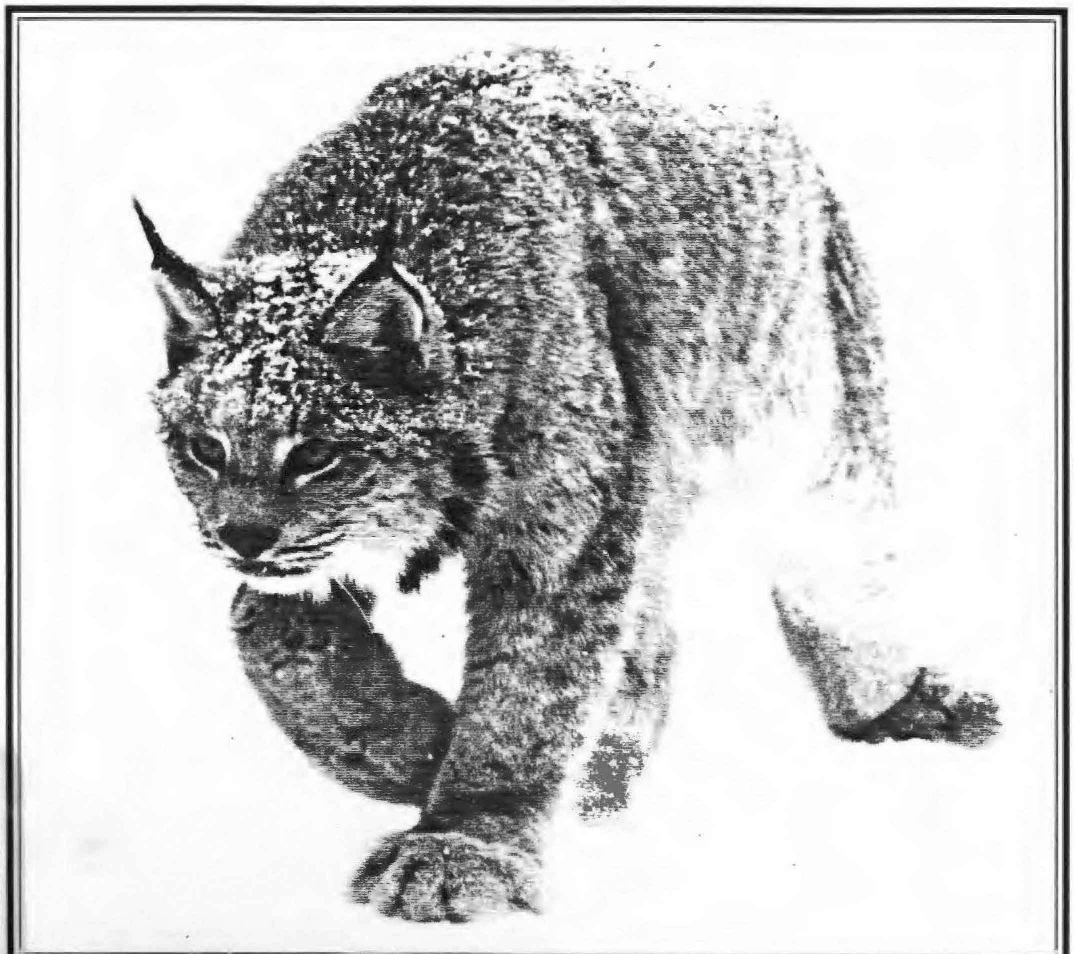
Alaska Department of Fish and Game
Division of Wildlife Conservation

Federal Aid in Wildlife Restoration
Research Progress Report

Furbearer Management Technique Development

1 January 1995- 30 June 1996

Howard N. Golden



LEONARD LEE RUE III

Grants W-24-3 and W-24-4
Study 7.18
November 1996

Alaska Department of Fish and Game
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STATE OF ALASKA
Tony Knowles, Governor

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RESEARCH PROGRESS REPORT

STATE: Alaska **Study:** 7.18

GRANT: W-24-3 and W-24-4

TITLE: Furbearer Management Technique Development

PERIOD: 1 January 1995 - 30 June 1996

SUMMARY

A comprehensive process to develop furbearer management techniques is presented. Research is focused on 4 projects that represent furbearer management issues, other than those affecting wolves (*Canis lupus*), of greatest concern in Southcentral Alaska. The goals of these 4 projects are: (1) develop ground and aerial techniques for counting tracks in winter to monitor the distribution and trend of marten (*Martes americana*), lynx (*Felis lynx*), and snowshoe hare (*Lepus americanus*) populations in Southcentral Alaska; (2) assess the accuracy of existing density-estimation techniques and develop techniques to monitor the trend and harvest potential of wolverine (*Gulo gulo*) populations in Southcentral Alaska; (3) develop techniques to index river otter (*Lutra canadensis*) populations, determine the availability and use of their habitat, and assess their harvest potential in coastal environments of Southcentral Alaska; and (4) develop a rule-based lynx management model for use in the decision-making process in the lynx-tracking harvest strategy.

Golden (1994) reported results of tests on the variability among track deposition and retention rates for marten, lynx, and snowshoe hare populations in several areas of Interior and Southcentral Alaska. Since then, plans were established to examine effects that track sightability and observer bias may have on the use of winter track counts as indices of relative abundance of furbearers and to evaluate how indices from harvest-related data compare with track-count data. No field work was conducted on these factors during this reporting period.

Progress on radiocollaring new wolverines and testing the accuracy of 2 density estimation techniques was limited due to poor snow and weather conditions. We radiocollared 6 new wolverines in February and March 1995 and 1996. These captures increased the total number of wolverines radiocollared in the study area since April 1992 to 18, 7 females and 11 males. We made 4 attempts to conduct density-estimation tests in winter 1994-95 and all were unsuccessful. Weather conditions permitted only a partial density estimate and an inconclusive test of the transect-intercept probability sampling scheme on 15 February 1996. During the survey, we encountered tracks of 6 individual wolverines in a 1611.4-km^2 area. We weighted calculations for unequal transect lengths to obtain a calculated population estimate of 8.3 wolverines (SE = 3.6; 90% CI = 6-18.2) in the count area, equivalent to an estimated density of 5.2 wolverines/1000 km^2 (90% CI = 3.7-11.3). We estimated wolverine density in 1 of 2 trend-count areas on the Kenai Peninsula using the sample-unit probability estimation technique. We counted tracks of 5 individual wolverines in the 2,050-km^2 area. This resulted in a calculated population size of 10.7 wolverines (SE = 4.2; 90% CI = 5-17.5) in the count area at an estimated density of 5.2 wolverines/1000 km^2

(90% CI = 3.8-8.5). This density was similar to densities of 4.7-5.2 wolverines/1000 km^2 found during other estimates in the eastern Talkeetna Mountains, the northern Chugach Range, the western Chugach Range, and the Chugach Mountains east of Anchorage. Wolverine harvest in 1994-95 was 11 for Unit 11 and 35 for Unit 13. In 1995-96 the take in Unit 11 dropped to 4 but remained about the same at 31 in Unit 13. Harvest in Unit 13A, which contains the eastern Talkeetna Mountains study area, was 6 in 1994-95 and 3 in 1995-96. One of the wolverines taken in Unit 13A in 1994-95 was a radiocollared animal. Four of the 18 wolverines collared since April 1992 have been harvested by trappers. Three of the 4 were trapped in the study area; 1 was taken by a trapper on the north side of the Alaska Range, approximately 144 km from its original capture location. A discussion of wolverine harvests and habitat characteristics on the Kenai Peninsula, prepared by Audrey Magoun for the 8th Northern Furbearer Conference, is presented in the Appendix.

We reexamined 51 river otter latrine sites in Tutka and Jakalof Bays originally found in 1994 along the south side of Kachemak Bay on the Kenai Peninsula. The number of scats per latrine site among the 23 sites that were sampled on 3 surveys ranged from 0 to 36; averages were 9.5 (SD = 7.5; n = 219) on 2-4 July, 14 (SD = 8.8; n = 323) on 24-25 July, and 8.9 (SD = 9.1; n = 205) on 15-17 August (Table 2). Mean scat deposition rates for those same sampling periods were 0.6 (SD = 0.4), 0.6 (SD = 0.4), and 0.4 (SD = 0.4) scats/day, respectively, which were significantly different (Kruskal-Wallis Test, $P = 0.047$, $\chi^2 = 6.10$, df = 2). The high variability of the rates reflects the wide difference in use of latrine sites by the river otters as the summer progressed. We set 16 Hancock live traps on 15 of the latrine sites and captured 5 otters after an average of 40.2 trap nights per otter. Radiotransmitters were surgically implanted into 2 females and 2 males, and we radiotracked these otters a combined total of 83 times between May 1995 and June 1996. Each of the animals were found on both sides and along the full length of Tutka Bay. One male traveled between Tutka Bay and nearby Sadie Cove, Jakalof Bay, and Kasitsna Bay. Preliminary analysis of 90 scat samples from 38 latrine sites sampled in 1995 indicates the river otters eat a wide variety of bony fishes.

I used a computer program shell to develop a rule-based lynx management model. I built upon an initial 50-rule model to develop a 257-rule prototype designed to assist wildlife managers in the decision-making process as part of the lynx tracking harvest strategy. This modeling approach, known as a knowledge system or expert system, incorporates the user's experience and available information into a decision tree. This model incorporates qualitative and quantitative variables the user provides. It calculates the potential of the lynx population in question. Population potential is a function of lynx abundance, food availability, production, and survival. The estimated optimal yield of the population is based on its potential and estimated size and leads to the calculation of the target harvest index. Harvest pressure is a function of lynx harvest, trapping effort, and the amount of refugia. The reciprocal of the target harvest index divided by the harvest pressure results in a determination of the risk factor to the lynx population. The risk factor in combination with the current lynx season results in a new season recommendation as the final choice in the model.

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WOLVERINES HEAD FOR THE HILLS ON THE KENAI PENINSULA, ALASKA
by Audrey J. Magoun, presented as a poster paper at the 8th Northern Furbearer Conference, Anchorage, Alaska, 3-4 May 1995

INTRODUCTION

Furbearers are one of the most diverse and widely used groups of wildlife in Alaska. They are some of the hardest species to monitor because of their small body size and secretive, wide-ranging behaviors. There are few methods to monitor the status of furbearer populations other than the collection of harvest data through trapper questionnaires, pelt sealing records, fur export reports, fur buyer reports, and furbearer carcasses. There is a strong need for reliable techniques that are independent of harvest data to manage populations and harvests of furbearer species, particularly lynx, marten, river otters, and wolverines. Developing useful techniques for these species requires a long-term approach because of the difficulties inherent in assessing their population status.

This is the first progress report in a comprehensive process to develop furbearer management techniques by (1) evaluating the scope of individual management problems, (2) designing methods to address specific management needs, (3) testing the reliability and usefulness of those methods, (4) refining methods where necessary, and (5) facilitating the implementation of suitable techniques. Research will focus on 4 projects that represent furbearer management issues, other than those affecting wolves, of greatest concern in Southcentral Alaska. The goals of these 4 projects are as follows:

1. Develop ground and aerial techniques for counting tracks in winter to monitor the distribution and trend of marten, lynx, and snowshoe hare populations in Southcentral Alaska.

2. Assess the accuracy of existing density estimation techniques and develop techniques to monitor the trend and harvest potential of wolverine populations in Southcentral Alaska.

3. Develop techniques to index river otter populations, determine the availability and use of their habitat, and assess their harvest potential in coastal environments of Southcentral Alaska.

4. Develop a rule-based lynx management model to use in the lynx-tracking harvest strategy.

JOB 1. DISTRIBUTION AND TREND OF MARTEN, LYNX, AND SNOWSHOE HARE POPULATIONS

BACKGROUND

Golden (1994) reported on the variability found among track deposition and retention rates for marten, lynx, and snowshoe hares in several areas of Interior and Southcentral Alaska. He found the rates were remarkably linear and correlated moderately to strongly with increasing time after snowfall, up to a period of approximately 5 days. He concluded that winter track counts can be used as indices of relative abundance if appropriate methodology and rigor are used in data collection. In addition, sources of bias in track counts (for example, those due to different observers or sightability of tracks among vegetation types) must be identified and their effects minimized to allow spatial and temporal comparisons (Golden 1987, 1988). The present project will expand on these earlier investigations to develop ground and aerial techniques for counting tracks in winter to monitor the distribution and trend of marten, lynx, and snowshoe hare populations in Southcentral Alaska.

OBJECTIVES

1.1 To design ground and aerial track-count procedures to reliably estimate the distribution and trend of marten, lynx, and snowshoe hare populations.

1.2 To measure levels of track count bias due to track sightability and identification and design procedures to minimize those biases.

Working Hypotheses

1. The number of marten, lynx, or snowshoe hare tracks (T) intersecting transects, trails, or roads in an area at a given time (i) is equal to the number of animals (N) present times a function (f) of track deposition (D) times a function of track retention (R); i.e.,

$$T_i = N \times f\mathrm{D} \times f\mathrm{R}$$

where D represents the number of days after snowfall (DAS) and track overlap by a given animal or another of the same species, and R represents the number of DAS and track overlap by animals of a different species.

2. Aerial track counts provide more precise estimates of furbearer trend across large areas than ground track counts provide.

3. Biases in track counts can be reduced through rigorous data collection and training of observers.

STUDY AREA

Most tests of track-count sightability and observer bias will take place in the Nelchina and Copper River basins. The Nelchina River basin runs east-west and is bordered on the north by the Alaska Range, on the south by the Chugach Mountains, on the west by the Talkeetna Mountains, and on the east by the Copper River basin. The latter runs north-south along the west side of the Wrangell Mountains and south past the Chitina River valley. Elevations range from approximately 450 m along the Nelchina and Copper Rivers to over 2,100 m in the rugged mountains on the periphery of the basins where permanent ice fields and glaciers are common. Temperatures average -14° C to -21.6° C in January to 6.3° C to 15.7° C in July (Gardner 1985). Vegetation in the area is similar to that described by Gardner (1985) with conifer, deciduous, or mixed forests generally below 1,000 m and shrub or alpine tundra zones at higher elevations. Forest vegetation is dominated by white spruce (*Picea glauca*), black spruce (*Picea mariana*), birch (*Betula papyrifera*), aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), willow (*Salix* spp.), and alder (*Alnus* spp.). Caribou (*Rangifer tarandus*), moose (*Alces alces*), Dall sheep (*Ovis dalli*), brown bears (*Ursus arctos*), black bears (*Ursus americanus*), wolves (*Canis lupus*), martens, lynx, and other furbearers, squirrels, and microtine rodents are relatively numerous in the area.

METHODS

Job 1.1 Design of Ground and Aerial Track-Count Procedures

This job was not addressed during the reporting period.

