Nuisance black bear (*Ursus americanus*) behaviour in central Ontario

by

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I would like to dedicate this thesis to bear LR04 whose relentless determination to return home amazed and inspired so many of us.

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Seasonal activity, age and sex composition, mortality, and relocation success for tagged nuisance black bears (*Ursus americanus*) from the Chapleau, Parry Sound, and Sudbury Districts of central Ontario

ABSTRACT

Data were obtained from tag-and-recover studies conducted on nuisance black bears by the Chapleau, Parry Sound, and Sudbury Districts of the Ministry of Natural Resources in Ontario. The information was examined to determine the seasonality, age and sex composition, mortality rates, and relocation success for translocated nuisance bears. Data were gathered over 4 years in Chapleau, 13 years in Parry Sound, and 4 years in Sudbury. Seasonal variation in nuisance bear captures appeared to be a result of changes in the availability of natural food sources, and seasonal fluctuations in human activity in rural areas. The age and sex composition of nuisance bears was not consistent across all three Districts, and varied as a result of hunting pressure and local bear management practices. In unprotected areas, the major cause of mortality was hunting, and areas with greater hunting pressure experienced lower rates of repeat nuisance behaviour. Eighty-one percent of adults homed successfully and only 23 percent of juveniles were successful, while juvenile males demonstrated the least homing success. Homing ability appeared to be dependent on age and the presence of an established home range. The distance from which juvenile bears homed was less than the distance from

which they did not home but this effect of distance on homing success was not seen for adult bears (for relocation distances up to 400 km).

INTRODUCTION

In many parts of central Ontario, sightings of black bears (*Ursus americanus*) are common. When food sources become scarce, bears forage more widely and are more likely to come into contact with humans and human-based food sources (Rogers, 1976; Alt *et al.*, 1977; Shull, 1994).

Black bears are often perceived as a hazard when they enter areas of human habitation and often the animal is either destroyed or removed from the area. Whether a particular bear is identified as a nuisance animal is often dependent upon the attitude and experience of the complainant. Reports of nuisance behaviour can range in severity from a single visit by a bear to graze on a clover-covered lawn, to a situation where a bear repeatedly breaks into homes, causing considerable property damage and posing a potential threat to residents (Ciarniello, 1997; M. N. Hall, pers. comm.).

When nuisance bear complaints cannot be dealt with by the removal of the attractant or if the animal is behaving in an aggressive manner, local authorities are often notified and assist in resolving the conflict. In most areas of central Ontario, nuisance bears are live-trapped and relocated to areas of low human population density. Relocations are conducted in an attempt to either remove the animal permanently from the area or delay return until seasonally available food sources ripen. In many areas, the capture and relocation of nuisance bears is conducted by the local office of the Ministry of Natural Resources (MNR).

The occurrence of human-bear conflicts has been correlated with low availability of natural foods (Alt *et al.*, 1977; Shull, 1994), with significant increases in the number of nuisance bear reports when natural food crops fail (Schorger, 1946; Rogers, 1976; M. N. Hall, pers. comm.). The majority of nuisance bears are young males (Erickson and Petrides, 1964; Harger,1970; Rutherglen and Herbison, 1977; Shull, 1994), which is likely a reflection of their lack of established home ranges and their dispersal behaviour (Rogers, 1987a; Schwartz and Franzmann, 1992).

Several studies conducted on the homing ability of black bears have determined that a high proportion of relocated nuisance bears return to the area of capture (Harger, 1970; Alt *et al.*, 1977; Rutherglen and Herbison, 1977; McArthur, 1981; Rogers, 1986a; Shull, 1994). Although relocation distance is often assumed to be the major factor affecting homing success, investigations of the effect of relocation distance have rarely yielded clear results (Harger, 1970; McArthur, 1981; Rogers, 1984).

This study examined the effectiveness of the trap-and-relocate method for managing nuisance bears using data recorded by the MNR in the Chapleau, Parry Sound, and Sudbury Districts. The primary objectives of this study were to describe and compare among the different Districts: (1) the seasonal variation in nuisance bear captures; (2) the age and sex composition of captured nuisance bears; (3) the incidence and causes of post-relocation mortality; (4) the post-relocation movement of nuisance bears; and (5) the effect of relocation distance on homing success.

METHODS

Study areas

For this study, data were gathered from nuisance black bear tagging studies conducted by the Chapleau, Parry Sound, and Sudbury MNR District offices.

i) Chapleau

The town of Chapleau is located in north-central Ontario and has a population of approximately 3,000 people (Figure 1-1). It is remote from other towns and is surrounded by several small First Nation Reserves. Immediately north of town is the 700,000 ha Chapleau Crown Game Preserve, which includes a minimum of 18 camping areas. Hunting of wildlife is not permitted within the boundaries of the Preserve, but no special restrictions exist with respected to forest harvesting.

Chapleau is in the Missinaibi-Cabonga region of the boreal forest (Rowe, 1972). The predominant forest is mixed deciduous-conifer, consisting of balsam fir (*Abies balsamea*), black spruce (*Picea mariana*) and white birch (*Betula papyrifera*), with scattered white spruce (*Picea glauca*), and trembling aspen (*Populus tremuloides*). Eastern white pine (*Pinus strobus*) and red pine (*Pinus resinosa*) can be found on rocky shores and ridges, although most have been removed by past logging. Sandy to gravelly soils are dominated by jack pine (*Pinus banksiana*) forests. The topography is rolling, but with numerous flats occurring along rivers and lakes.

Figure 1-1. Location of the communities of Chapleau, Parry Sound and Sudbury, from which records of tagged nuisance bears were obtained.


Ontario
Quebec
Chapleau
Sudbury
Parry Sound

Mean daily temperatures range from -17° C in January to 17° C in July, with a mean annual rainfall of 579 mm and a mean annual snowfall of 239 cm. The mean number of days with measurable snowfall is 91 (Anonymous, 1982a; 1982b).

ii) Parry Sound

Parry Sound is located in south-central Ontario, on the shore of Georgian Bay of Lake Huron (Figure 1-1). The town of Parry Sound has a population of approximately 6,000 residents with the District containing roughly 18,000 permanent residents and 66,000 seasonal residents. The Parry Sound area is a popular summer recreational area, with many cottages and six Provincial Parks.

Parry Sound is in the Georgian Bay region of the Great Lakes-St. Lawrence Forest (Rowe, 1972). The dominant trees are sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), basswood (*Tilia americana*), yellow birch (*Betula alleghaniensis*), eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), red maple (*Acer rubrum*), red oak (*Quercus rubra*), and white ash (*Fraxinus americana*). White spruce (*Picea glauca*) is common on sand flats. Although lowland areas are present, the topography is essentially hilly, rough, and irregular.

Mean daily temperatures range from -10° C in January to 19° C in July, with a mean annual rainfall of 763 mm and a mean annual snowfall of 331 cm. The mean number of days with measurable snowfall is 63 (Anonymous, 1982a; 1982b).

iii) Sudbury

Sudbury is located in central Ontario (Figure 1-1). The City of Sudbury has a population of approximately 90,000 people and is surrounded by numerous small communities contributing to a regional population of 162,000. Several additional towns and five Provincial Parks are found outside of the Regional Municipality, but within the District. The Sudbury MNR District office responded to nuisance bear reports within the Regional Municipality of Sudbury and occasionally responded to requests for assistance in outlying areas when resources were available.

Sudbury is in the Sudbury-North Bay region of the Great Lakes-St. Lawrence Forest (Rowe, 1972). Extensive disturbance from logging, fire and smelter operations has reduced or destroyed the abundance of many of the naturally occurring plant species, such that the tree cover is dominated by hardy early successional species such as, trembling aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), and white birch (*Betula papyrifera*). Distribution of tolerant hardwoods, such as sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*) is very limited. Stands of red oak (*Quercus rubra*) can be found on well-drained hilltops and ridges, while speckled alder (*Alnus incana* ssp. *rugosa*), Bebb's willow (*Salix bebbiana*), pussy willow (*Salix discolor*), and beaked hazel (*Corylus cornuta*) are common in the lowlands (Amiro and Courtin, 1981). Jack pine (*Pinus banksiana*) occurs frequently on sand flats and other coarse textured soils. Red pine (*Pinus resinosa*), eastern white pine (*Pinus strobus*), balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), and northern white cedar (*Thuja occidentalis*) are scattered where suitable soils remained. Mining and smelting operations in the Sudbury area have resulted in a reduced canopy cover and increased soil acidification, providing good conditions for the growth of blueberry shrubs (*Vaccinium* spp.). The topography in the Sudbury area is dominated by rugged outcrops of Precambrian granitic bedrock interspersed with sandy loam and coarse gravels.

Mean daily temperatures range from -14° C in January to 19° C in July, with a mean annual rainfall of 627 mm and a mean annual snowfall of 248 cm. The mean number of days with measurable snowfall is 79 (Anonymous, 1982a; 1982b).

Data collection

In all three nuisance black bear tagging endeavours, animals were tagged by local MNR staff to determine the fate of relocated bears. Captured bears were usually sedated, sexed, and ear-tagged before release. Whenever possible, a tooth was removed for aging purposes. Post-relocation movements were obtained from sightings, harvest information, recaptures, and nuisance kills. In all Districts, approximately 90 percent of captures were a result of bears repeatedly gaining access to human-based food sources.

Data were obtained from the Chapleau MNR District for the period from 1982 to 1984. In this case, exact capture and release locations were known, as well as sighting and recovery locations. A total of 21 different animals were captured and relocated from 1982 to 1983. Recovery information for tagged bears included information from1984.

The tagging information obtained from the Parry Sound MNR District office was collected from 1983 to 1996. Exact capture and release locations were known, as well as, sighting and recovery locations. A total of 82 different animals were captured and relocated from 1983 to 1995. Recovery information for tagged bears included information from 1996.

The Sudbury District MNR office began recording nuisance black bear relocations in 1990 and began tagging in 1994. During 1994 and 1995, approximately 90 percent of bears, excluding cubs, were tagged. All bears captured in 1996 and 1997 were tagged. From 1990 to 1997, approximately 202 bears were captured and 84 were ear-tagged. The exact locations of all captures and releases, as well as, sightings and recoveries were not always recorded; however, the township of capture and release was recorded. When exact locations were not available, the township center was used for the analysis. Townships in this section of central Ontario have an area of approximately 100 km^2 (10 x 10 km).

The Chapleau and Sudbury Districts relocated bears in all compass directions; however, the Chapleau District generally released animals south of the capture locations, with all bears captured within the Crown Game Preserve being relocated out of it, and the Sudbury District generally released to the north of the city. With few exceptions the Parry Sound District relocated bears to the most northerly section of the jurisdiction. Release distances were not chosen randomly in the Chapleau and Sudbury Districts, with juvenile bears often relocated a shorter distance than adults. Distances presented are straight line and do not take topographical features into consideration.

Data analysis

Whenever possible, animals were sexed and aged. Bears less than 4 years of age were grouped together as juveniles, whereas animals 4 years and older were categorized as adults (Kolenosky, 1990). When age classes were analyzed, each bear was included only once per year, even if it was captured more than once. Cubs and yearlings accompanying adult females were not used in the analyses.

To compare the seasonal variations in nuisance bear captures among the Chapleau, Parry Sound and Sudbury Districts, the total number of captures for each tagging study was calculated and the proportion of animals captured by month determined for each area.

Differences between the proportions of males and females captured and between the proportions of adults and juveniles captured, were determined using Chi-square goodness-of-fit tests. Non-parametric tests (Mann-Whitney test and Kruskal-Wallis test) were used to determine differences in mean ages to accommodate for the strong deviations from a normal distribution. When using the Mann-Whitney and Kruskal-Wallis tests, the probabilities presented assumed a Chi-square distribution.

Recovered bears were defined as relocated animals subsequently found by recapture, harvest, or reliable sightings. Ear-tags from harvested bears or bears destroyed as a nuisance by the public were returned on a volunteer basis. In Chapleau, bears demonstrating repeat nuisance behaviour were destroyed by local MNR personnel and accounted for 80 percent of nuisance kills. In Parry Sound and Sudbury, approximately 57 percent of nuisance kills were carried out by MNR personnel or local police officers, with the remaining animals destroyed by the public. In determining recovery and homing success, bears captured in the Sudbury District during 1997 were not included in the analyses due to the lack of time available for recovery.

Differences between the proportions of bears in each age and sex class that were captured and those recovered were determined using a Chi-square goodness-of-fit test. To determine whether there was a correlation between the proportion of bears recovered and the proportion of mortalities, a Spearman's correlation coefficient was calculated.

Bears were considered to have homed successfully if they returned to within 20 km of the capture site. This distance was chosen based on seasonal movement patterns of several radio-collared bears in the Sudbury area, which moved approximately 20 km from their spring use areas to summer foraging areas (pers. obs.). Bears relocated less than 30 km from their capture site were not used in the homing analyses. If bears had not homed and were harvested or killed in less than 20 days after release, they were not included when determining the proportion of recovered animals that homed successfully. Radio-collaring studies have shown that black bears tend to home quickly, with many animals capable of homing in excess of 100 km within 10 days (Rogers 1986a; pers. obs.); therefore, 20 days was deemed a sufficient time period for all animals to home considering the mean relocation distance of 70 km calculated for these Districts.

Homing success was determined using one-time data from recovered animals, irrespective of the number of times they were relocated. Two exceptions were made when bears homed from one relocation and not from the next. In these cases, both results were used for both animals. A Spearman's correlation coefficient was calculated to determine whether a relationship existed between the proportion of bears recovered and the proportion of bears that homed successfully. Differences between the proportions of bears in separate age and sex classes that homed successfully were determined using Chi-square goodness-of-fit tests.

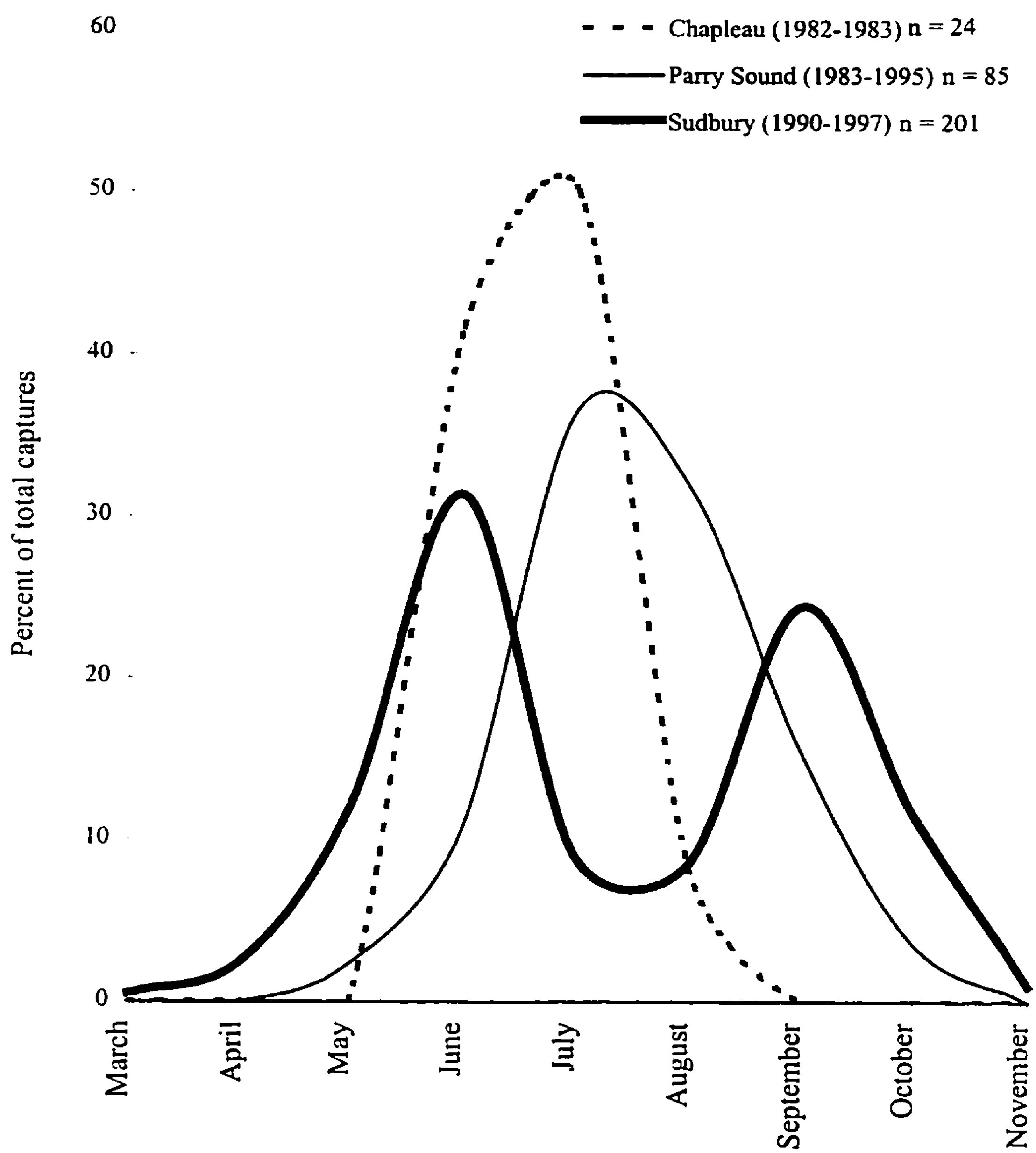
To determine the relocation distance for bears that had been relocated more than once, the longest relocation distance was used for animals that homed and the shortest for animals that did not home. In only two cases did bears home from one relocation and not the next. In these cases, both relocation distances and outcomes were used for each animal. The mean relocation distances of adult and juvenile bears that homed successfully were compared to the distances of those that did not home using Mann-Whitney tests. Variability presented for means are standard deviations.

RESULTS

Seasonality of nuisance captures

Seasonal variation in nuisance bear captures among the different Districts is illustrated in Figure 1-2. In the Chapleau District, a minimum of 80 percent of nuisance bears were captured at campgrounds within the boundaries of the Crown Game Preserve, and in Parry Sound approximately 90 percent of nuisance bear captures were a result of conflicts occurring either in local Provincial Parks or at seasonal residences. Nuisance black bear captures reached a peak during June and July in the Chapleau area, and during July and August in the Parry Sound area. In the Sudbury area, an estimated 70 percent of bears were captured at permanent residences. Nuisance bear captures in the Sudbury District had a bimodal distribution with the majority of captures occurring in the late

Figure 1-2. Percentage of total nuisance black bears captured per month in the Chapleau, Parry Sound, and Sudbury Districts.


Chapleau (1982-1983) n = 24
Parry Sound (1983-1995) n = 85
Sudbury (1990-1997) n = 201
Percent of total captures
60
50
40
30
20
10
0
March
April
May
June
July
August
September
October
November

spring (June) and early fall (September). Generally more captures were recorded in the spring than fall (Figure 1-2).

