males in 1977-78 is at best conjectural. It may reflect the actual sex ratio within the population, differential vulnerability to trapping, or sexing errors by donors, which have been noted in this and other studies (Frederickson and Rice, 1979; Hoppe, 1979). However, it is more likely an artifact of the small sample size, since juvenile sex ratios were approximately 1:1 and those of adults tended to favor females as the sample size increased. Changes in sex ratio were assumed to result from increasing sample size and to

approach that of the actual population, although sample sizes were relatively small (less than 11% of the number of bobcats tagged). The reason behind the shifts in sex ratio are unknown. The samples were drawn from commercial trappers who presumably place their traps randomly, and in locations thought to offer a high capture probability. There is a question of inherent bias toward females because of smaller home range and more intensive use of the range which should increase the probability of encountering traps. However, greater daily movements of males (Marshall and Jenkins, 1966; Bailey, 1974; Hall and Newson, 1976; Buie, et al., 1979), especially during the winter (Buie, et al., 1979), could result in more nearly equal intensity of home range use during the trapping season and minimize or negate bias toward females. The sex ratio for the pooled samples was considered to approximate that in the population. The significance of changes in the sex ratio as a measure of mortality was not estimated because this technique requires knowledge of the preharvest and postharvest sex ratios (Downing, 1980).

The age structure of the pooled sample suggested a sharp drop in survival between ages 1 and 2 and another between ages 3 and 4 (Table 3). Natural mortality is enigmatic but presumed to be higher in juveniles (Bailey

1972, cited by Crowe 1975b; D. Hassner 1981, pers. comm.). The preponderance of adults in the samples each year could be a reflection of poor recruitment into the state population or possibly the result of reduced mobility and trappability of juveniles which may still be under parental care (Ryden, 1981).

Smith (1974: 299) stated generally that the ratio of juveniles to adults was 2:1 in stable populations of most game species. However, in determining age structure of most game populations from harvest samples, some bias toward adults in the harvest may occur because of hunters selecting animals of higher trophy or food value. This is less likely to occur in the case of trapped bobcats. It seems unlikely that most commercial trappers can select for adult animals or even for larger ones. Therefore, the ratio of juveniles to adults may be higher in harvests of trapped predators than in harvests of hunted game species where juveniles can be identified and passed over, and estimates of the population's age structure may be more accurate in the case of trapped predators.

The relatively high percentage of juveniles (37.5%) in the 1977-78 sample (Table 3) was thought to be the result of the small sample size. The fairly consistent percentage of juveniles in the following 3 years' samples (20.0%, 23.7%,

and 24.4%) closely approached the percentage of juveniles in the pooled data (25%) as the sample size increased. These data are similar to those from a population whose density remained fairly constant (Miller, 1980). This suggests either that there is little or no age bias in the Virginia harvest or that insufficient bobcats are taken annually to cause a significant alteration of the age structure.

It was noted that males born in 1970 and 1971 were absent from the sample as were females born in 1972. The reason for this is unknown but may be related to disease and reflect an extremely high juvenile mortality for those years. Rabies may have been involved since the incidence of this disease in Virginia animals was at a nadir in 1970 and beginning to rise through 1972 (Va. Dept. of Health. 1982.) Disease would likely have had more impact on the juvenile portion of the population because of their close association while under parental care, and also because the loss of the mother could result in loss of the entire litter.

Disease could have impacted the bobcat population indirectly in 1970-72 by reducing the population of prey species and thus adversely affecting the survival of kittens (Crowe, 1975b). Jacobson et al. (1978) found that rabbit (Sylvilagus floridanus) harvests at Fort Pickett had declined to a low in the 1971-72 hunting season and

suggested that disease may have played a role in the apparent decline. Their rate of trapping success showed a similar decline and the authors suggested that harvest data was therefor indicative of population trend (Jacobson et al., 1978). Tularemia could have been a factor if rabbit populations had indeed declined. The type commonly associated with rabbits (tick-borne) is of high virulence and is capable of killing domestic rabbits with a minimal dose of inoculum (Jellison, 1974). The incidence of tularemia in humans reached high levels from 1970 to 1972, mostly in fall and winter (Virginia State Department of Health, 1970-72) and could possibly have been related to exposure by rabbit hunters. If so, these statistics could reflect the incidence of tularemia in wild rabbits and suggest a potential population decline, both in rabbits and their predators.

All of the bobcats examined were killed between December 1 and January 31, and the absence of mature follicles in these animals implies that the onset of breeding season does not occur until sometime after January 31, which is consistent with those of other authors (Mehrer, 1975; Blankenship and Swank, 1979). The actual onset of breeding in Virginia bobcats could not be determined from this study because carcass collection was limited to those

donated during the hunting and trapping seasons which end January 31. It appeared that the current harvest seasons do not extend into bobcat breeding seasons.

The proportionate values of adult and juvenile survivorship derived using Crowe's (1975b) model suggested that juvenile mortality was the dominant mortality factor in bobcats, which was consistent with the findings of other investigators (Crowe, 1975b; Hoppe, 1979). The adult survivorship found in this study (76%) falls between Toweill's (1980) figures of 69% for western Oregon (heavily harvested) and 80% for eastern Oregon (lightly harvested and following a 2-year moratorium on bobcat trapping). Since survivorship or mortality estimates are derived from age structures in this model, there is no indication of the proportion of mortality attributable to natural causes or human agencies. Juvenile mortality, however, is probably mainly due to natural causes (Crowe, 1975b). Crowe's (1975b) model for exploited bobcat populations used harvest data to calculate  $\lambda$  (the finite rate of increase) and hence juvenile survivorship. This procedure while useful, is subject to error when the numbers of animals taken are not a fairly static proportion of the population. He used predator control records as his data base, which he

considered to be the product of a relatively uniform trapping effort. Age-related bias in trapping could introduce error into age structures resulting in flawed estimates of adult and juvenile survivorship.

The life-table (Table 6) presents the apparent dynamics of Virginia's bobcat population based on the population characteristics found herein. The assumption of a stable age distribution is fundamental to all such tables and is likely to be violated here. Another consideration is whether the population parameters found in this project are truly representative of the population at large. The table is nonetheless presented to offer a view of the population dynamics based on available data.

Table 6. A life table for female Virginia bobcats, constructed from age structure and reproductive data from this study. Column headings are  $l_x$ =the probability at birth of surviving to age  $x$ ,  $d_x$ =the probability at birth of dying during the interval  $x$  to  $x+1$ ,  $q_x$ =the age-specific death rate,  $L_x$ =the average number of years lived,  $T_x$ = the total years lived,  $e_x$ =the life expectancy at age  $x$ ,  $m_x$ =the mean number of female young born to females age  $x$ ,  $v_x=l_x m_x$ =the expectancy at birth of the number of female young born to a female at age  $x$ .

AGE	$l_x$	$d_x$	$Q_x$	$L_x$	$T_x$	$E_x$	$m_x$	$V_x$
0	1.000	0.233	0.233	0.883	3.200	3.200	0.000	0.000
1	0.767	0.167	0.217	0.683	2.317	3.022	1.000	0.767
2	0.600	0.150	0.250	0.525	1.633	2.722	1.250	0.750
3	0.450	0.183	0.407	0.358	1.108	2.463	0.930	0.418
4	0.267	0.083	0.313	0.225	0.750	2.812	1.340	0.357
5	0.183	0.083	0.455	0.142	0.525	2.864	1.130	0.207
6	0.100	0.017	0.167	0.092	0.383	3.833	1.000	0.100
7	0.083	0.000	0.000	0.083	0.292	3.500	1.100	0.092
8	0.083	0.017	0.200	0.075	0.208	2.500	1.000	0.083
9	0.067	0.017	0.250	0.058	0.133	2.000	1.000	0.067
10	0.050	0.000	0.000	0.050	0.075	1.500	1.000	0.050
11	0.050	0.050	1.000	0.025	0.025	0.500	1.500	0.075
							RO =	2.966

## SECTION II. POPULATION STATUS

### Materials and Methods

Harvest records were compared with scent-station survey results, pelt prices, and meteorological records to determine whether annual harvests may be indicative of population trends or are under the influence of other factors. A mail survey of sportsmen, game wardens, taxidermists, and fur buyers was conducted to gather information on perceived population trends, distribution, trapper experience and success, and the extent of unrecorded harvest. Survey forms and letters are included as Appendices 1 through 7.

Scent-station survey data provided by the Virginia Commission of Game and Inland Fisheries, (VCGIF) were examined and compared statistically with harvest data by correlation analysis. Statistical analyses were done using SAS (SAS Institute, Inc., 1979. Helwig, J.T. and K.A. Council, eds.) The survey was conducted by counting tracks on 6654 sample points (scent-stations) on 68 sample routes throughout the state for 2 consecutive days in the early fall, prior to hunting or trapping season. Sampling effort and routes have remained essentially constant from year to year. A sample point or scent-station was a 3-foot diameter

circle of sand suitable for tracking in the center of which was placed a scent capsule as an attractant. Tracks which accumulated on a good night (i.e., a night with no rain or other disturbance to the station) were identified by species, and the number of stations visited was recorded for each species. "Total adjusted tracks" for each species were described as the "total tracks per 1000 spot nights" (VCGIF, 1981. Statewide wildlife population trend analysis. Richmond, VA. 23230). (A "spot night" was equal to 1 operative station for 1 night). These data were grouped into 4 regions (Fig. 1) and analyzed by region and statewide. The counties within each region were identified and harvest figures summed from tag records to give an annual harvest figure for each region. Adjusted track counts from the scent-station survey (total tracks per 1000 spot nights) for each region and statewide were compared with current year and previous year tag records by correlation analysis to determine if a relationship existed among these 3 variables.

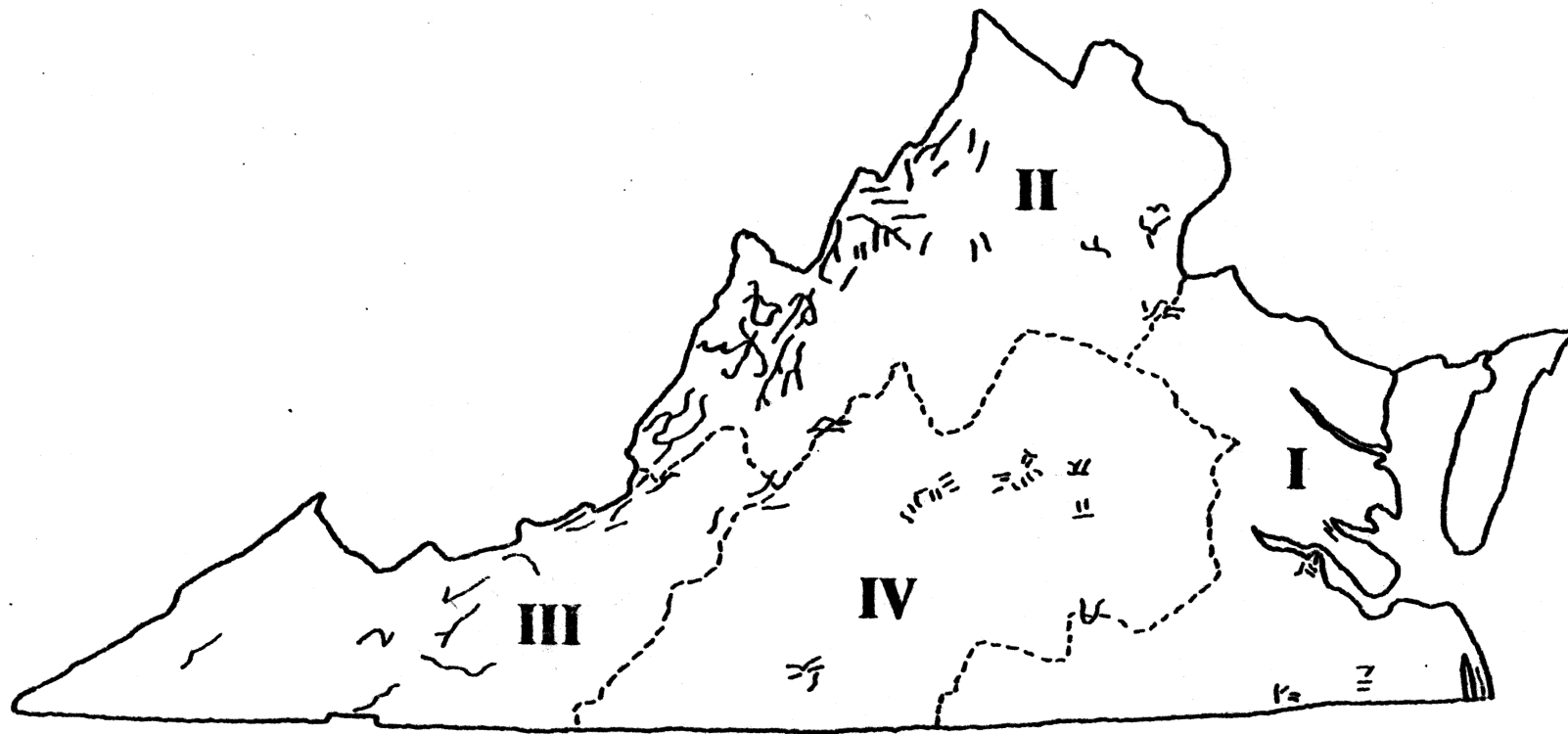


Figure 1. The boundaries of scent-station survey regions and the approximate locations of scent-station survey sample routes. Data provided by J.Coggin, Virginia Game Commission.

