THE UNIVERSITY OF MANITOBA

ECOLOGY OF BEAVER (*CASTOR CANADENSIS*) IN THE TAIGA OF SOUTHEASTERN MANITOBA

BY

MICHELLE WHEATLEY

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF SCIENCE

Department of Zoology
University of Manitoba
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ABSTRACT

Beavers (Castor canadensis) were studied in the vicinity of Taiga Biological Station, 51°02'40" N, 95°20'40" W, on the Blind River and Wallace Lake, Manitoba. Data were gathered between September, 1986 and May, 1989.

Beavers were live-trapped with Hancock traps from September, 1986 to October, 1988. Seventeen beaver were live-trapped a total of 24 times for an average of 24.9 trap nights per beaver. Trapping success was best in May and September - October. Cool temperatures may also be important in trapping success. Wind direction was significant in trapping success, but precipitation and lunar phase were not.

Live-trapped beavers were outfitted with tail collar transmitters (3) or intraperitoneally implanted transmitters (7). A new surgical method of implantation using a ventral muscle-split technique is described. Implanted transmitters had a longer lifespan than tail collars with no loss of range. Recapture of implanted animals showed continued growth of the beavers with no post-operative complications

at 3, 11 and 16 months. The loss of one of the tail collars after one month had resulted in severe injury to the tail in a recaptured animal.

Daily travel distances ranged from about 1 km to 8 or more km. Home range lengths varied from 0.55 km to 6 km. An adult male and subadult female had the largest daily movements and home ranges. No evidence was found of territoriality. Two dispersing beavers are known to have travelled 24 and 36 km, including at least 1 km of overland travel in the latter case. Winter under-ice movements were never more than 50 m from the lodge, and winter activity was sporadic. Above-ice activity was rare, and only occurred when night-time temperatures did not fall much below freezing.

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TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

SECTION III

APPENDIX II

LIST OF FIGURES

FIGURE PAGE

SECTION I

FIGURE PAGE

SECTION II

SECTION III

FIGURE		PAGE

APPENDIX I

INTRODUCTION

It has been said that "no other animal has influenced a nation to the extent that the beaver (*Castor canadensis*) has influenced the development of Canada." (CWS, 1978:1). Through trade in its fur, the beaver "did more to open up Canada than any other creature or product" (Seton, 1909:478). As beavers were extirpated in one area, the traders had to go farther and farther west to get the furs that were essential for the hat-making industry in Europe. Despite the importance of the beaver, little was known about it until this century. Early descriptions attributed extreme intelligence, high social organization and foresight to them. While some of the stories had a basis in fact, many were patently ridiculous, such as those of "lazy beavers" that were made to work as slaves by other beavers (Newman, 1985).

Seton (1909) was one of the first to begin to set the record straight with his general description of beaver natural history. Green's (1936) observations of beavers in Riding Mountain added to the factual knowledge. While Seton and Green provided general descriptions based on observations, little planned research was undertaken, and most literature was anecdotal and/or the result of casual observation (Bradt, 1938).

The original beaver population in Canada may have exceeded 10 million animals, but by the turn of the century it had been reduced to about 500,000 and had been extirpated in many areas of North America (Seton, 1909). Beavers increased in numbers with the advent of government protection and because of forest fires that led to the replacement of conifers by deciduous trees (Ingle-Sidorowicz, 1982). With this increase in numbers, research on beavers has also increased to cover many aspects of beaver biology. Literature on beaver in Canada constitutes only a small portion of that available. Most authors report on research undertaken in the United States. Research on beaver ecology in Canada has included work in Newfoundland (Bergerud and Miller, 1977; Payne, 1981; 1982; 1984), Quebec (Potvin and Bovet, 1975; Patenaude and Bovet, 1983; 1984; Courcelles and Nault, 1983), Ontario (Stephenson, 1969; Novak, 1977), Manitoba (Nash, 1951), Alberta (Novakowski, 1967; Bovet and Oertli, 1974) and the Mackenzie Delta region of the Northwest Territories (Aleksiuk, 1968; 1970; Aleksiuk and Cowan, 1969a; 1969b).

Populus tremuloides is a common food of beaver throughout its range. Though not necessarily the primary food choice, in all regions, P. tremuloides has a distribution remarkably similar to beaver (Hall, 1960). P. tremuloides is a frequent colonizer after forest fire (Rowe and Scotter, 1973). High beaver populations are therefore arguably a direct result of forest fires (Patric and Webb, 1953) and these fires have "always been an integral part of the boreal forest" (Rowe and Scotter, 1973:446). Hence, the boreal forest, or taiga, may be the most important part of the beaver's range. Despite this, information and research on beaver in the taiga is not extensive. Since even small differences in habitat may result in changes in characteristic behaviours (Green, 1936), information from other areas of North America may have limited application in a taiga habitat.

LITERATURE REVIEW

Methods of Study

Any study of beavers faces several obstacles to success. Beavers are primarily nocturnal, making visual observations during their activity period difficult. They are aquatic and can swim long distances underwater, complicating visual observations even in daylight. In winter, beavers generally remain in their lodge and below the ice, giving little opportunity for direct observation.

Sex of beavers is not readily determined since there is no sexual dimorphism and external sexual features are not present except in nursing or expectant females where mammae are visible. Beavers are sexually mature by 1.5 to 2 years of age, but may continue to grow to age 4 and beyond. Due to different growth rates, age cannot be easily determined. These problems have led to the development and use of special study methods for these unique animals.

For any meaningful observations, animals must be marked so as to identify individuals. Bradt (1938) used branding or hole punching of the tail since he believed beavers' ears to be too small for tags. Despite this assertion, most studies have used numbered ear tags, usually with an attached colour marker (Beer, 1955; Libby, 1957; Hibbard, 1958; Knudsen and Hale, 1965; Bergerud and Miller, 1977;

Brady and Svendsen, 1981; Courcelles and Nault, 1983; Busher and Jenkins, 1985; and Svendsen, 1989). Beaver movements when out of visual range have been monitored by radio-telemetry (Lancia et al., 1982; Courcelles and Nault, 1983; and Davis et al., 1984). Activity in the lodge has been monitored by visual observation with a special observation box (Patenaude-Pilote et al., 1980), with acoustic recordings (Bovet and Oertli, 1974; Potvin and Bovet, 1975) and with telemetry (Lancia et al., 1982). Brooks and Dodge (1978) developed an LED (Light Emitting Diode) neck collar that could be used for visual observations at night.

Sexing of live animals has usually relied on palpation for the baculum in males. In young animals, this may be very small and difficult to locate. In all animals, certainty of sex is possible when the baculum is found, but if not felt, absolute certainty of sex is not possible. A technique for sexing beaver based on an examination of neutrophils was developed by Larson and Knapp (1971), and has proved more reliable. Blood smears are stained and examined for drumstick appendages on the neutrophils. The presence of 6 or more drumsticks in 500 neutrophils identified the animal as a female.

The most reliable method of ageing beavers is the counting of annual cementum rings in the first premolar (Van Nostrand and Stephenson, 1964; Larson and Van Nostrand, 1968), but this technique cannot be applied to live animals

(Larson and van Nostrand, 1968). Attempts have been made to use eye lens dry weight (Larson, 1967; Malcolm and Brooks, 1981) but with limited success, and only for dead animals. Weight has proven to be a fairly accurate predictor of age in the first 2 years (Buckley and Libby, 1955; Patric and Webb, 1960; Brenner, 1964; Leege and Williams, 1967) but is not completely reliable. Increase in body weight is usually rapid in summer, but is slow to nonexistent to negative in winter (Buckley and Libby, 1955; Novakowski, 1967; and Aleksiuk and Cowan, 1969). Beavers of the same year class may vary greatly in weight due to individual variation, the colony site (forage quality), parturition date (young animals) and unequal development (Patric and Webb, 1960). Tail dimensions (Patric and Webb, 1960; Leege and Williams, 1967) and zygomatic breadth (Patric and Webb, 1960) may also be useful as predictors of age. Different methods do not always agree (Leege and Williams, 1967) and regional variation means that data from one area may not be transferable (Patric and Webb, 1960).

Dispersal

Most literature on dispersal of beavers refers to studies of tagged and released animals that are then caught by local trappers. This method has been used for transplanted beavers in North Dakota (Hibbard, 1958), Wisconsin (Knudsen and Hale, 1965), and near James Bay, Quebec (Courcelles and Nault, 1983). Some studies have proceeded similarily, but without transplanting any animals. These include studies in Minnesota (Beer, 1955), Alaska (Libby, 1957) and Idaho (Leege, 1968). Radio-telemetry was used to study dispersal after transplanting beavers near James Bay (Courcelles and Nault, 1983).

Territory

Bradt (1938) defined a beaver colony as "a group of beavers occupying a pond or stretch of stream in common, utilizing a common food supply and maintaining a common dam or dams. They may or may not be living in the same lodge or burrows."(p. 145). He found no evidence of colony overlap in Michigan. Hay (1958), however, found no evidence of a "property line" in the Rockies, and recorded a neutral area between colonies where intercolony co-operation took place when dam work was necessary. Bergerud and Miller (1977) and Busher et al. (1983) cited occasional intercolony movement in Newfoundland and in the Sierra Nevada respectively.

Daily movements may be used to delineate the home range of beavers but home range and territory are not necessarily synonymous (Townsend, 1953). Territory helps to separate colony groups (Bergerud and Miller, 1977). Beaver territories have been cited in Alaska (Boyce, 1981) and

Massachusetts (Howard and Larson, 1985). Hay (1958) and Aleksiuk (1968) relate scent mounds to territory, while Seton (1909) and Brenner (1964) referred to scent mounds as an indicator of breeding season and a means of advertising for a mate.

Winter Activity

Beavers are active throughout the winter and do not hibernate, but may conserve energy by reduced activity, dormancy and huddling (Novakowski, 1967). Activity patterns have been studied by the use of acoustic recordings in southwest Alberta (Bovet and Oertli, 1974) and southern Quebec (Potvin and Bovet, 1975), and by use of radiotelemetry in Massachusetts (Lancia et al., 1982). In ice-covered areas, studies relying on visual observations have reported little on winter activity except when above-ice activity occurred in Riding Mountain Park, Manitoba (Green, 1936), Algonquin Park, Ontario (Stephenson, 1969) and the Mackenzie Delta of NWT (Aleksiuk, 1970). Stephenson (1969) and Buech et al. (1989) also recorded lodge temperatures in winter.

Beaver Dwellings

Beavers use both bank burrows and lodges, and lodges often develop out of bank burrows (Seton, 1909). Beaver colonies have been found to use several lodges and bank burrows in the summer, but use only one lodge in winter, in Riding Mountain Park, Manitoba (Green, 1936), the Rockies (Hay, 1958), and Massachusetts (Howard and Larson, 1985), with no bank burrows found as the primary structure of a colony (Hay, 1958). Bank burrows were never found in Newfoundland due to rocky terrain (Payne, 1981). Conversely, in Michigan (Bradt, 1938), Louisiana (Chabreck, 1958) and Montana (Swenson *et al*., 1983), lodges were rare, and many colonies used only bank burrows. Lodge size is not necessarily an indicator of colony population (Hay, 1958), but may rather be an indicator of colony age (Green, 1936).

Food Selection

Trembling aspen (*Populus tremuloides*) has generally been considered as the food of choice of beavers (Hall, 1960; Brenner, 1962; Hall, 1972), but Jenkins (1975) argues that different sites vary in genera selected for harvest. Not all trees cut are required for food (Bradt, 1938); some are used in lodge or dam construction and some to add weight to the food pile (Slough, 1978). A preference for herbaceous and aquatic plants has been reported for Michigan (Bradt, 1938), Louisiana (Chabreck, 1958) and Pennsylvania (Brenner, 1962). In Ohio, Svendsen (1980) found a preference for non-woody vegetation in summer, while in the Mackenzie Delta of NWT, Aleksiuk (1970) found that summer preference was for leaves and buds of willows when available. Parovshchikov (1961) reported seasonal variation in the foods selected by Castor fiber in the Archangel province of the USSR. Beavers may use woody vegetation only when green vegetation is not available (Jenkins, 1981).

When woody vegetation is chosen, the species selected may vary. Aspen was a major choice in Michigan (Bradt, 1938), New York State (Gese and Shadle, 1943), Pennsylvania (Brenner, 1962), the Mackenzie Delta (Aleksiuk, 1970) and Algonquin Park, Ontario (Hall, 1972). Other foods chosen include willow in Michigan (Bradt, 1938), California (Hall, 1960), and the Mackenzie Delta (Aleksiuk, 1970); maple in Michigan (Bradt, 1938); birch, oak and witch-hazel in Massachusetts (Jenkins, 1979); and loblolly pine, spruce pine and sweetgum in Louisiana (Chabreck, 1958). Hall (1960) found that beavers would eat the lower bark of firs in California, but Seton (1909) noted that beavers never ate conifers but would use them in construction.

McGinley and Whitham (1985) found that beavers in Utah foraged more selectively at an increased distance from the central place (i.e. lodge). However, Belovsky (1984) found no change in food choice with distance from the pond in Michigan. The diameter of the trees harvested was found to decrease with increasing distance from shore in Massachusetts (Jenkins, 1980) and North Dakota (Pinkowski, 1983). Beavers showed a general preference for small diameter trees at all times in Louisiana (Chabreck, 1958) and Massachusetts (Jenkins, 1980).

Beaver logging and dam building may affect the environment in several ways. In Utah, beavers were found to affect the reproductive pattern of cottonwoods, with more vegetative reproduction where beavers harvested (McGinley and Whitham, 1985). Beavers may enhance forest diversity and benefit other animals (Hall, 1972). They may affect bog development (Rebertus, 1986) and may have a negative impact on forestry by promoting decay due to barking of standing trees (Chabreck, 1958).

OBJECTIVES

The objectives of my study were: 1. To determine the factors affecting success of beaver live-trapping; 2. To develop a reliable method of tracking beavers in a taiga environment; 3. To determine daily movement patterns and distances travelled; 4. To determine seasonal variation in movements of beaver; and 5. To determine the distances travelled by dispersing beavers.

SECTION I

BEAVER LIVE-TRAPPING:

FACTORS AFFECTING SUCCESS

ABSTRACT

Live-trapping of beavers using Hancock traps was undertaken from September, 1986 to October, 1988 in the taiga of southeastern Manitoba. Seventeen beaver were live-trapped a total of 24 times for an average of 24.9 trap nights per beaver. Trapping success was best in May and September - October. Cool temperatures may also be important in trapping success. Wind direction was significant in trapping success, but precipitation and lunar phase were not.

INTRODUCTION

Live-trapping of beavers has been accomplished with Bailey traps (Bradt, 1938; Townsend, 1953; Knudsen and Hale, 1965; Leege, 1968; Busher, 1975; Lancia, 1979; Buech, 1983; Davis, 1984), Hancock traps (Townsend, 1953; Lancia, 1979; and Buech, 1983) and snares (Davis, 1984). Buech (1983) found that Hancock traps had no misses whereas Bailey traps had up to 50 % misses. Davis (1984) similarly found misses exceeded captures for both Baileys and snares, but Baileys were more effective than snares. Traps may be biased towards older animals (Davis, 1984). Townsend (1953) found trapping success varied with the month and Leege and Williams (1967) cited that different ages and sexes of beaver are caught at different times of the year.

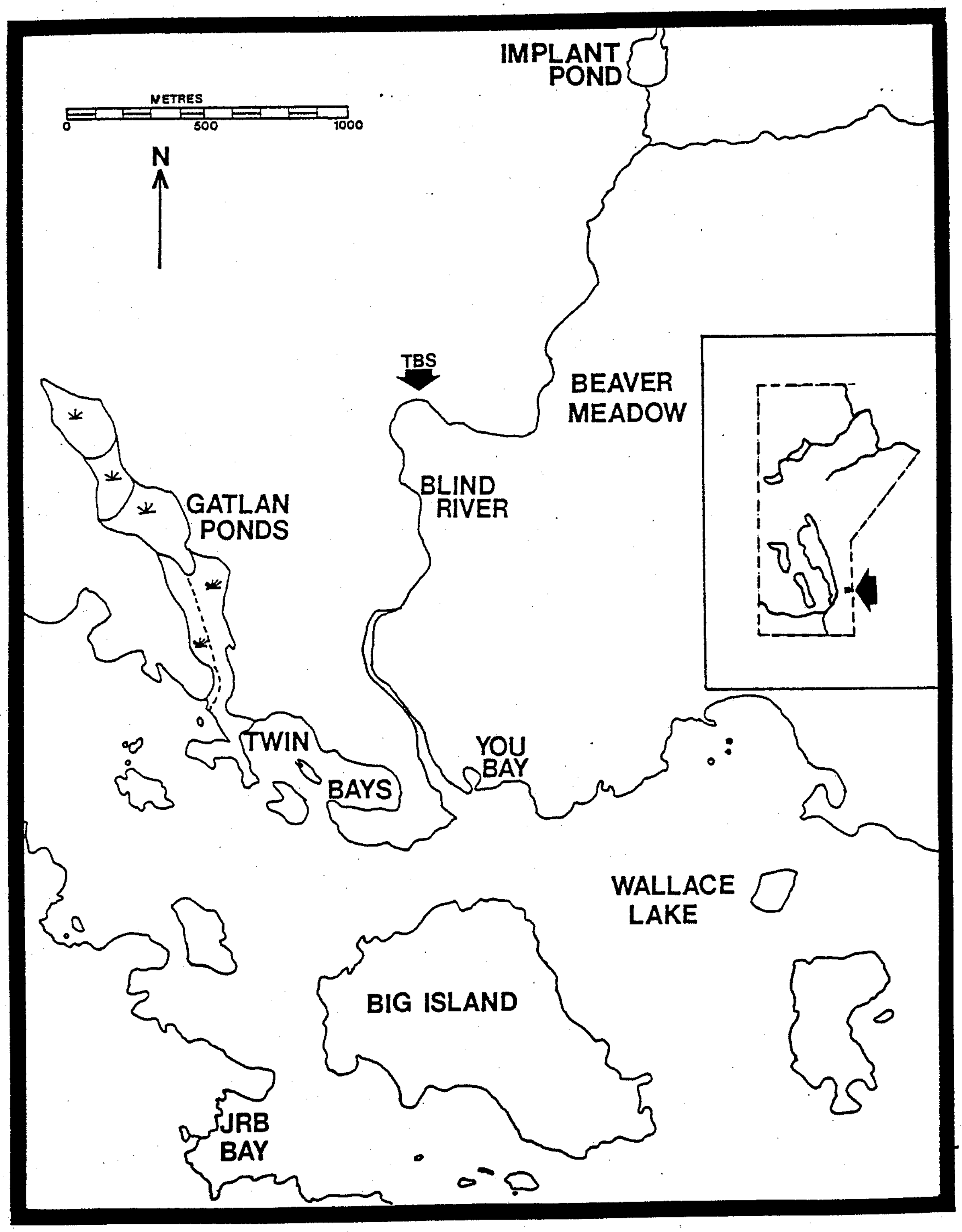
This paper examines the effect of month of capture, temperature, wind, precipitation and lunar phase on trapping success.

STUDY AREA

This study was based at Taiga Biological Station (TBS), 51°02'40" N, 95°20'40" W, 250 km northeast of Winnipeg, Manitoba (Figure 1). The study took place on Wallace Lake and the Blind River which enters Wallace Lake from the north. This area was burnt in the 1980 Wallace Lake fire. The river is bordered mainly by burnt bogs with a few burnt ridges. The lake is bordered primarily by burnt ridges. There are irregular patches of unburnt land in the area, some bordering the river and lake. To the east of TBS, the Blind River traverses and all but disappears in a large boggy area known as the beaver meadow (Figure 1). It is the result of numerous changes of river flow caused by beavers damming the river at various times in the past.

The bogs, and also some ridges where erosion has not been too extensive, support a good growth of Populus tremuloides and Alnus crispa. In most areas, these are the primary reforestation species, with Picea mariana and Pinus banksiana appearing later.

Figure 1. Location of study area in Manitoba, and detail of study area.


IMPLANT
POND
METRES
0
500
1000
N
TBS
BEAVER
MEADOW
BLIND
RIVER
GATLAN
PONDS
TWIN
BAYS
YOU
BAY
WALLACE
LAKE
BIG ISLAND
JRB
BAY

METHODS

Trapping

I used Hancock live traps baited with Trembling Aspen (*Populus tremuloides*) tied to the back of the trap above the trigger. One to three pieces were used, each piece 30 to 40 cm in length, and 2 to 5 cm in diameter (Figure 2). The bark of the pieces was scraped with a fork to expose the cambium layer and provide a scent to help lure the beavers to the trap. In addition, in all cases, I used a scent bait made of ground-up dried castor glands, either mixed with a little water and mud placed in a mound behind the trap to simulate a scent mound; or mixed with glycerine and anise extract (after Aleksiuk, 1968) and rubbed sparingly on the pieces of Poplar bait.

Trapping seasons were September 20 - October 19, 1986; May 26 - October 5, 1987; and May 5 - October 23, 1988 but were not continuous through each season. Twenty-five different trap sites were used in the 3 years: 8 in 1986; 9 in 1987; and 15 in 1988.

I selected sites for trap placement by examining the river banks and lakeshore for likely beaver areas. These would be scent mounds (piles of mud mixed with beaver castoreum) previously constructed by the beaver; areas where beavers had been feeding, as evidenced by the presence of

Figure 2. Hancock trap set against bank of Blind River. Three pieces of Aspen (Populus tremuloides) are tied to the back of the trap. The lower half is underwater.

beaver-chewed sticks; in front of entrances to trails leading back to food gathering areas; or in the vicinity of beaver activity such as dam construction. Traps were held in place by tying the back of the trap to a tree or stake using nylon rope. This was sufficient to keep the trap and beaver high enough out of the water to prevent drowning while in the trap (Figure 3). No attempt was made to disguise the back of the trap with grasses, branches or leaves.

Weather records were recorded twice daily at 0700 and 1900 hours at TBS. Temperature, barometric pressure, wind direction and strength, cloud cover and precipitation were recorded.

Traps were checked between 0600 and 0730 h, or just after sunrise in the fall, and at about sunset throughout the observation season. Beavers found in traps on the morning check were defined as "morning captures", and those found on the evening check as "evening captures". It is possible that morning captures were caught shortly after the evening check.

A trap night is usually defined as 1 trap set for 1 night. For the purpose of this study, the trap night is extended to be 1 trap set for the 24 hour period from immediately after checking traps one morning to the same time the next morning.

Figure 3. Beaver in trap at trap site. Trap is held by the rope tied to a stake.