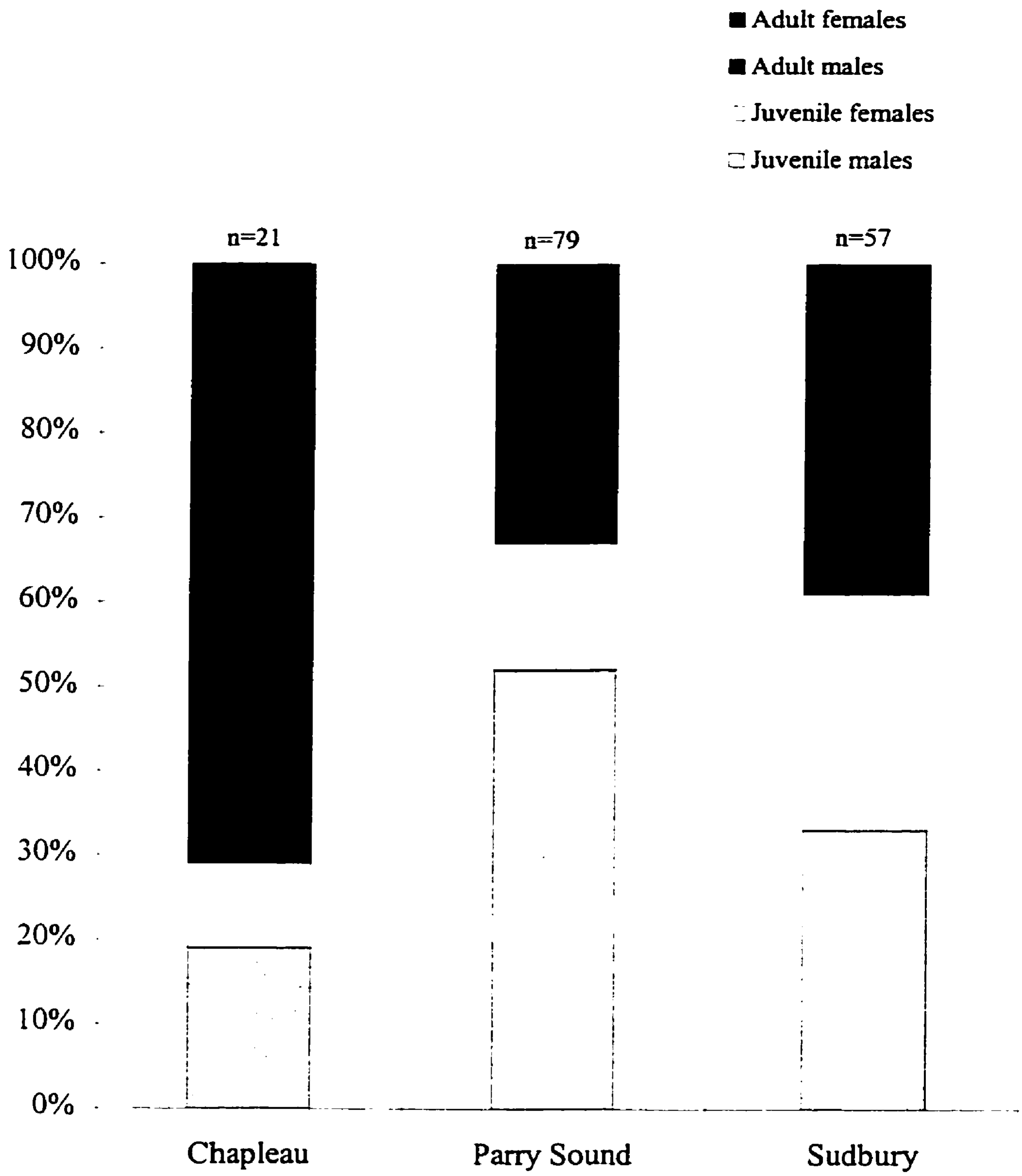
Age and sex composition

More males than females were captured as nuisance bears in both the Chapleau ($P < 0.05$) and Parry Sound ($P < 0.01$) Districts, with approximately 70 percent of captures being male (Figure 1-3). In contrast, the number of male and female bears captured in the Sudbury District did not differ significantly ($P > 0.6$).

When bears were separated into age categories, a significant difference ($P < 0.006$) in the proportions of adults and juveniles among the Districts was found. In the Chapleau District, 71 percent of captures were adults (mostly males). In the Parry Sound and Sudbury Districts, captures were 67 and 61 percent juveniles, respectively (Figure 1-3).

Mean ages of males and females in each District are listed in Table 1-1. No significant difference between the mean ages of males and females was found in the Chapleau ($P > 0.5$) and Sudbury ($P > 0.2$) Districts. However, a significant difference was found between the mean ages of males and females in the Parry Sound District ($P < 0.001$), with females having a greater mean age than males. No significant differences were found when comparing the mean ages of females among the Districts ($P > 0.6$); however, a significant difference was found when comparing the mean ages of males among the Districts ($P < 0.001$). Males in the Parry Sound District had a significantly lower mean age than those from the other two Districts.

Figure 1-3. Age and sex composition (%) of nuisance bears captured in the Chapleau, Parry Sound, and Sudbury Districts.



Adult females
Adult males
Juvenile females
Juvenile males
n=21
n=79
n=57
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Chapleau
Parry Sound
Sudbury

Table 1-1. Mean ages of relocated nuisance black bears in the Chapleau, Parry Sound, and Sudbury Districts.

District	Sex	Mean age ± s.d. (n)
Chapleau	F	4.5 ± 2.1 (6)
Chapleau	M	5.3 ± 2.9 (15)
Sudbury	F	4.0 ± 2.3 (30)
Sudbury	M	4.3 ± 4.5 (27)
Parry Sound	F	5.3 ± 4.0 (28)
Parry Sound	M	2.6 ± 2.3 (51)

Recoveries and mortalities

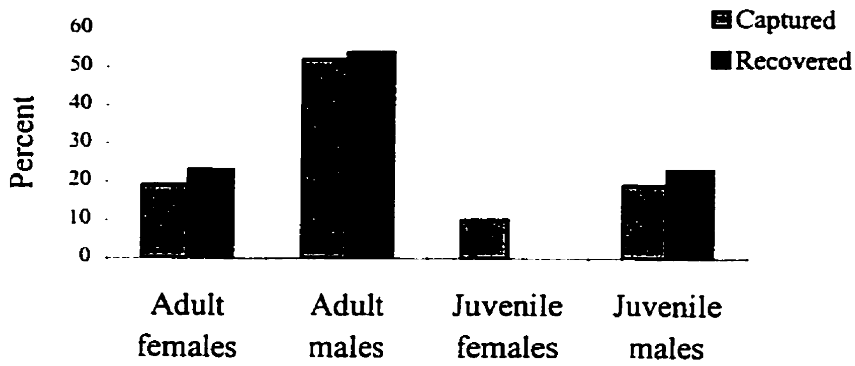
The percentage of tagged bears recovered was 60 for 25 relocations in the Chapleau District; 59 for 85 relocations in the Parry Sound District; and 31 for 112 relocations in the Sudbury District. Although the Parry Sound tagging operation was conducted for a substantially greater number of years than either the Chapleau or Sudbury operations, this had little impact on the recovery results. Only 8 percent of the tagged bears from the Parry Sound area were recovered more than 2 years after capture, 4 percent of which were recovered more than 3 years after capture.

When the age and sex composition of recovered bears was compared to captured bears, significant differences were evident in the Chapleau ($P < 0.002$) and Sudbury ($P < 0.001$) Districts (Figure 1-4). In the Chapleau District, juvenile females made up a lower proportion of the recovered bears than the captured bears, while in the Sudbury District, there was a greater proportion of adult females and a lower proportion of juvenile males in the recovered sample than in the captured sample. No significant differences were found in the Parry Sound area ($P < 0.006$), when the number of bears captured in each age and sex category was compared to the number recovered.

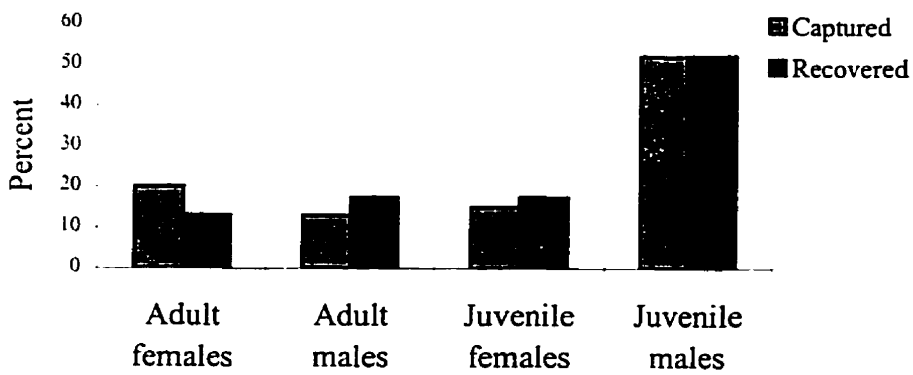
In both the Chapleau and Parry Sound Districts, there was a mortality rate of 38 percent within one year of initial capture. In the Sudbury District, however, there was only a 21 percent mortality rate within the first year. The mortality over all years was 52 percent for Chapleau, 57 for Parry Sound, and 27 for Sudbury. The proportion of recovered nuisance bears was strongly correlated ($r > 0.95$, $n = 4$) to the proportion of mortalities (Figure 1-5). The causes of mortality in each District were separated into

Figure 1-4. Age and sex composition (%) of captured and recovered nuisance bears from: A, the Chapleau District; B, the Parry Sound District; and C, the Sudbury District.

A


Captured
Recovered
Percent
0
10
20
30
40
50
60
Adult females
Adult males
Juvenile females
Juvenile males

B


Captured
Recovered
Percent
0
10
20
30
40
50
60
Adult females
Adult males
Juvenile females
Juvenile males

C

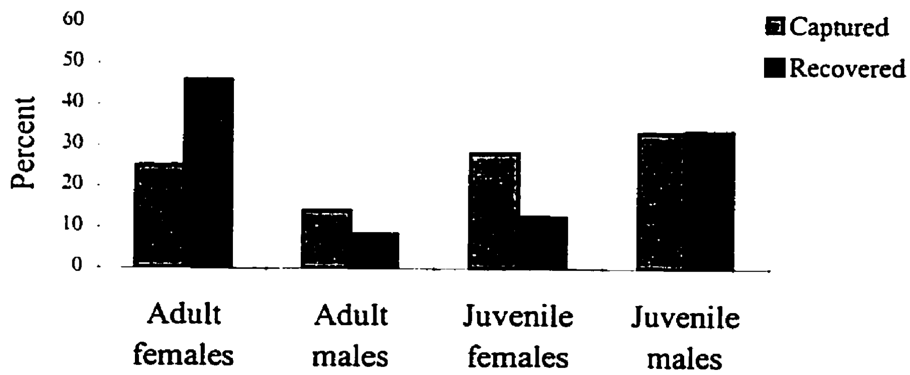
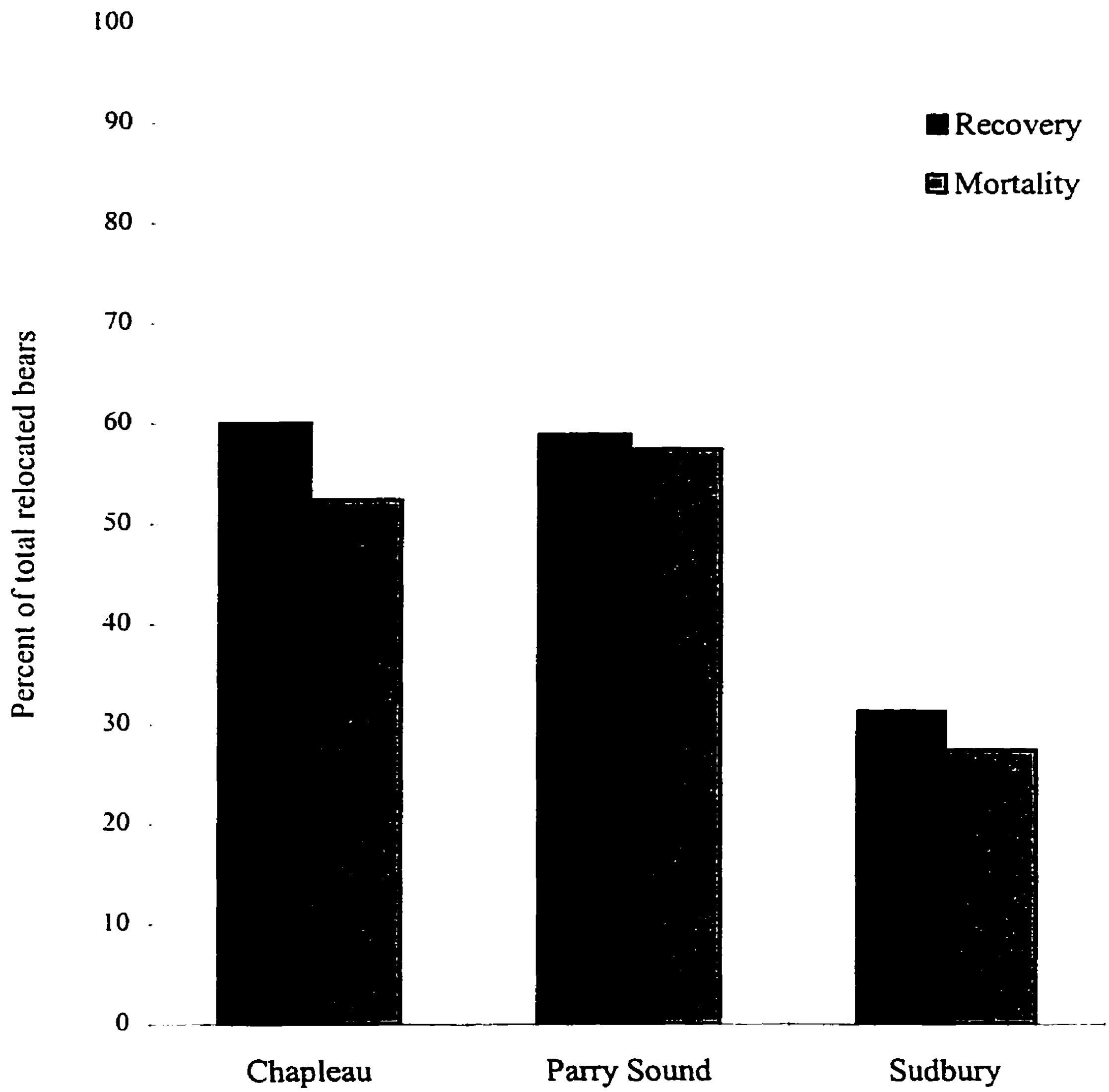

Captured
Recovered
Percent
0
10
20
30
40
50
60
Adult females
Adult males
Juvenile females
Juvenile males

Figure 1-5. Percentage of relocated nuisance bears that were recovered and the percentage that suffered from mortality for the Chapleau, Parry Sound, and Sudbury Districts.



100
90
80
70
60
50
40
30
20
10
0
Percent of total relocated bears
Recovery
Mortality
Chapleau
Parry Sound
Sudbury

categories which included; nuisance kills, harvests, and others (roadkill, trapping, etc.). Figure 1-6 illustrates that the major cause of mortality in both the Parry Sound and Sudbury Districts was hunting, while the major cause of mortality in the Chapleau District was the destruction of repeat nuisance offenders.

The proportion of bears known to have repeated nuisance behaviour varied among the Districts. The greatest proportion of repeat offenders were found in Chapleau, with a minimum of 48 percent of relocated bears known to have repeated their behaviour. In Sudbury and Parry Sound the proportions of repeat offenders were 25 and 10 percent, respectively.

Homing behaviour

The proportion of captured bears recovered was not strongly correlated to homing success ($r = -0.500$, $n = 3$). As seen in Figure 1-7, the percentage of relocated bears recovered and the percentage of recovered bears that homed were very similar in the Chapleau area. In the Parry Sound area, there was a substantially greater proportion of relocated bears recovered than recovered bears that homed, while in the Sudbury area the proportion of recovered bears was much smaller than the proportion of recovered bears that homed.

Homing results for relocated nuisance bears from the Chapleau, Parry Sound, and Sudbury Districts are presented in Table 1-2. A significantly greater proportion of adults homed than juveniles, in all three Districts ($P < 0.006$). A significantly greater proportion of juvenile females homed than juvenile males ($P < 0.04$), in both the Parry Sound and

Figure 1-6. Causes of mortality of relocated nuisance bears from the Chapleau, Parry Sound, and Sudbury Districts.

