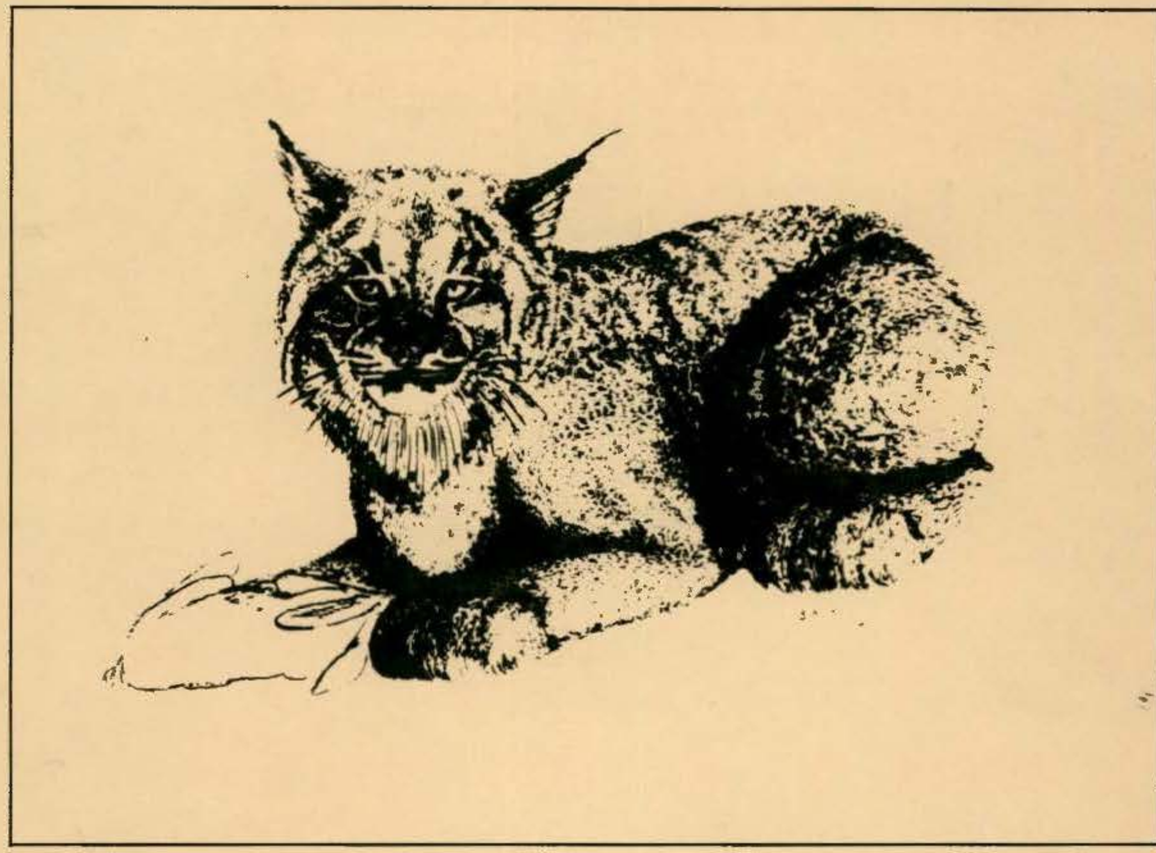
Alaska Department of Fish and Game
Division of Wildlife Conservation
Federal Aid in Wildlife Restoration
Research Final Report

DEVELOPMENT OF TECHNIQUES FOR EVALUATING LYNX POPULATION STATUS IN ALASKA



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Project W-23-1
Study 7.13
December 1989

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FINAL REPORT (RESEARCH)

State: Alaska

Cooperator: None

Project No.: W-23-1 Project Title: Wildlife Research and Management

Study No.: 7.13 Job Title: Development of Techniques for Evaluating Lynx Population Status in Alaska

Period Covered: 1 July 1986-30 June 1988

SUMMARY

We evaluated 4 techniques, or data sources, useful for lynx (Lynx canadensis) management in Interior Alaska, including mapping of trapline distribution, simulation modeling, refining pelt measurements to discriminate between kitten and adult lynx, and evaluating the relationship between track frequency and population density. The distribution of traplines relative to potential lynx habitat in Interior Alaska suggests that untrapped areas (areas more than 10 mi [16 km] from traplines) represent only a small percentage of the potential habitat, especially in road-connected management units.

A computer model employing 9 population variables and using values for periods of prey scarcity and abundance reported in the literature was developed. Computer simulations were conducted to assess the effects of harvest levels on the growth of the lynx population. The results of these simulations supported the use of a tracking harvest strategy in areas where trapping is an important source of mortality.

The relationship between age and pelt length and width was evaluated for 338 adults and 157 kittens. Kitten and adult pelt lengths were clearly separated; pelt lengths of 34 to 36 inches (86.5-91.6 cm) represented the upper limits for kitten pelts. Most kittens occurred in the 30- to 34-inch length classes. Pelt width appeared to be of little use in discriminating between adults and kittens, because, in part, it is not well standardized. The length of ear tufts and throat ruffs also appeared to be useful for reliably separating adults and kittens. Pelt lengths (ADF&G files) obtained from

Units 12, 20, 21, 24, and 25 from 1977 to 1988 were analyzed. The percentage of pelts less than 34 inches (86.4 cm) ranged from zero to 28.3%. A relatively high proportion of kittens in the harvest occurred between 1977 and 1981, corresponding to the high phase of the lynx-hare cycle.

Population density estimates were compared with the frequency of lynx tracks measured concurrently in the Tok and Wood River study areas. Annual changes in track accumulation rates were weakly correlated with changes in population density; the 2 indices showed the greatest divergence in years when snowshoe hares (*Lepus americanus*) were at or near minimum abundance. This pattern may have resulted from a change in lynx travel rate that apparently occurred below a certain hare density. Evaluating the usefulness of track counts as an index to lynx numbers may require obtaining track counts and population data at medium and high densities of lynx.

Key Words: Interior Alaska, lynx, *Lynx canadensis*, population ecology, population estimate, pelt measurement, survey, tracks.

CONTENTS

BACKGROUND

The ecology and management of lynx (Lynx canadensis) have become major topics of concern among North American wildlife biologists, trappers, and conservationists (Brand and Keith 1979, Quinn and Parker 1987). The combination of increased human population and a marked rise in pelt value during the last 2 decades has resulted in increased trapping pressure on lynx (Quinn and Parker 1987), heightening management concern for a more closely regulated harvest.

For more than 2 decades, wildlife researchers have refined our knowledge of the ecology of lynx. The cyclic fluctuations of lynx and snowshoe hare (Lepus americanus) populations have been studied (Keith 1963, Fox 1978, Finerty 1979, Winterholder 1980); food habits, movements, and reproductive biology have also been investigated (Saunders 1961, Nava 1970, Nellis et al. 1972, Berrie 1973, Brand et al. 1976, Brand and Keith 1979, Parker et al. 1983, O'Connor 1984); however, a more refined management of lynx has been hampered by an inability to reliably estimate numbers of lynx over large areas. These numbers have been determined in only a few relatively small areas through intensive field work (Iurgenson 1955, Brand et al. 1976, Parker et al. 1983, Stephenson 1986, Schwartz and Becker 1988). A primary goal of this study is the development and evaluation of techniques for estimating relative and/or absolute lynx density throughout Alaska.

The results of track surveys conducted in the Tok and Wood River study areas between 1982 and 1985 have been described by Stephenson (1986). This report includes data from 3 additional field seasons in the Wood River area as well as a reevaluation of previous track surveys in the Tok and Wood River areas. In addition, we explored the relationship between pelt measurements and age and developed methodology for using available lynx pelt-sealing data to monitor the lynx-hare population cycle. This report also describes trapline distribution in Interior Alaska so that trapping intensity and extent of trapped and untrapped lynx habitat can be understood. Finally, the effects of various harvest strategies on lynx population dynamics were evaluated through simulation modeling. This report also includes a historical review of the harvest and population trends (Appendix A) and a historical summary of the trapping seasons (Appendix B).

OBJECTIVES

Job 1. To employ computer modeling to maximize the interpretive value of available information on lynx population dynamics.

Job 2. To map trapline distribution in Interior Alaska so that trapping intensity and the extent of trapped and untrapped lynx habitat can be described.

Job 3. To refine pelt measurement criteria that can be used to separate kitten and adult lynx and to apply these criteria to the pelt sealing data obtained since 1977-78.

Job 4. To evaluate the relationship between track frequency and population density and develop a technique for estimating relative and/or absolute lynx numbers in large areas where access is limited and more intensive census methods are impractical.

STUDY AREAS

This study involved a review and analysis of harvest and pelt measurement data pertaining to a broad area in Interior Alaska, including Game Management Units 12, 20, 21, 24, and 25, as well as continued track surveys in the Wood River study area; i.e., 40 miles (64 km) south of Fairbanks. Trapping and track counts were begun on 13 March 1984 along a 25-mile (40-km) trail that included parts of the Rex and Bonnifield Trails. This area consists of mixed mature spruce and hardwood stands in the vicinity of the Wood River and open spruce muskeg and aspen/spruce parkland on higher elevations south and west of the Wood River. The study area is bounded on the east by the 1980 Blair Lakes burn, and its elevation varies between 700 and 1,200 feet (215 and 360 m). In addition to the intensive field work described above, trappers in Fort Yukon, Tok, Delta, Nenana, and Fairbanks were contacted for information on the status and history of lynx populations.

METHODS

Job 1. Population Model

The objectives of constructing a lynx population model were to evaluate (1) the strengths and weaknesses of current knowledge and assumptions about population dynamics and (2) the relative importance of various factors influencing lynx numbers. The model is a tool that wildlife managers can use to explore the potential effects of various harvest strategies and determine the adequacy of available data on lynx population status relative to cyclic changes in density, productivity, and survival.

The deterministic model was constructed using Lotus 1-2-3 software (D. Reed, ADF&G, unpubl. model). The model incorporates 10 population variables including winter (Nov-Apr) mortality for adults, kittens, harvest rates for adults and kittens, incidental harvest rate, fecundity of adult and short-yearling females, sex ratio (expressed as percentage of females), and summer (May-Oct) mortality for adults and kittens.

A range of values for the population variables was developed from the literature. Two sets of values representing population characteristics during periods of snowshoe hare scarcity and abundance were developed to assess harvest regimes of lynx during these phases of the lynx-hare cycle.

After population variables had been entered and the numbers of adults and kittens in the fall (i.e., pretrapping season) population provided, the model calculated the number of adults and kittens harvested, adults and short-yearlings remaining in May, kittens produced, pre- and post-harvest populations, total annual mortality, fall numbers of adults and kittens in the succeeding year, etc. Simulations usually covered 3- to 5-year periods to approximate the length of the low and high phases of the lynx-hare cycle.

Job 2. Trapline Mapping

The distribution of traplines in Units 12, 19, 20, 21, 24, and 25 was determined using records maintained by the Alaska Trappers Association (i.e., voluntary trapline registration program, Natural Resource Office, Fort Wainwright, Fairbanks), and through interviews with knowledgeable trappers and biologists in various parts of the Interior. Information on trapline distribution in parts of Unit 25 was obtained from the files of the Yukon National Wildlife Refuge. In addition, both published and unpublished data on trapline distribution near villages were obtained from the Subsistence Division, Alaska Department of Fish and Game, Fairbanks.

Trapline information was compiled on 1:250,000-scale topographic maps. In most cases we were able to delineate the actual trails used by trappers. Because of the mobility of trappers using aircraft, some trapping areas could not always be identified.

In this report the term "refugia" refers to habitat that is not trapped, whether or not it is lynx habitat. The general extent to which lynx habitat is included in refugia is described when possible; where this has not been determined the term "potential refugia" is used. To identify potential untrapped refugia, we delineated areas that were more than 10 miles (16 km) from a trapline; i.e., average home-range diameter for lynx. In studies of radio-collared lynx in Canada and Alaska, the maximum home range diameter has ranged from 3 to 17 miles (5 to 27 km) (Parker et al. 1983, Ward 1985, Stephenson 1986). One of the major management concerns is the survival of lynx through the 3- to 5-year periods of hare scarcity. Lynx travel more widely when hare numbers are low than when hares are abundant (Ward 1985).

For Units 20 and 25 we estimated the maximum extent of potential lynx habitat by determining the area of land below timberline; i.e., 3,000-4,000 feet (900-1,200 m) in most areas. This figure was used to place the estimated extent of refugia in perspective.

Job 3. Pelt Measurements

To evaluate the usefulness of pelt measurement criteria in separating kitten (<1 yr) and adult (>1 yr) lynx, we analyzed measurements for 338 adults and 157 kittens. Most data were obtained from lynx sealed during the previous 2 winters (i.e., 1986-87 and 1987-88). Prior to winter 1986-87, we asked a number of experienced fur buyers and sealers to indicate whether lynx pelts were kittens or adults with a notation next to the recorded length and width measurements. This classification was based on their extensive experience and familiarity with differences in the size and quality of pelts, as well as and other distinguishing pelt characteristics. In addition, we used measurements from 24 adults and 4 kittens for which age had been verified by carcass examination and cementum analysis and 34 adults and 61 kittens that had been classified by Dean Wilson (a fur buyer) during winter 1987-88. This resulted in a "known-age" sample of 338 adults and 157 kittens. For lynx pelts examined during 1987-88, we measured the lengths of the ear tufts and cheek ruff hair as well as the length and width of the pelts. In all cases, pelt length was the distance from the tip of the nose to the base of the tail. Width measurement was usually the distance across the fur at the hips, although some fur sealers recorded the distance across the hide. All original measurements were in inches. In cases where fractions of an inch were recorded, those less than 0.5 inches (1.3 cm) were rounded down and those greater than or equal to 0.5 inches were rounded up to the nearest whole number.

Differences in ear tuft and throat ruff lengths were also evaluated, based on measurements from 35 adults and 62 kittens. The Mann-Whitney U test (corrected for ties) was used to statistically evaluate differences in adult and kitten pelt measurements.

Based on pelt measurements obtained each year since winter 1977-78, we estimated the proportion of kittens in the annual harvests from each Interior management unit. Prior to this analysis, considerable effort had been devoted to checking all sealing records for correct dates and location codes, identifying and entering new sealing data into computer files, and recoding sealing data for the years prior to 1984-85 so that management unit boundary changes affecting Units 20 and 25 could be incorporated. Pelt length distribution was determined for 19,653 lynx harvested from 1977-78 through 1987-88 in Units 12, 20, 21, 24, and 25.

Job 4. Track Surveys

Efforts to radio-mark lynx and record lynx tracks in the Wood River study area continued in 1986 and 1987 using techniques described by Stephenson (1986). Field work was conducted from 28 February through 25 March 1986, 28 February through 20 March 1987, and 22 November through 9 December 1987. During these periods a 25-mile (40-km) triangular route (i.e., including portions of the Bonnifield and Rex Trails and the Wood River) was traveled daily by snow machine to check traps and record lynx track intercepts. The location and orientation of lynx tracks along these trails were recorded on 1:63,360-scale maps to determine the rate of track accumulation in each study period.

In previous analyses (Stephenson 1986), the technique used to "score" lynx track intercepts differed from that used in this report. Lynx sometimes travel on trails for several hundred yards, or they may cross a trail several times in the space of several yards. Our earlier method scored only 1 track crossing when track size and other characteristics suggested that multiple crossings of a trail within 100 yards (91.4 m) had been made by 1 lynx. The unnecessary subjectivity introduced by this method has caused us to alter the criteria for scoring track intercepts. To reduce subjectivity, we standardized the criteria by defining a track intercept as any lynx trail encountering the survey route that could not be connected to an adjacent trail, based on a visual examination from the survey route. When more than 1 set of lynx tracks was identified (usually family groups), a track intercept was scored for each individual. Track counts conducted prior to winter 1985-86 have been revised using these new criteria; thus track occurrence has increased, compared with the values presented and discussed by Stephenson (1986). We used a Student's t-test to evaluate differences in mean rates of track accumulation in the Tok and Wood River study areas.

Thirty to 40 No. 1-1/2 soft-catch leghold traps (Woodstream Corp., Lititz, Pa.) and 10 to 20 live traps (Tomahawk Live Trap Co., Tomahawk, Wisc.) were used to capture lynx. While field work was in progress, radio-marked lynx were relocated once or twice using a hand-held directional "H" antennae (Telonics, Mesa, Ariz.). A Piper PA-18 or Cessna 180 aircraft equipped with dual "H" antennaes was used for aerial telemetry.

In the Wood River study area, early winter numbers were estimated by adding the known harvest to the number marked and unmarked lynx that had been estimated after 16-35 days of field travel during late winter. However, estimates for winter 1987-88 were calculated by adding known mortality to the numbers estimated from field travel during early winter. Field estimates are based on a combination of aerial and ground radio-locations of marked lynx and concurrent observations of tracks along 25-60 miles (40-97 km) of trails. Lynx tracks that could not be accounted for by the known movements of radio-collared lynx were interpreted as being those of unmarked lynx. The number of unmarked individuals was estimated, based on the assumption that home range and movement rates for unmarked lynx were similar to those of radio-marked lynx. This assumption involved deciding whether lynx tracks observed at various times in different parts of the study area were made by the same or different animals. Differences in track and group sizes often aided in separating individuals. We recognize that our estimates of density and track frequency are not entirely independent, because estimates of lynx numbers are based partially on track occurrence. We assumed that lynx trapped or otherwise accounted for were residents. This assumption would, if incorrect, cause us to overestimate lynx numbers.

RESULTS AND DISCUSSION

Job 1. Population Modeling

Input Variables:

Sex Ratio. In most simulations we assumed an even sex ratio. We also explored the potential effects of disparate sex ratios by varying the proportion of females from 0.3 to 0.7. Brand and Keith (1979) and Ward (1985) assumed 50:50 sex ratios for all age classes.

Sex ratios for lynx populations were based primarily on carcass collections and secondarily on live-trapped lynx and information from pelt sealing documents. The misidentification of sex may have caused some inaccuracy in the reported sex ratios. The most frequent error was incorrectly identifying males (especially juveniles) as females. McCord and Cardoza (1982) reported a 17% rate of error in sexing bobcats in Vermont, concluding that bobcat pelts could not be reliably sexed based on genitalia. Because reproductive organs can be examined, the most reliable data are from carcasses.

The proportion of females in trapped samples from various lynx populations ranged from 32% to 67% (Van Zyll de Jong 1966, Mech 1980, Parker et al. 1983, Quinn and Thompson 1987). Where females constituted a high proportion of the harvest, hares were scarce; in contrast, when a preponderance of males was reported, hares were abundant. However, sex ratios not significantly different from 50:50 have been reported at all levels of hare abundance (Mech 1980, Brand and Keith 1979, Van Zyll de Jong 1963). Although Stewart (1973) found an equal sex ratio for all age classes combined, there was a preponderance of males among yearlings.

Koonz (1976) reported male:female ratios in Manitoba of 56:44, 57:43, 43:57, and 32:69 during 4 winters from 1972 to 1975, respectively. More females were trapped when hares were scarce; however, only small samples (18 carcasses in 1975) were available in those winters when females predominated. He hypothesized that males are more vulnerable to trapping because of greater mobility and are removed more rapidly than females during the declining phase of the population, accounting for the preponderance of females when hares were scarce. During a period of hare abundance in Ontario, Quinn and Thompson (1987) found that adult sex ratios in low, medium, and high harvest density zones were not significantly different.

<u>Trapping Mortality</u>. In this model, we assumed that trapping mortality was additive to other types of mortality. Intensive studies involving radio-collared or otherwise marked animals in Minnesota, Washington, Montana, Alaska, and various jurisdictions in Canada have shown that annual mortality from trapping is high, compared with other furbearer species, at least where trapping occurs at even moderate levels.

In Alaska, Baily et al. (1986) estimated trapping mortality in a heavily trapped area on the Kenai Peninsula at 65-80%. In our study near Tok, all 4 radio-marked lynx were trapped within 49 days of being released. In the Wood River study area, trapping mortality during 3 winters (i.e., 1983-84 to 1985-86) was estimated at 55%, 17.7%, and 41%, respectively.

During the 1st winter (1983-84), this area had been trapped at a normal level until mid-February. During the 2nd winter, the resident trapper tried to avoid catching lynx, but the high number of traps set for other species resulted in an incidental catch of 3 lynx that could not be released. During the 3rd winter, the trapper attempted to capture and radio-collar lynx, but because of trap injuries (traps were checked about every 3 days), 7 lynx were killed. During 2 subsequent winters (i.e., 1986-87 and 1987-88) estimated mortality rates were 7.7% and 9.1%, respectively. These lower rates appeared to result from increased efforts to avoid catching lynx, including the use of wolverine (Gulo gulo) gland lure at cubby sets and a reduced number of sets in areas used regularly by lynx.

Nellis et al. (1972) reported that 3 of 9 lynx tagged in Alberta had been trapped within 1 year; the fate of the remaining 6 was not determined. Mech (1980) determined that at least 7 of 14 radio-marked lynx in Minnesota were killed by humans. In Manitoba 5 lynx marked in a national park were all trapped outside the park boundaries within 27 months (Carbyn and Patriquin 1983). Parker et al. (1983) reported that 13 (65%) of an estimated 20 lynx in a study area on Cape Breton Island were trapped during 1 trapping season. Ward (1985) radio-marked 11 lynx in a sanctuary (i.e., closed to hunting and trapping) in the southwestern Yukon between February 1982 and June 1984. Seven of these lynx were trapped when they traveled outside the sanctuary and only 2 of 9 lynx that left the sanctuary during the open trapping season were not trapped. Trapping mortality of marked lynx was 71% and 33%, respectively, during these 2 winters.

Ward (1985) summarized the results of North American studies of marked lynx and concluded that 55% of 66 marked lynx died from human-related causes. In contrast, natural mortality in these studies was 5.6% annually. Quinn and Thompson (1987) calculated trapping mortality rates of 46% for males and 28% for females in Ontario, based on sex and age distribution in a trapped sample of 993 lynx. Annual trapping mortality was estimated to be approximately 40%, accounting for nearly all mortality experienced by the population. The high trapping mortality indicated by the above studies is in agreement with the opinions of experienced trappers in Alaska, whose estimates of trapping mortality range from 30% to 90% in areas where trapping occurs at moderate or high levels.

In a previous unpublished status report (ADF&G files), estimates of lynx density from various studies were used in combination with harvest figures to estimate the proportions of lynx populations removed annually by trapping in Units 20 and 25. This analysis suggested that harvest rates of 25-86%

are typical of most subunits. The proportion of lynx harvested may not differ greatly between highs and lows in the lynx cycle, but there are some factors that act to increase the proportion harvested during lows, including a more limited population distribution, greater individual travel rates, larger individual home ranges, and a possibly greater susceptibility to trap sets employing bait because of scarcity of prey. These factors could be easily offset by the reduced trapper effort resulting from a a scarcity of lynx or because remaining lynx are relatively "trap shy." However, high pelt prices in recent years have tended to keep trapper interest high. We used a wide range of harvest rates in model simulations to explore the effects of this highly variable and controllable factor.

In evaluating harvest effects on lynx, the potential for some type of compensatory mechanism should be considered. If nontrapping mortalities (e.g., starvation) declined as a result of reduced densities resulting from trapping, the effects of trapping could be compensated for to some extent. This would require the existence of a density-dependent source of mortality. Although no such mechanism has been described, it has been suggested that one may exist; i.e., more hares may be available for the remaining lynx and thereby increase their survival if lynx numbers were reduced by trapping.

The existence of an effective compensatory mechanism is unlikely. First, the 3- to 5-year scarcity of hares following a food-induced crash is influenced by the combined effect of predators (e.g., hawks, owls, foxes) (Keith et al. 1977). Therefore, a reduction in lynx numbers from trapping would not necessarily cause a proportional reduction in the level of predation on hares. Second, it appears that the adult lynx that remain after a crash in hare numbers are able to remain in good nutritional condition, apparently because of their skill in hunting.

Data from studies of marked lynx (Ward 1985, Bailey et al. 1986) indicate that during most parts of the lynx-hare cycle natural mortality among lynx is 5% or less. Immediately following a crash in hare numbers, natural mortality (especially among juvenile and yearling lynx) may be higher, but this higher mortality probably would not characterize more than a few years in the cycle. The apparent absence of consistently high levels of natural mortality means that there is no source of compensatory mortality other than the human-related one cited above. While one can imagine some minor compensation at certain points in the cycle, it is difficult to envision any factor that would compensate appreciably for the levels of mortality associated with trapping. Thus, in conformance with the assumptions of other investigators (Brand

and Keith 1979, Ward 1985, Quinn and Thompson 1987), our model assumes that trapping mortality is additive to other types of mortality.

Trapping-related Mortality. In our model, we estimated nonsealed, harvest-related mortality at 1% of the sealed harvest, recognizing that the sealed harvest is minimal. For a variety of reasons, a small number of trapped lynx are not sealed. Each year a small number of pelts are ruined (because of predation on trapped animals by wolves, wolverines, or other lynx; damaged by scavengers, including various small mammals and birds; or lost. In addition, some kittens die from starvation after adult females are trapped. On the Kenai Peninsula, 3 nontrapping mortalities occurred, and these were believed to have been trapping-related; i.e., 2 kittens starved after their mothers had been trapped and 1 kitten released by a trapper died, presumably because of a leg injury but also after its mother had been trapped (Bailey et al. 1986).

Natural Mortality. We assumed relatively low rates of natural mortality (i.e., from 1% to 5%) for adults during summer and winter and for kittens during winter. The assumed summer mortality among kittens varied widely (from 10% to 90%), depending on the phase of the cycle being simulated. However, there is little information concerning natural mortality for lynx, especially among yearlings and adults. The few reports addressing natural mortality involve feral dogs killing lynx in Newfoundland (Saunders 1961), predation on a lynx by mountain lions (Koehler et al. 1979), intraspecific strife (Seton 1911), and starvation of 1 of 11 marked lynx (Ward 1985). Brittell et al. (1989) estimated that natural mortality was 11.3% for 25 radio-collared adult and yearling lynx in an untrapped area when hares were scarce. Although Bailey et al. (1986) calculated an off-season mortality rate of 29% in 1983, he concluded these deaths were trapping related. As previously described, natural mortality among marked lynx in several North American studies averaged only 5.6% annually (Ward 1985). Similarly, natural mortality among adult bobcats (*Felis rufus*) was estimated at 3%, based on a study of 35 resident bobcats (Bailey 1972).

Based on a population model, estimated nontrapping mortality rates during a decline in the hare population (May-November) ranged from 54% to 68% during 4 of 5 years, dropping to 34% during the 5th year (Brand and Keith 1979). For 3 of these 5 years, the calculated age-specific nontrapping mortality rates ranged from 65% to 95% for kittens and 7% to 38% for adults. High summer mortality of kittens when prey are scarce is suggested by the near absence of kittens in the early winter populations. Although this is partly a result of lowered reproduction, especially among yearling females, examination of female reproductive tracts has shown that a considerable number of adult females continue to breed and bear young, even when hares are scarce (O'Connor 1984). Brand and Keith (1979) estimated that nontrapping mortality averaged 50-79% of the total mortality. These nontrapping mortality estimates for adults were not used in our model because they have not been corroborated by evidence from field studies of marked lynx, which have generally shown low natural mortality rates, even when prey are scarce.

Age Distribution in Trapped Samples. To select age structure values representing different phases of the hare cycle, we reviewed values obtained during winters following periods of hare abundance or hare scarcity. Previously, changes in age distribution in lynx populations during different phases of the lynx cycle have been inferred primarily from data on harvested lynx. The abundance of hares influences lynx reproduction and kitten survival, which are reflected in the proportions of kittens and adults during winter (Brand and Keith 1979).

In many of our modeling simulations, initial populations were set at 100 adults and 50 (33%) kittens. In most studies after hares had peaked (i.e., abundant), approximately 30% of the lynx harvest consisted of kittens (Stewart 1973, Parker et al. 1983, O'Connor 1984). For some studies, we pooled data on age distribution from several areas to increase the sample size; e.g., Stewart (1973) reported age structures for 5 areas or years. The data we pooled yielded 29% kittens overall ($\underline{n}$ = 129) and represented a period of general hare abundance. Koonz (1976) found 40% kittens in the Manitoba harvest in 1971-72. Pooled data from a part of Alberta (Van Zyll de Jong 1963) indicated 18% of the harvest were kittens during 1961, 1962, and part of 1963, when hares were abundant but declining. The proportion of kittens in a sample of 993 lynx trapped during a period of hare abundance in Ontario was 18.9% (Quinn and Thompson 1987).

