30 June 1993

LCMR Final Status Report - Summary - Research

I. **Black Bear Research in East Central Minnesota**
Wildlife - 23

Program Manager: Dr. Elmer C. Birney
Bell Museum of Natural History
University of Minnesota
St. Paul, MN 55108
612 - 624 - 6293

A. M.L.91 Ch. 254, Art. 1, Sec. 14, Subd. 9(l)

Appropriation: $100,000
Balance: $0 (approx.)

Black Bear Research in East Central Minnesota: This appropriation is to the University of Minnesota, Bell Museum of Natural History, to develop landscape ecology concepts and better understand the problem of bear damage to crops.

B. Compatible Data: N/A
C. Match Requirement: N/A

II. Narrative

In east-central Minnesota black bears (Ursus americanus) cause serious damage to crops. Crop damage appears to have increased in recent years, but reasons for any increase are unknown. It also is not known if bears in this area are residents, migrants, transient dispersers, or some combination thereof. We are proposing a study of population size and structure, movements and habitat-use patterns, and diet of the bears in this area.

III. Objective

A. Conduct an ecological study of black bears in east-central Minnesota with emphasis on origin of these bear populations and their role in crop damage in the area.

A.1. Narrative: East-central Minnesota is one of the state's worst problem areas for bear damage to crops. There is a need to determine movements and population characteristics of the bears in the crop damage areas in order to understand the nature of the problem and to develop recommendations for coping with it. The following are important questions that will be addressed in this study. 1) What is the historical nature of the increase in bears and bear-related problems in east-central Minnesota? 2) How many bears live in this area? 3) What proportion of the bears in the area at the time of crop damage are breeding residents, unsettled young prior to breeding, or seasonal migrants that visit the area when crop resources are abundant? 4) What is the role of the extensively forested areas farther north and east (e.g., in the Nemadji State Forest and adjacent Wisconsin) as habitat sources that supply the bears in the problem area, and what is the influence of forested corridors and landscape patterns on bear movement? 5) There is a north-south gradient of increasing habitat fragmentation of forest through Pine County. How does bear density, sex ratio, and age structure vary along that gradient? 6) What is the impact of hunters on this bear population? 7) What are the characteristics of crop fields that incur bear damage and how do they compare to fields that incur little or no damage? Answers to these and other questions that will present themselves during the study will provide management agencies with solid information on which to base management decisions regarding bears of this unique area.

A.2. Procedures: Research procedures will be of three major categories. These are: 1) trapping, marking, radio-collaring, and monitoring of collared bears; 2) analysis of hunter-killed bears in the area of crop damage and farther north; and 3) collection of data on crop damage from both a questionnaire (historical) and evaluation of fields in which damage is detected; also, bears killed specifically to control crop damage will be analyzed in the same manner as trapped and hunter-killed bears. The

following numbered statements refer to the methodology that will be employed to answer the questions posed above under Objectives.

1. A questionnaire will be developed for farmers and other long-time residents of the area to learn more of the history of the increase in bear numbers, changes in farm practices such as crop use and harvest methods, and observations of bears reproducing in the area. Aerial photographs and possibly satellite imagery will be used to help identify vegetative changes that may have contributed to an increase in bear-people conflicts in the area or created travel corridors that allowed bears to move into the area from farther north. Minnesota Department of Natural Resources (MNDNR) records of bears killed in the area will also be used to corroborate data gathered through the questionnaire.

2. All bears trapped in the study area will be individually marked, although not all will be radio-tagged. The proportion of tagged bears in the hunter kill sample will provide one estimate of the total density. All bears captured on the study area in 1991 were equipped with radio transmitters. Because we did not capture large numbers of bears in late summer 1991, we were unable to mark enough animals to generate a reliable population estimate for the study area. Trapping success during 1992 was higher than in 1991, and we were able to provide bear density estimates for 1992.

3. Radio-collared bears known to be in the area during the period of crop damage in 1991 will be followed for at least one year thereafter. In 1992, radio-collared bears will be monitored through denning. Analysis of their movement patterns and location of denning and breeding ranges should provide the information necessary to answer this question. However, because there are restrictions on capturing bears during the period when most crop damage occurs (late August and September), we will not be able to radio mark bears located in crop fields that moved into the area in response to ripening crops (seasonal migrants or immigrants). Age and sex ratios of radio-collared bears that use crop fields extensively will be compared to age and sex ratios of bears killed as part of damage abatement practices. Dissimilar age and sex composition might indicate an ingress of bears from outside of the study area or differing propensities to nuisance activity among sex/age groups.

4. Data collected in (3) will be used to determine summer breeding ranges and reproductive success of seasonal migrants originally trapped in Pine County. If funds permit, cubs of any such females will be radio-collared in the den as yearlings to determine if they move back to the crop damage area where their mother had taken them. Corridor use will be determined by frequent monitoring of migratory bears during periods of seasonal travel. Based on 1991 data, bears captured in the study area appear to remain there as year-round residents. Thus, there may be few transient bears in the area from which we can obtain data.

5. Composition of the hunter-kill sample at check stations in the study area and northward into less fragmented bear habitat will be determined and related to patterns of habitat fragmentation.

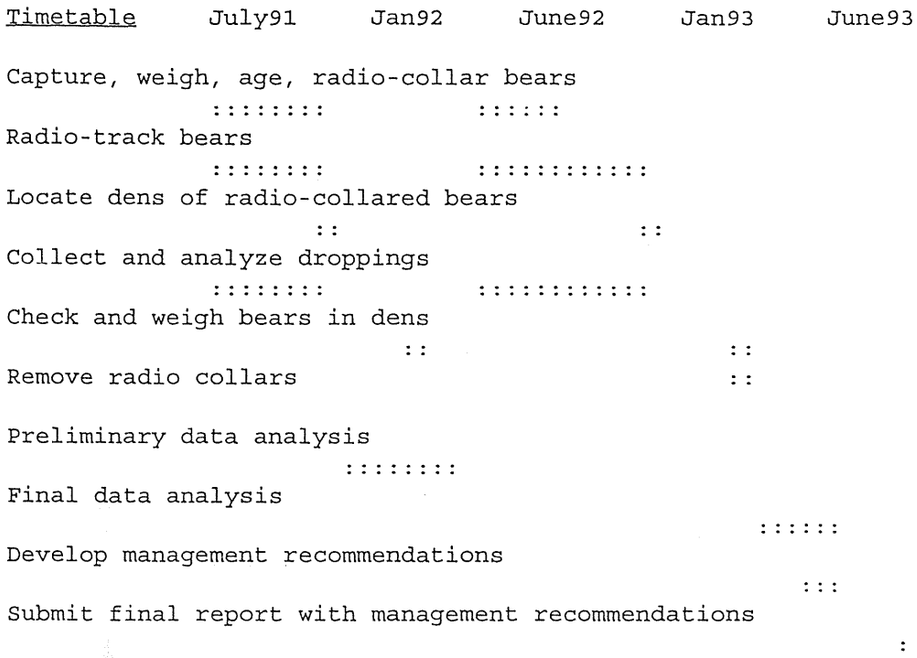
6. Hunter-induced mortality will be considered relative to: a) other types and amounts of mortality; b) estimated density; and c) sex and age composition of hunter-killed bears relative to that of the subsample of bears trapped. This analysis will be limited to radio-collared bears that are resident in the study area during hunting season.

7. All fields in the area known to incur damage will be evaluated as little, moderate, or high damage fields. These then will be evaluated by a number of criteria now being developed to determine such characteristics as crop type, crop variety, planting date, harvest type (ensilage vs. grain), proximity to woods, proximity to water, etc. A sample of undamaged fields in the area, if any, also will be evaluated by the same criteria in an effort to determine if crop damage can be predicted.

A.3. Budget

a. Amount Budgeted: $100,000
b. Balance: $0 (approx.)

A.4. Timetable



A.5. Status:

A.5.1. Study area: Investigations focused on a 360 km² study area in eastern Pine County, Minnesota. This area was chosen because it is a mosaic of agricultural lands and forests. Historically it has been an area of serious crop depredation by bears. Included in the study area are parts of St. Croix State Park (SCSP) and St. Croix State Forest.

A.5.2. Trapping: In 1991, trapping was carried out from 15 July to 24 August and trapping success averaged 1 bear per 55 trap-nights. Twelve bears were captured and fitted with radio collars: 6 males (2 subadults and 4 adults) and 6 females (4 subadults and 2 adults).

In March 1992, 1 female with cubs was captured and radio-collared at her den site. Trapping was conducted from 16 May to 24 August 1992. Overall, trapping success was 1 bear per 26 trap-nights and 30 previously uncaptured bears were trapped. During the final week of trapping, when bears began feeding on corn, we focused our efforts on capturing crop-depredating bears; 7 bears were trapped in corn fields.

A.5.3. Telemetry: During 1991, radio-collared bears were located weekly from capture until denning. For the most part, bears were found in large blocks of unbroken forest (especially SCSP) feeding on abundant natural foods. One bear, an adult male initially captured in SCSP, was found feeding in a corn field approximately 6 km from the park in late October.

In 1992, 28 radio-collared bears (11 females, 17 males) were located a total of 416 times. Bears that remained in the study area were located at least biweekly from den emergence in the spring until 15 July, weekly from 16 July to 24 August (when crops were ripe), twice weekly from 25 August to 30 September (during the hunting season), and weekly from 1 October until denning. Bears that moved from the study area were located at least biweekly.

Radio telemetry was used to differentiate migrant from resident bears. A migrant was defined as a female or an adult male bear that was present in the study area during late summer-early fall (August and September) but had its breeding and/or denning range outside of the study area. A resident was defined as a female or adult male bear that both bred and denned in the study area. (Because subadult males are unlikely to have stable breeding/denning ranges, they are not included in this analysis.) By this definition, all 6 female bears and 4 adult male bears captured and radio-collared in late summer 1991 were residents because they denned in the study area the following winter and were located there during the spring-early summer breeding season in 1992. Similarly, 6 female and 4 adult males captured and radio-collared from 15 March to 14 July 1992 also were classified as residents because they were present in the study area during the breeding season (all 7 that survived the hunting season also denned in the study area during the winter of 1992-1993). In late summer 1992, 1 adult female that was captured in August remained within 5 km of her point of capture through denning. One adult male that was captured in August 1992 left the study area in mid-September and denned 65 km to the east, and was thus the only migrant bear captured during the study. We were unable to determine the status of 2 other adult males captured during

late summer 1992 because they were killed by hunters in early September. Unfortunately, restrictions on trapping bears during the hunting season did not allow us to capture and drug bears after 24 August during either year of the study. Thus, we can not falsify the hypothesis that some seasonal migrants moved into the study area in late August or September.

We were unable to identify movement corridors for 2 reasons. First, long distance movements were rare, so it was difficult to predict when any given bear might make a long distance movement. Second, most movements occurred in forested areas where corridor use was neither expected nor observed.

Telemetry indicated that many radio-collared bears fed on corn. In 1992, 16 of 28 radio-collared bears were located in or within 0.5 km of corn fields at some time during late summer or early fall. Of these 16, 7 were adult males, 2 were subadult males, 6 were adult females, and 1 was a subadult female. The age and sex composition of this sample did not differ from the cohort actually trapped in corn fields nor from the cohort trapped throughout the study. The legal harvest differed from the cohort located in corn fields in that it contained more subadult males.

Many bears used SCSP during the spring and early summer but left during late summer to feed on corn or at hunters' bait stations. During July 1992, as many as 17 radio-collared bears were located in SCSP at one time, but only 4 were located there during the last week of August. The remaining 13 park bears were either making excursions described above or were in the agricultural area just north of the park (within 2 km of their spring-early summer ranges). By late October, 14 radio-collared bears were denned in SCSP.