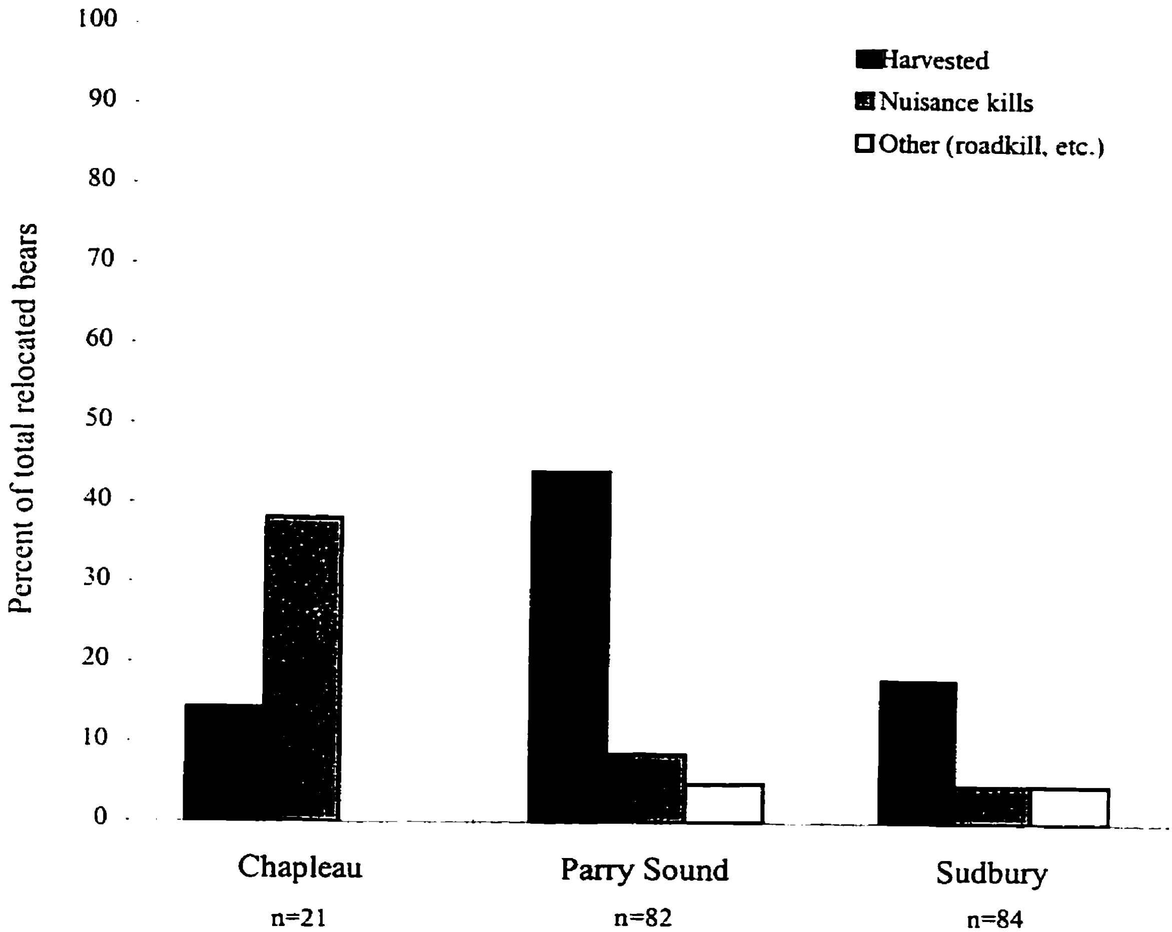
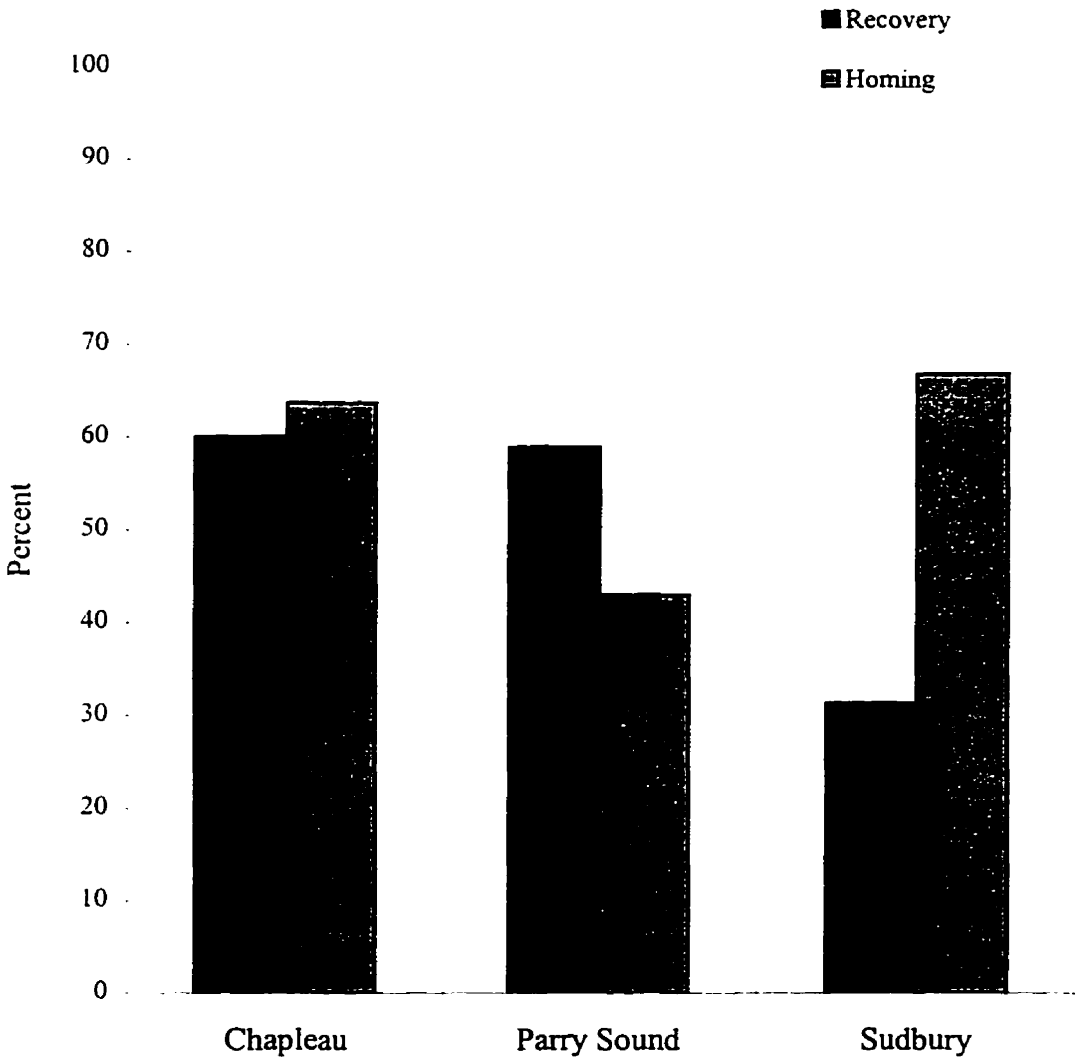

100
90
80
70
60
50
40
30
20
10
0
Percent of total relocated bears
Harvested
Nuisance kills
Other (roadkill, etc.)
Chapleau
n=21
Parry Sound
n=82
Sudbury
n=84

Figure 1-7. Percentage of relocated bears that were recovered compared to the proportion of recovered bears that homed in the Chapleau, Parry Sound, and Sudbury Districts.



Recovery
Homing
100
90
80
70
60
50
40
30
20
10
0
Percent
Chapleau
Parry Sound
Sudbury

Table 1-2. Homing success of relocated nuisance bears from the Chapleau, Parry Sound, and Sudbury Districts.

District	Homing success [a]					
	Adults	Juveniles	Adult males	Adult females	Juvenile males	Juvenile females
Chapleau	70% (7/10)	0% (0/1)	86% (6/7)	33% (1/3)	0% (0/1)	NA (0/0)
Parry Sound	73% (8/11)	29% (7/24)	83% (5/6)	60% (3/5)	22% (4/18)	50% (3/6)
Sudbury	100% (8/8)	40% (4/10)	100% (1/1)	100% (7/7)	29% (2/7)	67% (2/3)

[a] Homing success is the percentage of relocated bears that were recovered within 20 km of the capture site. Values in brackets are the number of recovered bears in each category.

Sudbury Districts. The Chapleau District was not included in this analysis due to the low proportion of juveniles recovered. A significantly greater proportion of adult males homed than adult females ($P < 0.007$), in both the Chapleau and Parry Sound Districts. The Sudbury District was not included due to the low sample of adult males recovered.

When the data from the three Districts were pooled, the mean relocation distance of juveniles that homed successfully was 57 km ($\pm$ 17), significantly ($P < 0.04$) less than the mean distance of 71 km ($\pm$ 21) seen for non-homing juveniles. The difference between the mean relocation distance of homing (82 km $\pm$ 73) and non-homing (71 km $\pm$ 22) adults was not significant ($P > 0.7$).

DISCUSSION

In localities with large influxes of seasonal visitors, such as Chapleau and Parry Sound, the temporal patterns of nuisance bear captures were unimodal and largely correlated with the increase in human activity in rural environments. In the Chapleau District, the largest number of nuisance bears were captured in the Crown Game Preserve in the early summer, when natural forage availability was still low and visitors began using the area. By late summer, wild berries became available and the number of nuisance captures decreased. In the fall, when natural forage again became scarce, the number of seasonal visitors to the area declined and the number of nuisance captures remained low. The Parry Sound area had a significant increase in the number of residents during the summer months; from 18,000 to 66,000 (R. Black, pers. comm.). As a result, even when natural forage such a wild berries may have been abundant, the number of nuisance bear reports and subsequent captures increased between the end of June and early September. By late September, hard mast such a acorns became available to foraging bears and seasonal visitors left the area. The result was a decrease in human-bear conflicts and therefore captures. It is unknown whether bears tended to congregate in populated areas during periods when human-based food sources were readily available or whether the animals were already foraging in the area and switched to human-based food sources as they became available.

In the Sudbury District, with relatively low numbers of seasonal residents in rural areas, nuisance bear captures coincided with periods of low natural forage availability, primarily the late spring and fall. This bimodal distribution of nuisance bear captures was also noted by Alt et al. (1977) in northeastern Pennsylvania, where the mid-summer blueberry crop was a major food source for bears. Correlation of nuisance bear captures and low availability of natural foods was also observed by Shull (1994) in the Interior Highlands of Arkansas.

Approximately 50 percent of nuisance bears captured in the Parry Sound District were juvenile males. This agrees with the majority of studies which have concluded that most nuisance bears are dispersing juvenile males (Harger, 1970; Rutherglen and Herbison, 1977; Rogers, 1987a; Schwartz and Franzmann, 1992; Shull, 1994).

A significantly larger proportion of adult males were captured as a nuisance from the Chapleau District, than from either the Parry Sound or Sudbury Districts. This is likely a reflection of the protection from hunting provided bears by the Chapleau Crown Game Preserve, from which 80 percent of Chapleau bears were captured. The mortality of black bears due to non-human causes has been shown to be low (Schwartz and

Franzmann, 1992; Samson and Huot, 1993; Shull, 1994). At 700 000 ha, the Chapleau Crown Game Preserve should be large enough to maintain a viable black bear population (Samson and Huot, 1993) with a low mortality rate. This would result in a greater proportion of mature animals in the game preserve than in harvested areas. Mature males with established home ranges generally use larger areas than established females (Erickson and Petrides, 1964; Jonkel and Cowan, 1971; Klenner, 1987). If sex ratios are approximately equal in the black bear population, this would be expected to result in a greater proportion of mature males without established home ranges than females. The Chapleau MNR policy of destroying nuisance bears that repeat their behaviour would provide territories for dispersing adult males in areas of the game preserve utilized by humans. Adult males have been known to severely injure and even consume, cubs, subadults, and adult female bears (Erickson, 1957; Jonkel and Cowan, 1971; M. E. Obbard, pers. comm.). Therefore, the presence of a high number of non-resident adult males in areas where nuisance captures occurred would be expected to reduce the number of bears of other age and sex classes as observed.

In the Sudbury District, the proportions of adults and juveniles captured as nuisance bears were similar to those in the Parry Sound District; however, the ratio of juvenile males to juvenile females was 1:1 in Sudbury and 3:1 in Parry Sound. The repeated relocation of adult females which homed and exhibited repeat nuisance behaviour may have affected the sex composition of nuisance animals captured in the Sudbury District. Bear cubs learn how to locate food sources from their mothers and have been known to repeat migrations to seasonal food sources several hundred kilometers away (Rogers, 1989; Schwartz and Franzmann, 1992). Therefore, it is not unreasonable to suggest that cubs of nuisance females would be more likely to exhibit nuisance behaviour. Juvenile males tend to disperse and are most likely to come into contact with humans and human-based food sources (Harger, 1970; Rutherglen and Herbison, 1977; Rogers, 1987a; Schwartz and Franzmann, 1992; Shull, 1994). In contrast, juvenile females generally take up residence in their maternal home range (Rogers, 1987a; Schwartz and Franzmann, 1992). As a result of nuisance females raising several litters near human habitations, the proportion of juvenile females captured as nuisances in Sudbury would be expected to be greater than in other areas. To test this hypothesis, kinship among captured nuisance bears would have to be determined.

In all Districts, adult bears were more likely to return to the capture area after relocation than juveniles, wherease juvenile males were least likely to return home. These results agree with those of Harger (1970) and Rogers (1986a). Most juvenile male black bears disperse between 2 and 4 years of age (Rogers, 1987a; Schwartz and Franzmann, 1992), prior to establishing home ranges. Some of the young males relocated as nuisance animals may not have been removed from established home ranges. It has been hypothesized that animals without established home ranges have low homing success due to a lack of effort rather than ability (Anderson *et al.*, 1977; Rogers, 1986b); however, homing ability may also be a result of age. It was hypothesized above that the majority of males captured in the Chapleau Crown Game Preserve did not have established home ranges, yet many of them (70%) homed. This may be a result of the greater mean age of the males from Chapleau. Many black bears cover extensive area during yearly foraging excursions (Rogers, 1987a; M.E. Obbard, pers. comm.) and these foraging excursions may allow bears to perfect orientation and homing skills, resulting in increased homing success in older bears.

In the Chapleau District, nuisance bears captured in the Crown Game Preserve were relocated to outside areas. This was done in an attempt to relocate animals to areas with lower bear densities and to expose these nuisance animals to hunting. The relocation of nuisance bears out of the preserve was unsuccessful, as the majority of adults homed successfully and were subsequently destroyed for repeat nuisance behaviour. In the harvested populations studied in this research, hunter kills provided the greatest number of recoveries, as noted by other researchers (Black, 1958; Rogers, 1987b).

The present data determined that the mean distance for homing juvenile bears was less than the mean distance for unsuccessful juveniles; however, no differences were found in the mean relocation distances of homing and non-homing adult bears. Several studies have found a reduction in homing success of relocated bears with an increase in relocation distance (Harger, 1970; McArthur, 1981; Rogers, 1984). However, the majority of these studies did not separate adults and juveniles in the analysis. The data presented in this study indicate that the relocation distances over which adult black bears are routinely relocated (30 to 150 km) are not far enough to deter homing. An adult female from the Sudbury District homed successfully from a relocation distance of 389 km (pers. obs), yet black bears transplanted from Minnesota to Arkansas (1400 to 1500 km) moved in random directions after release, apparently unable to home (Rogers, 1989). It appears that the distance from which adults can not home lies between 400 and 1400 km.

The results of the present study support the following conclusions: (1) seasonal variations in nuisance bear captures are a result of changes in the availability of natural food sources and fluctuations in seasonal human activity in rural areas; (2) age and sex classes of nuisance bears varied as a result of hunting pressure and local bear management practices; (3) homing success is dependent on age and the presence of an established home range; and (4) the distance from which juvenile bears homed was less than the distance from which they did not home but this effect of distance on homing success was not seen for adult bears (for relocation distances up to 400 km).

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Chapter 2

Post-relocation mortality and homing behaviour of radio-collared nuisance black bears (*Ursus americanus*) in the Sudbury area of central Ontario

ABSTRACT

From 1995 to 1997, 32 nuisance bears captured in the Sudbury area of central Ontario were fitted with radio-collars and tracked to determine post-relocation mortality and movement patterns. Mortality due to relocation was minimal, with only 1 bear killed by hunters within 30 days of release and one apparently preyed upon by another animal, a few kilometers from the release site. Translocated bears generally remained near the release site overnight and began moving the next morning. Adults of both sexes were more likely to home than juveniles and juvenile males demonstrated the lowest homing success. Homing bears traveled quickly (max. 18 km/day) and bears that homed once homed successfully from all subsequent relocations. Non-homing bears did not remain in the release area, with the exception of one individual. The non-homing animals did not wander randomly after release, but initially moved in a homeward direction. They subsequently reversed direction and dispersed from the homeward azimuth, usually moving along a north/south axis. A major two-lane highway (Hwy. 144) was not a barrier to the movement of relocated bears and likely had little influence on the observed movement patterns. The results are discussed in relation to some current theories on homing in birds and mammals.

INTRODUCTION

In many areas across Canada and the United States nuisance black bears (*Ursus americanus*) are live-trapped and relocated to areas of low human population in an attempt to either remove the animal permanently from the area or delay return until seasonally available food sources ripen. Of the studies that have been conducted on the homing behaviour of relocated nuisance bears (Harger, 1970; Alt *et al.*, 1977; Rutherglen and Herbison, 1977; McArthur, 1981; Rogers, 1986a; Shull, 1994), few have radio-collared animals to determine post-relocation behaviour.

Homing behaviour of animals removed from familiar territory has been recorded for several different species including; pigeons (Papi, 1992), deer mice (Bovet, 1968; Teferi and Millar, 1993), red squirrels (Bovet, 1995), raccoons (Belant, 1992), and wolves (Fritts *et al.*, 1984). As described by Papi (1992), homing by true navigation requires a map sense and a compass, where the map consists of a system of landmarks, each associated with a direction with respect to home and a compass that uses local cues to calculate the direction to home. Mammals have received far less attention with respect to homing behaviour than arthropods or birds and most mammal research has focused on small animals including rats, mice, and voles.

The location of stellar objects such as the sun and moon have been hypothesized to act as compasses. In a study conducted by Haigh (1979), ground squirrels moved towards the homeward direction, when placed in an arena which minimized auditory and olfactory cues. After being phase-shifted by 6 hours for a ten day period, squirrels released in the arena oriented in the predicted direction based on the phase-shifting, 90° off the homeward azimuth. These results suggested that solar cues are used in homing.

Geomagnetic cues have also been implicated in the homing behaviour of mammals, although it is still viewed with some skepticism (Papi, 1992). August *et al.* (1989) demonstrated that white-footed mice (*Peromyscus leucopus*) exposed to a reverse magnetic field during transportation exhibited a predictable change in orientation with respect to home. However, the results were only found to be significant in one of the two study locations.

The objectives of this study were to determine: (1) the mortality of nuisance bears due to relocation; (2) the spatial behaviour of both homing and non-homing bears; and (3) the effect of relocation distance on homing success. The results obtained in this study are discussed in relation to hypotheses on orientation and homing mechanisms.

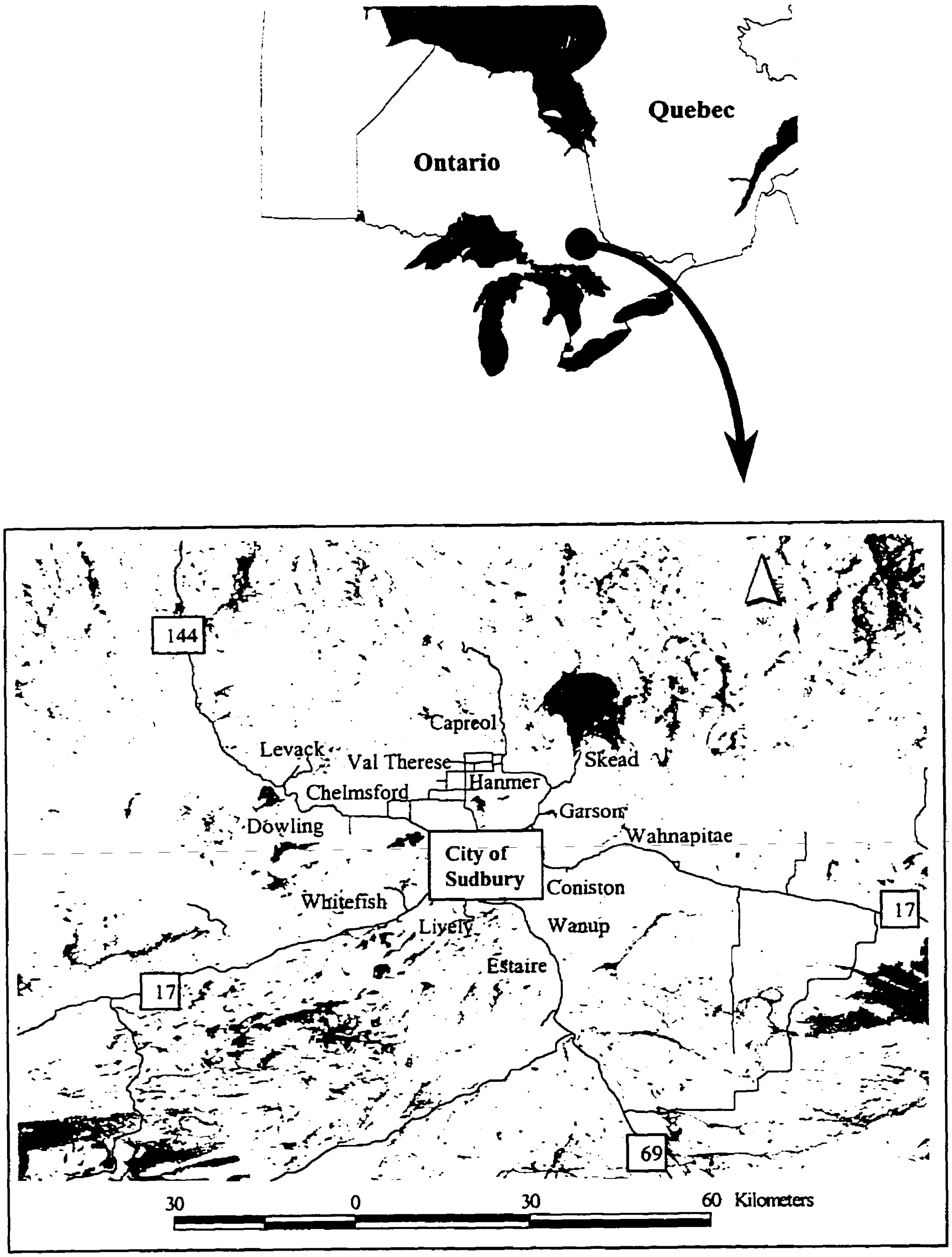
METHODS

Study area

i) Capture Locations

Nuisance black bears were captured in and around the City of Sudbury in central Ontario (Figure 2-1). The city has a population of approximately 90,000 people, with numerous nearby small towns increasing the regional population to approximately 162,000 individuals. Sudbury is located in the Sudbury-North Bay region of the Great Lakes-St. Lawrence Forest (Rowe, 1972). Extensive disturbance from logging, fire and smelter operations has reduced or destroyed the abundance of many of the naturally occurring plant species, such that the tree cover is dominated by hardy early successional species, such as trembling aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*),

Figure 2-1. The study area including the City of Sudbury and some of the surrounding communities, and the primary road network.