When hares are scarce, the proportion of kittens in the harvest drops to approximately 10% (O'Connor 1984) or less (Koonz 1976, Keith et al. 1979, Brand and Keith 1979, Parker et al. 1983). Field studies (5 years) in the Wood River study area yielded estimates of kittens in fall populations that ranged from 18% to 31% when hares were only moderately abundant in otherwise excellent lynx habitat. In some modeling simulations, we set initial populations at 10% kittens to represent the proportion of kittens present when hares are scarce.

The age distribution in a lynx harvest may not accurately reflect the age distribution in a population. Brand and Keith (1979) concluded that kittens were underrepresented in the harvest by 20-50%. Quinn and Thompson (1985) also found that kittens were underrepresented in trapped samples and in contrast, yearlings were overrepresented. While it is clear that kittens are generally underrepresented in trapped samples, the degree of bias is not known with certainty but appears to be significant.

Reproductive Rates. Lynx fecundity fluctuates with changes in hare abundance (Nava 1970, Brand and Keith 1979, Parker et al. 1983, O'Connor 1984). When hares are abundant, adult females and yearlings generally produce 3-4 and 2-3 kittens per year, respectively. When hares are scarce, reproductive rates decline to 1.4 kittens per adult female and few yearlings produce kittens (Table 1). Over 3,000 female lynx carcasses were collected in Alaska during an entire lynx population cycle (O'Connor 1984). Fecundity rates used in this model were derived from O'Connor (1984) using the following formula:

> (% females with corpora lutea) x (% females with recent placental scars) x (mean number of recent placental scars) = fecundity.

These values were selected for the model because they represent a large sample of Alaskan lynx and encompass a complete population cycle. Reproductive rates of lynx in Alberta were slightly lower than those indicated for Alaska (Brand and Keith 1979).

Modeling Simulations

The values or ranges of values that we employed in various simulations are summarized in Table 1. Also listed are values used in a model (Ward 1985) where the snowshoe hare cycle was divided into 3 years of high hare abundance, 2 years of intermediate hare abundance during increasing and declining phases, and 3 years of low hare abundance. Because we had relatively little data on population parameters during periods of moderate prey abundance, we chose to represent the cycle as 5 years each of low and high prey abundance. Many of the assumptions underlying Ward's model are similar to those used in ours; however, Ward assumed the total winter mortality (trapping plus nontrapping) was equal for kittens and adults and no summer mortality for yearlings and adults.

Because lynx density and productivity vary significantly between the high and low phases of the lynx-hare cycle (Brand and Keith 1979), 2 contrasting harvest strategies are considered necessary for the successful management of heavily harvested lynx populations. For this reason, simulations for low and high phases of the cycle are presented separately. Only harvest rates, nontrapping mortalities, sex ratios, and initial populations were varied. Once established, other variables were not changed. The effects of the harvest on lynx populations were explored by simulating harvest rates from 0% to 90% in 10% increments.

This model was developed as a tool for investigating the potential effects of trapping on lynx populations and uses of data available to wildlife managers, rather than as a definitive representation of population dynamics. The following discussion illustrates the uses of the model and the manner in which it contributes insights into how harvests affect lynx populations.

Simulation 1 - Effect of harvest rate, prey scarce. Baseline values (Table 1) and initial populations of 100 adults and 50 kittens (i.e., representative of a year prior to a crash in hare numbers) or 100 adults and 10 kittens (i.e., representative of a population influenced by prey scarcity) were used in this simulation. In addition, the effects of summer kitten mortalities of 75% and 90% were evaluated separately.

In this simulation, harvests of 10% or more caused steady declines at various rates (Table 2). The population grew at harvest rates of 0% to 7%, reaching stability at 147 lynx in year 5 with an 8% harvest. With kitten mortality at 90%, stability also occurred in year 5 at 147 lynx with no harvest. With only 10 kittens in the initial population, the pattern was similar; however, all harvest rates were lower. Increasing summer kitten mortalities from 75% to 90% caused a marked change in population behavior (Table 2); the population stabilized at 147 lynx with no harvest mortality, rather than increasing when kitten mortality was lower.

This simulation illustrates the strong influence various types of mortality have on lynx populations during periods of prey scarcity and low productivity. Additional trapping mortality during these periods appears to have an important influence on the number of lynx present at the beginning of a population high for hares; the remaining ones are able to increase rapidly.

Simulation 2 - Effect of initial population size, prey abundant. Simulation 2 illustrates the effects that reduced breeding populations, caused by continued trapping during the low phase of the cycle, have on population levels during the high phase of the cycle. In this simulation, initial conditions (Table 1) were used with a harvest rate of zero, representing a lynx population near the theoretical maximum rate of growth.

The smaller the initial population, the fewer the numbers achieved after 3 or 5 years of prey abundance (Table 3). This emphasizes the importance of maintaining the highest possible breeding populations during lows. The results of simulation 1 suggest that reductions of 90% in fall numbers could be achieved with a 40% annual harvest during a 5-year low.

Simulation 3 - Effect of harvest rate, prey abundant. This simulation explored the potential effects of harvests when prey are abundant. Harvest rates were varied from 0% to 90% (Table 4), using an initial population of 100 adults and 50 kittens and baseline conditions (Table 1). The rate of population growth was strongly affected by the harvest, but some positive growth occurred at harvest rates as high as 57%. With a simulated harvest rate of 58%, an initial population of 100 adults and 50 kittens remained stable at 155 lynx after 3 years. Harvests in excess of 58% caused declines, with the rate of decline increasing disproportionately with each 10% increase in harvest level. Thus if the conditions we assumed in our model occur naturally, even when lynx productivity is maximal and natural mortality minimal, trapping harvests in excess of 58% can curtail population growth. Clearly, for many populations harvests in excess of 50% of the standing stock can prevent population growth.

With initial populations of 100 adults and 50 kittens and harvests for adults and kittens ranging from 0% to 40%, populations simulated over 10-year periods of high prey abundance consistently stabilized at or near 59.4% kittens by the 3rd year. When differential harvests of 30% and 40% for adults and 10% for kittens were simulated the proportion of kittens stabilized at similar levels (58.9% to 59.1%). In comparable simulations under conditions of prey scarcity, the proportion of kittens was approximately 6% and 14% with kitten summer mortality rates set at 0.90 and 0.75, respectively.

The proportion of kittens in populations simulated to represent conditions of prey abundance was similar to that observed in field studies (Brand et al. 1976) and calculated from age distribution in trapped samples (Brand and Keith 1979). This supports the conclusion of various investigators that kittens, which rarely exceed 30% in trapped samples, are generally underrepresented in the harvest. Kitten occurrence in populations simulated under conditions of prey scarcity was similar to (i.e., slightly higher) previously observed or calculated values (Brand et al. 1976, Brand and Keith 1979), suggesting that values we used to represent kitten mortality during periods of hare scarcity are conservative.

We also explored the effects of skewed sex ratios on population growth and the proportion of kittens. A sex ratio favoring females enhanced population growth and increased the proportion of kittens in winter populations. Under simulated conditions of high prey abundance and a 30% harvest, female sex ratios of 0.3, 0.4, 0.5, 0.6, and 0.7 resulted in kitten percentages of 47.5%, 54.2%, 59.2%, 63.5%, and 66.8%, respectively. Population size in the 5th year was 425 with 30% females and 2,786 with 70% females; the spring kitten production in the 5th year ranged from 291 to 4,258. The greater vulnerability of males to trapping (Bailey et al. 1986, Quinn and Thompson 1987) suggests that females may predominate in some harvested populations. Assuming the proportion of males is sufficient to breed all receptive females, such a population should have an enhanced growth potential.

Simulation 4 - Evaluation of harvest strategies. One potential use of a lynx population model lies in exploring the effects of various harvest strategies. To illustrate this potential we conducted an exercise that allowed a comparison of the number of lynx harvested during a simulated 10-year cycle under tracking and nontracking harvest strategies. This exercise employed a 5-year period representing a cyclic low followed by a 5-year cyclic high. The initial population was set at 100 adults and 50 kittens; summer kitten mortality was at 90% during the low phase and at 10% during the high phase. Other variables for the 2 phases were set as listed in Table 1. The fall population in the 6th year (after the low) was used as the starting population for the high phase. The various harvest scenarios used were as follows:

1. 0% harvest during 5-year low, 30% harvest during high
2. 10% harvest during 5-year low, 30% harvest during high
3. 20% harvest during low, 30% harvest during high
4. 30% harvest during low, 30% harvest during high
5. 40% harvest during low, 40% harvest during high

Although this exercise is a simplified representation of the 10-year cycle (i.e., intermediate hare density was not included), it illustrates the effectiveness of a tracking strategy. The results (Table 5) suggest the greatest total harvest during a 10-year cycle occurs when harvests during the low phase is curtailed. Each increment in harvest during lows causes progressive reductions in overall harvest, with harvests above 10% during lows causing dramatic reductions in populations and harvest. Even with a 30% harvest throughout the cycle, the number of lynx in 11th year (1st year of the next low) was somewhat greater than the initial population of

150 in the 1st year. With a 40% harvest the simulated population declined rapidly to extinction.

The results of our simulations are in general agreement with those reported by Ward (1985) and based on his lynx population models. Ward employed values for low (3 years), intermediate (4 years), and high (3 years) levels of hare abundance that were set somewhat lower than levels for adult and yearling fecundity; adult mortality was set at 35% in 1 case. In a simulation in which trapping mortality was set at 55% annually and adult natural mortality at 6% (kitten summer mortality was 0%, 65%, or 92%, depending on the phase of the cycle), the population was virtually extinct at the end of 1 full cycle, declining dramatically when the annual harvest was 30% or more. With trapping mortality set at 14% and natural mortality at 35%, the simulated population declined, although at a slower rate, requiring 4 cycles to disappear.

The values representing natural mortality in our model may be conservative, relative to some phases of the cycle. The simulations described, therefore, may tend to underestimate the effects of a given harvest rate.

Job 2. Trapline Distribution

Because of the difficulty involved in providing a graphic portrayal of traplines in such a large area and the sensitivity of some trappers about revealing their trapline locations, we have elected to describe trapline distribution in a narrative form.

Unit 12:

The northern portion of Unit 12 supports a fairly dense network of traplines; the greatest density occurs adjacent to the road system and in the vicinity of human settlements. There appear to be some potential refugia along the northern edge of the Nutzotin Mountains in the vicinity of the Chisana, Nabesna, and Tetlin Rivers. The observations of biologists familiar with the area indicate that there are pockets of good lynx habitat within these untrapped areas.

Unit 19:

Traplines are a consistent feature in Unit 19, radiating in all directions from population centers. Trapping intensity generally declines as the distance of traplines from villages increases. However, remote mining camps and big game guiding facilities are typically used by trappers during the winter months, resulting in a rather consistent distribution of trapping effort over most of the unit. Much of Unit 19 is accessible by air to trappers from Anchorage and the Matanuska-Susitna Valley.

Because of relatively good access and the importance of a trapping income for many unit residents, trapping is widespread, and there appear to be few areas that act as lynx refugia. Most trapping is focused on marten and/or beaver, and a general scarcity of lynx has resulted in few trappers trapping specifically for lynx. However, potential refugia would appear to be quite limited and, to the extent they exist at all, they would most likely occur within Subunit 19C, encompassing the Kuskokwim River drainages of the Alaska Range. Based on trapper reports, these drainages include some good lynx habitat, and access to them is generally limited.

Unit 20:

Within Unit 20, trapline density is greatest in Subunits 20A, 20B, and 20D and significant in 20C, 20E, and 20F. In much of Subunits 20A, 20B, and 20D, traplines are rarely more than about 6 miles (10 km) apart. In Subunits 20C, 20E, and 20F, traplines in remote areas are sometimes separated by 10-18 miles (16-29 km).

We identified only 1 small refugium of about 40 mi^2 (104 km^2) in the eastern portion of Subunit 20A, and none were found in Subunits 20B or 20D. Five refugia totaling about 1,000 mi^2 (2,590 km^2) were identified in Unit 20E. Our knowledge of traplines in Subunit 20F is limited, but it appears that scattered blocks of habitat totaling about 300 mi^2 (777 km^2) could be considered refugia. Using these criteria, Unit 20 contains refugia totaling about 1,300 mi^2 (3,367 km^2), or 3% of the maximum potential lynx habitat of 42,804 mi^2 (110,862 km^2).

Unit 21:

The distribution of traplines is known in detail only in the northern two-thirds of the unit. As in other areas, traplines occur most frequently along major drainages such as the Yukon, Koyukuk, Yuki, Innoko, Anvik, and Nowitna Rivers and near population centers. Trapline density is variable, but in lower elevation habitat, traplines are rarely more than 10 miles (16 km) apart. In more remote, high-elevation habitat, traplines are more dispersed. Potential refugia appear to exist in some of the more remote uplands both north and south of the Yukon River. The largest expanse of untrapped habitat appears to be an area of about 3,000 mi^2 (7,770 km^2) in the western part of the unit, including the upper portions of the Kateel, Gisasa, and Nulato drainages. The hilly terrain in this area is largely inaccessible, and much of the area has burned in recent years, creating the potential for good small game habitat. In recent decades, lynx have occurred primarily in scattered pockets in Unit 21; most of the area supports few resident lynx, probably because of the relatively open habitat and the relative scarcity of deciduous forest. Thus an assessment of the distribution of traplines relative to lynx distribution is somewhat difficult. It is known that some of the better lynx habitat is used by trappers, while some pockets of abundance remain unexploited.

Unit 24:

The pattern of trapline distribution in Unit 24 is similar to other remote areas; traplines are most common along major drainages, near villages, and adjacent to the Dalton Highway. Upland areas remote from human populations provide the major refugia, but their actual extent is unknown. As in Unit 21, deciduous vegetation is limited; additionally, extensive areas in the southern and west-central portions of the unit have burned in recent years. This factor will probably diminish their value as lynx habitat for at least several years. Areas that appear to be lightly trapped include the upper Kanuti River, the north side of the Ray Mountains, the eastern portion of Indian Mountain, and the Upper Huslia and Alatna Rivers. Although the extent of lightly trapped habitat is relatively great, the observations of area residents and T. Osborne (ADF&G area biologist, Galena) suggest few areas support significant numbers of lynx.

Unit 25:

Virtually all major drainages with productive furbearer habitat in Unit 25 are subject to at least moderate trapping pressure. In eastern Unit 25, where knowledge of traplines is most complete, we identified a narrow refugium (about 1,000 mi^2 [3,590 km^2]) of predominantly high-elevation habitat along the U.S.-Canadian border. In the remainder of the unit, it appears that a few potential refugia of similar size exist (i.e., primarily in upland habitat) in the northern and western portions. These areas include at least some good lynx habitat.

We estimate that Unit 25 includes a maximum of approximately 36,900 mi^2 (95,571 km^2) of potential lynx habitat. While the extent of potential refugia is not precisely known, it would appear that they constitute a larger proportion of Unit 25 than the 3% estimated for Unit 20.

Job 3. Pelt Measurements

Both trappers and biologists have long recognized that lynx kittens are consistently smaller and have different fur quality and other characteristics than adults during their 1st winter. We analyzed pelt measurements to establish criteria that can be used to separate kitten and adult lynx, exploring other pelt characteristics that might help in this determination.

Mean length of adult lynx pelts (40.3 in [102.4 cm]) was significantly ($\underline{P}$ < 0.05) greater than that of kittens (32.2 in [81.8 cm]). Frequency distributions of pelt lengths and width for adults and kittens are presented in Figs. 1, 2, and 3. The numerical distributions of pelt lengths and widths and summary statistics for adults and kittens are included in Appendix C.

A bimodal distribution in pelt length is apparent in Fig. 1; some overlap between kitten and adult pelt lengths occurs between 33 inches (84.0 cm) and 39 inches (99.0 cm). However, only about 2% of the kittens were longer than 36 inches (91.6 cm), and only 5% were longer than 35 inches (89.0 cm). Similarly, only 7% of the adults were shorter than 37 inches (94.1 cm) and less than 4% were shorter than 36 inches (91.6 cm). The vast majority (88.5%) of kittens were 34 inches (86.5 cm) or less in length; the mean was 32 inches (82.0 cm). Most adults (88%) measured 38 inches (96.7 cm) or more, with a mean of 40 inches (102.6 cm).

In contrast to the relatively clear separation in kitten and adult pelt lengths, the overlapping of pelt widths was considerable (Fig. 2); however, he 0.8-inch (2 cm) difference in average pelt width was significant ($\underline{P}$ < 0.05). The large overlapping is partially caused by the variation in methods used to measure widths. Some fur sealers measure from one edge of the fur to the other, while others measure across the skin or "leather." To evaluate the resulting variation, we compared the 2 types of measurements for 21 adult and 62 kitten pelts. For adults the average difference was 1.67 inches (4.2 cm) (SD = 0.41, range = 1.0-2.5 in); for kittens it was 1.82 inches (4.6 cm) (SD = 0.34, range = 1.0-2.5 in). Combined with some variation in the stretching boards used by individual trappers and a relatively large amount of "true" overlapping in width, width measurements are of little use in separating kittens from adults. Width limits of 10 inches (25.5 cm) and less could be used because only a few kittens exceeded this width; however, it is doubtful that this would appreciably increase accuracy.

We also examined the relationship between the lengths of ear tufts and the neck ruff (i.e., black-tipped fur extending downward behind the mandible) and age. We found consistent differences in both characteristics. The mean length of adult ear tufts was 2.0 inches (6.1 cm) ($\underline{n}$ = 31, SD = 0.3 in, range

= 1.5-2.75 in); this measurement significantly greater (P < 0.05) than that of kittens, which averaged 1.0 inch (2.5 cm) (n = 62, SD = 0.35 in, range = 0.25-1.5 in). Similarly, mean adult throat ruff length was significantly greater (P < 0.05) at 3.5 inches (8.9 cm) (n = 35, SD = 0.29 in, range = 3.0-4.25 in), compared with 2.4 inches (6.1 cm) for kitten ruffs (n = 62, SD = 0.27 in, range = 1.5-3.0 in). These data indicate that ear tuft and throat ruff lengths are useful in separating kittens and adults and could be used in conjunction with pelt lengths. However, widespread implementation in Alaska's statewide sealing program would be difficult and perhaps unnecessary, considering the reliability of pelt length.

Quinn and Gardner (1984) compared pelt length measurements from 43 kittens, 119 yearlings, and 52 adults trapped in Ontario during a trapping season (i.e., 25 October-28 February). Carcasses were examined to verify age, based on lack of canine root foramen closure (kittens) or cementum aging. The study also assessed the relationship of age and sex to pelt value. Quinn and Gardiner's (1984) pelt length data were presented in terms of size classes used by the Ontario Trappers Association, rather than as specific lengths (Fig. 3).

The vast majority (95.4%) of Ontario lynx kittens were classed as small, whereas all yearlings and adults fell into larger size classes. There was a small overlapping between yearlings and adults in the 31.8- to 35.8-inch (80.9-91.1 cm) categories, but none with the larger size classes. The differences in pelt lengths reflected similar differences in body lengths, which were determined from carcasses. Quinn and Gardner's (1984) major conclusions were as follows: (1) kittens can be reliably identified by pelt measurement; (2) yearlings of both sexes are nearly adult size, but kittens are much smaller than older lynx; (3) total length of female lynx is less than that of males, although the differences among kittens is slight; (4) the mean value of lynx pelts varies considerably with age and sex (i.e., in descending order, kittens, adults and yearling males, yearling females, and adult females); and (5) pelt quality is not a reliable indication of age or sex.

Our data for Alaska lynx show a similar pattern with respect to size, but their pelt lengths are somewhat greater for both kittens and adults. Whereas the bulk of the Ontario kittens measured less than 32 inches (81.4 cm), a similar proportion of Alaska kittens were 34 inches (86.5 cm) or less in length. The difference appears to be due to the way pelts had been stretched in the 2 areas. Dean Wilson, an experienced fur buyer who has attended numerous fur sales in Canada, observed that, compared with Alaska trappers, trappers in southern

Canada traditionally stretch lynx and other furbearer pelts much wider. Accordingly, Canadian pelts are wider, especially in the neck and shoulders, and therefore shorter than similar pelts stretched in Alaska. Mr. Wilson stated that a wider stretch can easily shorten pelts by 2 inches (5 cm) or more. In addition, the observations of fur buyers who have examined numerous lynx pelts from various parts of North America indicate that Alaskan lynx are larger than those in southern Canada (L. McIntosh, Hudson's Bay Fur Sales, Rexdale, Ontario, pers. commun.).

Our data corroborate the observations of trappers and fur buyers and the conclusions reached by Quinn and Gardner (1984) regarding the usefulness of pelt lengths in differentiating lynx kittens from yearlings and adults. Ear tuft and throat ruff length also appear to be useful in separating kittens from older lynx. Pelt widths, however, appear to be of limited value to Alaska's pelt sealing program; however, standardization of the width measurements could increase its usefulness.

The selection of pelt length criteria to be used in a given analysis is subjective. Pelt lengths from 34 to 36 inches (86.5 to 91.6 cm) are potentially useful as upper limits for kitten length. As the size limit increases, the number of adults incorrectly classified as kittens would increase. Using 34 inches (86.5 cm) would result in correctly classifying about 89% of the kittens and incorrectly classifying about 1% of older lynx. If 35 inches (89 cm) were used, 95% of the kittens would be correctly classified, but 4% of the adults would be incorrectly classified. Using 36 inches (91.6 cm), the corresponding percentages would be 98% and 7%.

In selecting length criteria, various factors should be considered. Kittens are underrepresented in trapped samples by approximately 20% to 50% (Brand and Keith 1979) or more. As a result, pelt length analysis provides only an index to the cyclic pattern in recruitment. In addition, the probable degree of error associated with using various length criteria must be considered. In view of the relatively large proportion of adult lynx in most harvests, the error associated with using near-maximum pelt lengths for kittens could be significant, even though the percentage is not large. That is, the potential error associated with incorrectly classifying adults as kittens will usually be greater than a similar percentage of error associated with classifying kittens as adults. Therefore, maximum length for kittens should be used with caution.

Trapping season lengths and closing dates should also be considered when comparing kitten occurrence in different areas. In Ontario, Quinn and Thompson (1985) found that kittens increased markedly in the harvest after December. This pattern is corroborated by the observations of Alaskan trappers and fur buyers (D. Wilson, pers. commun.); thus samples of pelt measurements from areas with different seasons are not strictly comparable. In addition, the size of kittens (as well as small adults that overlap with kittens) increases somewhat during winter. In areas where the season stays open into February or March, a relatively greater length limit (i.e., 35 or 36 in) could be used. Where seasons close by 31 January, a 34-inch upper limit would probably be more reasonable. When a season extends from November through February or March it might be wise to use 34 inches (86.5 cm) as a limit for the first 2 or 3 months and 35-36 inches (89.0-91.6 cm) for the 2nd part of the season.

Our analyses also suggest that, rather than simply calculating the percentage of pelts equal to or less than a given length, it is more informative to count the number of lynx in each length class (Fig. 1). This type of analysis will show if there is a bimodal distribution in pelt length and a "normal" distribution of kittens or an unusual number of lynx in the 35- to 37-inch (89.0-94.1 cm) classes. Our analysis indicates that the vast majority of kittens occur in the 30- to 34-inch (76.3-86.5 cm) classes. An absence of this pattern would indicate that pelts in the 35- to 37-inch (89.0-94.1 cm) classes were primarily those of older lynx rather than kittens.

Our analysis corroborates the observations of experienced Alaskan trappers and fur buyers, whose estimates of the maximum length for kittens range from 34 to 36 inches (86.5-91.6 cm). Fur buyer Dean Wilson also observed that most overlapping between kittens and adults occurs in the 34- to 38-inch (86.5-96.7 cm) categories; more young adults (primarily females) than kittens are in this size range. This pattern was evident in our data, although we can only surmise that the later observation is probably correct. Quinn and Gardner (1984) found that a disproportionate number of yearling lynx occur in the length classes in which overlapping between kittens and adults occurs.

<u>Application of Pelt Measurement Analysis to Lynx Harvest Data in Interior Alaska:</u>

In this section, we have applied the criteria developed in the previous section to pelt length data obtained in Alaska's mandatory pelt sealing program between 1977-78 and 1987-88. For the purpose of describing patterns in kitten occurrence, we used 34 inches (86.5 cm) as an upper limit for kittens, recognizing that 10-12% of kittens could be excluded by this criteria. Our intent was to minimize errors associated with classifying adults as kittens.

This analysis focuses on pelt length distribution for lynx sealed from Units 12, 20, 21, 24, and 25 from 1977 to 1988 (Figs. 4-8). Numerical data on the number of lynx pelts measured in Alaska units and pelt length distribution in units 12, 20, 21, 24, and 25 are included in Appendix D. There are minor differences between total and "measured" harvests. For a small percentage of pelts, (1) harvest location or measurements were not recorded or (2) the recorded length exceeded the 52-inch (132 cm) maximum that we used in graphing length data. The latter discrepancy involved only 3 lynx from Unit 25 in 1987-88.

The portion of pelts 34 inches (86.5 cm) or less in length ranged from zero to 28.3%; only 1 annual unit is harvest (Unit 12, 1983-84) had no pelts in this size class (Appendix D). Relatively high levels of kittens generally occurred between 1977 and 1981, corresponding to the increasing and high phases of the cycle, followed by relatively low levels between 1982 and 1986. In most areas for which data are available, kitten occurrence has increased during the last 1 or 2 winters. This coincides with reports of increasing hare numbers in most of Interior Alaska. Units 20 and 25 showed the most sustained level of kittens in the harvest and the greatest total kitten occurrence (15-25%) during the 11-year period. The range in occurrence of kittens in Interior Alaska harvests have been similar to that observed in various studies of age structure based on lynx carcasses collected from trappers (Berrie 1973, Koonz 1976, Brand and Keith 1979, Parker et al. 1983, O'Connor 1984, Quinn and Thompson 1987).

There has been some variation in length distribution in the Alaska lynx harvests, relative to the bimodal pattern in the "known-age" sample discussed earlier. Although a bimodal pattern in pelt length has been apparent in most annual harvests, the dip in numbers occurred variously in the 35-, 36-, and/or 37-inch (89.0, 91.6, and/or 94.1 cm) classes (Figs. 5-9). In some annual harvests, notably in Unit 25, this pattern has been poorly defined.

We are unable to explain the relatively weak bimodal distribution found in some collections, but one possible explanation could involve the phase of the cycle during which the "known-age" sample was obtained. The known age data were collected during winters 1986-87 and 1987-88, which marked the beginning of the increasing phase in most areas. As a result, the number of yearlings in this sample may have been low, compared with years when the number of kittens and yearlings reached peak levels.

A trend toward an increasing proportion of lynx in the 35- to 37-inch (89.0-94.1 cm) classes during the peak harvest years (generally between 1981 and 1983) has been apparent in Units 20, 21, 24, and 25 and to a lesser extent in Unit 12 (Figs. 4-8). The presence of large cohorts of yearlings, which are highly vulnerable to trapping (Quinn and Thompson 1985, Bailey et al. 1986), could account for the lack of a clear bimodal distribution in some years.

Pelt length data may be of value in assessing the occurrence and relative strength of the high phase of the lynx productivity cycle in various areas and determining whether low productivity has been involved in low population levels during a given cycle; e.g., low productivity has been suspected by trappers and biologists as the cause for the relatively low lynx numbers observed during the early 1980's "high" in Unit 20. This suspicion stemmed from the comparatively low snowshoe hare populations observed during the early 1980's, when peak numbers had been expected. Although hares reached moderate levels in many areas, peak density appeared to be considerably lower than those during the early 1970's and the high numbers seemed to persist for only a short time. By comparison, the hare cycle in Unit 25 is reported to have been of normal strength and duration.

A comparison of pelt length distribution in Units 20 and 25 (Figs. 5 and 8) indicates that, contrary to what one might expect, the occurrence of kittens in the Unit harvests was slightly higher than that observed in Unit 25. Despite the weaker hare cycle, it does not appear that low productivity and survival played a major role in causing comparatively low lynx numbers and harvests in the early 1980's.

The absence of a mandatory harvest reporting program prior to 1977 makes a precise comparison of the relative abundance of lynx during the 1970 and 1980 cycles impossible; however, some indication can be obtained by comparing the 1970's harvest reported by individual trappers and fur buyers with that for the 1980's high. One of the clearest indications of the greater abundance of lynx during the 1970's is the observation of fur buyer D. Wilson (pers. commun.); during one winter in the early 1970's he purchased over 1,000 lynx pelts from trappers in the Nenana area alone, representing the harvest in approximately 25% of Unit 20. Similarly, the combined annual harvests reported by groups of 2 or 3 trappers using limited areas in Unit 20 commonly ranged from 100 to 300 lynx during the peak years in the early 1970's (R. Long and D. Grangaard, pers. commun.). By comparison, the unit-wide harvest during the 7 highest years in the later 1970's and early 1980's ranged from 267 to 927 and averaged 452 lynx (Appendix D), again suggesting considerably lower abundance in the Tanana Valley during the 1980's high.