Job 1.2 Track-Count Sightability and Observer Bias

This job was not addressed during the reporting period.

RESULTS AND DISCUSSION

Job 1.1 Design of Ground and Aerial Track-Count Procedures

No activities are reported for this period.

Job 1.2 Track-Count Sightability and Observer Bias

No activities are reported for this period.

JOB 2. DENSITY, TREND, AND HARVEST POTENTIAL OF WOLVERINE POPULATIONS

BACKGROUND

Golden et al. (1993*a,b*) presented thorough discussions of the background for this project, which has been funded through Federal Aid since January 1995. Efforts during the past 3 years have focused on testing the accuracy and relative precision of 2 density estimation techniques: the transect-intercept probability sampling scheme (TIPS) (Becker 1991) and the sample-unit probability estimator (SUPE) (E. Becker, pers. commun.). There is uncertainty concerning the validity of the assumptions basic to both of these methods and, therefore, whether or not they are unbiased estimators. Once these techniques have been evaluated, wolverine density estimates may be compared among several trend areas in Southcentral and other regions of Alaska. Progress in determining the relationships between trends in wolverine density, harvest, and abundance of large predators will help in estimating sustainable harvest levels of wolverine populations. This project was done in the eastern Talkeetna and Wrangell Mountains in cooperation with Bill Route and Kurt Jenkins of the National Park Service and on the Kenai Peninsula with Ted Bailey of the U.S. Fish and Wildlife Service, Sue Howell of the U.S. Forest Service, and Mike Tetreau of the National Park Service.

OBJECTIVES

2.1 To assess the accuracy and relative precision of wolverine density estimates derived from line-intercept and quadrat sampling techniques.

2.2 To estimate the density and trend of wolverine populations in different areas of Southcentral Alaska.

2.3 To determine if relationships exist between trends in wolverine density and trends in wolverine harvest, food availability, and abundance of large predators.

2.4 To estimate sustainable harvest levels of wolverine populations in Southcentral Alaska.

Working Hypotheses

1. All wolverines within a sample area are active enough after a fresh snowfall to deposit tracks that are visible from the air.

2. All wolverine tracks crossing a transect or occurring within a sample unit are observed during aerial surveys.

3. Wolverine density is positively related to food availability and the presence of large predators and negatively related to harvest levels and development by humans.

STUDY AREAS

The primary area used for testing the density estimation techniques is the eastern Talkeetna Mountains. Wolverine density trend counts will also be conducted in the Wrangell Mountains. Descriptions of these areas are similar to the study area described under Job 1 above. Work on the Kenai Peninsula encompasses most of its 26,000-km^2 area but is concentrated in the mountainous regions. The latter are in light forest, shrub, and tundra zones. Potential food for wolverines on the Kenai Peninsula include beached marine mammals, seabirds, mountain goats (*Oreamnos americanus*), Dall sheep, caribou, moose, marmots (*Marmota caligata*), tundra voles (*Microtus oeconomous*), and salmon (*Oncorhynchus* spp.). Large predators that may provide carrion for wolverines are brown bears, black bears, wolves, and coyotes (*Canis latrans*).

METHODS

Job 2.1 Tests of Wolverine Density-Estimation Techniques

I used helicopter darting to capture wolverines in the eastern Talkeetna Mountains study area. Capture and collaring techniques are described in Golden et al. (1993*b*).

Between January and April 1994, an attempt was made to capture wolverines by using aluminum live traps that could be broken down and transported in SuperCubs. These custom-built traps were a rectangular box design with a drop door, similar to those used earlier in the study area (Golden et al. 1993*b*). Two pilots, Jerry Lee and Harley McMahon, were hired to set, bait, and maintain up to 10 traps each. No wolverines were caught with this approach after using 16 trap-sets a combined total of 561 trap nights. Trap design flaws and incidental catches of foxes were believed to be important reasons for the failure of this technique. Redesign of the traps and their possible use as supplemental capture devices are being considered.

During the winter of 1994-95, I prepared to test the accuracy of the TIPS density estimator within the 4100-km^2 study area by plotting 24 linear transects, 51 km in length, on 1:250,000-scale maps. The transects were randomly selected from a systematic sample of the study area. Each of the 4 pilot/observer teams were prepared to fly 6 transects within a period of 12-24 hours after snowfall. Due to poor snow and weather conditions, none of the 4 attempts to conduct the test was successful that year. Such conditions were also responsible for the unsuccessful attempts to conduct this test during winter 1993-94. In February 1996 I reduced the number of transects to 20 so each of 4 teams would fly 5 transects over a total area of 3000 km^2. The smaller area allowed teams to search for tracks within a smaller core area that contained all of the radiocollared wolverines.

Job 2.2 Wolverine Density and Trend Counts

In cooperation with the U.S. Fish and Wildlife Service, U.S. Forest Service, and National Park Service personnel, I used the SUPE technique (Becker 1993) to estimate wolverine density in 1 of 2 count areas of the Kenai Mountains on 23-24 February 1995. We had planned to conduct the estimate in both count areas but lost the proper survey conditions due to heavy fog. The sampled area was Count Area 2. It is approximately 2,050 km^2 in size and is located at the north end of the Kenai Mountains between Turnagain Arm and the Kenai River and between the Quartz Creek/Six-Mile Creek valley and the foothills to the west. Count Area 5, which was not surveyed, is approximately 1,600 km^2 in size and located between Skilak Lake and Tustumena Lake and between the Harding Ice Field and the foothills to the west. We selected these count areas because they had the highest relative abundance of wolverine tracks found during an earlier aerial survey of the Kenai Peninsula (Golden et al. 1993*a*).

We divided Count Area 2 into 198 4-km^2 sample units (SUs), with 180 SUs from the portion of the area we classified as highly likely to have wolverine tracks and 18 SUs from the portion classified as having a moderate likelihood of tracks. No SUs were considered to have a low likelihood of wolverine tracks. We randomly selected 43 SUs from the high area (24% of total) and 2 SUs from the moderate area (11% of the total) to survey. SU sample size was based on a hypergeometric distribution with an expected population of 10-12 wolverines in the count area. The expected population size for the 2,050-km^2 area was based on density estimates from other areas in Alaska of 4.7-5.2 wolverines/1,000 km^2.

We surveyed the 45 SUs 36-72 hours after snowfall with 2 pilot/observer teams. Teams searched each of the selected SUs for wolverine tracks. When we found tracks, we followed them to locate the animal's current location and then backtracked it to its beginning (Becker 1991). We plotted track routes on 1:250,000-scale maps and noted which of the other SUs the wolverines traveled through.

We were unable to resurvey the Kenai Peninsula in winter 1995-96 due to unfavorable weather conditions and the lack of snow. A similar survey to estimate wolverine density was planned for the winters of 1994-95 and 1995-96 in the Wrangell Mountains in cooperation with Bill Route of the National Park Service and Kurt Jenkins of the National Biological Service. The same poor weather conditions that hampered tests of the density estimation techniques in the Talkeetna Mountains also made surveys in the Wrangell Mountains unworkable.

Job 2.3 Wolverine Harvest and Habitat Characteristics

I examined pelt-sealing reports and purchased carcasses of wolverines from trappers in Units 11 and 13. Carcasses were processed to determine sex, age, body condition, and reproductive status. Skulls were labeled and frozen for later cleaning and archiving. Canine teeth from each animal were sent to Matson's Laboratory (Milltown, Mont.) for analysis of cementum annuli. Xyphoid fat samples were taken from each animal and frozen for future weighing as an index to body condition. Female reproductive tracts were extracted and frozen for future examination of placental scars and luteal bodies.

I am examining movements of the radiocollared wolverines in relation to (a) availability of principal food items, (b) the distribution and relative abundance of wolves and bears, and (c) the vegetation and physiographic composition of their areas of use. An attempt was made to locate each radiocollared wolverine at least twice per month and record habitat associations and activities.

Job 2.4 Wolverine Population Model

This job was not addressed during the reporting period.

RESULTS AND DISCUSSION

Job 2.1 Tests of Wolverine Density-Estimation Techniques

I radiocollared 6 new wolverines in February and March 1995 and 1996. These captures increased the total number of wolverines radiocollared in the study area since April 1992 to 18, 7 females and 11 males (Table 1). I used helicopter darting to capture all but 2 wolverines (TF2 and TF3), which were caught in live traps. I recaptured and recollared 6 of the 18 wolverines for a total of 24 study-animal captures. I used teletamine HCl and zolazepam HCl (Telezol, Aveco Co., Inc., Fort Dodge, Iowa) in darts at a standardized dosage of 175 mg (i.e., 11 mg/kg for a 16 kg animal at a concentration of 100 mg/ml). Although males were significantly heavier than females ($P < 0.001$; $t = -8.46$; df = 19), this dosage ensured full immobilization of either sex within the safety tolerances of the drug without the need for different dart loads for each sex. Mean capture weights were 10.7 kg (SD = 1.0 kg) for females ($n = 9$) and 15.3 kg (SD = 1.3 kg) for males ($n = 12$). Thus the standardized capture dosage of 175 mg translated to actual mean dosages of 16.1 mg/kg (SD = 1.3 mg/kg) for females ($n = 7$) and 11.5 mg/kg (SD = 0.9 mg/kg) for males ($n = 13$). Among 20 captures by darting, induction times averaged 3.0 minutes for females ($n = 7$) and 4.2 minutes for males ($n = 13$). Animals remained adequately sedated for 30-45 minutes. Mean ages of the wolverines at time of capture, based on cementum annuli determined from premolars (Matson's Lab, Milltown, Montana), were 1.4 yr (SD = 0.7) for females and 2.4 yr (SD = 1.1) for males. The oldest animals were a 5-year-old male and a 4-year-old female. This female was lactating at her first capture in April 1992, and she was seen with 1 kit in May and with 2 kits in June of that year. The fate of the kits is unknown. Blood tests conducted for several study animals (TF1, TF2, TF5, TM2, TM3, and TM4) indicated none of them had been exposed to distemper, hepatitis, or leptospirosis (R. Zarnke, ADF&G: pers. commun.).

I will attempt to improve the proportion of females in the sample by conducting capture operations at any suitable opportunity between mid October and mid April. Adult females are of particular interest because their movements may be more limited, due to denning activities, than movements of animals in other age-sex classes. Our ability to observe movements of individual wolverines through their track patterns after snowfall is essential to assessing the validity of the density estimation techniques. Consequently, we began independent tracking of individual wolverine movements between days after snowfall outside of the actual tests so that the model's inclusion probabilities may be adjusted if necessary. Movements of the radiocollared wolverines recorded during these tracking flights will be entered into an ArcView database and plotted to determine if adjustments are needed in the TIPS design.

Weather conditions permitted only a partial density estimate and an inconclusive test of the TIPS estimator on 15 February 1996. Four pilot/observer teams each attempted to fly 5 transects, but rapidly advancing fog prevented any team from completing its assignment. The full lengths of most of the transects could not be flown due to poor visibility. One team completed only half of its transects, and another team was unable to complete any transect. In addition to the incomplete survey, none of the radiocollared wolverines was located in the portion of the test area that was flown, which precluded a measurement of TIPS accuracy. During the survey, we encountered tracks of 6 individual wolverines in a 1611.4-km^2 area. We weighted calculations for unequal transect lengths to obtain a calculated population estimate of 8.3 wolverines (SE = 3.6; 90% CI = 6-18.2) in the count area, equivalent to an estimated density of 5.2 wolverines/1000 km^2 (90% CI = 3.7-11.3). This was a slightly higher density estimate than the 4.7/1000 km^2 reported by Gardner and Becker (1991) for an estimated population of 12.7 wolverines (SE = 1.64) in a 2700-km^2 area in the eastern Talkeetna Mountains that overlapped the present survey area. Their estimated density would have resulted in a population estimate of 7.6 wolverines for the same area we surveyed. The difference between the 2 estimates may partly have been because the area we surveyed in 1996 was some of the most favorable wolverine habitat, whereas Gardner and Becker's survey area encompassed more varied habitat. The estimates are so close, however, the slight difference between them may best be explained by normal sampling error.

Because we have not yet been able to capture and maintain an adequate sample size of wolverines within the original test area, we will continue to use the smaller test area of 3,000 km^2 for future testing. With the original test area of 4,100 km^2, a sample size of 11-13 wolverines was needed to thoroughly test the density-estimation technique, based on a hypergeometric distribution for a population estimate of 18-20 wolverines (E. Becker, pers. commun.). The sample size needed for the smaller test area is 7-10 animals, based on an estimated population size of 15 wolverines. If 1 wolverine in that population violates the model assumptions, there would be a 0.5-0.7 probability of observing the assumption failures (E. Becker, pers. commun.). If the target sample size cannot be met due to capture constraints, an attempt will be made to shrink the size of the core area sampled.

To compare the efficacy of the TIPS and SUPE techniques, we will use data sets from this study area and from Gardner and Becker's (1991) study area in the eastern Talkeetnas in computer simulations to measure differences in variance between estimates calculated by each technique.

Job 2.2 Wolverine Density and Trend Counts

Snow and lighting conditions were good during the SUPE survey of Count Area 2 on the Kenai Peninsula 23-24 February 1995. We counted tracks of 5 individual wolverines in the 2,050-km^2 area. This resulted in a calculated population size of 10.7 wolverines (SE = 4.2; 90% CI = 5-17.5) in the count area at an estimated density of 5.2 wolverines/1000 km^2 (90% CI = 3.8-8.5). This density was similar to densities of 4.7-5.2 wolverines/1000 km^2 during other SUPE and TIPS estimates in the eastern Talkeetna Mountains (Gardner and Becker 1991), the northern Chugach Range (Becker 1991), the western Chugach Range, and the Chugach Mountains east of Anchorage (R. Sinnott and E. Becker, pers. commun.).

Job 2.3 Wolverine Harvest and Habitat Characteristics

Wolverine harvest in 1994-95 was 11 for Unit 11 and 35 for Unit 13. In 1995-96 the take in Unit 11 dropped to 4 but in Unit 13 it remained about the same at 31. Harvest in Unit 13A, which contains the eastern Talkeetna Mountains study area, was 6 in 1994-95 and 3 in 1995-

96. One of the wolverines taken in Unit 13A in 1994-95 was radiocollared. Four of the 18 wolverines collared since April 1992 have been harvested by trappers. Three of the 4 were trapped in the study area; 1 was taken by a trapper on the north side of the Alaska Range, approximately 144 km from its original capture location. Additional harvest analysis for this area was provided in Golden et al. (1993*b*).