Quebec
Ontario
144
Capreol
Levack
Val Therese
Skead
Hanmer
Chelmsford
Garson
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and white birch (*Betula papyrifera*). Distribution of tolerant hardwoods, such as sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*) is very limited. Stands of red oak (*Quercus rubra*) can be found on well-drained hilltops and ridges, whereas speckled alder (*Alnus incana* ssp. *rugosa*), Bebb's willow (*Salix bebbiana*), pussy willow (*Salix discolor*), and beaked hazel (*Corylus cornuta*) are common in the lowlands (Amiro and Courtin, 1981). Jack pine (*Pinus banksiana*) occurs frequently on sand flats and other coarse textured soils. Red pine (*Pinus resinosa*), eastern white pine (*Pinus strobus*), balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), and northern white cedar (*Thuja occidentalis*) are found where suitable soils remained. Mining and smelting operations in the Sudbury area have resulted in a reduced canopy cover and increased soil acidification, providing good conditions for the growth of blueberry shrubs (*Vaccinium* spp.). The topography in the Sudbury area is dominated by rugged outcrops of Precambrian granitic bedrock interspersed with sandy loam and coarse gravels.

Mean daily temperatures range from -14° C in January to 19° C in July, with a mean annual rainfall of 627 mm and a mean annual snowfall of 248 cm. The mean number of days with measurable snowfall is 79 (Anonymous, 1982a; 1982b).

ii) Release Locations

All nuisance bears captured and collared during 1996 and 1997 and approximately 60 percent of those from 1995 were released northwest of the City of Sudbury along an undivided, two-lane, highway (Hwy. 144) (Figure 2-1). These translocations moved bears from the Great Lakes-St. Lawrence Forest into the Boreal Forest Biome. Although this appears to be a major change in the habitat, Hwy. 144 was bordered by extensive clear-cut forests, which provided a wide variety of early successional plant species. However, some species such as oaks (*Quercus* spp.), which supply important late-fall forage for black bears (Rogers, 1976; McDonald and Fuller, 1993), are locally abundant in the Sudbury area, but are absent or in low abundance in the Boreal Forest.

Data collection

In 1995, a pilot project was initiated by Cambrian College in collaboration with the Sudbury District MNR to determine post-relocation movement patterns of nuisance black bears. Of the 106 nuisance bears captured in the Sudbury area in 1995, 49 were ear-tagged and 11 were fitted with VHF radio-collars. Nine of the collars were previously used on deer and 2 were new bear collars. Animals were released in remote locations determined by MNR personnel, with release locations in all compass directions. Post-relocation movement patterns were determined by ground-tracking bears as long as radio-contact could be maintained. On one occasion, the relocated animals were tracked by fixed-wing aircraft. Radio-contact was permanently lost with several bears due to the fast and unpredictable post-relocation movements of the animals and the low quality signals emitted by the older deer collars.

In 1996, Cambrian College and Laurentian University in collaboration with the Sudbury District MNR developed a research project aimed at determining the fate of relocated nuisance bears. From May 1996 until September 1997, a total of 22 bears was fitted with new VHF radio-collars (Lotek Engineering Inc.) and relocated. One of these animals had originally been collared in 1995 and was fitted with a new radio-collar in

1996. Cubs and yearlings accompanying their mothers were not collared. Females with cubs or yearlings were relocated as family units.

In 1996 and 1997, all animals were relocated to the northwest of Sudbury. In 1996, three different ranges of release distances were chosen; 81-120 km, 121-160 km, and 161-200 km. Captured animals were dropped-off at the three distance ranges consecutively. For example, the first bear captured was released within 81-120 km from the capture site, the second between 121-160 km, and the third between 161-200 km. In 1997, the release distance chosen for each bear was based on the age of the animal. Adults were relocated a minimum distance of 100 km and usually more than 150 km, whereas juvenile animals were relocated between 80 and 100 km from the capture site. If a bear was captured a second time, a new release distance was chosen. The distance was increased for the second relocation when bears homed successfully from the first distance. When collared bears were recaptured in other Districts, they were relocated by local MNR personnel. In these cases, the capture and release locations were obtained and all attempts were made to maintain radio-contact with each animal. Eight bears were ground-tracked intensively for the first 24 hours after release. Animals were located every 1-2 hours and tracking ceased after 24 hours or when the animal moved out of radio-range. Animals were subsequently located by fixed-wing aircraft on a biweekly basis.

All bears were captured in mobile barrel traps or darted. A mixture of ketamine hydrochloride and xylazine hydrochloride in a 2:1 ratio (300 mg/46 kg) was used to immobilize each animal. No cubs were immobilized or tagged. All other animals were ear-tagged with either metal or plastic tags. All bears regained consciousness a minimum of 1 hour prior to release. All bears were supplied with drinking water upon recovery from immobilization and were released very close to water to minimize the possibility of dehydration.

In 1995, a premolar tooth was extracted from 8 of the 11 animals collared. All three animals that did not have teeth removed for aging were males. The lack of ages for these animals excluded them from all analyses, except the calculation of mortality. In 1996 and 1997, premolars were also extracted for aging purposes. Animals previously captured and aged by MNR personnel did not have another tooth removed. Two young animals who recovered prematurely from the immobilization did not have premolars removed. These animals were estimated to be 2 years old based on body size, sex, weight, and tooth wear. Extracted premolars were sectioned, decalcified, stained with Harris' haemotoxylin, and aged using the cementum annuli technique described by Coy and Garshelis (1992). Bears less than 4 years of age were categorized as juveniles and animals 4 years or older were considered adults (Kolenosky, 1990).

All collars used in the study were equipped with canvas or rubber inserts to allow them to be torn off, if outgrown or caught on a stationary object. The collars used in 1996 and 1997 were also colour-coded with coloured tape to enable researchers to identify animals from sightings.

Data analysis

Of the 32 different bears fitted with radio-collars from 1995 until 1997, 3 could not be located after release, 2 adult males removed radio-collars upon release, and one animal died during handling so data are available for 26 animals.

Distances presented are straight line and do not take topographical features into consideration. Relocated bears were considered to have homed successfully if they returned to within 20 km of the capture site. This distance was chosen based on seasonal movements patterns of several bears in the Sudbury area, which moved approximately 20 km from spring use areas to summer foraging areas (pers. obs.). Bears were included only once when determining homing success, irrespective of the number of times they were relocated. One exception was bear LR01, who did not home from the first relocation, but did home from the second. She was included twice. If bears had not homed and were harvested, killed, recaptured, or dropped the radio-collar in less than 20 days after release, they were not included when determining homing success, nor were they used to determine the movement patterns of non-homing bears. Other collaring studies have shown that black bears home quickly, with many animals capable of moving in excess of 100 km within 10 days (Rogers, 1986a). Therefore, 20 days was deemed a sufficient time period for all animals to home with relocation distances ranging from 62 km to 200 km.

Speeds of travel estimated for homing bears presumed that animals traveled at a constant speed and in a straight line between point locations. Animals released after 1700 hours were assumed to have remained relatively stationary until the morning. This assumption was supported by data on the initial movements of released bears.

The initial orientation of non-homing bears was determined by the first point location obtained for each animal, a minimum of 2 days after release and a minimum of 5 km from the release site (no bears moved less than 5 km from the release site). The final location was the last known location for each animal as of December 8, 1997. The angle of each point location from the homeward azimuth was calculated for the initial and final locations, for each bear with more than one post-release point location. A measure of the concentration of the resulting angles (r), and the mean angle from the homeward azimuth were calculated for the set of initial locations (initial angles) and the set of final locations. A modified Raleigh's test (V-test) was applied to determine whether the initial and final locations were distributed randomly with respect to the homeward azimuth.

For each non-homing bear with several post-release locations, the distance moved in the north/south and east/west directions between every two consecutive point locations were determined, as well as, the total cumulative distance moved in the north/south and east/west directions. The ratio of cumulative distance traveled in the north/south direction to cumulative distance traveled in the east/west direction and the ratio of maximum movement to the north/south between two consecutive locations to maximum movement to the east/west between two consecutive locations, were estimated for each bear. These data were used to determine the axis (north/south or east/west) along which non-homing bears moved most frequently and along which animals moved furthest.

Non-homing bears with multiple post-release point locations were utilized to investigate post-relocation movement patterns of these animals. Point locations were examined for each non-homing bear and all locations a minimum of 2 km from the previous location were used in the analyses. Only bears with a minimum of 3 such locations were included, with the number of locations per bear ranging between 3 and 8. For these non-homing bears, the angle of each point location from the previous location was calculated and plotted with respect to geographic north and the individual bear's homeward azimuth. Mean angles and a measure of the concentration of the resulting angles (r) were calculated for each set of angles to determine whether bears were moving along their homeward azimuth or in a specific compass direction. Magnetic north lies approximately 11° west of the geographic north utilized in this analysis.

RESULTS

Mortality

The 32 nuisance bears collared between 1995 and 1997 had a minimum mortality level of 28 percent. Five bears were harvested and only one was killed within a 30 days period after release (LR02) and only was killed within 25 km of the release site (LR02). One adult female and one male (of unknown age) were killed by members of the public for nuisance behaviour. Another adult female, which had been released with two cubs, was found dead 26 km from the release site and appeared to have been preyed upon by another animal. When discovered, the body had been scavenged and exposed to the elements for a winter and there was no sign of the cubs. One juvenile female died as a result of a twisted and ruptured stomach.

Homing

Based on the information gathered from collared bears, 78 percent of adults homed (n = 9) and 25 percent of juveniles homed (n = 12). From Table 2-1, it can be seen that juvenile males demonstrated the least homing success. Bears that homed after the first relocation, homed from all subsequent relocations, irrespective of the relocation distance (e.g. LR04). However, bears that did not home after the first relocation may have homed to the second capture site, if relocated again (e.g. LB01). Only adult females had no decline in homing success with increased relocation distance. One female (LB03) did not home from 131 km, while 3 others homed from greater distances (Table 2-1). Three adult males retained their radio-collars for more than 20 days. The two adult males that did home returned from further relocation distances than any of the juvenile animals.

Eight relocated bears were intensively tracked immediately after release. All of these animals were released in the afternoon or early evening. One juvenile male moved more than 2 km within 3 hours; however, all other bears did not move more than 1.5 km within the first 10 hours after release and appeared to wander around the release site before settling down for the night. Of these 7 bears, 4 moved out of radio-tracking range by 0700 hours the next morning.

In general, bears that homed successfully did so quickly. Table 2-2 presents estimated speeds of travel for several relocated bears that returned to the capture area. In one case, a juvenile female (LR01-2) was relocated 54 km from the capture site and was sighted 17 km from the release site the next day. She subsequently proceeded to the capture location, moving a total of 52 km within 3 days, yielding a minimum speed of 17 km per day. Adult female (LR04-1) homed at an estimated speed of 13 km per day,

Table 2-1. Relocation distance and homing results for radio-collared nuisance bears. Only bears tracked for more than 20 days after release are included. N = non-homing bears, and H = bears which homed successfully.

Relocation range (km)	Juvenile males [a]	Adult males	Juvenile females [a]	Adult females [a]
<40	LR05-2(40 km) - N			S1-1(28 km) - H S2(35 km) - H
41-80	B2(41 km) - N		LR01-2(53 km) - H LR18(76 km) - H	S1-2(79 km) - H
81-120	B3(87 km) -N LR14(88 km) - N LR05-1(92 km) - N LR11(96 km) - N B6(108) - N	LR19(119 km) - H	LR13(92 km) - H LR01-1(109 km) - N	LR04-1(105 km) - H LR09-2(119 km) - H
121-160	LR10(142 km) - N		LR06(131 km) - N	LR03(131 km) - N
161-200		LR20(158 km) - H LR12(179 km) - N		LR21(132 km) - H LR04-2(169 km) - H LR09-1(182 km) - H
> 200				LR04-3(389 km) - H

[a] If a bear was relocated more than once, the number of the relocation is found after the bear's ID; for example, LR04-2 would mean that this was bear LR04's second relocation.

Table 2-2. Estimated speeds of travel for relocated nuisance bears that homed to the capture area.

Bear ID [a]	Age category	Sex	Maximum number of days	Minimum distance traveled (km)	Estimated speed (km/day) [b]
LR19	Adult	Male	13	120	9
LR04-1	Adult	Female	20	107	5
LR04-2	Adult	Female	13	163	13
LR09-1 [c]	Adult	Female	28	197	7
LR09-2 [c]	Adult	Female	19	108	6
B4-1	Juvenile	Male	14	101	7
LR01-2	Juvenile	Female	1	17	17
LR01-2	Juvenile	Female	3	52	17
LR13	Juvenile	Female	13	96	7
LR18	Juvenile	Female	18	79	4
SUD077-079 [d]	Juvenile	Female	6	110	18

[a] If a bear was relocated more than once, the number of the relocation is found after the bear's ID; for example, LR04-2 would mean that this was bear LR04's second relocation.

[b] Speed of travel was estimated based on the assumption that the bears would travel at a relatively constant rate.

[c] Bear LR09 was missing a front leg and was captured the second time with three cubs, at which time the family unit was relocated together.

[d] Bear SUD077-079 was tagged but not radio-collared.

traveling a total of 163 km in a minimum of 13 days. A young female (SUD077-079) tagged in 1995 is included in Table 2-2. She had been captured at a restaurant, relocated, and subsequently recaptured at the same restaurant after 6 days. She was estimated to have traveled at a minimum speed of 18 km per day.

Movements of non-homing bears

Although the majority of juveniles and some adults did not home, most bears did not remain within close proximity of the release site (Table 2-3). Only one animal, a juvenile male (LR05-2), remained in the immediate release area. He was found denning 0.4 km from the release site even though he had previously been located as far away as 13 km. In all other cases, none of the bears returned to within 10 km of their release location. Of the 10 releases of non-homing bears, only 2 bears had last known point locations closer to the capture site than to the release site (Table 2-3).

Figure 2-2 presents the initial point locations for animals that did not home (A) along with final known locations (B), with respect to capture and release sites. There was a greater concentration of initial bear locations along the homeward azimuths than final locations ($r = 0.76$ and 0.34, respectively). The mean angle from the homeward azimuth was less for the initial locations (36°), than for the final locations (70°). When the initial and final point locations were analyzed, it was found that the initial locations of non-homing bears were not distributed randomly in relation to the homeward direction ($P < 0.005$; Figure 2-2A), whereas, final locations were randomly distributed in relation to the homeward azimuth ($P > 0.05$; Figure 2-2B).

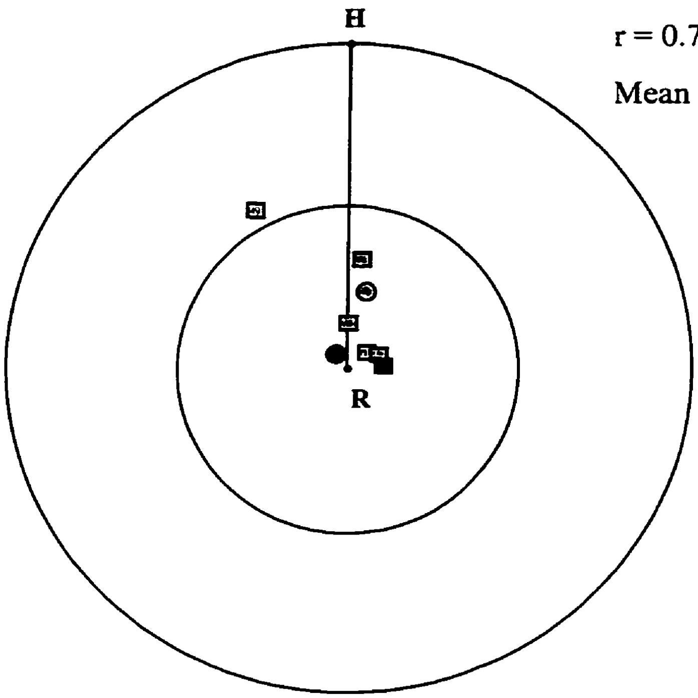
Table 2-3. Distance from last known location to the capture and release sites for non-homing nuisance bears.

Bear ID [a]	Age category	Sex	Distance from release site (km)	Distance from capture site (km)
LR12	Adult	Male	46.3	146.3
B3	Juvenile	Male	87.2	34.5
LR05-1	Juvenile	Male	40.7	128.6
LR05-2	Juvenile	Male	0.4	39.4
LR10	Juvenile	Male	79.1	84.2
LR11	Juvenile	Male	9.9	104.7
LR14	Juvenile	Male	83.9	46.9
LR01-1	Juvenile	Female	35.2	79.8
LR03	Juvenile	Female	14.4	136.4
LR06	Juvenile	Female	21.5	109.6

[a] If a bear was relocated more than once, the number of the relocation is found after the bear's ID; for example, LR05-2 would mean that this was bear LR05's second relocation.

Figure 2-2. Orientation of relocated bears that did not home: A, initial locations more than two days after release and a minimum of 5 km from the release site; B, final known locations as of December 8, 1997. The locations for each bear are relative to the release site (R) and home (H), but not to each other. The innermost circle represents one quarter of the distance to home, the next circle outward represents one half of the distance home, etc.. Dark colored circles represent adult females, dark squares adult males, light circles juvenile females, and light squares juvenile males. The value "r" is a measure of the concentration of the angles, which were calculated from each point location and the homeward azimuth (r = 1 when all points are concentrated in the same direction).