Job 4. Track Surveys

Lynx harvest and population levels in the Wood River Study Area:

Before discussing the results of track surveys in the Wood River study area, we will review the status of the area's lynx population during the period of study; i.e., extending from early 1984 to late 1987. A more complete history and detailed analysis of lynx harvests, population levels, and track occurrences during winters 1983-84 and 1984-85 were presented by Stephenson (1986).

The harvest of lynx in the Wood River area has ranged from zero to 102 during the past 19 years (Table 6), while the harvests ranged from 1 to 18 during the study. The relatively low harvests between 1984 and 1988 (i.e., 1 to 7 lynx) are attributable to low lynx numbers as well as efforts by the cooperating trapper to avoid catching lynx.

Estimated lynx numbers, population composition, and known mortalities during the 5 winters of study are shown in Table 7; estimates of population density are summarized in Table 8. During this period, we estimated that total lynx numbers in early winter ranged from 33 in 1983-84 to 11 in 1987-88, while the known harvest rate ranged from 54.6% to 7.7% (Table 7). The lack of agreement between estimated late winter numbers and fall numbers probably resulted from errors in population estimates, unaccounted immigration and emigration, and unknown mortality. No natural mortality of either marked or unmarked lynx was documented during this study.

The Wood River study area encompasses "core" lynx habitat (Stephenson 1986); moderate numbers of hares and lynx have been present even during areawide "lows." During highs, the area has in the past yielded harvests of lynx that have exceeded by several times the recent total population estimates.

The regular occurrence of kittens, even during the recent "low," is probably a further indication of the area's high-quality habitat. We estimate that kittens comprised from 18% to 31% of the population during the past 5 winters (Table 7), despite the relatively low hare numbers. Field observations suggest that hare numbers reached their lowest level during winter 1985-86; a noticeable increase occurred during the following 2 winters. The kittens enumerated usually represented only 1 or 2 litters; however, the actual percentages determined may not be as important as the fact that they are high compared with levels thought to occur over large areas during lows. These levels are, however, lower than those observed in field studies or estimated to occur during highs (Brand and Keith 1979).

Despite continued productivity, the Wood River lynx population did not increase; rather it continued to decline slowly (Table 18). Estimated early winter density in the core habitat declined from 6.7 mi^2 (17.4 km^2) per lynx in 1983-84 to 20 mi^2 (51.8 km^2) per lynx in 1987-88. In addition, the distribution of lynx during the 1980's is more limited than during the 1970's. According to a trapper (J. Smith, pers. commun.), lynx were formerly common in the wooded, higher elevation habitats south of the Japan Hills, whereas in recent years resident lynx have been almost entirely restricted to lower elevations near the Wood River. The wider distribution and far higher densities occurring in earlier years have coincided with similar conditions in the surrounding parts of Subunit 20A (Stephenson 1986).

The population densities given in Table 8 represent our best estimates of lynx numbers within the Wood River study area (i.e., A, B., and C). The boundary of the 375-mi^2 (971 km^2) area A, was established 6 miles (9.7 km) from the trails used to capture lynx and gather population data representing about half of the greatest linear dimension of the larger annual home ranges used by marked lynx and approximating the greatest dimension of smaller home ranges. The southern boundary of area A was considered to be the 3,000-foot (909 m) contour, above which marked lynx and lynx tracks had not been observed. The boundary of the 300-mi^2 (777 km^2) area B was the same as area A, except that the edge of the Blair Lakes burn was used as the eastern boundary, and a 47-mi^2 (122 km^2) area south of the Japan Hills was deleted.

One additional set of densities was calculated for 220-mi^2 (570 km^2) area C that included only the portion of area B within 6 miles (9.7 km) of the 25-mile (40-km) trail along which track occurrences were measured. Area C encompasses the vast majority of habitat regularly used by lynx during the study period. For the purpose of calculating lynx density in area C, lynx that inhabited the southern portions of area A were excluded.

The lower densities, based on the 375-mi^2 (971 km^2) in area A, should be viewed as representing marginal and unused habitat. Densities calculated for areas B and C were, in contrast, representative of moderate-to-good lynx habitat.

Estimated early winter density for area A ranged from 1 lynx/11.4 mi^2 (29.5 km^2) in 1983 to 1 lynx/34.1 mi^2 (88.3 km^2) in 1987. Comparable densities for area C ranged from 1 lynx/6.7 mi^2 (17.4 km^2) to 1 lynx/20 mi^2 (51.8 km^2). These densities are comparable to those estimated during the low phase of the lynx-hare cycle in good lynx habitat in other parts of North America (Brand et al. 1976, Bailey et al. 1986).

Relationship Between Lynx Track Frequency and Population Size:

Figs. 9A and 9B show the cumulative number of lynx tracks/mile observed along regularly surveyed routes in the Tok study area from October to December 1982 and in the Wood River area during March 1984-87 and November-December 1987. These data are also presented in tabular form along with a statistical summary and evaluation (Appendix E).

We statistically evaluated annual differences in track accumulation rate to determine whether observed changes were significant. We evaluated differences observed between the Tok (1982) and Wood River (1984, 1985, 1986, 1987) areas and also within the Wood River area during the 4 years of study. We found no significant differences in track frequencies between Tok 1982 and Wood River 1984, Wood River 1984 and Wood River 1985, and Wood River 1987 and Wood River fall 1987. There were, however, significant differences between the Tok 1982 and Wood River 1985 ($0.05 < P < 0.10$), 1986, and 1987 ($P < 0.05$) samples. Significant differences were also observed between the Wood River 1984 and 1986 ($P < 0.05$), 1985 and 1986 ($P < 0.05$), and 1986 and 1987 ($P < 0.05$) samples (Table 9).

These results suggest that "T-1" track surveys are capable of indicating annual changes in population density of approximately 50% or more. The amplitude of cyclic change in overwintering populations of lynx is reported to be on the order of 400% (Brand et al. 1976, Keith et al. 1977). The sensitivity of T-1 track surveys should therefore be a useful indicator of major changes in lynx population status.

Fig. 10 compares average track accumulation rates with estimated population densities in the Tok and Wood River (area C) study areas. We evaluated the correlation between track frequency and population density using the track frequencies observed on the 19-mile (30.6 km) Wood River and the Tok 15-mile (24 km) survey routes. The 2 measures of density are weakly correlated (Spearman Rank Correlation Test, $P = 0.2883$).

The greatest divergence between track frequency and population density occurred during winters 1984-85 and 1985-86 in the Wood River study area. Although a number of factors, including errors in population estimates, could account for the disparity, we suggest that changes in prey abundance accompanied by changes in lynx travel rates were probably involved.

Observations of tracks suggested that numbers of hares and grouse reached their lowest level in spring 1985; a slight increase occurred during the following winter. Prey abundance before and after this period was considerably greater. Ward and Krebs (1985) found that radio-marked lynx showed relatively consistent foraging effort, as indicated by straight-line distances traveled per day when snowshoe hare densities were above approximately 0.4 hare/acre (1.0 hare/ha); however, as hare densities declined, lynx daily travel distances increased rapidly; i.e., from 2 miles (3.3 km) at 0.2 hares/acre (0.5 hares/ha) to 3.4 miles (5.4 km) at 0.08 hares/acre (0.2 hares/ha). Such an increase in travel rate could account for the unexpectedly high track frequency observed in the Wood River area during the 2 winters when numbers of both lynx and their major prey were lowest. This phenomena could also account for the continued decline in lynx track frequency in 1987, despite an increase in lynx and prey numbers. As hare abundance increased, perhaps exceeding a threshold similar to that identified by Ward and Krebs (1985), a reduction in lynx travel rates may have occurred. This may have resulted in the observed lack of agreement between population trend and track frequency.

The relationship between daily travel and prey density described by Ward and Krebs (1985) may be critical to the interpretation of lynx track counts during the low phase of the cycle. Track counts conducted when hare abundance is at or near minimum levels would tend to overestimate lynx density, while similar counts conducted under conditions of slightly higher hare abundance would underestimate them. If lynx daily travel is relatively constant at hare densities ranging from 0.4 to 5.9 hares/acre (1 to 14.7 hares/ha) (Ward and Krebs 1985), the correlation between lynx track frequency and population density should be stronger than we have observed.

Our data are representative of only a small portion of the potential range in lynx densities and are restricted to the lower portion of this range. A more meaningful evaluation of the usefulness of track counts as an index to lynx numbers requires obtaining track counts and population data at medium and high lynx densities, as well as knowledge of prey densities and their effects on lynx movements.

An alternative method for estimating lynx numbers has been developed and tested by Schwartz and Becker (1988). This technique, as applied in their study area, involves randomly sampling 12 2-mile (3.2 km) systematic transects from 24 to 96 hours after a snowfall. This method requires that observers determine the number of individual lynx involved in making tracks intercepted on a transect. It also requires an estimate of distance traveled by lynx after a snowfall, which can be derived from radio-collared lynx or by following intercepted lynx tracks (Swartz and Becker 1988).

The systematic transect technique has been applied twice on the Kenai Peninsula in an area where lynx numbers had been independently approximated during an intensive study of radio-marked lynx. This approach yielded reasonable density estimates, although lynx numbers appear to have been overestimated in the 1st year (Schwartz et al. 1988).

Based on their results, Schwartz et al. (1988) suggested that track frequency may not reflect changes in population density. Estimated lynx numbers in their 110-mi^2 (285 km^2) study area declined from 14.5 to 5.81 lynx, while overall "T-1" track frequency on the 24 miles (39 km) of transects covered in each survey was virtually unchanged. Eighteen lynx tracks were recorded in 1987, compared with 17 in 1988; however, the number of transects on which tracks were intercepted changed markedly. In 1987 lynx tracks were intercepted on 8 of 12 transects, while in 1988 only 4 of 12 transects intercepted tracks. In addition, the 12 of 17 tracks recorded in 1988 on 1 transect were thought to represent the activity of 1 or 2 lynx. Thus an estimated 60% decline in population density was accompanied by a 50% decline in overall track distribution, while raw track frequency remained nearly constant.

Based on these results, we suggest it is important to consider track distribution as well as raw track frequency when interpreting track surveys. The systematic transect technique automatically accounts for differences in track distribution, while "T-1" track counts do not. A suggested but untested alternative index of lynx abundance requires sampling widely distributed areas or transects for presence or absence of lynx tracks. Based on the results of the Kenai Peninsula surveys (Becker and Schwartz 1988, Schwartz et al. 1988), it appears that this approach may be more sensitive to variability in track distribution than the "T-1" track counts.

Our data indicate that it may be difficult to obtain representative indices of lynx abundance with "T-1" track counts when lynx density is low and surveys are done soon after snowfall. When hares and lynx are scarce, we recommend conducting "T-1" track surveys from 3 to 10 days after snow in order to minimize the effects of day-to-day variation in track accumulation. In the Tok and Wood River areas, track intercepts were fairly evenly distributed along survey routes. Although there were some areas within the latter study area where lynx track frequency was usually higher (i.e., notably within about 3 miles of the Wood River on both the Bonnifield and Rex Trails), the pattern in distribution was similar from year to year with no apparent tendency toward an extremely clumped distribution. It is likely that in some situations track distribution may be uneven and/or show dramatic shifts in distribution from year to year, as encountered by Schwartz and Becker (1988) and Schwartz et al. (1988). An uneven or localized distribution of tracks should alert one to the possibility that small areas receiving intensive use by 1 or more lynx (possibly a family group) have elevated track frequency to a level that is not representative of a larger geographic area. The development of a technique based on "T-1" track frequency, with an added provision accounting for track distribution (i.e., presence or absence of tracks on individual segments of a survey route), may increase the usefulness of track surveys while adding little to their cost.

Logistical considerations must also be included in evaluating potential techniques for estimating lynx populations in Alaska. Except along the road system, ground access is limited in most northern and interior areas to scattered trails that are, to various degrees, accessible only by snow machine during winter. Track surveys conducted on the ground (trails or transects) have the general advantages of high track sightability, accuracy of track identification, repeatability, and relatively low cost. The state is generally accessible to aerial survey, which can cover large areas more rapidly; however, it is more costly and more susceptible to errors of identification and omission. The suitability of various techniques will vary among areas.

The high information and access requirements, number of personnel, and specific conditions required by the systematic transect technique (Becker and Schwartz 1988) may limit its application to small areas with good access. However, if an aerial version of the technique can be developed, the method's usefulness would increase. The simplicity of our "T-1" track surveys suggest their possible suitability for broad application in large, remote areas of the state.

RECOMMENDATIONS

The results of our lynx population modeling and our evaluation of trapline distribution underscore the appropriateness of using a "tracking" strategy in regulating harvests in areas where trapping is an important mortality factor. Harvests should be minimized during lows in the lynx reproductive cycle if the management goal is to maximize harvest over a 10-year cycle.

Pelt length measurements useful in separating kittens and adults range from 34 to 36 inches (86.5 to 91.6 cm). Where seasons extend into late winter, a maximum length of 36 inches (91.6 cm) is recommended, while lower length criteria are appropriate where seasons close in midwinter. Pelt length measurements provide a reliable technique for monitoring changes in the lynx-hare cycle in areas where trapping seasons are open. Pelt lengths should be analyzed annually.

While the relatively straightforward "T-1" track counts may have promise in providing an economical index to lynx population status and trend, a better evaluation of their utility requires an exploration of the relationship between track frequency and lynx population density at high lynx densities. The influence of snowshoe hare density on lynx travel rates (Ward and Krebs 1985) should be further explored. The possibility of seasonal changes in travel rates (e.g., during the mating season) should be evaluated. A better understanding of these relationships would aid in the interpretation of track surveys. Another direction for future work involves developing and evaluating an aerial method for obtaining T-1 track data similar to that employed by Golden (1987). This would increase the utility of this approach by allowing more rapid coverage, even in areas inaccessible to ground transportation.

ACKNOWLEDGMENTS

Many people contributed to the success of this study. I am especially indebted to Mr. Dan Grangaard of Tok and Mr. Jim Smith of Gold King Creek. Dan generously allowed us to use one of his better traplines for the Tok study, provided critically important help and advice during the early stages of field work, and freely shared a wealth of knowledge and ideas about lynx ecology. Jim cooperated in a similar manner by providing the use of a portion of his trapline in the Wood River area. He also assisted in field work and helped in radio-collaring lynx. Douglas Smith also provided considerable assistance during field work on the Wood River area. Tok area biologist Dave Kelleyhouse offered helpful advice and allowed part of the Tok office to be the field headquarters for the Tok study. Clay Hogan of North Pole was also helpful in providing the use of his cabin as a base camp for Wood River field work.

Many people at the Fairbanks ADF&G office provided support and field assistance. Statewide Furbearer Biologist Herb Melchior was helpful in obtaining funding for this and other furbearer research and also provided many helpful suggestions and critical review of this report. Wayne Regelin deserves thanks for his advice and support throughout the study. John Schoen also contributed many helpful editorial comments in his review of the manuscript. Robin Beasley provided valuable field assistance in Tok and was instrumental in developing the lynx population model. Dan Reed constructed the population model and provided important help and advice regarding statistical analyses. Various other people including Wayne Heimer, Brian Lawhead, and Audrey Magoun volunteered their time, effort, and ideas during field work. James Davis, Pat Valkenburg, Steve DuBois, and Sarah Watson cooperated in obtaining radio locations in the Wood River area. A special acknowledgment is due the many people who have, over the years, kept up with the painstaking task of computerizing and maintaining lynx sealing data on which our pelt measurement analysis is based. Herb Melchior, Karen Gordon, Sarah Watson, and Robin Beasley are some of the people who have done so much in this respect. ADF&G Area Biologists Dave Kelleyhouse, Roy Nowlin, Tim Osborne, and Jack Whitman provided essential information on trapline distribution.

The Alaska Trappers Association played an important role in obtaining funds and supported the work in other ways as well. Al Jones, Norm Phillips, Pete Buist, Ron Long, and Dean Wilson deserve special thanks for their support through the Association. We also thank Joe Mattie and Dean Wilson for their interest in the study, and for sharing their insights and concerns about lynx ecology and management. Dean Wilson deserves special recognition for making available lynx pelts for the pelt measurement study and for contributing many valuable insights and ideas regarding the characteristics of adult and kitten lynx pelts, historical fluctuations in lynx numbers, and numerous other aspects of lynx ecology and trapping. Tamarack Air Ltd. and pilots Kem Sibbits and Bill Lentsch deserve thanks for their safe and effective flying and flexibility in providing logistical support for field studies.

LITERATURE CITED

Bailey, T. N. 1972. Ecology of bobcats with special reference to social organization. Ph.D. Diss., Univ. Idaho. 82pp.

__________, E. E. Bangs, M. F. Portner, J. C. Malloy, and R. J. McAvinchey. 1986. An apparent overexploited lynx population on the Kenai Peninsula, Alaska. J. Wildl. Manage. 50(2):279-290.

Berrie, P. M. 1973. Ecology and status of the lynx in interior Alaska. Pages 4-41 in R. L. Eaton, ed. The world's cats. Vol. I. World Wildl. Safari, Winston, Oreg.

Brand, C. J., and L. B. Keith. 1979. Lynx demography during a snowshoe hare decline in Alberta. J. Wildl. Manage. 40:416-428.

__________, __________, and C. A. Fischer. 1976. Lynx responses to changing snowshoe hare densities in central Alberta. J. Wildl. Manage. 40:416-428.

Brittell, J. D., R. J. Poelker, S. J. Sweeney, and G. M. Koehler. 1989. Native cats of Washington. Washington Dep. Wildl. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-84-R. Olympia. 169pp.

Carbyn, L. N., and D. Patriquin. 1983. Observations on home range sizes, movements, and social organization of lynx, Lynx canadensis in Riding Mountain National Park, Manitoba. Can. Field Nat. 97:262-267.

Finerty, J. P. 1979. Cycles in Canadian lynx. Am. Nat. 114:453-455.

Fox, J. F. 1978. Forest fires and the snowshoe hare-Canada lynx cycle. Oecologica 31:349-374.

Golden, H. N. 1987. Survey of furbearer populations on the Yukon Flats National Wildlife Refuge. Alaska Dep. Fish and Game. Unpubl. Final Rep. 86pp.

Iurgenson, P. B. 1955. Ecology of the lynx in forests of the central zone of the U.S.S.R. Zool. J. 34:609-620.

Keith, L. B. 1963. Wildlife's ten-year cycle. Univ. Wisc. Press, Madison, Wisc. 201pp.

__________, L. B., A. W. Todd, C. J. Brand, R. S. Adamcik, and D. H. Rusch. 1977. An analysis of predation during a cyclic fluctuation of snowshoe hares. Proc. 13th Int. Congr. Game Biol. 13:151-175.

Koehler, G. M., M. G. Hornocker, and H. S. Hash. 1979. Lynx movements and habitat use in Montana. Can. Field-Nat. 93:441-442.

Koonz, W. H. 1976. A biological investigation of lynx in Manitoba. Manitoba Dep. Ren. Resourc. and Transportation Serv., Res. Branch MS. Rep. 76-2. 35pp.

McCord, C. M., and J. E. Cardoza. 1982. Bobcat and lynx. Pages 728-766 *in* J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America. John Hopkins Univ. Press. 1,147pp.

Mech, L. D. 1980. Age, sex, reproduction, and spatial organization of lynxes colonizing northeastern Minnesota. J. Wildl. Manage. 61:161-267.

Nava, J. A., Jr. 1970. The reproductive biology of the Alaska lynx (*Lynx canadensis*). M.S. Thesis. Univ. of Alaska, Fairbanks. 141pp.

Nellis, C. H., S. P. Wetmore, and L. B. Keith. 1972. Lynx-prey interactions in central Alberta. J. Wildl. Manage. 36:320-329.

O'Connor, R. M. 1984. Population trends, age structure, and reproductive characteristics of female lynx in Alaska, 1961 through 1973. M.S. Thesis. Univ. of Alaska, Fairbanks. 111pp.

Parker, G. R., J. W. Maxwell, L. D. Morton, and G. E. J. Smith. 1983. The ecology of the lynx (*Lynx canadensis*) on Cape Breton Island. Can. J. Zool. 61:770-786.

Quinn, N. W. S., and J. F. Gardner. 1984. Relationships of age and sex to lynx pelt characteristics. J. Wildl. Manage. 48:953-956.

__________, and G. Parker. 1987. Lynx. *In* M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds. Wild furbearer management and conservation in North America. Ontario Trappers Assoc. North Bay. 1150pp.

__________, and J. E. Thompson. 1985. Age and sex of trapped lynx, *Felis canadensis*, related to period of capture and trapping technique. Can. Field-Nat. 99:267-269.

__________, and __________. 1987. Dynamics of an exploited Canada lynx population in Ontario. J. Wildl. Mange. 51:297-305.

Saunders, J. K., Jr. 1961. The biology of the Newfoundland lynx (*Lynx canadensis sub-solanus* Bangs). Ph.D. Thesis. Cornell Univ. 109pp.

Schwartz, C. C., and E. F. Becker. 1988. Development of population assessment techniques for lynx. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-22-6. Juneau. 28pp.

__________, __________, and K. J. Hundertmark. 1988. Development of population assessment techniques for lynx. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-22-2. Juneau. 8pp.

Seton, E. T. 1911. The arctic prairies. Intl. Univ. Press, New YOrk. 308pp.

Stephenson, R. O. 1986. Development of lynx population estimation techniques. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Final Rep. Proj. W-22-2. Juneau. 84pp.

Stewart, R. R. 1973. Age distributions, reproductive biology, and food habits of Canada lynx (*Lynx canadensis* Kerr) in Ontario. M.S. Thesis. Univ. of Guelph, Guelph, Ontario. 61pp.

Van Zyll de Jong, C. G. 1963. The biology of the lynx (*Felis (Lynx) canadensis* Kerr) in Alberta and the MacKenzie District, N.W.T. M.S. Thesis. Univ. of Alberta, Edmonton. 76pp.

__________. 1966. Food habits of the lynx in Alberta and the MacKenzie District, N.W.T. Can. Field-Nat. 80:18-23.

Ward, R. M. P. 1985. Behavioral responses of lynx to declining snowshoe hare abundance. M.S. Thesis. The Univ. of British Columbia. 106pp.

__________, and C. J. Krebs. 1985. Behavioural responses of lynx to declining snowshoe hare abundance. Can. J. Zool. 63:2817-2824.

Winterholder, B. P. 1980. Canadian furbearer cycles and Cree-Ojibwa hunting and trapping practices. Am. Nat. 115:870-879.

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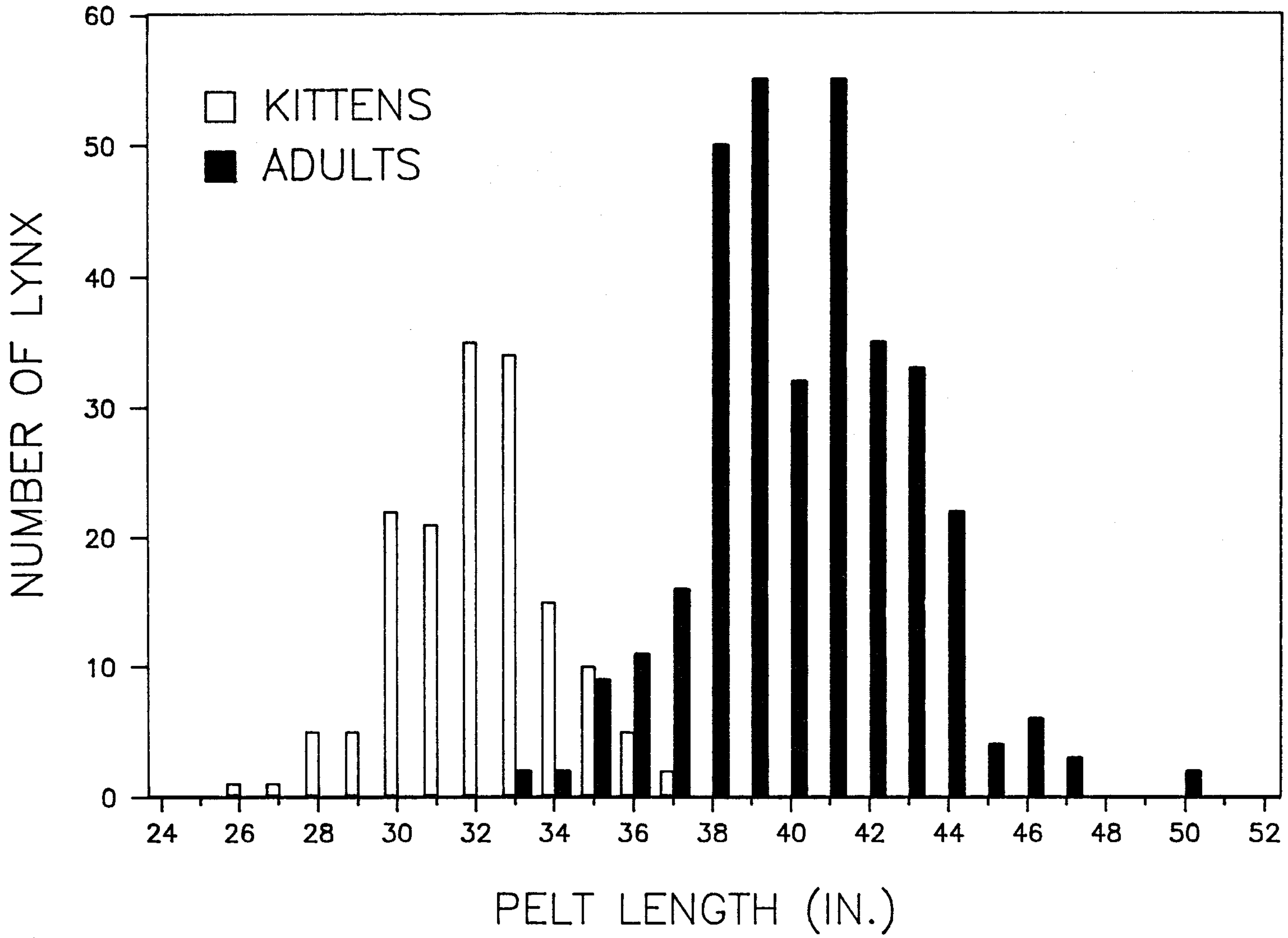


Fig. 1. Pelt length distribution for 157 lynx kittens and 338 adults in Alaska, 1986-88.