Wolverine harvests and habitat characteristics were reported for the Talkeetna and Wrangell mountains by Golden et al. (1993*b*) and on the Kenai Peninsula by Golden et al. (1993*a*). Audrey Magoun extended this investigation for the Kenai Peninsula; her report is in the Appendix.

Location data recorded for the 18 wolverines radiocollared since April 1992 are being processed into an ArcView database and will be analyzed and reported in the next progress report.

Job 2.4 Wolverine Population Model

No activities are reported for this period.

JOB 3. DISTRIBUTION, TREND, HABITAT USE, AND HARVEST POTENTIAL OF COASTAL RIVER OTTER POPULATIONS

BACKGROUND

River otters occupy much of the coastal environment of southern Alaska. These otters live along narrow intertidal, nearshore habitats, strongly selecting old-growth forests and avoiding areas that have been clear-cut from commercial logging (Larsen 1983, Woolington 1984, Bowyer et al. 1995). Because of their close association with the marine environment, coastal otters are also sensitive to aquatic pollutants, such as those resulting from the *Exxon Valdez* oil spill in Prince William Sound (Duffy et al. 1993*b*, Duffy et al. 1994, Bowyer et al. 1995). Although most coastal otter populations are considered healthy, this habitat selection creates potential risk of displacement due to logging, pollution, and other human development activities and increases their vulnerability to overharvest by humans due to favorable access to areas of otter concentration. There are few methods available for monitoring the status of coastal river otter populations other than harvest data acquired through pelt sealing.

Harvest data for Southcentral Alaska indicate a general pattern of low to moderate harvests. For example, harvests from Kodiak and Afognak islands ranged from 35 to 98 otters between the 1986-87 and 1994-95 seasons (Smith 1993). However, the 1980-81 harvest in this area exceeded 400 otters, a harvest density of up to 1 otter/1.6 km of coast. Harvest in the western portion of Prince William Sound ranged from 22 to 72 between the 1984-85 and 1994-95 seasons, with the exceptions of 1986-87 and 1987-88 when 160 and 181 otters were taken (Nowlin 1993). High harvests like these have not been common but exemplify potential for overharvest of otters, at least in local areas. There has not been a strong incentive for high otter harvests while pelt prices have languished over the last few decades, but trapper effort could quickly change if demand for otter fur increases. Managers need to be able to predict sustainable harvests for otter populations in their areas to minimize the risk of overharvest.

Techniques for monitoring population changes other than through harvests have focused on estimating density, primarily through radiotelemetry (Melquist and Dronkert 1987) or on indices of abundance determined through scat counts (Kruuk et al. 1986). Densities of river otters in Southeast Alaska were estimated from the movements and home ranges of radiomarked animals on Prince of Wales Island at 0.5 animals per km of coastline (Larsen 1983) and on Baranof Island at 0.8 animals per km of coastline. Testa et al. (1994) used a mark-recapture technique with scats containing radioisotopes, supplemented with movement data from radiomarked animals, to estimate otter densities in western Prince William Sound at 0.3 to 0.8 animals per km of coastline. The results from Prince William Sound, although similar to those from Southeast Alaska, were probably less biased. Density estimates are preferred measures of population status but time limitations and restrictions on the use of radioisotopes make their use impractical to management. Indices of relative abundance, such as scat counts, hold promise as being useful indicators of otter presence and habitat use (Bowyer et al. 1995). However, Kruuk et al. (1986) and Kruuk and Conroy (1987) cautioned researchers about the potential imprecision in their inferences about population change or habitat use that may result from scat counts.

River otters in coastal environments of Alaska tend to select old-growth forest habitats close to the shore, where their chief food items are marine bottom-dwelling fishes (Larsen 1983, Bowyer et al. 1994). Larsen (1983) reported otters on Prince of Wales Island normally within 20 m of forest edge along shorelines with short intertidal lengths of bedrock. Woolington (1984) found similar associations of otters and old-growth forests where approximately 75% of the radiolocations were within 30 m of the shore. Bowyer et al. (1995) studied river otter habitat selection and home ranges in the marine environment of Prince William Sound following the oiling of portions of the sound from the *Exxon Valdez* spill. Their habitat model showed otters strongly selected areas of old-growth forest in both the oiled and nonoiled areas and preferred large rocks in oiled areas and shallower tidal slopes in the nonoiled area. Otters in the nonoiled area seemed to avoid commercially logged habitats, yet home ranges were about twice the size for otters in oiled areas. Bowyer et al. (1994) found significant declines in the species richness and diversity of otter food items in oiled versus nonoiled areas. The effects of oil contamination and logging on habitat use, movements, and food habits of river otters indicate these animals are sensitive to disturbance by humans. River otter response to these types of human disturbances and to others, such as harvest and the construction of dwellings, are important management considerations that need to be addressed.

OBJECTIVES

3.1 To determine if latrine site use and fecal deposition rates are precise indicators of river otter abundance in coastal areas of Southcentral Alaska.

3.2 To determine which habitat features are most important in defining coastal river otter habitat.

3.3 To evaluate food habits of river otters relative to habitat types and geographic area.

3.4 To estimate sustainable harvest levels of river otter populations in coastal environments of Southcentral Alaska.

Working Hypotheses

1. Latrine site use and fecal deposition rates of coastal river otters are precise indicators of otter abundance.

2. Latrine site use by coastal river otters is positively related to the amount of high-quality habitat in an area and negatively related to development by humans.

3. The diversity and relative abundance of food items found in river otter scats are greatest in those areas of coastline with the highest density of latrine sites.

Study Area

Kachemak Bay

The initial area of investigation is the south side of Kachemak Bay from Halibut Cove southwest to Seldovia Bay. Latrine site presence and use by otters and habitat characteristics of those sites will continue to be determined along this entire area of coastline. We captured and radioimplanted otters in Tutka Bay and Jakalof Bay, and we will continue to monitor otter movements and food habits in the vicinity of these bays. Work along the south side of Kachemak Bay will continue through September 1997. Habitat features in this part of Kachemak Bay are similar to those described by Bowyer et al. (1995) for western Prince William Sound. Although the latter has been commercially logged to a greater degree, several areas of Kachemak Bay have been developed for housing, which seems to have reduced available habitat for river otters (J. Faro, pers. commun.).

Prince William Sound

River otter investigations are scheduled to begin in western Prince William Sound in April 1996. We will concentrate our latrine site searches and capture work in Herring Bay at the north end of Knight Island and in Jackpot Bay on the mainland west of Chenega Island. See Bowyer et al. (1995) for a description of habitat features in the area.

Methods

Job 3.1 Latrine Site Use and Fecal Deposition Rates by River Otters

We searched the coastline of Kachemak Bay by boat for river otter latrine sites, using methods described by Testa at al. (1994) and Bowyer et al. (1995) as part of the lower Cook Inlet contaminant study (Duffy et al. 1993*a*). The search area extended from Halibut Cove to Seldovia Bay, and active latrine sites were identified by the presence of fresh otter scats, scrapings, and burrows (J. Faro, pers. commun.). In June 1995 we marked and cleared sites of old scats, flagged the perimeter of the search area, and drew a map of the site to aid in future identification. On subsequent visits to the sites, we counted scats deposited over the intervening period. We sampled latrine sites approximately every 3 weeks between June and August 1995. When we revisited those sites in June 1996, scats deposited over winter were removed. We resampled those sites again after 3 days to obtain more accurate estimates of scat deposition rates. Thereafter, latrine site visitation was put on a 3-week, 3-day sampling schedule.

Job 3.2 Habitat Selection and Movements of River Otters

We set Hancock live traps at active otter latrine sites in Tutka Bay between mid April and mid May 1995 to capture and radiomark up to 7 otters. Captured animals were anesthetized with tiletamine/zolazepam at 10 mg/kg and transported to a qualified veterinarian in Homer for surgical implantation of a radiotransmitter into the abdominal cavity. These animals were given a broad-spectrum antibiotic and released near their capture sites within 48 hours of surgery, once the incisions seemed secure and the animals were stable.

We monitored the radiomarked otters daily by boat from late April to mid May and during latrine site visits from June through October 1995 and in June 1996. We also located the otters from a SuperCub every 2-4 weeks between January and May 1996. We recorded observations on 1:63,360-scale maps. Those data are being entered into an ArcView database for analysis during the next reporting period.

Job 3.3 Food Habits of River Otters Among Habitat Types

Scats collected at each latrine site were labeled and stored for food habits analysis. For the first sampling of the year in June, we saved only those scats thought to be less than 1 week old. We collected all scats on subsequent site visits. From the entire collection of scats saved in 1995, we randomly selected a subsample of scats from each latrine site in proportion to the abundance of scats found on each site on a particular visit. Scats were first sent to the North Pacific Universities Marine Mammal Research Consortium at the University of British Columbia where they were cleaned through an elutriation process. The scats were then forwarded to Pacific Identifications in Victoria, British Columbia for content identification.

Job 3.4 River Otter Population Model

This job was not addressed during the reporting period.

RESULTS AND DISCUSSION

Job 3.1 Latrine Site Use and Fecal Deposition Rates by River Otters

We reexamined 51 of the latrine sites in Tutka and Jakalof Bays originally found in 1994 (J. Faro, pers. commun.). During 13-17 June 1995, we cleared scats from 38 active latrine sites and resampled 35 of them on 2-4 July. Time constraints required that fewer sites be sampled. Thereafter, the 24 sites that had at least 2-3 scats in June and early July 1995 were resampled on later surveys. The number of scats per latrine site among the 23 sites sampled on 3 surveys ranged from 0 to 36; averages were 9.5 (SD = 7.5; n = 219) on 2-4 July, 14 (SD = 8.8; n = 323) on 24-25 July, and 8.9 (SD = 9.1; n = 205) on 15-17 August (Table 2). Mean scat deposition rates for those same sampling periods were 0.6 (SD = 0.4), 0.6 (SD = 0.4), and 0.4 (SD = 0.4) scats/day, respectively, which were significantly different (Kruskal-Wallis Test, $P = 0.047$, $\chi^2 = 6.10$, df = 2). The high variability of the rates reflects the wide difference in use of latrine sites by the river otters as summer progressed.

Job 3.2 Habitat Selection and Movements of River Otters

We set 16 traps at 15 latrine sites in Tutka and Jakalof Bays during 20 April-13 May 1995. We captured 5 river otters in Tutka Bay after 201 trap nights, for an average of 40.2 trap nights per otter. The composition of the captures was 1 old adult female, 1 young adult female, 1 young adult male, 1 yearling female, and 1 yearling male. We transferred the otters to holding boxes and transported them to the office of Homer veterinarian Dr. Ralph Brosches, who surgically implanted radiotransmitters into their abdominal cavities. The old female otter died during transport to Homer. An autopsy report is pending.

From May 1995 to June 1996, we obtained a combined total of 83 radiolocations for the 4 marked otters. Each of the animals was found on both sides and along the full length of Tutka Bay. One male traveled between Tutka Bay and nearby Sadie Cove, Jakalof Bay, and Kasitsna Bay. The other radiomarked male was found dead at a latrine site at the head of Tutka Bay on 4 June 1996. A necropsy report is pending. All radiolocations are being entered into an ArcView database for analysis during the next reporting period.

Job 3.3 Food Habits of River Otters Among Habitat Types

We collected, labeled, and saved 835 scat between June and August 1995 and sent a subsample of 138 scats to be cleaned and analyzed to identify contents. Preliminary analysis of 90 samples from 38 latrine sites indicates the river otters eat a wide variety of bony fishes (Table 3).

Job 3.4 River Otter Population Model

No activities are reported for this period.

JOB 4. FACILITATION OF THE LYNX TRACKING HARVEST STRATEGY THROUGH RULE-BASED MODELING

BACKGROUND

In 1987 the Alaska Department of Fish and Game (ADF&G) and the Board of Game (BOG) adopted a "tracking strategy" for managing lynx harvest. The strategy uses 2 basic and 3 supplemental criteria for changing seasons in the road-connected areas of Interior and Southcentral Alaska that have high trapper use. The 2 basic criteria are (1) percent kittens in the harvest and (2) evidence of increasing populations of both lynx and hares. The supplemental criteria are (1) period of pelt primeness, (2) probable negative effects of early seasons' orphaning kittens too young to survive, and (3) the effects of a late season on harvest due to increased movement of lynx. This tracking harvest strategy (THS) was designed to promote the dynamic management of lynx based on the ability of populations to support harvest.

The THS was implemented in 1988 and resulted in season closures in some units when lynx populations seemed to be at low levels and pelt prices (and the incentive to trap) were high. The THS became difficult to use in subsequent years because of the need to issue emergency orders to change seasons outside the usual regulatory schedule established by the BOG. This problem was resolved in 1992 when the BOG agreed to allow in-house regulatory changes within the broad seasons of 1 November or 10 November to 28 February. It became clear that another problem needed to be addressed before the THS could be implemented as designed: the THS criteria did not provide managers with sufficient guidelines to make their decisions.

To a large degree, lynx management in Alaska has depended on the abilities of individual area biologists to assess lynx population levels, to determine where lynx and hares are in their 9-11-year cycle, and select the most appropriate harvest regulations. These tasks have become more challenging due to (a) greater urbanization, (b) increased access by trappers, (c) the growing antitrapping movement, and (d) the influence of federal subsistence regulations. A lack of reliable, quantitative population trend data continues. There is also the difficulty in deciding how to adjust regulations with regard to pelt primeness, the potential for incidental catch and for orphaning kittens, and the possible changes in harvest pressure due to pelt prices. These conditions have placed area biologists in the position of relying on poor information and little guidance to make important management decisions. A clear decision-making protocol must be established based on existing knowledge of lynx population trends, production, survival, sustainable harvest, and new information.

The necessary protocol can be established in a model that employs a rule-based approach to decision-making. The advantage of the rule-based model is that it provides a documented, logical structure to the decisionmaking process that is both intuitive and experience-based (Ignizio 1991). Such models can process quantitative data but are most useful as we cope with qualitative information to reach decisions (Starfield 1990). Rule-based models build on what is known using available literature, in-house databases, and the collective knowledge of experts (Starfield and Bleloch 1991). These types of models have become known as knowledge-based systems or expert systems (Ignizio 1991).

Expert systems are used with a computer program shell to incorporate the user's, in this case the wildlife manager's, experience and available information into a decision tree, which is the foundation of the rule-based model (EXSYS 1994). For this process to occur, the builders of a model first establish all potential decisions or choices that could reasonably be made regarding a particular situation (e.g., to close, open, lengthen, or shorten lynx seasons). Second, questions using qualitative variables are formulated about the specific conditions or situations that may exist with lynx management at the time. Finally, a set of rules is devised in the form of if-then scenarios that direct the user toward an informed, logical, and consistent decision. This modeling approach can provide the manager with a protocol that, because it is fully documented, ensures accountability.