A.5.4 Den visits: Eight radio-collared bears were visited in their dens during February and March 1992. Six bears (3 males, 3 females) used excavated dens, 1 male denned under a root mass, and 1 female denned in an open nest. One adult male, which used heavily fragmented habitats, constructed its den in a 0.5 km^2 clearing within sight of an occupied house. One of 2 adult females had 3 cubs when visited in March.

We visited 19 dens during January-March 1993 and removed radio-collars from all but 3 males that will be monitored by the MNDNR and a female that fled when approached (the radio-collar on this bear is equipped with a breakaway insert and is expected to fall off by Fall 1993). Fourteen bears (8 males, 6 females) constructed excavated dens, 4 (2 males, 2 females) used open nests, and 1 male denned under a root mass. Of 5 radio-collared adult females that did not have cubs in 1992, 4 had cubs in 1993 (mean litter size = 2.75). All of the 6 cubs born to radio-collared females in the winter of 1991-1992 survived to den with their mothers as yearlings in 1992-1993.

A.5.5. Hunting: Harvest statistics provided by the MNDNR indicated that hunters killed 165 bears (106 males, 59 females) in the no-quota area in east-central Minnesota in 1991, down 46% from 1990. Four of 12 radio-collared bears were killed. Three hundred fifty-one bears (197 males, 154 females) were harvested by hunters in the no-quota area in east-central Minnesota in 1992, exceeding the previous record of 265 set in 1990.

Eight (22%) of 37 marked bears (including bears that dispersed from the study area) were known to have been killed in the 1992 harvest. A total of twenty-three bears was known to have been killed in the study area, 6 of which (26%) were marked. The age composition of harvested bears does not support the hypothesis that significant immigration of subadult bears into the study area occurred.

Harvest data for the period from 1988-1992 provided by the MNDNR were analyzed as an independent measure of whether subadult males were immigrating into the area in large numbers. Sex and age ratios of bears killed in east-central Minnesota were compared to sex and age ratios in the primary bear range, where the number of hunters is limited by lottery, and to the no-quota zone in northwest Minnesota, into which immigration of male bears is reported to be common by the MNDNR. Immigration is apparent in the age-sex structure of the harvest in northwestern Minnesota. The harvest structure in east-central Minnesota resembles that of the primary bear range, except that yearling males (not 2-year-olds) are relatively more frequent. This may be a result of intense harvest pressure on the population, and does not indicate immigration, because yearling males are less mobile than 2-year-olds.

In order to examine the effect of forest fragmentation on a local scale, we compared 1992 harvest data from the fragmented portion of the study area (< 50% forested) to harvest data from the predominantly forested area to the north. Subadult females were absent from the harvest in the fragmented portion of the study area but present in the unfragmented area to the north. This may be due to the proximity of refugia such as SCSP, which may differentially protect the relatively sedentary subadult females. The forested area to the north is composed of large blocks of public lands that are heavily hunted; thus, there are no refugia, and subadult females are exposed to more uniform hunting pressure.

We examined the effect of forest fragmentation on a large scale by comparing the legal harvest in 1988-1992 from 3 broad zones in east-central Minnesota. In the fragmented southern zone (the southernmost portion of Pine County and the northern halves of Chisago and Isanti Counties) the harvest was male-biased in all age classes, suggesting continued immigration of male bears. The moderately fragmented central zone (central Pine County) and the heavily forested northern zone (northern Pine County) did not exhibit a male bias in all age classes.

In addition to estimating bear density from the sample of hunter-killed animals, we used cameras with motion-sensitive triggers to photograph bears in SCSP and thereby estimate the proportion of marked bears in this unhunted area during the hunting season. Twenty-one bears were photographed, of which 5 (24%) were marked. Density in the park was estimated at 32 bears/100 km^2. Only 1 of 7 of the photographed bears were adult males based on size and body proportions indicating again that adult males are much more common in the study area than harvest results suggested.

A.5.6. Crop damage: The extent of crop damage caused by bears in the study area in 1991 and 1992 was determined by assessments of agricultural fields from the ground and by conducting aerial surveys. Crop damage assessments were conducted daily from 4 August through 11 September 1991, and once each week between 11 September and 24 October 1991. In addition, 1 aerial survey of corn fields in the area was conducted on 6 September 1991. Transects were flown at 0.8 km intervals 155 - 312 m above ground level. In 1992, crop damage assessments were conducted daily from 7 July through 21 September, and twice weekly between 21 September and 1 November. Aerial searches for crop damage were conducted 4 times between 21 August and 9 September 1992. Transects were flown at 0.8 km intervals, 92 - 312 m above ground level over the entire study area.

In 1991, a total of 39 corn fields on 21 farms was surveyed for crop damage. Of these 39 fields, 10 fields on 5 farms sustained crop damage by bears. The area of most extensive damage measured approximately 360 m^2, which was 0.91% of the 4-ha field. One additional report of known crop damage was filed by a farmer in Pine County, Minnesota, during 1991.

All fields containing damage in 1991 were bordered by forested areas on at least 2 sides, were within 0.4 km of free water, and 37 of 39 were not bordered by any type of maintained roadway. Of those corn fields sampled in 1991 and not damaged by bears, 11 (38%) of 29 were bordered by forest on at least 1 side, closer than 0.4 km to free water, and farther than 0.4 km from any maintained road.

We received no reports of bears shot as nuisance animals during the summer 1991 field season and only 1 complaint of nuisance activity. Subsequent review of MNDNR nuisance reports, however, indicated 7 complaints and 6 nuisance kills. Our data were limited on these incidents due to a lapse in communication regarding nuisance complaints and kills between agency personnel and our study.

In 1992, bear damage was observed in 9 (43%) of 21 oat fields surveyed. Of the 9 oat fields damaged by bears, 8 (89%) were bordered by forested areas, within 0.4 km of free water, and farther than 0.4 km from any type of maintained road. Of the 12 oat fields sampled in 1992 and not damaged by bears (57% of the total number of oat fields sampled), 10 (83%) were bordered by forest, 8 (66%) were bordered by forest and within 0.4 km of free water, and 5 (41%) were bordered by forested areas, within 0.4 km of free water, and farther than 0.4 km from any maintained roadway.

In 1992, we surveyed 61 corn fields on 40 farms. Thirty fields on 21 farms were damaged by bears. Twenty-four (80%) of the 30 damaged fields were bordered by forested areas, 21 (70%) were bordered by forested areas and within 0.4 km of free water, and 13 (43%) were bordered by forested areas,

within 0.4 km of free water, and more than 0.4 km from the nearest maintained road. The largest observed area of crop damage in corn in 1992 measured approximately 3,200 m^2, 2.9% of the field. The largest area of damage relative to the size of the field was 4.2%.

Of the 21 farms where crop damage was located in 1992, 8 landowners reported filing nuisance bear reports to the MNDNR. Official nuisance bear reports filed with the MNDNR for 1992 consisted of 5 nuisance complaints and 3 bears killed as nuisance animals. No bears were known to have been killed as nuisance animals during the summer of 1992 on the study area based on contact with the local MNDNR conservation officer.

On 13 April 1992, a questionnaire was mailed to farmers and landowners in the study area. The questionnaire solicited opinions concerning crop damage history, bear ecology, bear management, bear harvest history, farming practices, and general information regarding landowners. Four hundred eighty-six questionnaires were mailed out, 436 appeared to have been received by residents or landowners, and 281 were returned (65%). Postcard reminders were mailed on 23 April 1992, and second questionnaires were mailed to non-respondents on 8 May 1992.

Ninety-three (33%) of 281 respondents to the survey reported experiencing crop damage by bears and 64 (69%) of these 93 reported an increase in crop damage between 1972 and 1990 (mean year of increase = 1985). Fifty-seven (68%) of 83 respondents who reported crop damage by wildlife indicated that white-tailed deer (Odocoileus virginianus) caused the most crop damage. Bears were reported as causing the most crop damage by 23 (27%) of the respondents. Of the 83 respondents who had sustained crop damage by bears, 52 (63%) preferred the legal harvest of bears causing crop damage to the alternatives offered: unrestricted harvest or financial compensation. Of those respondents who had not experienced crop damage by bears, 65 (60%) of 109 preferred the legal harvest of bears causing crop damage to the same alternatives offered. The number of acres reported lost to bears per year ranged from 0.5 to 45 (mean = 7.5/year) for field corn, 0.1 to 30 acres (mean = 1.2/year) of sweet corn and 0.2 to 20 acres (mean = 4.3/year) of oats. Landowners experiencing crop damage reported monetary losses per year of $50 to 4,500 (mean = $729 /year) in field corn, $25 to 300 (mean = $182/year) in sweet corn and $30 to 1,000 (mean= $240/year) in oats. Only 3% of those respondents who had sustained crop damage by bears had ever used any type of energized fencing or other form of deterrent in an attempt to avert crop damage by bears.

Nuisance bear reports maintained by the MNDNR indicated a high level of crop damage in 1981 and again in the mid-1980's with fewer damage reports since 1987. As indexed by nuisance reports, 1981 was the year of highest incidence of nuisance activity with 60 complaints and 27 bears killed as nuisance animals between June and September. However, more bears were killed in 1986 than in any other single year (30 bears killed as nuisance animals between April and October).

A.6. Benefits: Important information will be obtained on which to base solid management decisions in east-central Minnesota where bear-related problems appear to be on the increase. Ways to mitigate the amount of crop damage may be found. New information on bear biology will be obtained in this previously unstudied area, which is ecologically very different from study areas near Grand Rapids and Ely. The north-south gradient of increasing fragmentation of the forest in Pine County will provide a basis for testing hypotheses concerning landscape ecology. As forest fragmentation increases throughout the world, including the United States, tropical areas, and areas intensively harvested for timber and firewood, managers must learn how to create and manage landscapes that allow for maximum human use of resources while preserving habitat for wide-ranging animals such as bears.

IV. Evaluation:

For the FY92-93 biennium the project can be evaluated by the success of the investigators to recruit graduate student field assistants, the number of bears captured and radio-collared, the number of other bears captured and marked, success of radio-tracking collared bears and of locating their dens, and the number of droppings recovered and analyzed. Finally, success of the project will depend on the usefulness of management recommendations developed for black bears in mixed habitats that include some farming and on the robustness of hypotheses developed in landscape ecology and management.

telemetry. His experience also includes writing, refereeing, and editing publications in wildlife ecology and management and working with government agencies concerning mitigation of negative human impacts. Dr. Andersen's primary role in this project will be in study design and to advise or co-advise one of the students on the project.

3. Cooperators:

A. Dr. Thomas R. Crow
Forestry Sciences Laboratory
P.O. Box 898
Rhinelander, WI 54501

M.S. Forest Biology, University of Michigan, 1966
Ph.D. Ecology, University of Minnesota, 1970

Dr. Crow is a research ecologist and project leader with the USDA Forest Service, North Central Forest Experiment Station. His primary research interests are in landscape ecology. He is project leader of the research unit "Principles of Landscape Ecology for Managing Temperate Forest." The mission of this unit is to develop the knowledge and technology for a landscape perspective in maintaining biological diversity. Studies of land use change since settlement and responses of resident and neotropical migratory birds to forest fragmentation are currently being conducted in the St. Croix River Valley. Crow will be responsible for (1) relating the movement of black bears in east-central Minnesota to broad landscape patterns and (2) studying the relation of a major landscape feature (the St. Croix River corridor) to the movement of a large-bodied, wide ranging species (the black bear).

B. Dr. David Garshelis
Bear Project Leader, Minnesota DNR
1201 E. Hwy 2, Grand Rapids, MN 55744

M.S. Zoology, University of Tennessee, 1978
Ph.D. Ecology, University of Minnesota, 1983

Dr. Garshelis has conducted field studies on black bears for 10 years, involving the capture and handling of over 700 animals. His primary expertise is in population monitoring. He also has done extensive work in analysis of telemetry data (mortality, movements, habitat use information). He presently serves on the Minnesota Bear Management Committee, which has attempted to deal with the bear problems addressed in this proposal. He also was elected to the Council for the International Association for Bear Research and Management and the Board of Directors for the North American Bear Society. Since 1986 he has Been an adjunct professor of Wildlife Conservation at the University of Minnesota where he has served or is serving on the graduate committees of four students involved in bear research.