Harvest records from the 1964-65 through 1980-81 trapping seasons were provided by the VCGIF (VCGIF, 1979a; J.V. Gwynn, VCGIF, 1981. Pers comm.). These data were based on fur buyer reports of the number of pelts traded through the 1979-80 trapping season. A pelt-tagging program was begun in 1977 and harvest records from this source were available through the 1980-81 trapping season. Because of some disparities noted between tag records and fur buyer reports, a 2-year running mean of buyer recorded data was constructed based on the average of 2 years' harvest. This was done at the suggestion of the Statistical Consulting Service at Virginia Tech.

Because of the relatively short trapping season (December 1 to January 31), the author surmised that previous year pelt prices were more likely to affect trapping effort and consequent bobcat harvest than current year prices. Therefore, previous year prices were also analyzed for a possible relationship to the numbers of bobcats killed. Similar analyses were done using fox and raccoon prices (VCGIF, 1979a) because the author felt that most bobcats were taken accidentally in traps set for these species. Additional harvest and license data drawn from a mink (Mustela vison) study (Benson, 1976) were similarly tested for effects of price on license sales and harvests to

test further the hypothesis that harvest was related to pelt price.

Weather was considered as a possible influence on harvest and was tested for correlation with harvest reports. The mean minimum monthly temperature, precipitation, and snow and sleet fall records for each of the 6 meteorological regions of Virginia [Tidewater (TW), Eastern Piedmont (EP), Western Piedmont (WP), Northern (N), Central Mountain (CM), and Southwest Mountain (SWM)] were collected from public records for the months of November, December, and January of each year from 1966 to 1981 (NOAA, 1965-1980). A mean of each factor (temperature, precipitation, and snow and sleet fall) was calculated by region for each trapping season from 1977 to 1981 and entered as a variable in the correlation analysis. As with the scent-station data, the regions established for meteorological records (Fig. 2) did not match those defined as fur trapping regions (Fig. 3). Harvest data were identified county-by-county and summed for each meteorological region for the 4 years for which tag information was available. Only 4 years of data could be used in the regional analyses. Additionally, correlation analysis of weather versus harvest was done on a statewide basis using 15 years of data.

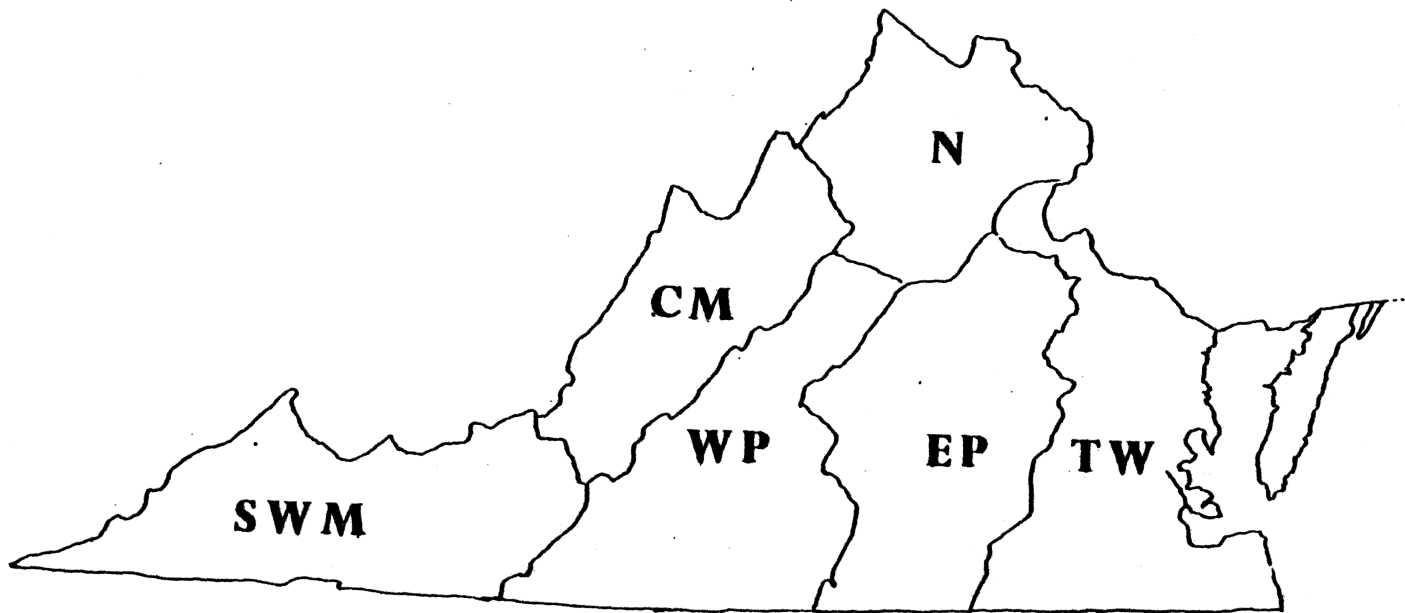


Figure 2. The meteorological regions of Virginia. Redrawn from NOAA, 1981.

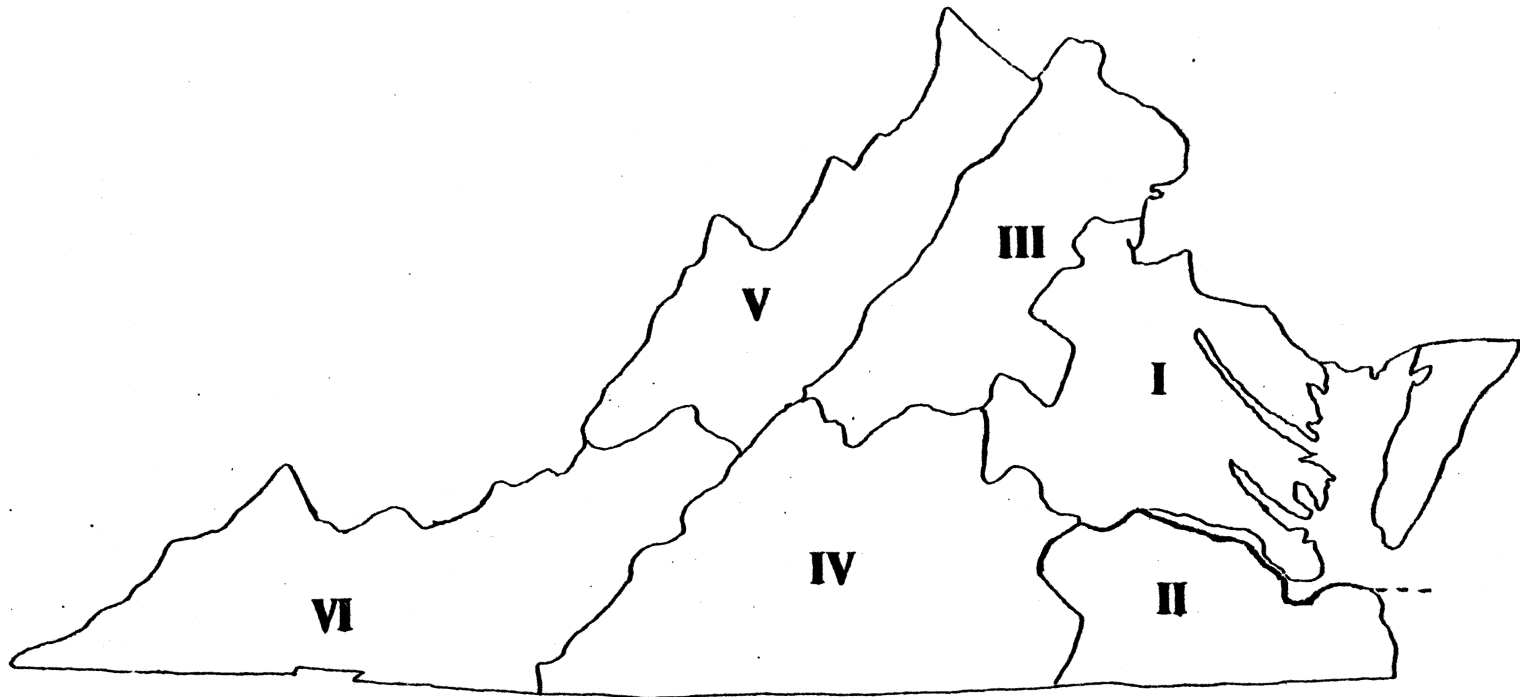


Figure 3. The fur-trapping regions of Virginia. Redrawn from Virginia Game Commission, 1979a.

A mail survey of trappers, hunters, fur buyers, taxidermists, and Game Wardens was conducted. Trappers, hunters, and wardens were asked whether they thought that the bobcat population was increasing, stable, or decreasing. The data were grouped by region and the responses compared by RxC contingency table test (Row x Column) for differences in response between groups and between regions.

Trappers and hunters were asked how many years they had been trapping and/or hunting; this was done to determine if there was any influence of experience on success. Other questions addressed were effort (number of days hunting or trapping), success (average number of bobcats taken per year), and which species they pursued. Trappers also were asked how many traps they operated each night. Responses of trappers' experience were stratified into 4 groups: 0-5 years experience, 6-10 years experience, 11-20 years experience, and over 20 years experience. Each of these groups was further categorized into those who only trapped for fox and those who purposely set traps for bobcats. Trap nights were calculated by multiplying the number of traps set per night times the number of operating nights. Traps were assumed to have been checked daily in accordance with

Virginia game laws. Success was calculated by the equation:

$$\text{Success} = \frac{\text{Average Annual Catch}}{\text{Trap Nights}}$$

Mean success (number of bobcats caught per trap night) was compared among the different experience levels to determine if the likelihood of trapping bobcats increased with experience.

Game Wardens were asked if bobcats occurred in their respective counties, and on what sort of evidence, if any, they based their opinions. These responses were used to estimate the distribution of bobcats in Virginia. Wardens were also asked if they believed that substantial numbers of untagged bobcats were delivered to taxidermists. This was done to evaluate the accuracy of tag records as a measure of actual kill.

Taxidermists were asked how many bobcats they received during the 1980-81 season and if this figure was more than, less than, or the same number as in the previous season.

The distribution of bobcats was assessed by examination of (1) harvest data, (2) Game Wardens' opinions of whether

or not bobcats occurred within their counties, and (3) comparison with the only previous study addressing the distribution of bobcats in Virginia (Progulske, 1952).