RESULTS

Seventeen beavers were captured a total of 24 times in the three trapping seasons (Table 1) for an average of 24.9 trap nights per beaver. Only 1 trap was set off with no capture. Teeth marks on the poplar bait indicated that a muskrat was likely responsible.

Of the 25 trap sites used, 9 were successful with 1 to 8 captures per site (Figure 4). All successful sites were on the river. The 24 captures included 20 morning and 4 evening captures. Notably, no beavers were recaptured at the same site.

Factors affecting trapping success

Monthly Variation

Trapping success varied significantly with the month (X^2=13.471, 5 df, $p<.025$) (Table 2). Trapping success was best in September, October and May and worst in July. There is also variation between the years which is significant for the 2 full trapping years, 1987 and 1988 (X^2=94.055, 5 df, $p<.001$) and is most notable for the months of June, 1987 and June, 1988. Evening captures occurred only in June and July, 1987 (2 captures each).

Table 1. Summary of beaver trapping seasons and trapping success.

YEAR	TRAPPING PERIOD	NUMBER OF TRAP NIGHTS	NUMBER OF BEAVERS CAPTURED		TRAP NIGHTS PER CAPTURE
			Initial	Recapture	
1986	09-20 to 10-19	24	3	1	6
1987	05-26 to 10-04	225	6	4	22.5
1988	05-05 to 10-23	349	8	2	34.9
TOTAL		598	17	7	24.9

Figure 4. Location of trap sites on the Blind River and Wallace Lake. Successful sites are underlined.

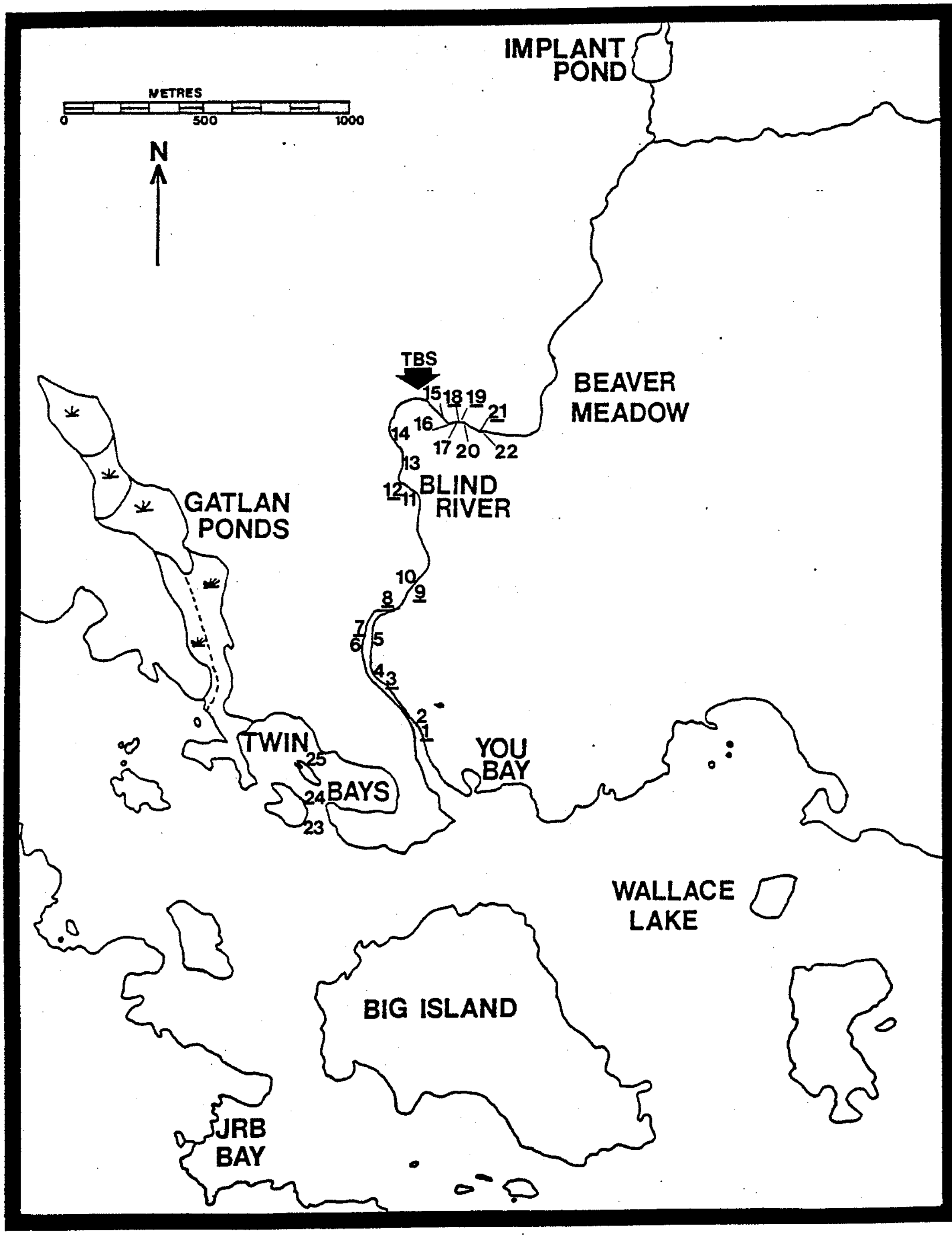

IMPLANT POND
METRES
0
500
1000
N
TBS
BEAVER MEADOW
15
18
19
21
16
14
17
20
22
13
BLIND RIVER
12
11
GATLAN PONDS
10
9
8
7
6
5
4
3
2
1
YOU BAY
TWIN
25
BAYS
24
23
WALLACE LAKE
BIG ISLAND
JRB BAY

Table 2. Trapping success by month and year with Hancock live-traps. # TN = number of trap nights, # B = number of beaver, TN/B = trap nights per beaver.

MONTH	YEAR											
	1986			1987			1988			AVERAGE		
	# TN	# B	TN /B	# TN	# B	TN /B	# TN	# B	TN /B	# TN	# B	TN /B
May	--	--	--	9	1	9	82	6	13.7	91	7	13
June	--	--	--	78	5	15.5	112	0	--	190	5	38
July	--	--	--	70	2	35	72	1	72	142	3	47.3
August	--	--	--	20	0	--	75	1	75	95	1	95
September	12	3	4	40	2	20	6	1	6	58	6	9.7
October	12	1	12	8	0	--	2	1	2	22	2	11
TOTALS	24	4	6	225	10	22.5	349	10	34.9	598	24	24.9

Trap site variation

Trapping success varied by trap site (X^2=27.892, 8 df, p<.001) (Table 3). The sites with single trap night captures were all locations showing new signs of beaver activity before trap placement. The 4 evening captures occurred at sites 2, 7 (2 captures) and 8.

Weather Effects

Temperature

Trapping success varied significantly with temperature in 1988, but not in 1986 and 1987. For morning captures only, the 0700 h temperatures on successful trapping mornings are compared to unsuccessful mornings. In 1986 temperature on successful mornings was not significantly different than unsuccessful mornings for September (t=0.733, 13 df, p>.5). For October the lone capture cannot be compared statistically, but was on a much warmer morning than the mean (Figure 5).

In 1987, the mean 0700 h temperatures for the 6 morning captures were lower than the mean for all trap nights, but not significantly (t=0.998, 229 df, p>.4) (Figure 6). The only May capture was lower than the mean. The mean of the 3 captures in June was not different from the month's mean (t=0.465, 79 df, p>.5). There was no difference between successful and unsuccessful nights in September (t=0.238, 40 df, p>0.5).

Table 3. Trapping success by trap site for successful trap sites: number of trap nights; number of beaver caught at the site; and trap nights per beaver.

TRAP SITE NUMBER	NUMBER OF TRAP NIGHTS	NUMBER OF BEAVER	TRAP NIGHTS/ BEAVER
1	1	1	1
3	144	8	18
7	121	6	20.2
8	1	1	1
9	20	1	20
12	1	1	1
18	88	2	44
19	51	1	51
21	82	3	27.3

Figure 5. Temperatures at 0700 h for all and successful trap nights for morning captures in September and October, 1986. Means - circles: ● all; ○ successful. Wide bar - 95% confidence limits. Narrow line - range.

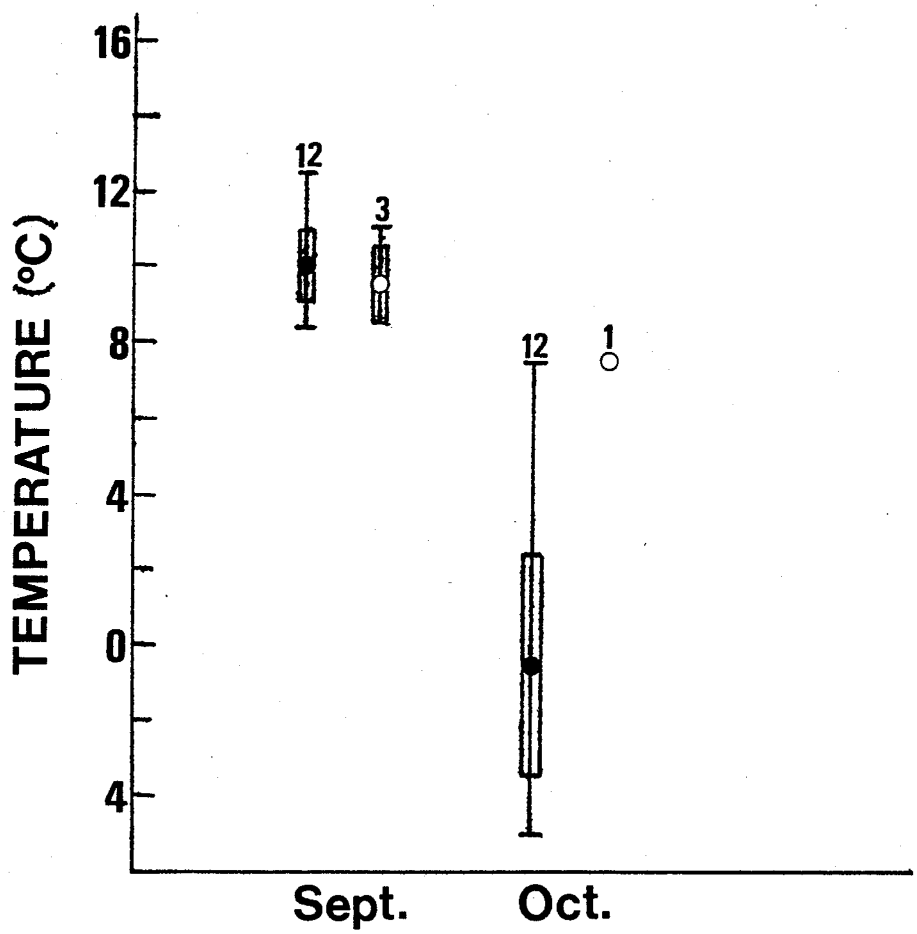
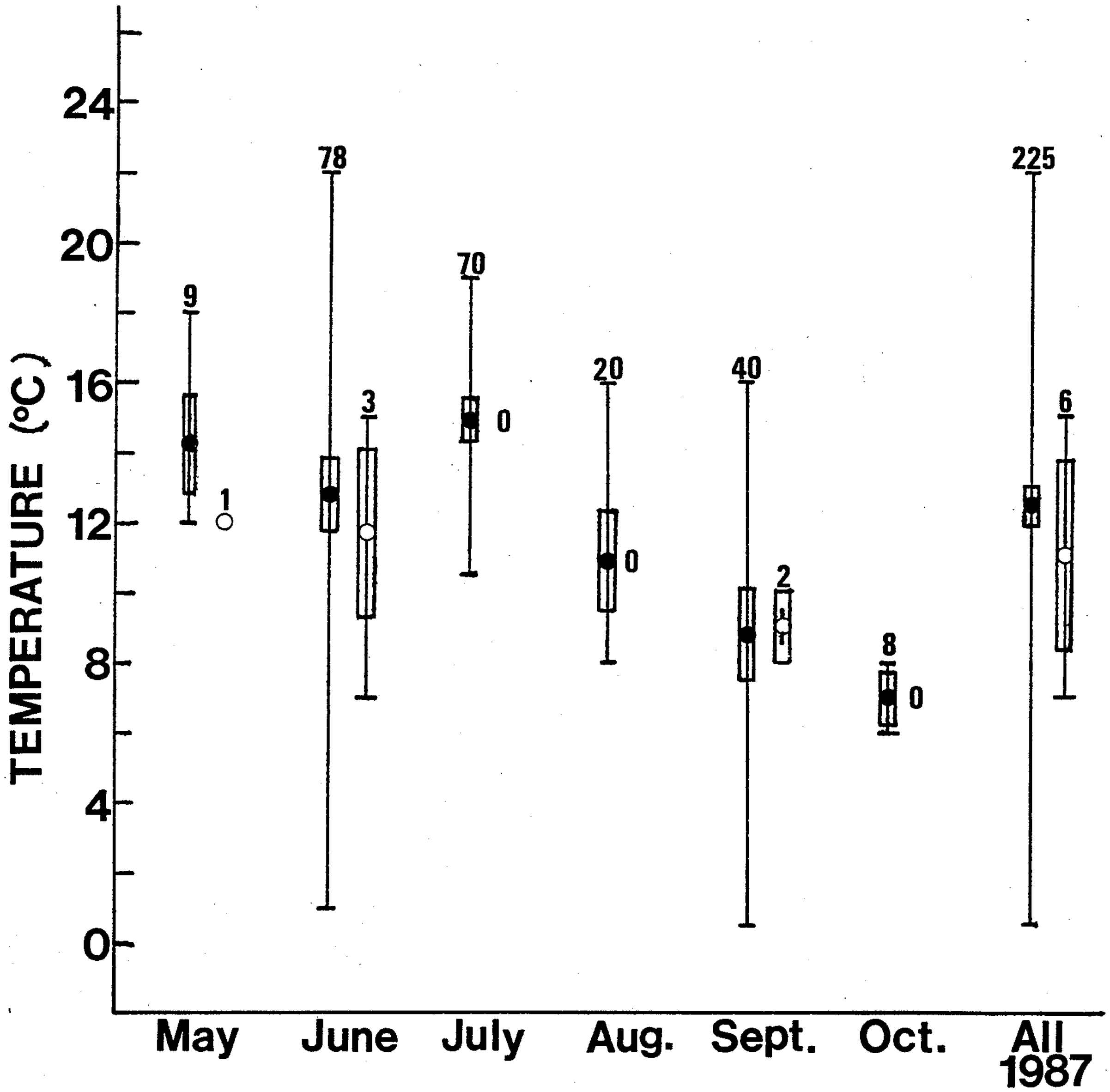

TEMPERATURE (°C)
16
12
8
4
0
4
12
3
12
1
Sept.
Oct.

Figure 6. Temperatures at 0700 h for all and sucessful trap nights for morning captures in 1987 for each month and the year as a whole. Means - circles: ● all; ○ successful. Wide bar - 95% confidence limits. Narrow line - range.



TEMPERATURE (°C)
0
4
8
12
16
20
24
9
1
78
3
70
0
20
0
40
2
8
0
225
6
May
June
July
Aug.
Sept.
Oct.
All 1987

The 1988 successful trap nights had a significantly lower mean 0700 h temperature than all the trap nights (t=4.625, 357 df, p<.001) (Figure 7). The 6 captures in May were on much cooler mornings than the mean (t=3.47, 86 df, p<.001). The temperature for the July capture was no different than the mean temperature for July trap nights. The temperatures for August and September captures were lower than their respective means. The October capture was on the only night that traps (2) were set.

The trap night temperatures were warmer in 1988 than 1987 (t=4.645, 572 df, p<.001) (Figure 8). The 1988 trap night temperatures were warmer than 1988 for May (t=3.755, 89 df, p<.001), June (t=4.86, 188 df, p<.001), July (t=4.058, 140 df, p<.001) and August (t=5.575, 93 df, p<.001). There was no difference between the September trap night temperatures for the 3 years ($F_{2,55}$=2.034, p>.1, 1 way ANOVA) (Figure 8). The October trap nights were colder in 1986 and 1988 than 1987 ($F_{2,19}$=8.479, p,.001, 1 way ANOVA) (Figure 8).

The evening captures occurred only in June and July, 1987. The mean 1900 h temperatures for captures in June were lower than the monthly mean, but not significantly (t=1.028, 80 df, p>.2). (Figure 9). In July, the 1900 h temperatures were significantly warmer for captures than the monthly mean (t=3.459, 68 df, p<.001) (Figure 9).

Figure 7. Temperatures at 0700 h for all and sucessful trap nights for morning captures in 1988 for each month and the year as a whole. Means - circles: ● all; ○ successful. Wide bar - 95% confidence limits. Narrow line - range.

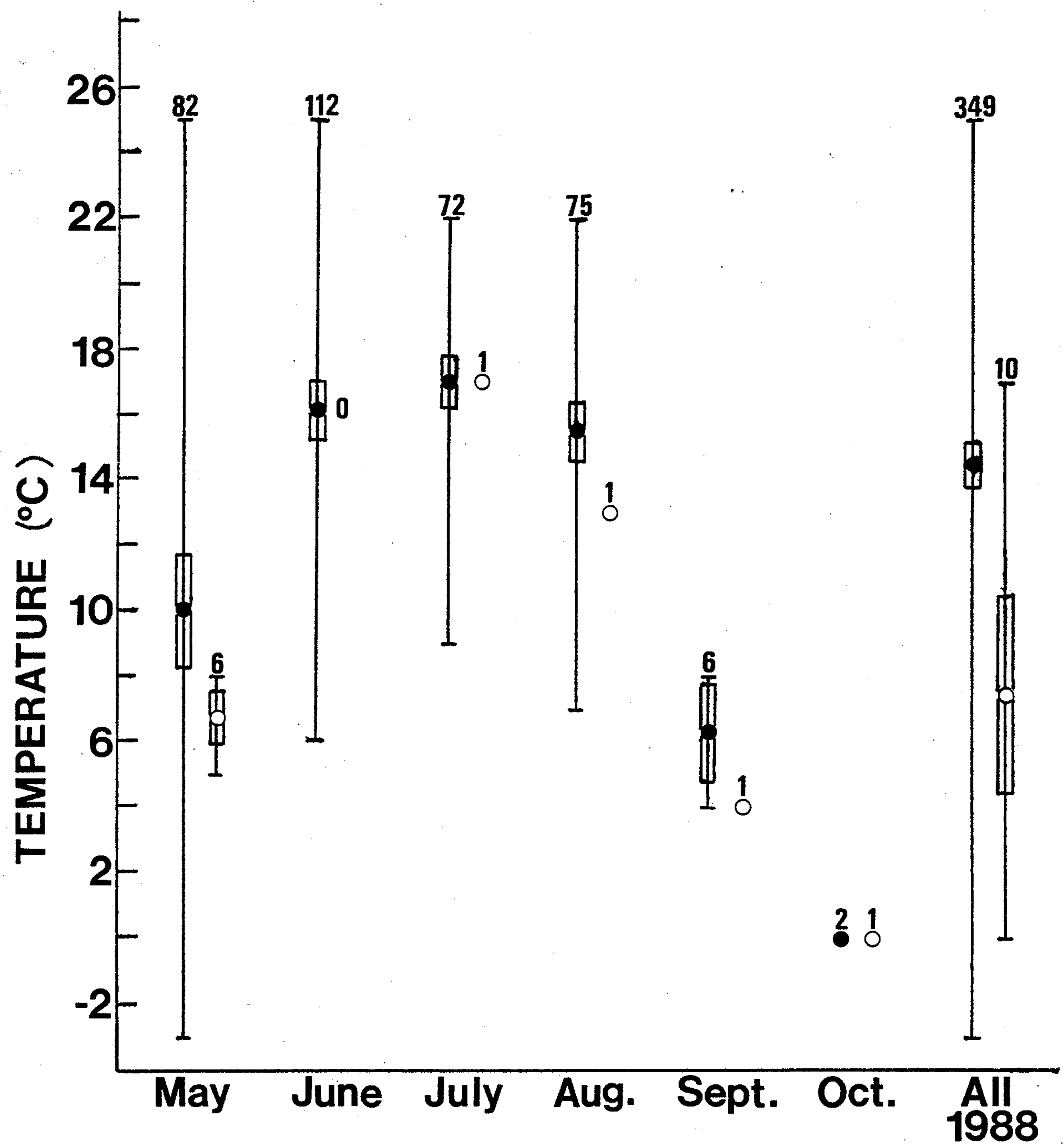
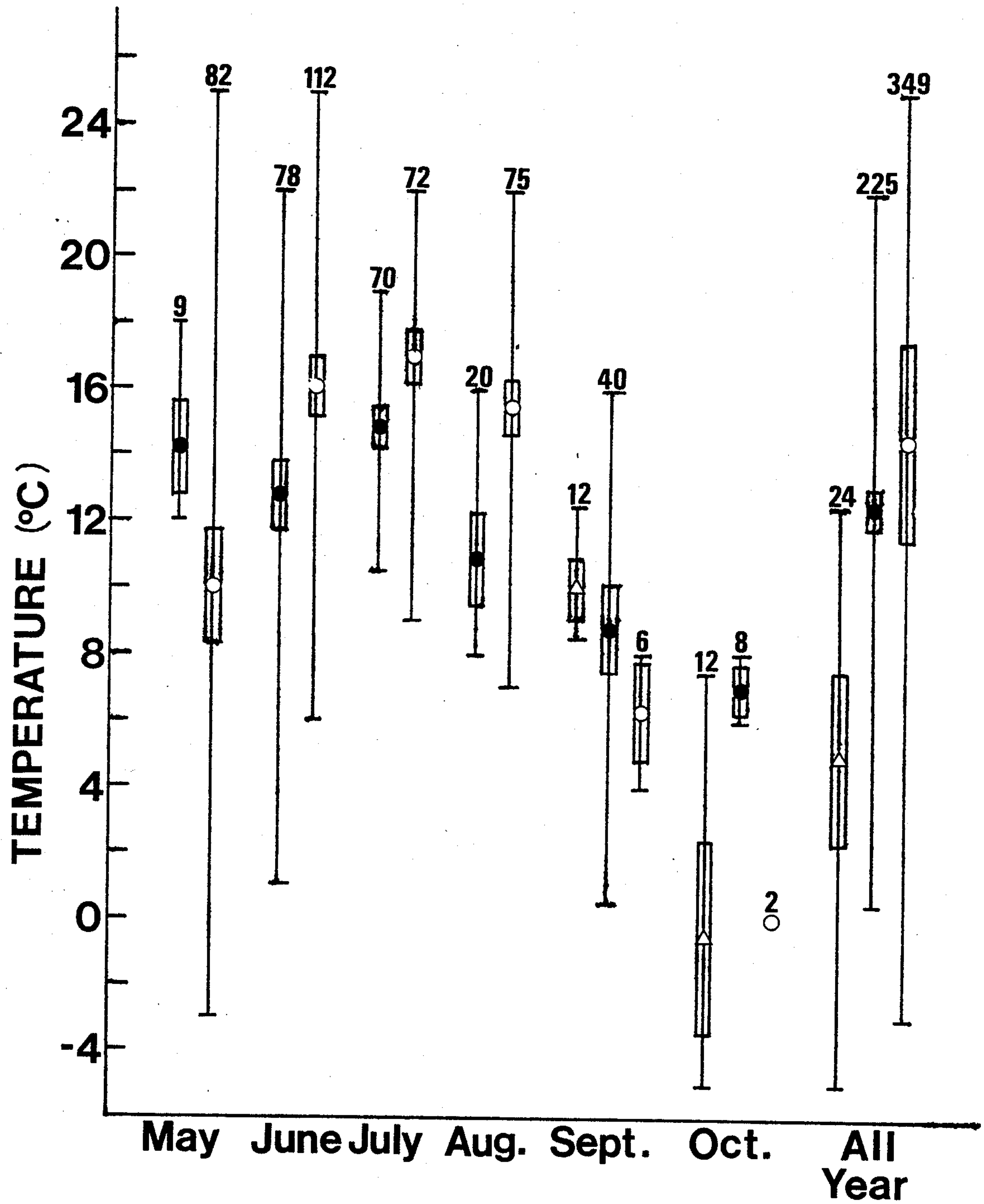
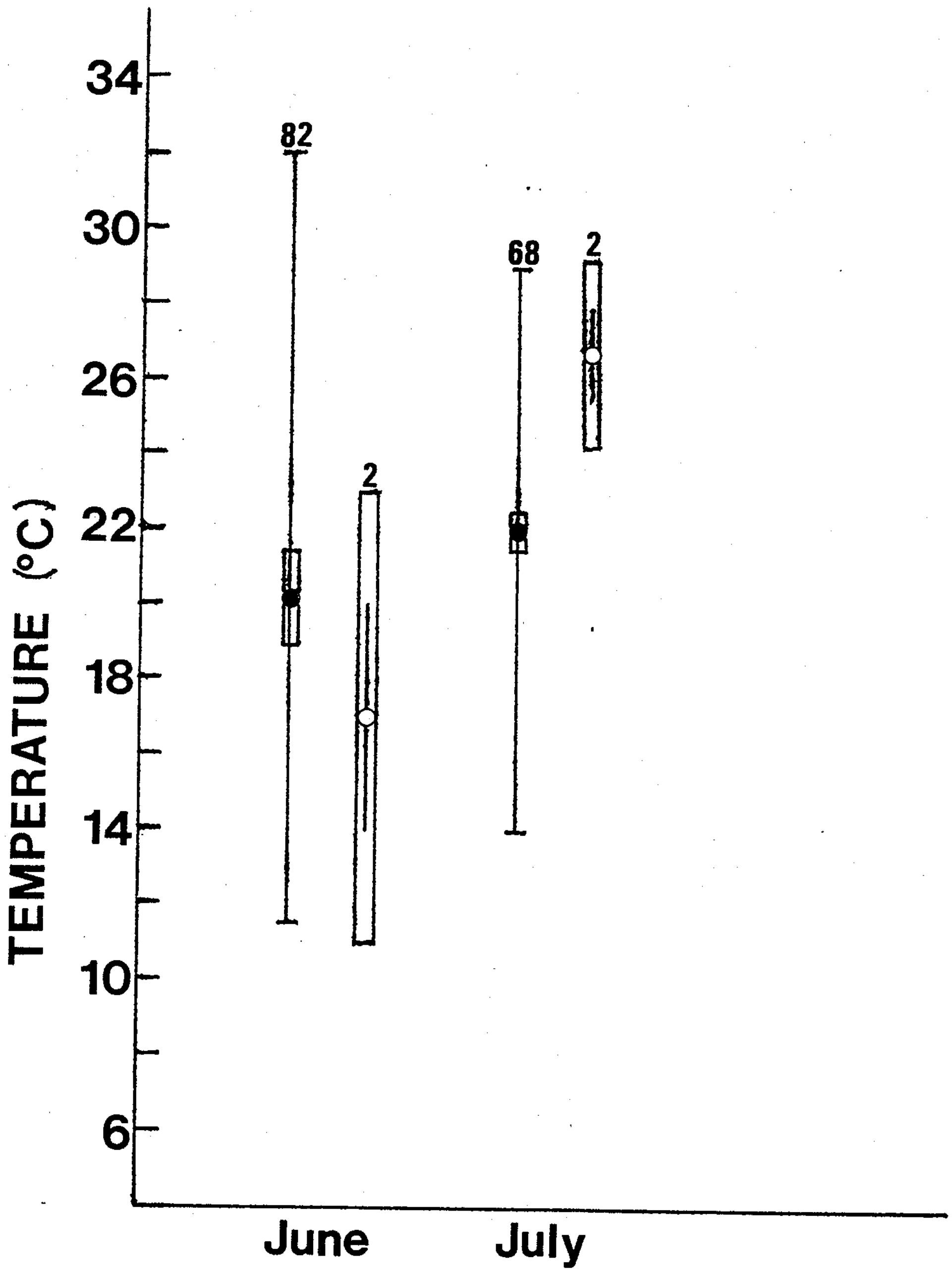