C. Dr. Peter A. Jordan
Associate Professor
Department of Fisheries and Wildlife
142 Hodson Hall
University of Minnesota

B.A. Wildlife Conservation, University of California, 1955
Ph.D. Zoology, University of California, Berkeley, 1967

Dr. Jordan has conducted research and has consulted on the problem of nuisance deer in the Metro area. He has been involved, personally and through students, with carnivore research on the timber wolf, the red wolf, and, in Nepal, the Bengal tiger. His work in wildlife encompasses some 30 years of studying the ecology and physiology of large, free-living mammals. He is on the faculty of Fisheries and Wildlife at the University of Minnesota where he teaches and advises graduate and undergraduate students preparing for careers in the management of wildlife resources. Dr. Jordan's primary role in this project will be to assist students in conducting and writing up field studies.

D. Dr. Lynn L. Rogers
Wildlife Research Biologist, USDA Forest Service
North Central Forest Experiment Station, Ely, MN 55731

M.S. Wildlife Ecology, University of Minnesota, 1970
Ph.D. Ecology, University of Minnesota, 1977

V. Context:

A. East-central Minnesota is one of the state's worst problem areas for bear damage to crops. Neither this bear population nor any other in similarly fragmented habitat has been studied. There is a need to determine movements and population characteristics of the bears in the crop damage areas in order to understand the nature of the problem and to develop recommendations for coping with it.

B. Studies by Rogers in northeastern Minnesota and Garshelis in north-central Minnesota were done in non-farming, ecologically very different areas and thus shed little light on the present problem. These studies do, however, provide us with a wealth of background information on all aspects of the natural history of black bears in this part of their range. They also have been highly successful in the development and perfection of research techniques for additional field studies of this species. Both Garshelis and Rogers will participate in the present study (see VI below). In addition, because of the fragmented nature of the habitat in east-central Minnesota, this study has the potential to contribute to the development of insight into the use of landscape theory in management policy for large, wide-ranging mammals in areas where resources are regularly harvested by humans.

C. Bear research in Minnesota to date has not been funded by LCMR. Because 2 years may be inadequate to answer all of the questions posed in the original application, it is likely that funds for 2 additional years to study the bear population in this unique area will be requested.

D. N/A

E. Biennial Budget System Program Title and Budget: Not available.

VI. Qualifications

1. Program Manager:
Dr. Elmer C. Birney
Professor of Ecology and Curator of Mammals
Department of Ecology, Evolution, and Behavior
Bell Museum of Natural History
University of Minnesota

M.S. Biology, Fort Hays State University (Kansas), 1963
Ph.D. Zoology, The University of Kansas, 1970

Dr. Birney has advised a number of both Masters and Ph.D. students in studies of mammalian behavior and ecology at the University of Minnesota during the past 20 years. Included among them is Dr. Lynn Rogers, who along with Dr. David Garshelis, is one of Minnesota's leading authorities on bear biology. Most recent field studies have been in the areas of bat conservation and the status of grassland small mammal communities. Other related professional activities include six years as an editor for *The Journal of Mammalogy* and more recently two years as President of the American Society of Mammalogists. Dr. Birney will serve as overall program coordinator and probably will serve as the academic advisor or co-advisor of one of the students on the project.

2. Co-Principal Investigator:

Dr. David E. Andersen
Assistant Unit Leader - Wildlife
Minnesota Cooperative Fish and Wildlife Research Unit
Assistant Professor, Department of Fisheries and Wildlife
University of Minnesota

M.S. Wildlife Ecology, University of Wisconsin, Madison, 1984
Ph.D. Wildlife Ecology/Zoology, Univ. Wisconsin, Madison, 1988

Dr. Andersen has conducted research on the impacts of human activity on wildlife, including raptorial birds, songbirds, large ungulates, and large carnivores and has extensive experience with radio

Dr. Rogers has conducted research on black bears in the Great Lakes Region for 24 years, beginning with studies of nuisance bear problems in Michigan in 1967. Research in Minnesota has included studies of black bear population dynamics, social organization, habitat use, and mitigation of problems between bears and people. Rogers is author of over 80 scientific papers on black bears. He will play a major role in designing the proposed study.

VII. Reporting Requirements

Semiannual status reports will be submitted not later than 1 January 1992, 1 July 1992, 1 January 1993, and a final report by 30 June 1993.

ABSTRACT

Black bears (Ursus americanus) have been reported to cause serious damage to crops in east-central Minnesota. Extent and severity of crop damage was reported to have increased sometime in the mid-1980's, but no quantitative data were available to document the purported change. Reasons for any increase were not known. It also was not known if bears in this area are residents, migrants, transient dispersers, or some combination thereof. This study was undertaken to determine population size and structure, movements and habitat-use patterns, diet of the bears in this area, the historical nature of crop damage, and landowner attitudes regarding bears and associated crop damage. The following seven questions were posed in the original work plan.

1) What is the historical nature of the increase in bears and bear-related problems in east-central Minnesota? The historical nature of the increase in bears and bear-related crop damage was determined by responses to a landowner opinion questionnaire. Ninety-three (33%) of 281 respondents reported experiencing crop damage by bears. Of those, 64 (69%) reported an increase in crop damage between 1972 and 1990 and most landowners reported greater economic losses to bears in field corn than in either sweet corn or oats.

Bear nuisance reports to the MNDNR from 1980 to 1990 were also examined to determine the trends in the numbers of nuisance complaints filed each year. These reports indicate that 1981 was the worst year for nuisance bear complaints, followed by a peak of nuisance reports in the mid-1980's. Bears reportedly causing crop damage were killed more often than bears causing other nuisance problems.

2) How many bears live in this area? Two estimates of black bear density on the study area were obtained using the Petersen mark-recapture formula. Bears were marked during July-August of 1991 and May-August of 1992. The proportion of marked bears shot by hunters in September of 1992 yielded a density estimate of approximately 36 bears /100 km^2. A second estimate of 32 bears /100 km^2 was obtained by remote photography of bears at bait stations in St. Croix State Park during September of 1992 to determine if they were marked or unmarked.

3) What proportion of the bears in the area at the time of crop damage are breeding residents, unsettled young prior to breeding, or seasonal migrants that visit the area when crop resources are abundant? Twenty-three of 29 bears monitored by radio-telemetry during 1991 and 1992 were resident females or adult males. These data indicate that a substantial proportion of bears in the study area are residents. Reproduction on the study area appeared to have been sufficient to replace the bears killed in the legal harvest.

The number of subadult male bears was difficult to assess due to their great mobility. However, only 2 of 9 bears trapped or harvested from corn fields in August and September of 1992 were subadult males. Furthermore, the composition of the legal harvest for the last 5 years did not indicate higher immigration of male bears relative to populations in non-agricultural areas.

Restrictions on trapping bears during the hunting season did not allow us to capture and drug bears after 24 August during either year of the study. Thus, we can not falsify the hypothesis that some seasonal migrants moved into the study area in late August or September. However, given the numbers of resident bears observed, it is unlikely that seasonal migrants play a major role in crop damage.

4) **What is the role of the extensively forested areas farther north and east (e.g., in the Nemadji State Forest and adjacent Wisconsin) as habitat sources that supply the bears in the problem area, and what is the influence of forested corridors and landscape patterns on bear movement?** Adjacent extensively forested areas did not appear to be a major source for bear recruitment into east-central Minnesota during our study. This conclusion is based on our observations that (1) few bears made long distance movements and (2) the study area is not a population sink. However, forests in the study area are contiguous to forests to the north, east, and southeast. Thus, no physical barriers would exist to prevent movement of bears into or out of the study area if food availability or bear population density changes at some future date.

5) **There is a north-south gradient of increasing habitat fragmentation of forest through Pine County. How does bear density, sex ratio, and age structure vary along that gradient?** This question was addressed on two scales. First, we compared the composition of the harvest in three broad zones in Pine County. In the heavily fragmented southern zone, the harvest was male-biased in all age classes, suggesting some immigration of male bears. The number of bears harvested was also low (< 2 bears/ 100 km^2). This male bias was not observed in the moderately fragmented central zone where the number of bears harvested was high (> 8 bears/ 100 km^2). A similar pattern was observed in the more heavily forested northern zone.

Second, we compared the composition of the harvest in a fragmented (< 50% forested) portion of the study area to a heavily forested area just to the north. The composition of the harvest differed between the 2 areas in that subadult females, the least mobile sex/age group, were present in the kill sample from the forested area but not from the fragmented area. This suggests that within the fragmented area subadult females remained protected in refugia such as St. Croix State Park.

6) **What is the impact of hunters on this bear population?** Annual mortality from hunting in the study area, which is managed as a no-quota zone, was 25% in 1992. This figure is not appreciably higher than the annual hunting mortality observed by the MNDNR in a study area near Grand Rapids, Minnesota, where the number of hunters is limited by lottery. Thus, it does not appear that hunter induced mortality has a greater impact on population levels in the study area compared to areas not experiencing crop damage.

7) **What are the characteristics of crop fields that incur bear damage and how do they compare to fields that incur little or no damage?** We postulated that whether an agricultural field experienced depredation by bears might be related to the proximity of the field to forested areas, free water, or maintained roads. There appears to be no significant difference between crop fields sustaining bear damage and those that did not in relationship to the proximity of forested areas or free water. In contrast, crop fields near maintained roads tended to be damaged less frequently than fields removed from roads. However, predicting potential crop damage based on these characteristics does not appear to be a viable means of targeting fields for preventing depredation.

MANAGEMENT IMPLICATIONS

1) Bear densities remain relatively high after 5 years of no-quota hunting in east-central Minnesota . If it becomes desirable to reduce density further, changes in the timing, duration, and method of hunting should be considered.
2) Given the large numbers of resident bears involved in crop damage and the dispersed nature of the crop resource, techniques aimed at individual problems bears (i.e., aversive conditioning or translocation) are not feasible.
3) Alternative food sources were available to bears concurrently with ripe crops during both years of this study. During years of widespread failure of the berry and mast crops, higher levels of crop damage are predicted.
4) The physical characteristics of the landscape surrounding agricultural fields does not seem to correlate strongly with the probability of damage by bears. If bear-related crop damage increases in extent or severity, additional research on the relationship between landscape features and patterns of crop damage may be warranted.
5) Most landowners in the study area appear to expect and tolerate the levels of crop damage by black bears experienced during the study. Except in years of low natural food availability, additional mitigation will not be necessary.

30 June 1993

Black Bear Research in East Central Minnesota
Wildlife - 23

Program Manager: Dr. Elmer C. Birney
Bell Museum of Natural History
100 Ecology Building
University of Minnesota
St. Paul, MN 55108
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ABSTRACT

Black bears (Ursus americanus) have been reported to cause serious damage to crops in east-central Minnesota. Extent and severity of crop damage was reported to have increased sometime in the mid-1980's, but no quantitative data were available to document the purported change. Reasons for any increase were not known. It also was not known if bears in this area are residents, migrants, transient dispersers, or some combination thereof. This study was undertaken to determine population size and structure, movements and habitat-use patterns, diet of the bears in this area, the historical nature of crop damage, and landowner attitudes regarding bears and associated crop damage. The following seven questions were posed in the original work plan.

1) What is the historical nature of the increase in bears and bear-related problems in east-central Minnesota?

The historical nature of the increase in bears and bear-related crop damage was determined by responses to a landowner opinion questionnaire. Ninety-three (33%) of 281 respondents reported experiencing crop damage by bears. Of those, 64 (69%) reported an increase in crop damage between 1972 and 1990 and most landowners reported greater economic losses to bears in field corn than in either sweet corn or oats.