### Results

The scent-station survey data from 1977 through 1981 showed an increase in track counts statewide from the 1979-80 surveys and decreased from 1977-78 1978-79, and 1980-81 surveys (VCGIF. 1981. Statewide wildlife population trend analysis. Richmond, VA. 23230). The area east of the Blue Ridge (Regions I and IV) showed an apparent decrease for 1977-78, followed by an apparent increase for the next 2 years, and a decrease from 1980-81 (Table 7). West of the Blue Ridge (Regions II and III), the trends were toward a stable count for 1977-78 followed by an apparent decline from 1978-79, an increase between 1979-1980 and another decline from 1980-81.

Correlations of track counts with harvests were not significant, although inverse relationships could be inferred from the results for Region III and also statewide (Tables 7 and 8). A direct relationship could also be inferred for Region IV. Track counts were not correlated with previous year harvest records.

Table 7. Adjusted track counts (TC), and harvest (HVST) by region and statewide (STWD) for 4 years of tag-based harvest information and 5 years of scent-station survey data from VCGIF. Harvests are for the seasons that began in December 19\_\_, and track counts are from scent-station surveys conducted in September/October 19\_\_. Trend=slope of regression. U=up. D=down.

YEAR	<u>REG I</u>		<u>REG II</u>		<u>REG III</u>		<u>REG IV</u>		<u>STWD</u>	
	TC	HVST	TC	HVST	TC	HVST	TC	HVST	TC	HVST
1977	0.00	15	10.72	73	15.71	88	1.35	25	10.36	201
1978	0.00	17	7.35	113	15.46	144	0.00	47	8.97	321
1979	6.69	12	6.18	132	8.31	182	0.95	58	6.15	389
1980	3.33	6	10.52	138	9.56	137	6.05	113	8.57	394
1981	2.48	--	8.30	---	8.68	---	5.41	---	6.80	---
TREND	U	D	D	U	D	U	U	U	D	U

Table 8. Correlation analysis, by region and statewide, of track counts, and harvest records. LYH=Last Year Harvest, and HVST=Current Year Harvest. R=Pearson correlation coefficient, P=Probability  $> |R|$  under  $H_0: \rho=0$ , N=Number of observations.

REGION		LYH	HVST
I	R=	-0.31	0.32
	P=	0.69	0.62
	N=	4	4
II	R=	0.50	-0.41
	P=	0.50	0.59
	N=	4	4
III	R=	-0.78	-0.72
	P=	0.22	0.28
	N=	4	4
IV	R=	0.73	0.87
	P=	0.27	0.13
	N=	4	4
STWD	R=	-0.08	-0.80
	P=	0.92	0.20
	N=	3	4

Harvest records based on fur buyer reports from the 1964-65 to 1979-80 trapping seasons reflected a low of 47 bobcats taken in the 1968-69 trapping season and a peak of 491 in 1976-77. An estimate of harvest based on a running mean of 2 trapping seasons fur buyer reports was constructed and reflected a low of 70.5 bobcats in 1971-72 and a maximum of 471 in 1976-77. Records based on a pelt-tagging program begun by the VCGIF with the 1977-78 trapping season showed an increase from 201 bobcats tagged in 1977-78 to a peak of 394 in 1980-81. Tag records for 1977-78, 1978-79, and 1979-80 (the only 3 years for which both tag-based and buyer-based data were available) indicated that tag information and fur buyer reports did not agree. Fur buyer reports exceeded the number of bobcats reported tagged in 1977-78 and 1978-79 but were exceeded by the number tagged in 1979-80 (Table 9 and Fig. 4).

Correlation analysis of pelt prices, trapping license sales, and harvest records indicated a relationship between the current year price of bobcat pelts and harvest only when tag records were used as a measure of harvest ( $r=0.90$ ,  $p=0.29$ )

but this is suspect because of the limited number (3) of observations and lack of statistical significance. A similar relationship was noted when harvest was correlated with previous year price although the correlation was not significant ( $r=0.61$ ,  $p=0.58$ ). No significant correlations were found between numbers of pelts sold or their 2-year running means and bobcat pelt prices, either current or previous year.

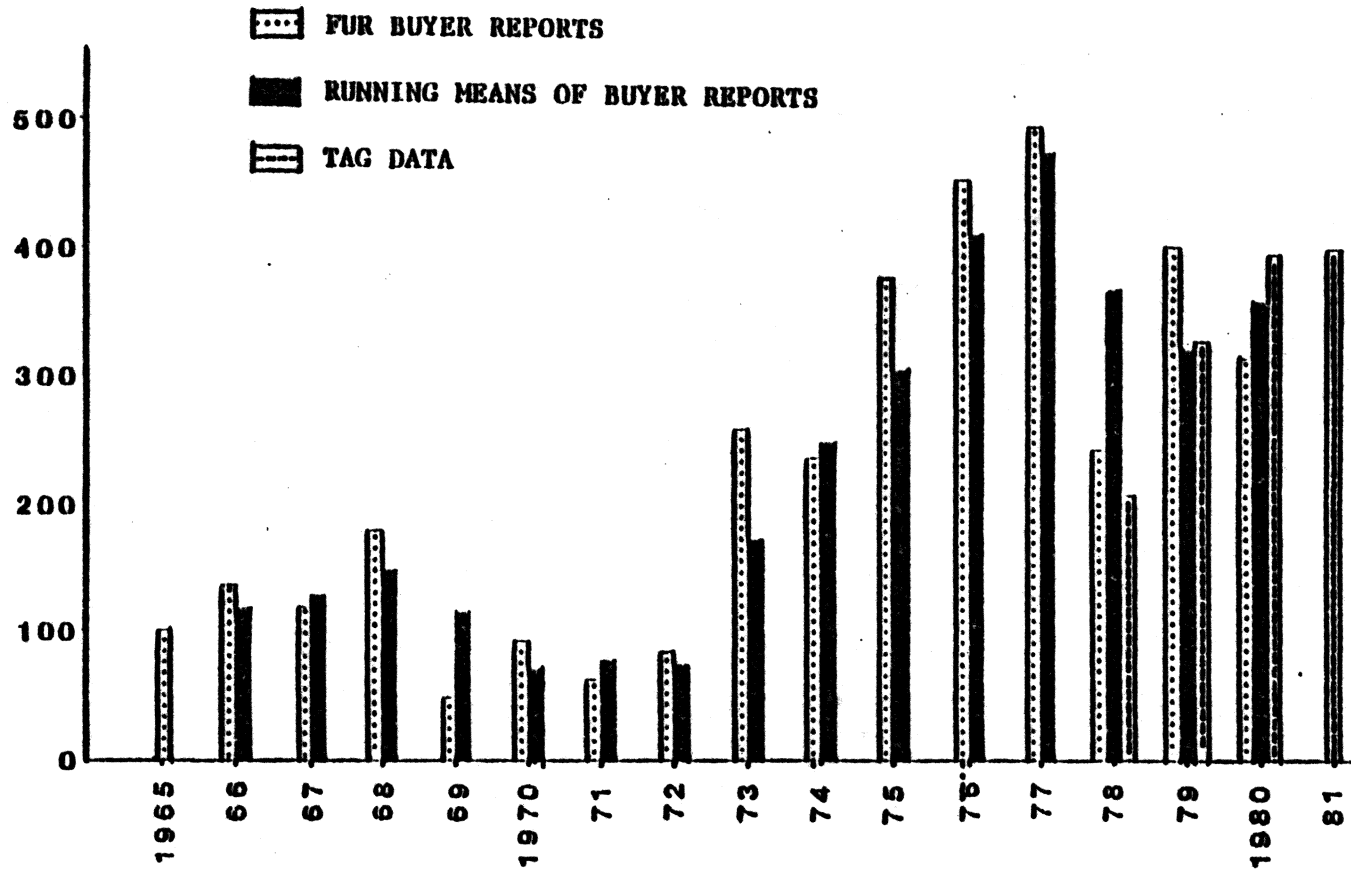


Figure 4. Harvest records from trapping seasons ending in January 1965 through January 1981. Data provided by VCGIF.

Running mean figures of bobcat harvests were correlated with the pelt prices of fox ( $r=0.87$ ,  $p=0.02$   $n=6$ ), and raccoon ( $r=0.81$ ,  $p=0.05$   $n=6$ ). Trapping license sales were correlated with current year bobcat pelt price ( $r=0.80$ ,  $p=0.02$   $n=8$ ) and with previous year price ( $r=0.80$ ,  $p<0.01$   $n=7$ ). License sales were not correlated with running mean harvest figures ( $r=0.46$ ,  $p=0.26$   $n=8$ ) and were not correlated with fur buyer reports ( $r=-0.63$ ,  $p=0.88$   $n=8$ ) or tag records ( $r=0.40$ ,  $p=0.74$   $n=3$ ).

Correlation analysis of Benson's (1976) data on Minnesota mink harvests failed to reveal a relationship between either the number of mink trapped or the number of trapping licenses sold and the price of mink pelts. Other factors tested were season length which ranged from 31 to 61 days, and the number of licensed trappers which ranged from 7000 to 17000. Neither of these factors was correlated with harvests. An inverse relationship ( $r=-0.58$ ,  $p=0.004$   $n=22$ ) was noted between the numbers of licenses sold and the number of mink taken per trapper.

Table 9. Bobcat harvests, pelt prices, and trapping licenses sold from 1964-65 to 1980-81. Data supplied by the VCGIF. Running means were calculated from fur buyer reports.

	NUMBER OF BOBCATS TAGGED	FUR BUYER REPORTS	RUNNING MEAN	BOBCAT PELT PRICE	NUMBER OF LICENSES SOLD
1964-65	---	98	----	-----	1377
1965-66	---	135	116.5	-----	1496
1966-67	---	117	126.0	-----	1569
1967-68	---	178	147.5	-----	1428
1968-69	---	47	112.5	-----	996
1969-70	---	90	68.5	-----	1178
1970-71	---	59	74.5	-----	1320
1971-72	---	82	70.5	-----	1165
1972-73	---	255	168.5	15.97	1210
1973-74	---	232	243.5	22.71	2592
1974-75	---	370	301.0	13.32	2380
1975-76	---	451	410.5	27.56	2390
1976-77	---	491	471.0	39.03	3061
1977-78	201	237	364.0	33.08	4517
1978-79	321	397	317.0	58.31	3864
1979-80	389	311	354.0	55.86	5293
1980-81	394	---	----	-----	----

Neither fur buyer reports nor their running means were correlated with minimum temperature, precipitation, or snow/sleet fall statewide (Table 10). Regionally, harvests (from tag records) were inversely correlated with precipitation in the Eastern Piedmont (EP) ( $r=-0.96$ ,  $p<0.04$ ), Western Piedmont (WP) ( $r=-0.98$ ,  $p<0.02$ ), and Central Mountains (CM) ( $r=-0.97$ ,  $p<0.03$ ). For the Tidewater (TW) region, a direct correlation with precipitation ( $r=0.96$ ,  $p<0.05$ ) was noted. In all 6 regions, an inverse relationship between harvest and snow/sleet fall was indicated. This was strongest in the case of the Northern (N) region ( $r=-0.86$ ,  $p<0.14$ ), although none of the correlations was significant.

Table 10. Mean weather parameters, annual harvest from fur buyer reports, mean price, and license sales from the 1965-66 to 1979-80 trapping seasons. (S/S =snow and sleet in water equivalents. TEMP=mean minimum temperatures in degrees Fahrenheit, PRECIP=precipitation in inches, HVST=annual harvest, PRICE=mean price in dollars, and LIC=number of trapping licenses sold.) Weather data from NOAA 1965-1980.