TEMPERATURE (°C)
26
22
18
14
10
6
2
-2
82
112
72
75
349
0
1
1
6
6
1
2
1
10
May
June
July
Aug.
Sept.
Oct.
All 1988

Figure 8. Comparison of 1986, 1987 and 1988 temperatures at 0700 h for all trap nights by month and for the whole years. Means: △ 1986; ● 1987; ○ 1988. Wide bars - 95% confidence limits. Narrow line - range.



TEMPERATURE (°C)
24
20
16
12
8
4
0
-4
82
112
78
72
75
349
225
9
70
20
40
12
6
12
8
2
24
May
June
July
Aug.
Sept.
Oct.
All Year

Figure 9. Temperatures at 1900 h for all and successful trap nights for evening captures in June and July, 1987. Means: ● all; ○ successful. Wide bars - 95% confidence limits. Narrow line - range.



TEMPERATURE (°C)
34
30
26
22
18
14
10
6
82
2
68
2
June
July

Precipitation

Trap nights were separated into 3 categories based on 0700 h records for morning captures and 1900 h records for evening captures on the day of checking traps: a) rain overnight/during the day; b) no rain but cloudy (>/= 0.7 cloud); and c) clear to partially cloudy (</= 0.6 cloud).

For all trap nights there were more clear mornings in 1988, more rainy mornings in 1987 and more cloudy mornings in 1986 (X^2=15.384, 4 df, p<.005). (Table 4). There were more than the expected number of captures on rainy days, but this was not significant for the three years together (X^2=2.425, 2 df, p>.1). This trend was best shown in 1988, but was still not significant (X^2=5.261, 2 df p>.05).

For the evening captures in 1987, the 2 captures in each of June and July do not provide a good statistical base. In June, both captures were on evenings in the rain category, which comprised 50% of all trap nights (Table 5). In July, one capture was in category c, the other in b although this latter capture was at the start of an intense thunderstorm. In July, 21% of trap nights were in category c and 28% in category b (Table 5).

Wind

For the morning captures, there was no variation in success with wind speed (X^2=2.414, 4 df, p >.5) (Table 6). Wind direction was significant. Fifty percent (10) of the

Table 4. Comparison of percentage of successful trap nights to percentage of all trap nights with rainy conditions; clear conditions (</= 60 % cloud); and cloudy conditions (>/= 70 % cloud cover) for morning captures only.

YEAR	WEATHER					
	RAIN		CLEAR		CLOUD	
	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)
1986	25	25	37.5	25	37.5	50
1987	40	33	41	66	19	0
1988	28	60	50	30	22	10
OVERALL	32	45	46	40	22	15

Table 5. Comparison of percentage of successful trap nights to percentage of all trap nights with rainy conditions; clear conditions (</= 60 % cloud); and cloudy conditions (>/= 70 % cloud, for June and July, 1987 evening captures (2 captures in each month).

MONTH	WEATHER					
	RAIN		CLEAR		CLOUD	
	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)
June	51	100	35	0	14	0
July	51	0	21	50	28	50
OVERALL	51	50	28	25	20	25

Table 6. Number and percentage of all and successful trap nights with different wind speeds.

WIND SPEED	ALL TRAP NIGHTS	SUCC. TRAP NIGHTS
Calm	121 (20 %)	2 (10 %)
Light	296 (50 %)	11 (55 %)
Moderate	79 (13 %)	2 (10 %)
Fresh	55 (9 %)	2 (10 %)
Strong	47 (8 %)	3 (15 %)

morning captures occurred with the wind from NNE to SSE, but this range of wind direction comprised only 27% (164) of the trap nights (X^2=3.898, 1 df, p<.05). For evening captures in June and July, 1987, wind directions were west, southwest, north and calm. They cannot be adequately compared statistically because of insufficient data.

Moon Phase

The percent of captures within 2 days of the full moon was more than expected, and the percent within 2 days of the new moon slightly less than expected but neither was significant for all 3 years combined (X^2=1.36, 3 df, p>0.5) (Table 7). Additionally there was no significant difference in trapping success with moon phase for each year independently (1986, X^2=2.678, 3 df, p>.1; 1987, X^2=5.112, 3 df, p>.1; 1988, X^2=2.77, 3 df, p>.1).

Table 7. Comparison of percentage of successful trap nights and percentage of all trap nights at different moon phases. New includes 2 days each side of the new moon; full includes 2 days each side of the full moon; new to full includes from 3 days past new to 3 days before full; and full to new includes from 3 days past full to 3 days before new.

YEAR	MOON PHASE							
	NEW		NEW TO FULL		FULL		FULL TO NEW	
	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)	ALL (%)	SUCC. (%)
1986	0	0	37.5	0	25	25	32.5	37.5
1987	18	0	38	60	17	30	28	10
1988	21	40	28	20	16	20	35	20
OVERALL	19	17	32	33	17	25	32	25

DISCUSSION

Although Buech (1983) and Davis (1984) cite 50% or greater missesfor Bailey traps, and Buech (1983) cites 0% misses for Hancocks, several authors have had reasonable success with the Bailey traps. With Baileys, Busher (1975) averaged 4.2 trap nights per beaver and Davis (1984), 13.9 trap nights per beaver. Townsend (1953) did not differentiate between Hancock and Bailey traps, but averaged 12.6 trap nights per beaver. Bailey trapping at TBS in the summer of 1986 resulted in 62 trap nights per beaver. This difference may be due to differences in habitats. Canals (Busher, 1975) or runways (Townsend, 1953) are ideally suited to Bailey trap sets, because they trap the beaver as it swims over the trap; there is no need to lure him in with bait and scent. Where beavers must be baited in, trapping is less successful (Townsend, 1953). On the Blind River, baiting was necessary because there are very few obvious runways or canals. Setting Bailey traps is much more difficult where there is a steep drop-off from the bank. Alternatively, Hancock traps can be set almost anywhere. They may be more successful as a bait set since animals cannot swim under the trap and must be almost fully in the trap when the trigger is set off. Although Bradt (1938) asserted that beavers were very suspicious of strange objects above the water and therefore traps must be below the water surface, the results in this study seem to belie this.

Most beavers followed in this study were active well before sunset (Section III). Despite this, most captures occurred after dark. Although beavers are active in daylight, they may hesitate to venture ashore or near shore before dark. Alternatively, since the traps were mainly luring in by scent, this may reflect their activity pattern. At the start of their activity period, beaver may concentrate on food gathering, and respond to scents or other signs of intrusion in their area only after feeding.

The most important factors affecting trapping success demonstrated in this study are cool temperatures and early and late season, which may be interrelated, because early and late season temperatures are generally cooler. But in 1988, the early season captures were on much cooler mornings than the mean for all trap nights, indicating that the monthly trend does not fully explain the trend to cooler temperatures. The much cooler temperatures in June, 1987 compared to June, 1988 may well explain the higher trapping success in June, 1987. Townsend (1953), using both Hancock and Bailey traps found an increase in trapping efficiency with season progression, with September and August the best, in Michigan. He did not trap in May. Busher (1975) similarly found success to be best in September and lowest in June in California. Neither author considers temperature in his study.

Dispersing beavers usually leave their home lodge just after the birth of the new kits. As they wander, they may be more susceptible to trapping. In the fall, beavers settle down and prepare for winter. Dispersing animals may be more curious as they try to find a new home site. Established animals may react to the scent more in early and late season. In early season, established animals may be sensitive to strange objects and scents due to the presence of kits. In late season, they may be sensitive because the locally available food supply may be more crucial as winter approaches.

Lunar and precipitation effects on trapping success have not been examined in previous literature. In trap sets such as Baileys, in runways where the beaver has only to swim over the trap, these factors may not be important unless they affect the beaver's movement patterns. Any effect on their movement patterns would also affect success with Hancocks. Further study and data should provide a larger sample size which will better explain their effect or lack thereof.

Wind direction was apparently important for beaver trapping in my study. In attracting beavers to a scent bait, if the wind comes from behind the trap, it may help attract the beaver. Forty percent of captures were in traps facing north-northwest to south-southwest, i.e. where north-northeast and south-southeast winds would be blowing from behind. But, on the river, winds tend to be channelled along the river, and therefore actual wind direction and direction at the trap site may not be synonymous.

CONCLUSIONS

From the evidence available, there is a suggestion that month and temperature have an effect on trapping success in the TBS area. Live-trapping success was greatest in May and September - October and when temperatures were in the 5°C to 15°C range. Wind, precipitation and lunar phase may be important, but further research is necessary.

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SECTION II

IMPLANTABLE TELEMETRY FOR BEAVERS:

A NEW TECHNIQUE

ABSTRACT

Live-trapped beavers were outfitted with tail collar transmitters (3) or intraperitoneally implanted transmitters (7). A new surgical method of implantation using a ventral-lateral muscle-split technique is described. Implanted transmitters had a longer lifespan than tail collars with no loss of range. Recapture of implanted animals showed good growth with no post-operative complications at 3, 11 and 16 months. Loss of the tail collar after one month had resulted in severe injury to the tail in a recaptured animal.

INTRODUCTION

Beavers (Castor canadensis) are aquatic, nocturnal and, in many parts of their range, confined to lodges and under-ice movement in winter. Radio-telemetry appears to be an ideal method for their study. The use of neck collars (Lancia *et al.*, 1982) and tail collars (Busher, 1975; Courcelles and Nault, 1983) has provided some information about their movement patterns, but with inherent problems due to the beaver's fusiform body shape and lifestyle. Davis (1984) implanted transmitters with some success. In this paper I discuss the use of external versus internal transmitters and present an alternative method of implanting transmitters.

METHODS

Beavers were trapped using Hancock live traps. When a beaver was caught in a trap, it was transported back to Taiga Biological Station (TBS), in the trap, by freighter canoe. Two types of transmitters were used: tail collars and implanted transmitters.

Tail Collars

Tail collars (Wildlife Materials Inc., Carbondale, Illinois) measuring 12.5x7.5x4.5 cm and weighing about 295 g were attached snugly to the base of the tail with 5 cm wide rubberised webbing, bolted to the transmitter. The beaver was sedated with 0.11 ml/kg Ketamine hydrochloride (Rogarsetic, Rogar/STB Inc., London, Ontario N6A 4C6) intramuscularly (Lancia et al., 1978) while the attachment was made. The beaver was placed in a cool dark building for 24 hours to recover from anaesthesia before release at the trap site or off the TBS dock.

Implanted Transmitters

Intraperitoneally implanted transmitters (Austec Electronics, Edmonton, Alberta) measured 6x4 cm and weighed about 80 g. The transmitter and a C-cell lithium battery were encased in beeswax and then in a biologically inert paraffin wax.

Surgical Procedure

After transport to TBS, the beaver was placed in a cool, darkened log building while preparations were made for surgery. Holding time was usually 1.5 hours before surgery, but up to 12 hours for an evening capture.

The primary anaesthetic was Ketamine hydrochloride (Rogarsetic, Rogar/STB Inc., London, Ontario N6A 4C6) as described by Lancia et al. (1978). I gave an initial dose of 0.2 ml per kg body weight (20 mg per kg of body weight) intramuscularly. This was usually sufficient to sustain anaesthesia for 30 - 40 minutes. Further booster doses of 0.5 ml intramuscularly were given as necessary, independent of weight. Each booster resulted in an additional 10 - 20 minutes of anaesthesia dependent on the weight of the animal. In addition to the ketamine, I used acepromazine maleate (Atravet, Ayerst Laboratories, Montreal, Quebec), as a muscle relaxant. The dose for all beavers was 0.25 ml, intramuscularly (2.5 mg). I injected this at the same time as the ketamine. Two ml (40 mg) of Lidocaine (Lidocaine HCl, Langford Inc., Guelph, Ontario N1K 1E4), a local anaesthetic, was injected subcutaneously along the incision site.

I performed the surgery in a log and mosquito screen `gazebo' or in a log cabin. Before surgery, the operating table was scrubbed with a 70:1 solution of Savlon, wiped off and swabbed with alcohol.

When all preparations were complete, the beaver was moved, in the trap, next to the gazebo or cabin. An assistant then stood on the upper mesh part of the trap, pinning the beaver at one side of the trap while I injected the ketamine hydrochloride and acepromazine maleate into the gluteal muscle. Full anaesthesia resulted in 1 - 4 minutes. The beaver was then removed from the trap and placed on the operating table. The front and hind legs were tied snugly to the table legs using 1 inch strips of gauze. An antibiotic ointment (Rogar-mycine, Rogar/STB Inc., London, Ontario N6A 4C6) was placed on the eyes to protect them during surgery. A wet paper towel was wrapped around the beaver's tail to prevent overheating.

I clipped an area about 3 cm wide and 8 cm long of excess fur on the ventral surface immediately caudate to the right side of the rib cage. About 4 mm of fur was left. The area was washed with a 70:1 solution of Savlon and then rinsed with 70% ethanol after which excess moisture was soaked up. Lidocaine was injected subcutaneously along the incision site.

During the operation, surgical gloves were sterilised by rinsing in 70% ethanol. A plastic incise drape (Steridrape, 3M Medical-Surgical Division, St. Paul, MN, 55144-1000) was placed over the beaver, and a hole was cut in the plastic over the clipped area, using scissors. I made the incision using a #22 scalpel blade after separating the fur in a line to expose the skin. The incision was made 3 - 4 cm below the costal margin, starting 1.5 - 2 cm from the midline and extending about 8 cm perpendicular to the midline.

The skin was grasped with a haemostat and lifted gently. The membranous connective tissue between the skin and the external oblique muscle was carefully clipped using fine scissors, and the two layers were gently separated. Haemostats were placed on the subcutaneous tissue, to hold back the edges of the incision, and to allow access to the muscle layer beneath. The external oblique muscle was opened using a muscle split technique. A small, blunt haemostat was placed against the muscle. The haemostat was opened, with gentle downward pressure, along the line of the muscle fibres. This was repeated if necessary until the internal oblique muscle could be viewed through the incision. The muscle split could be extended by gently pulling the fibres apart. The external oblique muscle was then separated from the internal oblique muscle using the same technique as described above for separating the skin and external oblique muscle. The internal oblique muscle was split as was done for the external oblique. The internal oblique muscle and the transversus abdominis muscle were separated as described above. The transversus abdominis muscle was then split, as described above. In all the beavers used in this research, the peritoneum was attached to the inner wall of the transversus abdominis muscle, and was opened at the same time as the transversus abdominis was split.

Once the opening in the transversus abdominis muscle and peritoneum was large enough, I placed haemostats at each end of the incision in the peritoneum to prevent further splitting while inserting the transmitter. The transmitter was sterilised for 2 hours in 70% ethanol, allowed to dry briefly, and then rinsed in sterile water. It was slid through the incision and gently pushed towards the midline. A 1 million IU dose of Penicillin G Sodium (Crystapen, Glaxo) was then poured into the peritoneal cavity.

I sewed up the transversus abdominis muscle and the peritoneum together using continuous 3`0' gut. The internal oblique and external oblique muscles were sewn up in turn with continuous 3`0' gut sutures. I sutured the skin with interrupted 3`0' or 4`0' silk sutures. Usually 12 stitches were sufficient to close the skin incision, although this varied slightly.

Derapen (Ayerst Laboratories, Montreal, Quebec), an antibiotic, was then given intramuscularly. The dose was 0.22 ml per kg body weight (66,000 IU per kg). The steridrape was removed, the legs untied, and the beaver was moved back into the Hancock trap. The beaver, in the trap, was kept in a cool, dark building for 48 hours after surgery.

After the first 24 hours, the beaver, in the trap, was moved to a canoe that was partly filled with water. I gave poplar branches to the beaver at that time. The trap was left in the canoe, covered with wet towels for 4 - 5 hours. The beaver was then moved back to the building until release. The incision was inspected before release, to ensure that stitches were still intact. I released the beavers as close to the site of their capture as possible.

RESULTS

Tail Collars

Four tail collars were attached to beavers weighing 12.3 to 19.6 kg with a mean weight of 17.2 +/- 3.3 kg. One collar was removed before release because the tail was too narrow to prevent slippage. One was lost after one month with much damage to the tail (Figure 1). When retrieved, this collar was hooked on submerged branches in a dense willow bog. The tail damage indicates the beaver had probably had to pull free from the collar to free himself. The other two tail collars had lifespans of 6 weeks and 8 months (Table 1).

Implanted transmitters

Intraperitoneal transmitters were implanted into 7 beavers in this study. Implanted animals weighed 9.1 to 13.2 kg with a mean weight of 10.8 +/- 1.4 kg. I know of no mortality due to the surgical procedure. One animal disappeared from the study area after 2 weeks. All other animals were active 6 months to 2 years after surgery. I recaptured two implanted beavers a total of 3 times. Number 1848-50 was recaptured 3 and 16 months after surgery, and 1846-47, 11 months after surgery. Both beavers had a

Figure 1. Tail of beaver 1842-43 showing damage due to loss of the tail collar. The lighter areas on the tail are the result of scarring. A large piece is also missing from the right side of the tail.

Table 1. Information on beavers and transmitters, including type of transmitter, ear tag numbers, date of transmitter installation, sex and age of beavers, number of days transmitter was active and status as of May 1, 1989.