Bear nuisance reports to the MNDNR from 1980 to 1990 were also examined to determine the trends in the numbers of nuisance complaints filed each year. These reports indicate that 1981 was the worst year for nuisance bear complaints, followed by a peak of nuisance reports in the mid-1980's. Bears reportedly causing crop damage were killed more often than bears causing other nuisance problems.

2) How many bears live in this area?

Two estimates of black bear density on the study area were obtained using the Petersen mark-recapture formula. Bears were marked during July-August of 1991 and May-August of 1992. The proportion of marked bears shot by hunters in September of 1992 yielded a density estimate of approximately 36 bears /100 km^2. A second estimate of 32 bears /100 km^2 was obtained by remote photography of bears at bait stations in St. Croix State Park during September of 1992 to determine if they were marked or unmarked.

3) What proportion of the bears in the area at the time of crop damage are breeding residents, unsettled young prior to breeding, or seasonal migrants that visit the area when crop resources are abundant?

Twenty-three of 29 bears monitored by radio-telemetry during 1991 and 1992 were resident females or adult males. These data indicate that a substantial proportion of bears in the study area are residents. Reproduction on the study area appeared to have been sufficient to replace the bears killed in the legal harvest.

The number of subadult male bears was difficult to assess due to their great mobility. However, only 2 of 9 bears trapped or harvested from corn fields in August and September of 1992 were subadult males. Furthermore, the composition of the legal harvest for the last 5 years did not indicate higher immigration of male bears relative to populations in non-agricultural areas.

Restrictions on trapping bears during the hunting season did not allow us to capture and drug bears after 24 August during either year of the study. Thus, we can not falsify the hypothesis that some seasonal migrants moved into the study area in late August or September. However, given the numbers of resident bears observed, it is unlikely that seasonal migrants play a major role in crop damage.

4) What is the role of the extensively forested areas farther north and east (e.g., in the Nemadji State Forest and adjacent Wisconsin) as habitat sources that supply the bears in the problem area, and what is the influence of forested corridors and landscape patterns on bear movement?

Adjacent extensively forested areas did not appear to be a major source for bear recruitment into east-central Minnesota during our study. This conclusion is based on our observations that (1) few bears made long distance movements and (2) the study area is not a population sink. However, forests in the study area are contiguous to forests to the north, east, and southeast. Thus, no physical barriers would exist to prevent movement of bears into or out of the study area if food availability or bear population density changes at some future date.

5) There is a north-south gradient of increasing habitat fragmentation of forest through Pine County. How does bear density, sex ratio, and age structure vary along that gradient?

This question was addressed on two scales. First, we compared the composition of the harvest in three broad zones in Pine County. In the heavily fragmented southern zone, the harvest was male-biased in all age classes, suggesting some immigration of male bears. The number of bears harvested was also low (< 2 bears/ 100 km^2). This male bias was not observed in the moderately fragmented central zone where the number of bears harvested was high (> 8 bears/ 100 km^2). A similar pattern was observed in the more heavily forested northern zone.

Second, we compared the composition of the harvest in a fragmented (< 50% forested) portion of the study area to a heavily forested area just to the north. The composition of the harvest differed between the 2 areas in that

subadult females, the least mobile sex/age group, were present in the kill sample from the forested area but not from the fragmented area. This suggests that within the fragmented area subadult females remained protected in refugia such as St. Croix State Park.

6) What is the impact of hunters on this bear population?

Annual mortality from hunting in the study area, which is managed as a no-quota zone, was 25% in 1992. This figure is not appreciably higher than the annual hunting mortality observed by the MNDNR in a study area near Grand Rapids, Minnesota, where the number of hunters is limited by lottery. Thus, it does not appear that hunter induced mortality has a greater impact on population levels in the study area compared to areas not experiencing crop damage.

7) What are the characteristics of crop fields that incur bear damage and how do they compare to fields that incur little or no damage?

We postulated that whether an agricultural field experienced depredation by bears might be related to the proximity of the field to forested areas, free water, or maintained roads. There appears to be no significant difference between crop fields sustaining bear damage and those that did not in relationship to the proximity of forested areas or free water. In contrast, crop fields near maintained roads tended to be damaged less frequently than fields removed from roads. However, predicting potential crop damage based on these characteristics does not appear to be a viable means of targeting fields for preventing depredation.

MANAGEMENT IMPLICATIONS

1) Bear densities remain relatively high after 5 years of no-quota hunting in east-central Minnesota . If it becomes desirable to reduce density further, changes in the timing, duration, and method of hunting should be considered.

2) Given the large numbers of resident bears involved in crop damage and the dispersed nature of the crop resource, techniques aimed at individual problems bears (i.e., aversive conditioning or translocation) are not feasible.

3) Alternative food sources were available to bears concurrently with ripe crops during both years of this study. During years of widespread failure of the berry and mast crops, higher levels of crop damage are predicted.

4) The physical characteristics of the landscape surrounding agricultural fields does not seem to correlate strongly with the probability of damage by bears. If bear-related crop damage increases in extent or severity, additional research on the relationship between landscape features and patterns of crop damage may be warranted.

5) Most landowners in the study area appear to expect and tolerate the levels of crop damage by black bears experienced during the study. Except in years of low natural food availability, additional mitigation will not be necessary.

30 June 1993

LCMR Final Status Report-Detailed for Peer Review-Research

I. **Black Bear Research in East Central Minnesota**
Wildlife - 23

Program Manager: Dr. Elmer C. Birney
Bell Museum of Natural History
University of Minnesota
St. Paul MN 55108
612 - 624 - 6293

A. M.L.91 Ch. 254, Art. 1, Sec. 14, Subd: 9(1)

Appropriation: $100,000
Balance: $0 (approx.)

Black Bear Research in East Central Minnesota: This appropriation is to the University of Minnesota, Bell Museum of Natural History, to develop landscape ecology concepts and better understand the problem of bear damage to crops.

B. Compatible Data: N/A
C. Match Requirement: N/A

II. Narrative

In east-central Minnesota black bears (Ursus americanus) cause serious damage to crops. Crop damage appears to have increased in recent years, but reasons for any increase are unknown. It also is not known if bears in this area are residents, migrants, transient dispersers, or some combination thereof. We are proposing a study of population size and structure, movements and habitat-use patterns, and diet of the bears in this area.

III. Objective

A. Conduct an ecological study of black bears in east-central Minnesota with emphasis on origin of these bear populations and their role in crop damage in the area.

A.1. Narrative: East-central Minnesota is one of the state's worst problem areas for bear damage to crops. There is a need to determine movements and population characteristics of the bears in the crop damage areas in order to understand the nature of the problem and to develop recommendations for coping with it. The following are important questions that will be addressed in this study. 1) What is the historical nature of the increase in bears and bear-related problems in east-central Minnesota? 2) How many bears live in this area? 3) What proportion of the bears in the area at the time of crop damage are breeding residents, unsettled young prior to breeding, or seasonal migrants that visit the area when crop resources are abundant? 4) What is the role of the extensively forested areas farther north and east (e.g., in the Nemadji State Forest and adjacent Wisconsin) as habitat sources that supply the bears in the problem area, and what is the influence of forested corridors and landscape patterns on bear movement? 5) There is a north-south gradient of increasing habitat fragmentation of forest through Pine County. How does bear density, sex ratio, and age structure vary along that gradient? 6) What is the impact of hunters on this bear population? 7) What are the characteristics of crop fields that incur bear damage and how do they compare to fields that incur little or no damage? Answers to these and other questions that will present themselves during the study will provide management agencies with solid information on which to base management decisions regarding bears of this unique area.

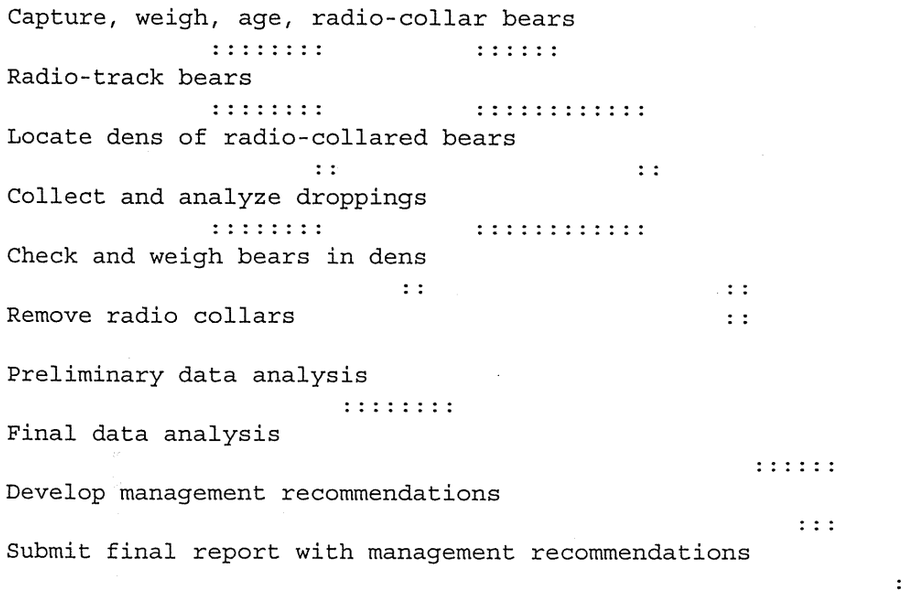
A.2. Procedures: Research procedures will be of three major categories. These are: 1) trapping, marking, radio-collaring, and monitoring of collared bears; 2) analysis of hunter-killed bears in the area of crop damage and farther north; and 3) collection of data on crop damage from both a questionnaire (historical) and evaluation of fields in which damage is detected; also, bears killed specifically to control crop damage will be analyzed in the same manner as trapped and hunter-killed bears. The following numbered statements refer to the methodology that will be employed to answer the questions posed above under Objectives.

1. A questionnaire will be developed for farmers and other long-time residents of the area to learn more of the history of the increase in bear numbers, changes in farm practices such as crop use and harvest methods, and observations of bears reproducing in the area. Aerial photographs and possibly satellite imagery will be used to help identify vegetative changes that may have contributed to an increase in bear-people conflicts in the area or created travel corridors that allowed bears to move into the area from farther north. Minnesota Department of Natural Resources (MNDNR) records of bears killed in the area will also be used to corroborate data gathered through the questionnaire.
2. All bears trapped in the study area will be individually marked, although not all will be radio-tagged. The proportion of tagged bears in the hunter kill sample will provide one estimate of the total density. All bears captured on the study area in 1991 were equipped with radio transmitters. Because we did not capture large numbers of bears in late summer 1991, we were unable to mark enough animals to generate a reliable population estimate for the study area. Trapping success during 1992 was higher than in 1991, and we were able to provide bear density estimates for 1992.
3. Radio-collared bears known to be in the area during the period of crop damage in 1991 will be followed for at least one year thereafter. In 1992, radio-collared bears will be monitored through denning. Analysis of their movement patterns and location of denning and breeding ranges should provide the information necessary to answer this question. However, because there are restrictions on capturing bears during the period when most crop damage occurs (late August and September), we will not be able to radio mark bears located in crop fields that moved into the area in response to ripening crops (seasonal migrants or immigrants). Age and sex ratios of radio-collared bears that use crop fields extensively will be compared to age and sex ratios of bears killed as part of damage abatement practices. Dissimilar age and sex composition might indicate an ingress of bears from outside of the study area or differing propensities to nuisance activity among sex/age groups.
4. Data collected in (3) will be used to determine summer breeding ranges and reproductive success of seasonal migrants originally trapped in Pine County. If funds permit, cubs of any such females will be radio-collared in the den as yearlings to determine if they move back to the crop damage area where their mother had taken them. Corridor use will be determined by frequent monitoring of migratory bears during periods of seasonal travel. Based on 1991 data, bears captured in the study area appear to remain there as year-round residents. Thus, there may be few transient bears in the area from which we can obtain data.
5. Composition of the hunter-kill sample at check stations in the study area and northward into less fragmented bear habitat will be determined and related to patterns of habitat fragmentation.
6. Hunter-induced mortality will be considered relative to: a) other types and amounts of mortality; b) estimated density; and c) sex and age composition of hunter-killed bears relative to that of the subsample of bears trapped. This analysis will be limited to radio-collared bears that are resident in the study area during hunting season.
7. All fields in the area known to incur damage will be evaluated as little, moderate, or high damage fields. These then will be evaluated by a number of criteria now being developed to determine such characteristics as crop type, crop variety, planting date, harvest type (ensilage vs. grain), proximity to woods, proximity to water, etc. A sample of undamaged fields in the area, if any, also will be evaluated by the same criteria in an effort to determine if crop damage can be predicted.