YEAR	TEMP	PRECIP	S/S	HVST	PRICE	LIC
1965-66	----	4.03	26.73	135	-----	1496
1966-67	29.3	2.46	8.04	117	-----	1569
1967-68	25.8	4.14	7.40	178	-----	1428
1968-69	27.9	2.16	9.25	47	-----	996
1969-70	25.6	3.52	7.39	90	-----	1178
1970-71	29.3	2.60	5.20	59	-----	1320
1971-72	33.4	2.07	.20	82	-----	1165
1972-73	32.1	3.61	1.53	255	15.97	1210
1973-74	33.8	5.14	4.58	232	22.71	2592
1974-75	30.4	4.07	5.32	370	13.32	2380
1975-76	29.2	3.44	.80	451	27.56	2390
1976-77	21.7	2.24	7.88	491	39.03	3061
1977-78	28.8	5.34	6.73	237	33.08	4517
1978-79	30.4	5.13	2.27	397	58.31	3864
1979-80	31.4	2.76	6.14	311	55.86	5293
1980-81	25.8	-----	-----	---	-----	-----

Mail survey response was 37.7%, with 19 of 38 (50%) taxidermists, 77 of 180 (42.7%) fur buyers, 19 of 85 (22.4%) hunters, 97 of 382 (25.4%) trappers, and 88 of 110 (80%) Virginia Game Wardens questionnaires returned. Trapper, hunter, and Warden responses differed on the question of whether they believed that the bobcat population was increasing, decreasing, or steady (Table 11). The majority of respondents (137 of 168, 81.5%) expressed the opinion that the population was either increasing (44.6%) or steady (36.9%), and 31 respondents (18.5%) replied that the population was decreasing. The responses among groups were not independent when tested by RxC Contingency Test (Chi-square=30.41, 4 d.f.  $p < 0.005$ ). An RxC test was done on hunters' and trappers' responses and no significant difference was detected (Chi-square=0.023, 2 d.f.  $p > 0.975$ ), so the data were pooled and tested against those of Game Wardens. The responses of the 2 groups were significantly different (Chi-square=30.38, 2 d.f.  $p < 0.005$ ).

Table 11. Questionnaire responses of 168 sportsmen and Game Wardens regarding bobcat population trends in Virginia, 1979-1981.

	TRAPPERS	HUNTERS	WARDENS	TOTAL	%
Increasing	47	9	19	75	44.6
Stable	17	3	42	62	36.9
Decreasing	20	4	7	31	18.5
Total	84	16	68	168	100.0

Game Wardens were asked whether or not they believed that bobcats were present in their counties. Responses from 88 Wardens indicated the actual or probable presence of bobcats in 72 of 97 counties including the cities of Chesapeake, Suffolk, and Virginia Beach (Fig. 5). Tag records indicated that bobcats have been killed in 13 additional counties for which no responses were received from the Wardens. Wardens in 2 counties (Charles City and James City) answered "possibly" and 8 others replied "no". The latter responses ("possibly" and "no") were all from Wardens in Region I (Upper Tidewater). There were 6 duplications where 2 Wardens were assigned to the same county, but in these cases both Wardens gave similar responses (possibly after discussion). None of the counties for which the Wardens response was "no" have a history of bobcats being taken according to tag records, but the estimate of "possibly" for Charles City County was substantiated by a bobcat taken there during the 1980-81 season. Tag records showed that bobcats have been killed in 76 counties since November 1977 and were believed to be present by Game Wardens in 14 more counties. [This is an increase of at least 33 counties since Progulsk's (1952) study (Fig. 6).]

Tag records also showed that the number of counties in which bobcats have been recorded as being killed has increased from 41 in 1977-78 to 55 in 1980-81, with the greatest regional increase in the lower Piedmont (Region IV).

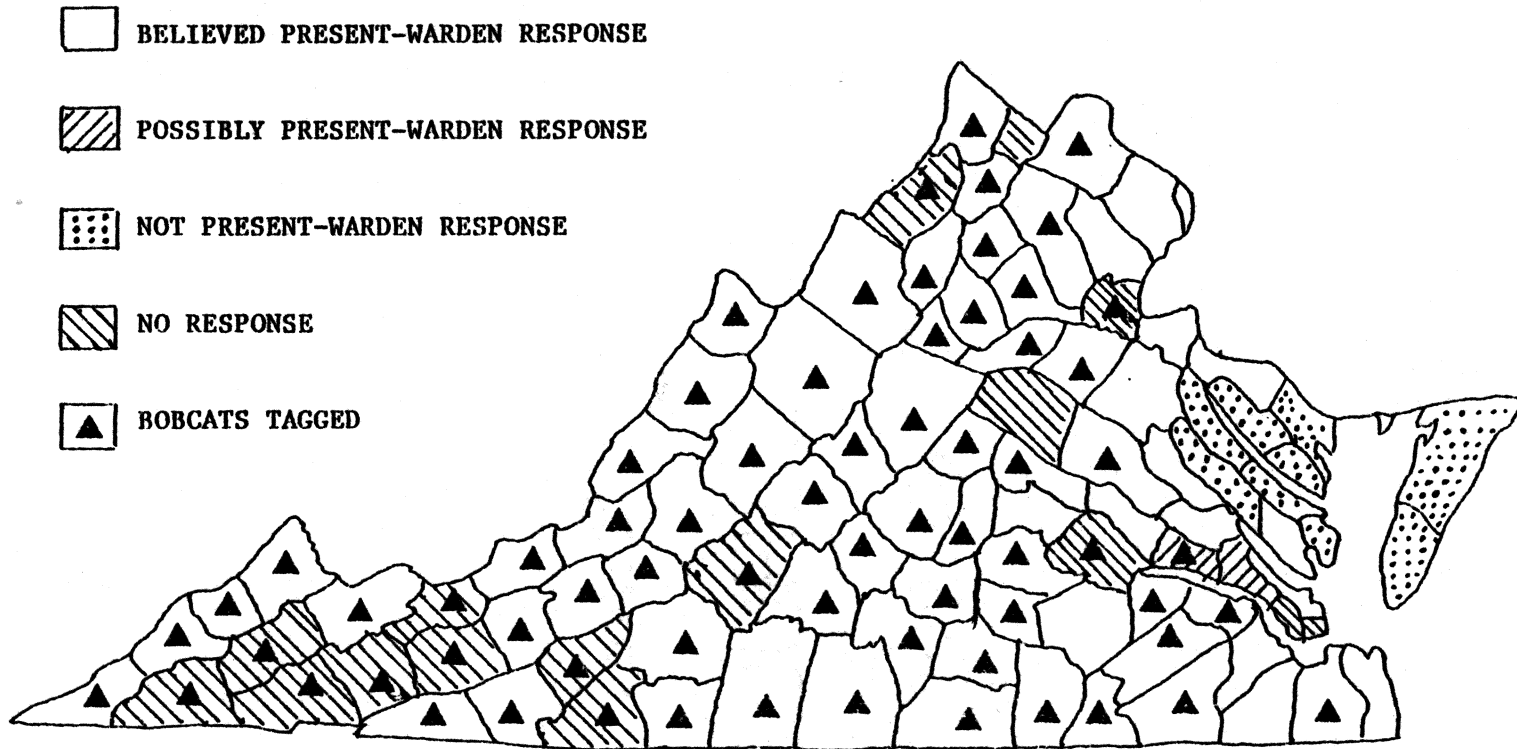


Figure 5. The probable range of bobcats in Virginia, 1981.

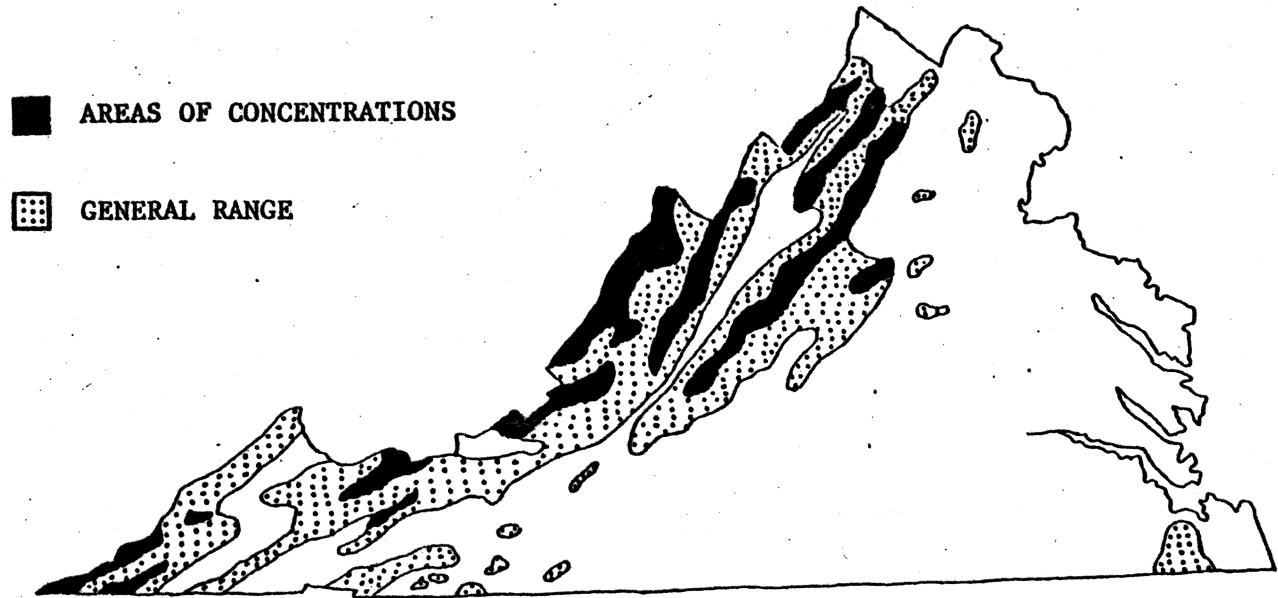


Figure 6. The probable range of bobcats in Virginia, 1952. From Progulske, 1952.

Taxidermists reports indicated that an additional 51 bobcats (equal to 13.1% of the number tagged) were received by taxidermists during the 1979-80 hunting season, and 61 (equal to 15.5% of the number tagged) in 1980-81. These numbers were added to tag records for those years to get a more accurate harvest record. The harvests for 1977-78 and 1978-79 were also corrected by multiplying the tag numbers by (1.143) (mean of 13.1% and 15.5%) to include the numbers delivered to taxidermists.

The mail survey of trappers revealed that the majority of bobcats trapped in Virginia were most likely taken in traps set for other species (principally fox). Of 81 respondents, 45 (55.6%) said that their bobcats were taken in fox sets, and 11 others (13.6%) stated that their bobcats were taken in traps set for species other than bobcat or fox. Only 25 respondents (30.9%) claimed to have taken bobcats in traps set purposely for bobcats.

No correlation was found between experience and success, as measured in trap-nights per bobcat caught (Table 12). Trappers setting purposely for bobcats seem to have had a higher success rate (0.0026 bobcats per trap-night) than those trapping exclusively for fox (0.0013 bobcats per trap-night). For all trappers combined, the catch rate was 0.0015 bobcats per trap-night.

Table 12. Trap nights per bobcat caught versus experience among trapping groups listed by target species. Means plus S.E.

EXPERIENCE (in years)	FOX TRAPPERS	BOBCAT TRAPPERS	ALL TRAPPERS
1-5	832±178	664±254	796±148
6-10	821±433	178±61	500±236
11-20	851±399	320±142	647±255
20+	552±158	414±200	506±121

Only 19 of 56 respondents reported catching more than 1 bobcat per year while 5 of 56 reported taking over 4 bobcats per year. The respondents who reported taking 6 bobcats in a year had 15 to 40 years experience. The number of bobcats per trap night reported by those harvesting more than 1 bobcat ranged from 0.125 to 0.001. One respondent reported catching 5 bobcats in a year in fox sets at a rate of 0.009 bobcats per trap night.

From the end of season reports of 6 trappers provided by the VCGIF, a much higher success rate appeared. These 6 trappers reported a success rate between 0.005 and 0.125 (mean=0.019) bobcats per trap night, even though 1 of these 6 indicated that no bobcats were caught. The number of days trapping in these reports ranged from 3 to 45 (mean=16).

Only 23 of 56 respondents (41.1%) trapped for the entire 60-day season. Five reported trapping between 40 and 50 days, while the remainder trapped less than 40 days. The most traps claimed to have been set by any respondent was 75 to 100, and only 10 of 56 respondents claimed to have set over 30 traps. Some respondents reported the number of traps as a range, (e.g. 25 to 30 or 75 to 100). Low and high means were calculated as 21.5 and 22.3 traps respectively, from the high and low sums of traps. The mean experience level of 11 trappers who used less than 10 traps was 16.2 years.