TRANS. TYPE	BEAVER NUMBER	DATE OF INSTALL.	EST.AGE AT INST. (YEARS)	PROB. SEX	DAYS ACTIVE	STATUS ON 89-05-01
Tail	1830	86-09-29	4+	M	40	failed 86-11
Implant	1834-35	87-06-12	2	?	700+	active
Tail	1844-45	87-06-08	4+	M	265	failed 88-02
Implant	1846-47	87-06-08	2	M	170	failed 87-11
Tail	1842-43	87-06-11	2	M	20	lost 87-07
Implant	1848-50	87-07-03	2	F	480	failed 88-11
Implant	B280-81	87-07-06	2	?	17+	disappeared 87-07-23
Implant	B286-87	88-05-12	2	F	353	active
Implant	B434-37	88-08-25	2.5	M	260+	active
Implant	B294-95	88-09-26	2.5	M	165	failed 89-03

palpable scar, but no signs of infection around the incision site. The incision site was not visible at 3 months post-surgery. Number 1848-50 showed a significant increase in size over the 16 months (Table 2) while 1846-47 showed less growth in 11 months (Table 3), but both appeared healthy when recaptured. This second beaver may have had a low weight on recapture because the capture was shortly after breakup, when winter weight loss may be evident. Excluding the beaver that left the study area, life of the transmitters varied from 6 months to 2 years (Table 1), with an average life span of over 357 days.

The range of both types of transmitters was 0.1 km (transmitter and receiver in dense alder bog) to 2 km (receiver on a high ridge). On the lake, range was about 1 km and from the air about 4 km.

Table 2. **Weight and body measurements of beaver number 1848-50 for three successive capture dates.**

MEASUREMENT	DATE OF CAPTURE		
	1987-07-03	1987-09-28	1988-10-23
Weight (kg)	13.2	15.9	17.2
Total length (mm)	952	1020	1020
Tail length (mm)	287	307	310
Hind foot length (mm)	160	160	160
Ear from notch (mm)	22	--	29
Neck circumference (mm)	305	--	--
Tail circumference (mm)			
base	158	151	200
widest	--	214	235

Table 3. Weight and body measurements of beaver number 1846-47 for two successive capture dates.

MEASUREMENT	DATE OF CAPTURE	
	1987-06-08	1988-05-08
Weight (kg)	9.5	11.4
Total length (mm)	895	1002
Tail length (mm)	280	297
Hind foot length (mm)	150	157
Ear from notch (mm)	22	30
Neck circumference (mm)	--	--
Tail circumference (mm)		
base	170	161
widest	--	250

DISCUSSION

The beaver's fusiform shape, semi-aquatic lifestyle and habitat must all be considered when deciding how to outfit them with a telemetry system. A radio-collar attached to the neck (Lancia, 1980) or tail (Busher, 1975; Courcelles and Nault, 1983) may catch on vegetation in the habitat, as in this study, and result in injury or death. In addition, a collar that is snug enough to prevent its loss by slippage will quickly become too tight in a growing animal and result in death or injury as happened in Busher's (1975) study. Growing animals must either be recaptured frequently or cannot be used with externally mounted transmitters. Injury to the neck or base of the tail may also result from abrasion of the transmitter (Busher, 1975; Lancia and Dodge, 1977).

Implanted transmitters, on the contrary, can be used in almost any sized animal because they provide no hindrance to growth, and are safer for the beaver because there is no potential for snagging. The only risk to the animal is infection due to surgery, but this can be reduced by sterile technique and antibiotics. Guynn <u>et al</u>. (1987) report one death due to adhesion to the large intestine with resultant blockage of the lumen in Davis' (1984) study. After 6 weeks, intraperitoneally implanted transmitters appear to be encapsulated in necrotic fibrous tissue (Guynn <u>et al</u>., 1987). Once encapsulated, there should be little effect on the animal, as evidenced by pregnancy in implanted animals (Guynn et al., 1987). Davis (1984) attempted two subcutaneous implants with poor success. Both animals died within a year - one from infection after loss of the transmitter, and the other from unknown causes. As in this present study, Davis (1984; Davis et al., 1984) found little problem with intraperitoneal implants. His method used a dorsal incision rather than ventral. This could be more dangerous to the animal. From my observations of beaver, I have found that their natural range of movements during grooming and feeding tends to stretch the dorsal muscles and skin more than the ventral muscles and skin. In addition, the kidneys and blood vessels on the dorsal wall of the abdomen present a greater chance for complications with a dorsal incision.

Kenward (1987) reports that a mid-ventral, or linea alba, incision is the usual means of access to the peritoneal cavity. While this procedure may contribute to a faster operation, because there are fewer layers, other problems may arise. Connective tissue (the linea alba) is slower to heal than muscle and provides for a much weaker incision after suturing than the muscle-split technique. The alternating directions of the muscle layers with my technique provide a much better seal than the linea alba incision. With a mid-ventral incision, the transmitter may sit directly over the incision (Kenward, 1987) and affect healing, whereas with the off-centre incision I used, this is much less likely. More abrasion of the incision site is likely with a mid-ventral incision because it is on the lowest part of the abdomen as the beaver moves around and is much more likely to catch on the ground and vegetation than the off-centre incision.

Implanted transmitters demonstrated a much longer life (up to 700+ days) than external transmitters (maximum 265 days) in this study. Busher's (1975) tail collars lasted 1 to 39 days (mean 16.5 days), Lancia's (1979) neck collars 4 to 6 months and Davis' (1984) implanted transmitters up to 465 days (mean 173.4 days). Implanted transmitters are in a relatively stable environment, are not subject to fluctuating temperatures or damage from grooming or the environment. As a result, studies of beavers with implants do not need to rely on recapturing animals to maintain long term transmissions.

Range of transmission does not appear to be affected by implanting; the range was similar for both tail collars and implants in this study. Davis (1984) had a similar range of 0.1 to 2 km for his implants. The tail collars used by Busher (1975) had a range of only 0.2 to 0.4 km and the neck collars had a range of about 500 m (Lancia and Dodge, 1977).

CONCLUSIONS

Intraperitoneal transmitters, though requiring an invasive technique initially, appear to have a lesser potential for long term harm than external transmitters, with a greater potential transmitter life and no loss of range. They appear to be the best option available for an animal such as the beaver. The new surgical technique described in the present study provides a safe, relatively straightforward method of implantation.

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SECTION III

BEAVER MOVEMENT IN THE TAIGA

ABSTRACT

Beaver (*Castor canadensis*) were followed using radio-telemetry with implanted and tail collar transmitters. Daily travel distances ranged from about 1 km to 8 or more km. Home range lengths varied from 0.55 km to 6 km. An adult male and subadult female had the largest daily movements and home ranges. No evidence was found of territoriality. Two dispersing beavers are known to have travelled 24 and 36 km, including at least 1 km of overland travel in the latter case. Winter under-ice movements were never more than 50 m from the lodge, and winter activity was sporadic. Above-ice activity was rare, and only occurred when night-time temperatures did not fall much below freezing.

INTRODUCTION

Studies of beaver dispersal have generally relied on commercial trapping of previously live-trapped, tagged and released animals. Transplanted animals (Hibbard, 1958; Knudsen and Hale, 1965; Courcelles and Nault, 1983) and also non-transplanted animals (Beer, 1955; Libby, 1957; Leege, 1968) have been studied. Transplanted animals may not give accurate information on natural dispersal (Libby, 1957). The above studies cited very variable dispersal distances with sex and age variations. There is usually little adult dispersal (Beer, 1955) and males may disperse farther than females (Knudsen and Hale, 1965; Leege, 1968).

Busher (1975) and Davis (1984) have quantified the daily movements of beavers, while Green (1936), Bergerud and Miller (1977) and Brady and Svendsen (1981) have described some colony activity with little quantification of movement distances. Despite this paucity of data on movement patterns and distances, territoriality has been inferred for beavers, primarily from the presence of scent mounds (mud piles mixed with beaver castoreum, constructed by the beaver) (Hay, 1958; Aleksiuk, 1968). Other authors have referred to distances between colony centres, with little observation of whether movement between these areas exists (Boyce, 1981; Howard and Larson, 1985).

Beavers are active throughout the winter and do not hibernate. In ice-covered areas, studies relying on visual observations are limited to above-ice activity (Green, 1936; Stephenson, 1969; Aleksiuk, 1970). Acoustic recordings of lodges give some information on activity rhythms (Bovet and Oertli, 1974; Potvin and Bovet, 1975). Radiotelemetry with fixed receivers (Lancia, 1979) provides information on movement, but does not necessarily determine the outside limits of this movement.

Beavers use both bank burrows and lodges. Lodges were prevalent in Newfoundland (Payne, 1981) while bank burrows were more important in Michigan (Bradt, 1938), Louisiana (Chabreck, 1958) and Montana (Swenson et al., 1983).

In this study, I tracked beavers using radiotelemetry in order to determine their movement patterns and distances travelled in both summer and winter.

STUDY AREA

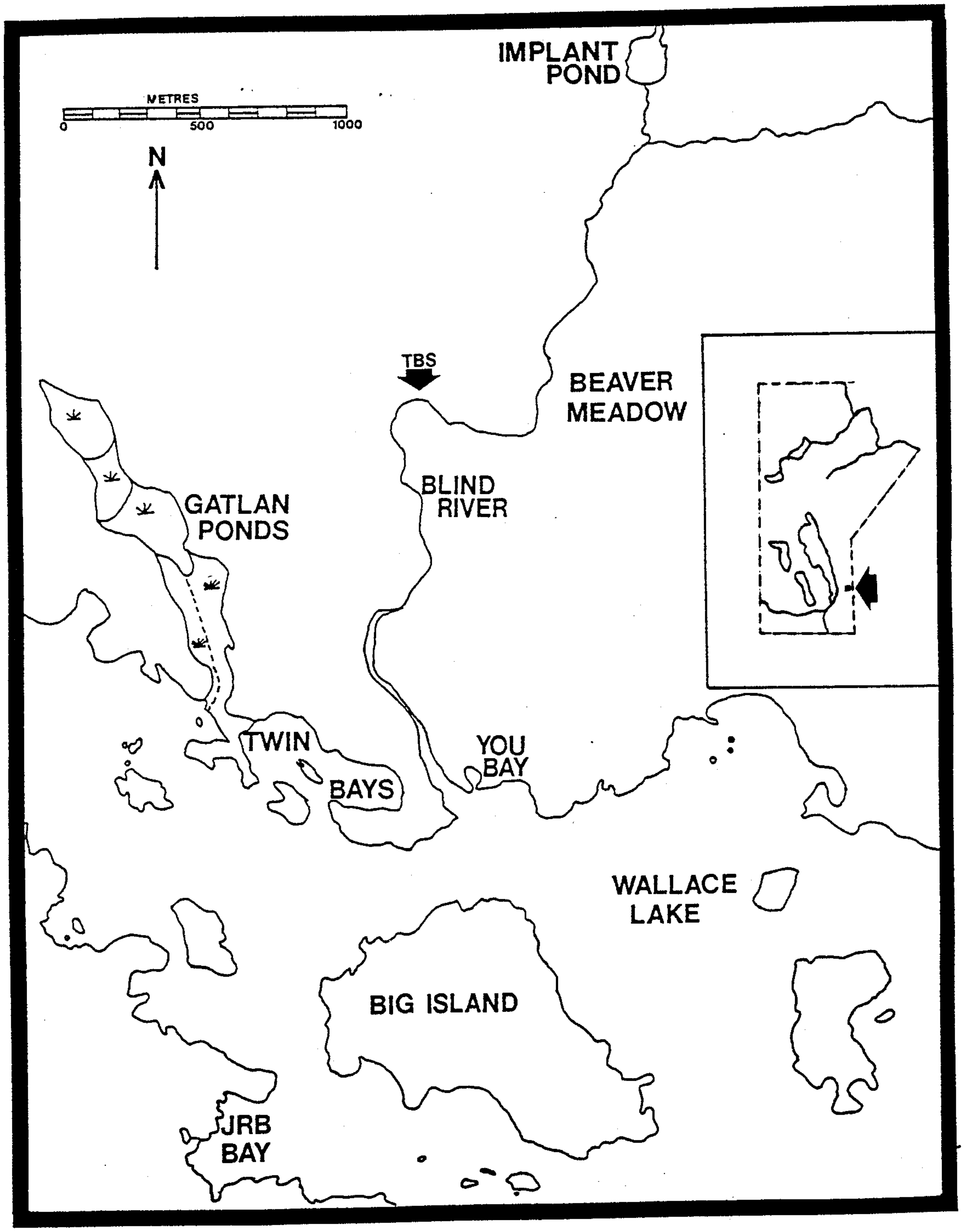
This study was based at Taiga Biological Station, 51°02'40" N, 95°20'40" W, 250 km northeast of Winnipeg, Manitoba (Figure 1). The study took place on Wallace Lake and the Blind River which enters Wallace Lake from the north. This area was burnt in the 1980 Wallace Lake fire. The river is bordered mainly by burnt bogs with a few burnt ridges. The lake is bordered primarily by burnt ridges. There are irregular patches of unburnt land in the area, some bordering the river and lake. To the east of TBS, the Blind River traverses and all but disappears in a large boggy area known as the beaver meadow (Figure 1). This is the result of numerous changes of river flow caused by beavers damming the river at various times in the past.

The bogs, and also some ridges where erosion has not been too extensive, support a good growth of *Populus tremuloides* and *Alnus crispa*. In most areas, these are the primary reforestation species, with *Picea mariana* and *Pinus banksiana* appearing later.

Trapping History

The study area is within the boundaries of Registered Trap Line 10, Hole River, and is trapped by Bill Conley. Beavers were last taken on the Blind River in 1984 and 1980,

Figure 1. Location of study area in Manitoba, and detail of study area.

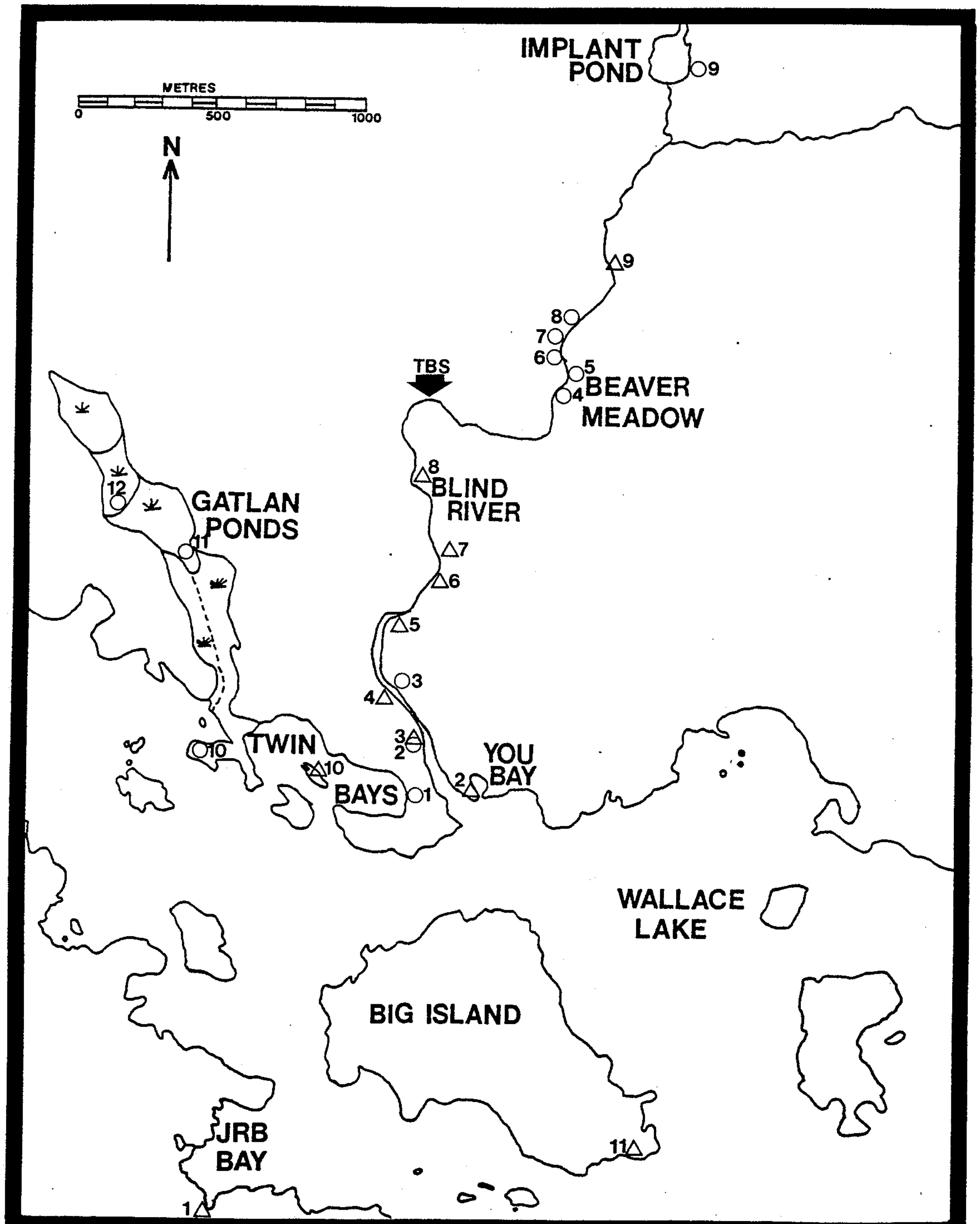

IMPLANT POND
METRES
0
500
1000
N
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

two beavers in each year. Seven beavers were trapped in the Gatlan Ponds in 1987 and 4 in 1986. Prior to that, 3 were taken in 1979. The south shore of Wallace Lake including JRB Bay yielded 3 beavers in each of 1986 and 1978. The Siderock River, flowing into Wallace Lake, produced 1 beaver in 1988, 8 in 1987, 1 in 1984 and 5 in 1981. The Wanipigow River, flowing out of Wallace Lake, yielded 2 beavers in each of 1987 and 1984 (Bill Conley, personal communication).

Lodge Use History

The lodges and burrows used by beavers during this study are indicated in Figure 2. The age and history of occupation of the lodges varies as summarized in Table 1.

Figure 2. Location of beaver lodges – ○; and bank burrows – △ used by beavers during this study. Lodges: 1. Twin Bays Lodge; 2. New Blind River Lodge; 3. Old Blind River Lodge; 4. South Beaver Meadow Lodge; 5. Observation Lodge; 6. Middle Lodge; 7. New Beaver Meadow Lodge; 8. North Beaver Meadow Lodge; 9. Implant Pond Lodge; 10. Rock Lodge; 11. Lower Gatlan Pond Lodge; 12. Upper Gatlan Pond Lodge. Bank burrows: 1. JRB Burrow; 2. Blind River – You Bay Burrow; 3. Refuge Burrow; 4. Blind River Burrow; 5. Short Burrow; 6. Rock Burrow; 7. Corner Burrow; 8. Tourist Trap Burrow; 9. Gorge Burrow; 10. Twin Bays Burrow; 11. Big Island Burrow.



IMPLANT POND
METRES
0
500
1000
N
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

Table 1. History of use of beaver lodges on the Blind River, Wallace Lake and Implant Pond. ? indicates uncertainty about the dates of occupation.

LODGE NAME	DATE OF CONSTRUCTION	KNOWN OCCUPANT(S)	OCCUPATION HISTORY
Twin Bays	fall 1987	1848-50	winter 1987-88
New Blind River	fall 1988	2 beavers	winter 1988-89
Old Blind River	unknown (pre-1973)	---	1973-1980
		4 beavers incl. 1830	1985-1987
		1844-45	summer 1987
		1848-50	summer 1988
South Beaver Meadow	unknown (pre-1973)	1842-43	1987-88
Observation	unknown	---	1982-83 and before
	(pre-1973)	1834-35	winter 1988-89
Middle	fall 1986	---	winter 1986-87 (2 dead beavers found nearby, May, 1987)
New Beaver Meadow	fall 1987	1844-45 & 1834-35	1987-88
North Beaver Meadow	fall 1986	---	1986-87
Implant Pond	about 1979	---	1979-87 (?)
		5 beavers incl. 1846-47	1987-88
		---	1988-89
Rock	fall 1988	B294-295	1988-89
Lower Gatlan Pond	unknown (pre-1986)	4+ beavers incl. B286-87	1986-88
Upper Gatlan Pond	unknown (pre-1986)	3+ beavers incl. B286-87	winter 1988-89

METHODS

Beavers were trapped using Hancock live-traps. All beavers were transported back to TBS to be measured, weighed, ear-tagged and outfitted with a transmitter, in some cases.

Measurement of Beavers

All beavers captured had a series of measurements taken. To do this when anaesthesia was not used; one person would stand on the mesh side of the Hancock trap, so as to pin the beaver and hold it still. Measurements were then taken of (a) total length, (b) tail length, (c) length of hind foot, (d) length of ear from notch, (e) circumference of the tail at the base and (f) circumference of the tail at the widest point. These latter two measurements were not recorded for some of the earlier beaver captured. Weight was determined by weighing the beaver and trap and then subtracting the known weight of the trap. When beavers were recaptured, all the measurements and weight were again recorded to determine if any changes had occurred. The accuracy of the body length measurement may be questionable, since it was difficult to "persuade" an unanaesthetized animal to stretch out fully, and the mesh of the trap prevented direct access to the animal. An attempt was made to determine sex by palpating for the baculum. This was usually quite easy to find, if present, when the animal was fully anaesthetized. With unanaesthetized animals, the accuracy of this technique was much more questionable, since palpation was difficult.

Ear Tagging

Both ears were tagged with number 3 Monel chick wing tags with coloured vinyl swatches attached to the metal tag using melted holes (Miller, 1964). The colour and shape combination of the vinyl was the same for both ears but unique for each beaver. Each metal tag had a unique number to ensure correct identification, when the animal was recaptured, even if the coloured vinyl had been lost .

Telemetry

Beavers were followed using a collapsible H shaped Yagi antenna connected to a 24 channel TRX-24 receiver (Wildlife Materials, Inc., Carbondale, Illinois). Two different types of transmitters were used. For adult beavers (18 kg or more, usually) tail collars could be used (Wildlife Materials Inc.). These transmitters measured 12.5x7.5x4.5 cm and weighed about 295 g, including the webbing used for attachment to the base of the tail. In order to prevent the collar from slipping down the tail and being lost, these transmitters could only be attached to beavers that were no longer growing, and had a tail that was not very flexible from side to side and that widened from the base. For smaller beavers, and some adults, implanted transmitters were used (Austec Electronics). These consisted of a transmitter coupled with a C cell lithium battery, encased in beeswax and then in a biologically inert paraffin wax. They measured 6x4 cm and weighed about 80 g. These were implanted intraperitoneally, using a muscle-split technique described fully in Section II.