A.3. Budget

a. Amount Budgeted:	$100,000
b. Balance:	$0 (approx.)

A.4. Timetable



A.5. Status:

A.5.1. Study area: Investigations have focused on a 360 km² study area in eastern Pine County, Minnesota. This area was chosen because it is a mosaic of agricultural lands and forests. Historically it has been an area of serious crop depredation by bears. Included in the study area are parts of St. Croix State Park (SCSP) and St. Croix State Forest.

A.5.2. Trapping: In 1991, trapping was carried out from 15 July to 24 August. Trapping success averaged 1 bear per 55 trap-nights. Twelve bears were captured and fitted with radio collars: 6 males (2 subadults and 4 adults) and 6 females (4 subadults and 2 adults).

In March 1992, 1 female with cubs was captured and radio-collared at her den site. Trapping was conducted from 16 May to 24 August 1992. Overall, trapping success was 1 bear per 26 trap-nights. Thirty previously uncaptured bears were trapped (Table 1). During the final week of trapping, when bears began feeding on corn, we focused our efforts on capturing crop-depredating bears; 7 bears were trapped in corn fields.

Table 1. Status of radio-collared bears in Pine County, Minnesota, through 30 June 1993.

ID no.	Date of capture	Sex	Capture wt (kg)	Comments
3001	29 Jul 1991	F	54	Killed in 1991 hunt
3002	30 Jul 1991	M	42	Killed in 1991 hunt
3003	6 Aug 1991	F	36	1 cub in 1993, collar removed 1993
3004	7 Aug 1991	F	63	Killed in 1992 hunt
3005	8 Aug 1991	F	41	Killed in 1991 hunt
3006	8 Aug 1991	M	102	Collar removed 1993
3007	14 Aug 1991	M	93	Collar removed 1993
3008	15 Aug 1991	F	59	Collar removed 1993
3009	18 Aug 1991	M	123	Collar removed 1993
3010	18 Aug 1991	F	91	3 yearlings 1993, collar removed 1993
3011	18 Aug 1991	M	52	Killed in 1991 hunt
3012	20 Aug 1991	M	136	Collar removed 1993
3013	15 Mar 1992	F	84	3 yearlings 1993, collar removed 1993
3014	18 May 1992	M	181	Dropped collar Sep 1992
3015	19 May 1992	F	45	Collar removed 1993
3016	19 May 1992	F	55	2 yearlings in 1992, killed in 1992 hunt
3017	19 May 1992	M	25	Offspring of 3016, killed in 1992 hunt
3018	21 May 1992	F	46	Collar removed 1993
3019	30 May 1992	F	49	3 cubs 1993, on air (164.930 MHz)
3020	6 Jun 1992	F	74	3 cubs 1993, collar removed 1993
3021	8 Jun 1992	M	170	Collar removed 1993
3022	10 Jun 1992	M	100	Collar removed 1993
3023	16 Jun 1992	F	60	No collar
3024	16 Jun 1992	F	95	Killed by car Jul 1992
3025	24 Jun 1992	M	57	No collar
3026	27 Jun 1992	M	69	Killed in 1992 hunt
3027	27 Jun 1992	M	125	No collar
3028	30 Jun 1992	M	35	No collar

Table 1 (cont.)

ID no.	Date of capture	Sex	Capture wt (kg)	Comments
3029	9 Jul 1992	F	44	No collar
3030	10 Jul 1992	F	37	No collar, killed in 1992 hunt
3031	21 Jul 1992	M	59	No collar
3032	23 Jul 1992	M	59	No collar
3033	24 Jul 1992	F	61	No collar
3034	25 Jul 1992	M	37	Collar removed 1993
3035	4 Aug 1992	M	91	Collar failed
3036	5 Aug 1992	M	69	On air (164.390 MHz)
3037	9 Aug 1992	F	111	4 cubs 1993, collar removed 1993
3038	10 Aug 1992	M	80	On air (164.913 MHz)
3039	18 Aug 1992	M	39	No collar, killed in 1992 hunt
3040	19 Aug 1992	M	57	On air (164.352 MHz)
3041	20 Aug 1992	M	32	Collar removed 1992
3042	23 Aug 1992	M	55	Killed in 1992 hunt
3053	18 Aug 1992	M	68	Killed in 1992 hunt

A.5.3. Telemetry: During 1991, radio-collared bears were located weekly from capture until denning. One subadult male moved 24 km to the north and was shot by a hunter; the remaining 11 were located within 10 km of their intitial points of capture until they denned or were harvested by hunters. For the most part, bears were found in large blocks of unbroken forest (especially SCSP) feeding on abundant natural foods. One bear, an adult male initially captured in SCSP, was found feeding in a corn field approximately 6 km from the park in late October.

In 1992, 28 radio-collared bears (11 females, 17 males) were located a total of 416 times. Bears that remained in the study area were located at least biweekly from den emergence in the spring until 15 July, weekly from 16 July to 24 August (when crops were ripe), twice weekly from 25 August to 30 September (during the hunting season), and weekly from 1 October until denning. Bears that moved from the study area were located at least biweekly. Most locations were obtained from a vehicle-based receiving system; bears that left the study area were located by aerial telemetry. Locations were obtained between 8:00 AM and 5:00 PM except during the first 2 weekends of the bear hunting season when telemetry was conducted in the evening to estimate more accurately the number of bears potentially available to hunters (most bears are shot at dusk).

Radio telemetry was used to differentiate migrant from resident bears. A migrant was defined as a female or an adult male bear that was present in the study area during late summer-early fall (August and September) but had its breeding and/or denning range outside of the study area. A resident was defined as a female or adult male bear that both bred and denned in the study area. (Because subadult males are unlikely to have stable breeding/denning ranges, they were not included in this analysis.) By this definition, all 6 female bears and 4 adult male bears captured and radio-collared in late summer 1991 were residents because they denned in the study area the following winter and were located there during the spring-early summer breeding season in 1992. Similarily, 6 female and 4 adult males captured and radio-collared from 15 March to 14 July 1992 also were classified as residents because they were present in the study area during the breeding season (all 7 that survived the hunting season also denned in the study area during the winter of 1992-1993). In late summer 1992, 1 adult female that was captured in August remained within 5 km of her point of capture through denning. One adult male that was captured in August 1992 left the study area in mid-September and denned 65 km to the east, and thus was the lone migrant bear captured during the study. We were unable to determine the status of 1 other adult male captured during late summer 1992 because it was killed by hunters in early September. Unfortunately, restrictions on trapping bears during the hunting season did not allow us to capture and drug bears after 24 August during either year of the the study. Thus, we can not falsify the hypothesis that some seasonal migrants moved into the study area in late August or September.

Few resident bears made late summer excursions away from their spring-early summer ranges. Of bears for which we have sufficient data to define their spring-early summer ranges (> 8 locations), 2 of 10 females and 2 of 7 adult males made excursions > 5 km from the edge of their spring-early summer ranges. The proportion of males making excursions was significantly lower (X^2 = 4.68, 1 df, P < 0.05) than reported for bears in northeastern Minnesota (Rogers, 1987). The proportion of females making excursions

was also lower, but the difference was not significant (X^2 = 2.62, 1 df, P = 0.11).

We were unable to identify movement corridors for 2 reasons. First, long distance movements were rare, so it was difficult to predict when any given bear might make a long distance movement. Second, most movements occurred in forested areas where corridor use was neither expected nor observed. One adult male was exceptional in that it used highly fragmented habitats and made a brief excursion south of Pine City, Minnesota, where the landscape is < 10% forested. Snow tracking of this bear in the study area on 20 October 1992 revealed that it freely crossed large fields and open marshes.

Telemetry indicated that many radio-collared bears fed on corn. In 1992, 16 of 28 radio-collared bears were located in or within 0.5 km of corn fields at some time during late summer or early fall. Of these 16, 7 were adult males, 2 were subadult males, 6 were adult females, and 1 was a subadult female. The age and sex composition of this sample did not appear to differ from the cohort actually trapped in corn fields (X^2 = 1.48, 3 df, P > 0.50) nor from the cohort trapped throughout the study (X^2 = 4.25, 3 df, P > 0.20). The legal harvest differed from the cohort located in corn fields in that it contained more subadult males (X^2 = 7.113, 3 df, P < 0.10).

Many bears used SCSP during the spring and early summer but left during late summer to feed on corn or at hunters' bait stations. During July, 1992, as many as 17 radio-collared bears were located in SCSP at one time, but only 4 were located there during the last week of August. The remaining 13 park bears were either making excursions described above or were in the agricultural area just north of the park (within 2 km of their spring-early summer ranges). By late October, 14 radio-collared bears were denned in SCSP.

In 1992, denning dates were determined for 18 bears that remained in the study area (it was not feasible to determine denning dates for 2 bears that dispersed from the study area). Denning dates were recorded as the middle of the week preceding three successive weekly locations at a bear's eventual den site. The median denning date for 9 females was 23 October (range = 3 October - 13 November); the median denning date for 9 males was 27 November (range = 27 October - 7 December). Fresh bear tracks were sighted in the study area as late as 20 December 1992. These dates are substantially later than previously observed in north-central (Garshelis et al., 1989) and north-eastern Minnesota (Rogers, 1987).

A.5.4 Den visits: Eight radio-collared bears were visited in their dens during February and March 1992. Six bears (3 males, 3 females) used excavated dens, 1 male denned under a root mass, and 1 female denned in an open nest. One adult male, which used heavily fragmented habitats, constructed its den in a 0.5 km^2 clearing within sight of an occupied house. One of 2 adult females had 3 cubs when visited in March.

We visited 19 dens during January-March 1993 and removed radio-collars from all but 3 males that will be monitored by the MNDNR and a female that fled when approached (the radio-collar on this bear is equipped with a breakaway insert and is expected to fall off by Fall 1993). Fourteen bears (8 males, 6 females) constructed excavated dens, 4 (2 males, 2 females) used open nests, and 1 male denned under a root mass. Of 5 radio-collared adult females that did not have cubs in 1992, 4 had cubs in 1993 (mean litter size = 2.75). All of the 6 cubs born to radio-collared females in the winter of 1991-1992 survived to den with their mothers as yearlings in 1992-1993. Weights of these yearlings in March 1993 ranged from 24 to 27 kg.

A.5.5. Hunting: Harvest statistics provided by the MNDNR indicated that hunters killed 165 bears (106 males, 59 females) in the no-quota area in east-central Minnesota in 1991. Hunters reported difficult hunting conditions possibly due to abundant berry and acorn crops. The bear kill in this area in 1991 was down 46% from 1990. Four of 12 radio-collared bears were killed.

Three hundred fifty-one bears (197 males, 154 females) were harvested by hunters in the no-quota area in east-central Minnesota in 1992. This exceeded the previous record of 265 set in 1990.