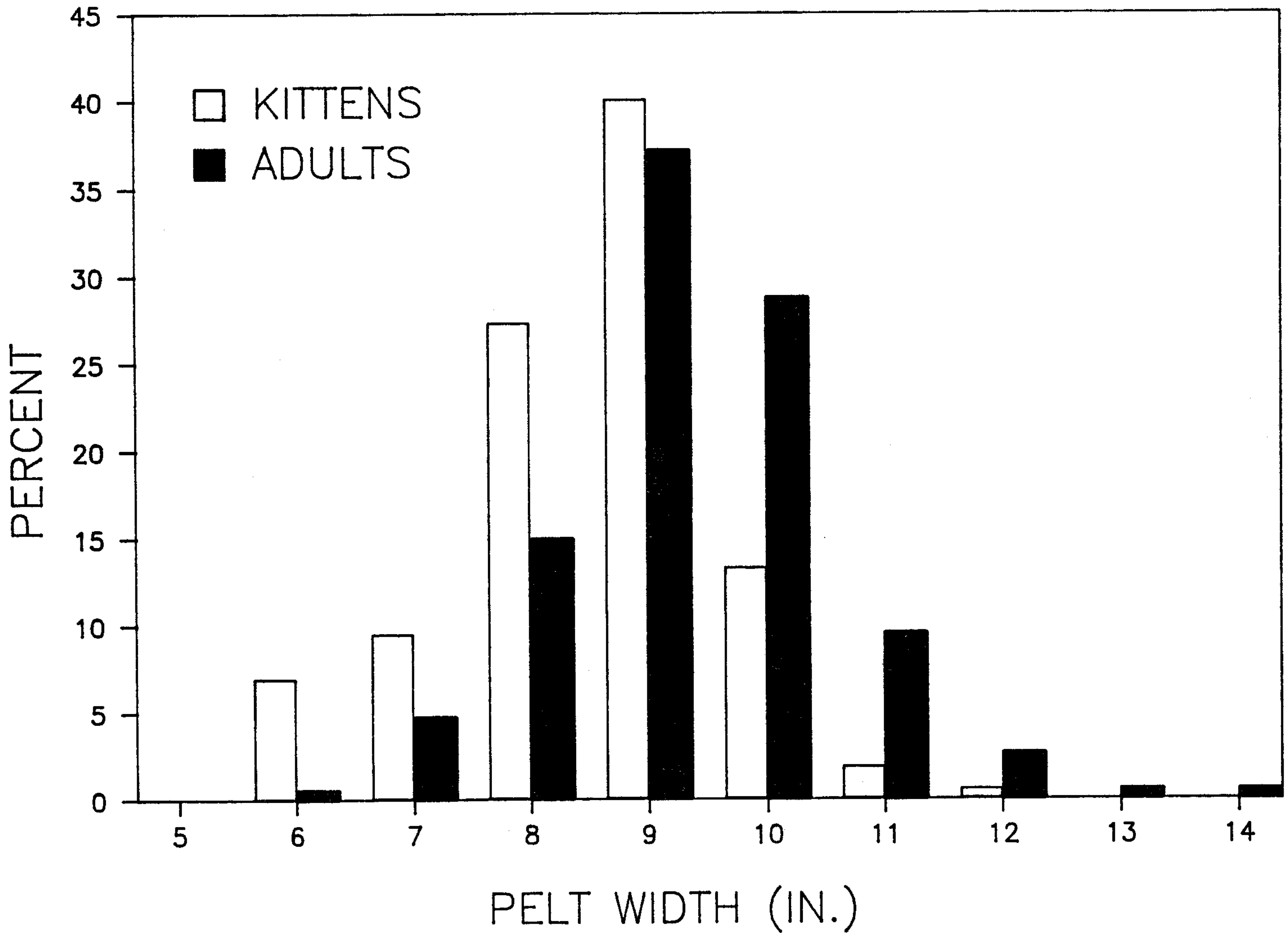


Fig. 2. Pelt width distribution for 157 lynx kittens and 333 adults in Alaska, 1986-88.

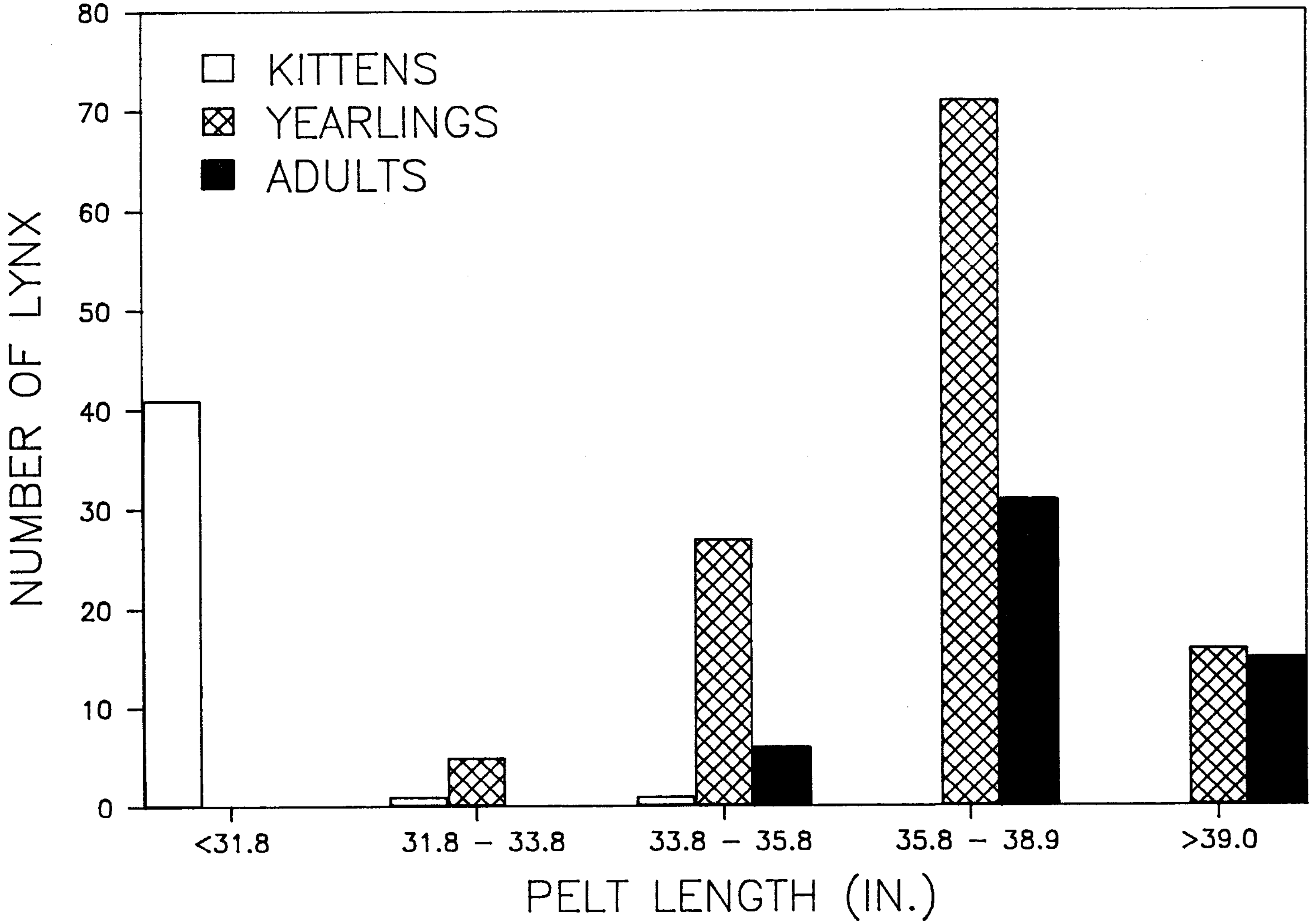


Fig. 3. Pelt length distribution for 213 known-age lynx in Ontario, from Quinn and Gardner (1984).

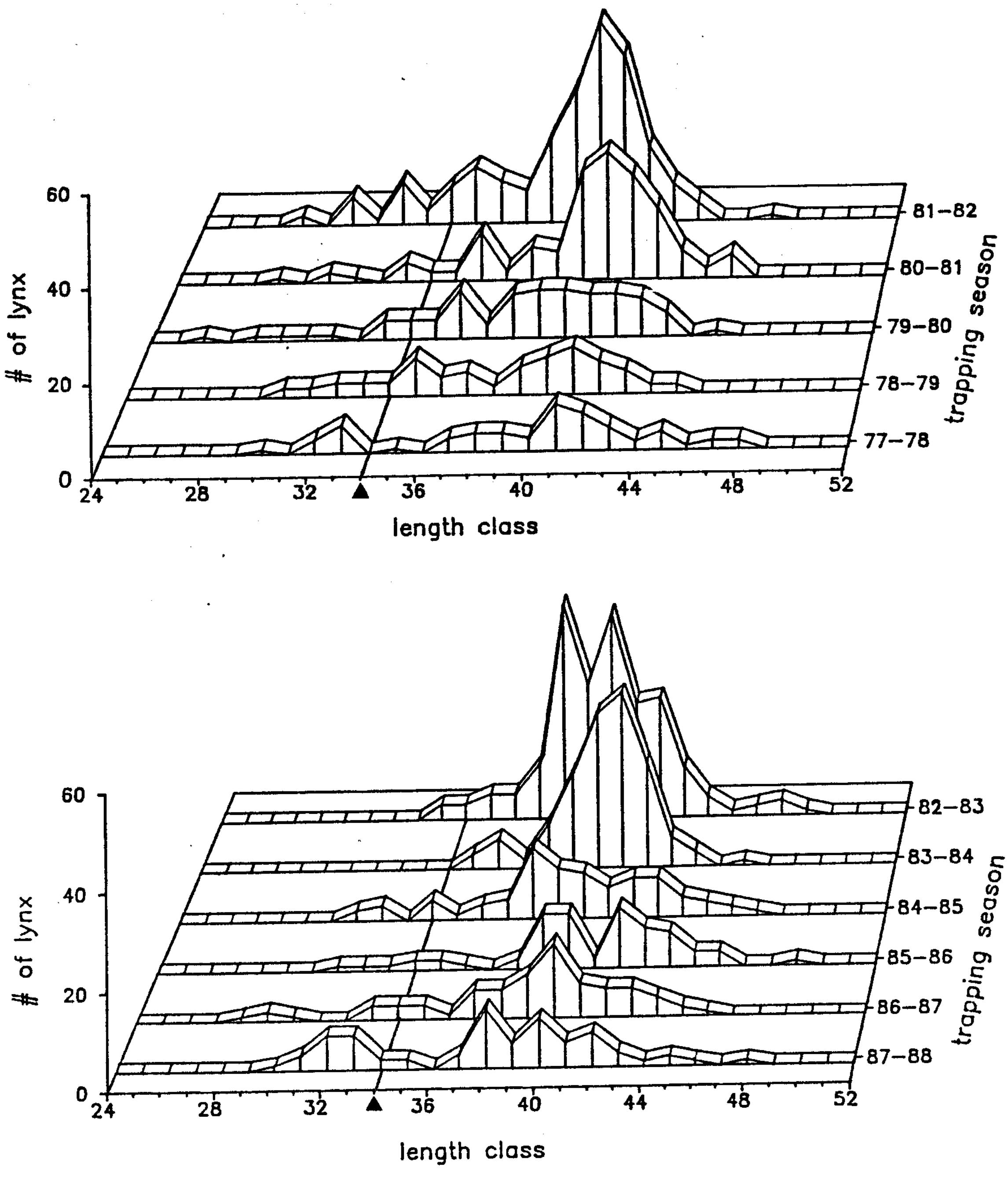


Fig. 4. Three-dimensional portrayal of lynx pelt length (in) distribution in GMU 12, Alaska, 1977-78 through 1987-88 (n = 1,255). The maximum kitten length used in our analysis is indicated by ▲ .

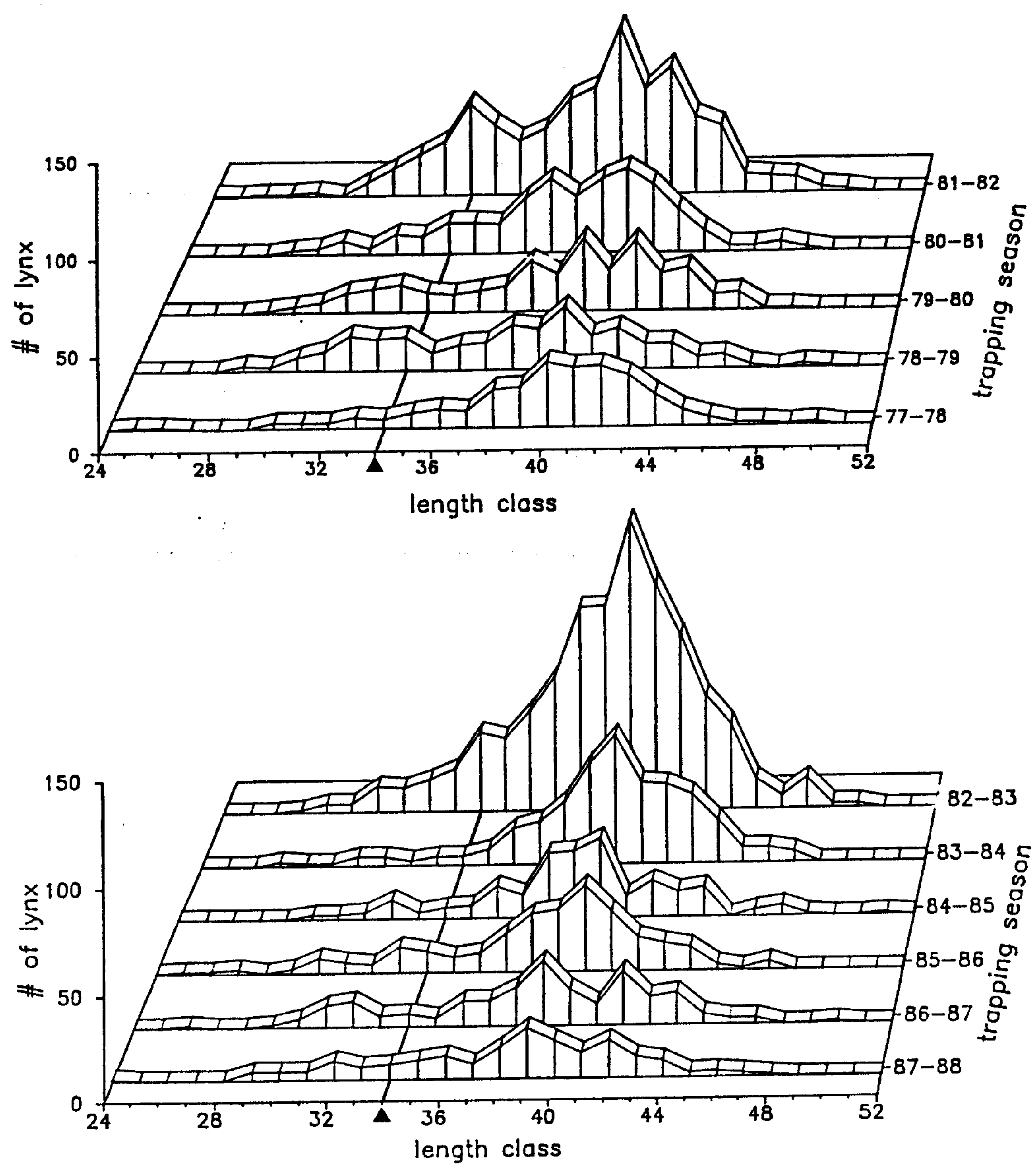


Fig. 5. Three-dimensional portrayal of lynx pelt length (in) distribution in GMU 20, Alaska, 1977-78 through 1987-88 (n = 4,027). The maximum kitten length used in our analysis is indicated by ▲ .

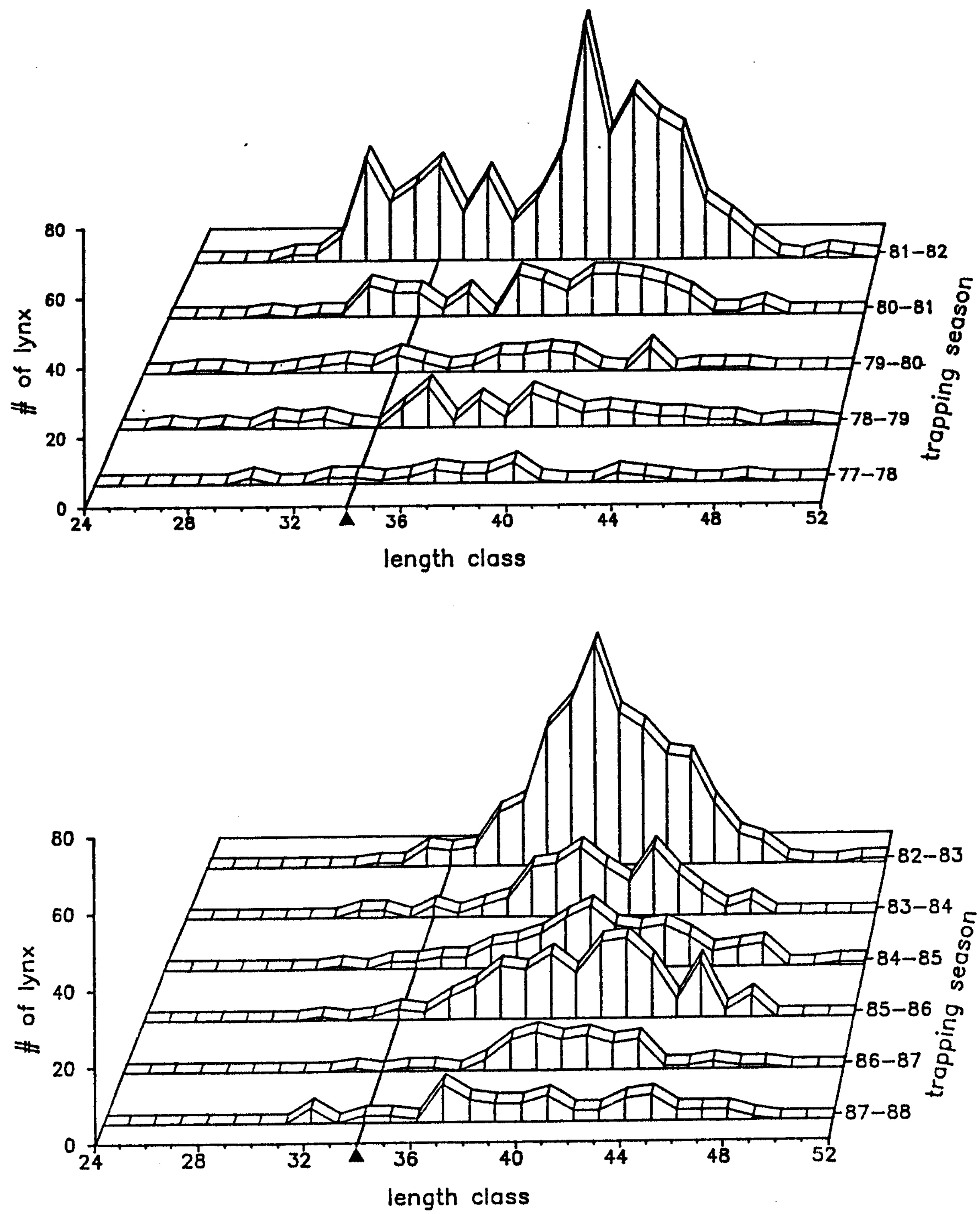


Fig. 6. Three-dimensional portrayal of lynx pelt length (in) distribution in GMU 21, Alaska, 1977-78 through 1987-88 ($\underline{n}$ = 1,691). The maximum kitten length used in our analysis is indicated by ▲.

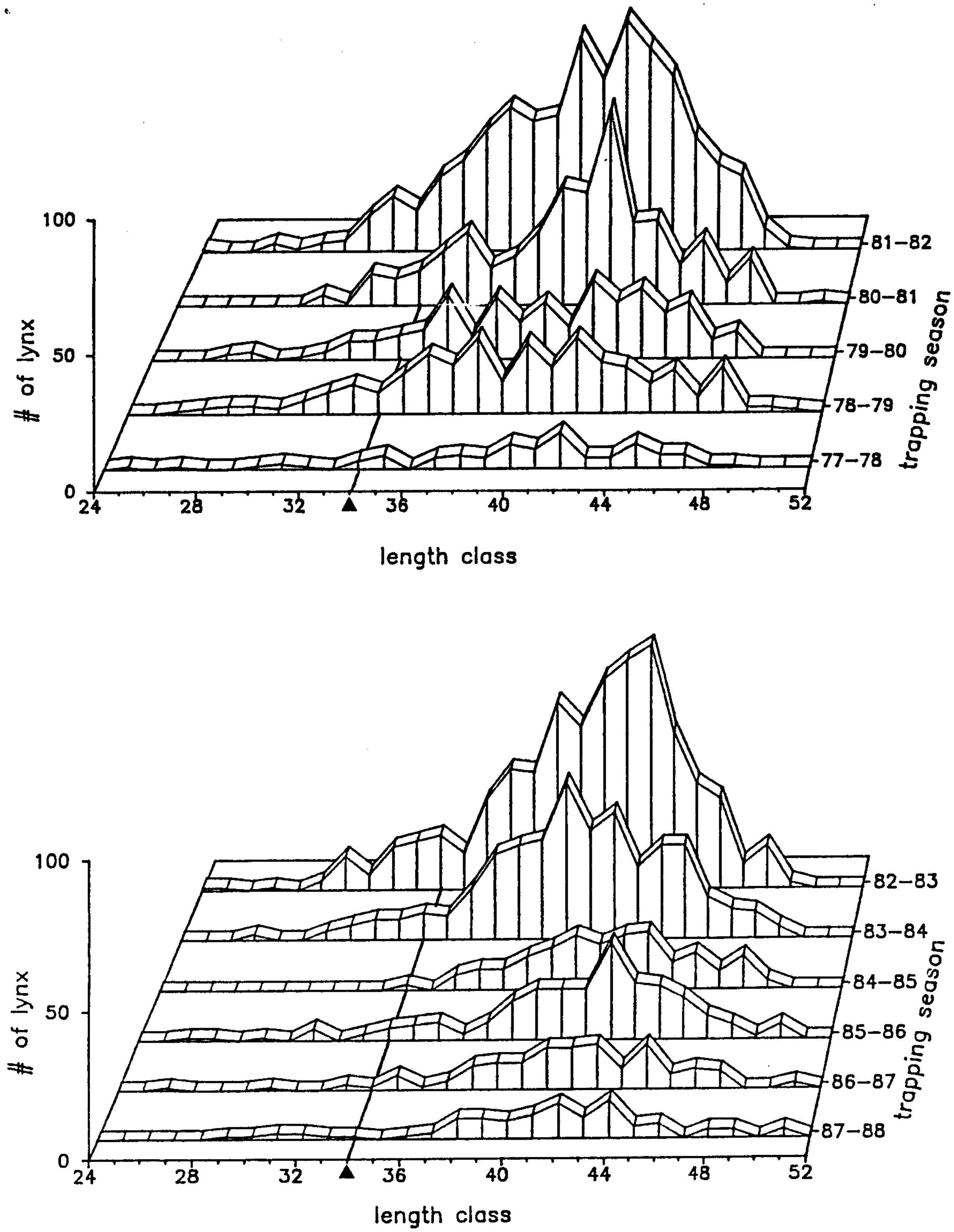
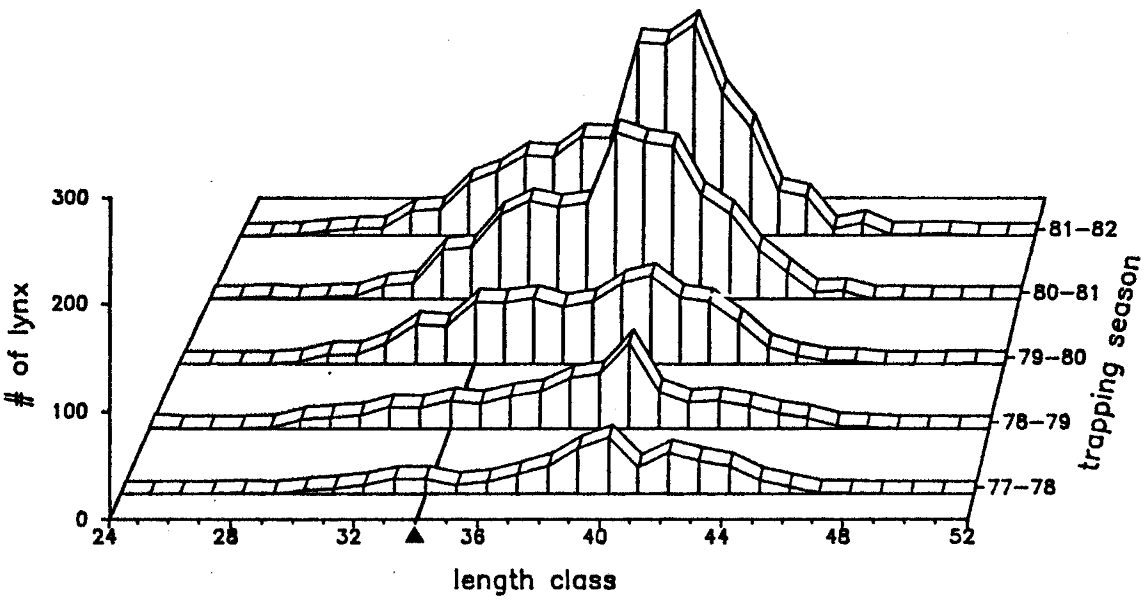


Fig. 7. Three-dimensional portrayal of lynx pelt length (in) distribution in GMU 24, Alaska, 1977-78 through 1987-88 (n = 3,578). The maximum kitten length used in our analysis is indicated by ▲ .



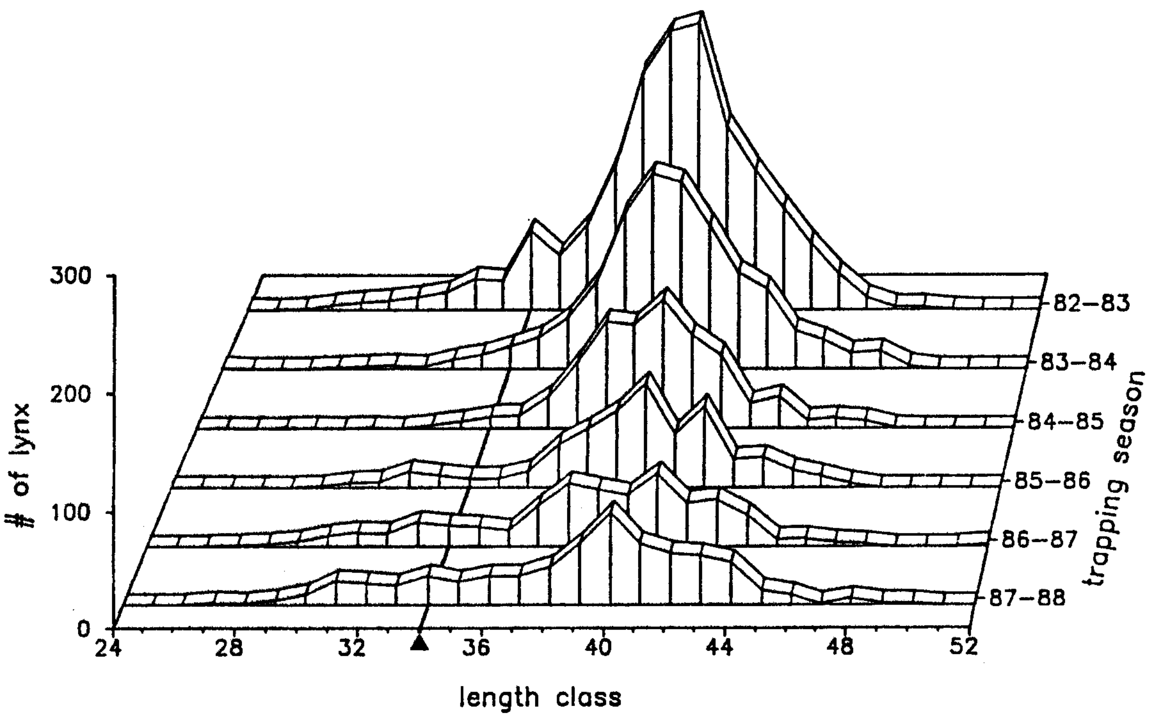


Fig. 8. Three-dimensional portrayal of lynx pelt length (in) distribution in GMU 25, Alaska, 1977-78 through 1987-88 (n = 9,102). The maximum kitten length used in our analysis is indicated by ▲ .