RESULTS

Seventeen beavers were captured a total of 24 times in the three trapping seasons (Table 2). All but three of the beavers captured were juveniles (Table 3). Eight were male, 5 female, and 4 were of undetermined sex. Half the beavers were outfitted with transmitters - 3 with tail collars and 7 with implants.

VISUAL OBSERVATIONS

Summer

Visual observations were broken down into 6 categories: a) sightings of unmarked (no tags seen) animals; b) sightings of marked, identifiable animals; c) sightings of marked but unidentifiable animals; d) sightings of animals with transmitters, but not through use of telemetry; e) sightings of animals with transmitters after location with telemetry; f) sightings of other animals made as a result of radiotelemetry to locate an associated animal. Only the first 4 categories will be considered here. Observations from e) and f) are considered in part 2.

I made thirty-two visual observations. Twenty-four were of unmarked, or apparently unmarked, individuals; two were of identifiable animals; three of marked but unidentifiable animals; and three of transmittered animals

Table 2. Summary of beaver trapping seasons and trapping success.

YEAR	TRAPPING PERIOD	NUMBER OF TRAP NIGHTS	NUMBER OF BEAVERS TRAPPED		TRAP NIGHTS PER CAPTURE
			Initial	Recapture	
1986	09-20 to 10-19	24	3	1	6
1987	05-26 to 10-04	225	6	4	22.5
1988	05-05 to 10-23	349	8	2	34.9
TOTAL		598	17	7	24.9

Table 3. Information on beavers and transmitters, including type of transmitter, ear tag numbers, date of transmitter installation, sex and age of beavers, number of days transmitter was active and status as of May 1, 1989.

TRANS. TYPE	BEAVER NUMBER	DATE OF INSTALL.	EST. AGE AT INST. (YEARS)	PROB. SEX	DAYS ACTIVE	STATUS ON 89-05-01
Tail	1830	86-09-29	4+	M	40	failed 86-11
Implant	1834-35	87-06-12	2	?	700+	active
Tail	1844-45	87-06-08	4+	M	265	failed 88-02
Implant	1846-47	87-06-08	2	M	170	failed 87-11
Tail	1842-43	87-06-11	2	M	20	lost 87-07
Implant	1848-50	87-07-03	2	F	480	failed 88-11
Implant	B280-81	87-07-06	2	?	17+	disappeared 87-07-23
Implant	B286-87	88-05-12	2	F	353	active
Implant	B434-37	88-08-25	2.5	M	260+	active
Implant	B294-95	88-09-26	2.5	M	165	failed 89-03

when telemetry was not in use. Eight of the observations were made on the lake or at the river mouth, 19 on the river and 5 in Implant Pond (Figure 3).

I observed more beavers with each succeeding year (Table 4), but this coincides with a longer observation season which was similar to the trapping season. More observations were also made early and late in the season. The daily observation period during the midsummer months was usually longer than early and late in the season due to later sunset and earlier sunrise times. Only 2 of the observations occurred in the morning.

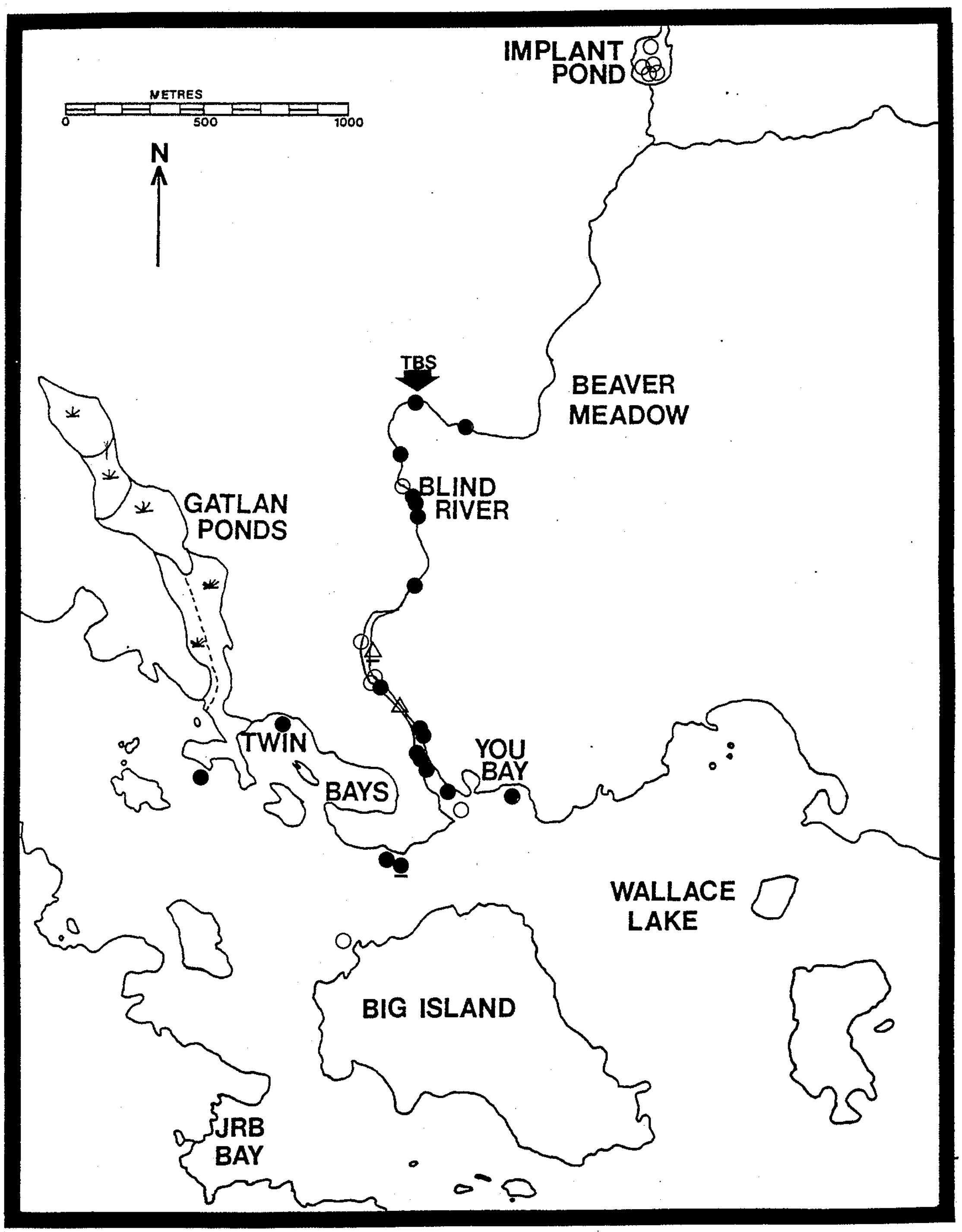
The majority of observations were near the mouth, in the area below TBS and in Implant Pond (Figure 1). The beavers in the lake were all observed north of the Big Island and all were close to shore, swimming parallel to it when sighted.

Seventy-eight percent of observations were made when wind conditions were calm to light (Table 5). The lake observation with strong winds occurred in a shallow sheltered bay.

Behaviour

I observed all beavers, except those in the pond, from the canoe. Upon approach, they would usually dive. This was preceded by a tail-slap in many instances. On calm days, I watched the air bubbles to determine the beaver's

Figure 3. Visual observations of beaver in the study area. △ 1986; ○ 1987; ● 1988. Underlined indicates morning observation.


IMPLANT
POND
METRES
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N
TBS
BEAVER
MEADOW
BLIND
RIVER
GATLAN
PONDS
TWIN
BAYS
YOU
BAY
WALLACE
LAKE
BIG ISLAND
JRB
BAY

Table 4. Number of visual sightings of beavers on Wallace Lake, the Blind River and Implant Pond, by month and year.

MONTH	YEAR			TOTAL
	1986	1987	1988	
April	--	--	4	4
May	--	--	7	7
June	--	2	2	4
July	--	2	--	2
August	--	--	1	1
September	1	1	3	5
October	1	6	2	9
TOTAL	2	11	19	32

Table 5. Number of visual observations of beavers made in pond, lake and river habitats at different wind speeds.

HABITAT	WIND SPEED				
	Calm	Light	Moderate	Fresh	Strong
River	5	7	3	1	3
Lake	5	1	--	1	1
Pond	--	5	--	--	--
TOTAL	10	13	3	2	4

underwater route. River beavers usually doubled back and headed for the nearest shore, rarely reappearing. Most went to bushes along the bank and seemed to stay hidden in the overhanging vegetation. Occasionally more bubbles were spotted heading farther away. Beavers seen in the lake resurfaced a short distance away in the same direction of travel, and continued along, head up, but would dive again if followed.

The pond beavers were approached on foot and I observed them while standing at the base of a 1.2 m dam so that only my head and shoulders were above the dam. They would sniff the air and turn away circling in a group. However, the transmittered beaver in the group, after sniffing, would hiss loudly and slap its tail repeatedly. Possibly this beaver recognized my scent. Apart from a large beaver that stayed at the far end of the pond, no attempt was made to put any great distance between themselves and me. They would in turn approach within 2 m of the dam. No prolonged underwater swimming was observed.

Marked Animals

Of the 5 identifiable beavers seen, 2 were only ear tagged. Both these animals were seen the same day as tagged. Both had been trapped at site 2, one on May 12, 1988 (B286-287), the other on May 17, 1988 (B282-283). B286-287, a 2 year-old female, was seen swimming 400 m downstream near the river mouth towards the lake at 1700 h. She disappeared round the point into You Bay. B282-283, a 2 year-old male, was seen at 2100 h near the TBS dock, 1.2 km upstream from the trap site. No further sightings were made of either beaver.

The three transmittered animals were all seen within the area where I usually found them with telemetry. Number 1846-1847 was observed on October 31, 1987 in Implant Pond as described above. The sighting in conjunction with the family group may help determine his age. No kits were seen with the group, but 1846-1847 was one of the 2 smallest beavers of the 5. This may mean he was a yearling at the time of original capture (or 1.5 years of age at this observation).

Beaver 1830, an adult male, was seen October 12, 1986 at 1745 h, swimming upstream, about 200 m downstream from his lodge. This was the only time he was found out of the lodge in daylight.

Beaver 1848-1850 was spotted swimming along the north shore between Twin Bays and the Blind River at 2035 h on April 28, 1988, the day of break-up. This was the first sighting since the previous fall. On approach she dove, reappeared and then headed towards Big Island. She was not followed due to onset of darkness.

Unidentified animals

The three marked but unidentifiable animals were seen in April and May, 1988. All were of intermediate size and all were seen on the lake. Four of the unmarked animals were seen in Implant Pond with 1846-1847. One was similar in size to 1846-1847 (about 10 kg), 2 were larger (15 kg or more) and one was very large (20-25 kg).

The remaining unmarked animals ranged from a very small kit (June 24, 1988) to a very large beaver (25+ kg, September 28, 1986). Many were seen at such distance, or near dark, or so briefly, that size could not be estimated. All sightings were usually brief, as previously described.

Winter

I never made a visual observation of a beaver during the ice-covered periods. One sighting of a beaver walking on the just-frozen river, November 2, 1984 has been reported (Jim Schaefer, personal communication). It was about 500 m upstream from the mouth heading downstream near the west bank. It slapped its tail on the ice several times then continued on its way.

Visual observations were made of signs of above-ice activity: exit holes from under the ice, and trails in the snow. Exit holes were found near 3 lodges in February and March, 1987, and near 1 lodge in April, 1989. No sign of above-ice activity was found in 1988 even though I looked for it.

On February 21, 1987 an exit hole was found behind the Blind River lodge with a trail and signs of cutting. On March 15, exploration showed exit holes behind the lodge and 20 m downstream, on the river edge. Trails connected these 2 holes with signs of cutting of <u>Alnus</u> and <u>Cornus</u>. The trails had not been used for several days and were overlaid by wolf tracks. Two holes were found on the opposite shore, one very old and snowed in. The other was a snow tunnel .25 m wide and .75 m long leading down to the ice (Figure 4). This appeared fresher (48 h or less) than the other holes. Again a trail led to the stumps of small <u>Alnus</u> sp. Two exit holes were also found on March 15, 1987 in the beaver meadow. Both were near occupied lodges, but were next to dams. The holes were quite old, with no trails visible.

On April 14, 1989, I found an exit hole and trails near the New Blind River lodge. These had not been present the day before. The exit was 8 m upstream from the lodge, and 2 m from the river edge (Figure 5). Good prints of hind feet were found that could be measured. There were 2 different sizes. One group averaged 164 mm (n=7) in length, the other 130 mm (n=3). The large prints were more prevalent. All the <u>Alnus</u> sp. within the flattened area had been harvested, and apparently taken under the ice. The stumps were all

Figure 4. Tunnel leading from under the ice to the river bank. Width of tunnel about 0.25 m. Length about 0.75 m. March 15, 1987.

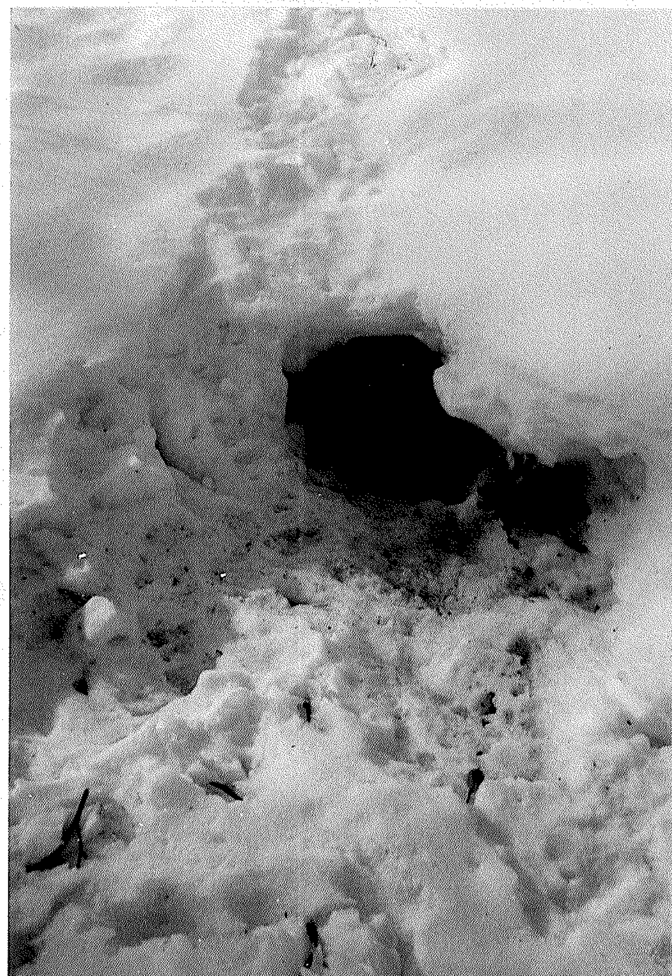
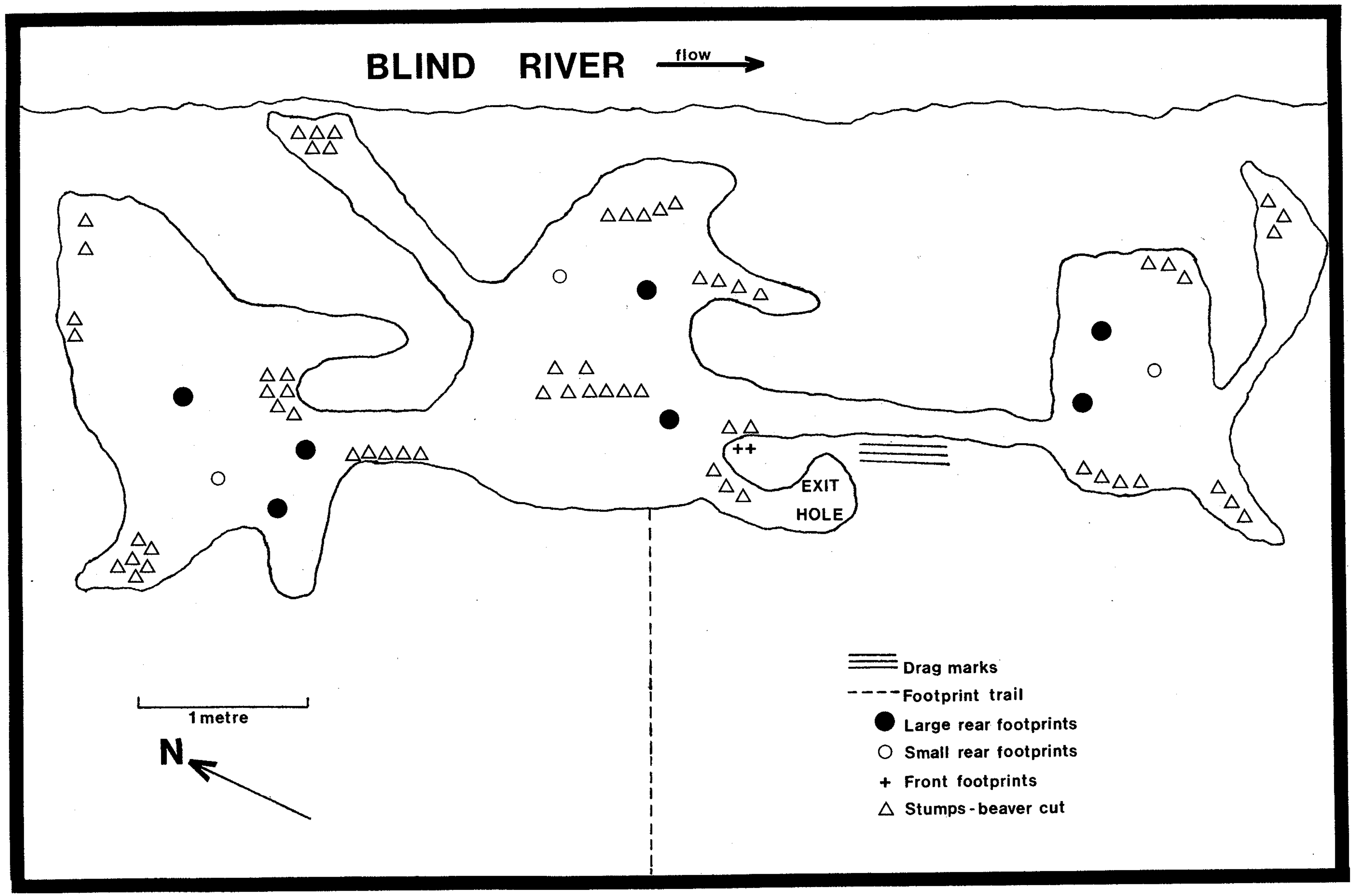


Figure 5. Area of beaver above-ice activity. The outlined area was flattened snow. The footprint trail was not flattened. Exit hole was 8 m upstream from the New Blind River Lodge.


BLIND RIVER
flow
EXIT
HOLE
Drag marks
Footprint trail
Large rear footprints
Small rear footprints
Front footprints
Stumps - beaver cut
1 metre
N

less than 1 cm in diameter. Some exploration was also apparently made -tracks went back about 10 m from the exit hole. A snowmobile track was crossed but not followed despite the feet sinking into the soft snow off the track. The lodge seemed to have partially collapsed over the previous few days.

RADIOTELEMETRY OBSERVATIONS

Ten beavers were outfitted with transmitters (3 tail collars and 7 implants). The beavers' probable age ranged from 1 to 4 or more years. Transmitter life varied from about 40 days to 700+ days. Table 3 shows that implanted transmitters appear to be more reliable than the tail collars. The number of location records for each beaver varies considerably (Table 6). The life of the transmitter, accessibility of the animal, distance moved by the beaver, and variability in movements all affected the number of records for each animal.

The range of signal reception was highly variable, and depended on habitat. Range varied from less than 100 meters when both transmitter and receiver were in a dense alder bog, to up to 2 km when the receiver was on a ridge or both were on the lake. Range during the aerial survey was about 4 km.

Table 6. Summary of recorded observations of transmittered beavers. Numbers include telemetry only, telemetry and visual, visual only and trapping data.