Eight (22%) of 37 marked bears (including bears that dispersed from the study area) were known to have been killed in the 1992 harvest. A total of twenty-three bears was known to have been killed in the study area, 6 of which (26%) were marked. Table 2 summarizes the legal harvest and pre-harvest bear density in the study area. Although small sample sizes make comparisons between sex-age classes tenuous, subadult males seem to be over-represented in the harvest compared to their actual density whereas adult males are under-represented. This is not consistent with the hypothesis that higher than normal densities of immigrating subadult males (relative to the primary bear range in Minnesota) occur as a result of the continued removal of adult male bears in the unrestricted harvest.

Table 2. Summary of bear harvest, density, and hunting mortality on the study area in 1992. The number of bears available was calculated by weighting bears by the proportion of time they spent on the study area during the hunting season. The number of eartagged-only bears present was estimated based on the movements of radio-equipped bears (many subadult males dispersed prior to the hunting season).

Age-sex class	Total harvest	Proportion marked bears	Available marked bears	Study area hunting mortality	Density (bears/ 100 km^2)
Subadult females	3	0.33	3.0	0.30	8
Adult females	5	0.40	8.3	0.24	9
Subadult males	11	0.18	3.0	0.67	7
Adult males	4	0.25	9.5	0.11	15
Total	23	0.26	23.8	0.25	34

Harvest data for the period from 1988-1992 provided by the MNDNR were analyzed as an independent measure of whether subadult males were immigrating into the area in large numbers. Sex and age ratios of bears killed in east-central Minnesota were compared to sex and age ratios in the primary bear range, where the number of hunters is limited by lottery, and to the no-quota zone in northwest Minnesota, into which immigration of male bears is reported to be common by the MNDNR (Figure 1). Immigration is apparent in the age-sex structure of the harvest in northwestern Minnesota because 2-year-old males (the most mobile segment of the population) are the most frequent class of bears harvested, subadult females (the least mobile) are relatively infrequent, and adult males outnumber adult females (because subadult males are more susceptible to hunting than subadult females, adult females are expected to outnumber adult males in hunted populations with no net immigration of males.) In contrast, the harvest structure in east-central Minnesota resembles that of the primary bear range, except that yearling males (not 2-year-olds) are relatively more frequent. This may be a result of intense harvest pressure on the population, and does not indicate immigration, because yearling males are less mobile than 2-year-olds.

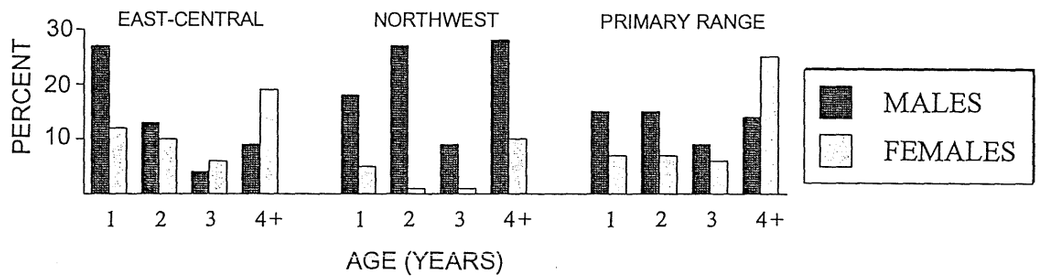


Figure 1. Age and sex structure of the bear harvest in east-central Minnesota (which includes the study area), northwest Minnesota, and the primary bear range in Minnesota.

In order to examine the effect of forest fragmentation on a local scale, we compared 1992 harvest data from the fragmented portion of the study area (< 50% forested) to harvest data from the predominantly forested area to the north (Figure 2). Subadult females were absent from the harvest in the fragmented portion of the study area but present in the unfragmented area to the north. This may be due to the proximity of refugia such as SCSP within the fragmented area, which may differentially protect the relatively sedentary subadult females. The forested area to the north is composed of large blocks of public lands that are heavily hunted; thus,

there are no refugia, and subadult females are exposed to more uniform hunting pressure.

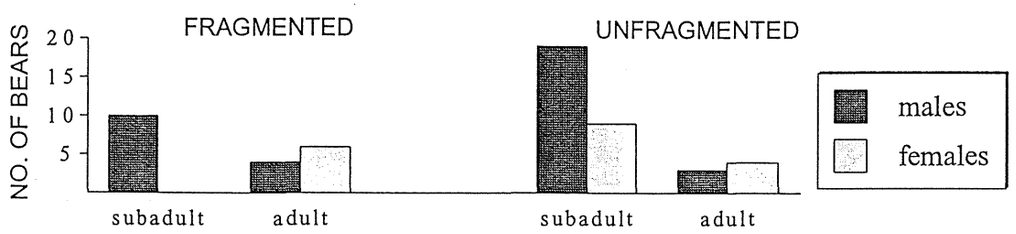


Figure 2. Age/sex structure of bear harvest in the fragmented portion of the primary study area and the heavily forested area to the north.

We examined the effect of forest fragmentation on a large scale by comparing the legal harvest in 1988-1992 from 3 broad zones in east-central Minnesota (Figure 3). In the fragmented southern zone (the southernmost portion of Pine County and the northern halves of Chisago and Isanti Counties) the harvest was male-biased in all age classes, suggesting continued immigration of male bears. The moderately fragmented central zone (central Pine County) and the heavily forested northern zone (northern Pine County) did not exhibit a male bias in all age classes.

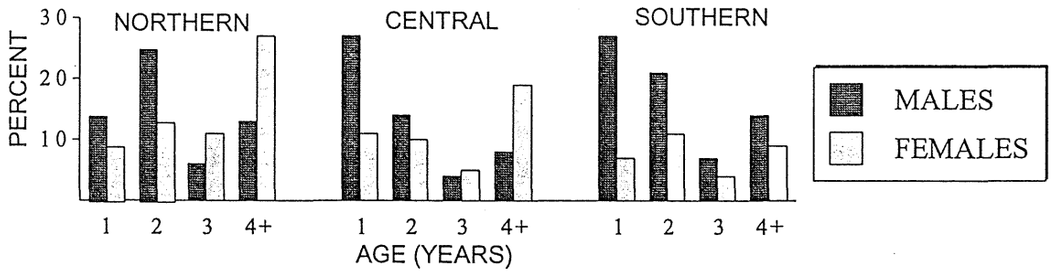


Figure 3. Age/sex ratios of bear harvest in three broad zones in east-central Minnesota.

In addition to estimating bear density from the sample of hunter-killed animals, we used cameras with motion-sensitive triggers to photograph bears in SCSP and thereby estimate the proportion of marked bears in this unhunted area during the hunting season. Twenty-one bears were photographed, of which 5 (24%) were marked. Density in the park was estimated at 32 bears/100 km^2. Seven of the photographed bears were adult males based on size and body proportions, and only one of these was marked, indicating again that adult males are much more common in the study area than harvest results suggested.

A.5.6. Crop damage: The extent of crop damage caused by bears in the study area in 1991 and 1992 was determined by assessments of agricultural fields from the ground and by conducting aerial surveys. Crop damage assessments were conducted daily from 4 August through 11 September 1991, and once each week between 11 September and 24 October 1991. In addition, 1 aerial survey of corn fields in the area was conducted on 6 September 1991. Transects were flown at 0.8 km intervals 150 - 310 m above ground level. In 1992, crop damage assessments were conducted daily from 7 July through 21 September, and twice weekly between 21 September and 1 November. Aerial searches for crop damage were conducted 4 times between 21 August and 9 September 1992. Transects were flown at 0.8 km intervals, 90 - 310 m above ground level over the entire study area.

Ground surveys for corn damage involved walking the perimeter of a field to determine if use by bears was evident. Bear trails found were followed and the extent of any damage sites was estimated. If no bear trails were found on the field perimeter, every tenth row of the field was walked to locate damage sites. Due to the shorter height of oats and the concern of damage caused by walking the field interior, oat fields were sampled by walking the field perimeter to determine whether bears had entered the field. Trees bordering oat fields were climbed to gain a higher vantage point in an attempt to locate damaged areas within a field's interior. No previously unseen damage areas were visible from the higher vantage points gained by climbing trees.

Damage to agricultural crops was initially determined to be bear-caused if bear sign (e.g., tracks, scat, bear trails) was evident at the site. The physical characteristics of bear-related corn damage were determined during ground surveys. Large (> 3 m^2), localized areas of broken smashed stalks, piling of stalks in the centers of these damage areas, trampling, and wide paths of broken stalks were characteristic of bear-related crop damage (Davenport 1953, Hyngstrom and Craven 1985, Cardoza 1976). A lack of chewed cobs in the damage sites was also noticeable (Hyngstrom and Craven 1985). Once these characteristics of damage were determined, physical evidence (tracks, scat) of a bear's presence was not required to determine that damage was due to bear activity.

In 1991, a total of 39 corn fields on 21 farms was surveyed for crop damage. Of these 39 fields, 10 fields (26%) on 5 farms sustained crop damage by bears. The area of most extensive damage measured approximately 360 m^2, which was < 1% of the 4-ha field. One additional report of known crop damage was filed by a farmer in Pine County, Minnesota, during 1991.

All fields containing damage in 1991 were bordered by forested areas on at least 2 sides, were within 0.4 km of free water, and 37 of 39 were not bordered by any type of maintained roadway. Of those corn fields sampled in 1991 and not damaged by bears, 11 (38%) of 29 were bordered by forest on at least one side, closer than 0.4 km to free water, and farther than 0.4 km from any maintained road.

Oat fields were not surveyed in 1991 because of the initial priority placed on trapping bears and the lateness of the starting date of the project relative to the maturation of oats.

In August 1991, a mailer was created to generate response concerning both bear-related crop damage and nuisance animals destroyed in the county. Approximately 600 mailers were sent to farmers and landowners in the study area. During late summer and fall 1991, only 12 responses to the mailer were received.

We received no reports of bears shot as nuisance animals during the summer 1991 field season and only 1 complaint of nuisance activity. Subsequent review of MNDNR nuisance reports, however, indicated 7 complaints and 6 nuisance kills. Our data were limited on these incidents due to a lapse in communication regarding nuisance complaints and kills between agency personnel and our study.

In 1992, bear damage was observed in 9 (43%) of 21 oat fields surveyed. Of the 9 oat fields damaged by bears, 8 (89%) were bordered by forested areas, within 0.4 km of free water, and farther than 0.4 km from any type of maintained road. Of the 12 oat fields sampled in 1992 that were not damaged by bears), 10 (83%) were bordered by forest, 8 (66%) were bordered by forest and within 0.4 km of free water, and 5 (41%) were bordered by forested areas, within 0.4 km of free water, and farther than 0.4 km from any maintained roadway.

In 1992, we surveyed 61 corn fields on 40 farms. Thirty fields (49%) on 21 farms were damaged by bears. Twenty-four (80%) of the 30 damaged fields were bordered by forested areas, 21 (70%) were bordered by forested areas and within 0.4 km of free water, and 13 (43%) were bordered by forested areas, within 0.4 km of free water, and > 0.4 km from the nearest maintained road. The proportion of sampled corn fields damaged by bears in 1992 was higher than the proportion damaged in 1991 (X^2 = 6.32, 1 df, P < 0.025). Whether or not corn fields were bordered by forest (X^2 = 0.008, 1 df, P > 0.90) or in close proximity to free water (X^2 = 0.014, 1 df, P > 0.90) did not appear to affect their chance of being damaged. However, fields not damaged by bears tended to be closer to a maintained roadway (X^2 = 3.646, 1 df, P < 0.10) than fields damaged by bears.

The largest observed area of crop damage in corn in 1992 measured approximately 3,200 m^2, 2.9% of the field. The largest area of damage relative to the size of the field was 4.2%.

Table 3. Corn fields sustaining bear-related crop damage 1991-1992.