OBJECTIVES

4.1 To construct a prototype rule-based model for lynx management as part of the decision-making process in the lynx tracking harvest strategy.

4.2 To revise and refine the lynx management model after field-testing and user-evaluation into a useful tool for wildlife managers' decision-making.

Working Hypothesis

Implementation of the lynx tracking harvest strategy will be enhanced through the use of a rule-based system for lynx management.

METHODS

Job 4.1 Construction of a Lynx Management Model Prototype

I built upon my original 50-rule model to develop a full working version of the lynx-management model, using the EXSYS program shell. I used input from research and management staff at ADF&G during a review of the original model to address the most important parameters involved in the lynx-hare cycle, harvest scenarios, and management options.

Job 4.2 Revision and Refinement of a Lynx Management Model

This job was not addressed during the reporting period.

RESULTS AND DISCUSSION

Job 4.1 Construction of a Lynx Management Model Prototype

I constructed a 257-rule model called "LynxTrak" that incorporates qualitative and quantitative variables the user provides. The model calculates the potential of the lynx population in question. Population potential is a function of lynx abundance, food availability, production, and survival. The estimated optimal yield of the population is based on its potential and estimated size and leads to the calculation of the target harvest index. Harvest pressure is a function of lynx harvest, trapping effort, and the amount of refugia. The reciprocal of the target harvest index divided by the harvest pressure results in a determination of the risk factor to the lynx population. The risk factor and the current lynx season result in a new season recommendation as the final choice in the model.

I presented LynxTrak at the 8th Northern Furbearer Conference in May 1995. During the next performance period, I will refine and distribute it to interested conference participants, ADF&G staff, and biologists with other agencies to test its sensitivity and usefulness.

Job 4.2 Revision and Refinement of a Lynx Management Model

No activities are reported for this period.

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LITERATURE CITED

BECKER, E. F. 1991. A terrestrial furbearer estimator based on probability sampling. J. Wildl. Manage. 55:730-737.

——. 1993. Evaluation of a GMU subunit wolf estimator for wolf populations in Arctic, Interior, and Southcentral Alaska, using a probability sampling design. Alaska Dep. Fish and Game, Draft Res. Study Plan. Anchorage, Alas. 11pp.

BOWYER, R. T., J. W. TESTA, and J. B. FARO. 1995. Habitat selection and home ranges of river otters in a marine environment: effects of the *Exxon Valdez* oil spill. J. Mammal. 76:1-11.

——, ——, ——, C. C. SCHWARTZ, and J. B. BROWNING. 1994. Changes in diets of river otters in Prince William Sound, Alaska: effects of the *Exxon Valdez* oil spill. Can. J. Zool. 72:970-976.

DUFFY, L. K., R. T. BOWYER, J. B. FARO, and D. ROBY. 1993*a*. Intertidal fish, river otters, and pigeon guillemots as biomonitors of pollution in lower Cook Inlet. Letter of intent submitted to Univ. of Alaska Coastal Marine Inst., Univ. of Alaska Fairbanks. 9pp.

——, ——, J. W. TESTA, and J. B. FARO. 1993*b*. Differences in blood haptoglobin and length-mass relationships in river otters (*Lutra canadensis*) from oiled and nonoiled areas of prince William Sound, Alaska. J. Wildl. Dis. 29:353-359.

——, ——, ——, and ——. 1994. Chronic effects of the *Exxon Valdez* oil spill on blood and enzyme chemistry of river otters. Environ. Toxicol. and Chem. 13:643-647.

EXSYS. 1994. Expert system development software: EXSYS Professional, ver. 5.0. EXSYS, Inc., Albuquerque, N.M.

GARDNER, C. L. 1985. The ecology of wolverines in Southcentral Alaska. M.S. Thesis, Univ. of Alaska Fairbanks. 82pp.

——, and E. F. BECKER. 1991. Wolf and wolverine density estimation techniques. Fed. Aid in Wildl. Rest. Res. Prog. Rep., Proj. W-23-4. Juneau. 8pp.

GOLDEN, H. N. 1987. Survey of furbearer populations on the Yukon Flats National Wildlife Refuge. Final Rep. Coop. Agree. Proj. No. 14-16-007-84-7416. Alaska Dep. Fish and Game and U. S. Fish and Wildl. Serv., Fairbanks, Alas. 86pp.

——. 1988. Distribution and relative abundance, population characteristics, and harvest of furbearers in Gates of the Arctic National Park and Preserve. Final Rep. NRFR AR-8808. Natl. Park Serv., Anchorage, Alas. 33pp.

——. 1994. Furbearer track count index testing and development. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor., Final rep., Grant W-24-2. Juneau, Alas. 45pp.

——, T. N. BAILEY, M. TETREAU, and S. HOWELL. 1993*a*. Wolverine population survey on the Kenai Peninsula. Alaska Dep. Fish and Game, U.S. Fish and Wildl. Serv., Nat'l. Park Serv., U.S. For. Serv., Coop. Res. Proj. Prog. Rep. Anchorage, Alas. 17pp.

——, W. T. ROUTE, and E. F. BECKER. 1993*b*. Wolverine demography and ecology in Southcentral Alaska. Proj. outline and prog. rep. Alaska Dep. Fish and Game and Nat'l. Park Serv., Coop. Res. Proj. Anchorage, Alas. 27pp.

IGNIZIO, J. P. 1991. Introduction to expert systems: the development and implementation of rule-based expert systems. McGraw-Hill, Inc., N.Y. 402pp.

KRUUK, H., and J. W. H. CONROY. 1987. Surveying otter *Lutra lutra* populations: a discussion of problems with spraints. Biol. Conserv. 41:179-183.

——, ——, U. GLIMMERVEEN, and E. J. OUWERKERK. 1986. The use of spraints to survey populations of otters *Lutra lutra*. Biol. Conserv. 35:187-194.

LARSEN, D. N. 1983. Habitats, movements, and foods of river otters in coastal southeastern Alaska. M. S. Thesis, Univ. of Alaska Fairbanks. 131pp.

MELQUIST, W. E., and A. E. DRONKERT. 1987. River otter. Pages 626-641 *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.

NOWLIN, R. A. 1993. Furbearers. Pages 47-58 *in* S. M. Abbott, ed. Survey-inventory management report: 1 July 1989 - 30 June 1991. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor., Proj. W-23-3 and W-23-4. Juneau, Alas.

PETERSON, S, ed. 1994. Alaska trapper questionnaire report 1993-94. Alaska Dep. Fish and Game. Juneau, Alas. 52pp.

SMITH, R. B. 1993. Furbearers. Pages 73-79 *in* S. M. Abbott, ed. Survey-inventory management report: 1 July 1989 - 30 June 1991. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Restor., Proj. W-23-3 and W-23-4. Juneau, Alas.

STARFIELD, A. M. 1990. Qualitative, rule-based modeling. BioSci. 40:601-604.

——, and A. L. BLELOCH. 1991. Building models for conservation and wildlife management. Burgess Intern'l Group, Inc. Edina, Minn. 253pp.

TESTA. J. W., D. F. HOLLEMAN, R. T. BOWYER, and J. B. FARO. 1994. Estimating populations of marine river otters in Prince William Sound, Alaska, using radiotracer implants. J. Mammal. 75:1021-1032.

WOOLINGTON, J. D. 1984. Habitat use and movements of river otters at Kelp Bay, Baranof Island, Alaska. M. S. Thesis, Univ. of Alaska Fairbanks. 147pp.

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Table 1. Age, size, and status of wolverines captured in the eastern Talkeetna Mountains, April 1992 through June 1996.

Access. Number	Sex	Date of Capture	Age at Capture[a]	Live Weight (kg)	Body Length (cm)	Tail Length (cm)	Total Length (cm)	Head Circum. (cm)	Neck Circum. (cm)	Heart Girth (cm)	Current Status
TF1	F	4/20/92	3	10.0	76.0	22.0	98.0	32.5	29.0		
Recap		4/20/93		10.0	73.0	19.0	94.0	32.5	30.0	44.5	Transmitter failure -- Lost 2/95
TF2	F	4/21/92	1	9.5	76.0	20.0	96.0	31.0	28.0	41.0	Died from infection -- 3/93
TF3	F	4/3/93	1	10.0	84.0	22.0	106.0	35.0	31.5	42.5	
Recap		4/19/93									Trapper harvest -- 1/95
TF4	F	3/6/94	1	10.0	80.0	10.4	90.4	34.4	30.3	40.0	Shed Collar -- 7/96
TF5	F	3/7/94	1	11.5	78.5	18.5	97.0	34.0	32.5	46.5	
Recap		3/13/96		12.6	79.0	20.5	99.5	35.0	31.5	44.0	Alive and within study area
TF6	F	3/27/94	1	11.6	81.2	19.5	100.7	33.5	31.0	42.5	Shed collar 5/95; Trapper harvest -- 12/95
TF7	F	3/14/96	2	11.0	82.0	21.5	103.5	33.5	30.0	39.0	Alive and within study area
TM1	M	4/18/92	1	15.0	91.0	20.0	111.0	38.0	36.0	46.0	Trapper harvest -- winter 92-93
TM2	M	4/19/92	3	18.0	91.0	20.5	111.5	38.0	37.0	47.0	
Recap		2/17/93		17.0	91.0	18.0	109.0	40.5	36.0	52.0	Trapper harvest -- 1/94
TM3	M	3/3/93		15.0	88.0	23.0	111.0	37.5	36.5	47.5	
Recap		4/20/93	2	16.0				37.0	38.0		Dispersed -- Trapper harvest -- 12/93
TM4	M	3/3/93	3	15.0	82.0	21.0	103.0	37.0	36.5	45.5	
Recap		4/17/93						38.0			Lost signal -- 4/94
TM5	M	3/28/94	5	14.5	89.0	17.5	106.5	37.5	36.5	47.0	Lost signal -- 10/95
TM6	M	3/28/94	2	14.5	95.5	18.5	114.0	37.0	35.5	48.0	Lost signal -- 1/95
TM7	M	3/19/95	1	15.0	88.5	21.5	110.0	37.0	34.2	41.5	Alive and within study area
TM8	M	3/19/95	1	14.5	92.0	14.0	106.0	37.0	32.5	42.0	Alive and within study area
TM9	M	2/17/96	3	16.2	83.0	18.0	101.0	37.0	38.0	49.0	Alive and within study area
TM10	M	2/17/96	2	12.8	92.0	21.0	113.0	33.0	31.0	46.0	Alive and within study area
TM11	M	3/13/96	3	15.5	88.5	21.5	110.0	37.5	35.5	47.0	Alive and within study area

[a] Age was determined from cementum annuli of premolars through Matson's Lab, Milltown, Montana.

Table 2. Number of river otter scats deposited, number of days of accumulation between sampling periods, and mean number of scats deposited per day among 23 primary latrine sites in the Kachemak Bay study area on the Kenai Peninsula, Alaska, July and August 1995.

	2-4 July			24-25 July			15-17 August		
Latrine Site	Scats Depos.	Days Accum.	Scats/ Day	Scats Depos.	Days Accum.	Scats/ Day	Scats Depos.	Days Accum.	Scats/ Day
1	0	18	0.00	0	22	0.00	2	22	0.09
2	2	18	0.11	2	22	0.09	5	22	0.23
5	6	18	0.33	20	22	0.91	2	22	0.09
7	3	18	0.17	17	22	0.77	3	22	0.14
8	15	18	0.83	25	22	1.14	34	22	1.55
10	7	17	0.41	11	22	0.50	1	23	0.04
11	3	17	0.18	0	22	0.00	2	23	0.09
13	6	17	0.35	6	22	0.27	7	23	0.30
14	5	17	0.29	15	22	0.68	11	23	0.48
17	19	18	1.06	13	21	0.62	19	23	0.83
18	7	17	0.41	15	21	0.71	2	23	0.09
19	16	17	0.94	30	21	1.43	12	23	0.52
21	15	17	0.88	14	22	0.64	10	22	0.45
22	5	17	0.29	5	22	0.23	7	22	0.32
23	36	17	2.12	36	22	1.64	27	22	1.23
24	9	17	0.53	15	22	0.68	5	22	0.23
27	13	18	0.72	10	21	0.48	20	22	0.91
28	14	18	0.78	21	21	1.00	22	22	1.00
30	11	18	0.61	14	21	0.67	4	23	0.17
32	8	18	0.44	8	21	0.38	4	23	0.17
34	8	16	0.50	17	22	0.77	4	23	0.17
35	3	16	0.19	21	22	0.95	2	22	0.09
37	8	16	0.50	8	22	0.36	0	22	0.00
n	219			323			205		
√	9.5	17.3	0.6	14.0	21.7	0.6	8.9	22.4	0.4
SD	7.5	0.7	0.4	8.8	0.5	0.4	9.1	0.5	0.4

Table 3. Frequency of occurrence among 38 latrine sites of food items identified in 90 river otter scats collected in Kachemak Bay, Alaska, July and August 1995.

Common Name	Species Name	Frequency of Occurrence
Flatfish	Pleuronectiformes	23
Yellowfin Sole	*Limanda aspera*	5
Starry Flounder	*Platichthys stellatus*	8
Rock Sole	*Lepidopsetta bilineata*	23
Sand Lance	*Ammodytes hexapterus*	11
Ronquill	Bathymasteridae	7
Herring	*Clupea harengus*	5
Irish Lord	*Hemilepidotus* spp	2
Padded Sculpin	*Artedius fenestralis*	4
Great Sculpin	*Myoxocephalus polyacanthocephalus*	1
Staghorn Sculpin	*Leptocottus armatus*	2
Other Sculpins	Cottidae	22
Sand Fish	*Trichodon trichodon*	1
Gadids	Gadidae	8
Tomcod	*Microgadus proximus*	2
Pacific Cod	*gadus macrocephalus*	2
Saffron Cod	*Eleginus gracilis*	27
Pollock	*Theragra chalcogramma*	19
Threespine Stickleback	*Gasterosteus aculaeatus*	12
Whitespotted Greenling	*Hexagrammos stellerii*	1
Other Greenlings	*Hexagrammos* spp	11
Smelt	Osmeridae	1
Salmon	*Oncorhynchus* spp	10
Snake Prickleback	*Lumpenus sagitta*	6
Other Pricklebacks	Stichaeidae	13
Crescent Gunnel	*Pholis laeta*	15
Other Gunnels	Pholididae	23
Eelpout	Zoarchidae	1
Rockfish	*Sebastes* spp	3
Unidentified Fish	Pisces	12
Polycaete Worm	Unidentified	1
Barnacle	Unidentified	5
Crab	Unidentified	2
Chiton	Unidentified	1
Snail	Unidentified	6
Clam	Unidentified	5
Mussel	*Mytilus* spp	6
Sea Urchin	Unidentified	1

APPENDIX

WOLVERINES HEAD FOR THE HILLS ON THE KENAI PENINSULA, ALASKA

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INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) suspended wolverine trapping in Unit 15A on the Kenai Peninsula of Alaska in 1988-1989. Unit 15A comprises the Kenai lowlands and the western foothills of the Kenai Mountains north of the Kenai River (Fig. 1). Unit 15A has supported high densities of moose, wolves, coyotes, and black bears. In the 17 years preceding the wolverine trapping closure, only 17 wolverines were harvested from Unit 15A (Table 1). The trapping closure was prompted by concern that trapping is preventing an increase in wolverine numbers in Unit 15A.