BEAVER #	NUMBER OF RECORDS					
	SUMMER 1986	SUMMER 1987	WINTER 1987-8	SUMMER 1988	WINTER 1988-9	TOTAL
1830	27	--	--	--	--	27
1834-35	--	22	39	28	20	109
1844-45	--	73	18	--	--	91
1846-47	--	14	1	1	--	16
1842-43	--	19	--	--	--	--
1848-50	--	127	47	196	--	370
B280-81	--	6	--	--	--	6
B286-87	--	--	--	16	2	18
B434-37	--	--	--	4	2	6
B294-95	--	--	--	9	18	27

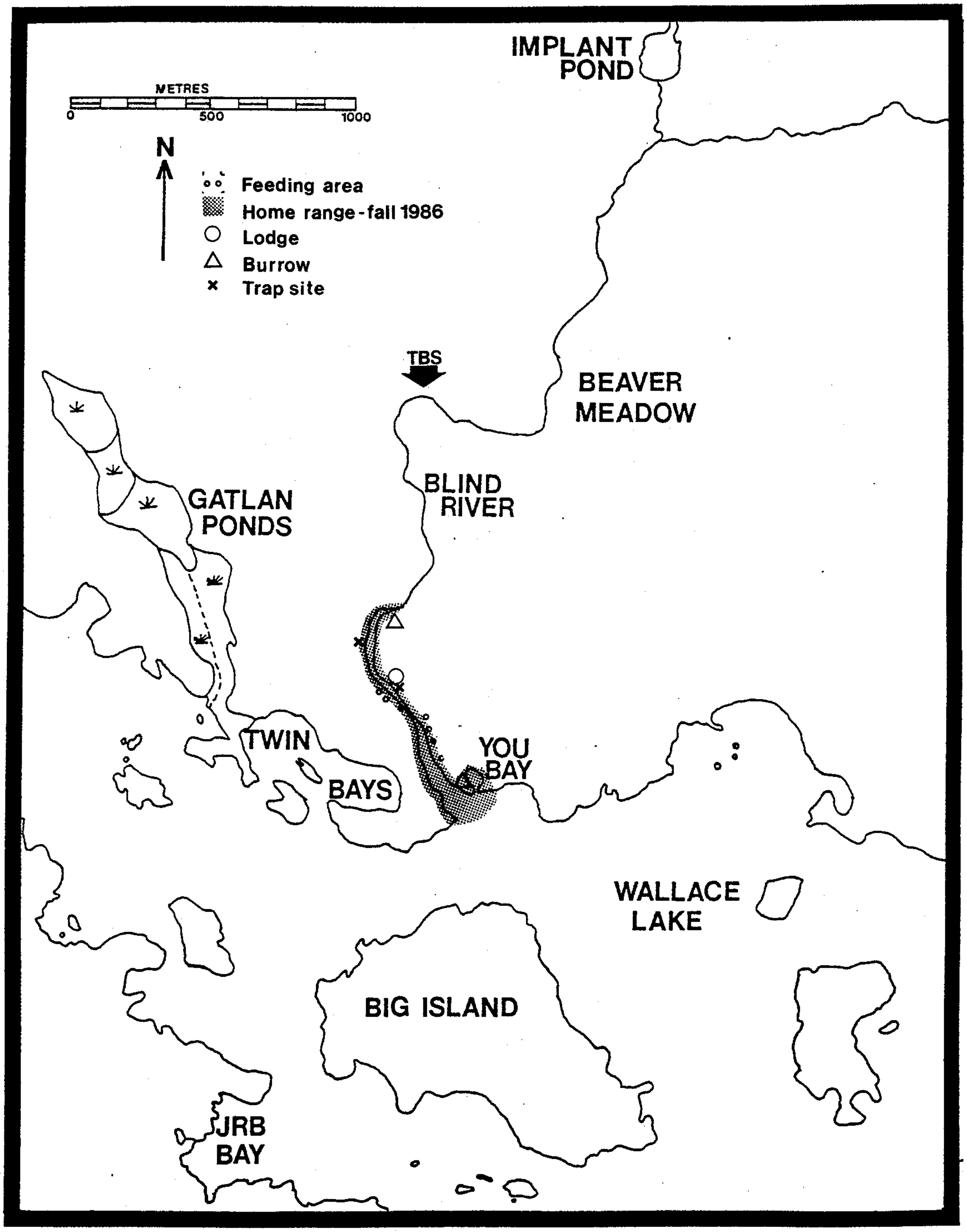
Ground Survey

Adult Males

Beavers 1830 and 1844-45 are adult males, both outfitted with tail collar transmitters. Number 1830 was monitored from September 29, 1986 to November 7, 1986. During this time, he was retrapped once. He was usually found in the Old Blind River Lodge during the day. Upon release from the TBS dock, he swam down-stream and entered the Short Bank Burrow (Figure 6) on both occasions. Number 1830 was only found in this burrow on 1 other occasion and that was the day after release the second time, despite having been active near his usual home lodge on the intervening night. Observations on several evenings found him between the Old Blind River Lodge and the river mouth, usually swimming alone, but with other beavers when nearer the lodge. He was heard feeding once. He used the Blind River - You Bay Bank Burrow October 18, the night before recapture. At least 3 other beavers were in the Old Blind River Lodge with 1830. Although the beavers built a food pile during this monitoring period, no activity of this type, by any of the beavers, was observed. Number 1830 was in the Old Blind River Lodge just after freeze-up, but the transmitter apparently failed shortly thereafter.

I monitored beaver 1844-45 from June 8, 1987 to February, 1988. During this time he was never seen. All data gathered are based on telemetry. On a few occasions, I

Figure 6. Map showing lodges, bank burrows feeding areas, and location of trap sites where captured for 1830, an adult male beaver, in September and October, 1986.

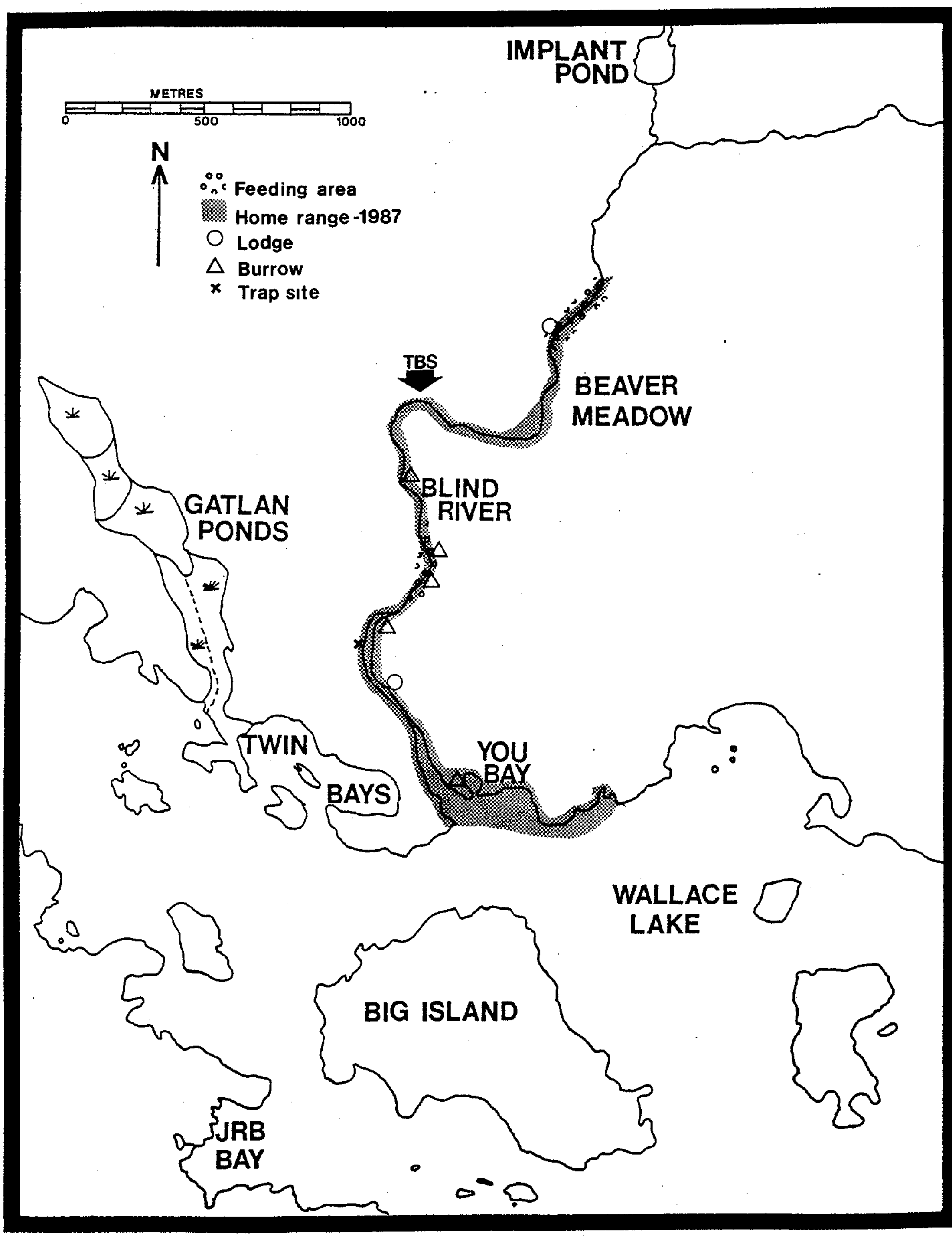


IMPLANT POND
METRES
0
500
1000
N
Feeding area
Home range - fall 1986
Lodge
Burrow
Trap site
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

saw a few ripples or air bubbles as the canoe rounded a bend in the river. His general behaviour pattern in July, August and early September, was to spend days in the north end of the beaver meadow, around the North Beaver Meadow Lodge, and nights in the Blind River (Figure 7). He used 1 other lodge and at least 5 bank burrows. A burrow was assumed to exist when a beaver was found in the same place on 3 or more separate occasions. He usually moved downstream at about 2000 h, and could be found in any of the burrows between 2100 and 2200 h. He was usually located in a different burrow between 0600 and 0800 h, but was in the beaver meadow later each morning. One burrow was used only in the morning, the others both morning and evening. The Blind River Lodge and the Blind River - You Bay Burrow at the river mouth (the same ones used by 1830) were used only once each. He used the other burrows 2 to 4 times each in a short (usually less than 1 week) time period, and then apparently did not use them again for 2 to 3 weeks, if at all. Only one sojourn onto the lake was noted, on August 27.

Weather had no apparent effect on general behaviour pattern, but may explain some anomalies. Number 1844-45 was known to stay overnight in the meadow on only 2 occasions. On July 7, he remained there as a massive thunderstorm approached and moved through the region with a rainfall of 37 mm in 1.5 h. On July 20, he also stayed, another windy

Figure 7. Map showing lodges, bank burrows, feeding areas and location of trap sites where captured for 1844-45, an adult male beaver, from June, 1987 to February, 1988.


IMPLANT POND
METRES
0
500
1000
N
Feeding area
Home range -1987
Lodge
Burrow
Trap site
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

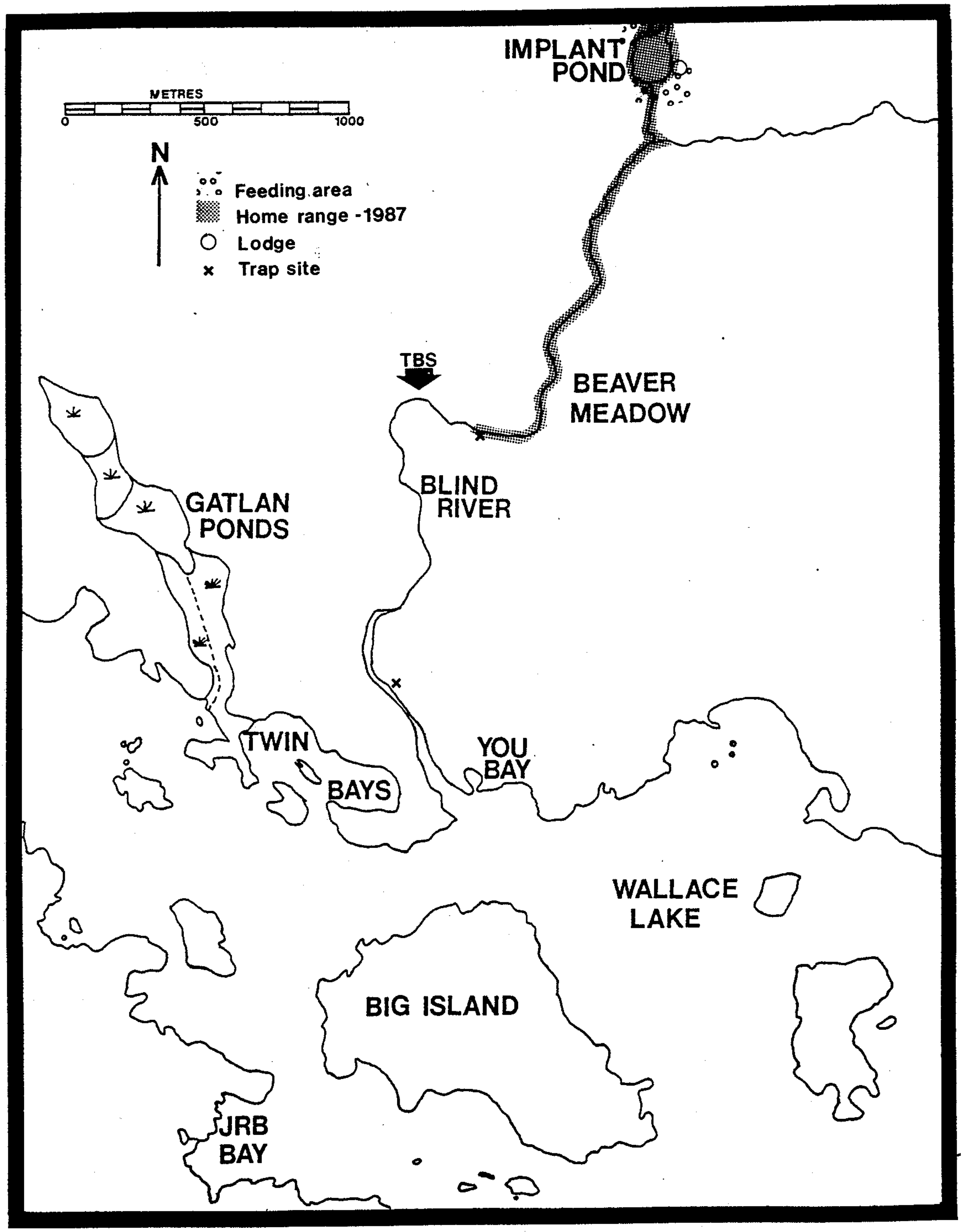
and rainy night. On July 28, he was upstream from the lodge at 2130 h and upstream from TBS at 2215 h. That evening it was 32°C, one of the hottest days of the year. He only spent one day in the river, September 5. Weather that day was unremarkable, but it was his last known trip down the river.

From September 6 onwards he was always in the north end of the beaver meadow. He built and shared the New Beaver Meadow Lodge with 1834-35 and was always in the lodge when checked in winter. Movement to the foodpile may have occurred, but was difficult to discern because the foodpile directly abutted the lodge. There was no sign of movement beyond the foodpile.

Two Year-old Males

I monitored beaver 1846-47 from June 8, 1987 to November 1987 when the implanted transmitter failed. After release at trap site 8, he moved upstream about 2 km to Implant Pond on a small tributary of the Blind River (Figure 8). The pond contains a very large lodge that, because of its external outline, may contain 2 chambers. The dam is about 1.2 m high. All checks on him showed him to be in the Implant Pond Lodge except on September 14, when no signal could be found anywhere in the vicinity. On July 10, he was in the lodge at 1445 hours, but left the lodge briefly at 1500 h and swam in a small circle in front before returning

Figure 8. Map showing lodges, feeding areas and trap sites where captured for 1846-47, a 2 year-old male beaver, from June, 1987 to November, 1987.


IMPLANT
POND
METRES
0
500
1000
N
Feeding area
Home range -1987
Lodge
Trap site
TBS
BEAVER
MEADOW
BLIND
RIVER
GATLAN
PONDS
TWIN
BAYS
YOU
BAY
WALLACE
LAKE
BIG ISLAND
JRB
BAY

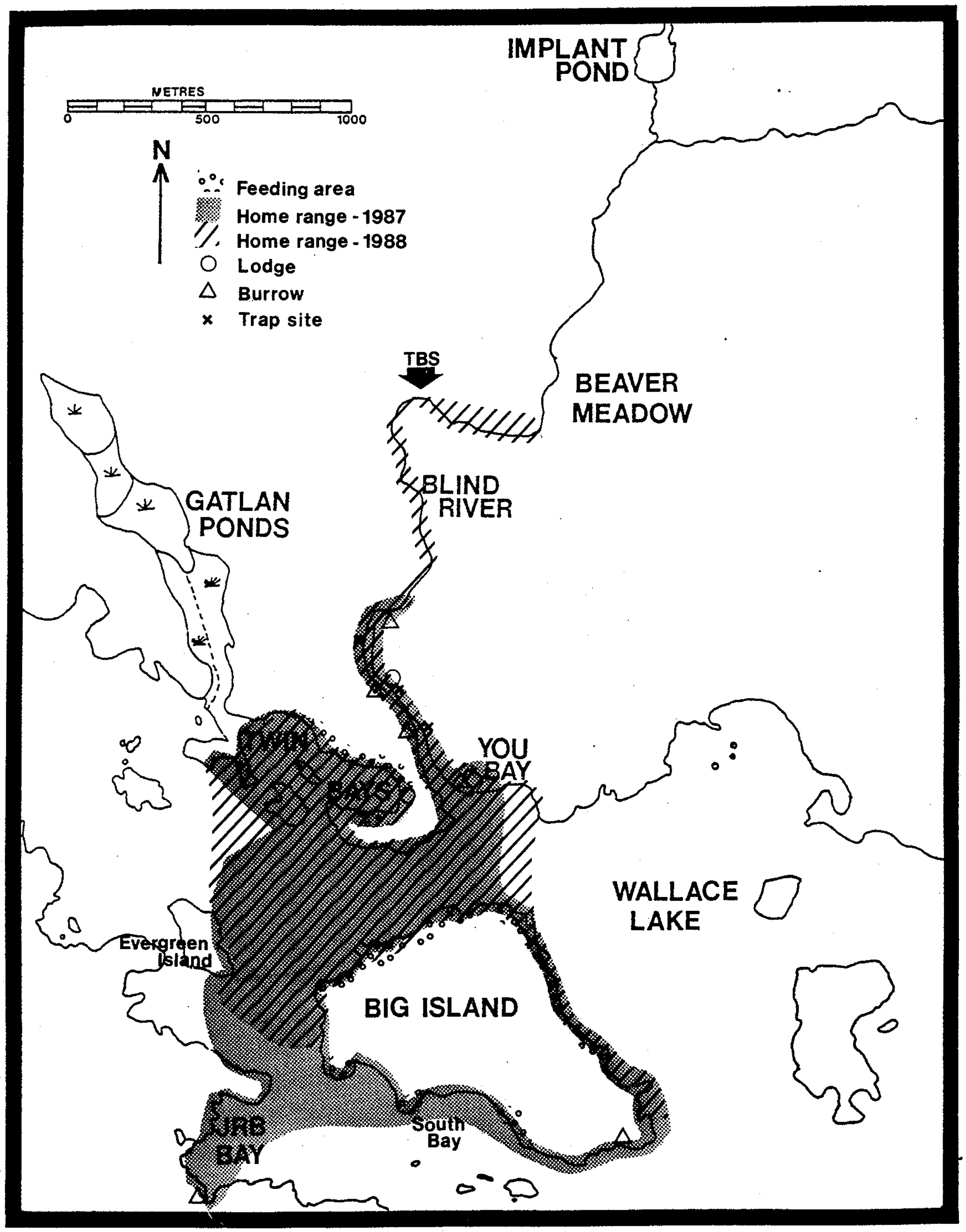
to the lodge. A much larger beaver also appeared at that point and circled the north end of the pond before apparently returning to the lodge an hour later. That afternoon it was 28°C with clear skies. Number 1846-47 was in that lodge at the beginning of the winter before the transmitter failed.

Beaver 1842-43 was outfitted with a tail collar on June 11, 1987, and released from the TBS dock. He went upstream into the beaver meadow, and was thought to use the South Beaver Meadow Lodge there. Recapture on September 14, 1987 showed he had lost the tail collar. It was recovered in May, 1988 from a dense willow bog about 150 m east of the lodge (UTM 34895703). Because the signal apparently did not move after June 28, the collar was probably lost about that time. In the period June 11 to 28, there was movement a short distance south of the lodge.

Two Year-old Females

I monitored beaver 1848-1850 July 3, 1987 to October 24, 1988. After release at site 7, she initially went to the Blind River Bank Burrow a short way downstream. That evening, she was found swimming through the river mouth at 1930 h. I then could not locate her until July 12 when she was found to be in the Big Island Burrow (Figure 9). The next morning, she had moved back to the Blind River Bank Burrow. Until August 2, she followed a fairly constant

Figure 9. Map showing lodges, bank burrows, feeding areas and location of trap sites where captured for 1848-50, year-old female beaver, from July, 1987 to October, 1988.


IMPLANT
POND
METRES
0
500
1000
N
Feeding area
Home range - 1987
Home range - 1988
Lodge
Burrow
Trap site
TBS
BEAVER
MEADOW
GATLAN
PONDS
BLIND
RIVER
TWIN
BAYS
YOU
BAY
WALLACE
LAKE
Evergreen
Island
BIG ISLAND
South
Bay
BAY

behaviour pattern. Days were spent in the Blind River Burrow. She would leave there about 1900 h, and be near the river mouth at 1930 h. She would swim across the North Channel, with her head up, to the nearest point. She then swam close to shore along the north shore and down the west side of Big Island. She either fed on the southwestern tip, or in the South Bay on Big Island or went to the south end of JRB Bay where there apparently was a bank burrow. The two Big Island feeding sites had large stands of 8 year old Populus tremuloides. When using the South Bay feeding area, she was with a second, unmarked beaver. She was often in the Blind River Burrow again by 0700 h, but could be as late as 0900 h in returning. Her usual route back appeared to be the reverse of the evening route.

There were a few deviations from this normal routine. On July 22 and 25, she swam down the east side of Big Island to get to the south shore. On the 22, this was in the lee from strong southwest winds, but on the 25, it was not protected from moderate, northwest winds.

On July 16 and 19, she did not return to the Blind River, but stayed in the JRB burrow. In both cases, the preceding nights had been stormy with very high winds. Due to the channelling effects in that area, both the southeast winds of the 15/16 and northeast winds of the 18/19 would have meant large head-on waves for at least part of her journey home.

On her return journey from her last trip of the summer to the south of Big Island, she left the mouth of JRB Bay at 0630 h and swam northwestward to Evergreen Island and then northeastward to the east mouth of Twin Bays. She then swam along the north shore of the lake and up the river, reaching the Blind River Burrow by 0740 h. Winds were light southwest. She took only 10 minutes to cross from Evergreen Island to Twin Bays, but appeared to swim much more slowly once she reached the river.

After August 2, she continued to use the Blind River Burrow during the days, but could not be located in the evenings until August 13, when she was found in the northeast end of Twin Bays. From that time on she was found in Twin Bays each evening, usually in the northeast end, but on some occasions in the centre or west end. On 5 occasions she used the Short Bank Burrow in the river, farther upstream, during the day. These were August 15 and 25 and September 12, 26 and 27. There is no obvious common factor linking these 5 days. She used this burrow immediately preceding her move to the Twin Bays Lodge. She began using that lodge at the end of September, and was found there during the days, but usually was active in the east end of Twin Bays in the evenings. She built a foodpile consisting primarily of sedges with only a few woody stems. She was active throughout the early part of freeze-up, as evidenced by broken ice around the food pile.

Movement through the winter was very limited. The water around the food pile at freeze-up was only about 40 cm deep. She was never found to move beyond the food pile. Ice drilling showed the surrounding area to be frozen to the bottom, and some of the substrate was also frozen. Number 1848-50 showed variable amounts of movement. Her visits to the food pile appeared to be irregular. She would usually spend about 10 minutes out of the lodge on each trip. Time between visits to the foodpile ranged from 15 to 90 minutes. Movement was not always detected, even during observation periods 4 to 5 hours long. Movement was sometimes difficult to discern due to the close proximity of the foodpile and the lodge.

After breakup (April 28), she remained in Twin Bays until May 9. During this time she was only found in the Twin Bays lodge on the morning of May 7. The rest of the time, she used the Twin Bays Bank Burrow. Evening activity was centred around the islands and west end of Twin Bays.