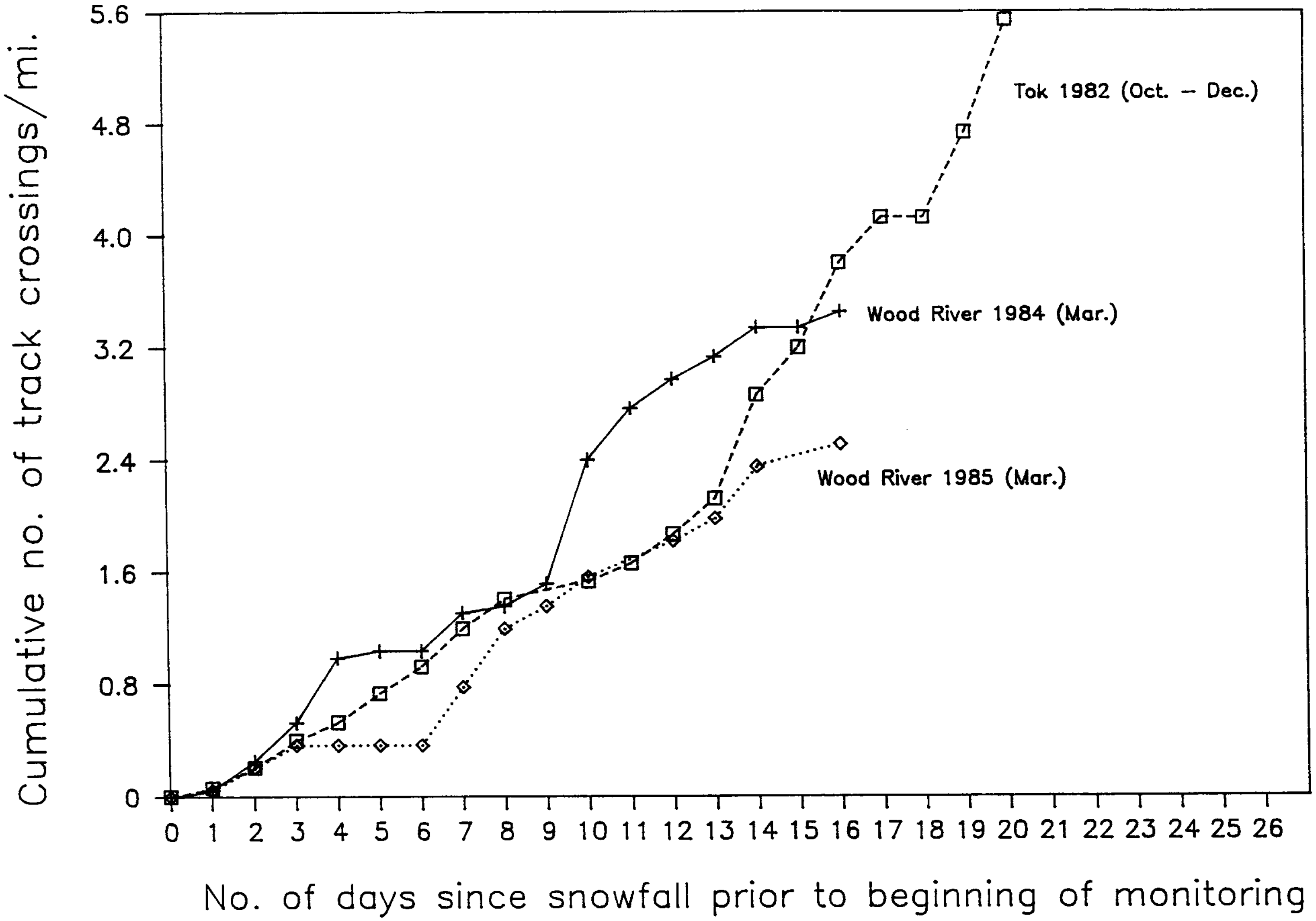


Fig. 9A. Cumulative lynx track frequency in the Tok (1982) and Wood River (1984 and 1985) study areas. Wood River values are based on the 19 mi survey distance.

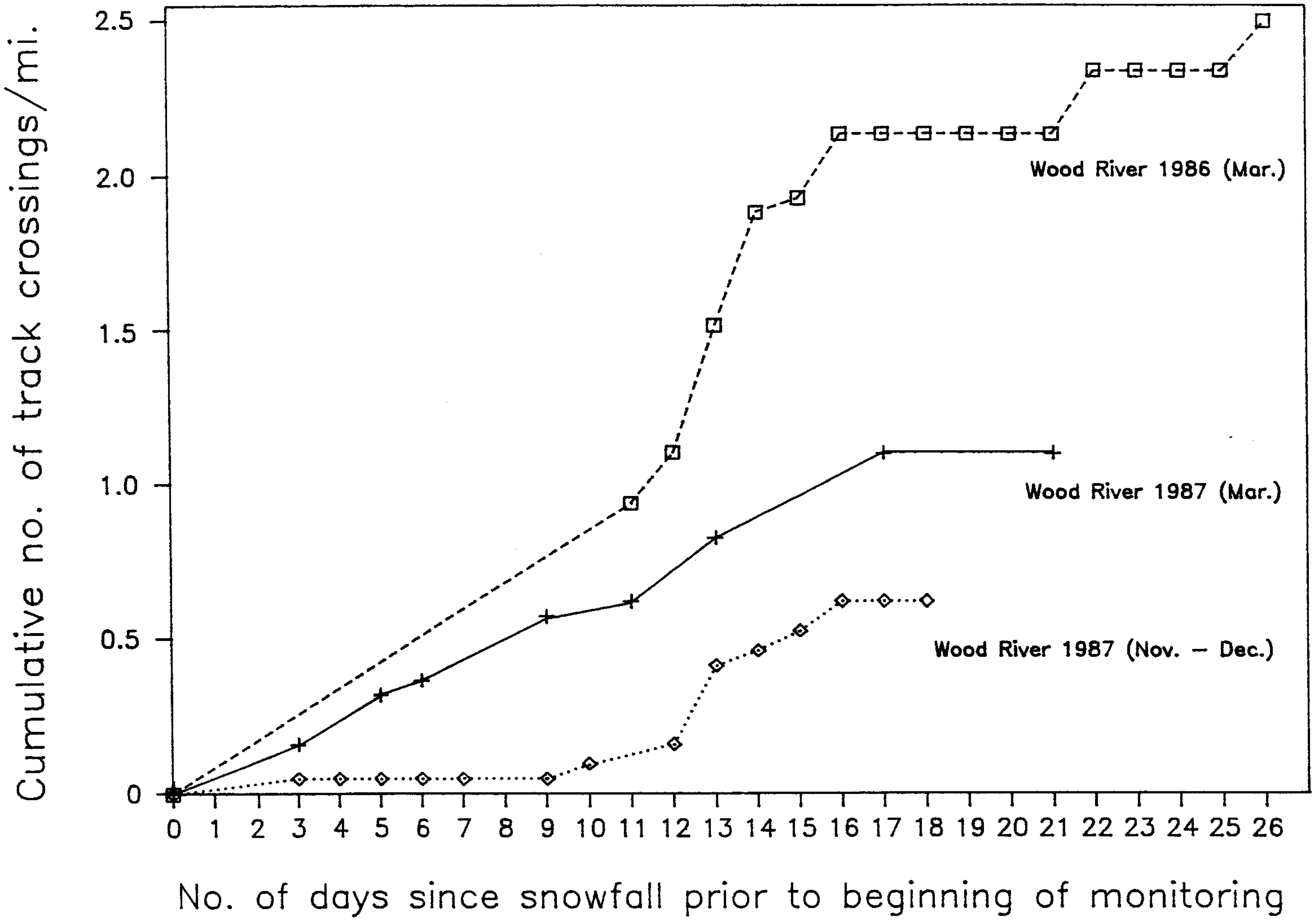


Fig. 9B. Cumulative lynx track frequency in the Wood River study areas in 1986 and 1987, based on the 19 mi survey distance.

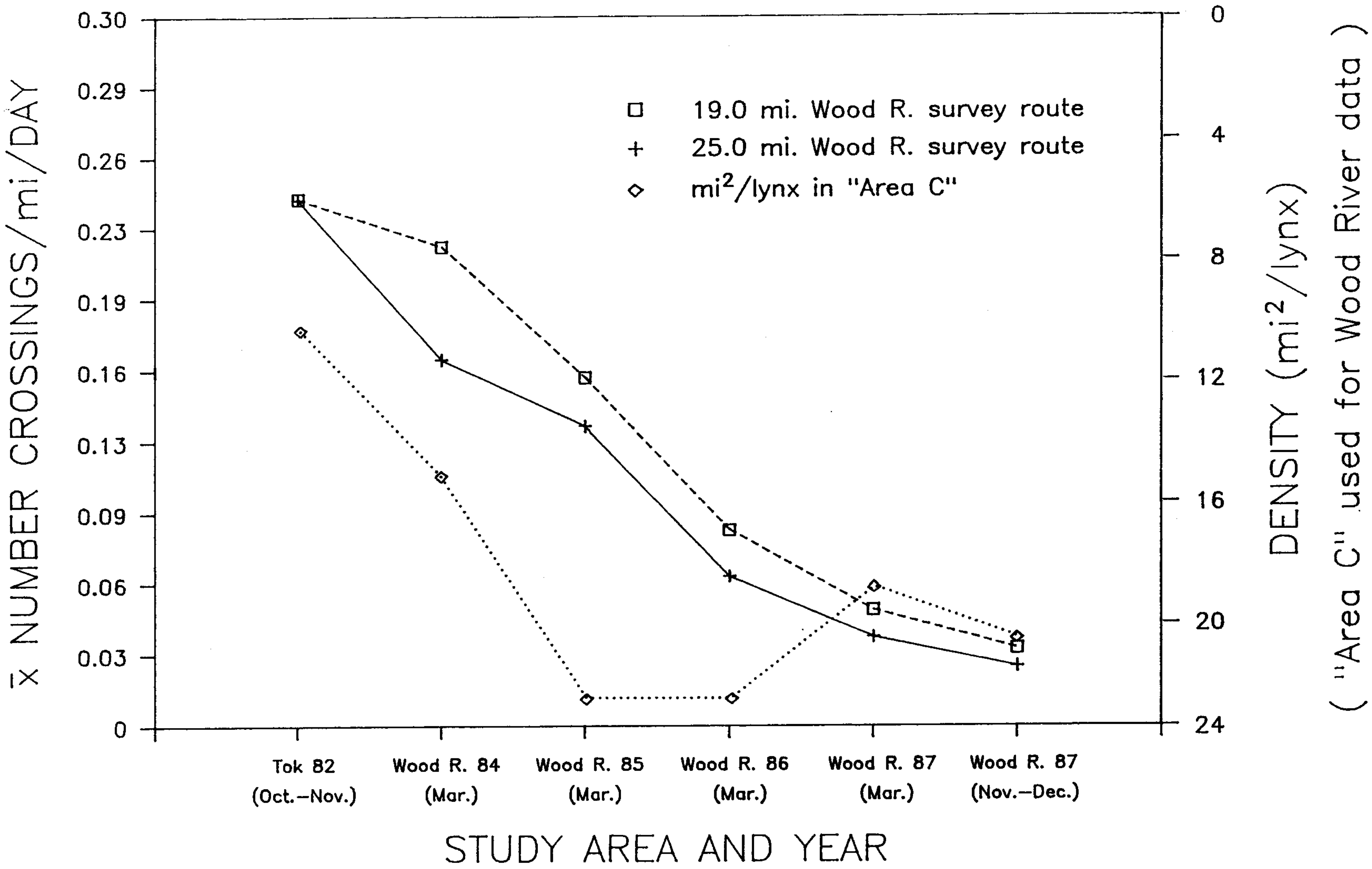


Fig. 10. Average "T-1" track accumulation rates compared with estimated population densities in the Tok and Wood River study areas.

Table 1. Range of values for population variables used in Alaska (this study) and Yukon (Ward 1985) lynx models.

	This study Alaska values		Values used by Ward (1985) Yukon values		
	Snowshoe hare population level		Snowshoe hare population level		
Parameter	Abundant	Scarce	Abundant	Inter-mediate	Scarce
Winter adult natural mortality	0.01	0.025	0.06	0.06	0.06
Winter kitten natural mortality	0.01	0.05	0.06	0.06	0.06
Adult harvest rate	0.0-0.9	0.0-0.5	0.14 or 0.55	0.14 or 0.55	0.14 or 0.55
Kitten harvest rate	0.0-0.9	0.0-0.5	0.14 or 0.55	0.14 or 0.55	0.14 or 0.55
Incidental harvest mortality	0.01	0.01	0	0	0
Adult fecundity	3.7	1.4	3.4	1.8	1.2
Short yearling fecundity	2.9	0.2	1.6	0	0
Sex ratio (% females)	0.5	0.5	0.5	0.5	0.5
Summer adult mortality	0.01	0.025	0	0	0
Summer kitten mortality	0.1	0.75-0.9	0	0.65	0.92

Table 2. Effects of various harvest rates on lynx population growth (simulation 1) under conditions of prey scarcity and with an initial population of 100 adults and 50 kittens.

	Total fall numbers in year 5 (kitten summer mortality rate)	
Harvest rates	(0.75)	(0.90)
0.0	203	147
0.1	135	96
0.2	82	57
0.3	45	34
0.4	23	16
0.5	9	6

Table 3. Effects of varying initial population size on lynx population growth (simulation 2) under conditions of prey abundance and no harvest.

Initial population		Total fall numbers	
Adults	Kittens	Year 3	Year 5
100	50	897	5,229
75	25	600	3,494
50	16	391	2,271
25	8	183	1,058
10	3	59	328

Table 4. Effects of various harvest rates on lynx population growth (simulation 3) under conditions of prey abundance and an initial population of 100 adults and 50 kittens.

Harvest rate	Total fall numbers	
	Year 3	Year 5
0.0	897	5,229
0.1	725	3,418
0.2	568	2,105
0.3	432	1,228
0.4	318	660
0.5	216	301
0.6	137	125
0.7	74	30
0.8	30	0
0.9	3	0

Table 5. Effects of 5 harvest strategies on a hypothetical lynx population during 5 years of prey scarcity followed by 5 years of prey abundance (simulation 4) starting with an initial population of 100 adults and 50 kittens.[a]

	1st 5-year period			2nd 5-year period			
Scenario No.	Harvest rate	Total 5-year harvest	Fall numbers year 6	Harvest rate	Total 5-year harvest	Fall numbers year 11	Total 10-year harvest
1	0.0	0	147	0.3	850	2,107	850
2	0.1	57	85	0.3	485	1,200	542
3	0.2	94	44	0.3	246	617	340
4	0.3	117	23	0.3	109	269	226
5	0.4	131	7	0.4	2	0	133

[a] See Table 1 for baseline population variables.

Table 6. Known trapping harvest of lynx on the Wood River study area, 1969-88.[a]

Regulatory year	Adult male	Adult female	Male kittens	Female kittens	Unknown sex and age	Total	Comments
1969-70					102	102	
1970-71					70	70	
1971-72					20-50	20-50	20 lynx caught in 1 week
1972-73					20-30	20-30	General estimate
1973-74					20-30	20-30	General estimate
1974-75					20-30	20-30	General estimate
1975-76					20-30	20-30	Long trap lines; good lynx year; general estimate
1976-77					20-30	20-30	General estimate
1977-78	5	3	0	0	0	8	From sealing records
1978-79	9	8	1	0	0	18	From sealing records
1979-80	3	3	1	1	0	8	From sealing records
1980-81	0	0	0	0	0	0	No trapping effort
1981-82	2	0	0	1	0	3	Light trapping effort
1982-83	8	9	2	2	1	22	From sealing records
1983-84	11	6	0	1	0	18	From sealing records
1984-85	2	1	0	0	1	4	From sealing records
1985-86	1	4	1	1	0	7	From sealing records
1986-87	0	1	0	0	0	1	From sealing records
1987-88	0	0	0	1	0	1	From sealing records

[a] Sex and age data are not available prior to 1977-78. Harvests prior to 1977-78 are based on records maintained by resident trapper J. Smith.

Table 7. Estimated early and late winter lynx populations, composition, and mortality in the Wood River study area during winters 1983-84 to 1987-88.

Winter	Adult males	Adult females	Adult unknown sex	Total adults	Total kittens no. (%)	Total number	Estimated mortality rate (%)
1983-84							
Early winter	7	9	10	26	6 (18.2)	33	
Known mortality	4	5	6	15	2	18	54.6
Late winter	3	4	4	11	4	15	
1984-85							
Early winter	5	6	2	13	4 (23.5)	17	
Known mortality	2	1	0	3	0	3	17.7
Late winter	3	5	2	10	4	14	
1985-86							
Early winter	3	6	4	13	4 (23.5)	17	
Known mortality	1	4	0	5	2	7	41.2
Late winter	2	2	4	8	2	10	
1986-87							
Early winter	3	3	3	9	4 (30.8)	13	
Known mortality	0	1	0	1	0	1	7.7
Late winter	3	2	3	8	4	12	
1987-88							
Early winter	3	2	3	8	3 (27.3)	11	
Known mortality	0	0	0	0	1	1	9.1
Late winter	3	2	3	8	2	10	

Table 8. Estimated early and late winter lynx population size and density on the Wood River study area during winters 1983-84 to 1987-88.

Winter	Total adults	Total kittens	Total number	Estimated population density (mi^2 per lynx)		
				Area A[a] ($375mi^2$)	Area B[b] ($300mi^2$)	Area C[c] ($220mi^2$)
1983-84						
Early winter	26	6	33	11.4	9.1	6.7
Known mortality	15	2	18			
Late winter	11	4	15	25.1	20.0	14.7
1984-85						
Early winter	13	4	17	22.1	17.6	12.9
Known mortality	3	0	3			
Late winter	10	4	14(10)[d]	26.8	21.4	15.7(22.0)[d]
1985-86						
Early winter	13	4	17	22.1	17.6	12.9
Known mortality	5	2	7			
Late winter	8	2	10	37.5	30.0	22.0
1986-87						
Early winter	9	4	13	28.8	23.1	16.9
Known mortality	1	0	1			
Late winter	8	4	12	31.2	25.0	18.3
1987-88						
Early winter	8	3	11	34.1	27.3	20.0
Known mortality	0	1	1			
Late winter	8	2	10	37.5	30.0	22.0

[a] Includes all habitat within 3.7 mi of trails used to gather population data, except that the southern boundary of the area was set at the 300 m elevation (timberline).

[b] Boundaries are as for Area A except that 2 areas where no sign of lynx activity was observed were excluded (part of Blair Lakes Burn and an area south of the Japan Hills).

[c] Includes that portion of Area B within 3.7 mi of the trails along which track frequency was monitored and the area known to be used by radio-collared lynx.

[d] Population estimate and density in parentheses exclude a female and 3 kittens which temporarily used only the southern edge of the study area and whose tracks were not observed along the trails used in measuring track occurrence.

Table 9. Values for mean number of "T-1" crossings per mile per day and standard deviation (SD) in track samples in the Tok and Wood River study areas, 1982, 1984, 1985, 1986, 1987.

Area, year, transect length, interval, and number of days on which tracks were recorded (*n*)	$\bar{x}$ no. crossings/ mi/day	SE ($\bar{x}$)
Tok, 1982, 15 mi, 16 days, *n* = 15	0.2388	0.0492
Tok, 1982, 15 mi, 20 days, *n* = 19	0.2782	0.0539
Wood River, 1984, 25 mi, 16 days, *n* = 16	0.1659	0.0426
Wood River, 1984, 19 mi, 16 days, *n* = 16	0.2169	0.0557
Wood River, 1985, 25 mi 16 days, *n* = 14	0.1358	0.0257
Wood River, 1985, 19 mi, 16 days, *n* = 14	0.1577	0.3121
Wood River, 1986, 25 mi, 26 days, *n* = 16	0.0681	0.0137
Wood River, 1986, 19 mi, 26 days, *n* = 16	0.0890	0.0178
Wood River, 1987, 25 mi, 21 days, *n* = 8	0.0402	0.0010
Wood River, 1987, 19 mi, 21 days, *n* = 8	0.0526	0.0132
Wood River, fall 1987, 25 mi, 18 days, *n* = 16	0.0269	0.0119
Wood River, fall 1987, 19 mi, 18 days, *n* = 16	0.0351	0.0154

Appendix A. Historical review of lynx harvest and population trends.

The following discussion provides a historical perspective on lynx populations and harvest in Alaska and makes various historical data more accessible to other investigators. This discussion relies on records of lynx pelt exports from 1910 to the present (Courtright 1968, ADF&G files), lynx sealing records maintained since 1977, and information provided by numerous biologists, trappers, fur buyers, and other interested members of the public.

The historical changes in season lengths (Appendix B) should be kept in mind when interpreting harvest data. Prior to 1963, lynx trapping seasons were considerably shorter than those of more recent years.

The number of lynx exported and/or sealed from 1909 through 1988 are provided in Table 1 and Fig. 1. Export figures represent minimum estimates of the harvest, because not all lynx pelts are exported. Since 1977 all lynx pelts in Alaska have been required to be sealed; thus sealing data should closely reflect actual lynx harvests.

It should be remembered that population and harvest peaks do not always coincide. To measure the relative strength of each "high," we compared export data from specific years and also the total number of pelts exported/sealed during the 6 highest years in each cycle.

The highest reported annual exports of lynx pelts from Alaska occurred in the 1916-17 and 1917-18 trapping seasons. More than 21,000 pelts were exported during each of those periods. By current standards, exports were also high for 3 years before and 1 year after these 2 peak seasons; the total 6-year (1912-17) export was 70,986 pelts. Following the subsequent low from 1918-19 through 1922-23, pelt exports again peaked at about 10,000 pelts in 1926-27 and 1927-28; the 6-year (1923-28) export was 46,295 pelts. Trapping pressure was very high during this period; trappers were numerous and widely distributed because of high fur prices (Koontz 1968; S. Huntington and F. Thomas, pers. commun.).

After a low during the 1930-31 to 1933-34 seasons, exports increased only slightly with a peak of 2,705 in 1938-39; the 6-year (1934-39) export was 12,381 pelts. Exports of other furbearers remained relatively high during this period (Courtwright 1968), as did lynx pelt value. The reduction in the export of lynx pelts was probably not caused by a drastic reduction in trapping pressure; rather, reduced lynx numbers may account for the relatively low exports during this period.

Despite reasonably high fur prices, low numbers of pelts exported during the 1930's were followed by very low exports during the 1940's, with no apparent peak; i.e., exports were less than 1,000 (F. Thomas, pers. commun.). Reasons for these low exports may include the occurrence of World War II, the availability of alternative sources of income, and the relatively low number of lynx available. Exports of other furbearers, as well as lynx pelt values, remained fairly high, suggesting that trapping pressure had not markedly declined. Fred Thomas, who trapped on the Black River during this period, said that lynx were relatively scarce during the 1940's, despite an abundance of hares; he attributed the scarcity to heavy trapping during the previous 30 years.

A small peak in exports occurred during the 1950's: 3,100 lynx for the 1954-55 season. The 6-year (1952-57) export was 12,600 pelts. This peak followed a dramatic decline in fur prices during the late 1940's and early 1950's, and it probably reflects an historic low in trapping pressure in Alaska. Many people who had formerly depended on trapping for winter income quickly abandoned this pursuit (Koontz 1968; F. Thomas, pers. commun.). Although the precise status of lynx populations is not known, trappers on the Black River (Unit 25), in the Glennallen-Nabesna area (Units 12 and 13), and near Fort Richardson (Subunit 20B) reported that lynx were abundant during the high phase of the cycle in the mid-1950's. Interviews with other trappers who traveled in the Interior during the 1950's indicate these areas with good lynx populations were the exception. In the remainder of the Interior and in Southcentral Alaska, lynx did not appear to be abundant.

Following a low in the late 1950's and early 1960's, the number of pelts exported rose to a peak of 5,134 in 1965-66, with a 6-year (1962-67) export of 18,958. Increases in Alaska's human population as well as fur prices appear to have increased trapping pressures compared with those of the 1950's. In contrast to earlier lows, annual exports exceeded 1,000 pelts during the low in the mid-1960's.

During the 1970's pelt exports peaked at 7,902 for the 1973-74 season; the 6-year (1971-76) export was 24,298 pelts. The already high trapping pressures increased in most areas as the value of lynx, marten, and fox pelts rose rapidly. Lynx were abundant in most areas, but in the upper Tanana Valley trappers reported that the 1970's high was noticeably lower than the 1960's high; e.g., two-thirds lower (D. Grangaard, pers. commun.). Thus more lynx pelts were exported in the

1970's than in the 1960's, despite indications of higher populations in the 1960's. The snowmachine, which was well developed and in widespread use by the early 1970's, dramatically altered the nature of trapping. Generally travel became more rapid and convenient, increasing the incentive to trap even when furbearers were relatively scarce.

Following the 1973-74 peak, the number of pelts exported remained at levels higher than those recorded during lows in previous cycles; the lowest annual number of pelts exported was 1,738. Pelt exports peaked at 3,984 for the 1981-82 season with a 6-year (1978-83) export of 15,850. A mandatory sealing requirement was instituted for the 1977-78 season, and 2,014 lynx pelts were sealed. The number of pelts sealed peaked at 5,652 for the 1982-83 season, before declining to 3,045 pelts the following season. The total number of lynx pelts sealed during the 6-year (1978-83) high was 22,579. During the 11 years for which both export and sealing data are available, reported exports averaged 79% (range = 56.6-97.6%) of the number sealed.

During the 1980's lynx in the Tanana Valley and in Units 12 and 13 have been far less abundant than during the 1970's peak, perhaps because of the comparatively low peak in hare numbers in most areas during the 1980's. However, the pelt length analysis described earlier indicates that lynx productivity in the Tanana Valley was comparable with areas where hares were more abundant. Sustained high harvests during the 1970's high and intervening low may have contributed to the comparatively low peak in the number of pelts sealed from Unit 20. In contrast, during the early 1980's lynx (and hares) were abundant in the Black River drainage in Unit 25 and in parts of Units 22 and 24. In some previous cycles, peaks in the hare-lynx cycle in Unit 25 seem to have occurred 1 or 2 years before peaks in the Tanana Valley (O'Connor 1984; R. Long and D. Grangaard, pers. commun.). During the most recent cycle, declines have occurred simultaneously in the 2 areas, possibly because in the Tanana Valley lynx and hare abundance declined after a peak having a lower than expected amplitude.

Extremely high lynx harvests between 1910 and 1930 (Table 1) may have had long-term effects on lynx populations. Low peak exports in the late 1930's and the absence of high exports in the 1940's may have been partly caused by extremely high harvests during the 2 previous cycles. Likewise, we suspect that the high peak exports between 1910 and 1930 were possible because trapping pressure had been relatively light prior to the influx of miners and accompanying steel traps and snares.

Data in Table 1 and Fig. 1 suggest that cyclic peaks in lynx numbers are declining. For instance, the average 6-year export during peaks of the last 3 cycles (i.e., 1962-67 = 18,958, 1971-76 = 24,298, 1978-83 = 15,850) is 19,702, which is 28% of the 1912-17 6-year export and 42% of the 1923-28 6-year export. Because trapping pressure has increased to high levels during recent years (i.e., few areas supporting significant numbers of lynx are not being trapped), the lower harvests in recent cycles may be due to lower numbers of lynx. In addition, fire suppression has probably lowered habitat carrying capacity for hares as well as lynx in some areas (Stephenson 1984). This change is probably greatest south of the Yukon River in Unit 20 and in southcentral Alaska, where fire suppression has been greatest.

The numbers of pelts exported during the low phase of the 1970's cycle were 1.4 to 5.5 times higher than in earlier cycles; this factor probably reflects the increased incentive to trap lynx even when they are not abundant as well as the availability of the modern snowmachine, which makes trapping more feasible, even when furbearers are relatively scarce.

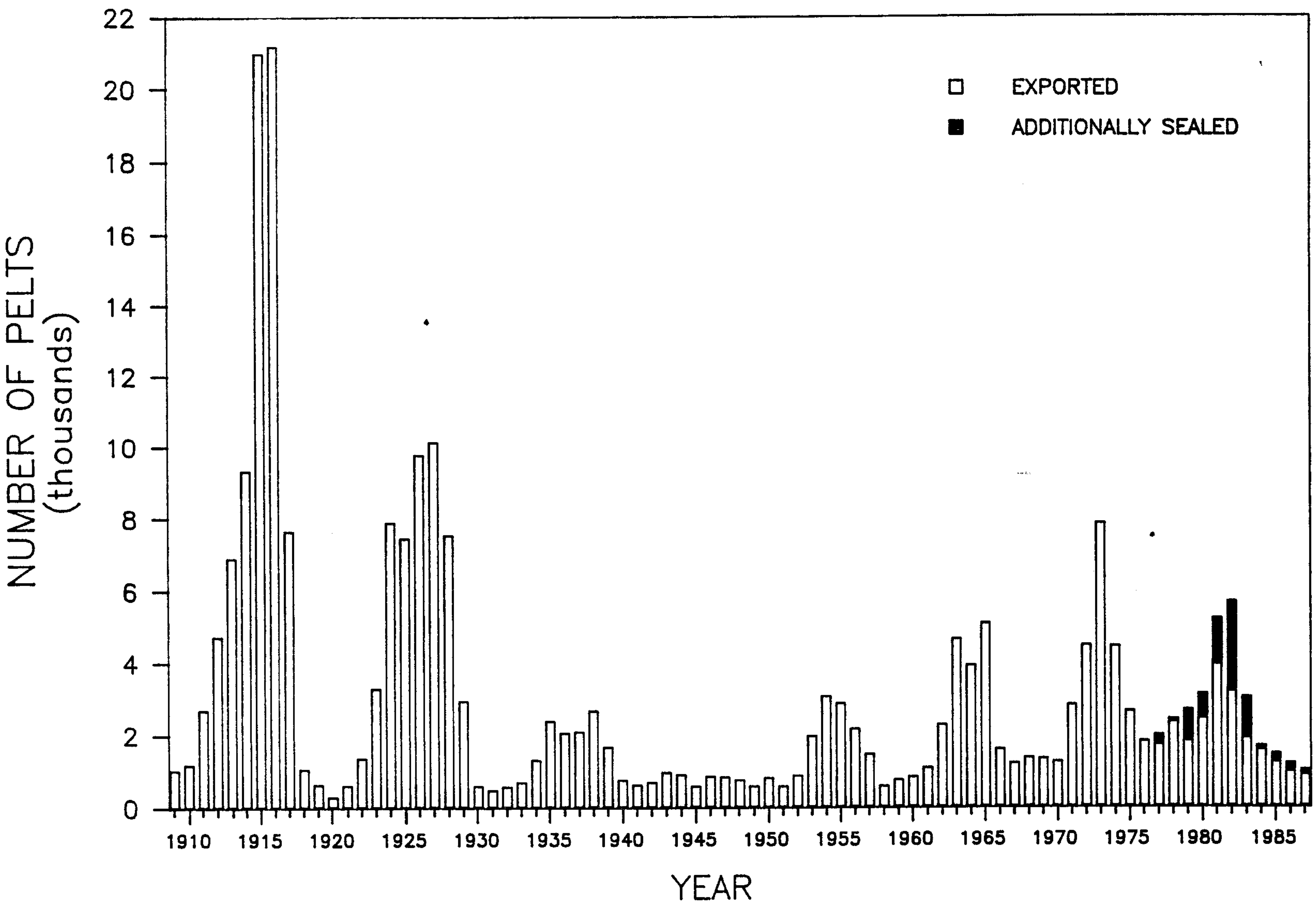
LITERATURE CITED

Courtright, A. M. 1968. Game harvests in Alaska. Alaska Dep. of Fish and Game. Juneau. 70pp.