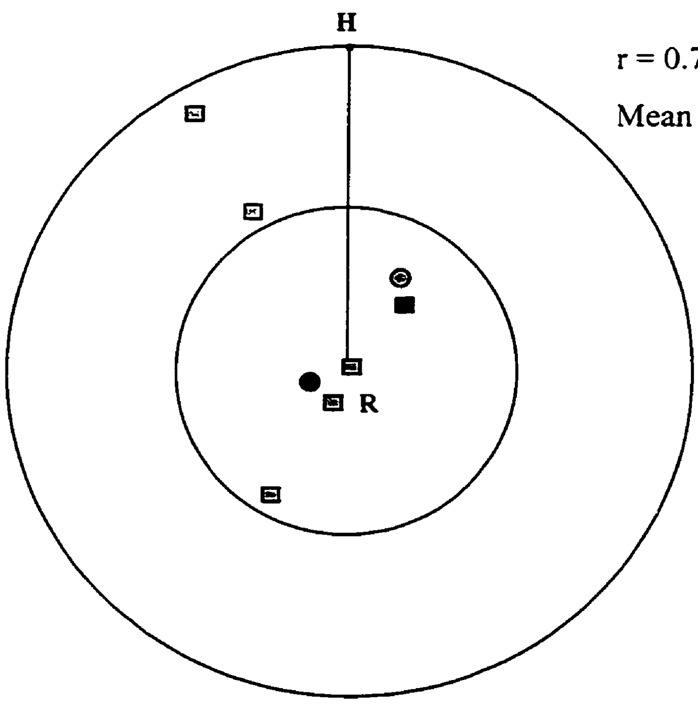
A



r = 0.76

Mean angle off azimuth = 36 degrees

B



r = 0.76

Mean angle off azimuth = 36 degrees

For some of the non-homing bears, several locations were obtained after release. All these bears had been relocated from the Sudbury area to the northwest, along Hwy. 144. There appeared to be a tendency for non-homing bears to move in a north/south direction parallel to Hwy. 144, with very little movement to the east or west (Figure 2-3). This pattern was not a result of the tracking method as bears were tracked from a fixed wing aircraft using a grid pattern that would allow animals to be located a minimum of 30 km east or west of Hwy. 144.

To determine whether non-homing bears moved greater distances in a north/south direction than in an east/west direction, the ratio of cumulative distance moved along the north/south axis over cumulative distance moved along the east/west axis was calculated. The ratio of the maximum change in distance in the north/south direction between any two consecutive point locations over the maximum change in distance in the east/west direction between any two consecutive point locations was also calculated. These two ratios for each non-homing bear with a minimum of 3 point locations more than 2 km apart are found in Table 2-4.

As seen in Table 2-4, non-homing bears generally moved a minimum of 2 times the total distance north/south than east/west and had maximum movements to the north/south 2 times further than the maximum movements to the east/west. Bears LR10 and LR01 were exceptions. Bear LR10 moved an equal distance along both axes and his two locations a substantial distance to the east of Highway 144 can be seen in Figure 2-3. Bear LR01 moved quickly to a location along her homeward azimuth and remained in that area, generally moving small distances east/west, resulting in almost equal movement along both axes.

Figure 2-3. Distribution of post-release point locations for non-homing bears. Shaded areas are populated areas and dark lines represent major roads.

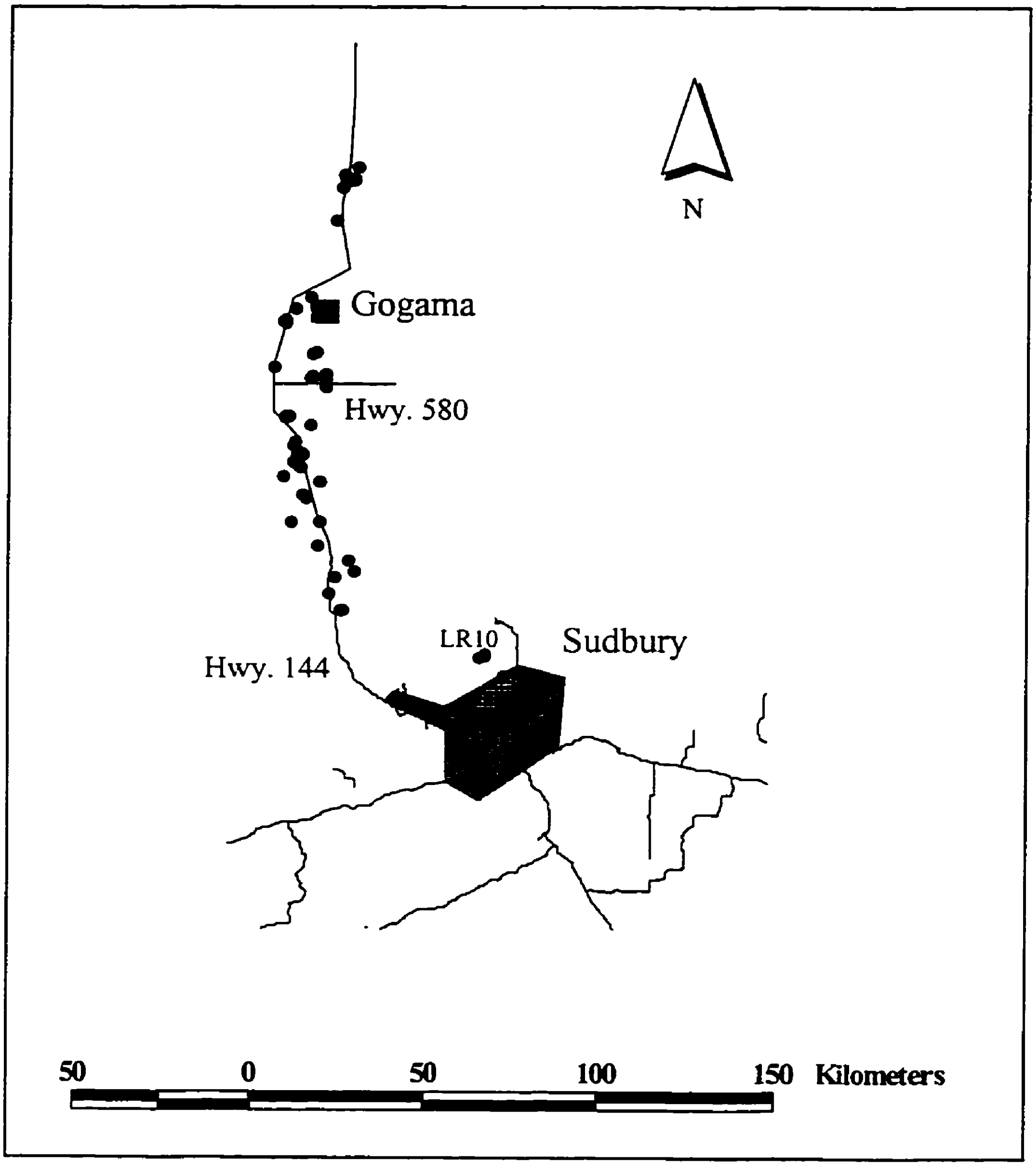

N
Gogama
Hwy. 580
LR10
Sudbury
Hwy. 144
50
0
50
100
150
Kilometers

Table 2-4. Directional post-release movements of non-homing relocated bears.

Bear's ID [a]	Cumulative distance moved - north-south / east-west	Maximum change in distance between two consecutive locations - north-south / east-west
LR01-1	1.7	1.6
LR03	3.2	4.8
LR05-1	2.2	2.6
LR05-2	2.1	2.5
LR06	2.8	3.3
LR10	1.0	1.1
LR11	2.2	3.1

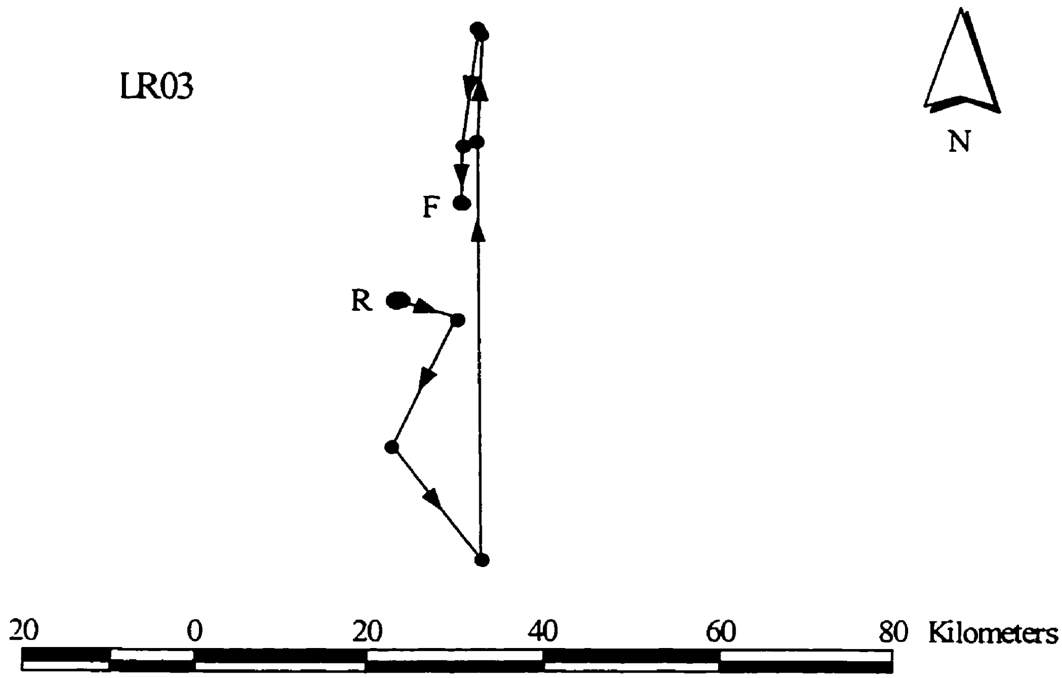
[a] If a bear was relocated more than once the number of the relocation is found after the bear's ID; for example, LR05-2 would mean that this was bear LR05's second relocation.

Of the 7 non-homing bears listed in Table 2-4, 5 reversed direction after leaving the release area. These animals initially moved to the north or south of the release site a minimum of 10 km and subsequently reversed direction and traveled past the release site (Figure 2-4). Bears did not appear to backtrack along the initial route and some individuals reversed direction more than once. This pattern was not evident in bears LR01 and LR10. Both of these animals moved a significant distance in one direction then remained in one area.

For non-homing bears, the angle of each location from the previous location was calculated and plotted in relation to the homeward azimuth (Figure 2-5A) and geographic north (Figure 2-5B). In both cases, the distribution of the angles appeared axially bimodal as angles were concentrated in opposite compass directions. The concentration of angles plotted with respect to the homeward azimuths and geographic north were both relatively low ($r = 0.42$ and 0.37, respectively). The mean angle was larger when locations were plotted relative to the homeward azimuths (23°), than when plotted relative to north (2°), implying that bears moved in a north/south direction, rather than along the homeward azimuth.

Highway 144 runs in a general north/south direction through the area where bears were released. To determine whether Highway 144 was avoided by non-homing bears and influenced post-relocation movement patterns, the minimum number of times each animal crossed the highway was determined. Of the 6 non-homing bears presented in Table 2-4, 4 crossed the highway at least twice. Of the 2 bears that apparently did not cross Highway 144, one was released on the same side of the highway as the capture

Figure 2-4. Post-relocation reversal patterns observed for non-homing bears LR03 and LR11. Dark circles represent point locations obtained between the release site (R) and the final known location (F). Arrows indicate direction of travel.


LR03
N
F
R
20 0 20 40 60 80 Kilometers

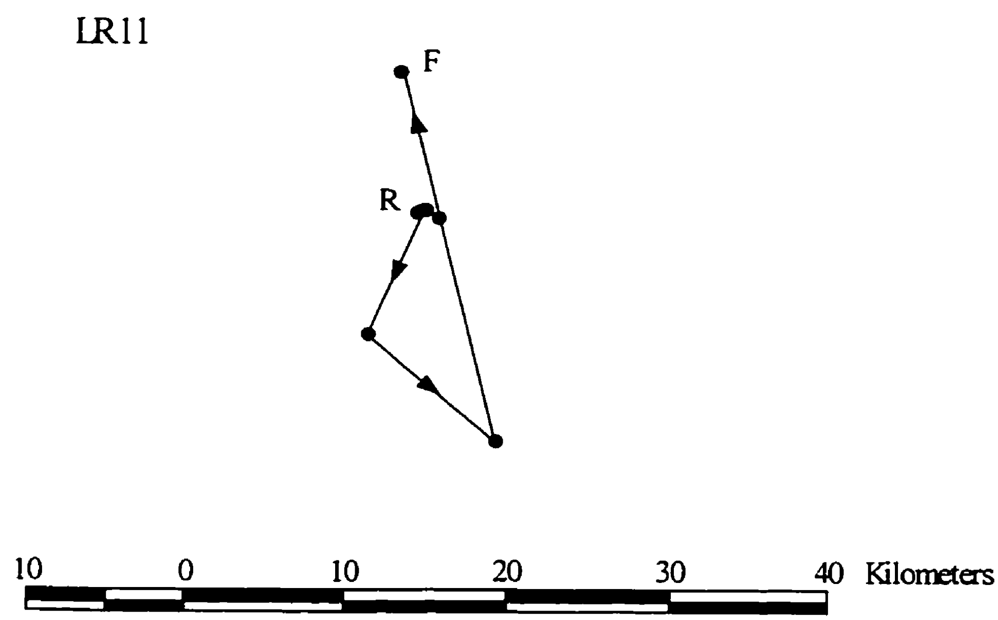
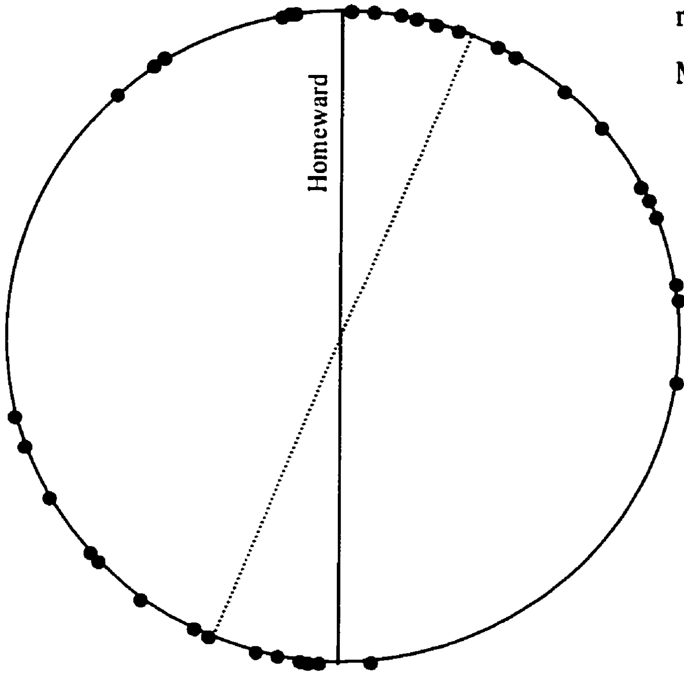

LR11
F
R
10 0 10 20 30 40 Kilometers

Figure 2-5. Post-relocation movement patterns of non-homing bears. For each bear, the angle of each location relative to the previous location was plotted as a point with respect to: A, each animal's homeward azimuth; B, north. The solid lines represent the azimuths and the dashed lines represent the mean angles. The value "r" is a measure of the concentration of the angles ($r = 1$ when all angles lie along the same axis).

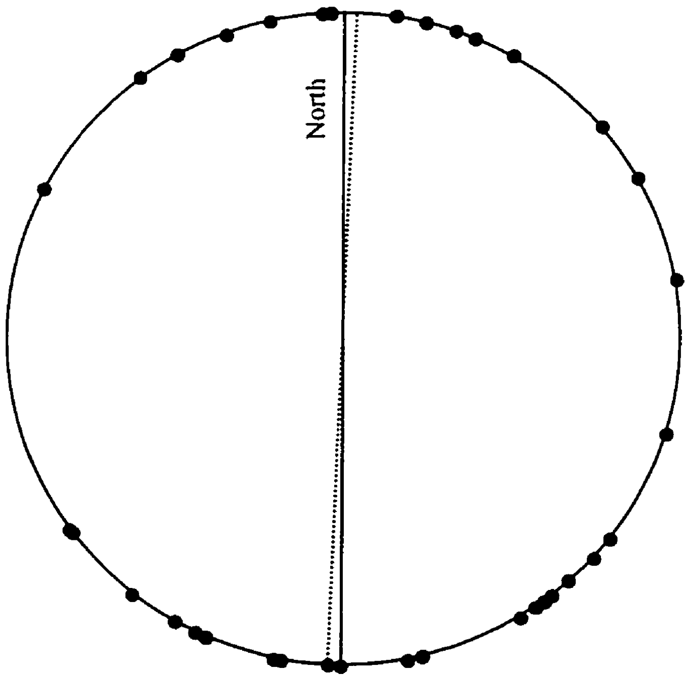
A



r = 0.42

Mean angle lies along 23 degrees

B



r = 0.42

Mean angle lies along 23 degrees

location, while the other bear was released on the opposite side of the highway as the capture location.

Case histories

During the three years of monitoring relocated nuisance bears, two animals have shown remarkable homing behaviour. Adult female LR04 was captured a total of 6 times by the Sudbury District MNR and consistently returned to her capture area (Table 2-5). This female was initially captured as a nuisance on June 20, 1994 and weighed approximately 65 kg. She was ear-tagged and was estimated to be at least 9 years old, based on the examination of premolar cementum annuli. She was relocated approximately 40 km to the south of the capture site. She was recaptured on June 14, 1995, 6 km from her first capture location. At that time, she weighed 76 kg and was lactating; however, no cubs could be found. She was fitted with a radio-collar and relocated a second time, 105 km to the north. She was subsequently recaptured on September 18, 1995, 7 km from her second capture location, weighed 147 kg, and was accompanied by three cubs. The four bears were relocated as a family unit, approximately 112 km to the north. She was recaptured again on June 8, 1996, within 17 km of her previous capture location. She weighed 67 kg and was accompanied by two yearlings. A third animal was heard in the brush, but could not be captured. The three animals were relocated 169 km to the north and LR04was subsequently captured a fifth time on July 5, 1996, within 11 km of her previous capture site. She was alone and weighed 82 kg. On this fifth relocation, she was transported 389 km to the north and was recaptured on

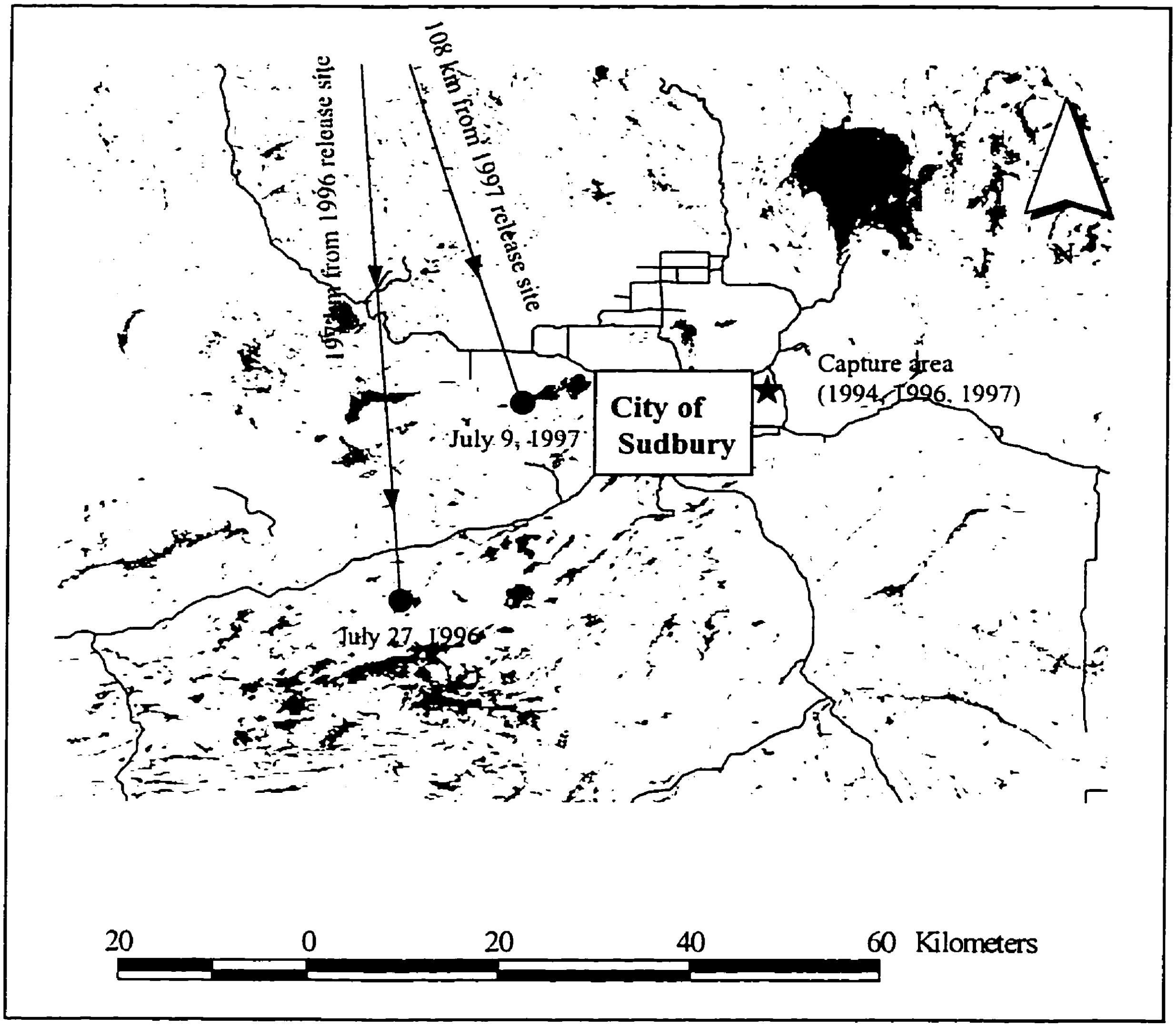
Table 2-5. Relocation history of nuisance adult female LR04.