On the morning of May 9, she was found in the Blind River Burrow. Over the next 10 days, she used 3 other burrows, including 4 nights in the Short Burrow, 3 in the Rock Burrow and 1 in the Blind River - You Bay Burrow. She then returned to using the Blind River Burrow until August 21. She would usually be in this burrow by 0700 h. There is no apparent cause of her use of the other burrows. In addition, she made 3 journeys well up the river in the summer. On May 26 and 27, she was in the beaver meadow upstream from the station at 0700 h, but went back downstream a short time later. On August 10, at 0700 h, I detected her about 100 m below TBS heading downstream.

Evening and night activity was centred around Twin Bays until mid-June except for May 29 and 30 when she was feeding on the northeast corner of Big Island. After June 12, she was found on Big Island most evenings with occasional visits to Twin Bays. Usually, she left her burrow about 1915 h. On June 21, she was still in her burrow at 2210 h, but moved to Twin Bays by 2410 h. This was a very smoky night due to forest fires in the area. On June 23, she was on the north side of Big Island at 0515 h, and remained there all day. This was another smoky day, with visibility at 0500 h of about 100m. She would not have been able to see the mainland clearly.

The area of Big Island that she used varied; the north shore most in June; the north and east shores both about equally in July and August. Both shores were used in all wind and weather conditions. From August 22, 1848-50 used the Short Burrow, and never returned to the Blind River Burrow. She would leave the Short Burrow a little later in the evening, about 2000 h and return about the same time, 0700 h. In September and October, she could not be located on the lake at night.

She had a burrow (Refuge Burrow) about 150 m south of the Blind River Burrow. This was never used for a full day, but appeared to be used as a refuge, for instance if the canoe got too close, on her way to her regular burrow. The New Blind River Lodge was built on this site in September, but 1848-50 was never found in this lodge. After her recapture opposite the New Blind River Lodge on October 23, 1988, she did not go to the New Blind River Lodge, but upstream to the Old Blind River Lodge opposite her usual bank burrow. She was there October 24 as well, the day before freeze-up. She also used this lodge briefly on June 30 and July 6. On those nights, she returned up the river after encountering anglers at the river mouth. She left later in the evening on both days. Her signal was not detected after freeze-up.

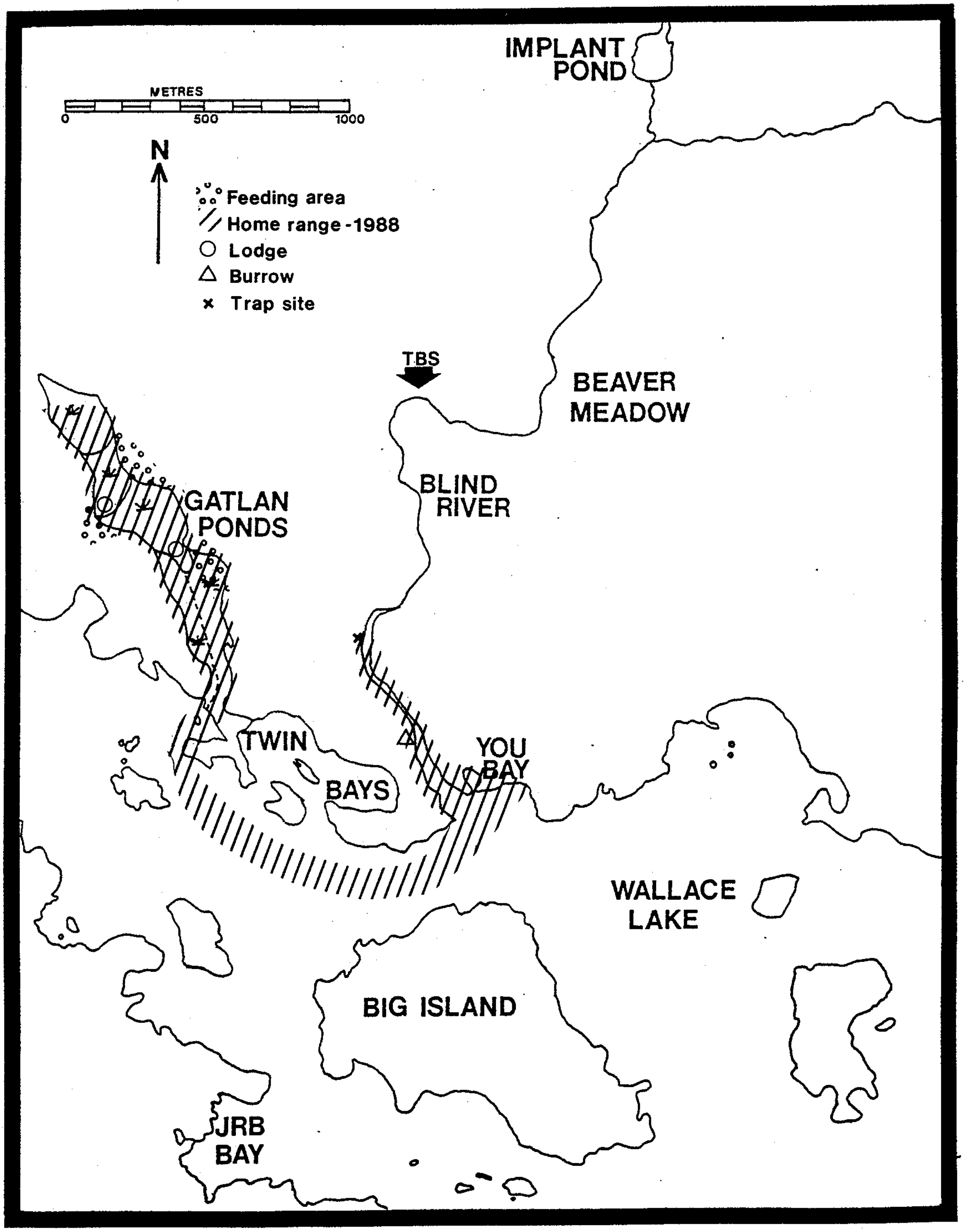
Overnight observations of her activity were made June 29 and 30 and July 1 and 26, 1988. On the first 3 nights she used the north shore of Big Island and on July 26, the east shore. On all 4 occasions, she met another beaver on the Big Island. This second beaver had one metal ear tag, and was similar in size to 1848-50.

She left her burrow about 1915 h and swam to the river mouth, then swam head-up across the north channel. (The only exception was June 30, as described previously, when she returned upriver to the Blind River Lodge and left at 2120 h). She then swam along the shore, with several trips on shore to get food; she ate at each spot. On the 3 nights on the north shore, she spent most of her time in a bay on the northwest corner, with some brief trips around to the west side of the island. Each night she made a trip away from the Island, to Twin Bays or Evergreen Island and back.

The night she spent on the east shore, she gradually worked her way farther south, feeding at several spots. She worked her way back along the shore on all 4 occasions, with feeding and grooming stops along the way. She returned to her burrow between 0500 and 0600 h. On July 2 (July 1, overnight) she was accompanied home by the second beaver.

I have monitored beaver B286-287 since May 12, 1988. She moved to the Refuge Bank Burrow at UTM 34225578 (1848-50's refuge) after release, and was there the following two mornings, but not the intervening evening. On the evening of May 16, she left and went briefly east of the river mouth, then west through the middle of the north channel. She then could not be located for several days, but was contacted May 29 in the well established Lower Gatlan Pond Lodge in a pond about 500 m north of Wallace Lake, accessible only by a very intermittent creek in a dense alder bog (Figure 10). She shared this lodge with at least 2 large beavers and one kit. Overnight observations, on July 4, 5 and 6 found that she had left the lodge by 2000 h and was in the northeast end of the pond. She would remain in that area all night, with some movement along the north

Figure 10. Map showing lodges, bank burrows, feeding areas and location of trap sites where captured for B286-87, a 2 year-old female beaver, from May, 1988 to May, 1989.


IMPLANT POND
METRES
0
500
1000
N
Feeding area
Home range -1988
Lodge
Burrow
Trap site
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

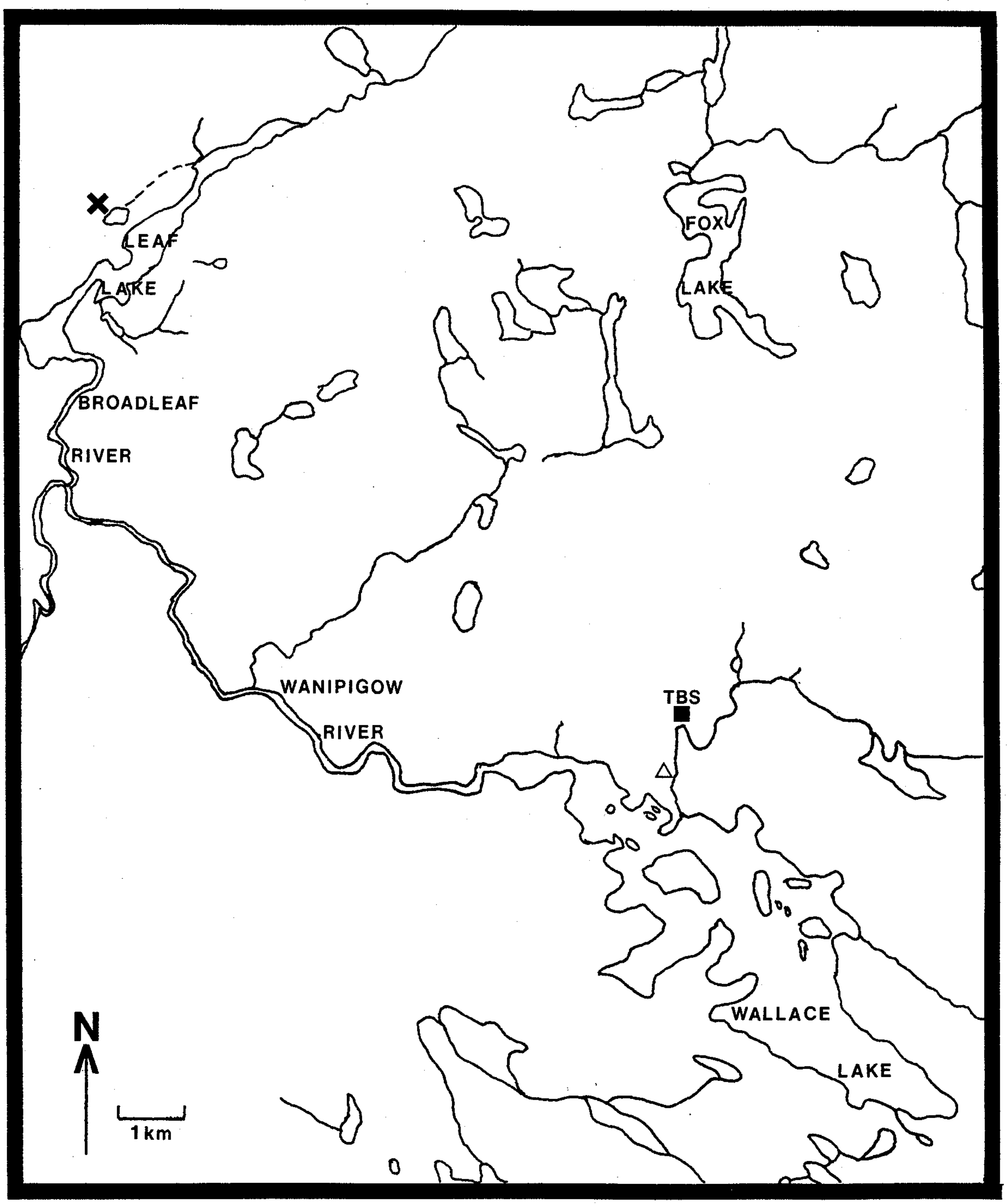
bank. Other beavers from the lodge were active much closer to the lodge. She returned to the lodge by about 0600 h. On the night on July 6-7 a massive thunderstorm and tornadoes went through the vicinity. Although telemetry could not be continued, beaver activity persisted, with several tail slaps heard throughout the storm's 6 hour duration.

In the winter of 1988-89, B286-287 moved to the Upper Gatlan Pond Lodge in the next pond upstream from the 1988 summer pond. There was no food pile built at the Lower Gatlan Pond Lodge, and the dam was not maintained. The entire group appears to have changed lodges. After break-up, 1989, she moved back to the Lower Gatlan Pond Lodge.

1.5 to 2.5 Year-old Males

I have monitored B434-437 since August 25, 1988. He moved upstream past TBS the day after release, and then disappeared. On March 30, 1989, I located him, during an aerial survey, in the vicinity of Leaf Lake, 12 km direct or 26 km along waterways from his capture site (Figure 11) . A ground trip the next day located a signal from the vicinity of UTM 253653 west of Leaf Lake. Due to deep snow and thawing temperatures, I was unable to gain direct access to the site. The aerial photo shows an apparent pond in that vicinity.

Figure 11. Map showing location of original, August 25, 1988 capture, △ , of B434-437 and approximate location on March 30 and 31, 1989 as found by aerial survey and follow-up ground survey: **X**.


LEAF
LAKE
FOX
LAKE
BROADLEAF
RIVER
WANIPIGOW
RIVER
TBS
WALLACE
LAKE
N
1 km

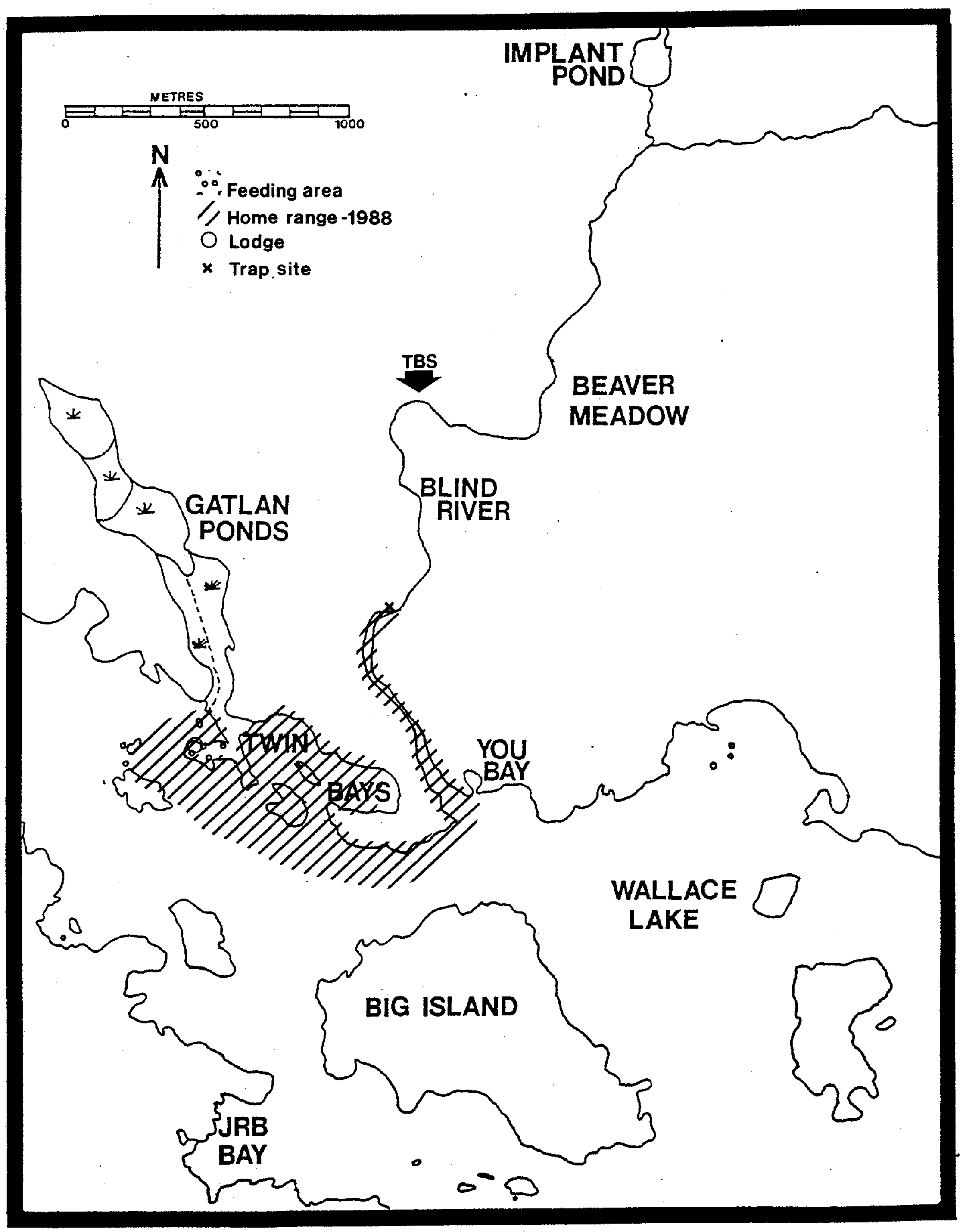
I monitored B294-295 from September 28, 1988 to March, 1989. He disappeared for a few days after release, but was then located in an apparent north-facing cave (the Rock Lodge) in a small bay on the north side of the lake (Figure 12). He plastered mud and a few sticks on the rock face to fill cracks, and built a large food pile. Activity continued through freeze-up, as evidenced by open water around the foodpile and trails heading up onto the ridge above the lodge.

During the winter he was in the vicinity of the lodge when checked. Most movement from the lodge was just to the food pile. These trips occurred at irregular intervals of 20 to 90 minutes. There then seemed to be a much longer period during which there was very little movement if any. During the period of activity, he usually took one short trip beyond the food pile to about 40 m out and then returned. Tracking was often difficult due to thick snow cover and underwater rocks that apparently reflected the signal. The transmitter failed in March, 1989.

Two Year-olds, Unknown Sex

Beaver B280-281 was a 2 year-old of undetermined sex. A signal was received from July 6 to July 23, 1987. It remained either upstream from TBS or near the TBS dock for 4 days after release, before moving out of signal range on July 13, 1987. A signal was received and visual contact

Figure 12. Map showing lodges and feeding areas and location of trap sites where captured for B294-95, a 2.5 year-old male beaver, from September 26, 1988 to February, 1989.


IMPLANT POND
METRES
0
500
1000
N
Feeding area
Home range -1988
Lodge
Trap site
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

made on July 23, about 1 km downstream from TBS, just below the Short Burrow. The signal remained in the same place all day, but could not be located later that evening.

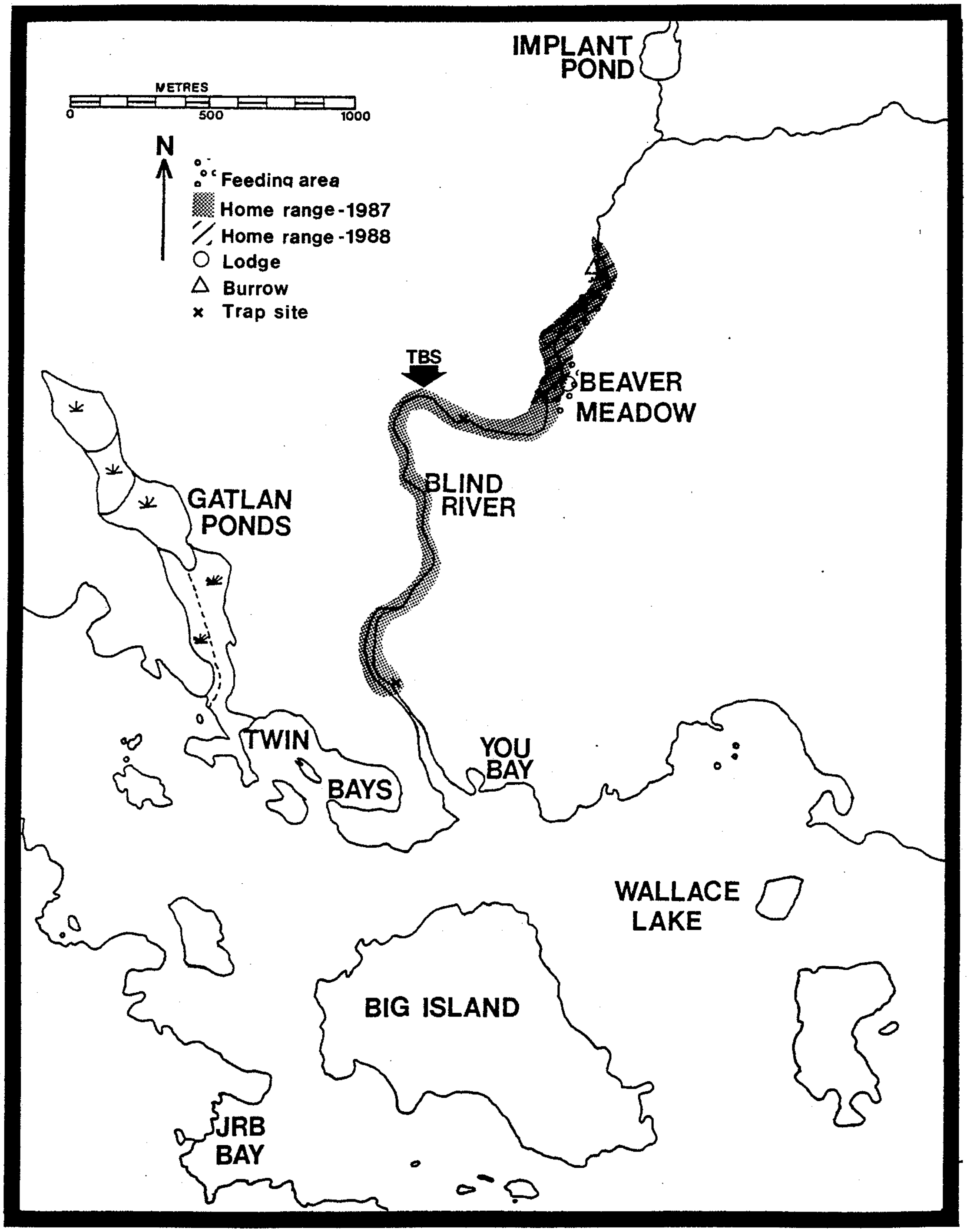
Beaver 1834-1835 was monitored from June 12, 1987 to present. Since implantation, it has never been found outside the beaver meadow. The summer of 1987 was spent in the extreme north end of the meadow, in the Gorge Bank Burrow below the falls (Figure 13). There was some apparent movement up and down the river in that area. The winter of 1987-88 was spent in a New Beaver Meadow Lodge about 150 m downstream from the centre of summer activity. This lodge was shared with beaver 1844-45.

Winter movement was limited. The food pile was visited several times in the "activity period", usually at about one hour intervals. One trip 50 m downstream that lasted about 13 minutes was noted. Some extended periods of observation showed no movement from the lodge.