Koontz, K. C. 1968. Small game and furbearers of the Rampart Dam impoundment area. Unpubl. M.S. Thesis. Univ. of Alaska-Fairbanks. 165.

O'Connor, R. M. 1984. Population trend, age structure, and reproductive characteristics of female lynx in Alaska, 1961 through 1973. M.S. Thesis. Univ. of Alaska, Fairbanks. 111pp.

Stephenson, R. O. 1984. The relationship of fire history to furbearer populations and harvest. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. bob, is it Prog. Rep. or Final Rep.???? Proj. W-22-2. Juneau. 86pp.



Appendix A, Fig. 1. Number of lynx pelts exported from Alaska (white bars), 1909-10 through 1987-88, and number of lynx pelts sealed (black bars) from 1977-78 through 1987-88.

Appendix A, Table 1. Lynx harvests in Alaska based on number of pelts exported and, beginning in 1977-78, on the number of pelts sealed.

Winter	Number[a]	Winter	Number[a]
1909-10	1,049	1949-50	608
1910-11	1,208	1950-51	843
1911-12	2,720	1951-52	600
1912-13	4,772	1952-53	900
1913-14	6,930	1953-54	2,000
1914-15	9,374	1954-55	3,100
1915-16	21,008	1955-56	2,900
1916-17	21,210	1956-57	2,200
1917-18	7,692	1957-58	1,500
1918-19	1,085	1958-59	605
1919-20	649	1959-60	782
1920-21	318	1960-61	864
1921-22	628	1961-62	1,107
1922-23	1,385	1962-63	2,312
1923-24	3,323	1963-64	4,700
1924-25	7,920	1964-65	3,957
1925-26	7,495	1965-66	5,134
1926-27	9,809	1966-67	1,615
1927-28	10,173	1967-68	1,240
1928-29	7,575	1968-69	1,386
1929-30	2,980	1969-70	1,360
1930-31	623	1970-71	1,277
1931-32	502	1971-72	2,853
1932-33	591	1972-73	4,520
1933-34	723	1973-74	7,902
1934-35	1,338	1974-75	4,500
1935-36	2,421	1975-76	2,676
1936-37	2,089	1976-77	1,847
1937-38	2,130	1977-78	1,738 (2,015)
1938-39	2,705	1978-79	2,387 (2,446)
1939-40	1,698	1979-80	1,849 (2,739)
1940-41	781	1980-81	2,483 (3,293)
1941-42	639	1981-82	3,984 (5,243)
1942-43	713	1982-83	3,222 (5,691)
1943-44	990	1983-84	1,925 (3,167)
1944-45	992	1984-85	1,596 (1,696)
1945-46	601	1985-86	1,261 (1,495)
1946-47	883	1986-87	997 (1,207)
1947-48	862	1987-88	907 (1,039)
1948-49	777		

[a] Numbers of pelts exported from 1909-10 through 1965-66 are from Courtright (1968). Numbers from 1966-67 through 1976-77 are a sum of furdealer, trapper, and personal use exports (ADF&G unpubl. data). From 1977-78 through the present, the number of pelts sealed is given in parentheses.

Appendix B. Historical summary of lynx trapping seasons in Alaska.

The history of lynx trapping seasons in Alaska is based on a review of regulations established by the Alaska Game Commission prior to statehood and on regulations established by the Alaska Board of Game. These documents are on file at the Fairbanks office of the Alaska Department of Fish and Game, and also at the University of Alaska Library.

Prior to 1931-32, Alaska was divided into 3 Fur Management Districts. District 1 included the Aleutian Islands, Alaska Peninsula south of Lake Iliamna, and southeastern Alaska from Cape Fairweather to Dixon Entrance. District 2 included all of the mainland and islands of Alaska not included in District 1 and south of the headwaters and streams entering the Arctic Ocean north of 68° and the Noatak, Kobuk, Selawik, and Buckland Rivers. In 1931-32, 8 fur districts were established; seven of them were subdivisions of the earlier Districts 1 and 2. In 1956-57, 26 wildlife management units were created; to a large degree, these boundaries correspond to the 26 units currently in use.

In Territorial regulations lynx were generally grouped with other furbearers (i.e., mink, otter, weasel, and fox) for which there was a general season. The species included in this general season sometimes changed; e.g., some times marten were included in the general season, and at other times they were regulated separately when it was necessary to shorten or close their season.

The opening and closing dates listed in the following table describe the various season lengths existing in mainland Alaska during the period indicated; the seasons in the southern portion of the state are listed first:

Period	Opening dates	Closing dates
1926-30	November 16	March 1
	November 16	January 31
1931-43	November 6	February 20
	November 16	February 20
	December 1	February 28
1944-46	November 16	January 15
	November 16	February 28
	November 1	January 31
1947-57	November 16	January 31
1958-63	November 1	January 31
	November 10	January 31
	November 16	January 31
1963-85	November 1	March 31
	November 10	March 31

Appendix C. Tables relating to numerical distribution and summary statistics for lynx pelt measurements.

Appendix C, Table 1. Lynx pelt length distribution in a sample of 157 lynx kittens and 338 adults in Alaska, 1986-88.

Length (in)[a]	Kitten		Adult	
	No. in class	% in class	No. in class	% in class
26	1	0.64	0	0.00
27	1	0.64	0	0.00
28	5	3.18	0	0.00
29	5	3.18	0	0.00
30	22	14.01	0	0.00
31	21	13.38	0	0.00
32	35	22.29	0	0.00
33	34	21.66	2	0.59
34	15	9.55	2	0.59
35	10	6.37	9	2.66
36	5	3.18	11	3.25
37	2	1.27	16	4.73
38	0	0.00	50	14.79
39	1	0.64	55	16.27
40	0	0.00	32	9.47
41	0	0.00	55	16.27
42	0	0.00	35	10.36
43	0	0.00	33	9.76
44	0	0.00	22	6.51
45	0	0.00	4	1.18
46	0	0.00	6	1.78
47	0	0.00	3	0.89
48	0	0.00	1	0.30
49	0	0.00	0	0.00
50	0	0.00	2	0.59
	157		338	

[a] 1 in = 2.54 cm.

Appendix C, Table 2. Summary statistics for pelt measurements from 495 adult and kitten lynx in Alaska, 1986-88.[a]

Measurement (in)[a]	Average	Minimum	Maximum	Sample variance	Standard deviation	n
Kitten length	32.23	26.00	39.00	4.29	2.07	157
Kitten width	8.65	6.00	12.00	1.38	1.17	157
Adult length	40.32	33.00	50.50	7.45	2.73	338
Adult width	9.41	6.00	14.00	1.44	1.20	333

[a] 1 in = 2.54 cm.

Appendix C, Table 3. Lynx pelt width distribution in a sample of 157 kittens and 333 adults, 1986-88.

Width (in)[a]	Kitten		Adult	
	No. in class	% in class	No. in class	% in class
5	0	0.00	0	0.00
6	11	7.01	2	0.60
7	15	9.55	16	4.80
8	43	27.39	50	15.02
9	63	40.13	124	37.24
10	21	13.38	96	28.83
11	3	1.91	32	9.61
12	1	0.64	9	2.70
13	0	0.00	2	0.60
14	0	0.00	2	0.60
	157		333	

[a] 1 in = 2.54 cm.

Appendix D. A series of 6 tables and 5 figures relating to the number of lynx pelts measured and pelt length distribution in Game Management Units 12, 20, 21, 24, and 25 from 1977-78 through 1987-88.

Appendix D, Table 1. Total number of lynx pelts for which measurements were recorded. Game Management Units 1-26, 1977-88.

GMU	Regulatory year 77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	All years	% ea. GMU
1			1			39	15	2	1			58	0.211
2					1							1	0.004
3					1							1	0.004
4												0	0.000
5				1		5	3		2			11	0.040
6					1		1	1	2	7	2	14	0.051
7					3	4	2	2	14	23		48	0.175
8							2					2	0.007
9			141	118	61	98	25	52	44	50	10	599	2.183
10												0	0.000
11			53	57	57	136	111	76	22	16		528	1.924
12	70	72	93	139	214	211	151	82	73	78	72	1,255	4.574
13			36	40	122	205	138	48	22	9	1	621	2.263
14			5	2	7	21	6	15	8	6		70	0.255
15			14	3	20	44	31	28	47	52	6	245	0.893
16			6	1	2	6	10	1	2	6		34	0.124
17			25	40	17	25	12	29	8	13	1	170	0.620
18			62	46	70	65	21	23	13	8	10	318	1.159
19			215	171	259	144	53	30	33	26	47	978	3.564
20	317	267	293	346	647	927	368	221	251	214	176	4,027	14.676
21	49	86	56	119	480	357	126	123	162	62	71	1,691	6.163
22			257	80	478	807	432	154	23	18	3	2,252	8.207
23			406	299	481	281	84	26	40	16		1,633	5.951
24	88	301	280	429	779	693	427	162	203	127	89	3,578	13.039
25	371	497	762	1,256	1,443	1,576	1,027	618	514	487	551	9,102	33.171
26			2	4	10	9	2	3	2			32	0.117
Unk	0	0	0	0	99	69	0	0	3	0	1	172	0.627
Measured harvest	895	1,223	2,707	3,151	5,252	5,722	3,047	1,696	1,489	1,218	1,040	27,440	100.00
Total harvest	2,015	2,446	2,739	3,293	5,252	5,722	3,167	1,696	1,495	1,218	1,040	30,083	

Appendix D, Table 2. Lynx pelt length distribution in GMU 12 harvests, 1977-87.

Pelt length (in)[a]	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Kitten[b]	4	0										4
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	1	0	0	0	0	0	0	0	0	1
27	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	1	1	2	0	0	0	0	1	0	5
29	0	0	1	0	0	0	0	0	0	2	0	3
30	1	2	1	2	6	0	0	0	0	1	1	14
31	0	2	1	1	1	0	0	2	1	0	3	11
32	3	3	0	0	9	0	0	3	1	0	7	26
33	6	3	4	4	3	3	0	0	1	3	7	34
34	0	3	4	2	8	3	0	4	2	3	2	31
35	1	8	4	2	12	5	3	1	2	3	2	43
36	0	4	10	10	9	5	6	3	1	1	0	49
37	3	5	3	2	7	11	2	4	0	6	3	46
38	4	2	9	7	18	43	9	14	2	6	12	126
39	4	6	10	6	28	27	19	10	11	9	5	135
40	3	8	10	23	42	41	31	9	11	15	10	203
41	10	10	9	27	35	23	35	6	2	7	5	169
42	8	7	9	22	16	24	21	8	12	6	7	140
43	5	5	8	15	8	10	6	8	8	6	3	82
44	2	2	5	6	4	4	3	4	7	4	1	42
45	4	2	0	2	0	1	0	3	3	2	2	19
46	1	0	1	5	0	2	1	2	3	1	1	17
47	2	0	0	0	1	3	0	1	0	0	0	7
48	2	0	0	0	0	1	0	0	0	0	1	4
49	0	0	0	0	0	0	0	0	1	0	0	1
50	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0
Adult[c]	7											7

Appendix D, Table 2. Continued.

Pelt length (in)	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Total	59	72	91	137	209	206	136	82	68	76	72	1,208
≤34"	10	13	13	10	29	6	0	9	5	10	20	125
>34"	49	59	78	127	180	200	136	73	63	66	52	1,083
% ≤34"	16.95	18.06	14.29	7.30	13.88	2.91	0.00	10.98	7.35	13.16	27.78	10.35
% >34"	83.05	81.94	85.71	92.70	86.12	97.09	100.00	89.02	92.65	86.84	72.22	89.65

[a] 1 in = 2.54 cm.

[b] Total for all pelts entered on sealing form as "kitten," but with no length measurement. Not used for calculation of total or percentages.

[c] Total for all pelts entered on sealing form as "adult," but with no length measurement. Not used for calculation of total or percentages.

Appendix D, Table 3. Lynx pelt length distribution in GMU 20 harvests, 1977-87.

Pelt length (in)[a]	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Kitten[b]	15	0	0	0	0	0	0	0	0	0		15
24	0	0	0	0	1	0	0	0	0	0	1	2
25	1	0	0	0	0	0	0	0	1	0	0	2
26	1	0	0	0	1	0	0	0	1	1	0	4
27	0	0	0	0	1	1	2	0	2	0	0	6
28	0	3	1	2	2	4	1	0	0	0	0	13
29	0	2	3	3	0	4	1	2	2	1	4	22
30	3	7	5	7	7	12	4	2	7	4	4	62
31	3	10	10	3	14	11	4	3	5	10	4	77
32	3	18	12	10	21	15	2	9	4	12	9	115
33	6	16	14	9	28	20	4	3	12	5	6	123
34	5	17	10	16	47	37	4	5	10	6	7	164
35	8	9	9	16	36	34	7	6	7	4	9	145
36	10	13	11	15	28	47	17	15	9	12	11	188
37	9	14	13	28	34	63	20	11	18	12	7	229
38	20	23	26	38	49	95	29	30	27	18	15	370
39	21	21	19	29	55	96	47	31	29	30	24	402
40	34	32	37	38	85	136	60	37	40	17	18	534
41	31	17	21	43	54	106	38	10	28	10	12	370
42	32	21	36	35	65	82	37	17	16	25	18	384
43	27	13	19	22	40	53	32	12	13	13	10	254
44	17	13	22	11	35	40	20	14	11	15	8	206
45	9	6	8	3	10	14	7	0	3	5	2	67
46	5	7	9	3	9	6	7	3	1	3	3	56
47	2	2	1	5	8	14	5	5	4	3	2	51
48	2	0	1	2	3	2	0	1	0	0	1	12
49	1	2	0	0	2	2	0	0	0	0	0	7
50	2	1	0	0	0	0	0	0	0	1	0	4
51	0	0	0	0	0	0	0	1	0	0	0	1
52	0	0	0	0	0	0	0	0	0	0	0	0
Adult[c]	50	0	0	0	0	0	0	0	0	0		50

Appendix D, Table 3. Continued.

Pelt length (in)	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Total	252	267	287	338	635	894	348	217	250	207	175	3,870
≤34"	22	73	55	50	122	104	22	24	44	39	35	590
>34"	230	194	232	288	513	790	326	193	206	168	140	3,280
% ≤34"	8.73	27.34	19.16	14.79	19.21	11.63	6.32	11.06	17.60	18.84	20.00	15.25
% >34"	91.27	72.66	80.84	85.21	80.79	88.37	93.68	88.94	82.40	81.16	80.00	84.75

[a] 1 in = 2.54 cm.

[b] Total for all pelts entered on sealing form as "kitten," but with no length measurement. Not used for calculation of total or percentages.

[c] Total for all pelts entered on sealing form as "adult," but with no length measurement. Not used for calculation of total or percentages.

Appendix D, Table 4. Lynx pelt length distribution in GMU 21 harvests, 1977-87.

Pelt length (in)[a]	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Kitten[b]	2	0										2
24	0	0	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0	0	0
26	0	1	1	0	0	0	0	0	0	0	0	2
27	0	0	1	0	0	0	0	0	0	0	0	1
28	0	1	0	1	2	0	0	0	0	0	0	4
29	0	0	0	0	2	0	0	0	0	0	0	2
30	2	3	1	1	7	0	0	0	0	0	0	14
31	0	2	2	1	30	1	2	1	1	0	0	40
32	0	3	3	9	17	1	2	0	0	0	4	39
33	2	1	2	7	22	5	0	2	1	1	0	43
34	2	0	5	7	28	4	3	2	3	0	2	56
35	1	6	3	2	14	5	1	3	2	1	2	40
36	2	12	1	7	25	14	3	3	6	1	1	75
37	4	2	2	0	11	17	5	6	9	0	10	66
38	3	8	5	12	18	36	13	7	14	3	6	125
39	3	3	5	10	31	43	14	9	13	8	5	144
40	6	10	6	7	68	58	18	13	17	10	5	218
41	1	7	5	12	36	40	13	16	12	8	7	157
42	0	4	1	12	48	36	9	11	20	9	3	153
43	0	5	0	11	41	29	18	10	21	7	3	145
44	3	4	7	9	37	28	11	11	15	8	6	139
45	2	3	0	6	17	16	6	8	5	1	7	71
46	1	3	1	1	12	8	2	4	15	1	3	51
47	0	2	1	1	6	6	4	5	2	2	3	32
48	0	2	1	3	1	1	0	6	6	1	3	24
49	1	0	0	0	0	0	0	0	0	1	1	3
50	0	1	0	0	2	0	0	0	0	0	0	3
51	0	1	0	0	1	1	0	1	0	0	0	4
52	0	0	0	0	0	1	0	1	0	0	0	2
Adult[c]	14											14

Appendix D, Table 4. Continued.

Pelt length (in)	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Total	33	84	53	119	476	350	124	119	162	62	71	1,653
≤34"	6	11	15	26	108	11	7	5	5	1	6	201
>34"	27	73	38	93	368	339	117	114	157	61	65	1,452
% ≤34"	18.18	13.10	28.30	21.85	22.69	3.14	5.65	4.20	3.09	1.61	8.45	12.16
% >34"	81.82	86.90	71.70	78.15	77.31	96.86	94.35	95.80	96.91	98.39	91.55	87.84

[a] 1 in = 2.54 cm.

[b] Total for all pelts entered on sealing form as "kitten," but with no length measurement. Not used for calculation of total or percentages.

[c] Total for all pelts entered on sealing form as "adult," but with no length measurement. Not used for calculation of total or percentages.

Appendix D, Table 5. Lynx pelt length distribution in GMU 24 harvests, 1977-87.

Pelt length (in)[a]	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Kitten[b]	0	0										0
24	0	0	0	0	1	1	0	0	0	0	0	2
25	1	0	0	0	0	1	0	0	0	0	0	2
26	0	1	0	0	0	0	0	0	1	1	0	3
27	1	2	2	0	3	1	2	0	1	0	0	12
28	0	3	3	0	1	0	0	0	0	0	0	7
29	0	3	0	0	3	3	0	0	1	0	1	11
30	1	2	1	4	4	11	3	0	0	1	1	28
31	2	5	3	1	13	5	5	0	4	0	2	40
32	1	8	7	12	20	14	7	0	0	0	2	71
33	0	11	7	10	15	16	7	0	2	2	1	71
34	3	8	9	13	27	18	9	2	4	1	1	95
35	5	15	11	20	33	12	8	0	5	5	0	14
36	0	22	24	27	44	30	17	5	6	1	1	77
37	4	18	9	14	52	40	28	7	2	3	2	79
38	5	28	23	18	47	39	31	7	6	8	7	19
39	4	12	14	27	49	62	33	11	13	9	7	41
40	9	26	21	43	77	54	52	14	17	9	6	28
41	7	17	12	41	62	70	36	18	17	14	8	02
42	13	28	29	71	83	76	42	15	17	14	12	00
43	4	19	21	30	73	81	24	18	32	15	7	24
44	4	17	26	31	63	52	31	19	19	7	13	82
45	9	11	17	15	41	35	31	9	18	15	4	05
46	5	16	21	24	31	30	14	12	14	5	5	77
47	5	6	7	8	27	8	10	6	8	7	0	92
48	1	17	10	17	8	14	9	11	5	6	3	01
49	1	2	0	0	1	2	4	3	1	0	3	17
50	0	2	0	0	0	0	0	0	5	0	0	7
51	0	1	0	1	0	0	0	0	0	2	3	7
52	0	0	0	0	0	0	0	0	0	0	0	0
Adult[c]	3											3

Appendix D, Table 5. Continued.

Pelt length (in)	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Total	85	300	277	427	778	675	403	157	198	125	89	3,172
≤34"	9	43	32	40	87	70	33	2	13	5	8	342
>34"	76	257	245	387	691	605	370	155	185	120	81	3,172
% ≤34"	10.59	14.33	11.55	9.37	11.18	10.37	8.19	1.27	6.57	4.00	8.99	9.73
% >34"	89.41	85.67	88.45	90.63	88.82	89.63	91.81	98.73	93.43	96.00	91.01	90.27

[a] 1 in = 2.54 cm.

[b] Total for all pelts entered on sealing form as "kitten," but with no length measurement. Not used for calculation of total or percentages.

[c] Total for all pelts entered on sealing form as "adult," but with no length measurement. Not used for calculation of total or percentages.

Appendix D, Table 6. Lynx pelt length distribution in GMU 25 harvests, 1977-87.

Pelt length (in)[a]	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Kitten[b]	18	0										18
24	0	2	0	0	0	1	1	0	0	0	0	4
25	0	0	0	1	0	0	0	0	0	0	0	1
26	0	0	0	2	1	1	0	0	0	0	0	4
27	0	0	0	0	4	4	0	0	0	1	2	11
28	1	1	2	2	6	6	1	1	0	2	1	23
29	0	8	9	3	7	8	2	0	1	4	4	46
30	3	10	9	12	23	11	3	1	4	9	9	94
31	5	12	19	15	25	15	2	0	5	12	21	131
32	8	20	37	46	51	27	8	3	14	11	19	244
33	14	19	35	49	61	25	12	6	11	21	17	270
34	14	26	58	80	77	67	19	10	8	18	25	402
35	8	23	57	93	75	46	27	11	8	17	20	385
36	11	30	61	87	94	72	44	27	14	14	25	479
37	18	34	53	91	93	124	74	56	37	35	25	640
38	26	47	58	158	182	202	133	91	50	54	33	1,034
39	42	51	75	149	180	238	166	88	65	49	53	1,156
40	52	80	82	145	198	245	159	109	88	44	79	1,281
41	25	34	62	99	135	157	122	79	46	62	53	874
42	38	24	58	81	102	119	82	62	69	37	45	717
43	31	26	39	47	43	87	68	21	24	40	43	469
44	26	21	16	26	37	57	33	27	26	27	37	333
45	13	14	8	6	6	31	25	7	15	6	13	144
46	7	10	3	8	12	11	13	9	10	7	9	99
47	1	3	3	0	1	3	15	7	4	4	1	42
48	1	2	0	1	1	3	3	1	0	3	6	21
49	0	0	0	0	2	1	0	0	0	0	2	5
50	0	0	0	0	0	0	0	0	0	0	2	2
51	0	0	1	0	0	0	0	0	0	0	0	1
52	0	0	0	0	0	0	0	0	0	2	0	2
Adult[c]	9											9

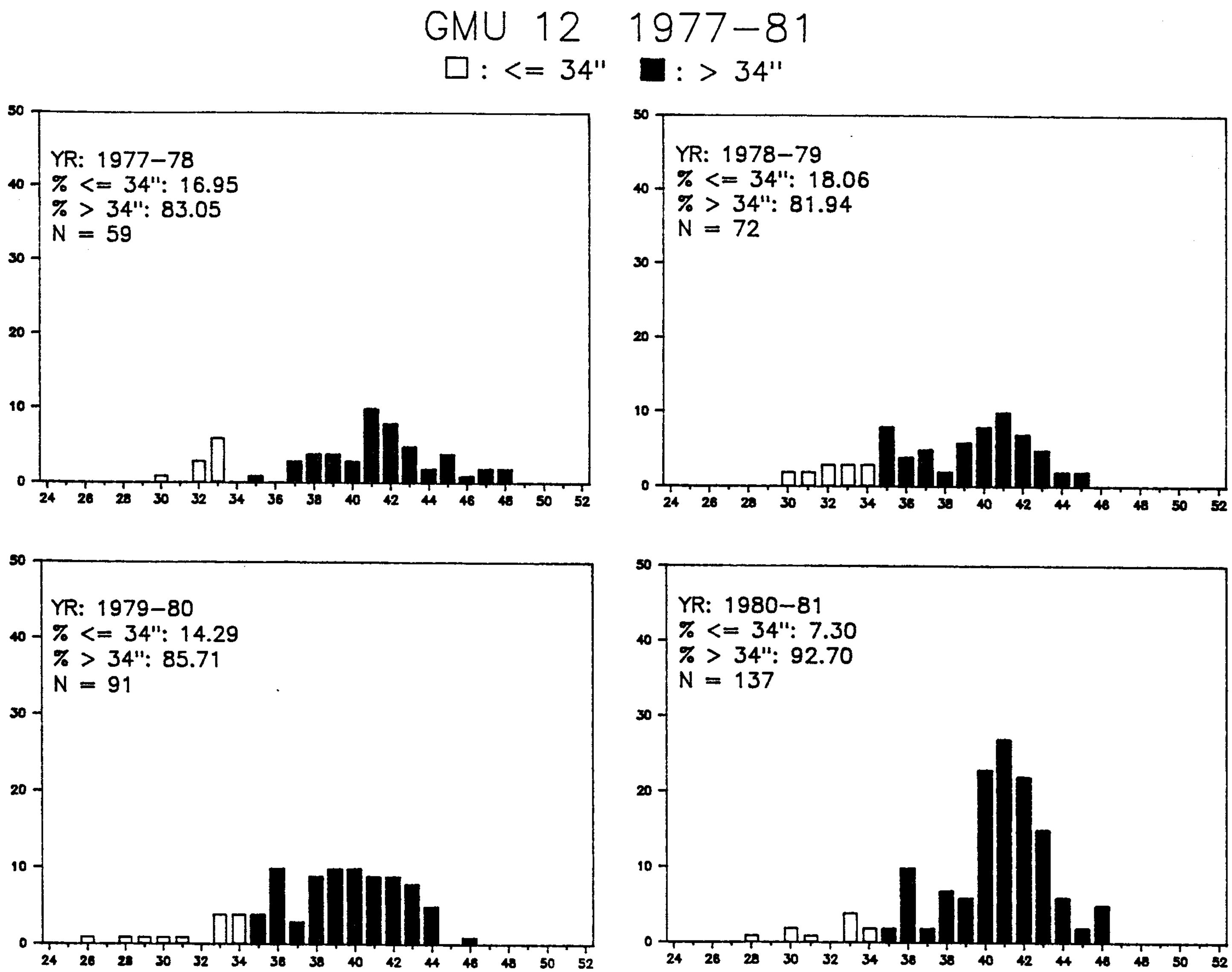
Appendix D, Table 6. Continued.