Capture #	Date	Relocation distance	Results
1	June 20, 1994	40 km	recaptured 6 km from this capture site
2	June 14, 1995	105 km	recaptured 7 km from this capture site
3	Sept. 18, 1995	112 km	recaptured 17 km from this capture site
4	June 8, 1996	169 km	recaptured 11 km from this capture site
5	July 5, 1996	389 km	recaptured 7 km from this capture site
6	Oct. 1, 1997	100 km	N/A

October 1, 1997, within 7 km of her previous capture location. She was not wearing her radio-collar and apparently had dropped it out of range of the tracking flights. Once again, she was alone and weighed approximately 140 kg. She was relocated approximately 100 km to the north.

Another bear with a relocation history worth noting was an adult female with only three legs (LR09). This animal was first captured and ear-tagged on June 9, 1994. She was missing her front right leg, just below the shoulder. There was no evidence of scarring and fur covered the stump. She was relocated approximately 49 km to the south and was recaptured June 28, 1996, in the same area as her first capture and weighed 64 kg. At this time, she was fitted with a radio-collar and a premolar was extracted. She was estimated to be 9 years of age based on the cementum annuli. She was relocated 182 km to the north and was located by radio-telemetry on July 27, 1996, 44 km southwest of her capture location, with the City of Sudbury between her and the capture site (Figure 2-6). By August 13, 1996, she had moved within 1 km of her second capture location. She was captured a third time on June 20, 1997, weighed 64 kg and was accompanied by three cubs. These animals were relocated as a family unit, 119 km to the north. On July 9, 1997, these bears were located by radio-telemetry approximately 25 km west of the capture location. The female was sighted several times in this area with all three cubs. Instead of continuing to her capture area, she hibernated near this last location.

Figure 2-6. Post-relocation movement patterns of nuisance bear LR09 in 1996 and 1997. Dark circles are point locations obtained by radio-telemetry and the star represents the capture area.



108 km from 1997 release site
197 km from 1996 release site
City of Sudbury
Capture area (1994, 1996, 1997)
July 9, 1997
July 27, 1996
N
20
0
20
40
60
Kilometers

DISCUSSION

Data obtained on the mortality of radio-collared nuisance bears do not suggest that the relocation of these animals to unfamiliar areas increased the chance of death. Relocated bears were not particularly susceptible to hunting or predation after release, as only one bear was harvested within 30 days of release and only one of the 32 relocated bears was killed by another animal near the release site.

Adults demonstrated significantly greater homing success than juveniles and juvenile males were least likely to home. Lower levels of homing success in juvenile males has also been recorded in Alaskan brown bears (Miller and Ballard, 1982). Most juvenile male black bears disperse between 2 and 4 years of age (Rogers, 1987a; Schwartz and Franzmann, 1992), before establishing home ranges. It has been hypothesized that having an established home range is a motivating factor in bear homing. When animals without established home ranges are displaced their lack of homing success may be a result of a lack of effort rather than ability (Anderson *et al.*, 1977; Rogers, 1986b). The greater homing success of juvenile females than juvenile males observed in the present study supports this hypothesize. Many juvenile females take up residence in their maternal home range (Rogers, 1987a; Schwartz and Franzmann, 1992) and as a result more juvenile females than juvenile males would have established home ranges.

Bears that homed successfully after the first relocation were successful after all subsequent relocations. This was also observed by Blanchard and Knight (1995), who determined that the homing success of grizzly bears increased with the number of times that the animals had been relocated. These results suggest that homing ability may be enhanced with experience. Adult female LR04 homed after being relocated 389 km to the north of her capture location. This appears to be a record distance for homing in black bears although it represents the absolute minimum distance traveled by this animal. Homing pigeons are commonly trained by gradually increasing the displacement distance from the home loft, and young birds displaced too far early in their training do not home successfully (Papi, 1992). The successful return from a relatively short distance appears to enhance homing effort and/or skill, and increases the chance of an animal homing successfully from longer distances. Inadvertent training by gradually increasing the relocation distances may explain the extraordinary homing feat accomplished by bear LR04.

The presence of cubs may reduce homing effort. Accompanied by three cubs, female LR09 retraced the route she had utilized when relocated alone the year before. However, she ceased any directional movement approximately 25 km from home and remained in the area, eventually hibernating there. This behaviour may have been a reaction to the physiological needs of the cubs. After having traveled a substantial distance, the cubs may have been in poor condition, although they appeared quite lively when sighted. A good blueberry crop and readily available food scraps from hunter bait sites in the area provided LR09 and her cubs with the high energy diet required for them to survive. Rogers (1987a) found that starvation was the main cause of death among yearlings and cubs, and that lightweight yearlings were most likely to starve after emergence from the den in the spring.

With few exceptions, non-homing bears did not remain near the release site. This was also noted by Harger (1970) and Shull (1994). Non-homing bears in this study tended to move in a homeward direction initially, before deviating from the homeward azimuth. This suggests that these animals were able to orient themselves in the homeward direction, although they subsequently did not home. This initial homeward orientation and movement of non-homing bears was also observed by Miller and Ballard (1982) and Rogers (1987b). In the present study, non-homing bears reversed direction after an initial homeward excursion and tended to move in a north/south direction, parallel to the major highway near the release site. The reversal of direction from generally well-oriented routes has also been recorded for other displaced animals including; deer mice (Bovet, 1968), wolves (Fritts *et al.*, 1984), and marten (Slough, 1989). This reversal of direction appears to represent exploratory behaviour or as expressed by Bovet (1968), a state of "uncertainty". Data from this study support the conclusion that non-homing bears do not wander randomly after release. The repetition of this reversal pattern irrespective of release site excludes the possibility that bears were reacting to local conditions, such as the presence of territorial bears or the direction of watercourses or secondary roads. The majority of bears crossed Hwy. 144 at least once; therefore, it was concluded that the movement of non-homing bears along a north/south axis was not a result of bears traveling along the highway rather than crossing it. Miller and Ballard (1982) also concluded that two-lane highways were not barriers to homing in bears, although Shull (1994) found that none of the relocated bears in Arkansas crossed the four-lane, divided highway in the study area.

The results of the present collaring study agreed with those obtained for tagged nuisance bears in the Sudbury area. The estimates of mortality were the same at 28 percent and both studies determined that adults were more likely to home successfully than juveniles and that juvenile males were least likely to home. Although the sample size was limited for collared animals, both studies agreed that increases in relocation distance reduced homing success in juvenile bears, but had little effect on the homing success of adults.

To study true navigation, animals must be removed from familiar areas and cannot home by random wandering or relying on route based information (Papi, 1992). The data from this study support the conclusion that black bears use true navigation. The long distances over which bears were relocated precluded familiarity with either the release area or other bears near the release site. The proximity of the initial movements of relocated bears to the homeward azimuth also precluded random wandering in search of home, even for non-homing bears. Many of the bears in the present study were unconscious for part of the transportation period to the release site, excluding the gathering of information over the entire outbound route. In other studies on homing in bears, animals were unconscious during the entire transportation period (Harger, 1970; Miller and Ballard, 1982; Rogers, 1986a) and still homed in proportions similar to bears in studies that did not involve sedation during transportation (Alt *et al.*, 1977; McArthur, 1981; Shull, 1994). Assuming that black bears do not store sensory information while unconscious, these studies would suggest that bears do not home using only the cues obtained along the relocation route.

Although one juvenile male left the release site shortly after release and moved 4 km in the homeward direction, the majority of relocated bears wandered around the release site and settled in the area overnight. These animals all left the release site the following day and many bears moved out of radio-tracking range by 0700 hours. This diurnal activity pattern was consistent in all radio-collared bears. This behaviour has also been described by Harger (1970). The diurnal activity patterns displayed by relocated black bears in this study support the conclusion that bears do not use celestial bodies in the night sky (e.g. moon, stars) as a compass or as a means of determining their position relative to home.

Data have suggested that many different organisms use the geomagnetic field of the earth as a compass including; bacteria (Frankel *et al.*, 1981), bees (Gould, 1980), birds (Papi, 1992), and mice (Mather and Baker, 1981; August *et al.*, 1989). The radio collars utilized in this study have minimal influence on hand-held compasses and therefore, they would be unlikely interfere with geomagnetic orientation. The observed tendency of non-homing bears to move along a north/south axis suggests a magnetic influence. However bears were moving with respect to geographic north and not magnetic north. Magnetic north lies approximately 11° west of geographic north.

Evidence suggests that pigeons are able to create an olfactory map of their home (Papi, 1992) and orient based on this map. If bears can create olfactory maps of home ranges and navigate based solely on olfactory cues obtained at the release site, the distances over which they could home would depend on the acuity of their sense of smell and on the quantity and quality of the olfactory information forming the map of home. Older animals which have inhabited an area for longer periods of time should have a more complete olfactory map of home and should be more capable of homing successfully. This hypothesis was supported by the fact that adults demonstrated a greater homing ability than juveniles. With a complex olfactory map of home, wind blown cues from any direction could conceivably aid in orientation (Rogers, 1986a).

Most relocated bears were released a short distance (1-5 km) off dirt roads perpendicular to Hwy. 144. If the non-homing bears were moving in response to olfactory cues obtained during the final phase of transportation, they would have been expected to move in a north/south direction slightly off the highway, as observed.

It is likely that bears utilize a combination of cues to determine their location with respect to home. A recent model developed by Kohler (1994) uses the earth's magnetic field along with the azimuth of an extraterrestrial object (e.g. sun or moon) to determine the homeward direction for relocated animals. Theoretically, this model allows animals to return home from any location on the earth. However, the distance over which black bears have homed successfully is not limitless. Although bear LR04 managed to home from 389 km, black bears transplanted from northern Minnesota to Arkansas (1400 to 1500 km) did not home and moved in random directions, sometimes several hundred kilometers away from the release site (Rogers, 1989).

In summary, the data support the following conclusions: (1) tagging studies are adequate means of estimating mortality and homing success for relocated nuisance bears; (2) relocation does not expose nuisance bears to increased mortality; (3) homing success is dependent on homing experience and the presence of an established home range; (4) increases in relocation distance reduce homing success in juvenile bears, but has little effect on the homing success of adults; (5) non-homing bears do not wander randomly after release, but orient along the homeward azimuth initially then reverse their direction; (6) two-lane highways are not barriers to bear homing; and (7) relocated bears do not home based on cues only visible at night (e.g. moon, stars).

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Chapter 3

Mortality, seasonal movement patterns, and nuisance behaviour in black bears (*Ursus americanus*) utilizing hunter bait sites in the Sudbury area of central Ontario

ABSTRACT

Bears captured at hunter bait sites were radio-collared in two different areas near the City of Sudbury, Ontario. The Windy Lake area had a low human population and few roads, while the Estaire area had a higher human population and a more extensive road network. Two bears were collared in the Windy Lake area between 1996 and 1997 and 14 bears were collared in the Estaire area during 1997. The mean home range sizes in the Estaire area were 104 km^2 (sd = 79) for females and 87 km^2 (sd = 40) for males. Home ranges overlapped extensively for all bears in the Estaire area. Approximately 70 percent of the bears from the Estaire area undertook mid-summer foraging excursions north of their spring and fall use areas, even though forage was relatively abundant throughout the region. This type of movement was not observed in either of the Windy Lake animals. Bears in the Estaire area foraged at a local landfill site; however, these animals did not limit their home ranges to the immediate area and moved away from this location during blueberry season. Neither of the collared bears in the Windy Lake area were lost to hunting or other causes of mortality. The Estaire bears had a mortality rate of 50 percent and all deaths were due to hunting, including a single illegal harvest at the landfill site. The incidence of nuisance behaviour for baited bears was low (25%), although the majority of animals frequently moved through residential areas. Four of the 16 collared

bears were classified as nuisance animals over the duration of the study. Two of these bears had previously been fed table scraps by seasonal residents and the other two were known to frequent the landfill site.

INTRODUCTION

In Ontario, there are spring and fall hunting seasons for black bears, *Ursus americanus*. The spring hunt generally occurs between mid-April and mid-June, whereas the fall hunt opens at the beginning of September and ends in mid-October. The most popular method of hunting black bears in Ontario is by baiting (Lompart, 1996). Hunters choose a location in the forest where bears are likely to be found and leave out food (meat, grain, donuts, etc.). Most hunters pre-bait sites to attract bears before the hunting season begins, in an attempt to ensure that the bears will become habituated to foraging in these locations. Once a bear is known to frequent a bait site, hunters will position themselves near the bait, generally in tree-stands, and will kill the bear when the animal approaches the food. In Ontario, baiting is practiced by 74 percent of bear hunters and accounts for 85 percent of all harvested black bears (Lompart, 1996). The remaining 15 percent of bears are obtained by still hunting without baits, stalking, driving, or with the use of dogs.

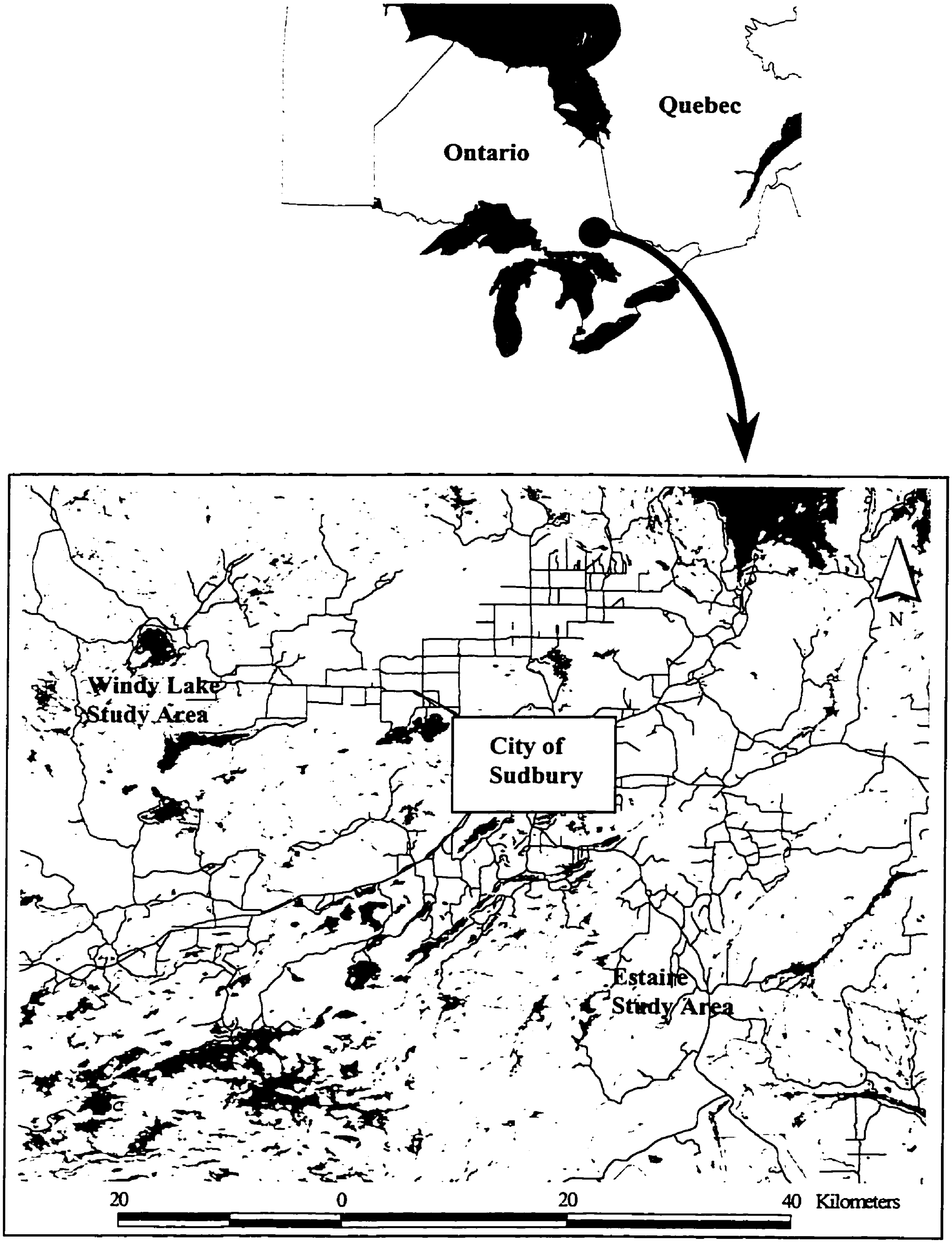
It has been suggested by groups against the hunting of bears at bait sites that baiting may result in the habituation of bears to human scent and that this association with easily accessible food fosters nuisance behaviour. Research focusing specifically on the behaviour of baited black bears has not been conducted to date. It has been hypothesized that bears foraging on bait sites would seek other human-based food sources when baiting ceased. In this study, radio-collared bears known to forage at bait sites established by local harvesters were radio-collared and tracked to determine the incidence of nuisance behaviour after baiting ceased. From data gathered for these animals rates of nuisance behaviour, movement patterns, use of local landfills, and mortality rates are described.