Are there factors other than trapping that could be influencing wolverine numbers in Unit 15A? Banci (1994) described the wolverine as a management and conservation enigma because we know so little about the attributes of good wolverine habitat. In this paper I examine 4 hypotheses that explain wolverine distribution on the Kenai. Among the contributing factors I considered are food, dispersal, trapping, interspecific competition, and physiographic and climatic features.

DISTRIBUTION OF THE WOLVERINE HARVEST

I plotted 572 wolverine harvest locations (88% of the known harvest; Table 2) for 1963-1964 through 1967-1968 and 1971-1972 through 1992-1993 (Fig. 1). Locations not plotted on Figure 1 were either missing for those years or not specific enough to be included. Locations were obtained from bounty and sealing forms and from University of Alaska museum records.

On Figure 1, I delineated the lowland and mountainous areas of the Kenai with a dashed line drawn 5 km from the 625 m (2000 ft) contour line. I chose 5 km because this distance approximates the radius of the home range of a female wolverine with young (Magoun 1985), the wolverine sex and age class with the smallest home range (Banci 1994). I assumed that wolverines captured within 5 km of the 625 km contour could have had home ranges that included mountainous terrain. In this paper "mountains" refer to areas generally east of the line and "lowlands" to areas generally west of the line. The area around the Caribou Hills is defined as "mountains" for the purposes of this paper.

Most wolverines harvested on the Kenai were taken in the mountains. Only 8.6% of the harvest locations in Figure 1 were in the lowlands despite the fact that the lowlands comprise 34% of the land area on the Kenai (excluding icefields, lakes, and settled areas). The density of the harvest locations for the lowland area in Figure 1 was 8.1 wolverines/1000 km^2; for the mountains, 49.7/1000 km^2. Density of the harvest locations in the lowlands increased from north to south: 4.2/1000 km^2 in Unit 15A, 11.2/1000 km^2 in Unit 15B, and 11.9/1000 km^2 in Unit 15C.

HYPOTHESIS 1: Wolverines have been overharvested in Unit 15A in the past and have not recovered because of continued trapping in and adjacent to Unit 15A.

Arguments for:

- A history of unregulated trapping and predator control programs that included poisoning and bounties led to the disappearance of wolves (Peterson et al. 1984) and low furbearer populations on the Kenai in the early part of this century (Bailey 1921).
- An 8-fold increase in the number of trapping permits issued for the Kenai National Wildlife Refuge (KNWR) occurred between 1960 and 1983 (Fig. 2).
- Wolf trapping, which can result in incidental catches of wolverines, began to increase on the Kenai in the early 1970s (KNWR records).
- The wolverine has a relatively low recruitment rate (Banci 1994) and may not be able to rebuild populations rapidly after overharvest has occurred.
- Dispersal of wolverines into Unit 15A from other areas of the Kenai may occur slowly because movements into Unit 15A are restricted by ocean on the north and west and, to some degree, by human development and Skilak Lake to the south.
- The level of wolverine harvests in Unit 7 to the east may be high enough that few dispersers are available to repopulate Unit 15A (see footnote).

Arguments against:

- Wolverine populations on the Kenai have had more than 25 years to recover from unregulated trapping and predator control programs. The increase in recreational trapping in the 1970s had little impact on the wolverine population on the Kenai because Unit 15A received most (71%-86%) of the increased trapping pressure (Bailey 1986), yet only 4% of the Kenai Peninsula wolverine harvest came from Unit 15A. Furthermore, an average 52% (range 31%-88%) of the Kenai Peninsula harvest is taken by only 4 trappers each year (Table 2), indicating that wolverine harvests on the Kenai are influenced more by the skill of individual trappers than by the number of trappers.

- The wolverine population was relatively high in the late 1960s and early 1970s based on harvest levels (Fig. 3), average number of wolverines caught by wolverine trappers (Fig. 3), and reports by trappers (B. Bolstridge, pers. commun.). Wolverine populations were probably responding to unusually abundant food resources on the Kenai during this period (Fig. 4). Biologists and trappers on the Kenai in the 1960s and early 1970s observed little evidence of wolverines in the Kenai lowlands even though there were wolverines in the mountains and along the Chickaloon River close to the mountains (B. Richey, A. Thayer, B. Bolstridge, and W. Sather, pers. commun.). Wolverine harvests were not relatively high in the early 1970s in Unit 15A as they were in other areas of the Kenai (Table 1).

- Despite 7 years of trapping closures for wolverine in Unit 15A, there is no evidence that wolverines have noticeably increased in that area. Yet, wolverine populations occur close to Unit 15A in areas that have remained open to wolverine trapping. Surveys in March 1992 in Unit 7, east of Unit 15A, indicated that wolverine tracks were at intermediate levels compared with those in the Talkeetna, Wrangell, and Chugach mountains north of the Kenai Peninsula (Golden et al. 1993). Golden (pers. commun.) estimated the wolverine density in northwestern Unit 7 in 1995 was 5.2/1000 km^2 just after the trapping season ended. This density is comparable to estimated wolverine densities in the Talkeetna and Chugach mountains (Gardner et al. 1993).

- Wolverines disperse over long distances (Banci 1994, Gardner et al. 1986) and should easily recolonize heavily harvested areas that are adjacent to productive wolverine habitat. Dispersers may be immigrating in sufficient numbers to maintain the population in Unit 7 (see footnote) and provide dispersers to Unit 15A.

Footnote: Using a technique to estimate wolverine density based on probability sampling, Golden (pers. commun.) estimated a density of 5.2/1000 km^2 in the mountains east of Unit 15A (west of Resurrection Creek and north of the Kenai River) in March 1995 after the close of the trapping season. Densities were not estimated for other areas in Unit 7. The average annual wolverine harvest for Unit 7 from 1979-1980 to 1992-1993 was 11.3 or 1.6/1000 km^2 (excluding icefields). Assuming that an average after-harvest density of 5.2/1000 km^2 is typical of most of Unit 7, an average wolverine harvest of 1.6/1000 km^2 is a harvest level of 23%. Using a modeling technique, Gardner et al. (1993) estimated that an annual sustainable harvest for wolverines is 4%-15% of the fall population. These estimates indicate that the wolverine harvest in Unit 7 has been unsustainable for 14 years. This is surprising because the harvest in Unit 7 has been relatively stable for the past 14 years and was even higher in the 8 years preceding those (17.6 wolverines/year). I believe that either 1) the estimates of density and/or wolverine recruitment are inaccurate, 2) the estimates cannot be applied to all of Unit 7, or 3) there are enough wolverines immigrating into Unit 7 (7-10/yr) to replace the wolverines which were harvested above the sustainable level. Immigrants into Unit 7 would have to enter from Unit 15B across the Kenai and Russian rivers, from the mainland across the 16-km wide isthmus, or from Unit 6 along the Nellie Juan River or around Day Harbor from Unit 6. There is no evidence to indicate that wolverine population densities are higher in these potential source areas than in Unit 7. A wolverine density estimate for the Chugach Mountains north of the Kenai was 5.4/1000 km^2 (Becker and Gardner 1992) and, based on harvest statistics, wolverine density is probably lower in Unit 15B than in Unit 7.

HYPOTHESIS 2: Food for wolverines is low or unavailable in Unit 15A.

Arguments for:

- During spring and summer, large ungulate carrion may be scarce in Unit 15A. Large ungulate survival is better in summer than in winter, and abundant black bears, coyotes, and wolves compete for any carrion that becomes available (see Hypothesis 3)

- In addition to carrion, female wolverines with young may rely on smaller mammals and ground-nesting birds to feed their young in summer (Magoun 1985). Marmots, available in the mountains, are not found in the lowlands.

- Carrion may last longer in the mountains because wolverines can protect it from other scavengers and from decomposition by caching it in remnant snowdrifts (Magoun 1979, 1985).

Arguments against:

- All studies of wolverine diets have shown that large mammal carcasses are one of the most important items in the wolverine's diet (Banci 1994). Biomass of large ungulates on the Kenai is at least as high in the lowlands as in the mountains (Fig. 5). Some of the highest densities of moose in Alaska have occurred on the Kenai Peninsula largely in the lowlands (Bailey 1978).

- Snowshoe hare can be an important item in the wolverine's diet (Banci 1994). Hare have been periodically abundant in the Kenai lowlands (Bailey et al. 1986).

- Wolverines are found in other lowland areas of Alaska where moose are the predominant ungulate and black bears and wolves are common.

HYPOTHESIS 3: Competition with other species is greater in the lowlands than in the mountains.

Arguments for:

- Black bears, wolves (since the mid-1970s), and coyotes (since 1930s) are more common in the lowlands than in the mountains. These species compete with wolverines for carrion. Peterson et al. (1984) reported that fresh bear sign was common at 100 moose carcasses they examined in the Kenai lowlands in May. All the carcasses were thoroughly scavenged.

- Adult wolverines are sometimes killed by larger carnivores (Banci 1994) and this is likely to occur more often in the lowlands where black bears and wolves are common than in the mountains. The highest wolverine harvests on the Kenai came from mountainous areas that were characterized as secondary wolf habitat by Peterson et al. (1984) and have far fewer black bears than the lowlands. Krott (1982) stated that the distribution of wolverines is influenced by the presence of wolves, with wolverines eluding wolves by "drawing back into mountainous regions, large bogs and into areas with long-lasting deep snow cover."

- Wolverine kit survival may be low in areas that have abundant large predators and limited den or rendezvous sites that can afford protection from these predators (see Hypothesis 4).

<u>Arguments against</u>:

- Large predators provide a source of carrion for wolverines (Banci 1994).

- Wolverines and their kits can climb trees to avoid most predators.

- Wolverines are found in other areas of Alaska where wolves, bears, and coyotes are common.

HYPOTHESIS 4: The lack of large snowdrifts that last well into the summer (remnant snowdrifts) limit the range of reproductive female wolverines in Unit 15A.

<u>Arguments for</u>:

- Wolverines are adapted to life in the snow and snowdrifts are an important feature of wolverine habitat. Wolverines use long tunnels dug into snowdrifts as natal dens and rendezvous sites for wolverine kits (Magoun 1985, Pulliainen 1968; Fig. 6). Pulliainen (1968) postulated that snow cover is an important feature of natal dens because of its insulative qualities. Food is often stored in snow tunnels (Pulliainen 1968, Haglund 1966) and under remnant snowdrifts even in the summer (Magoun 1985). Wolverines of both sexes use snow tunnels to escape predators (Magoun, pers. observ.) and females use them to seek respite from the attention of males during the breeding season (Krott and Gardner 1985, Magoun 1985).

- Elevation, topography, and wind affect the number, distribution, and longevity of snowdrifts. Cooler temperatures at higher elevations and the deeper drifts that form along drainages in the mountains create better conditions for long-lasting snowdrifts. The greatest snowpack occurs in northeastern Unit 7 and the lowest in the Unit 15A lowlands and at the western edge of the mountains (Jean Lake) in Unit 15A (Fig. 7).

- Data on the 30-year average snowpack on the Kenai Peninsula indicate that wolverine harvest density is highest in areas with the greatest snowpack (Fig. 7).

Arguments against:

- Information concerning wolverine natal dens in forested habitat is limited; most North American studies are biased to tundra regions (Banci 1994). Descriptions of natal dens from forested areas mention logs, boulders, caves, and beaver lodges, but in most cases, these structures were snow-covered at the time they were used as dens (Hatler 1988). More information is needed on natal dens in forested habitat.

CONCLUSIONS

It is unlikely that a wolverine trapping closure in Unit 15A on the Kenai Peninsula will result in appreciable numbers of wolverines because of habitat limitations. I believe that where large predators and scavengers are common, long-lasting snowdrifts are necessary for consistently productive wolverine habitat. Transients and even some reproductive female wolverines may periodically occur in Unit 15A, but the turnover rate for the Unit 15A wolverine population would be high even without trapping.

ACKNOWLEDGMENTS

This paper would not have been possible without the help of Ted Spraker, Larry Lewis, Becky Strauch, Howard Golden, Sandy Kennedy, Laura McCarthy, Ted Bailey, Nancy Carver, and Dan Reed.

LITERATURE CITED

Bailey A. 1921. Notes on game conditions in Alaska. Unpubl Rep. Kenai National Moose Range. Kenai National Wildlife Refuge files. 18pp.

Bailey TN. 1978. Moose populations on the Kenai National Moose Range. Pages 1-20 *in* Proceedings 14th North Am Moose Conf and Workshop. Halifax, Nova Scotia.

Bailey TN, EE Bangs, MF Portner, JC Malloy, and RJ McAvinchey. 1986. An apparent overexploited lynx population on the Kenai Peninsula, Alaska. J Wildl Manage. 50(2):279-290.

Banci V. Wolverine. 1994. Pages 99-127 *in* LF Ruggiero, KB Aubry, SW Buskirk, LJ Lyon, and WJ Zielinski, eds. American marten, fisher, lynx, and wolverine in the western

United States. General Tech Rep RM-254. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. Chapter 5.

Becker EF and C Gardner. 1992. Wolf and wolverine density estimation technique. Alaska Dep Fish and Game. Fed Aid in Wildl Restor. Res Proj Rep. Proj W-23-5. 18pp.

Gardner CL, WB Ballard, and RH Jessup. 1986. Long distance movement by an adult wolverine. J Mammal. 67:603.

Gardner CL, ME McNay, and R Tobey. 1993. Estimates of wolverine densities and sustainable harvests in the Nelchina Basin in southcentral Alaska. Unpubl Rep. *In*: Abstracts; 7th Northern Furbearer Conference; April 22-23, Whitehorse, Yukon. Abstract. 33pp.

Golden HN, TN Bailey, M Tetreau, and S Howell. 1993. Wolverine population survey on the Kenai Peninsula. Alaska Dep Fish and Game. Prog Rep. Anchorage. 17pp.

Haglund B. 1966. Winter habits of the lynx (*Lynx lynx* L.) and wolverine (*Gulo gulo* L.) as revealed by tracking in the snow. Viltrevy 4:81-299.