Pelt length (in)	Regulatory year											All years
	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	
Total	344	497	745	1,201	1,416	1,561	1,012	616	499	479	544	8,914
≤34"	45	98	169	210	255	165	48	21	43	78	98	1,230
>34"	299	399	576	991	1,161	1,396	964	595	456	401	446	7,684
% ≤34"	3.08	9.72	2.68	17.49	18.01	10.57	4.74	3.41	8.62	16.28	18.01	13.80
% >34"	6.92	0.28	7.32	82.51	81.99	89.43	95.26	96.59	91.38	83.72	81.99	86.20

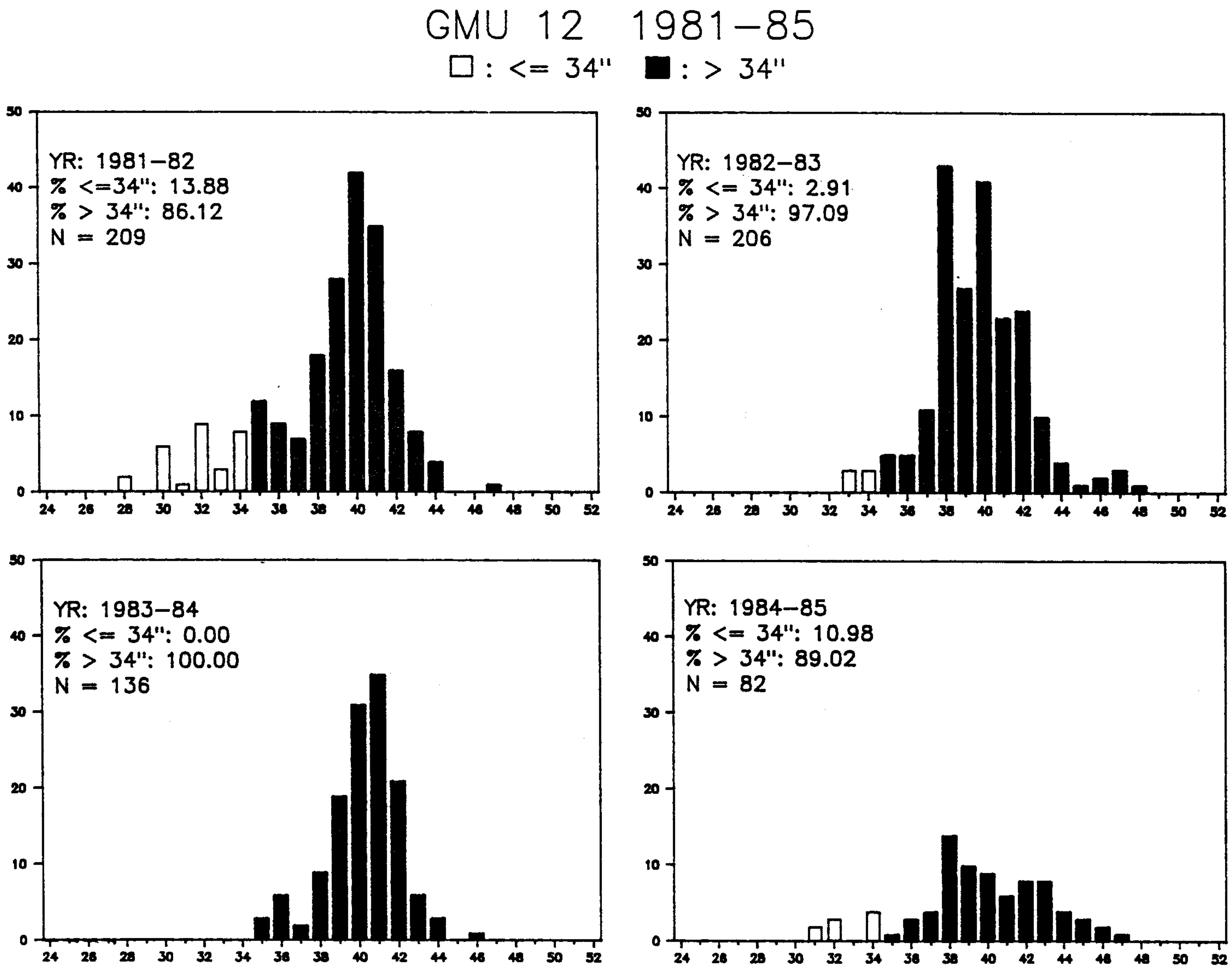
[a] 1 in = 2.54 cm.

[b] Total for all pelts entered on sealing form as "kitten," but with no length measurement. Not used for calculation of total or percentages.

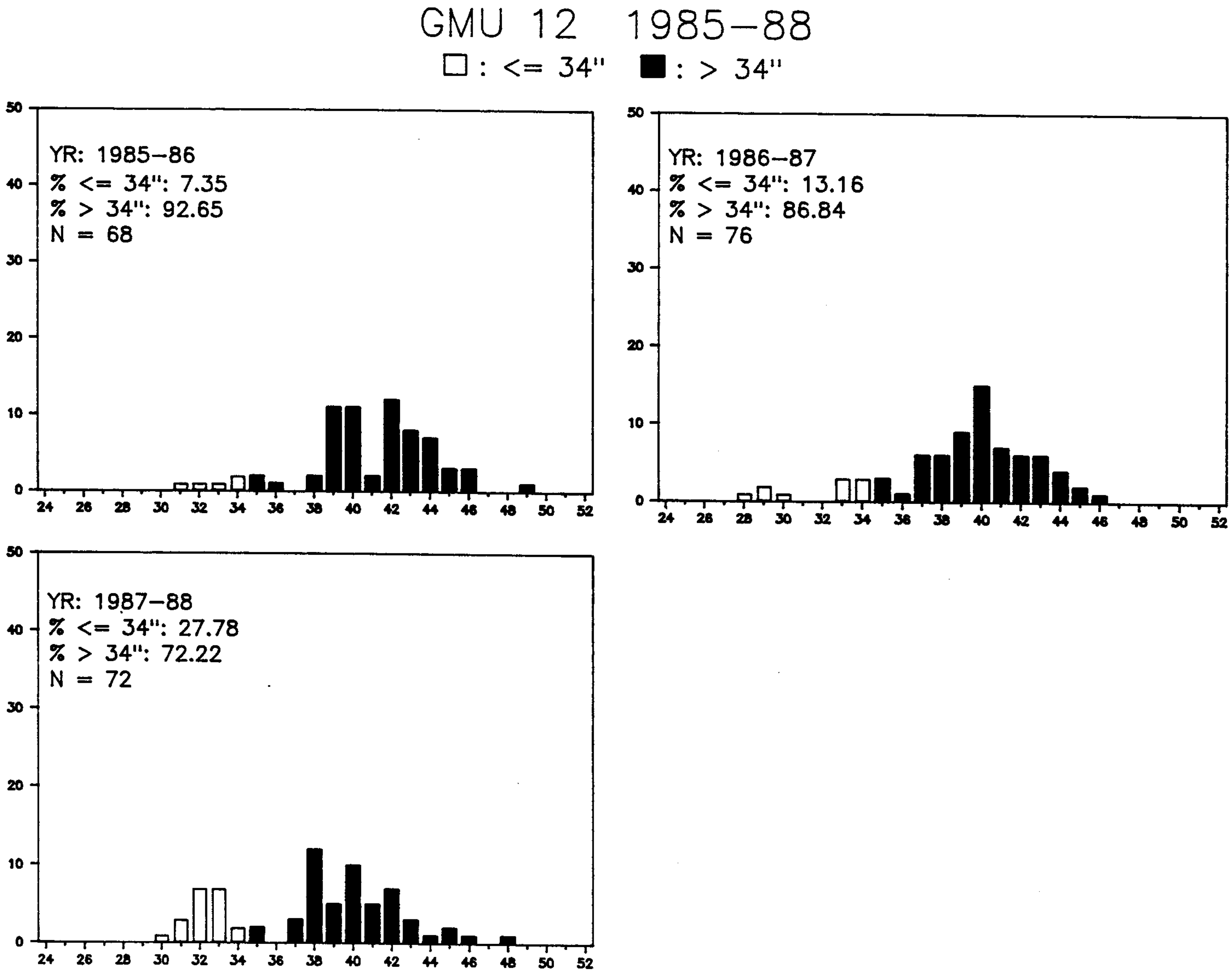
[c] Total for all pelts entered on sealing form as "adult," but with no length measurement. Not used for calculation of total or percentages.



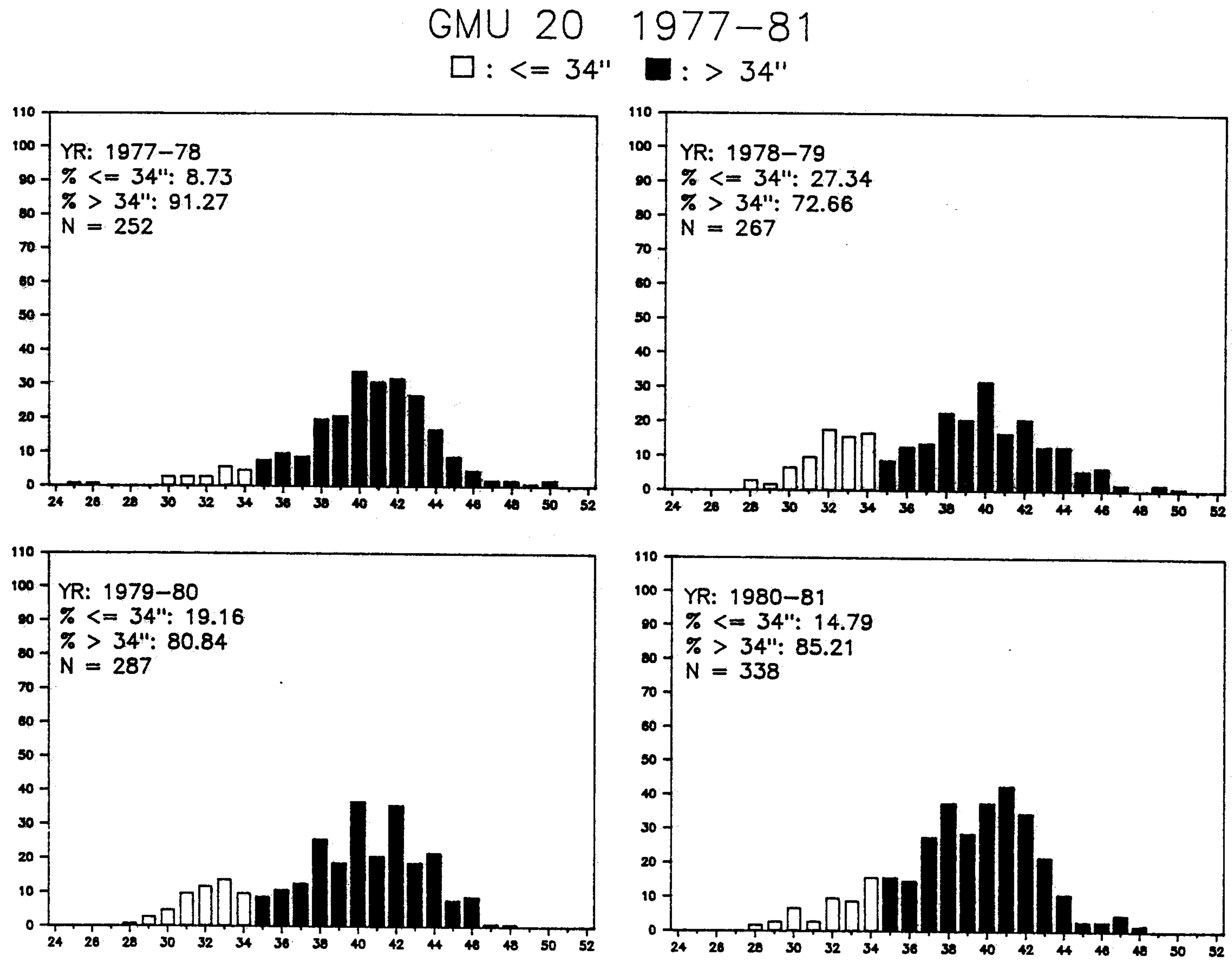
Appendix D, Fig. 1. Annual pelt length distribution of lynx taken in GMU 12, Alaska from 1977-78 through 1987-88.



Appendix D, Fig. 1. Continued.



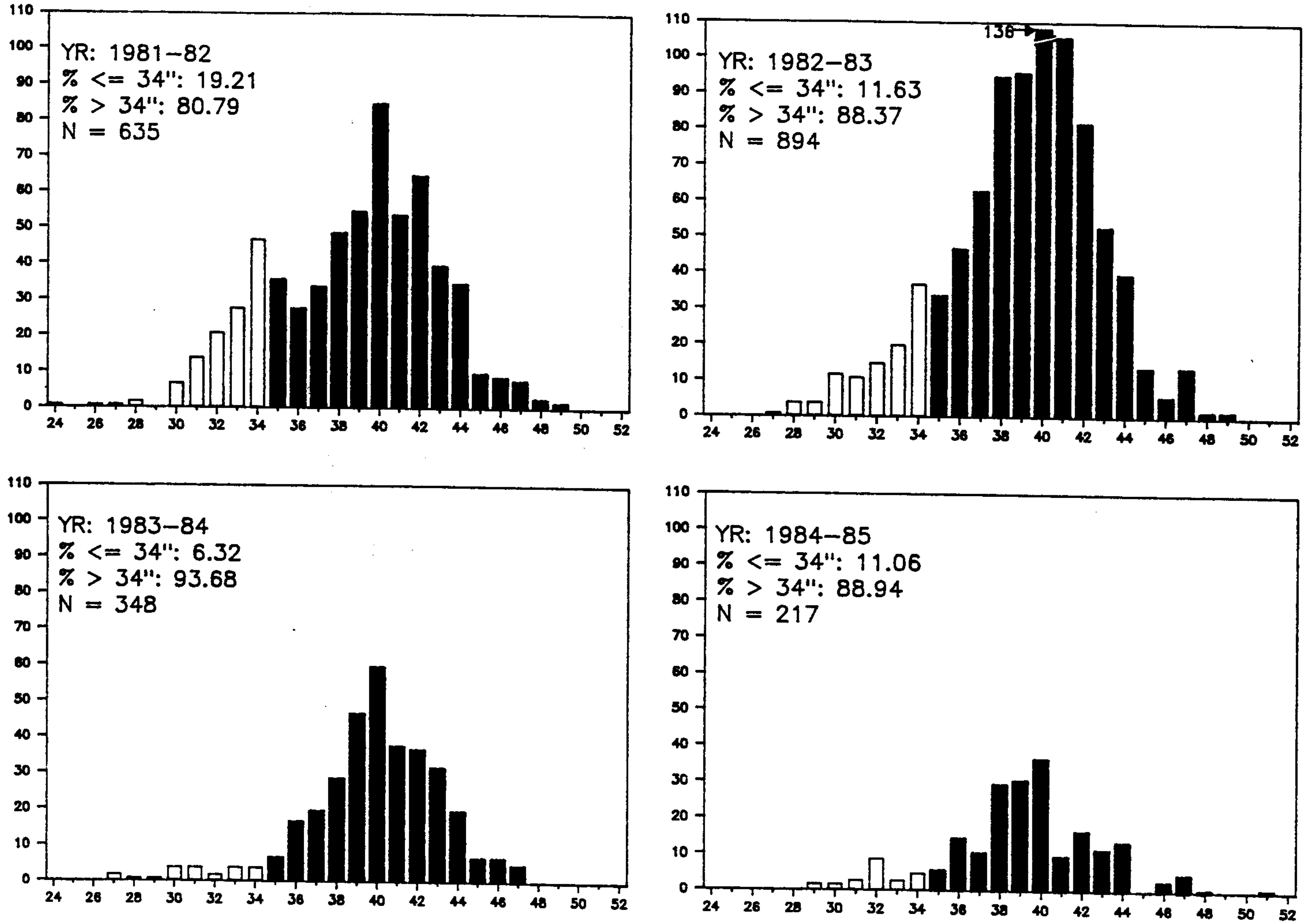
Appendix D, Fig. 1. Continued.



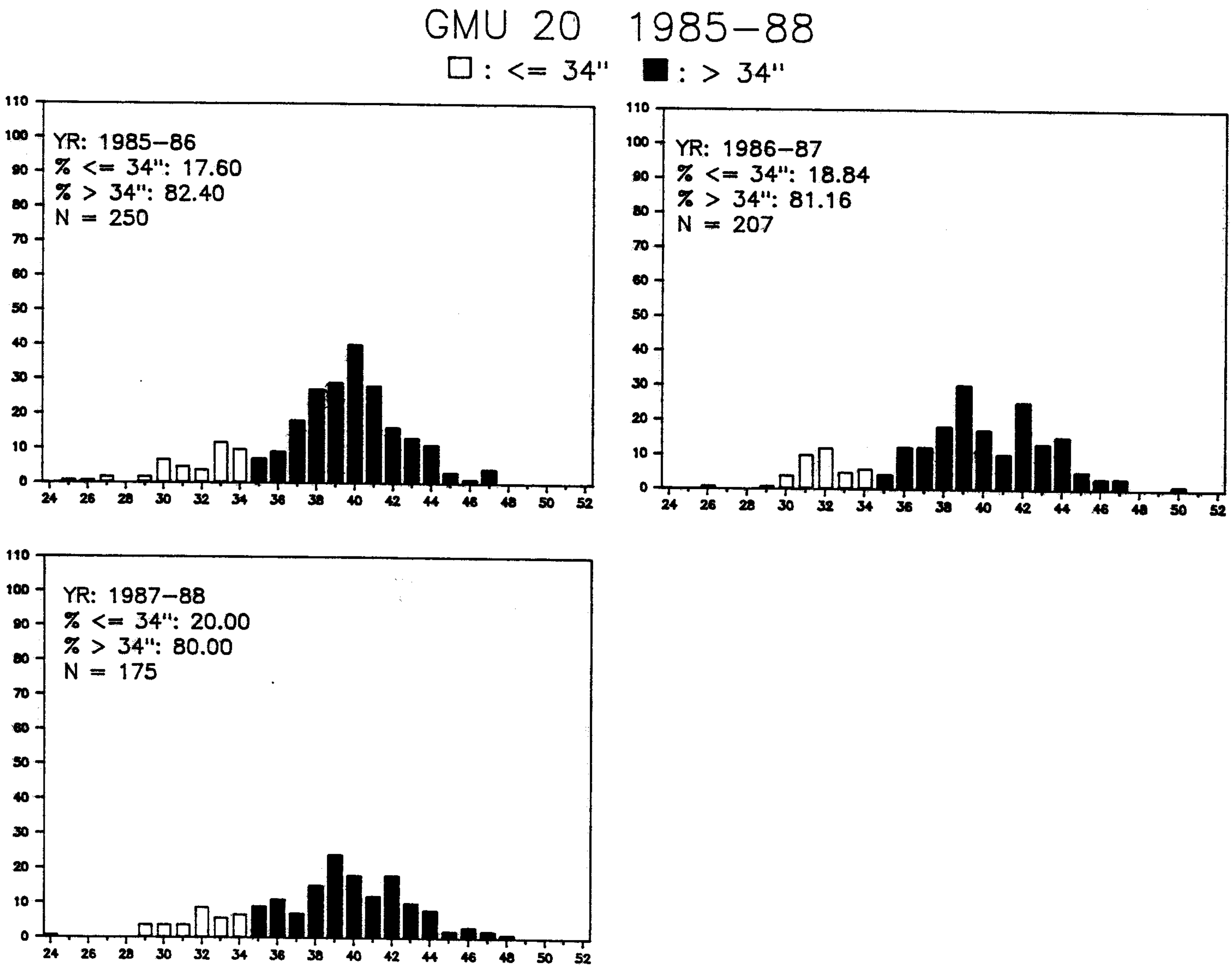
Appendix D, Fig. 2. Annual pelt length distribution of lynx taken in GMU 20, Alaska, from 1977-78 through 1987-88.

GMU 20 1981–85

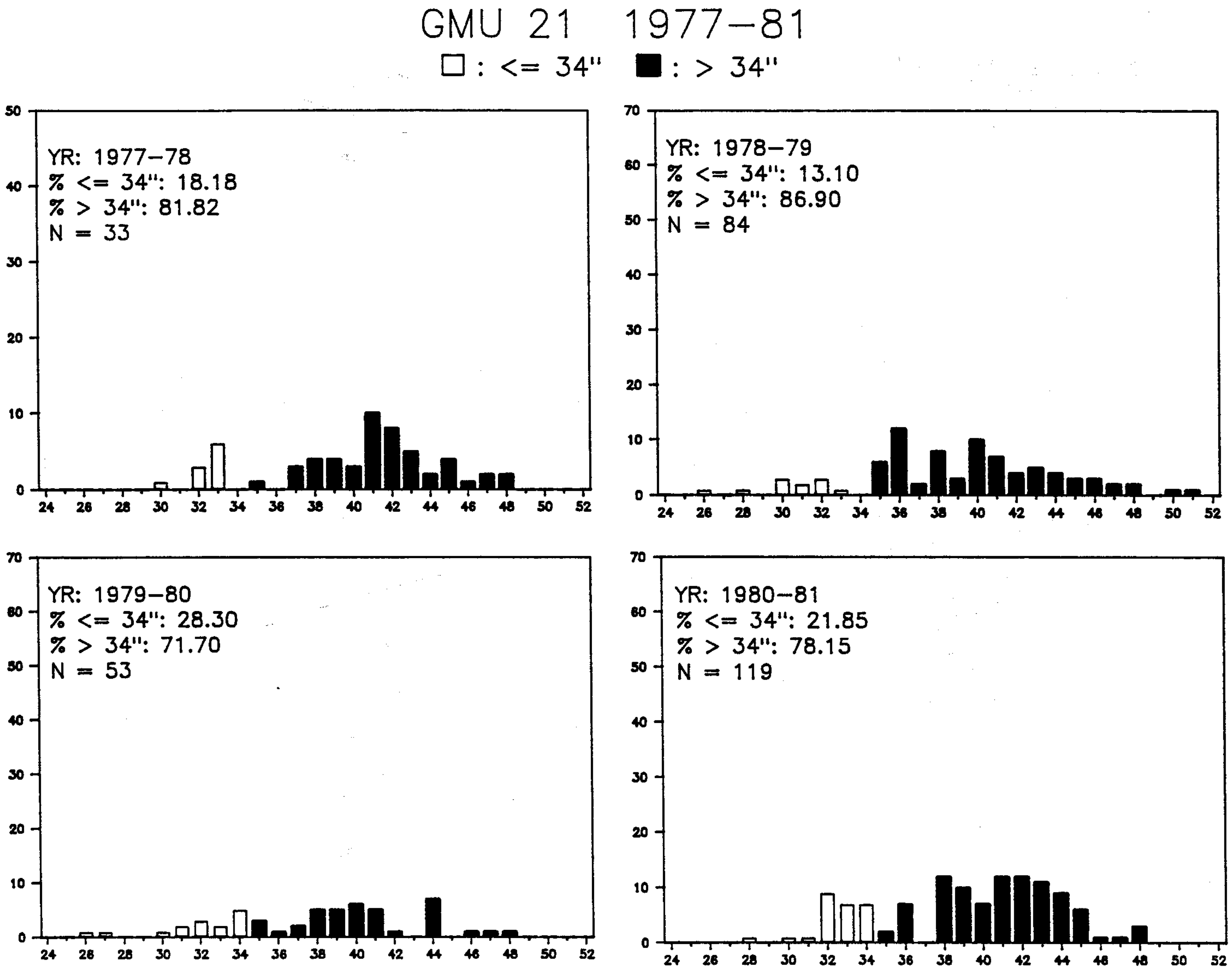
□ : <= 34" ■ : > 34"



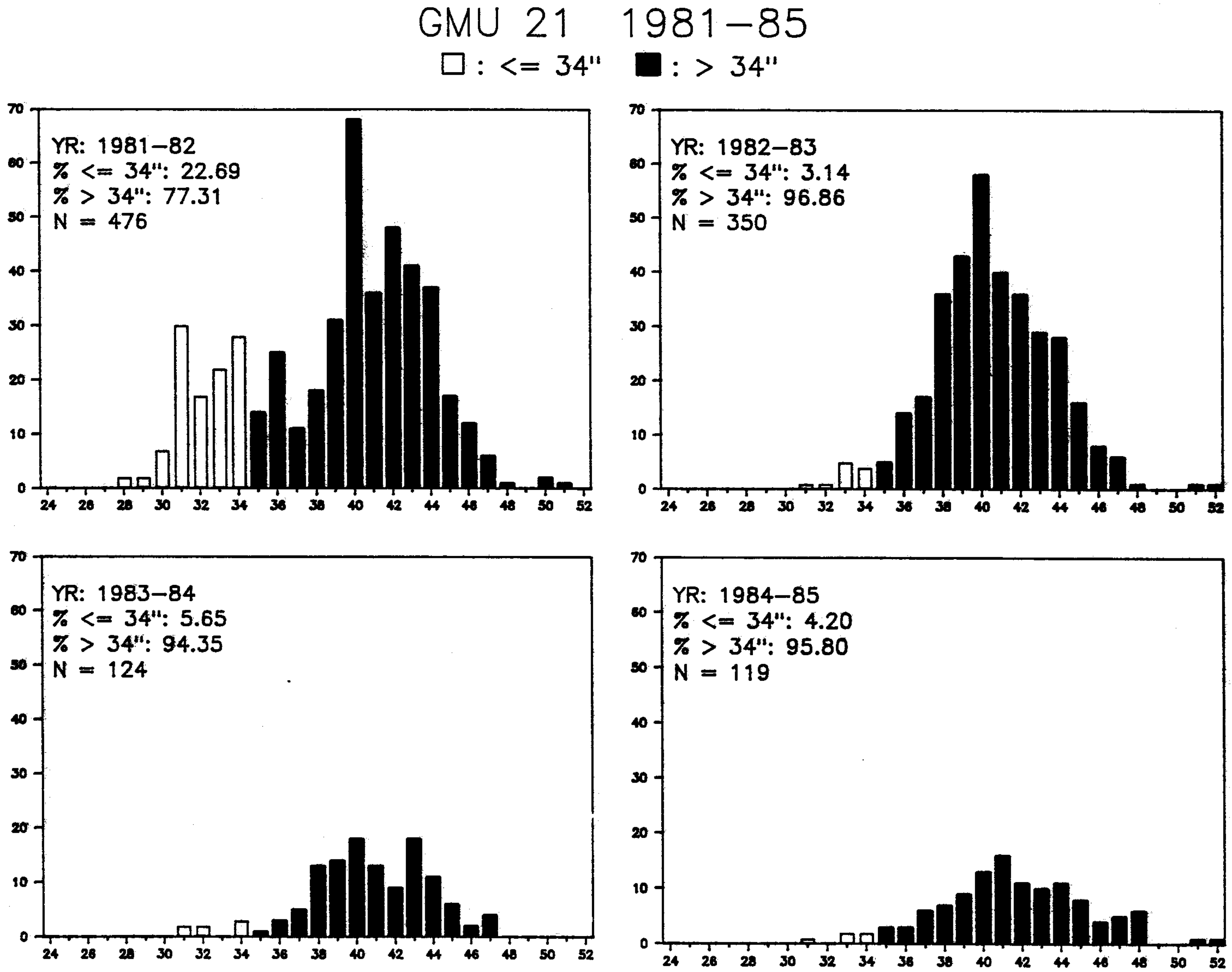
Appendix D, Fig. 2. Continued.



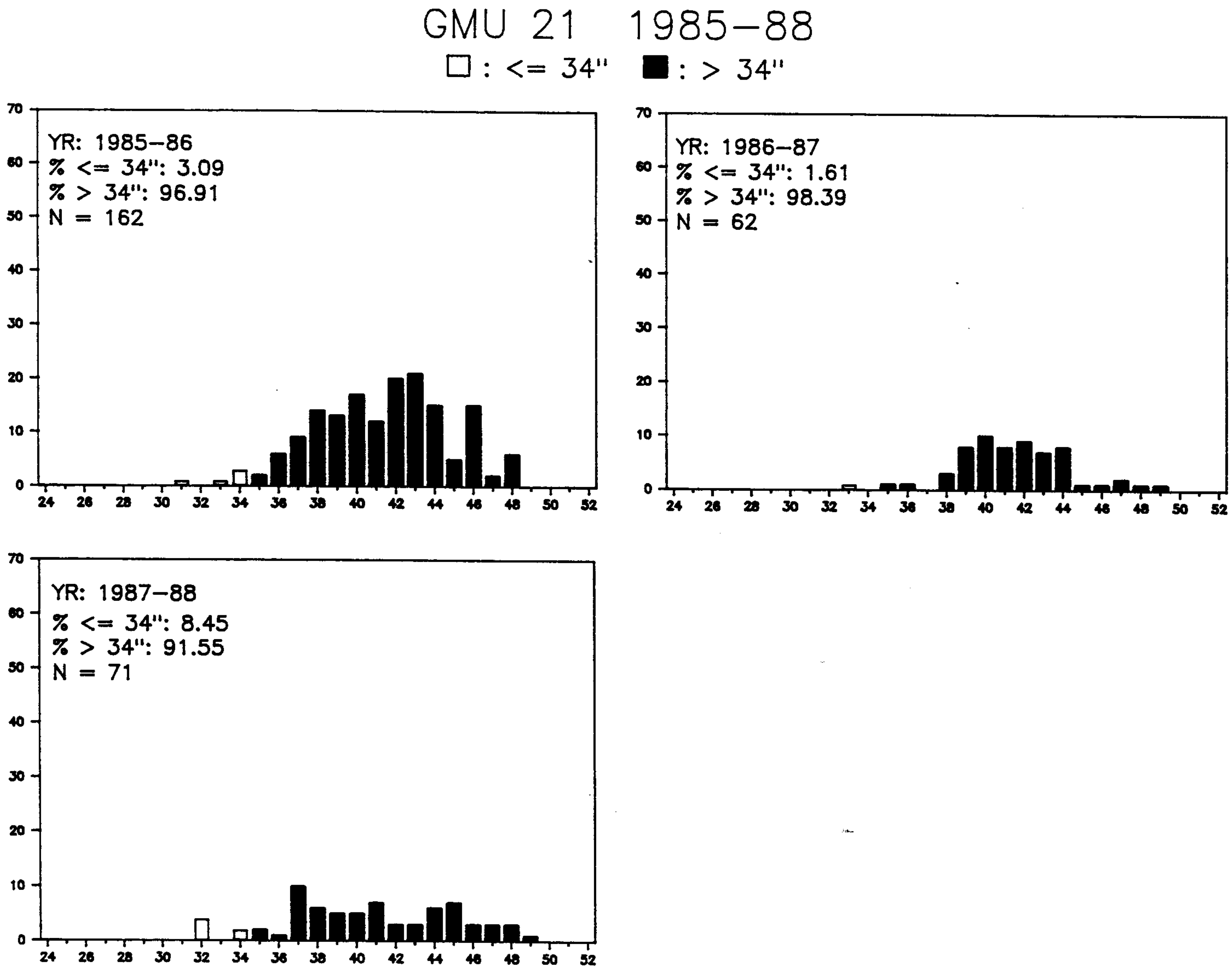
Appendix D, Fig. 2. Continued.