METHODS

Study areas

Both the Windy Lake and the Estaire areas are in the Sudbury-North Bay region of the Great Lakes-St. Lawrence Forest (Rowe, 1972). The Windy Lake area is located approximately 30 km to the northwest of Sudbury, Ontario and the Estaire area is located approximately 25 km south of the city (Figure 3-1). These two areas are similar with respect to forage species available to bears. However, in Estaire, an abandoned prison farm provides a substantial amount of open grassland, with a broad choice of early spring forage. The Estaire area also contains a landfill site which was active throughout the course of this study. In both areas, disturbance from logging, fire, and smelter operations has reduced, or destroyed, the abundance of many of the naturally occurring plant species, such that the tree cover is dominated by hardy early successional species, such as trembling aspen (***Populus tremuloides***), balsam poplar (***P. balsamifera***), and white birch (***Betula papyrifera***). Distribution of tolerant hardwoods, such as sugar maple (***Acer saccharum***) and yellow birch (***Betula alleghaniensis***) is very limited. Stands of red oak

Figure 3-1. Location of the Windy Lake and Estaire study areas near the City of Sudbury in central Ontario.



Quebec
Ontario
Windy Lake
Study Area
City of
Sudbury
Estaire
Study Area
N
20
0
20
40 Kilometers

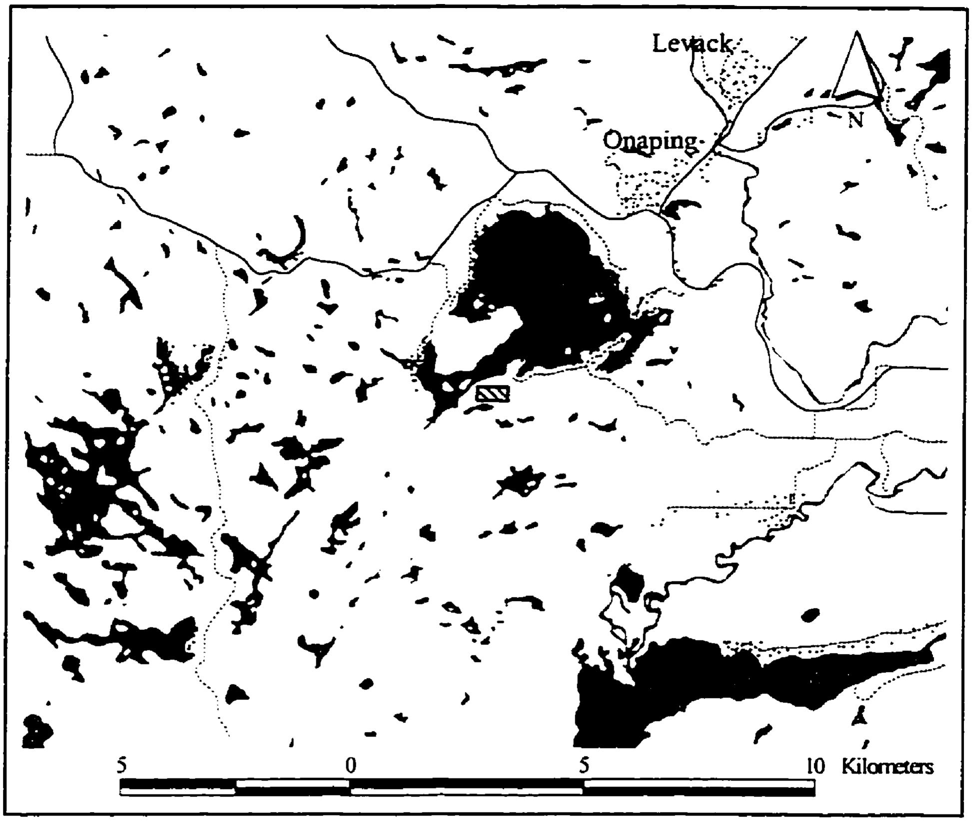
(*Quercus rubra*) can be found on well-drained hilltops and ridges and speckled alder (*Alnus incana* ssp. *rugosa*), Bebb's willow (*Salix bebbiana*), pussy willow (*Salix discolor*), and beaked hazel (*Corylus cornuta*) are common in the lowlands (Amiro and Courtin, 1981). Jack pine (*Pinus banksiana*) occurs frequently on sand flats and other coarse textured soils. Red pine (*Pinus resinosa*), eastern white pine (*Pinus strobus*), balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), and northern white cedar (*Thuja occidentalis*) are scattered where suitable soils remained. Mining and smelting operations in the Sudbury area resulted in a reduced canopy cover and increased soil acidification, providing good conditions for the growth of blueberry shrubs (*Vaccinium* spp.). Blueberries are very common in both study areas though there was a more homogeneous distribution in the Estaire area. In both areas, the topography consists mostly of rugged outcrops of Precambrian granitic bedrock interspersed with sandy loam and coarse gravels.

Mean daily temperatures range from -14° C in January to 19° C in July, with a mean annual rainfall of 627 mm and a mean annual snowfall of 248 cm. The mean number of days with measurable snowfall is 79 (Anonymous, 1982a; 1982b).

There is a greater number of permanent residences and a more complex network of roads in the Estaire trapping areas than in the Windy Lake trapping area (Figure 3-2). The Estaire area is bisected by a major highway (Hwy.69) and has numerous secondary roads and trails. In the Windy Lake area, Hwy.144 is situated along the north shore of the lake and only one secondary road and a few trails are found to the south of the lake, where bears were trapped. In both areas an estimated 60 to 80 percent of residents along lake shores are seasonal.

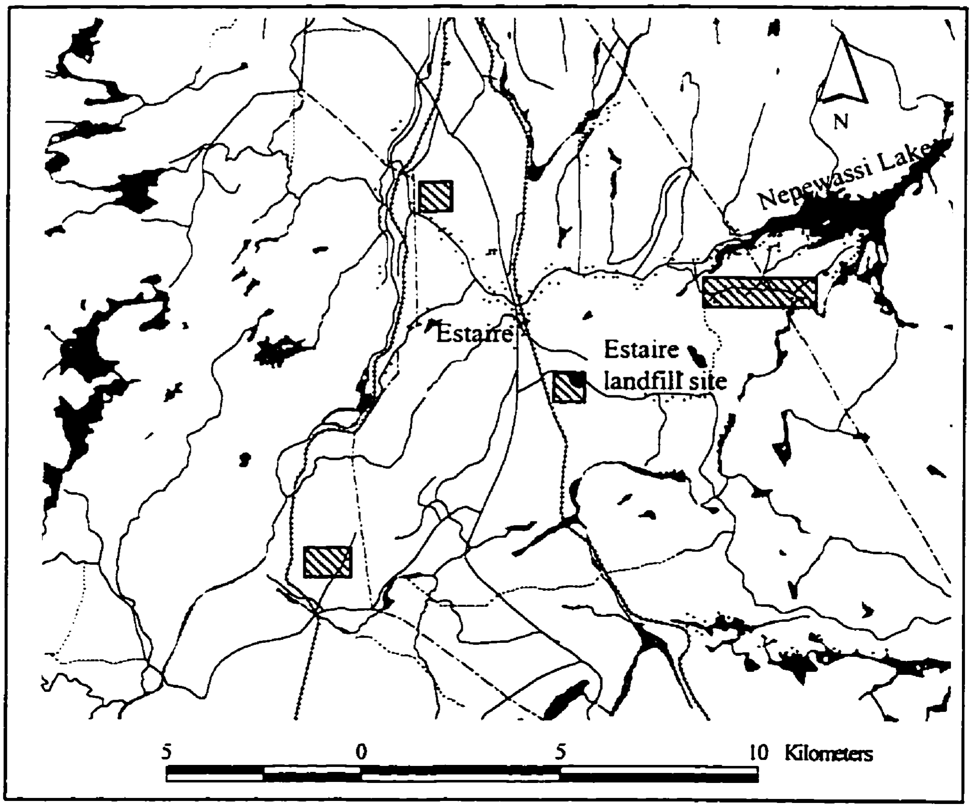
Figure 3-2. The Windy Lake (A) and Estaire (B) study areas. Hatched sections identify baited areas, where traps were set during 1996 and 1997. The dark circle in the Estaire area represents the landfill site.

A



Levack
Onaping
N
5
0
5
10 Kilometers

B



N
Nepewassi Lake
Estaire
Estaire
landfill site
5
0
5
10 Kilometers

Data collection

In the spring of 1996, a new bait site was established south of Windy Lake (Figure 3-2). One barrel trap was placed on this site and was used to capture bears in the spring of 1996 and 1997. In 1996, trapping was conducted from early May until late July and in 1997, trapping began in early May and continued to mid-June.

In 1997, black bears were also trapped in the Estaire area on bait sites established by local outfitters and at the local landfill site (Figure 3-2). Traps were placed at 6 different bait sites including the landfill, with one barrel trap per site. Bears were trapped from early May to mid-June, concurrent with the spring black bear hunt. Bait sites with traps were also utilized by hunters; however, traps were closed when sites were in use.

Bait included apples, donuts, meat, and fish, and was left at all sites a minimum of one week before bear capturing efforts began and a minimum of one week after the last animal was captured. All bears were captured in barrel traps and immobilized with a mixture of ketamine hydrochloride and xylazine hydrochloride in a 3:1 ratio (200mg/46 kg). All captured animals were ear-tagged and fitted with VHF radio-collars (Lotek Engineering Inc.) equipped with canvas or rubber inserts to allow collars to be torn off if outgrown or caught on a stationary object. A premolar tooth was extracted from each animal, sectioned, decalcified, and stained with Harris' haemotoxylin. Age was estimated using the cementum annuli technique described by Coy and Garshelis (1992). Bears less than 4 years of age were categorized as juveniles and animals 4 years or older were considered adults (Kolenosky, 1990).

Windy Lake bears were tracked a minimum of once per week from spring until fall, whereas the Estaire animals were tracked at least twice per week in early spring and late fall and a minimum of 5 times per week during the summer months (July and August). This resulted in a substantially greater number of point locations for animals in Estaire, than those in the Windy Lake area. Collared bears were generally ground-tracked; however, aerial tracking was conducted whenever ground-tracking efforts were repeatedly unsuccessful. The bear captured in the Windy Lake area in the spring of 1996 was only tracked until fall 1996. All other bears were tracked until hibernation in the fall of 1997 unless collars were lost. Mortality was estimated from the time of capture to the spring of 1998 and is a minimum as some bears did not keep radio collars for the entire time.

Data analysis

Home range sizes were determined using the minimum convex polygon method (White and Garrott, 1990) and were only calculated for bears tracked from spring to fall. Due to the small sample sizes, a non-parametric test (Mann-Whitney test) was used to determine whether differences existed between the home range sizes of males and females. Variability presented for means are standard deviations.

Qualitative data obtained while ground-tracking during 1996 and 1997 indicated that the blueberry crop began to ripen in mid-July (Julian date 200) and continued through to mid-September (Julian date 265). During 1996 and 1997, blueberries were abundant throughout the Sudbury region and persisted until late October.

Collared bears were categorized as nuisance animals only after a report was made to the Sudbury District Ministry of Natural Resources (MNR) and the animal was positively identified by ministry or research personnel. Collars were easily visible and aided in the positive identification of nuisance bears. Bears located in close proximity to human habitation were not listed as nuisance animals unless reported.

RESULTS

All bears captured in this study had used bait sites established by local harvesters. Although the two Windy Lake animals were originally captured at new bait sites created for the study, they were also located several times at hunter bait sites approximately 5 km from the capture area. The three bears captured at the Estaire landfill were each located at bait sites established by a local outfitter at least once.

During 1996 and 1997, a total of 16 bears was captured. Two juvenile males were captured in the Windy Lake area (LB01 was captured in 1996 and LB03 was captured in 1997). Fourteen animals were captured in the Estaire area in 1997 (4 females and 12 males). The oldest of the adult males (LB14) had a crippled front paw, but was otherwise in excellent condition. The majority of captured bears were young males (Table 3-1). The mean age of males was 2.5 years in the Windy Lake area and 4.6 years in Estaire. The mean age of females from the Estaire area was 5.5 years.

Table 3-1. Age, sex, and home range size of bears captured at bait sites.

Study area	ID	Sex	Age	# of point locations used in home range calculation	Home range size (km^2) [a]
Windy Lake	LB01	M	3	17	12.12
Windy Lake	LB03	M	2	19	30.22
Estaire	LB02	M	2	56	77.05
Estaire	LB04	M	4	-	N/A
Estaire	LB05	M	12	-	N/A
Estaire	LB06	M	2	44	34.77
Estaire	LB07	M	4	24	107.3
Estaire	LB09	M	2	52	137.4
Estaire	LB12	M	3	30	118.2
Estaire	LB13	M	4	45	91.67
Estaire	LB14	M	11	38	22.99
Estaire	LB16	M	2	65	109.6
Estaire	LB08	F	4	-	N/A
Estaire	LB10	F	14	49	149.2
Estaire	LB11	F	2	55	11.81
Estaire	LB15	F	2	55	149.6

[a] Home ranges were estimated using the minimum convex polygon method.

Home range estimates

Home ranges were estimated for 13 baited bears tracked from spring to fall in the year of capture (Table 3-1). The mean home range size of females in the Estaire area was 104 km^2 ($\pm$ 79), whereas, the mean home range size for males in the Estaire area was 87 km^2 ($\pm$ 40). No significant difference was found in home range size between the sexes ($P > 0.4$). The mean home range size of the 2 juvenile males in the Windy Lake area was 21 km^2, whereas the mean home range size of juvenile males in the Estaire area was 95 km^2.

The spatial arrangement of home ranges of the Windy Lake and Estaire baited bears are illustrated in Figures 3-3 and 3-4, respectively. Figure 3-4 illustrates the overlap in home ranges of the bears captured in Estaire in 1997.

Seasonal movement patterns

Locations obtained for bears in the Windy Lake area did not show any seasonal movement patterns. Neither bear showed a directional displacement as forage species and availability changed throughout the year, or returned to the capture area (spring use area) in the fall (Figure 3-5). However, the limited number of point locations obtained for these animals may have been too few to reveal any existing patterns.

Eight of the 11 Estaire bears tracked from spring until fall moved away from their capture areas (spring use areas) during blueberry season and subsequently returned in the fall. As illustrated in Figure 3-5, this movement away from the spring use area was found to be consistently to the north. Three Estaire bears did not display this pattern. A juvenile male (LB09) moved northward early in the summer and subsequently moved

Figure 3-3. Home ranges of bears captured at bait sites in the Windy Lake area. Home ranges were estimated by the minimum convex polygon method.

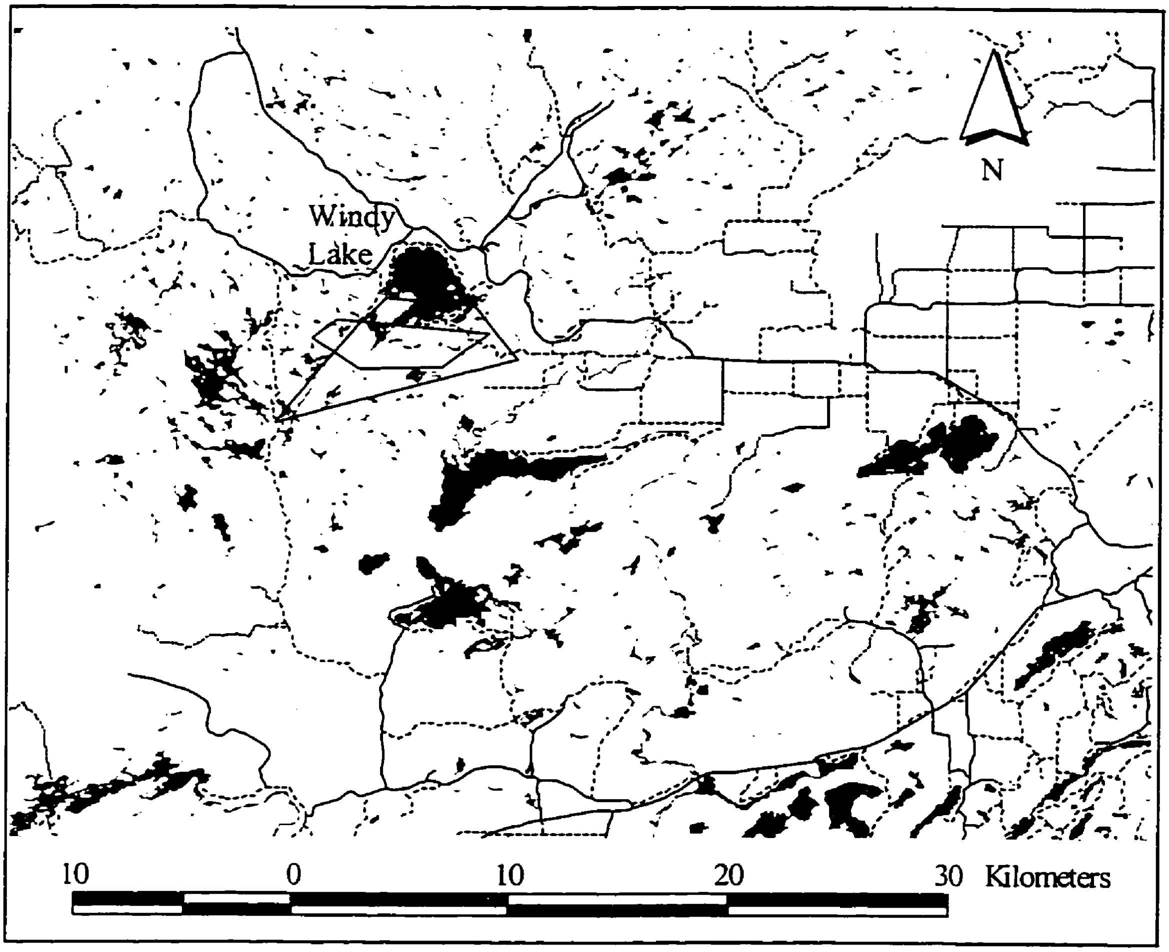

Windy Lake
N
10 0 10 20 30 Kilometers

Figure 3-4. Home ranges of bears captured in the Estaire area. Home ranges were estimated by the minimum convex polygon method.