Hatler DF. 1988. A wolverine management strategy for British Columbia. Unpubl Rep. British Columbia. Ministry of Environment and Parks, Vancouver. 126pp.

Krott P. 1982. Der Vielfraß (*Gulo gulo* Linnaeus 1758) im Ökosystem. Saugietierk. Mitt. 30:136-150.

Krott P and C Gardner. 1985. Wolverine breeding behavior in Alaska. Saugietierk. Mitt. 32:87.

Magoun AJ. 1979. Chapter 4. Studies of wolverines on and adjacent to NPR-A. Pages 89-128 *in* PC Lent (Tech Ed). Vol 1. Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR-A 1977-1978. National Petroleum Reserve in Alaska 105 (6) Field Study 3. USDI NPR-A, Anchorage, Alas.

Magoun AJ. 1985. Population characteristics, ecology, and management of wolverines in northwestern Alaska. PhD dissertation, University of Alaska, Fairbanks. 197pp.

Pulliainen E. 1968. Breeding biology of the wolverine (*Gulo gulo* L.) in Finland. Ann Zool Fenn. 5:338-344.

Peterson RO, JD Woolington, and TN Bailey. 1984. Wolves of the Kenai Peninsula, Alaska. Wildl Monogr. No 88. 52pp.

LIST OF FIGURE LEGENDS

Figure 1. Location of wolverine harvests on the Kenai Peninsula for the years 1963-1964 through 1967-1968 and 1971-1972 through 1992-1993. The green dashed line is the boundary between the lowland areas of the Kenai and the mountains. The Game Management Units are highlighted in yellow. The boundary was placed 5 km from the 625 m (2000 ft) contour line; 5 km is an approximate radius of the home range of a reproductive female wolverine. Most of the locations were specific only to the drainage in which they occurred, so locations were distributed randomly along the drainages. Occasionally, a location occurred in a drainage that crosses the boundary between lowlands and mountains and was not specific enough to place it in the correct area. These few locations were distributed evenly between the lowlands and mountains close to the boundary line. A trapping closure was instituted in Unit 15A in 1988-1989. Based on the harvest from previous years, only 2 additional wolverines would have been harvested in the lowlands had trapping remained open in Unit 15A and 1 of these wolverines probably would have been trapped near the mountains in the Chickaloon River drainage.

Figure 2. Data for the KNWR was provided by T. Bailey. Kenai Peninsula wolverine harvests for some early regulatory years were extrapolated (dashed line) using KNWR harvest statistics and do not necessarily represent the actual harvest. In particular, the Kenai Peninsula harvest in 1968-1969 was probably higher than indicated in this figure. The KNWR harvests were used for the extrapolation because the pattern of harvest on the KNWR roughly approximates the pattern on the Kenai Peninsula. The KNWR harvest averages about 20% of the Kenai Peninsula harvest.

Figure 3. Kenai Peninsula wolverine harvests for some early regulatory years were extrapolated (dashed line) using KNWR harvest statistics (Table 2) and do not necessarily represent the actual harvest. In particular, the Kenai Peninsula harvest in 1968-1969 was probably higher than indicated in this figure. The number of Kenai Peninsula wolverine trappers and the average wolverines/successful trapper were also extrapolated for the same early regulatory years. The hypothetical Kenai Peninsula harvest since 1984-1985 was determined by calculating the percentage of wolverines that had been harvested in March before the season was shortened and in Unit 15A before the season was closed and adding these percentages to the harvests since 1984-1985.

Figure 4. The estimated moose population was obtained using data from Bailey (1978) and from Alaska Department of Fish and Game survey and inventory reports. The estimated Dall sheep population was derived from unpublished survey data for 3 areas on the Kenai Peninsula (provided by L. Nichols) and extrapolating for the entire Kenai Peninsula; the population in the survey areas were approximately 31% of the estimated Kenai Peninsula sheep population in 1994. Mountain goat numbers were not included in this graph, but the T. Spraker (pers. commun.) believed fluctuations in mountain goat population approximated those that occurred in the sheep population, with a notable decrease in numbers occurring in the early 1970s. Snowshoe hare numbers were not included in this graph, but snowshoe hare peaks in the early

1990s were notably lower than those in the 1960s and early 1970s (T. Spraker and T. Bailey, pers. commun.). T. Spraker (pers. commun.) believed the snowshoe hare high in the early 1980s was about 25% lower than in the early 1970s. Note that some wolverine harvests in the early regulatory years were extrapolated (dashed line, see Table 2) and may not represent the actual harvest. In particular, the harvest in 1968-1969 was probably higher than that represented in this figure.

Figure 5. Distribution of large ungulates on the Kenai Peninsula. Moose are found in the lowlands and mountains, but the highest densities are in the lowlands.

Figure 6. Drawing of an excavated wolverine natal den showing the complex snow tunnel system (Magoun 1985). Measurements are in centimeters.

Figure 7. Average snowpack for sites located on the Kenai Peninsula, 1961-1990. Snowpack was measured at the beginning of each month. Data was obtained from the Natural Resources Conservation Service and location of the sites are given in Figure 1. Eagle Lake and Deep Creek are located in the "mountain" area around the Caribou Hills in Unit 15C. Lowland sites in Unit 15C (Bridge Creek and Demonstration Forest) have snowpacks that are similar to those in mountain areas. Snowpack in the lowlands of Unit 15A, which is low in comparison with other areas on the Kenai, is almost gone by the first of May.

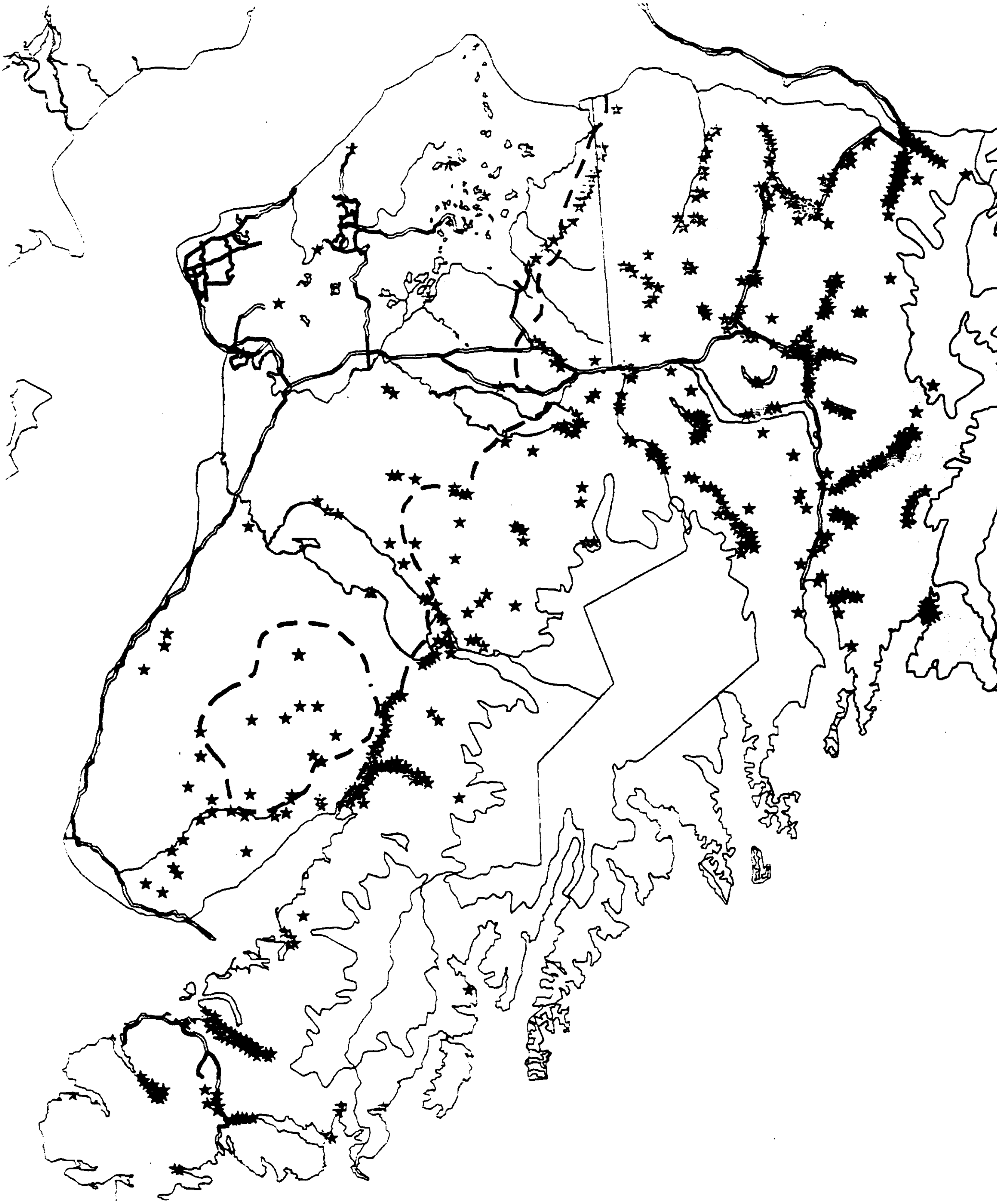


Figure 1. Location of wolverine harvests on the Kenai Peninsula for the years 1963-1964 through 1967-1968 and 1971-1972 through 1992-1993.

Figure 2. Comparison of Number of Trapping Permits Issued for the Kenai National Wildlife Refuge and Wolverine Harvests on the Kenai Peninsula and the Kenai National Wildlife Refuge, 1960-1995.

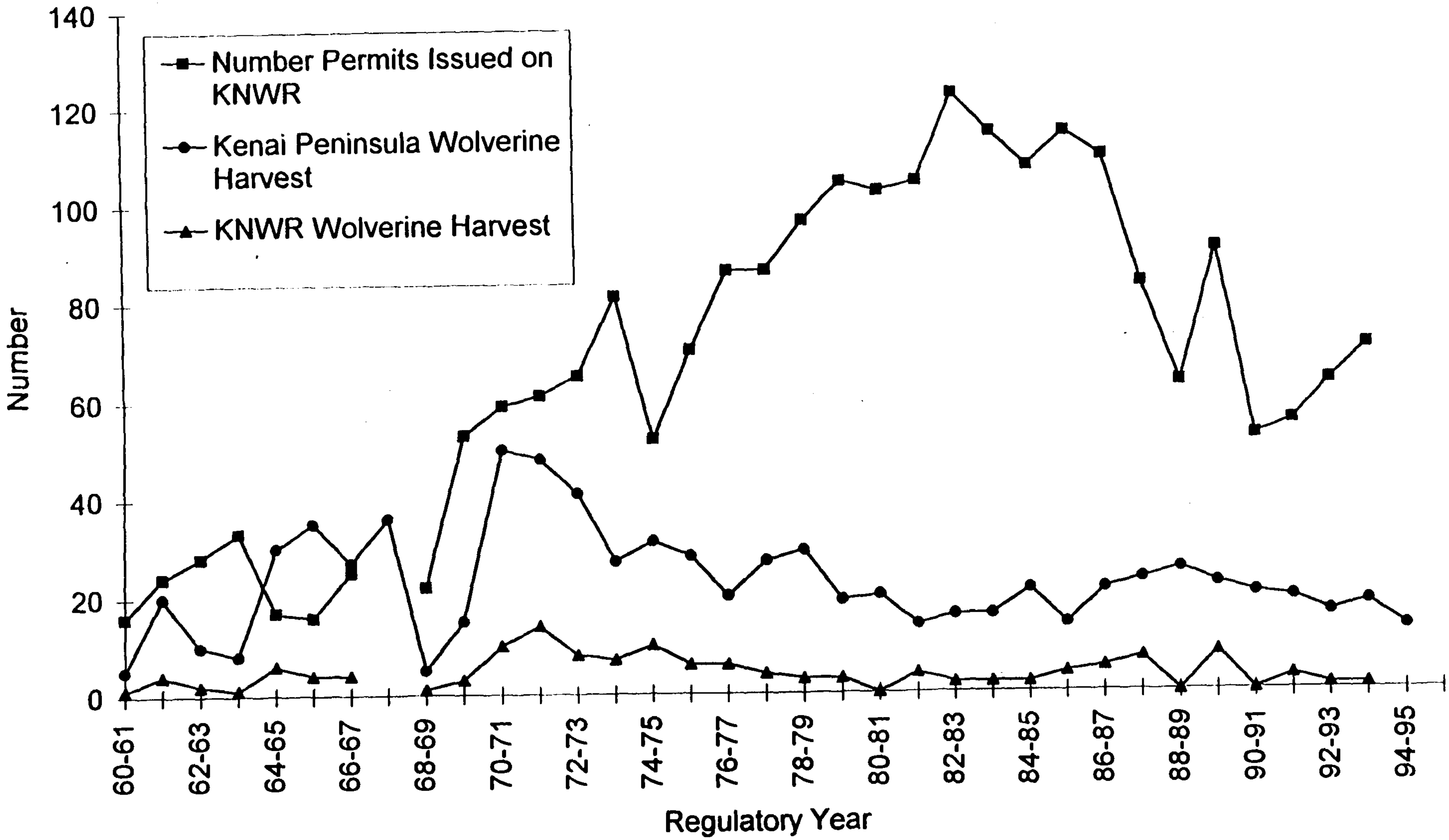


Figure 3. Comparison of the Kenai Peninsula Wolverine Harvest, Number of Trappers Harvesting Wolverines, and the Average Number of Wolverines/Successful Wolverine Trapper, 1960-1995.