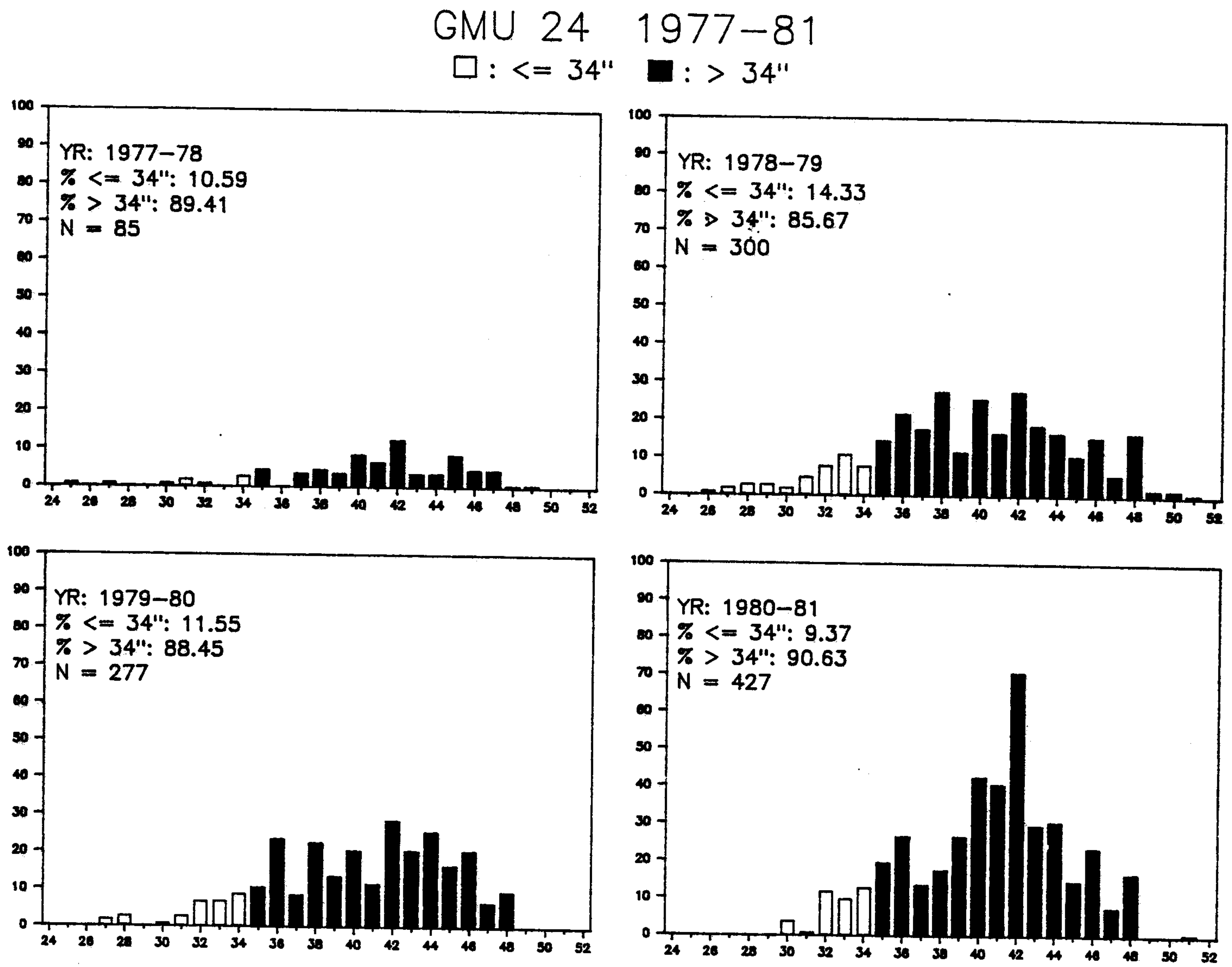
Appendix D, Fig. 3. Annual pelt length distribution of lynx taken in GMU 21, Alaska, from 1977-78 through 1987-88.



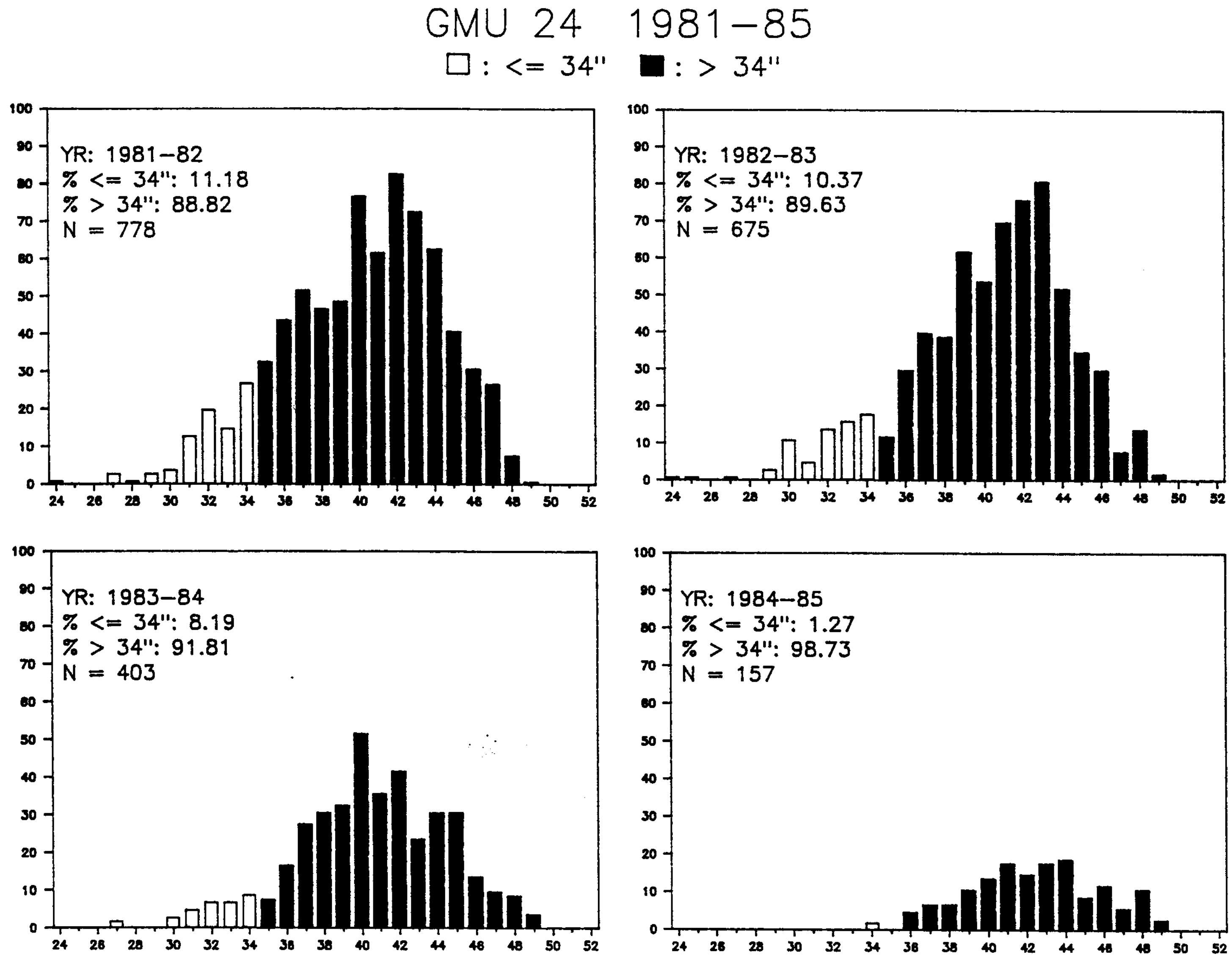
Appendix D, Fig. 3. Continued.



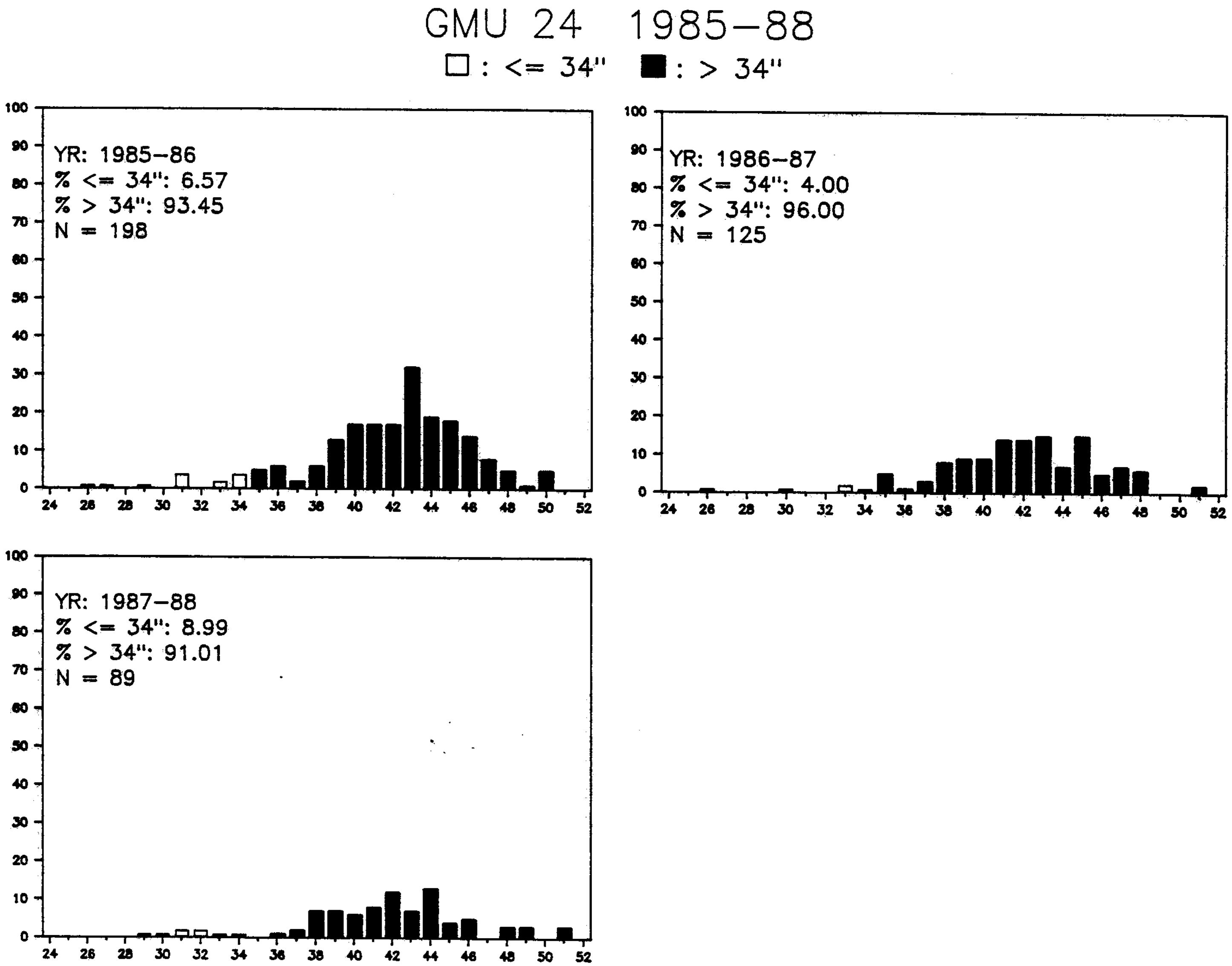
Appendix D, Fig. 3. Continued.



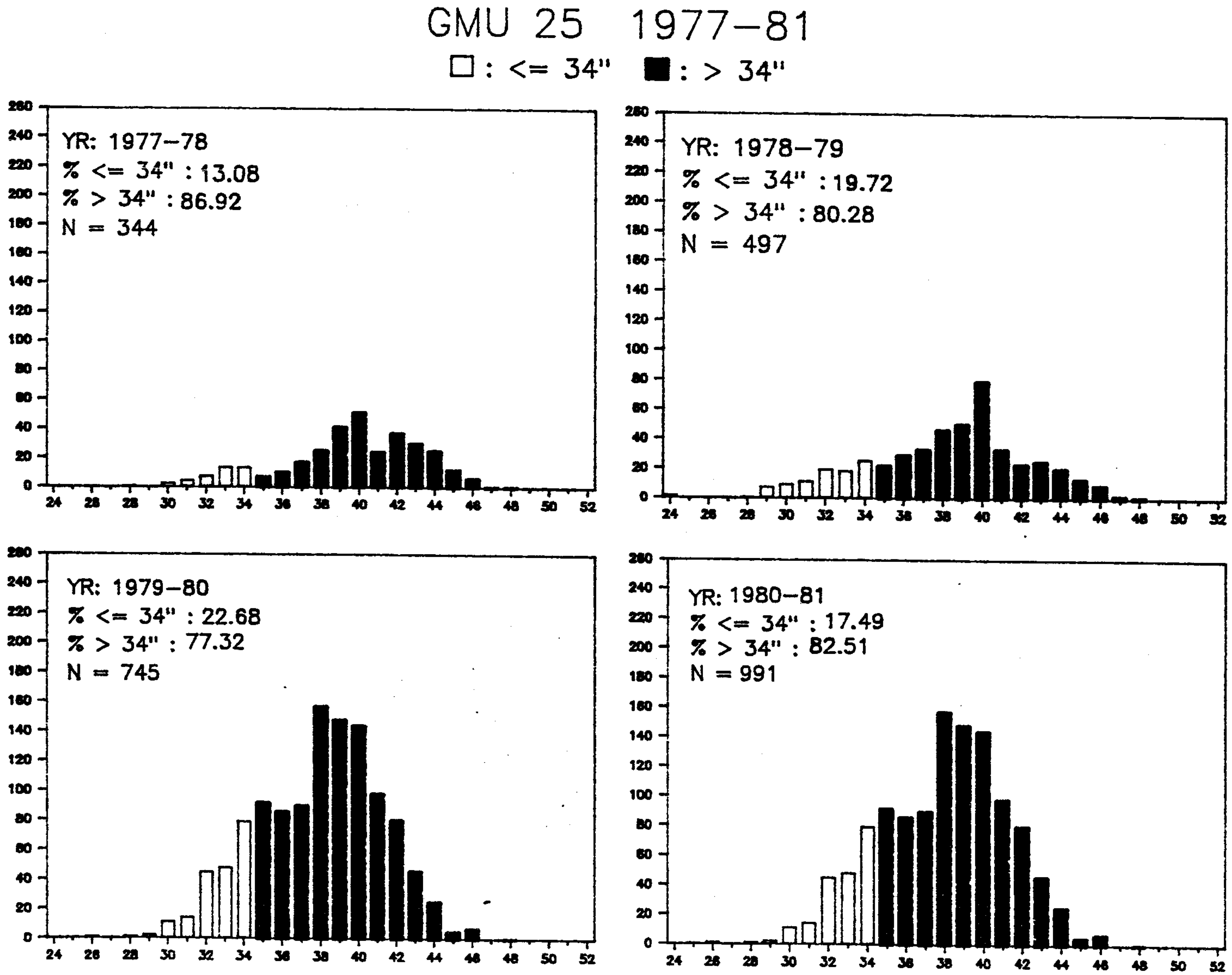
Appendix D, Fig. 4. Annual pelt length distribution of lynx taken in GMU 24, Alaska, 1977-78 through 1987-88.



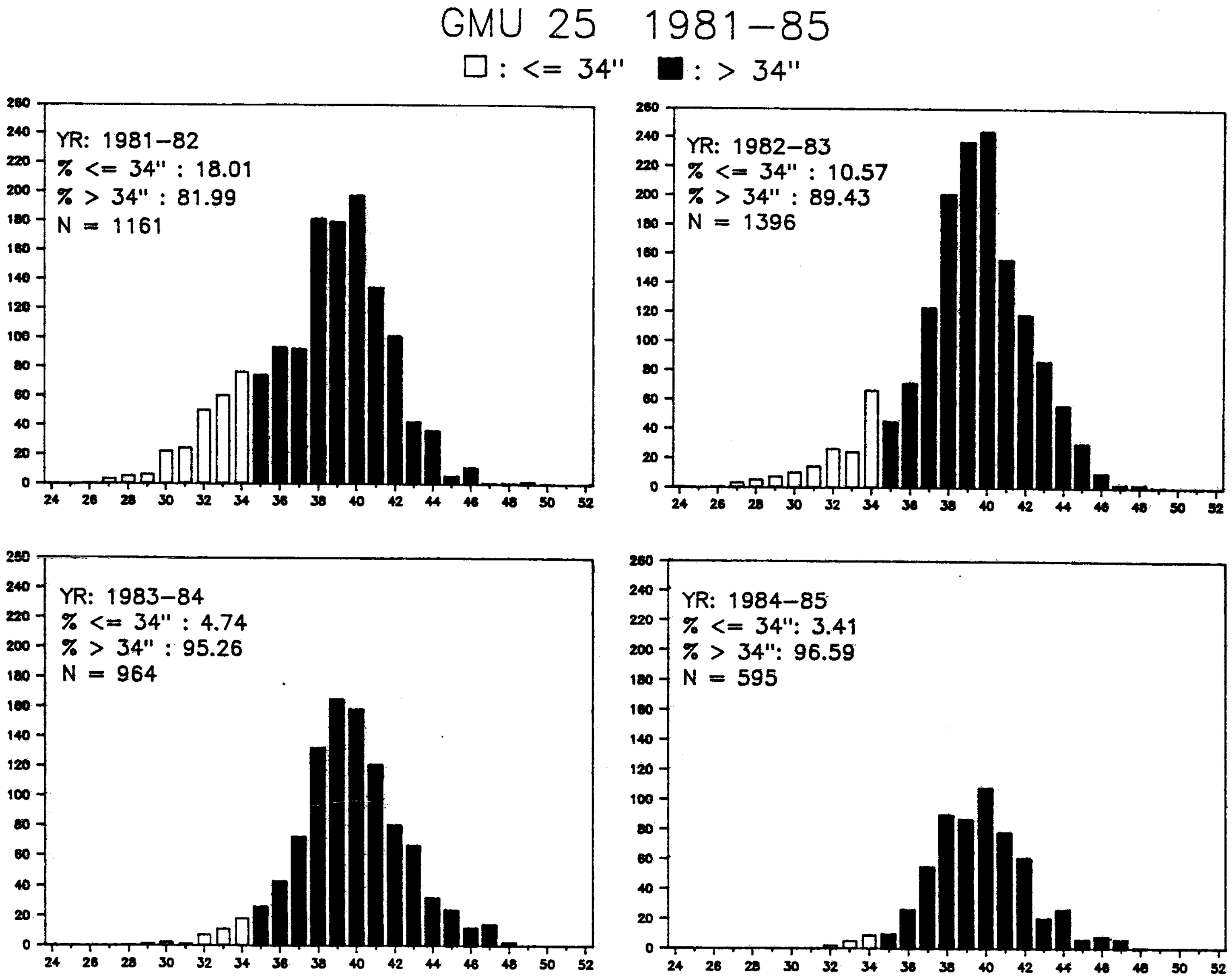
Appendix D, Fig. 4. Continued.



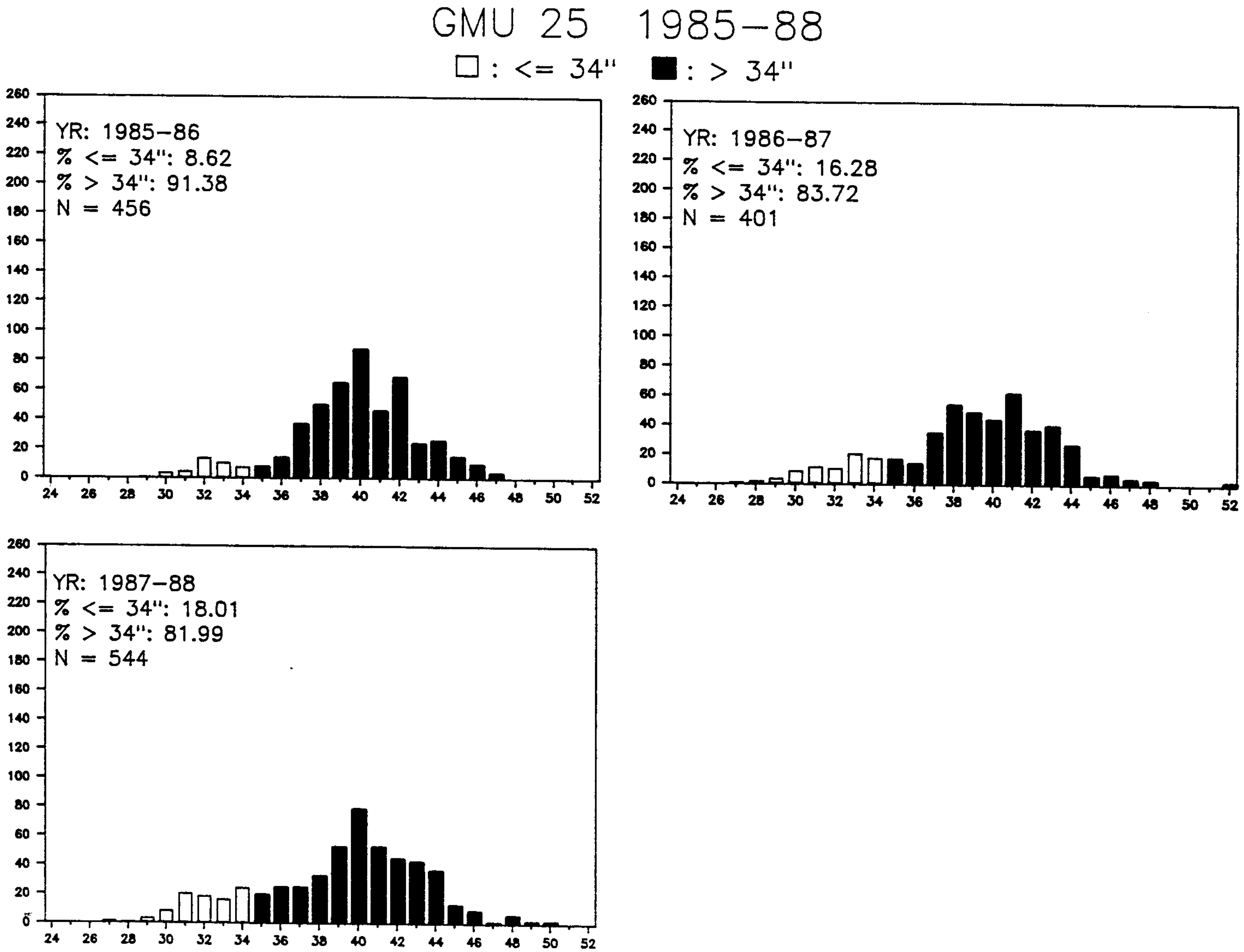
Appendix D, Fig. 4. Continued.



Appendix D, Fig. 5. Annual pelt length distribution of lynx taken in GMU 25, Alaska, from 1977-78 through 1987-88.



Appendix D, Fig. 5. Continued.



Appendix D, Fig. 5. Continued.

Appendix E. Track frequency values for the Tok study area in 1982 and Wood River study area in 1984, 1985, 1986, and 1987. Values represent "T-1" track intercepts as defined in the text.

	Tok Study Area 1982		Wood River Study Area 1984			Wood River Study Area 1985		
Day No.	Cumulative no. crossings (14 Oct-20 Nov)	15 mi cumulative no./mi	Cumulative no. crossings (15 Mar-31 Mar)	25 mi cumulative no./mi	19 mi cumulative no./mi	Cumulative no. crossings (8 Mar-23 Mar)	25 mi cumulative no./mi	19 mi[b] cumulative no./mi
1	1	0.06	1	0.05	0.05	1	0.05	0.05
2	3	0.21	5	0.21	0.26	4	0.16	0.21
3	6	0.40	10	0.40	0.53	7	0.29	0.37
4	8	0.53	19	0.77	1.00	12	0.48	0.37
5	11	0.74	20	0.80	1.04	12	0.48	0.37
6	14	0.93	20	0.80	1.04	12	0.48	0.37
7	18	1.21	25	1.01	1.32	18	0.72	0.79
8	21	1.41	26	1.04	1.37	26	1.04	1.21
9	–[c]	–	29	1.17	1.53	29	1.17	1.37
10	23	1.54	46	1.85	2.41	33	1.34	1.58
11	25	1.67	53	2.14	2.78	–	–	–
12	28	1.88	57	2.30	2.99	38	1.53	1.83
13	32	2.14	60	2.41	3.15	44	1.77	1.99
14	43	2.88	64	2.57	3.36	51	2.06	2.36
15	48	3.22	64	2.57	3.36	–	–	–
16	57	3.83	66	2.65	3.47	54	2.17	2.53
17	62	2.81						
18	62	2.81						
19	71	4.76						
20	83	5.57						

Appendix E. Continued.

Day No.	Wood River Study Area 1986: Cumulative no. crossings (15 Mar–31 Mar)	25 mi cumulative no./mi	19 mi[b] cumulative no./mi	Wood River Study Area 1987: Cumulative no. crossings (8 Mar–23 Mar)	25 mi cumulative no./mi	19 mi[b] cumulative no./mi	Wood River, fall 1987: Cumulative no. crossings (22 Nov–9 Dec)	24 mi cumulative no./mi	19 mi[b] cumulative no./mi
1	--	--	--	--	--	--	0	0	0
10	--	--	--	--	--	--	0	0	0
11	18	0.72	0.95	3	0.13	0.16	1	0.05	0.05
12	21	0.85	1.11	--	--	--	1	0.05	0.05
13	29	1.17	1.53	6	0.24	0.32	1	0.05	0.05
14	36	1.45	1.90	7	0.29	0.37	1	0.05	0.05
15	37	1.50	1.95	--	--	--	1	0.05	0.05
16	41	1.66	2.16	--	--	--	--	--	--
17	41	1.66	2.16	11	0.45	0.58	1	0.05	0.05
18	41	1.66	2.16	--	--	--	2	0.05	0.10
19	41	1.66	2.16	12	0.48	0.63	--	--	--
20	41	1.66	2.16	--	--	--	3	0.13	0.16
21	41	1.66	2.16	16	0.64	0.84	8	0.32	0.42
22	45	1.82	2.36	--	--	--	9	0.37	0.47
23	45	1.82	2.36	--	--	--	10	0.40	0.53
24	45	1.82	2.36	--	--	--	12	0.48	0.63
25	45	1.82	2.36	21	0.85	1.11	12	0.48	0.63
26	48	1.93	2.53	--	--	--	12	0.48	0.63
				--	--	--			
				--	--	--			
				21	0.85	1.11			

[a] 6.0 continuous miles with no activity. Deleting this distance alters data as shown.

[b] 6.0 continuous miles with only temporary activity. Deleting this distance alters data as shown.

[c] Attempts to collect data were unsuccessful due to weather.

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