Year	Township	Section	Total # fields/ section	Number of fields sustaining damage
1991	Arlone	5	2	2
		16	3	0
		33	2	0
		34	1	0
	Barry	25	2	0
		35	1	0
		36	2	0
	Clover	17	1	0
		20	1	1
		29	2	2
	E. Crosby	4	1	0
		6	1	0
		7	1	0
		8	1	0
		13	2	0
	W. Crosby	18	2	0
	Ogema	15	4	2
		18	4	0
		17	1	0
		21	1	1
		27	2	0
		30	2	2
1992	Arlone	16	3	1
		19	1	1
		20	1	1
		21	4	0
		33	2	0
		34	1	0
	Barry	25	2	1
		35	1	0
		36	2	1

Table 3 (cont.)

Year	Township	Section	Total # fields/ section	Number of fields sustaining damage
1992	Clover	17	1	0
		19	2	0
		20	1	0
		26	3	1
		29	2	0
		30	1	1
	E. Crosby	4	1	1
		6	1	1
		7	1	0
		8	1	1
		13	2	0
	W. Crosby	18	2	2
	Munch	2	3	2
		12	2	0
		17	1	1
		20	2	2
	Ogema	15	4	0
		17	1	1
		18	4	4
		21	1	1
		27	2	2
		28	1	1
		30	2	1
	Pine	3	3	3

Table 4. Oat fields sustaining bear-related crop damage in 1992.

Township	Section	Total # fields/ section	Number of fields sustaining damage
Arlone	8	2	1
	16	2	0
	17	3	1
	21	3	1
Clover	13	2	0
	16	3	1
	26	1	1
	30	4	2
Ogema	21	1	1
	27	1	1

Of the 21 farms where crop damage was located in 1992, 8 landowners reported filing nuisance bear reports to the MNDNR. However, official nuisance bear reports filed with the MNDNR for 1992 consisted of 5 nuisance complaints and 3 bears killed as nuisance animals. No bears were known to have been killed as nuisance animals during the summer of 1992 on the study area based on contact with the local MNDNR conservation officer.

On 13 April 1992, a questionnaire was mailed to farmers and landowners in the study area. The questionnaire solicited opinions concerning crop damage history, bear ecology, bear management, bear harvest history, farming practices, and general information regarding landowners. Four hundred eighty-six questionnaires were mailed out, 436 appeared to have been received by residents or landowners, and 281 were returned (65%). Postcard reminders were mailed on 23 April 1992, and second questionnaires were mailed to non-respondents on 8 May 1992.

Ninety-three (33%) of 281 respondents to the survey reported experiencing crop damage by bears and 64 (69%) of these 93 reported an increase in crop damage between 1972 and 1990 (mean year of increase = 1985). Fifty-seven (61%) of 93 respondents who reported crop damage by wildlife indicated that white-tailed deer (Odocoileus virginianus) caused the most crop damage. Bears were reported as causing the most crop damage by 23 (27%) of the respondents. Of the 93 respondents who had sustained crop damage by bears, 52 (56%) preferred the legal harvest of bears causing crop damage to the alternatives offered: unrestricted harvest or financial compensation. Of those respondents who had not experienced crop damage by bears, 65 (60%) of 109 preferred the legal harvest of bears causing crop damage to the same alternatives offered. The number of acres reported lost to bears per year ranged from 0.5 to 45 (mean = 7.5/year) for field corn, 0.1 to 30 acres (mean = 1.2/year) of sweet corn and 0.2 to 20 acres (mean = 4.3/year) of oats. Landowners reported significantly more area (acres) lost to bears in field corn ($F_{2,130} = 4.2$, $P > 0.01$) than in either sweet corn or oats. Landowners experiencing crop damage reported monetary losses per year of $50 to $4,500 (mean = $729 /year) in field corn, $25 to $300 (mean = $182/year) in sweet corn and $30 to $1,000 (x= $240/year) in oats. Reported economic losses in field corn were significantly greater than losses in sweet corn or oats ($F_{2,120} = 9.4$, $P < 0.01$). Landowners experiencing crop damage farmed in eastern Pine County an average of 29 years (range 0-110 years) and those landowners not experiencing crop damage by bears farmed in eastern Pine County an average of 20 years (range 0-65 years). Seventy-four (92%) of 80 respondents who had experienced crop damage planted field corn in May, and 34 (89%) of 38 respondents who had not experienced crop damage planted field corn in May ($X^2 = 0.3$, 1 df, $P > 0.05$). Only 3% of those respondents who had sustained crop damage by bears had ever used any type of energized fencing or other form of deterrent in an attempt to avert crop damage by bears.

Nuisance bear reports maintained by the MNDNR indicated a high level of crop damage in 1981 and again in the mid-1980's with fewer damage reports since 1987 (Figure 4). As indexed by nuisance reports, 1981 was the year of highest incidence of nuisance activity with 60 complaints and 27 bears killed as nuisance animals between June and September. However, more bears were killed in 1986 than in any other single year (30 bears killed as nuisance animals between April and October). Nuisance bear complaints were categorized by the MNDNR into 8 types of activity; (1) threat to humans, (2) garbage disturbance, (3) property damage, (4) campground nuisance, (5) livestock threat/loss, (6) damage to beehives, (7) crop damage, or (8) other. A single nuisance report could include activities in more than 1 category. Combining nuisance complaints from 1981 through

1992, 82 (41%) of 201 occurred in the month of August. Seventy-three (59%) of 124 complaints involving crop damage occurred in August (Figure 5). The frequency of crop damage complaints in August was significantly greater (X^2 =40.7, 6 df, P << 0.001) than the frequency of damage complaints reported in other months. Bears reportedly causing crop damage were killed significantly more often than bears causing other nuisance problems [X^2 = 16.9, 1 df, P < 0.001, 119 (72%) of 196 bears killed between 1981 and 1992].

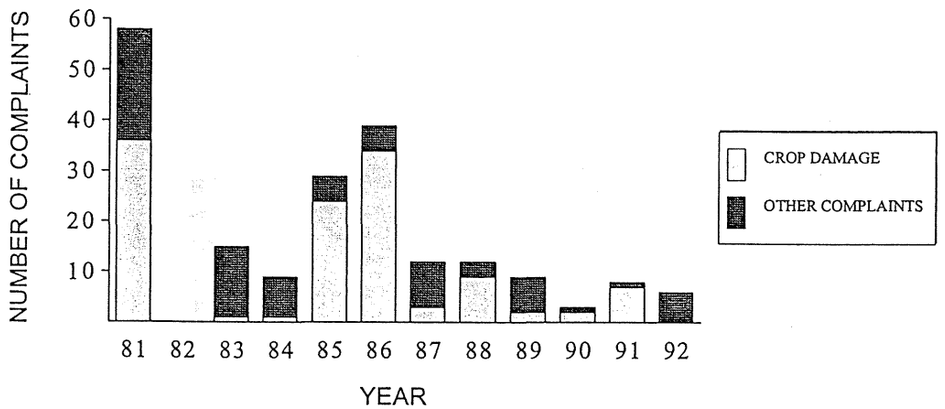


Figure 4. Bear nuisance complaints filed with the MNDNR in Pine County, Minnesota, from 1981 through 1992. "Other" complaints include: threat to humans, garbage disturbance, property damage, campground nuisance, livestock threat/loss, damage to beehives, other.

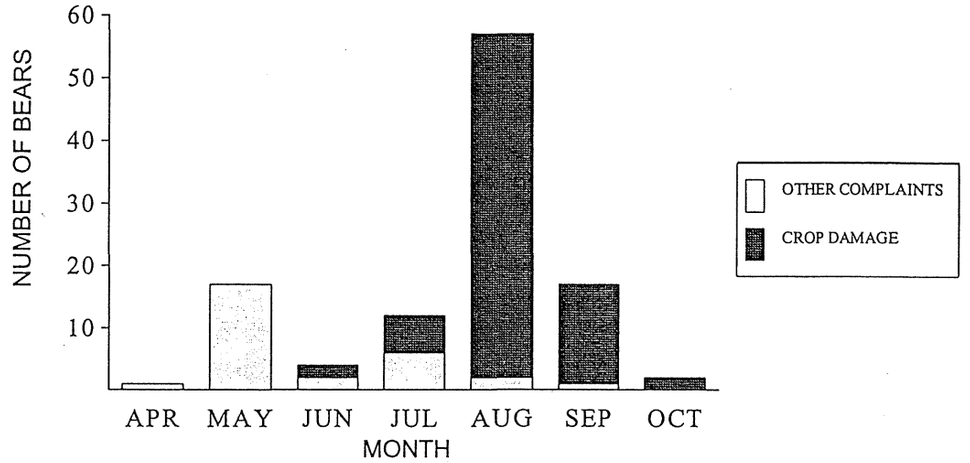


Figure 5. Bears killed as nuisance animals in Pine County, Minnesota, from 1985 through 1992 as reported to the MNDNR.

In 1992, one incident where 3 calves were reportedly killed by a bear was investigated in Brook Park Township. One MNDNR trailer trap was set near the site where the calves were killed, but no bears were captured. In addition, a private campground located in Ogema Township had repeated problems with nuisance bears during the summer of 1992. Four bears were trapped and tagged in the campground and translocated to the northern edge of the Nemadji State Forest. One of these bears was subsequently killed by a hunter near Lewis, Wisconsin.

A.5.7. Scat Analysis: Because we were unable to obtain an unbiased sample of bear scats during the period when crops were ripe, we did not undertake an analysis of diet of black bears in east-central Minnesota.

A.5.8. Remote Sensing: Analysis of aerial photographs to determine an increase in available travel corridors was not conducted because no evidence suggested that bears were using corridors in this area.

A.6. Benefits: Important information will be obtained on which to base solid management decisions in east-central Minnesota where bear-related problems appear to be on the increase. Ways to mitigate the amount of crop damage may be found. New information on bear biology will be obtained in this previously unstudied area, which is ecologically very different from study areas near Grand Rapids and Ely. The north-south gradient of increasing fragmentation of the forest in Pine County will provide a basis for testing hypotheses concerning landscape ecology. As forest fragmentation increases throughout the world, including the United States, tropical areas, and areas intensively harvested for timber and firewood, managers must learn how to create and manage landscapes that allow for maximum human use of resources while preserving habitat for wide-ranging animals such as bears.

IV. Evaluation:

For the FY92-93 biennium the project can be evaluated by the success of the investigators to recruit graduate student field assistants, the number of bears captured and radio-collared, the number of other bears captured and marked, success of radio-tracking collared bears and of locating their dens, and the number of droppings recovered and analyzed. Finally, success of the project will depend on the usefulness of management recommendations developed for black bears in mixed habitats that include some farming and on the robustness of hypotheses developed in landscape ecology and management.

V. Context:

A. East-central Minnesota is one of the state's worst problem areas for bear damage to crops. Neither this bear population nor any other in similarly fragmented habitat has been studied. There is a need to determine movements and population characteristics of the bears in the crop damage areas in order to understand the nature of the problem and to develop recommendations for coping with it.

B. Studies by Rogers (1987) in northeastern Minnesota and Garshelis et al. (1989) in north-central Minnesota were done in non-farming, ecologically very different areas and thus shed little light on the present problem. These studies do, however, provide us with a wealth of background information on all aspects of the natural history of black bears in this part of their range. They also have been highly successful in the development and perfection of research techniques for additional field studies of this species. Both Garshelis and Rogers will participate in the present study (see VI below). In addition, because of the fragmented nature of the habitat in east-central Minnesota, this study has the potential to contribute to the development of insight into the use of landscape theory in management policy for large, wide-ranging mammals in areas where resources are regularly harvested by humans.

C. Bear research in Minnesota to date has not been funded by LCMR. Because 2 years may be inadequate to answer all of the questions posed in the original application, it is likely that funds for 2 additional years to study the bear population in this unique area will be requested.