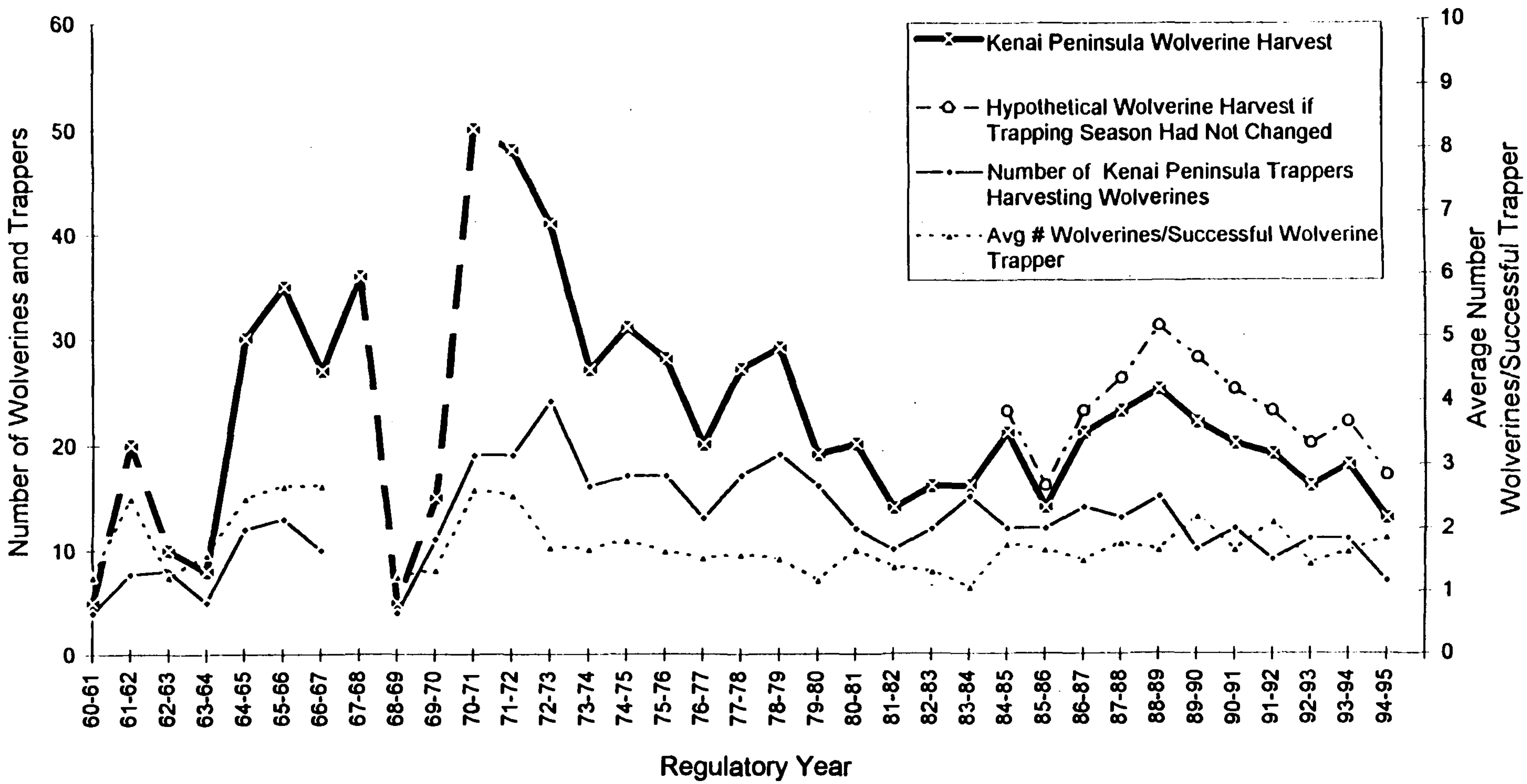
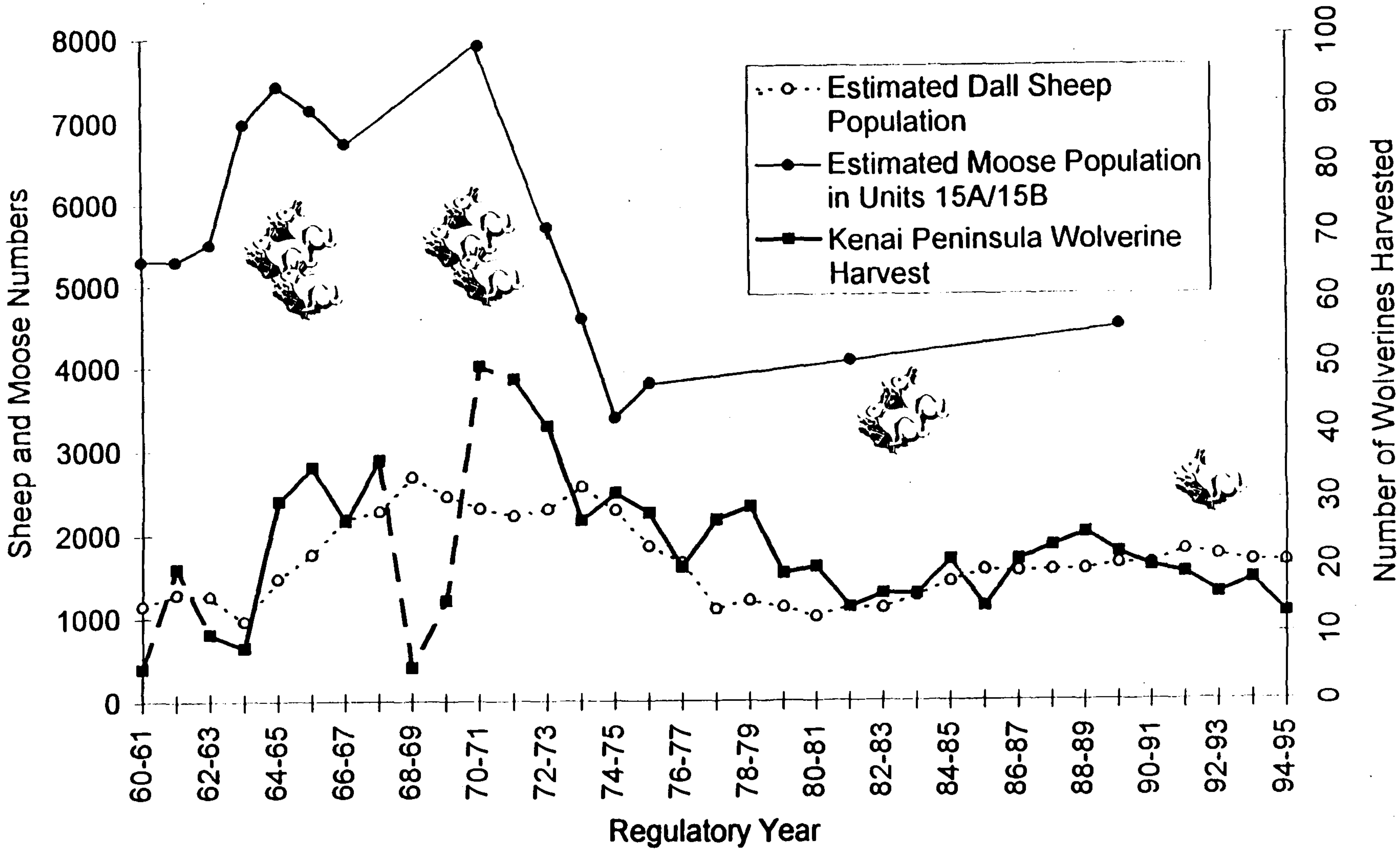
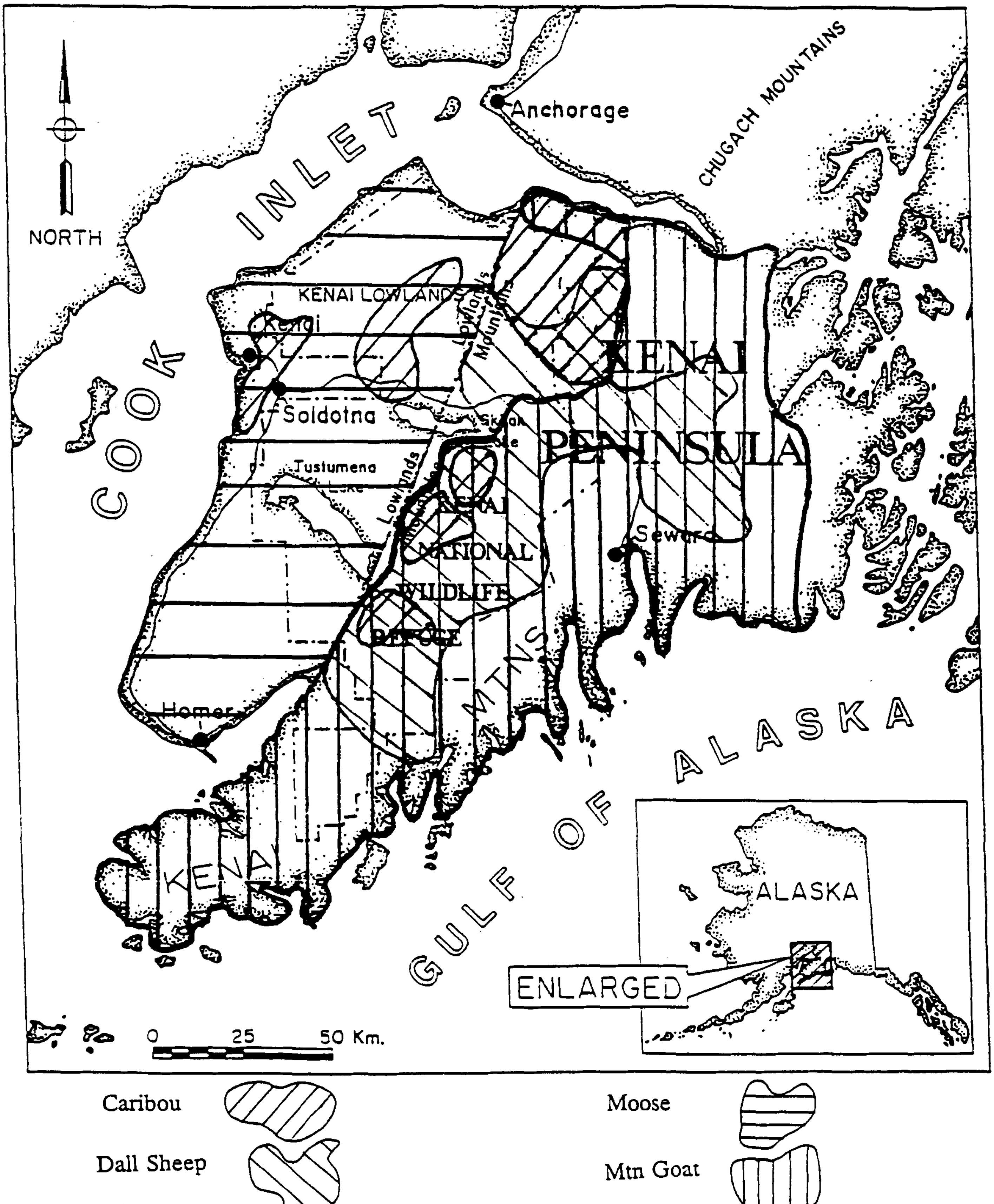


Figure 4. Comparison of the Kenai Peninsula Wolverine Harvest with Estimated Food Abundance, 1960-1995.





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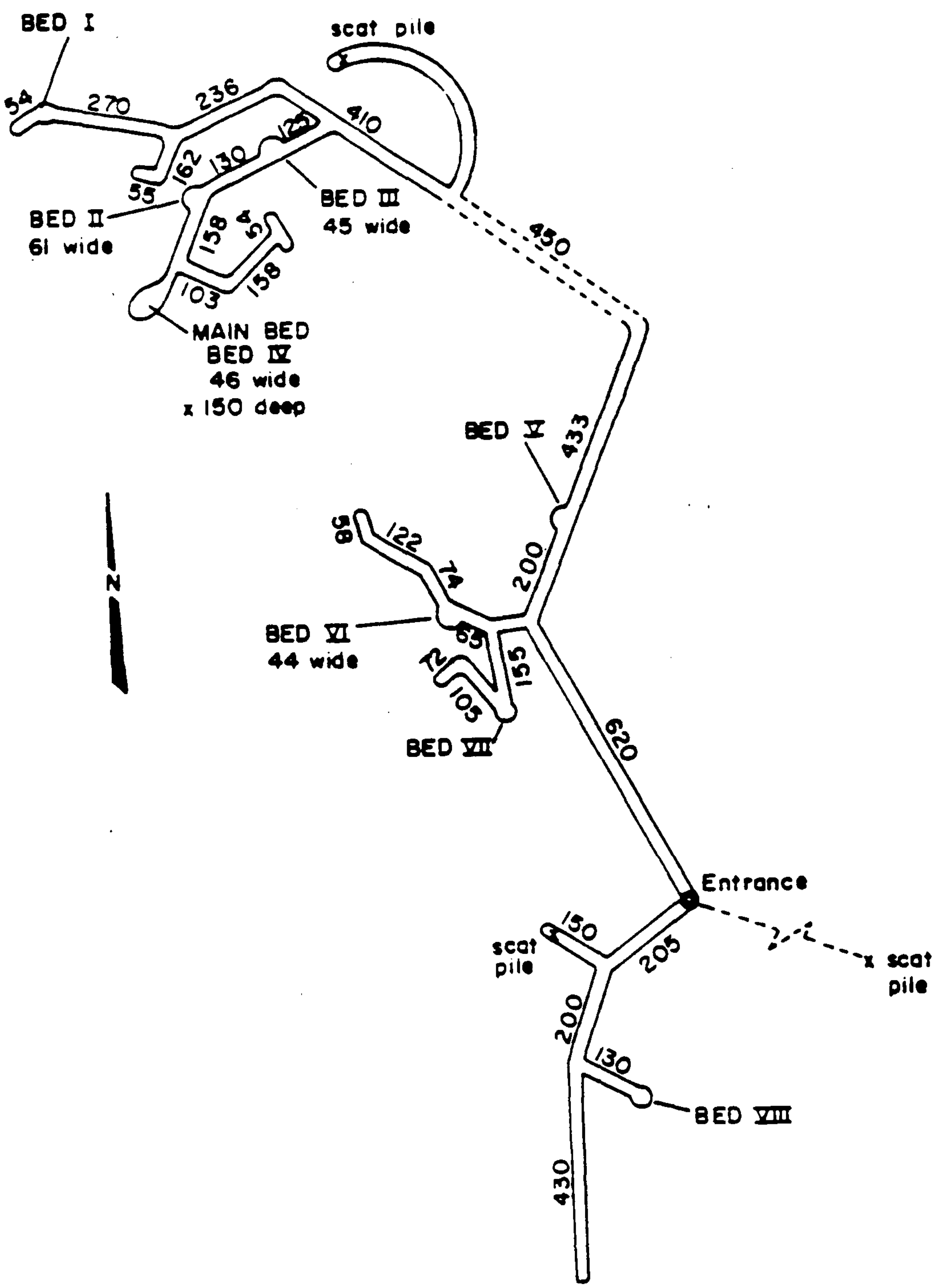
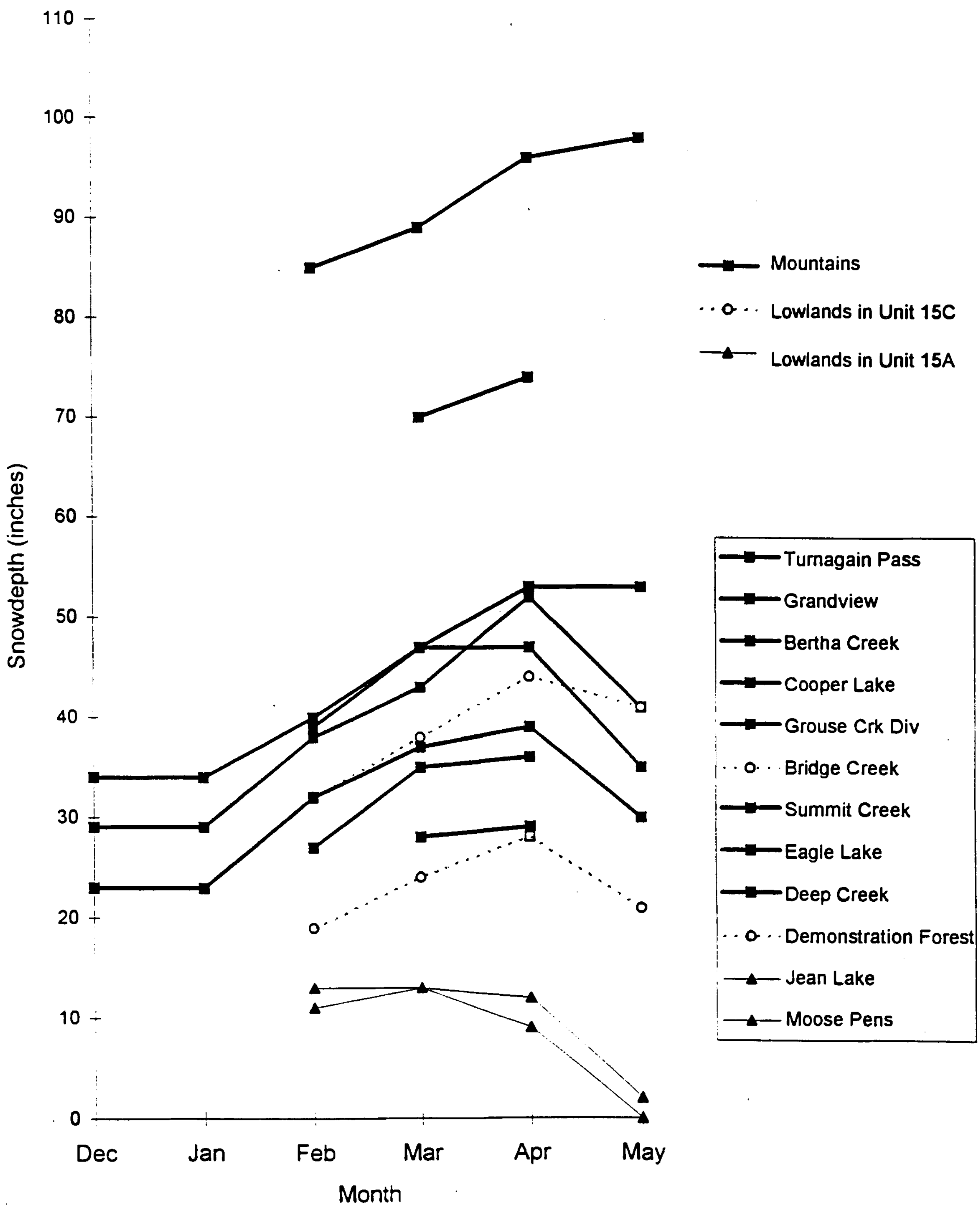