### Discussion

The scent-station survey conducted by the Virginia Game Commission was not designed specifically for bobcats and the results should be interpreted with caution. The number and locations of scent-station lines were essentially static and unevenly distributed throughout the state. Most were located on National Forest lands, state-owned forests, wildlife refuges, wildlife management areas, and military posts. The majority were in the Jefferson and George Washington National Forests. The relatively sparse distribution of scent-station lines in the Piedmont and Tidewater regions gives rise to the question of whether fluctuations in track counts from year-to-year in those regions are a function of change in bobcat population level or distribution, or observer effort.

Correlations between scent-station survey results and current and previous year harvest figures (Tables 5 and 6) suggested that in Region III the annual mortality may be greater than recruitment, although the correlations were not significant, while in Region IV a direct relationship between harvest (which increased roughly four-fold) and track counts may (although not statistically significant) indicated an increase in population density. Scent-station surveys were conducted in the fall prior to hunting and

trapping seasons. A direct correlation with harvest over several years may therefore indicate that either or both records are indicative of population trend but an inverse correlation is more difficult to analyze. Disagreement between these measures cannot be resolved by simply assuming that one is a more accurate method than the other. If the harvest is increasing from year to year but inversely correlated with track counts, it may signify increasing mortality of a declining and heavily exploited population, but if harvests are decreasing while track counts increase, there is a possibility that the population is increasing while trapping effort or success is decreasing.

Harvest records from fur buyer reports offer the advantage of long term data but their accuracy as a measure of actual numbers of bobcats killed is questionable because these records only indicate the number of pelts sold to fur buyers. These records may include duplications when a pelt is sold from one dealer to another. Since these reports are grouped by source (trapper or dealer), the degree of duplication is probably small. The major question is how many pelts are held by trappers in anticipation of higher prices. If these are held until the following year, the figures for both years would be biased and present a false

indication of the impact of price on harvest. The disparity between the numbers of bobcats tagged by VCGIF personnel and the numbers reported purchased by fur dealers in the 1977-78 and 1978-79 trapping seasons (Table 8) appears to be a result of either an influx of pelts into the market from prior years or adjacent states, and/or perhaps some duplications. In the 1979-80 season, the number of bobcat pelts purchased by fur dealers dropped below the number of bobcats tagged, when a modest reduction in the average pelt price occurred (Table 8); this may reflect a reluctance to sell on the part of trappers.

Data from reports of bobcat pelts tagged were considered the most reliable record of the numbers of bobcats killed. The requirement for pelts to be tagged prior to sale offered the advantage of recording kills, whether or not the pelt was sold and permitted recording of the county of kill. Unfortunately, tag records may still underestimate the actual numbers of bobcats taken because some may have been tanned or mounted as trophies.

The lack of significant correlation between pelt prices and harvest records seemed to refute the assumption that fluctuations in pelt prices directly influence annual harvests as Ryden (1981) implied. Correlation analysis of pelt prices and tag records indicated that there may be a relationship between pelt price and harvest but the data are

too limited to support a conclusion. The lack of significant correlation between license sales and harvests suggested that the number of licensed trappers does not necessarily represent an accurate measure of harvest effort. It does not seem likely that additional licensees are focusing their efforts on bobcats nor that new licensees are sufficiently skilled to trap effectively for bobcats.

Analyses of Benson's (1976) mink data suggested that fluctuations in pelt prices of selected species were unlikely to affect directly the number of animals taken. An upsurge in sales of trapping licenses may occur but for various reasons this increase in numbers of licensed trappers did not appear to have any substantial effect on harvest levels. Shortening of the trapping season for a particular species may well result in increased trapping intensity for that species for the duration of the season, while longer seasons allow less intensive efforts over a longer period.

Because of the relatively short trapping season for bobcat and fox, it could be surmised that the impact of fur prices on trapping effort or harvest would be delayed by at least one trapping season. The time and expense involved in acquiring and preparing traps and gaining access to suitable areas as well as the time and effort required to establish

and operate a trap line are apt to preclude any significant upswing in trapping intensity within a 2 month season. Increases in trapping license sales, while correlated with both previous and current year pelt prices, were thought to reflect a rising interest in trapping as a sport and source of additional income or may simply result from human population increase. The correlation between running means of fur buyer reports and prices of fox and raccoon pelts was not surprising since mail survey respondents indicated that most bobcats (69%) were caught in traps set for other species. Increases in trapping effort for these more numerous and less retiring species might parallel rising pelt prices, and result in incidental bobcat harvest.

The difference between sportsmen and Game Wardens in response to a question addressing population status is difficult to explain. Several factors may have influenced the answers. It is possible that sportsmen's replies may have been influenced by the suspicion that an indication of a declining population would result in further restrictions or a closed season. The responses from Wardens were not believed to be thus biased. On the other hand, there is a possibility that sportsmen may spend more time in the field on foot and thus have more opportunity to observe signs of bobcat presence or activity. Hunters offered the most

pessimistic view of the bobcat population with 25% indicating that they believed the population to be decreasing, while a minority of trappers and Game Wardens (23.8% and 10.3% respectively) expressed a similar belief. Sportsmen and Wardens disagreed whether the population is stable or increasing. This disparity may be due to factors previously mentioned but it appears that the population is thought to be at least stable in spite of a steadily rising annual harvest.

The distribution of the bobcat appears to be virtually statewide, with the possible exception of some areas of the upper Tidewater region and 2 counties of the Eastern Shore. The apparent absence of bobcats from these areas may be related to trapping methods if the principal target species are semi-aquatic animals such as beaver (Castor canadensis), otter (Lutra canadensis), or muskrat (Ondatra zibethica), since traps set for these species are usually set underwater and are unlikely to catch bobcats. Land use on the Eastern Shore is principally row crops and scarcity of suitable habitat or prey may preclude the existence of bobcats there. Since none of the counties where the Wardens believed bobcats to be nonexistent has recorded bobcats killed (according to tag records), it seems likely that they are either absent or present in such low numbers as to escape

notice. Nonresponse from several counties in this region tend to cloud the picture but there is a likelihood that bobcats may occur in several additional counties in low numbers, or the nonresponse may indicate that the species was thought to be absent.

The increase from 43 (Progulske, 1952) to 72 counties thought by Wardens to harbor bobcats suggested that the bobcat's distribution has increased over the last 28 years, although densities may not have increased. More likely, Progulske's (1952) survey ("personal interviews with all county Game Wardens") may have underestimated the actual distribution of bobcats, because there was little interest in trapping bobcats, and no pelt tagging program was in effect. Bobcats trapped at that time would probably not have come to the attention of Game Wardens except where bounty payments were involved or in cases where they were taken as a function of predator control activities. The presence of bobcats also may have been somewhat obscured by their absence in harvests if there were fewer people engaged in dry land trapping.

No significant correlations between experience and success were noted. It may be that access to suitable areas for bobcat trapping may be more important than skill or experience in determining the likelihood of trapping them.

The possibly limiting effects of land ownership and access on harvests was mentioned by Hill and Sumner (1980. Scent-stations as indices of abundance in some furbearers of Alabama. Final report P-R Proj. W-44-5, Study VI. Alabama Dept. of Cons. and Nat. Res.). There is also a possibility that deliberate efforts to trap bobcats were at best desultory on the part of most trappers, although trappers setting for bobcats did appear to have greater success in catching them than those trapping for other species. The high success rates of trappers who submitted end of season reports to the VCGIF and the limited number of such reports might indicate that the probability of a trapper submitting the report varies with his or her success.

The small percentage of trappers who indicated that they trapped for the entire season and the small number of traps used suggested at best a limited effort to trap bobcats. Time, travel, and land access may impose some constraints on the efforts of individual trappers or hunters, and the cost of traps and/or limited land access may restrict the number of traps used. The price of traps may constrain the number owned and used, but probably at some number greater than 20, since the price of traps could be considered as a business investment.

The relatively small number of respondents who claimed to have trapped for the entire season suggest that many trappers were either unable or unwilling to devote more time or effort to trapping, and achievement of a yearly bag limit can be ruled out as a reason. Few trappers catch the annual limit of 6 bobcats and no limits are listed for fox or raccoon trapping.

X Correlation analyses of harvest versus weather factors suggested the possibility that weather can have an effect on bobcat harvests. Precipitation is likely to reduce the trap success by washing out sets, destroying attractants, or reducing animal movements or number of traps set. The positive correlation between precipitation and bobcat harvest noted for the Tidewater region thus appeared to be anomalous and may be the result of limited observations or a chance parallel trend of both bobcat harvest and precipitation.

A Temperatures apparently were not a significant factor in bobcat harvest but a strong negative correlation between snow and sleet fall and bobcat harvest figures in the Northern region was noted. Weather factors thus did not appear to play a large or uniform role in the fluctuations of the Virginia bobcat harvest, probably because of the relatively mild climate. Similar analyses of data from more

northern states may disclose a significant relationship as might long-term analyses of regional data in Virginia.

### SECTION III. MODELS

#### Materials and Methods

Age structure and reproductive data from this study were used as inputs to a population simulation program (Coyle and Tipton, 1979. Dept. of Fisheries and Wildlife Sciences, 100 Cheatham Hall, VPI & SU, Blacksburg, VA 24061). The age structure used was that from the pooled data from the 1977-78 through 1980-81 trapping seasons. The number of females age 0,  $N(0)$ , was artificially generated by calculating the number of female kittens that would be born to a population of adult females having this age structure and using reproductive data from this study. The simulation was run as a single-sex model because of the approximately 1:1 sex ratio found in this study, and was run through as many breeding seasons (=years) as necessary to reach a stable age distribution. The values used in this simulation are shown in Table 13. Age-specific values of %B (the percent of the female population in breeding condition),  $P(x)$  (the probability that an animal in age class  $x$  will remain in age class  $x$  past the next breeding season), and  $f(x)$  (the number of female kittens born to a breeding female of age  $x$ ) were used in the simulation. The older age classes were pooled and the age structures were truncated at

the age where reproductive parameters and survivorship appeared to become relatively steady. In addition, the model was run as a  $Dx$  series with the age data from this study and  $P(x)$  determined by the simulation from raw data. In this run, 12 age classes (0-11) were used, and truncated at age 11 so that  $N(x+1)$  would not exceed  $N(x)$  at any time. The numbers in each age class ( $Nx$ ), the percent of females in age class  $x$  in breeding condition ( $\%B$ ), and the number of female young per female of age  $x$  ( $Fx$ ) are shown in Table 14. The simulations were also run using arbitrary values of juvenile survivorship above and below that found in this study and with higher and lower estimates of litter size drawn from the literature to discern the effect of changes in these parameters on population growth. Because the litter size estimates drawn from other sources (Fritts and Sealander, 1978A; Lembeck and Gould, 1979) were not age-specific, the mean litter sizes from these sources were applied to all age classes except juveniles. For each combination of  $F(x)$  and  $P(x)$  series' used, the simulation produced a value of  $\Lambda$  (the finite rate of increase), predicted the number of females in the population after each breeding season, and produced a life table based on the age structure and reproductive potential. The simulations were also run using a lower value of  $\%B$  drawn from the literature

(Hall, 1979) to assess the effect on the population of a lesser percentage of females breeding. This was done because it was felt that my data on %B (arbitrarily set at 90% for ages >2 for use in the model although all females over 2 years old appeared to have reproduced in the previous breeding season) may be higher than that which occurs in the wild.

Table 13. The parameters used in the Modust population simulation: Age, percent of females breeding (%B), the number of female kittens per breeding female (Fx), the probability of an animal remaining in age class (x) after the next breeding season (Px), and the number of animals in each age class (Nx). The values of Fx were based on litter sizes of 2.0 (Column A), 2.27 (Column B), and 2.5 (Column C). The values of Px were varied by different values of juvenile mortality (Columns a, b, and c). The simulation was run using all possible combinations of Px and Fx with the values of %B from column A, and with combination Bb of Fx and Px using values of %B from column B. The values of Px were derived using Crowe's (1975b) method and varying the value of Lambda in the calculations.