D. N/A

E. Biennial Budget System Program Title and Budget: Not available.

VI. Qualifications

1. Program Manager:
   Dr. Elmer C. Birney
   Professor of Ecology and Curator of Mammals
   Department of Ecology, Evolution, and Behavior
   Bell Museum of Natural History
   University of Minnesota

   M.S. Biology, Fort Hays State University (Kansas), 1963
   Ph.D. Zoology, The University of Kansas, 1970

Dr. Birney has advised a number of both Masters and Ph.D. students in studies of mammalian behavior and ecology at the University of Minnesota during the past 20 years. Included among them is Dr. Lynn Rogers, who along with Dr. David Garshelis, is one of Minnesota's leading authorities on bear biology. Most recent field studies have been in the areas of bat conservation and the status of grassland small mammal communities. Other related professional activities include six years as an editor for *The Journal of Mammalogy* and more recently two years as

President of the American Society of Mammalogists. Dr. Birney will serve as overall program coordinator and probably will serve as the academic advisor or co-advisor of one of the students on the project.

2. Co-Principal Investigator:

Dr. David E. Andersen
Assistant Unit Leader - Wildlife
Minnesota Cooperative Fish and Wildlife Research Unit
Assistant Professor, Department of Fisheries and Wildlife
University of Minnesota

M.S. Wildlife Ecology, University of Wisconsin, Madison, 1984
Ph.D. Wildlife Ecology/Zoology, Univ. Wisconsin, Madison, 1988

Dr. Andersen has conducted research on the impacts of human activity on wildlife, including raptorial birds, songbirds, large ungulates, and large carnivores and has extensive experience with radio telemetry. His experience also includes writing, refereeing, and editing publications in wildlife ecology and management and working with government agencies concerning mitigation of negative human impacts. Dr. Andersen's primary role in this project will be in study design and to advise or co-advise one of the students on the project.

3. Cooperators:

A. Dr. Thomas R. Crow
Forestry Sciences Laboratory
P.O. Box 898
Rhinelander, WI 54501

M.S. Forest Biology, University of Michigan, 1966
Ph.D. Ecology, University of Minnesota, 1970

Dr. Crow is a research ecologist and project leader with the USDA Forest Service, North Central Forest Experiment Station. His primary research interests are in landscape ecology. He is project leader of the research unit "Principles of Landscape Ecology for Managing Temperate Forest." The mission of this unit is to develop the knowledge and technology for a landscape perspective in maintaining biological diversity. Studies of land use change since settlement and responses of resident and neotropical migratory birds to forest fragmentation are currently being conducted in the St. Croix River Valley. Crow will be responsible for (1) relating the movement of black bears in east-central Minnesota to broad landscape patterns and (2) studying the relation of a major landscape feature (the St. Croix River corridor) to the movement of a large-bodied, wide ranging species (the black bear).

B. Dr. David Garshelis
Bear Project Leader, Minnesota DNR
1201 E. Hwy 2, Grand Rapids, MN 55744

M.S. Zoology, University of Tennessee, 1978
Ph.D. Ecology, University of Minnesota, 1983

Dr. Garshelis has conducted field studies on black bears for 10 years, involving the capture and handling of over 700 animals. His primary expertise is in population monitoring. He also has done extensive work in analysis of telemetry data (mortality, movements, habitat use information). He presently serves on the Minnesota Bear Management Committee, which has attempted to deal with the bear problems addressed in this proposal. He also was elected to the Council for the International Association for Bear Research and Management and the Board of Directors for the North American Bear Society. Since 1986 he has Been an adjunct professor of Wildlife Conservation at the University of Minnesota where he has served or is serving on the graduate committees of four students involved in bear research.

C. Dr. Peter A. Jordan
Associate Professor
Department of Fisheries and Wildlife
142 Hodson Hall
University of Minnesota

B.A. Wildlife Conservation, University of California, 1955
Ph.D. Zoology, University of California, Berkeley, 1967

Dr. Jordan has conducted research and has consulted on the problem of nuisance deer in the Metro area. He has been involved, personally and through students, with carnivore research on the timber wolf, the red wolf, and, in Nepal, the Bengal tiger. His work in wildlife encompasses some 30 years of studying the ecology and physiology of large, free-living mammals. He is on the faculty of Fisheries and Wildlife at the University of Minnesota where he teaches and advises graduate and undergraduate students preparing for careers in the management of wildlife resources. Dr. Jordan's primary role in this project will be to assist students in conducting and writing up field studies.

D. Dr. Lynn L. Rogers
Wildlife Research Biologist, USDA Forest Service
North Central Forest Experiment Station, Ely, MN 55731

M.S. Wildlife Ecology, University of Minnesota, 1970
Ph.D. Ecology, University of Minnesota, 1977

Dr. Rogers has conducted research on black bears in the Great Lakes Region for 24 years, beginning with studies of nuisance bear problems in Michigan in 1967. Research in Minnesota has included studies of black bear population dynamics, social organization, habitat use, and mitigation of problems between bears and people. Rogers is author of over 80 scientific papers on black bears. He will play a major role in designing the proposed study.

VII. Reporting Requirements

Semiannual status reports will be submitted not later than 1 January 1992, 1 July 1992, 1 January 1993, and a final report by 30 June 1993.

VIII. Literature Cited

Cordoza, J. E. 1976. The history and status of the black bear in Massachusetts and adjacent New England states. Mass. Div. Fish. Wildl. Res. Bull. 18. 113 pp.

Davenport, L. B. 1953. Agricultural depredation by the black bear in Virginia. J. Wildl. Manage. 17:331-340.

Garshelis, D. L., K. V. Noyce, and P. L. Coy. 1989. Ecology and population dynamics of black bears in north-central Minnesota. Pages 36-49 in B. Joselyn, ed. Summaries of Wildlife Research Project Findings. Minnesota Dep. Nat. Resourc., unpubl. rep.

Hyngstrom, S. E. and S. Craven. 1985. Bear damage and nuisance problems in Wisconsin. Univ. of Wisc. Ext. Pub. No. G-3300. 6 pp.

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ABSTRACT

Black bears (Ursus americanus) have been reported to cause serious damage to crops in east-central Minnesota. Extent and severity of crop damage was reported to have increased sometime in the mid-1980's, but no quantitative data were available to document the purported change. Reasons for any increase were not known. It also was not known if bears in this area are residents, migrants, transient dispersers, or some combination thereof. This study was undertaken to determine population size and structure, movements and habitat-use patterns, diet of the bears in this area, the historical nature of crop damage, and landowner attitudes regarding bears and associated crop damage. The following seven questions were posed in the original work plan.

1) **What is the historical nature of the increase in bears and bear-related problems in east-central Minnesota?** The historical nature of the increase in bears and bear-related crop damage was determined by responses to a landowner opinion questionnaire. Ninety-three (33%) of 281 respondents reported experiencing crop damage by bears. Of those, 64 (69%) reported an increase in crop damage between 1972 and 1990 and most landowners reported greater economic losses to bears in field corn than in either sweet corn or oats.

Bear nuisance reports to the MNDNR from 1980 to 1990 were also examined to determine the trends in the numbers of nuisance complaints filed each year. These reports indicate that 1981 was the worst year for nuisance bear complaints, followed by a peak of nuisance reports in the mid-1980's. Bears reportedly causing crop damage were killed more often than bears causing other nuisance problems.

2) **How many bears live in this area?** Two estimates of black bear density on the study area were obtained using the Petersen mark-recapture formula. Bears were marked during July-August of 1991 and May-August of 1992. The proportion of marked bears shot by hunters in September of 1992 yielded a density estimate of approximately 36 bears /100 km^2. A second estimate of 32 bears /100 km^2 was obtained by remote photography of bears at bait stations in St. Croix State Park during September of 1992 to determine if they were marked or unmarked.

3) **What proportion of the bears in the area at the time of crop damage are breeding residents, unsettled young prior to breeding, or seasonal migrants that visit the area when crop resources are abundant?** Twenty-three of 29 bears monitored by radio-telemetry during 1991 and 1992 were resident females or adult males. These data indicate that a substantial proportion of bears in the study area are residents. Reproduction on the study area appeared to have been sufficient to replace the bears killed in the legal harvest.

The number of subadult male bears was difficult to assess due to their great mobility. However, only 2 of 9 bears trapped or harvested from corn fields in August and September of 1992 were subadult males. Furthermore, the composition of the legal harvest for the last 5 years did not indicate higher immigration of male bears relative to populations in non-agricultural areas.

Restrictions on trapping bears during the hunting season did not allow us to capture and drug bears after 24 August during either year of the study. Thus, we can not falsify the hypothesis that some seasonal migrants moved into the study area in late August or September. However, given the numbers of resident bears observed, it is unlikely that seasonal migrants play a major role in crop damage.

4) **What is the role of the extensively forested areas farther north and east (e.g., in the Nemadji State Forest and adjacent Wisconsin) as habitat sources that supply the bears in the problem area, and what is the influence of forested corridors and landscape patterns on bear movement?** Adjacent extensively forested areas did not appear to be a major source for bear recruitment into east-central Minnesota during our study. This conclusion is based on our observations that (1) few bears made long distance movements and (2) the study area is not a population sink. However, forests in the study area are contiguous to forests to the north, east, and southeast. Thus, no physical barriers would exist to prevent movement of bears into or out of the study area if food availability or bear population density changes at some future date.

5) **There is a north-south gradient of increasing habitat fragmentation of forest through Pine County. How does bear density, sex ratio, and age structure vary along that gradient?** This question was addressed on two

scales. First, we compared the composition of the harvest in three broad zones in Pine County. In the heavily fragmented southern zone, the harvest was male-biased in all age classes, suggesting some immigration of male bears. The number of bears harvested was also low (< 2 bears/ 100 km^2). This male bias was not observed in the moderately fragmented central zone where the number of bears harvested was high (> 8 bears/ 100 km^2). A similar pattern was observed in the more heavily forested northern zone.

Second, we compared the composition of the harvest in a fragmented (< 50% forested) portion of the study area to a heavily forested area just to the north. The composition of the harvest differed between the 2 areas in that subadult females, the least mobile sex/age group, were present in the kill sample from the forested area but not from the fragmented area. This suggests that within the fragmented area subadult females remained protected in refugia such as St. Croix State Park.

6) **What is the impact of hunters on this bear population?** Annual mortality from hunting in the study area, which is managed as a no-quota zone, was 25% in 1992. This figure is not appreciably higher than the annual hunting mortality observed by the MNDNR in a study area near Grand Rapids, Minnesota, where the number of hunters is limited by lottery. Thus, it does not appear that hunter induced mortality has a greater impact on population levels in the study area compared to areas not experiencing crop damage.

7) **What are the characteristics of crop fields that incur bear damage and how do they compare to fields that incur little or no damage?** We postulated that whether an agricultural field experienced depredation by bears might be related to the proximity of the field to forested areas, free water, or maintained roads. There appears to be no significant difference between crop fields sustaining bear damage and those that did not in relationship to the proximity of forested areas or free water. In contrast, crop fields near maintained roads tended to be damaged less frequently than fields removed from roads. However, predicting potential crop damage based on these characteristics does not appear to be a viable means of targeting fields for preventing depredation.

MANAGEMENT IMPLICATIONS

1) Bear densities remain relatively high after 5 years of no-quota hunting in east-central Minnesota . If it becomes desirable to reduce density further, changes in the timing, duration, and method of hunting should be considered.
2) Given the large numbers of resident bears involved in crop damage and the dispersed nature of the crop resource, techniques aimed at individual problems bears (i.e., aversive conditioning or translocation) are not feasible.
3) Alternative food sources were available to bears concurrently with ripe crops during both years of this study. During years of widespread failure of the berry and mast crops, higher levels of crop damage are predicted.
4) The physical characteristics of the landscape surrounding agricultural fields does not seem to correlate strongly with the probability of damage by bears. If bear-related crop damage increases in extent or severity, additional research on the relationship between landscape features and patterns of crop damage may be warranted.
5) Most landowners in the study area appear to expect and tolerate the levels of crop damage by black bears experienced during the study. Except in years of low natural food availability, additional mitigation will not be necessary.