Figure 6. Drawing of an excavated wolverine natal den showing the complex snow tunnel system (Magoun 1985). Measurements are in centimeters.

Figure 7. 30-Year Average Snowpack for Sites Located on the Kenai Peninsula, 1961-1990.



APPENDIX (Continued)

Table 1. Wolverine trapper harvests on the Kenai Peninsula by unit for regulatory years 1971-1972 through 1987-1988 and relative density of the total harvest for each unit.

	Unit			
Regulatory year	15A	15B	15C	7
1971-1972	2	7	12	23
1972-1973	1	0	18	21
1973-1974	1	4	9	13
1974-1975	0	6	7	19
1975-1976	0	2	6	20
1976-1977	2	2	10	6
1977-1978	1	3	5	18
1978-1979	1	1	6	21
1979-1980	1	6	1	11
1980-1981	0	2	7	11
1981-1982	3	1	2	8
1982-1983	1	2	2	11
1983-1984	1	1	6	8
1984-1985	2	0	2	17
1985-1986	0	1	4	9
1986-1987	0	3	7	11
1987-1988	1	3	4	15
Total	17	44	108	242
Area of Unit (km^2)	3403	2904	6322	9117
Total 17-yr harvest/ 1000 km^2	5.0	15.2	17.1	26.5

APPENDIX (Continued)

Table 2. Wolverine trapper harvest on the Kenai Peninsula and Kenai National Wildlife Refuge (KNWR), regulatory years 1960-1961 through 1994-1995.

Regulatory year	Kenai Peninsula wolverine harvest	Number of Kenai Peninsula trappers harvesting wolverines	Average no. wolverines per successful Kenai Peninsula wolverine trapper	% taken by 4 most successful trappers	Number of permits issued on the KNWR	KNWR wolverine harvest
1960-1961	5[a]	4[a]	1.25[a]		16	1
1961-1962	20[a]	8[a]	2.50[a]		24	4
1962-1963	10[a]	8[a]	1.25[a]		28	2
1963-1964	8	5	1.60	0.88	33	1
1964-1965	30	12	2.50	0.57	17	6
1965-1966	35	13[a]	2.69[a]		16	4
1966-1967	27	10[a]	2.70[a]		25	4
1967-1968	36	--	--		--	--
1968-1969	5[a]	4[a]	1.25[a]		22	1
1969-1970	15[a]	11[a]	1.36[a]		53	3
1970-1971	50[a]	19[a]	2.63[a]		59	10
1971-1972	48	19	2.53	0.54	61	14
1972-1973	41	24	1.71	0.36	65	8
1973-1974	27	16	1.69	0.44	81	7
1974-1975	31	17	1.82	0.52	52	10
1975-1976	28	17	1.65	0.39	70	6
1976-1977	20	13	1.54	0.55	86	6
1977-1978	27	17	1.59	0.48	86	4
1978-1979	29	19	1.53	0.45	96	3
1979-1980	19	16	1.19	0.37	104	3
1980-1981	20	12	1.67	0.50	102	0
1981-1982	14	10	1.40	0.57	104	4
1982-1983	16	12	1.33	0.50	122	2
1983-1984	16	15	1.07	0.31	114	2
1984-1985	21	12	1.75	0.52	107	2
1985-1986	14	12	1.67	0.36	114	4
1986-1987	21	14	1.50	0.48	109	5
1987-1988	23	13	1.77	0.43	83	7
1988-1989	25	15	1.67	0.52	63	0

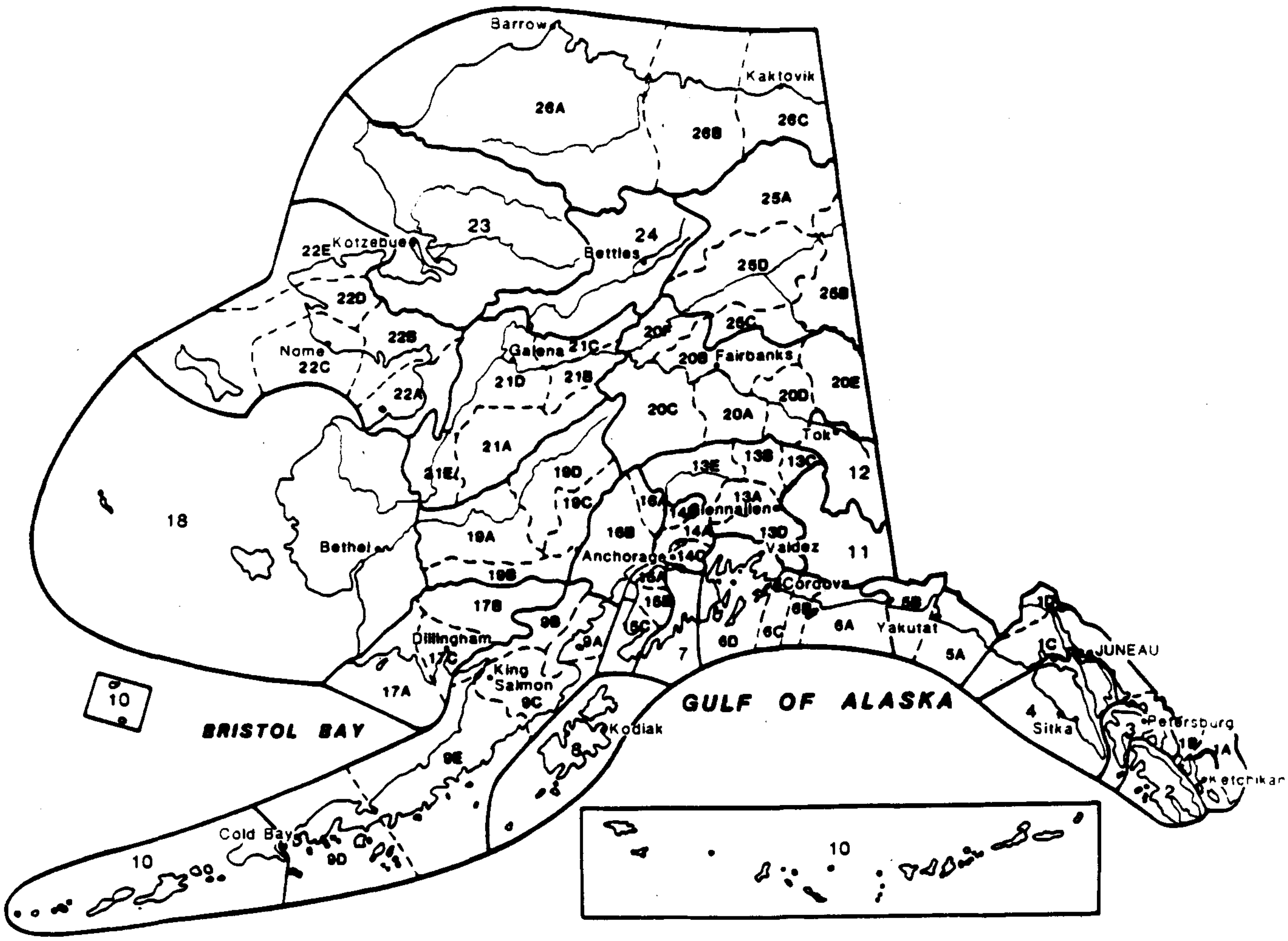
APPENDIX (Continued)

Table 2. Continued.

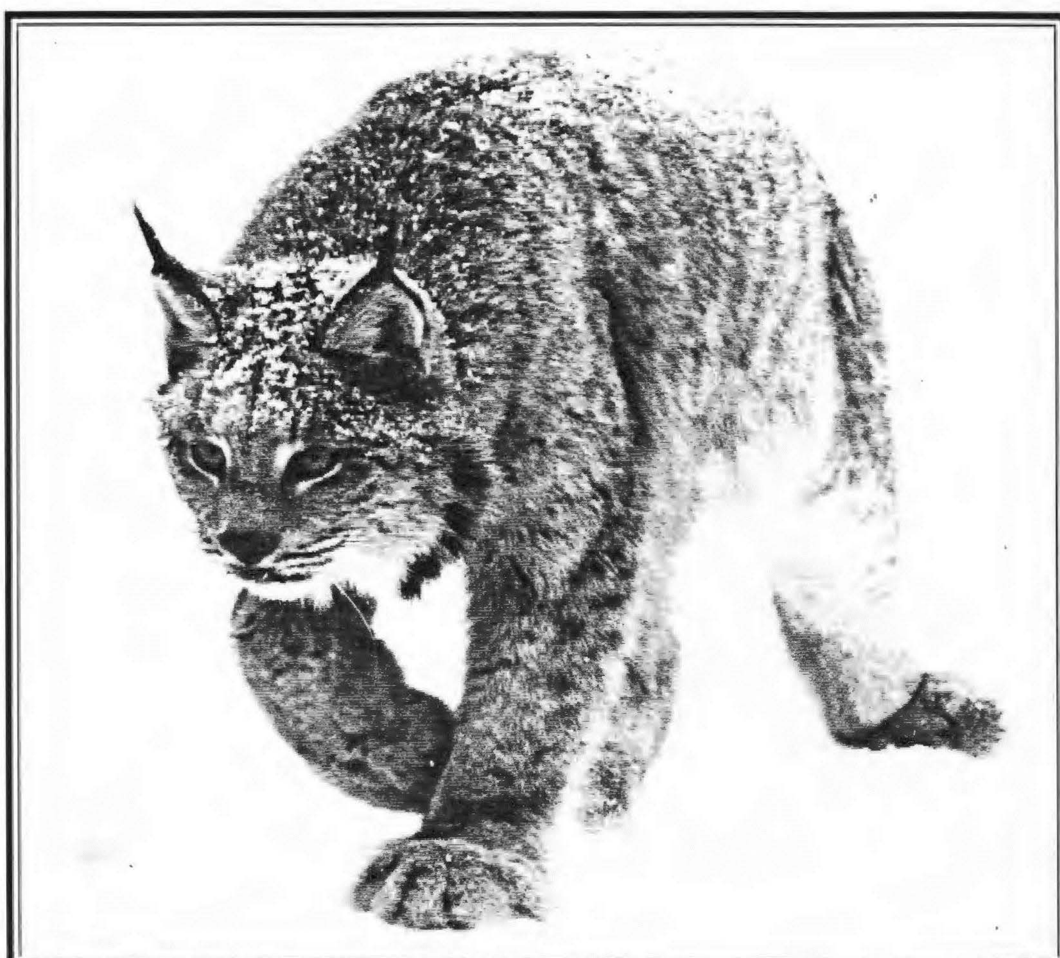
Regulatory year	Kenai Peninsula wolverine harvest	Number of Kenai Peninsula trappers harvesting wolverines	Average no. wolverines per successful Kenai Peninsula wolverine trapper	% taken by 4 most successful trappers	Number of permits issued on the KNWR	KNWR wolverine harvest
1989-1990	22	10	2.20	0.68	90	8
1990-1991	20	12	1.67	0.50	52	0
1991-1992	19	9	2.11	0.74	55	3
1992-1993	16	11	1.45	0.56	63	1
1993-1994	18	11	1.64	0.61	70	1
1994-1995	13	7	1.86	0.63		

[a] Data on the number of wolverine harvested on the Kenai Peninsula are incomplete for regulatory years 1960-1961 through 1962-1963 and 1965-1966 through 1970-1971. This figure was extrapolated using wolverine harvest data from the KNWR. The refuge harvest averages 20% of the Kenai Peninsula harvest.

Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.



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