AGE	Nx	%B		Fx			Px		
		A	B	A	B	C	a	b	c
0	129	0.00	0.00	0.00	0.00	0.00	0.30	0.33	0.38
1	46	0.30	0.30	1.00	1.00	1.25	0.78	0.78	0.78
2	36	0.75	0.71	1.00	1.25	1.25	0.75	0.75	0.75
3	27	0.90	0.71	1.00	0.93	1.25	0.60	0.60	0.60
4+	53	0.90	0.71	1.00	1.24	1.25	0.71	0.71	0.71

Table 14. The population parameters used in running the MODUS1 simulation with raw data. Nx=the number of females age x, %B=the percent of females age x in breeding condition during the breeding season, and Fx=the number of female young born to a female of age X.

AGE (x)	Nx	%B		Fx
		A	B	
0	60	0.00	0.00	0.00
1	46	0.30	0.30	1.00
2	36	0.75	0.71	1.25
3	27	0.90	0.71	0.93
4	16	0.90	0.71	1.34
5	11	0.94	0.71	1.13
6	6	0.90	0.71	1.00
7	5	0.90	0.71	1.10
8	5	0.90	0.71	1.00
9	4	0.90	0.71	1.00
10	3	0.90	0.71	1.00
11	3	0.90	0.71	1.50

Retrospective estimates of minimum populations were made by Fry's (1949) "virtual population" method. The percentage of animals in each age class from the pooled data from this study was applied to the running mean harvest estimate for each trapping season from 1965-66 to 1976-77 to derive age distributions for those years. Harvest data from tag records and age distributions from this study were used to derive age distributions for the 1977-78, 1978-79, 1979-80, and 1980-81 harvests. Tag records and age data from tooth annuli analysis for each season from 1977-78 through 1980-81 were used instead of pooled data because they were believed to be more accurate.

For each season, the numbers of bobcats in each year class (cohort) taken in that or subsequent seasons were summed to give the minimum number extant for that year class and season. These numbers were then summed to arrive at a minimum population for that season. These minimum or "virtual" populations (Fry, 1949) and harvest figures for each season were used to estimate the percentage of the population taken by hunters or trappers in that season. Running means of fur buyer reports were used as harvest estimates for the 1965-66 through 1976-77 trapping seasons. Tag records were used for harvest figures for the 1977-78 through 1980-81 seasons because they were thought to be more

accurate. An additional 51 and 61 bobcats reported as received by taxidermists were added to tag records for the 1979-80 and 1980-81 seasons.

Estimates of the percentage of mortality caused by human activity ranged from 67% in a harvested area (Lembeck and Gould, 1979) to 82% (Berg, 1979). These estimates suggest a cautious approach to assessing the population size. If my adult survivorship (76%) is accurate, then adult mortality (Q) is 24%. And if harvest (X) represents a known proportion (Y) of total mortality, then the number of adult animals dying annually (Nd) can be calculated by

$$Nd = X/Y$$

and the preharvest adult population (Pp) could be calculated by

$$Pp = Nd/Q.$$

Population estimates for the 1977-78 through 1980-81 trapping seasons were constructed by using human-related proportions of mortality drawn from the literature (Lembeck and Gould, 1979; Berg, 1979) (67% and 82% respectively). These values (Y), total mortality (Q) (=24% from this study), and harvest data from tag records (TAG) and taxidermists reports (T+T) were used to calculate the

percentage of the population harvested and the preharvest populations for 1979-80 and 1980-81. Only these years were used because of the lack of information from taxidermists for prior years. The values of  $(T+T)$  were calculated as TAG plus 14.3% (the mean of the percentages of tagged harvest that went to taxidermists in 1979-80 and 1980-81).

Because these estimates were based on adult mortality, they can only reflect the adult portion of the population. Since my pooled data indicated that juveniles represented 25% of the harvest (Table 4), the harvest data (X) were reduced by 25% before calculation of Nd. The resultant population estimates therefore represent only the number of adults in the population or roughly 75% of the total population.

### Results

The Modus1 simulation produced values of Lambda ranging from 0.95 to 1.17 (Table 15). Population increases were predicted in 4 of 10 simulations but were substantial only when the data in Table 14 were used. In 1 case (Ac, Table 15), an initial increase was followed by a decline, while in case Bc (Table 15) an initial sharp decline was followed by a slow increase in population. Minimum statewide

populations (Table 16) ranged from a low of 392 in 1965-66 to a high of 1107 in 1975-76. Harvest levels (percent of the population harvested) (Table 16) ranged from a low of 10.7% of the population in 1971-72 to a maximum of 56.5% in 1979-80. The harvest level for 1979-80 is suspect because of insufficient data from subsequent years to calculate the minimum population. The mean harvest level for seasons 1965-66 to 1976-77 was  $26.5 \pm 3$  (S.E.)%. The populations constructed from mortality breakdown estimates and harvest data are shown in Table 17.

Table 15. Results of MODUS1 population simulations. Aa represents results using Px column A and Fx column a, Ab represents results using Px column A and Fx column b, etc. (Table 14). Ts= the number of breeding seasons to reach a stable age distribution, Ns=the number of females in the population when a stable age distribution has been reached, N1=the number of females in the population after 1 breeding season, and L=Lambda (the finite rate of increase. N(0)=291 females. Nr=the initial number of females in the raw data simulation (=222). RAW=the results of simulation using the data in Table 15. Under combination Bb, the results in column A are those obtained using my data for %B (column A Table 14) and those in column B are the results of using other published values for %B (column B Table 14). The data under RAW1 uses %B from column A and RAW2 uses %B from column B (Table 15).

	Aa	Ab	Ac	Ba	Bb <sup>1</sup>		Bc	Ca	Cb	Cc	RAW1	RAW2
					A	B						
Ts	7	6	7	6	7	7	6	7	5	6	12	12
N1	268	284	296	272	225	269	216	279	295	334	287	222
Ns	195	247	274	228	210	211	222	264	316	397	1645	1081
L	0.95	0.97	0.99	0.96	0.99	0.96	1.01	0.99	1.02	1.04	1.17	1.14

<sup>1</sup> My data.

D.M.H.

Table 16. Minimum population levels (MPOP), harvest data from running means of fur buyer reports (RMEAN), harvest data from tag records (TAGS), and harvest data from tag records plus taxidermists reports (TAG + TAX). Harvest levels (LEVEL) are percentages of the population killed, calculated from harvest data and minimum populations. Data are for the trapping seasons ending in January 19\_\_.

SEASON	MPOP	RMEAN	TAGS	TAG + TAX	LEVEL (%)
66	392	117			29.8
67	406	126			31.0
68	436	148			33.9
69	402	113			28.1
70	442	69			15.6
71	530	75			14.2
72	662	71			10.7
73	880	169			19.2
74	1020	244			23.9
75	1064	301			28.3
76	1107	411			37.1
77	1016	471			46.4 <sup>1</sup>
78	834		201	230	24.1 <sup>1</sup>
79	947		321	367	33.9 <sup>1</sup>
80	786		389	440	56.5 <sup>1</sup>
81	---		394	455	----

<sup>1</sup> MPOP and LEVEL values are suspect because insufficient data are available for subsequent years to account for the longevity of bobcats in these year classes past age 5.

Table 17. Population estimates calculated from proportions of mortality represented by harvest (Y), harvest data from tag records (TAG), and tag records plus taxidermists reports (T+T). The numbers represent only the numbers of adults in the population.

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-----			
Source of Harvest Data			
-----			
	YEAR	TAG	T+T
-----			
Y=0.67	1977-78	944	1073
	1978-79	1506	1712
	1979-80	1825	2052
	1980-81	1850	2122
Y=0.82	1977-78	767	876
	1978-79	1225	1399
	1979-80	1483	1677
	1980-81	1504	1734
-----			

### Discussion

The Modus1 population simulation employed age distribution and reproductive data from this study to calculate age-specific mortality and reproductive capability, and predicted the growth of hypothetical populations until stable age distributions were reached (Table 15). The age structures used in this model were configured as Dx series' because all of the data were drawn from the age at death, and harvest was considered to be the major mortality factor. Because the age distribution found in this study was such that some age classes had more animals than younger age classes, age-specific survivorship calculated from the raw data was sometimes greater than 1. The use of a Dx series in the Modus1 simulations overcame this problem. Since total mortality (human-related and natural) was presumed to be reflected in the age structure used, this simulation tested recruitment against loss to predict the fates of the populations simulated. The difference between the values of Lambda generated by Modus1 runs using Px/Fx series' Bb and RAW (Tables 13, 14, and 15) appeared to result from different values of juvenile survivorship. Juvenile survivorship used in Modus1 simulations Aa through Cc was derived from Crowe's (1975b) model and was lower than that derived from the Modus1

simulations "RAW1" and "RAW2" which calculated juvenile survivorship from the age distribution. Crowe's (1975b) model is based on determining the value of Lambda from harvest data where these data are considered to be products of a relatively constant trapping effort, and therefore reflect population growth. In this procedure, Lambda is used to calculate adult and juvenile survivorship. Rate of survivorship determined by this method is suspect in the case of Virginia bobcats where harvests may be affected by factors other than population growth, but this method does provide a data input from a source other than the age distribution for determining Lambda and was used in an effort to evaluate potential population growth.

A somewhat tautological situation occurred when the number of juveniles (N0) was calculated from reproductive data and the adult age structure, and used with this same adult age distribution. The effect of this in the Modus1 model was to lock the population into a virtually static age distribution, and thus a static population.

The relatively modest rates of increase or decrease noted in all runs of the simulation suggested that the data used were probably fairly realistic.

Reconstructing populations by Fry's (1949) "virtual population" method produced an estimate of the minimum

numbers of animals extant at the beginning of the hunting or trapping season for a specified year. This technique can be very reliable if age determinations are accurate and all animals taken are aged and accounted for. Reliable estimates of the impact of hunting or trapping can also be made using this method if the total number of animals killed is known. The data available or acquired in this study were limited. Age information for Virginia bobcats encompassed only 4 years as did pelt tag records. Age information was based on a relatively small sample of the harvest, ranging from 7.6% to 10.4% of the number of bobcats tagged. The estimates of minimum populations and harvest levels (Table 16) are therefore admittedly crude but are nonetheless thought to be reasonable estimates of the minimum possible population levels from year to year. These minimum population estimates are probably low because only bobcats whose pelts were marketed or tagged could be counted. Additional bobcats taken but not recorded cannot be accounted for, nor can those that died of natural causes. The minimum populations shown (Table 16) for 1969-70 and onward are truncated by the absence of representatives of these year classes for years past 1979-80. In view of the approximately 12 to 13 year life span of bobcats found in this and other studies, it appeared that the cohorts must be followed for at least this long. The constant rise in the minimum populations from

1969-70 onward may be attributed in part to increases in the number of bobcats killed annually, but the absence of older animals from the tally in later years could cause underestimation. Harvest increases would result in upward adjustments of minimum populations across several years unless the animals killed were concentrated in a very few age classes. It seems possible that the steady increases in the reconstructed populations in spite of the decrease in the number of age classes represented may suggest population increases.

The causes and rates of mortality are difficult to assess. Lenbeck and Gould (1979), in comparing lightly and heavily harvested areas in California, found that harvest amounted to 20% of total mortality in the lightly harvested area and 67% in the heavily harvested area. Bailey (1974) reported that of 20 known deaths of his subject bobcats in Idaho, 16 (80%) were human-related (3 were study-related). Berg (1979) reported that 14 of 17 known deaths (82%) of ear-tagged or radiocollared bobcats in Minnesota were caused by humans. The adult survivorship found in this study (73%) falls between Towell's (1980) figures of 69% for western Oregon (heavily harvested) and 80% for eastern Oregon (lightly harvested and just after a 2-year moratorium on bobcat trapping).