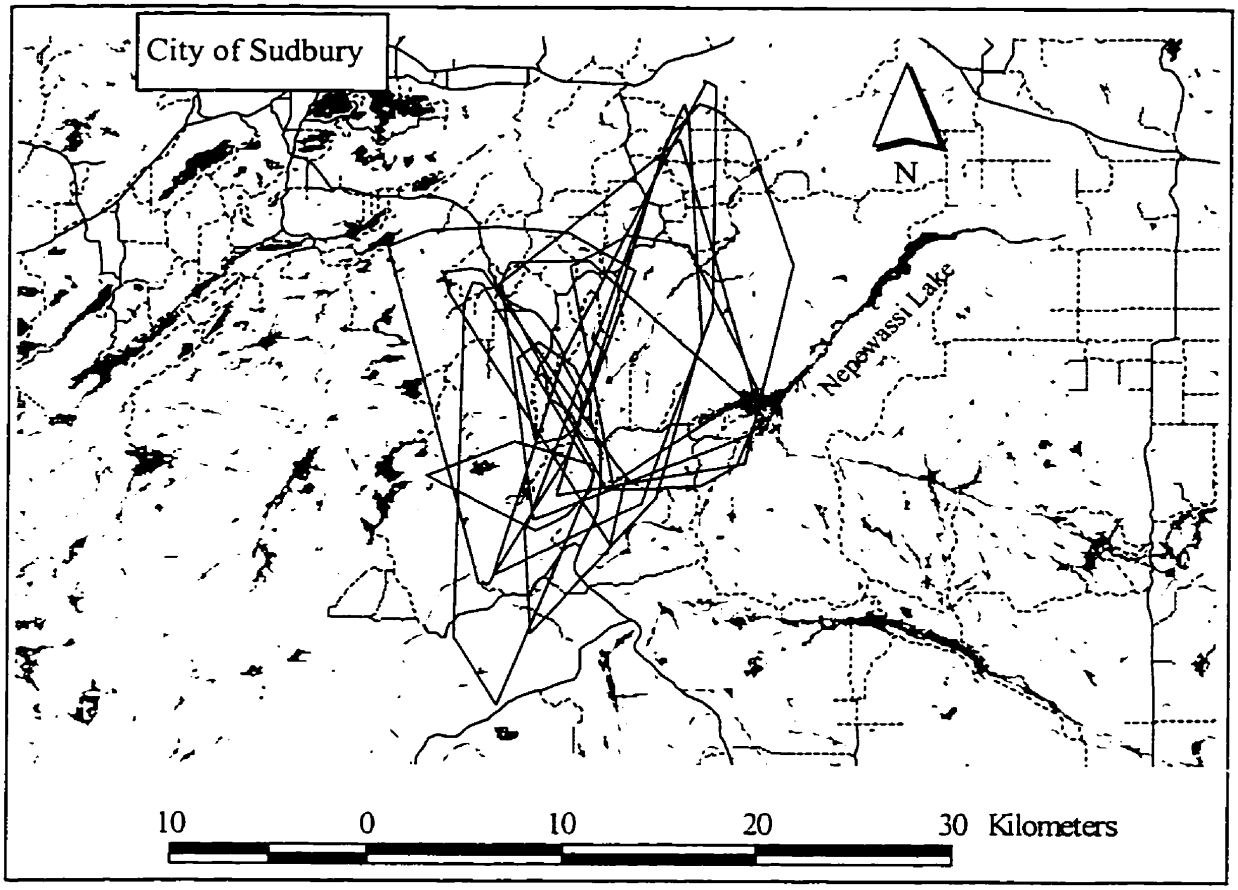
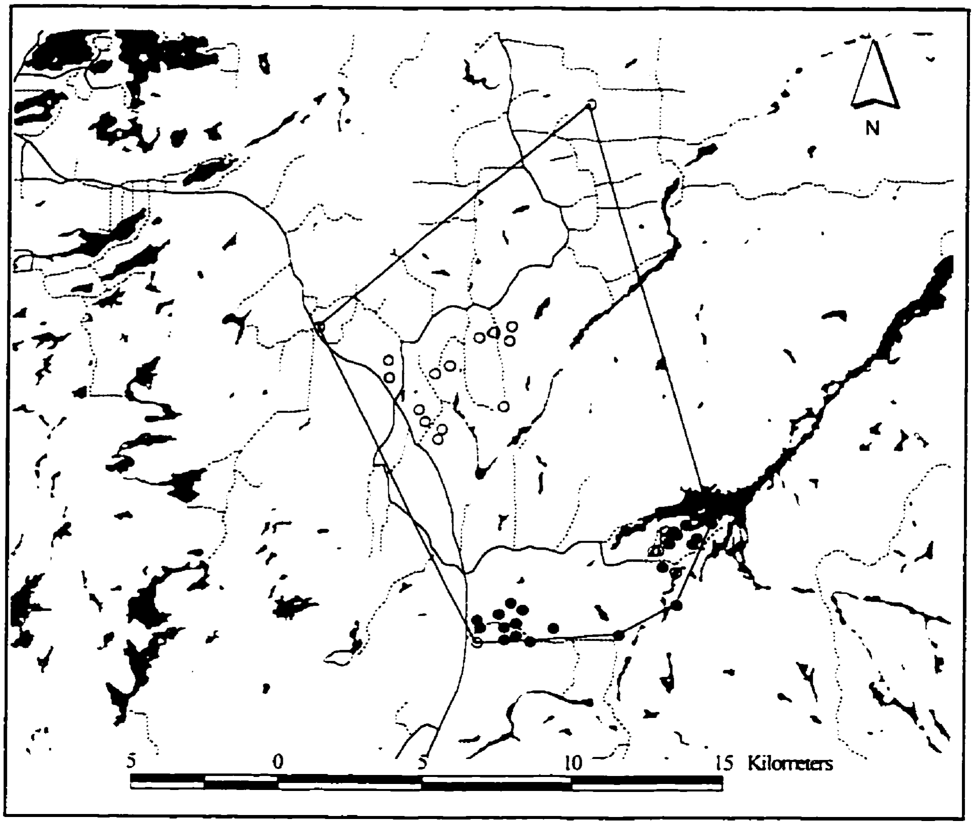
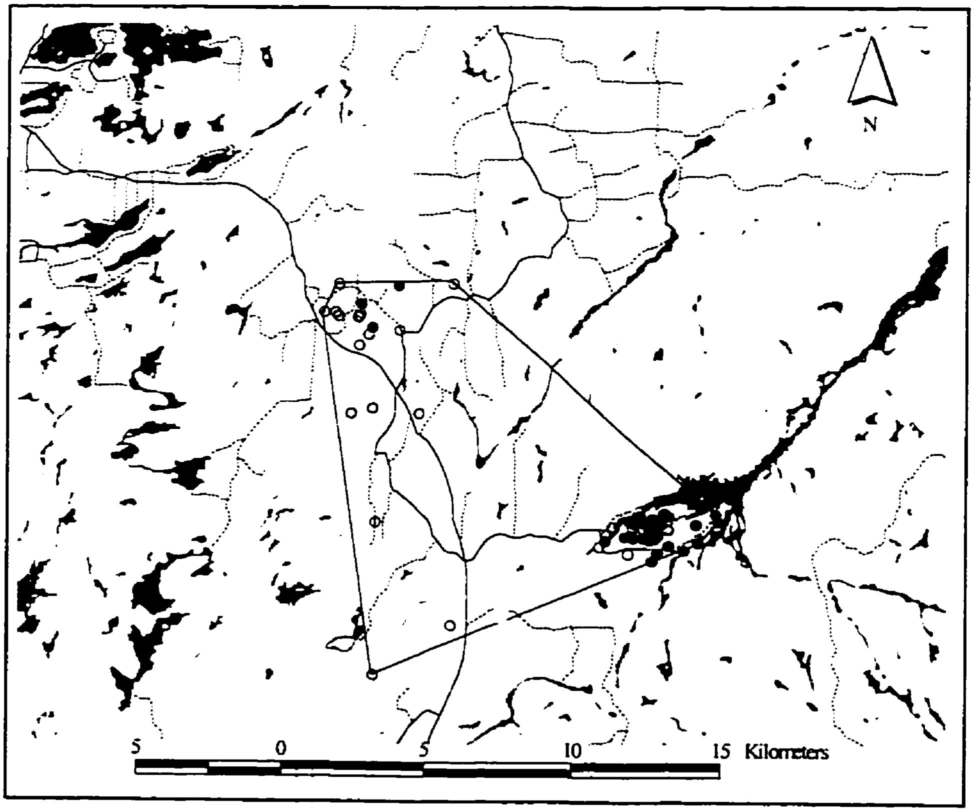

City of Sudbury
N
Nepewassi Lake
10
0
10
20
30
Kilometers

Figure 3-5. Seasonal movement patterns of bears baited in the Estaire area: A, adult female LB10; B, juvenile male LB16. Grey circles represent bear locations during blueberry season (mid-July to mid-September) and black circles are locations during spring and fall.

A



B



randomly without returning to the capture area in the fall. Juvenile female LB11 moved randomly on her small home range, remaining relatively close to the capture area and a large crippled male (LB14) also appeared to utilize his home range randomly throughout the year.

Mortality

The mortality rate of baited radio-collared bears in the Estaire area was a minimum of 50 percent (7 bears) over one year. Of these animals, 6 were harvested legally and one animal was poached at the landfill site. The poached animal (LB06) had been located within 0.5 km of the landfill site in 16 percent of the telemetry locations. Neither of the Windy Lake bears was known to have died. Hunting was the only cause of mortality for bears in this study of baited bears.

Use of landfills

Three male bears from Estaire were captured at the local landfill site and 3 additional collared animals were located there at least once. In total, 43 percent of the collared bears from Estaire used the landfill and 64 percent of the bears had home ranges which included the landfill site. These animals included individuals of all age and sex classes. The numbers and proportions of telemetry locations within 0.5 km and 1 km of the landfill were calculated for each bear tracked from spring until fall (Table 3-2). Only one bear had more than 10 percent of locations within 0.5 km of the landfill site and only 3 bears had more than 10 percent of locations within 1 km of the landfill. None of the 3

Table 3-2. Number and percentage of telemetry locations obtained for bears in proximity to the landfill site in the Estaire area. All bears had been tracked from spring to fall.

Bear ID	Locations within 0.5 km of landfill	Locations within 1 km of landfill
LB10	4 (9%)	10 (21%)
LB06	7 (16%)	12 (28%)
LB02	0 (0%)	1 (2%) - capture
LB09	0 (0%)	0 (0%)
LB07	1 (4%) - capture	2 (9%)
LB11	0 (0%)	0 (0%)
LB12	2 (7%)	5 (19%)
LB13	0 (0%)	0 (0%)
LB14	0 (0%)	0 (0%)
LB15	0 (0%)	0 (0%)
LB16	0 (0%)	0 (0%)

animals that appeared to remain in their spring home ranges throughout the year (LB09, LB11, and LB14) were located within 1 km of the landfill.

Nuisance activity

Neither of the bears from the Windy Lake area were reported as nuisance animals. However, one of these animals was seen feeding from a garbage bin used by residents of the area. The garbage bin was located at least 1 km from the nearest full-time residence and approximately 0.3 km from the nearest seasonal residence.

Four (29%) of the 14 Estaire bears were reported exhibiting nuisance behaviour. These animals consisted of one adult male, one adult female, one juvenile male, and one juvenile female. All were reported as a nuisance at seasonal residences in the Nepewassi Lake area. The two juveniles bears had been fed intentionally by seasonal residents in the area prior to being reported as nuisance animals. A barrel trap was set for the adult male when he was reported rolling an unused refrigerator around a seasonal resident's yard several days in a row. When captured, he was relocated approximately 200 km to the northwest and removed his radio-collar shortly after release, thus precluding the monitoring of his post-relocation movements. An adult female was incidentally captured in the trap set for the adult male. She had been located several times in the previous week near the cottages and was likely one of the animals reported damaging garbage bins. This animal was subsequently relocated west of Highway 69, approximately 8 km from her capture site. Within 3 days of release, she crossed the highway and returned to her spring use area without any further reported incidents of nuisance behaviour. In the Estaire area, all collared bears exhibited nuisance behaviour near their original capture locations and none were reported during mid-summer, when they moved north towards the City of Sudbury.

All four bears identified as nuisances were reported after the spring bear hunt when baiting had ceased. For comparison, the proportion of nuisance bears captured in the Sudbury District during June of each year between 1990 and 1997, were divided into those captured during the spring hunt (June 1-15) and those captured after (June 16-30). Of 63 nuisance bears captured during June, 55 percent were captured after the spring bear hunt.

DISCUSSION

Male home ranges have been shown to be highly variable, ranging from 30 to 500 km^2 (Erickson and Petrides, 1964; Amstrup and Beecham, 1976; Klenner, 1987; Jonkel and Cowan, 1971). The mean home range size for all collared males in the Estaire area was 87 km^2. However, the mean home range size obtained for female bears in the Estaire area was 104 km^2. This was much larger than the 5 to 50 km^2 ranges reported by other researchers (Erickson and Petrides, 1964; Jonkel and Cowan, 1971; Amstrup and Beecham, 1976; Fuller and Keith, 1980; Klenner, 1987; Rogers, 1987). When blueberry crops in the Sudbury area fail there is a large increase in the number of nuisance bear reports (M. N. Hall, pers. comm.) implying that these berries form a significant component of the diet of local bear populations. Blueberry patches do not fruit each year and those that do have variable ripening success depending on environmental conditions

(C. Lalande, pers. comm.). It is likely that the large home ranges displayed by both male and female bears in this study were a result of the discontinuous distribution of blueberries.

There was extensive overlap in the home ranges of bears captured near the town of Estaire. This overlap may have been a result of hunting pressure. The harvest of 10 to 20 bears from the Estaire area annually may result in ever changing home range boundaries. Klenner (1987) suggested that the constant harvesting of bears from a population can cause social instability and interfere with the establishment of defended territories, resulting in extensive overlap in home ranges.

The majority of bears from the Estaire area moved north towards the City of Sudbury during blueberry season (July-September); however, this directional movement was not observed in bears from the Windy Lake area. Several researchers have reported annual excursions by bears to seasonal food sources (Amstrup and Beecham, 1976; Rogers, 1987; Samson and Huot, 1993). Amstrup and Beecham (1976) observed bears leaving foraging areas and traveling substantial distances to feed on the same plant species elsewhere. They suggested that the nutritive value of berry patches varied annually and that the familiarity gained by exploration would result in greater long-term efficiency in exploiting foraging opportunities. The area north of Estaire was damaged by industrial activities and the acidified soil and lack of forest cover resulted in a high density of blueberry shrubs, the main summer forage of black bears in the Sudbury area. It is unknown whether the bears moved north to forage on berries even though blueberries were abundant in the Estaire area, or whether they were attracted to the area by other resources unavailable in their spring use areas.

Landfill sites provide year-round sources of food for black bears. Approximately 40 percent of the Estaire bears were located at least once at the local landfill, although none of these bears limited their home ranges to this site. These results agree with those of Erickson and Petrides (1964), who found that the home range size of adult males foraging in landfills were similar to those of bears not using landfill sites as food sources.

The mortality rate of bears captured at bait sites in the Estaire area was 50 percent in one year. This was substantially greater than the 21 percent mortality determined for tagged nuisance bears within one year of release (pers. obs.). This difference may have been a result of the uneven distribution of hunter bait sites. Bait sites are not distributed randomly throughout the Sudbury area. Hunters generally bait several small areas intensively, while other areas are baited periodically or not at all. The Estaire study was conducted in a relatively small area with several bait sites, thereby selecting bears that were at high risk of being hunted. In contrast, nuisance bear captures were distributed throughout the entire region and represented a more random sample of the bear population with respect to the hunting pressure exerted on the animals.

Considering that human-based food sources were readily available to both the Windy Lake and Estaire bears, it was noteworthy that only 25 percent were reported as nuisance animals. This is especially the case considering the high proportion of juvenile males in the baited sample, as they generally make up the largest proportion of nuisance bears (Harger, 1970; Rutherglen and Herbison, 1977; Shull, 1994). All of the incidents of nuisance behaviour reported in the Estaire area occurred after baiting had ceased, implying that these bears were dependent on bait sites as a spring food source. Whether the two juvenile animals reported as nuisances would have attempted to secure food from local residences if they had not previously been intentionally feed is unknown. Both adult bears captured for nuisance behaviour frequented the local landfill where they were exposed to humans and the association of human scent with food. Although some baited black bears did display nuisance behaviour, the results suggest that baiting alone does not lead to nuisance behaviour.

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GENERAL CONCLUSIONS

The results of the present study support the following general conclusions:

1) tagging studies are adequate means of estimating mortality and homing success for relocated nuisance bears;

2) seasonal variations in nuisance bear captures are a result of changes in the availability of natural food sources and fluctuations in seasonal human activity in rural areas;

3) age and sex classes of nuisance bears varied as a result of hunting pressure and local bear management practices;

4) relocation does not expose nuisance bears to increased mortality;

5) Two-lane highways are not barriers to homing;

6) homing success is dependent on age, homing experience, and the presence of an established home range;

7) the distance from which juvenile bears homed was less than the distance from which they did not home but this effect of distance on homing success was not seen for adult bears (for relocation distances up to 400 km).

8) non-homing bears do not wander randomly after release, but orient along the homeward azimuth initially, then reverse their direction;

9) relocated bears are not homing based on cues present only at night (e.g. moon, stars); and

10) the present data suggest that baiting alone does not lead to nuisance behaviour.

MANAGEMENT RECOMMENDATIONS

From the results obtained in this study several recommendations can be made concerning nuisance bear management in Ontario.

1) Because the majority of nuisance bear reports are made by seasonal residents, every effort should be made to educate the vacationing public about behaviour which leads to human/bear conflicts.

2) Although mortalities of bears due to relocation are low, a high proportion of nuisance bears returned home quickly; therefore, the efficiency of nuisance bears relocation should be questioned and only be used as a last resort.

3) The standard practice of relocating adults over long distances is ineffective and costly, as most adult bears are quite capable of returning from greater than 200 km. Homing bears return quickly; therefore, relocating them long distances to delay return until seasonally available food sources ripen is also ineffective.

4) Juveniles are less likely to home than adults and their homing success decreases with increased relocation distance; therefore, captured juveniles of both sexes should be relocated between 60 and 100 km to minimize the chances of their return. The recognition of juvenile individuals (< 4 years of age) is critical for efficient nuisance bear management.

5) Bears that do not return home rarely remain near the release site and the majority of these animals move further than 10 km away. It should not be assumed that relocated animals will remain near the release site and these animals should not be released in an attempt to restock specific areas.

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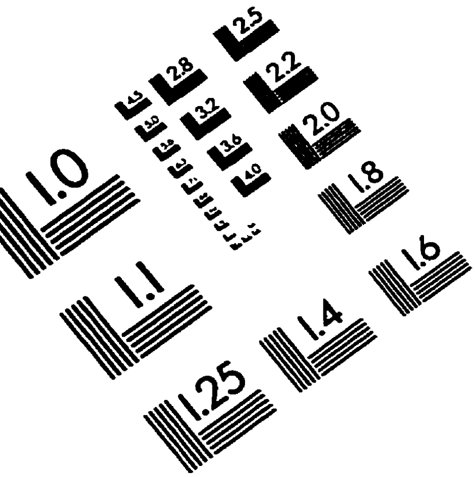

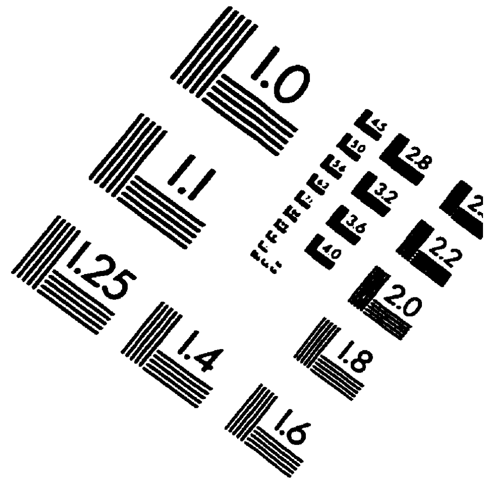

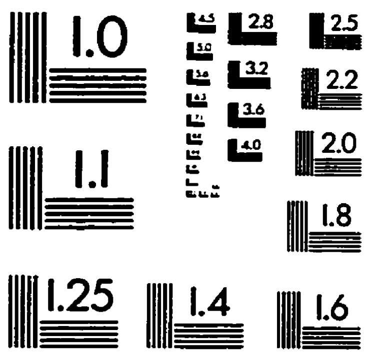

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