The population estimates in Table 17 were constructed using adult mortality and therefor represent only the adults in the population. These estimates are subject to error because (1) the actual number of bobcats killed is unknown, (2) the proportion of total mortality caused by hunting and trapping is not well established, (3) adult mortality and/or the percentage of the population in the harvest may not be stable from year to year, and (4) the age structure used may not be truly representative of the population. Despite these objections, the figures were thought to be reasonable estimates of the population size for the years shown and to reflect the population status. They can be refined and validated over time by comparing predictions of future populations and harvests, but the accuracy of annual harvest data needs to be improved, and human-caused mortality investigated by other methods.

### SUMMARY and CONCLUSIONS

Age and reproductive data from 67 bobcat carcasses and 15 lower jaws were collected during the 1979-80 and 1980-81 trapping seasons. Sex and age information on 16 bobcats taken in 1977-78 and 25 taken in 1978-79 were provided by the VCGIF. Ages in 1979-80 and 1980-81 were determined by analysis of tooth cementum annuli. Ages of the 1977-78 and 1978-79 sample were determined by G. Matson, Milltown, Montana. Reproductive tracts of females were examined macroscopically for corpora lutea and placental scars to assess reproductive performance.

The mean age from the pooled sample was  $2.83 \pm 0.24$  (S.E.) years. Juveniles comprised 25% of the pooled sample and the maximum age was 12 years. The sex ratio of the pooled sample was approximately 1:1.

The mean litter size, by counts of placental scars, appeared to be  $2.27 \pm 0.18$  (S.E.). All females over 3 years old appeared to have both OB's and placental scars as did 1 of 3 yearling females and 6 of 8 two year olds.

Scent-station survey data and bobcat harvest records provided by the VCGIF were directly correlated only in the Piedmont region where sharp upswings in both harvest and track counts were noted. Bobcat harvest records for the

last 8 years were not correlated with bobcat pelt prices, but adjusted harvest figures based on a 2-year running mean were correlated with pelt prices of fox ( $r=0.87$ ) and raccoon ( $r=0.81$ ) at the 0.05 probability level. License sales were not correlated with bobcat harvest. Bobcat harvests were found to be inversely related to precipitation in 3 regions and to snow and sleet fall in another. The data do not support the supposition that pelt prices alone are the determinants of bobcat harvest levels.

The response to a mail survey of sportsmen, Game Wardens, taxidermists, and fur buyers was 37.7%. The survey results indicated that the majority of sportsmen (56%) believed the bobcat population to be increasing, 20% reported the population to be stable, and 24% indicated that the population is decreasing. The majority of Game Wardens (61.8%) said that they believe the population to be stable, while 27.9% indicated that they believe the population to be increasing.

The survey also revealed that most bobcats killed in Virginia are taken fortuitously by sportsmen seeking other species, and that a substantial proportion of the annual harvest (13-16%) is taken to taxidermists to be prepared as trophies.

Game Wardens surveyed were of the opinion that bobcats were present in 72 counties or cities and absent from 8 other counties. This survey, coupled with pelt tag records, indicates that bobcats are distributed almost statewide, except for the "Eastern Shore" and are more widely distributed than indicated by a previous study in 1952.

Models based on population characteristics and harvest data produced conflicting results. While those models based on harvest data suggested an increasing population, simulations based on population dynamics generally predicted a slow decline. The adult survivorship (76%), juvenile survivorship (33%), and relatively low estimates of reproductive potential produced rates of population change ranging from a 5% annual decline to a 17% annual increase. Increases were noted in only 5 of 12 simulations, and exceeded 4% in only 2 cases.

Harvest data and scent-station data do not coincide and the relative reliability of the 2 indices is questionable. They were in agreement only for the Piedmont region (IV) where the population appears to be increasing. Track counts were found to be increasing in Regions I and IV. Harvests appeared to be declining only in Region I (Table 8).

Recruitment and survivorship appear to be relatively low, and modeling of population change demonstrated that they are probably inadequate to support a population increase at current mortality rates. Since these parameters were derived from a limited number of samples, mostly from the mountain area, conclusions based on these models must be regarded cautiously. They may not be characteristic of the population statewide, and the relatively modest declines indicated by the results may underestimate the actual rate of decline.

Increased commercial value of bobcat pelts does not directly result in increased harvests in Virginia. Most of the bobcats taken in the state are caught incidentally to trapping for other species, and a relationship has been shown between the prices of fox and raccoon pelts. However, a cause-and-effect relationship has not been established.

The reported perceptions of sportsmen and Game Wardens suggest that the bobcat population is at least stable. The difference in opinion between these 2 groups is thought to be somewhat self-cancelling but no relative weights were assigned to the opinions of each group. The author preferred the more conservative view.

The apparent increase in range might reflect a population increase with a concomitant expansion into

formerly unpopulated or sparsely populated areas or a shift in distribution of bobcats or trapping activity.

The overall conclusion, cautiously expressed, is that the bobcat population is at best stable and that it has shown a modest increase in 2 regions, while declining in 2 others, warranting special concern in the Tidewater area (Region I). Estimates of the population status based on harvest data and mail survey results could be overoptimistic and subject to influence by other than biological factors. Estimates based on population dynamics suggest a declining population. The author prefers this more cautious view.

Future research and management programs should be designed on a regional basis, with close monitoring of harvest and efforts to clarify the rate of mortality. The requirement for pelts to be tagged should be extended to include all bobcats taken, regardless of the ultimate disposition of the pelts. The carcasses or lower jaws should be submitted for analysis as a condition for issuance of tags, and sex and/or age data compiled therefrom. Future research should focus on elucidating the rate of juvenile mortality and the proportion of the population represented in annual harvests. A concerted marking program with emphasis on locating and marking kittens could serve both

purposes. Annual scent-station surveys should be expanded to provide more uniform coverage of the Piedmont and Tidewater physiographic regions. Timber and paper companies could be approached for access to property in early stages of reforestation which would be suitable for long-term survey efforts without undue shifting of scent-station line locations. Volunteer labor could be solicited in establishing the lines (the major effort required) from interested sportsmens associations and school or university groups such as chapters of The Wildlife Society and Biology Clubs or service fraternities.

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## Appendix 1

NOTES ON REPRODUCTIONMethods

The ovaries and uteri of females shot or trapped between November 1 and January 31 were removed, stripped of remnants of the broad ligament, and weighed on an Ainsworth balance (Fisher Co., Model A200). The uteri were opened and each horn examined for placental scars (PS).

The uteri were examined while fresh to avoid the difficulties noted by Wright and Coulter (1967) in fishers and by Martin et al. (1976) in rodents. The uteri were opened longitudinally and held to the light, and areas of discoloration (considered to be placental scars) were counted (Gashwiler, et al., 1961; Brand and Keith, 1979). Ovaries were sectioned and examined for the presence of follicles and ovarian bodies (presumed to have resulted from the maturation and ovulation of follicles and henceforth referred to as OB's) (Kirkpatrick, 1980). The ovaries were kept in formalin for 10 to 15 minutes which was found to result in suitable firmness for scalpel sectioning. All follicles were counted but only follicles greater than 3 mm.

in diameter were considered as indicators of incipient estrus, as Crowe (1975b) had reported that the maturing follicles measured between 6 and 8 mm. in diameter from 10 to 0 days before the onset of estrus. Means and standard errors were calculated for counts of OB's and placental scars.

### Results

The ovaries and uteri of 39 female bobcats taken in the 1979-80 and 1980-81 trapping seasons were examined. Of these, 9 were from bobcats less than 1 year old and none in this age class was found to have either OB's or placental scars. Of 3 yearling females (approximately 1.5 years old), 2 had neither OB's nor placental scars, while 1 had 4 OB's and 2 placental scars. Of the 2 year old females (approximately 2.5 years old) (N=8), 6 had both OB's and placental scars, and 2 had OB's but no scars. These 2 may be suggestive of either fertilization or implantation failure or early fetal resorption. All females 3 or more years old had both OB's and placental scars, including females aged 10, 11, and 12 years old. Some of the discolored or pigmented areas were faint or pale brown and could possibly have arisen from some agency other than fetal implantation. All, however, were counted as placental scars.

The mean number of placental scars and OB's was calculated for all females showing placental scars. The mean number of OB's was 6.65 ( $\pm 0.59$ ) and the mean number of scars was 2.27 ( $\pm 0.18$ ). The 2 year olds (N=6) showed a mean OB count of 5.16 ( $\pm 1.25$ ) and a mean scar count of 2.50 ( $\pm 0.43$ ). Bright yellow OB's were found in the ovaries of 1 bobcat. All others were various shades of brown or gray. The difficulties of assigning relative age to these ovarian bodies precluded attempting to assess ovum loss. No follicles greater than 3mm. in diameter were found.

#### Discussion

While placental scar counts as estimators of the previous year's litter size were within the range of other estimates of litter size (Table 18), the interpretation of the less distinct or light colored areas in the uterine horns was problematic. Conaway (1955) found considerable color variation in placental scars in rats, frequently in the same uterine horn. These range in color from orange to dark brown (Moberg and Conaway, 1956) or black (Conaway, 1955) in rats, older scars being darker than new ones (Moberg and Conaway, 1956). Sanderson and Nalbandov (1973) described the placental scars in captive raccoons examined from October through January, 3 to 8 months after the birth of litters, as generally pale brown, small, and slightly

opaque while those in wild females examined during the same period were larger and more opaque, often black. Color variation in placental scars might indicate differences in the time elapsing between parturition (or resorption) and examination of uteri. Although all areas of discoloration were counted as PS's, it is possible that they could have resulted from some other cause. If so, then the estimates of litter size from these counts would be biased upward. It is possible that some could have been overlooked if they were very light and this could cause underestimation of litter size.

Table 18. Estimates of mean bobcat litter size in ascending order. NS=not specified, EC=embryo counts, PS=placental scar counts, LO=litter observations, and N=number of observations.

MEAN LITTER SIZE <sup>1</sup>	N	LOCATION	METHOD	SEASON	REFERENCE
1.33 <sup>3</sup>	3	Florida	LO	NS	Doug Wassner, pers. comm.
2.0	?	Calif.	LO	NS	Lenbeck and Gould, 1979
2-5	6	Calif.	EC	NS	Young, 1958: 48
2.27	26	Virginia	PS	Winter	This study
2.5	4	Arkansas	EC	All Year	Fritts and Sealander, 1978
2.5	64	Arkansas	EC-PS	All Year	Fritts and Sealander, 1978
2.67 (1-5)	97	Texas	EC-PS	NS <sup>2</sup>	Blankenship and Swank, 1979
2.69	100	Arizona	EC	NS	Young, 1958: 49
2.8 (1-7)	52	Wyoming	PS-EC-LO	All Year	Crowe, 1975
2.8	16	Idaho	LO	Winter	Bailey, 1974
3.0	124	Kansas	PS	NS <sup>4</sup>	Johnson, 1979
3.0	2	Florida	LO	NS	Doug Wassner, pers. comm.
3.04	27	Oregon	PS	Trap Season	Toweill, 1980
3.2 (1-8)	356	Utah	EC	NS <sup>2</sup>	Gashwiler, et al., 1961
3.2	37	Minn.	PS	Winter	Berg, 1979
3.5 (1-6)	47	Utah	LO	NS <sup>2</sup>	Gashwiler et al., 1961
3.9 (3-5)	12	Utah	PS	NS <sup>2</sup>	" "
4.0	2	Virginia	LO	NS	Progulske, 1952

<sup>1</sup> Figures in parentheses are the range.

<sup>2</sup> Probably winter.

<sup>3</sup> Apparent mange epizootic noted during the period.

<sup>4</sup> Probably winter. Carcasses received from trappers.

Descriptions of placental scars are sparse and the paucity of published information on their longevity and their appearance at various intervals postpartum make interpretation of apparent uterine scars difficult. The absence of these discolorations in juvenile females suggests that if they were not PS's, then they must have been caused by some agency that affects only adult animals. In any case, the results of counting PS's must be regarded with caution, and population characteristics based on estimates of litter size were also done using other estimates drawn from the literature. The mean litter size of 2.27 kittens from this study may underestimate the actual mean litter size in Virginia because of the relatively small sample size. The accuracy of this technique is open to question. Counts of placental scars could possibly overestimate litter size since they only indicate fetal implantation. Prepartum losses and stillbirths could reduce this number. The author prefers to consider the estimated litter size based on PS counts as a probable maximum.

Martin et al. (1976) suggested that placental scar counts could underestimate litter size, depending on the time between parturition and uterus examination, due to migration and dispersal of macrophages (which are the source of the discoloration characteristic of placental scars) into

the area of circular muscle in the uterine wall, thus effectively concealing the scars. It would seem, though, that macrophage migration should occur essentially simultaneously throughout the uterus and therefore all placental scars should disappear at roughly the same time. This would result in an apparent absence of placental scars with OB's present in the ovaries, which would appear to indicate early reproductive failure. If, however, migration was well advanced at the time of examination it may be possible that slight differences in the extent of the scar or rates of migration could effectively conceal 1 or more scars while others were faintly visible. The time between parturition (or resorption) and uterus examination could also affect the accuracy of these estimates. Elder (1952) found that in ranch-raised Minnesota mink with known reproductive histories, nearly all placental scars had disappeared by December.

The extent of ovum loss is suggested by the yearling female which had 4 OB's and 2 PS's, but inferences based on this single case are risky. The likelihood that some bobcats may breed in their first breeding season precludes estimating ovum loss in older age classes unless it can be determined whether OB's present are from a current or prior breeding season (Hossmann and Duke, 1973; Crowe, 1975b;

Fritts and Sealander, 1978a). The subtlety in the variation of OB pigmentation was considered to preclude confident judgement of which were from previous years' breeding. The term OB was used to denote these structures since more precise terminology (e.g., corpora lutea, corpora albicantia) implies a distinct identity based on color which was not found in these specimens.

The extent of prenatal mortality is conjectural but the few accounts of observations of bobcat kittens (Progulske, 1952; Gashwiler, et al., 1961; Hassmer, Douglas. 1981. pers. comm.) suggest that the mean litter size exceeds 3 kittens with a mode of 4.

Appendix 2

LEGENDS FOR APPENDICES 3 THROUGH 9

The appendices which follow are reduced reproductions of the questionnaires and cover letters mailed to various people throughout the state in the mail survey discussed earlier. The titles therefor do not appear on the appendices but are presented here.

<u>APPENDIX NUMBER</u>	<u>PAGE</u>	<u>TITLE</u>
3	118	Cover letter for the hunter and trapper questionnaires.
4	119	Hunter questionnaire.
5	120	Trapper questionnaire.
6	121	Cover letter for the fur buyer and taxidermist questionnaire.
7	122	Fur buyer/taxidermist questionnaire.
8	123	Cover letter for Game Warden questionnaire.
9	124	Game Warden questionnaire.



COLLEGE OF AGRICULTURE AND LIFE SCIENCES

## VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

*Blacksburg, Virginia 24061*

SCHOOL OF FORESTRY AND WILDLIFE RESOURCES—DEPARTMENT OF FISHERIES AND WILDLIFE SCIENCES



Dear Sportsman:

I am requesting your help in compiling information on bobcats. Many of you have already made a valuable contribution to the knowledge of Virginia's bobcats.

I need to know more about the distribution of bobcats and whether they are increasing in numbers or becoming scarcer. Over 200 bobcats were reported harvested in the 1978-79 season and over 300 were reported for 1979-80. This information was gained from the pelt tagging program. In a number of localities, no bobcats were recorded in either year. I need to learn if they are actually absent from those counties or simply not killed or reported. Only those pelts being sold are required to be tagged and many sportsmen prefer to keep the pelt as a valuable trophy. Therefore, harvest records may not accurately show the total kill or the areas where bobcats exist.

Please answer the enclosed questionnaire and return to me in the enclosed self-addressed, stamped envelope. All answers will be held in strict confidence. I wish to thank you in advance for your cooperation and wish you a successful and enjoyable outdoor season.

Yours truly,

Richard B. Drinkwater  
Research Assistant  
Va. Cooperative Wildlife  
Research Unit

kw  
Enclosure

## TRAPPER QUESTIONNAIRE

NAME \_\_\_\_\_ TELEPHONE: \_\_\_\_\_

ADDRESS \_\_\_\_\_

1. For how many years have you been trapping? \_\_\_\_\_
  2. How many bobcats do you trap each year (average)? \_\_\_\_\_
  3. In what counties do you usually trap?  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
  4. How many days (approximately) did you trap last season? \_\_\_\_\_
  5. How many traps did you usually set each day? \_\_\_\_\_
  6. How did you trap your bobcats this past season?  
 Incidental to fox trapping.  
 In trap set for bobcat.  
 Other (please describe) \_\_\_\_\_
- 
7. In your opinion, how does the bobcat population compare with 5 years ago?  
 More plentiful than 5 years ago.  
 About the same.  
 Less plentiful than 5 years ago.  
 No opinion.
  8. Comments. Please add any comments or thoughts you would like to offer regarding populations, regulations, sightings, or anything else concerning bobcats.

## HUNTER QUESTIONNAIRE

NAME \_\_\_\_\_ TELEPHONE \_\_\_\_\_

ADDRESS \_\_\_\_\_

1. How many years have you been hunting? \_\_\_\_\_
2. How many years have you hunted bobcats? \_\_\_\_\_
3. How many days did you hunt last season? \_\_\_\_\_
4. Did you hunt with dogs? \_\_\_\_\_
5. What animals did you hunt?
  - Bobcats       Bear       Fox       Raccoon       Deer
  - Rabbit       Other (Please describe) \_\_\_\_\_
6. How many days (or nights) did you hunt for bobcats? \_\_\_\_\_
7. Approximately how many bobcats do you bag per year (average)? \_\_\_\_\_
8. In what counties do you do most of your hunting?
   
\_\_\_\_\_
   
\_\_\_\_\_
   
\_\_\_\_\_
9. In what counties did you hunt for or kill bobcats?
   
Hunted: \_\_\_\_\_ Killed: \_\_\_\_\_
   
\_\_\_\_\_
   
\_\_\_\_\_
10. In your opinion, are bobcats:
  - More numerous than 5 years ago       Less numerous than 5 years ago
  - About the same       No opinion
11. Comments: Please add any comments or thoughts you would like to offer regarding populations, regulations, sightings, or anything else concerning bobcats.



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*Blacksburg, Virginia 24061*

SCHOOL OF FORESTRY AND WILDLIFE RESOURCES—DEPARTMENT OF FISHERIES AND WILDLIFE SCIENCES



Dear Sir:

I am requesting your help in compiling information on bobcats. Many of you have already made a valuable contribution to the knowledge of Virginia's bobcats and such help is much appreciated.

I need to learn more about the distribution of bobcats and whether they are increasing or becoming scarcer. Over 200 bobcats were reported taken in the 1978-79 season and over 300 were reported in 1979-80. This information was gathered from the pelt tagging program. In a number of counties, no bobcats were recorded as killed in either year. I need to find out if they are absent from those localities or simply not killed or recorded. Since only those pelts to be sold are required to be tagged, it seems possible that many are kept as a trophy. There exists also the possibility that some bobcats are tagged in counties other than the one in which they were taken. Thus, the records may not accurately indicate the total kill or distribution, and I need information from those most likely to have good knowledge of the animals in their areas.

Please answer the enclosed questionnaire and return to me in the enclosed self-addressed, stamped envelope. All answers will be held in strict confidence. I wish to thank you in advance for your cooperation and wish you a successful and enjoyable season this year.

Yours truly,

Richard B. Drinkwater  
Research Assistant  
Va. Cooperative Wildlife  
Research Unit

kw  
Enclosure

FUR BUYER/TAXIDERMIST QUESTIONNAIRE

NAME \_\_\_\_\_ TELEPHONE \_\_\_\_\_

ADDRESS \_\_\_\_\_

1. For how many years have you been a fur buyer or Taxidermist? \_\_\_\_\_
2. How many bobcats or bobcat pelts did you receive this last season? \_\_\_\_\_
3. Is this more or less than last year or about the same number? \_\_\_\_\_
4. Do you have more, fewer, or about as many customers as last year? \_\_\_\_\_
5. Have you raised your prices within the last 5 years (taxidermists only)? \_\_\_\_\_
6. In your opinion, are there more people hunting and/or trapping for bobcats than 5 years ago? \_\_\_\_\_
7. In your opinion, are there more people hunting and/or trapping for fox than 5 years ago? \_\_\_\_\_
8. From which counties do you get most of your customers?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

9. Comments. Please add any comments or thoughts you may like to offer regarding populations, regulations, sightings, or anything else concerning bobcats.



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*Blacksburg, Virginia 24061*

SCHOOL OF FORESTRY AND WILDLIFE RESOURCES - DEPARTMENT OF FISHERIES AND WILDLIFE SCIENCES



Dear Warden:

I am requesting your help in compiling information on bobcats. Most of the information presently available is based on harvest records and some laboratory studies and is limited as to distribution statewide.

Some counties have not been represented in tag records and others have shown marked changes in numbers of bobcats taken. I suspect that a substantial number of bobcats are taken by hunters and kept as trophies, and this not reflected in tag records. There is also some doubt in my mind as to whether some cats are tagged in counties other than the one in which they were killed. I also feel that people who are in the field may be able to shed more light on the existence of bobcats, especially in areas where trapping pressure is light or nonexistent.

Please answer the enclosed questionnaire and return to me in the enclosed self-addressed, stamped envelope. All answers are to be held in strict confidence. I wish to thank you in advance for your cooperation.

Yours truly,

Richard B. Drinkwater  
Research Assistant  
Va. Cooperative Wildlife  
Research Unit

kw

Enclosure

## GAME WARDEN QUESTIONNAIRE

The following information is requested as a supplement to tag information in estimating the distribution of bobcats:

1. Do you believe that bobcats are present in the county? \_\_\_\_\_
2. If so, why?
  - ( ) Sighted
  - ( ) Heard
  - ( ) Reported by others (Please explain) \_\_\_\_\_
  - ( ) Damage complaint (Please explain) \_\_\_\_\_
  - ( ) Tracks sighted \_\_\_\_\_
  - ( ) Pelts tagged \_\_\_\_\_
3. Of the pelts you have tagged last season, were they taken mostly by hunters or trappers? \_\_\_\_\_
4. Do you believe that substantial numbers of bobcats are delivered to taxidermists without being tagged? \_\_\_\_\_
5. In your opinion, are more bobcats taken in:
  - ( ) traps set for bobcats?
  - ( ) traps set for other species?
6. In your opinion, is the population of bobcats in your county or area:
  - ( ) increasing?
  - ( ) decreasing?
  - ( ) steady?

Comments: Please add any comments you would like to offer regarding populations, regulations, sightings or anything else concerning bobcats.

Name \_\_\_\_\_ County \_\_\_\_\_

## APPENDIX 10

### List of Cooperators

Fred H. Alger	Larry Mohn
Beverly M. Anderson	Johnny Morris
Howard L. Anderson	Charles Mullins
Emmet Artrip	E.D. Mullins
Mack Atkinson	Clem O'Brine
Alvin Ayers	Richard Patterson
A.R. Bryant	Rodger Propst
Charles D. Cave	Alvin B. Purvis
R.B. Chenault	Claude A. Roberts
Grover C. Childress	John G. Roberts
James Clifton	George Robertson
Victor Craighead	Sandy Shelor
R.W. Duncan	James F. Shiflett
H.K. Ferguson	Jerry Sias
Howard Gillespie	John A. Slowasky
Larry Gray	John C. Spraker
Marvin Groseclose	Willard E. Starkey
Dick Hansberger	W.H. Taylor
Steve Harless	Tom Teichler
Giles R. Heflin	Robert Tripp
Chris Holt	R.A. Weakley

Fred A. Howery

A.L. Jenkins

Odell Little

D.H. Martin

Charles Wells

Barrie M. Whitt

Wilcox Bait and Tackle

Harmie Wiley

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