In the summer of 1988, this beaver remained very close to the winter lodge. The activity period appeared to begin between sunset and dusk - the signal received at TBS would suddenly increase in strength, most likely due to an exit from the lodge. The strength of the signal varied through the night, but was quite weak after daybreak.

In the winter of 1988-89, it moved 150 m downstream to an old lodge that had been unused for 5 years. The dams below this lodge had been completely reworked the previous

Figure 13. Map showing lodges, bank burrows, feeding areas and trap sites where captured for 1834-35, a 2 year-old beaver of undetermined sex, from June, 1987 to May, 1989.


METRES
0
500
1000
N
Feeding area
Home range-1987
Home range-1988
Lodge
Burrow
Trap site
IMPLANT POND
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

fall. The foodpile could not be seen in the ice. There was a lot of variability in the signal at the lodge, but actual movement distance and direction was hard to quantify. The signal was receivable from TBS, and the occasional lack of signal may have indicated movement.

Aerial Survey

The aerial survey was successful in locating 1 missing animal, B434-437 as described above. Moreover, 1848-50 and B294-295 were not detected, a further indication of probable transmitter failure during the winter.

Live Trapping

The site or sites of capture for each beaver are summarized in Table 7. Figure 14 shows the location of each trap site. Beaver 1834-35 was trapped farther downstream than found during telemetry, on both occasions. Similarly 1846-47 was never located as far downstream with telemetry as when trapped. The latter beaver was recaptured May 8, 1988, after the transmitter failed, at site 3.

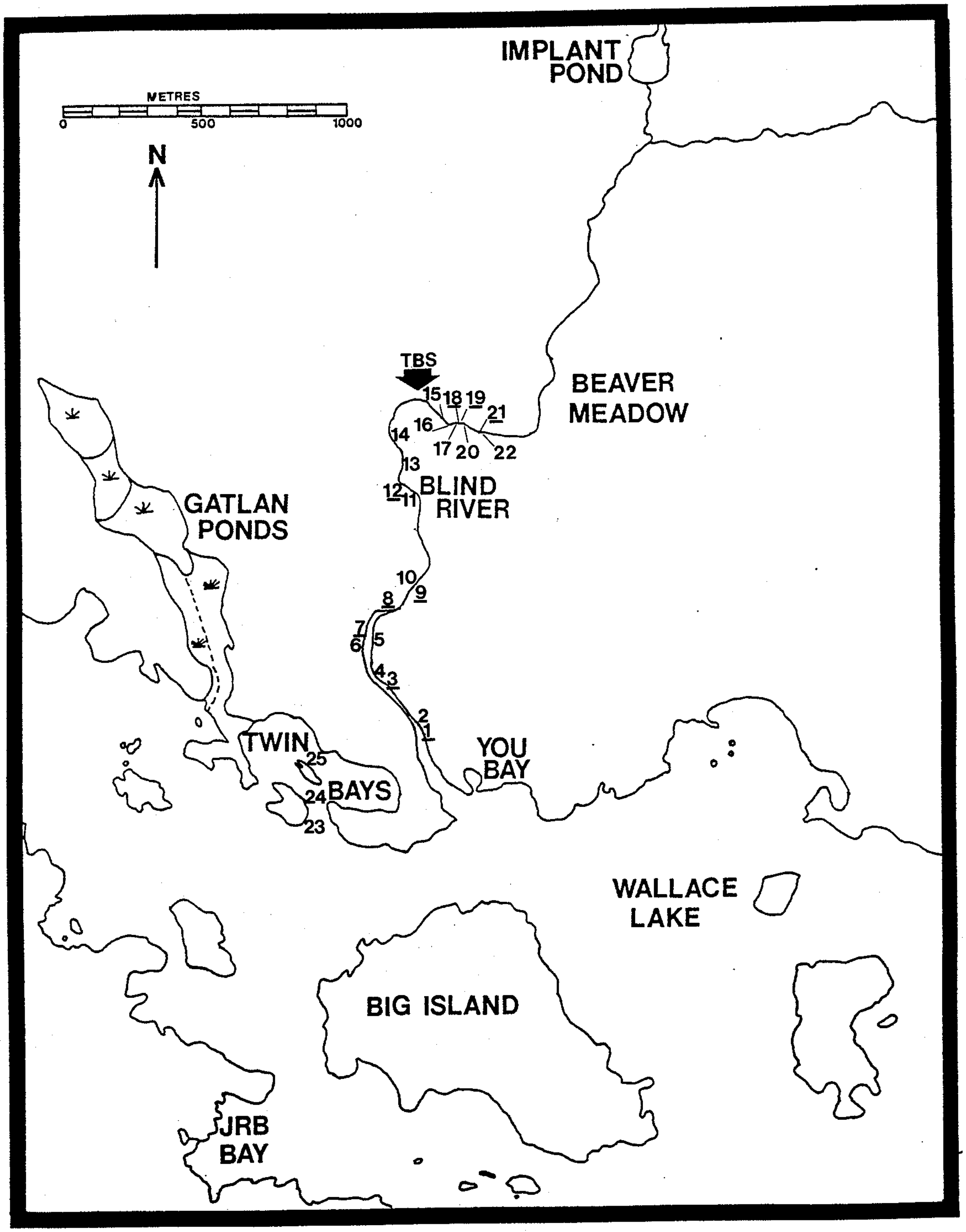
Commercial Trapping

Only 1 marked beaver is known to have been taken by commercial trapping. Number 1836-37 was trapped on Tinney Creek, southeast of Beresford Lake in early, November, 1988

Table 7. Site or sites of capture of each beaver. No beavers were caught twice at the same site.

BEAVER NUMBER	SITE NUMBER								
	1	3	7	8	9	12	18	19	21
1820-32	–	1	1	–	–	–	–	–	–
1829	–	–	–	–	–	1	–	–	–
1830	–	1	1	–	–	–	–	–	–
1834-35	–	1	–	–	–	–	1	–	–
1836-37	–	–	1	–	–	–	–	–	–
1842-43	–	1	–	–	–	–	1	–	–
1844-45	–	–	1	–	–	–	–	–	–
1846-47	–	1	–	–	–	–	–	–	1
1848-50	1	1	1	–	–	–	–	–	–
B276-77	–	1	–	–	–	–	–	–	–
B280-81	–	–	–	–	–	–	–	–	1
B282-83	–	1	–	–	–	–	–	–	–
B286-87	–	–	1	–	–	–	–	–	–
B288-89	–	–	–	–	–	–	–	–	1
B294-295	–	–	–	1	–	–	–	–	–
B296	–	–	–	–	–	–	–	1	–
B434-37	–	–	–	–	1	–	–	–	–
TOTALS	1	8	6	1	1	1	2	1	3

Figure 14. Location of Hancock trap sites on the Blind River and Wallace Lake from 1986 to 1988. Successful sites are underlined.


IMPLANT
POND
METRES
0
500
1000
N
TBS
15
18
19
21
16
14
17
20
22
13
BEAVER
MEADOW
12
11
BLIND
RIVER
GATLAN
PONDS
10
8
9
7
6
5
4
3
2
1
TWIN
25
24
BAYS
23
YOU
BAY
WALLACE
LAKE
BIG ISLAND
JRB
BAY

by Harry Bruce (Figure 15). Beresford Lake is 20 km (direct line) from the original trap site, and is on a different watershed. An overland trip of at least 1 km would have been required in this beaver's migration, and the minimum total travel distance was 36 km.

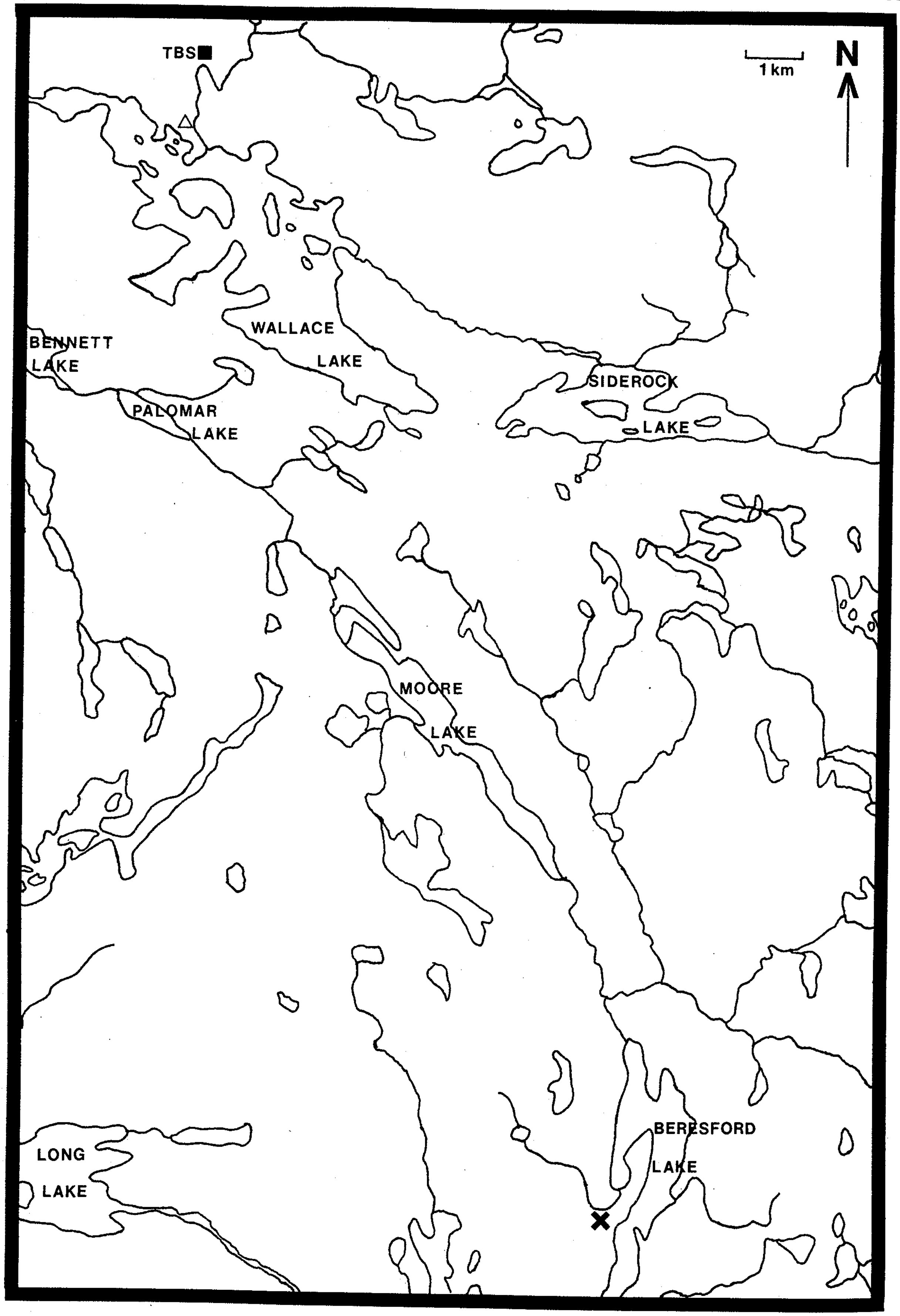
HOME RANGE

It is difficult to delineate the home range with standard methods. On the lake, the land area of the islands may constitute large portions of the home range as defined by its outer limits and hence a home range area cannot be accurately delineated. Defining home range by use of distance between extreme points cannot be done with straight line distances because straight lines do not necessarily represent the routes used by the beaver, especially on the river, or where islands are involved.

In view of these limitations I believe the best method of quantifying home range is to determine the length from extreme points as the beaver would travel between the points. I only calculated this for the beavers for whom I had sufficient data to make a reasonably accurate assessment i.e. either an extended period of records or a shorter time period with relatively more records.

Home range lengths during any one period of open water varied from 0.55 km to 4.4 km, and overall home range

Figure 15. Map showing location of original, May 17, 1988 capture, △ , of 1836-37 and approximate location of November, 1988 capture, **X** .


TBS
1 km
N
BENNETT LAKE
WALLACE LAKE
SIDEROCK LAKE
PALOMAR LAKE
MOORE LAKE
BERESFORD LAKE
LONG LAKE

lengths for each beaver are from 1.5 to 6 km (Table 8). The largest home range was for 1848-50, the 2 to 3 year old female, and smallest for the adult male (1830). This small latter home range may be an artefact of the short observation season that was limited to the fall.

There is much overlap of the home ranges of these beavers. In 1987, three of them, and 5 other beavers are known to have used the beaver meadow-Implant Pond area (compare Figures 3, 7, 8 and 13). The Blind River south of the beaver meadow was used by 3 beavers with known home ranges and at least 6 other beavers in 1987 (compare Figures 3, 7, 9 and 13). The lake area was used by at least 2 other beavers in addition to 1848-50 (compare Figures 3 and 9) in 1987. The north lake area was only seen to be used by 1848-50 (Figure 9). In 1988, the beaver meadow-Implant Pond area constituted part of 2 known home ranges (compare Figures 9 and 13). The Blind River made up part of 2 home ranges and was used by up to 12 or more other beavers (compare Figures 3, 9, 10, 12 and 15). The south lake area including Big Island was used by 1848-50 and at least 1 other animal (compare Figures 3 and 9). The north lake area was part of the home range of 3 beavers, and used by at least 3 other beavers (compare Figures 3, 9, 10, 11 and 12).

Table 8. Home range lengths for transmittered beavers (only includes beavers with sufficient data to calculate a home range).

BEAVER NUMBER	SEX	AGE (Years)	LENGTH OF HOME RANGE (km)			
			1986	1987	1988	OVERALL
1830	M	4+	1.5	--	--	1.5
1834-35	?	2	--	3.1	0.55	3.1
1844-45	M	4+	--	4.4	--	4.4
1846-47	M	2	--	2.2	4.1	4.1
1848-50	F	2	--	4.3	4.2	6
B286-87	F	2	--	--	3.45	3.45
B294-295	M	2.5	--	--	3	3

DISCUSSION

DAILY MOVEMENT

Summer

In this study, the daily movements in summer covered 1 to 8 or more km. Davis (1984) found adult male beaver moved up to 6.8 km in an activity period with a maximum of 1.6 km between extreme points, and adult females registered at 5.5 and 1.9 km respectively. Sub-adults moved slightly less; females moved 4.6 and 1.7 km respectively and males 3.7 and 0.8 km. In the present study, the distance between extreme points very closely approximated half the total distance moved because the beavers generally did not wander back and forth, but continued in the same general direction until turning to return home. An adult male and a subadult female showed the most movement. While Davis (1984) found that the adult males moved more than the females, Seton (1909) argued that the adult pair never moved more than half a mile (0.8 km) and the younger beavers moved more. Busher (1975) implied that the younger animals wandered more, but did not give specific distances except that the members of each of 2 colonies stayed within 800 m and 200 m stretches of river respectively. The younger animals did seem to wander in my study, as evidenced by 1846-47 and B286-87 who returned to established lodges well away from the vicinity of their capture. Older animals, especially the adult female could be expected to have more restricted movement especially if kits are present. This could account for 1834-35's relatively sedentary life in 1988.

Busher's (1975) study was restricted to a river, while Davis (1984) had 1 colony on a lake and another a very short way up a river from the first colony. While this may account for some differences between distances beavers moved in their studies, I found movement distances for the beavers on the lake and in the river to be very similar. Davis' (1984) beavers travelled to feeding areas, but he does not discuss the availability of food in the intervening areas. In my study, however, all the beavers I followed moved much greater distances than necessary to obtain food. Often they moved past seemingly better feeding areas. It would not appear to be energetically efficient to move farther than necessary to gather food. It may be that some food areas provide better safety for the beavers - a factor not necessarily visible to the human eye. Alternatively, plants available in some areas may be better nutritionally due to variations in the soil or other growing conditions. Jenkins (1979) suggested that beavers may be able to determine nutritional quality of a tree by sampling.

Although beavers are generally viewed as nocturnal animals, I found the activity period for most began well before dark and ended some time after sunrise. Busher

(1975), Davis, 1984 and Belovsky (1984) cited similar activity periods. Green (1936) recorded frequent, brief diurnal activity in late morning and early afternoon, similar to the activity I observed in Implant Pond. Davis (1984) found that the activity period was longer with longer nights, but I found very little change in length of activity periods as nights grew longer in the fall. He found December to have the longest activity period, but since that is an ice-covered period in my study area, a true comparison is not possible. Busher's (1975) study ran only from June to September, making comparisons difficult.

In the taiga, activity in the fall is centred around lodge, food cache, and possibly dam, construction. To accomplish this and maintain adequate food intake, a longer activity period would seem to be necessary. However, I found the beavers travelled much less in the fall, while maintaining the same length of activity period, and this reduction in travelling time may well result in a sufficient gain in time to allow for both activities. This may tie in with them travelling extra distances for food. If the beavers go farther than necessary for food when they are able to and are not restricted by ice or time limitations, then the food nearer their lodge will be available when time is more restricted, such as the fall, and as an emergency supply, if necessary, in winter.

All the beavers I tracked used more than 1 lodge or bank burrow. Two beavers used 5 burrows and 2 lodges. Green (1936), Bradt (1938), Busher (1975), Davis (1984) and Howard and Larson (1985) all cited the use of multiple burrows or lodges. Bradt (1938) reported 1 lodge and many bank burrows, but never more than 2 lodges per colony, a finding echoed in Busher's (1975) study. Green (1936) gives no limit on lodge numbers, while Davis (1984) and Howard and Larson (1985) argue a colony may use several lodges. Since lodges develop, over time, from bank burrows (Seton, 1909), it is probable that areas that beavers have used for an extended period of time would have a higher number of lodges than areas of new beaver activity. Bradt's (1938) arguments were made when the beaver population was low (and had been for some time), and areas with extended beaver occupation may have been few.

None of these previous studies mention shared accommodations, such as I found with some of the lodges and burrows. As Bradt (1938) defines a colony, such sharing would not be possible unless the beavers were all from the same colony. If this were the case, they would all have to occupy 1 lodge in winter (Green, 1936; Bradt, 1938; Howard and Larson, 1985), which they did not in my study. Familial relationships may explain some of the sharing. Bradt (1938) cites examples of 2 year-old animals remaining in a colony's area but occupying a separate burrow. Other occupiers (at different times) of a burrow or lodge may be tolerated due to family ties. If food is plentiful, as it appears to be in the study area, family members may stay longer.

Seton (1909) states that rock bound lakes are shunned and Payne (1981) implies that they are restrictive. This did not seem to be the case for B294-295 in this study. He selected a rocky area for his lodge/burrow even though other areas might have been more suitable. The use of a rocky area with a natural cave would mean less effort for the beaver to exert in building a lodge.

Territory and Home Range

Although the beavers in this study had fairly definite limits to their movements, no direct evidence of territoriality was apparent, and there were large overlaps in home range. Scent mounds have generally been thought of as indicators of territoriality (Hay, 1958; Aleksiuk, 1968; Davis, 1984). They may also communicate other information however, such as sexual availability (Seton, 1909). Scent mounds are reportedly located near the edge of the colony (Aleksiuk, 1968) and do not occur between inhabited sites (Hay, 1958). However, I found scent mounds all along the Blind River, with beavers frequently passing them. There was no concentration of scent mounds around the edges of any beaver's home range. If scent mounds were an important tool in outlining territory, the adult female would be expected to play an important part in their construction in order to help protect her kits. Aleksiuk's (1968) observations showed the adult female to be the least frequent visitor to scent mounds. Some role may also be played by family ties. If there are some familial relationships between the beavers using these common areas, scent mounds may be "friendly" rather than "hostile" communication to them. All beavers followed in this study, that remained in the river area, used established lodges, apparently indicating they were already residents of the area and not settling transients. Townsend (1953) found that wandering animals "did not use areas utilized by breeding residents" (p. 476). Davis (1984) found that scent mounds were constructed near foreign beavers held in cages inside another colony area.

Territory size may vary from year to year and by area (Swenson et al., 1983). There is no standardized method of determining the density of beaver. Some authors have described the size by "nearest neighbour" distances (Boyce, 1981; Busher et al., 1983); colonies per square mile or kilometre (Aleksiuk, 1968; Bergerud and Miller, 1977); or number of colonies per kilometre of stream (Howard and Larson, 1985). Distances between colonies vary from 0.48 km (Boyce, 1981) to 1.55 km (Busher et al., 1983). Both Aleksiuk (1968) and Bergerud and Miller (1977) gave a maximum population density of 1 colony per 2.6 km^2. Howard and Larson (1985) cited 0.83 colonies per kilometre of stream as an average. These values cannot be taken as direct indicators of territory size, because they do not indicate how the area between the colony centres is utilized or divided up, if it is. I have found no direct evidence of territoriality. Home range distances are larger than "nearest neighbour" distances in many cases. "Nearest neighbour" distance, taken from 1 lodge to the next would range from less than 100 m to about 1.5 km. The presence of shared accommodation also suggests a lack of territoriality.

Movement between colonies, such as I found, may indicate a lack of territoriality. Bergerud and Miller (1977) found little adult movement between colonies, but some sub-adult movement. Busher et al. (1983) report that members of larger colonies showed more movement into other colonies. Although Davis (1984) referred to territorial behaviour as evidenced by scent mounds, the lodge of one colony was within the principle use area of an adjacent colony. Busher (1975) found no inter-colony movement, and only 1 case of movement into the "no-man's land" between the two colonies. It is possible that the scent mounds are a passive form of defining occupation. While they may delineate the area of use, they do not necessarily warn an animal to stay out, but rather not to settle. Since adjacent colonies in many cases may have family ties, less active defense may result.

Defining and defending a territory has inherent costs, and in areas of plentiful food supply, there may be limited benefits from defending a territory. If food supplies are poor, it is more important for the beaver to ensure its supply, in which case, a territory may be worth defending. The Blind River and Wallace Lake area appear currently to have a good food supply and this may account for the lack of obvious territorial behaviour.

WINTER ACTIVITY

I found beaver movement under the ice to be very limited. In one case it was limited by thickness of the ice. Lancia (1979) described winter activity patterns of beavers but, because he used fixed receivers, did not quantify movement. Ice-cover in his Massachusetts study area was not always complete and frequent above-ice activity occurred. Semyonoff (1953) reported *Castor fiber* moved extended distances under the ice, usually by taking advantage of the sushinetz (air passages created between the ice and shore). Green (1936) said deep water was essential to winter survival, but the evidence from my study is that if the food cache is reasonable, even shallow water will suffice for winter survival. Movement under the ice will be limited by air supply. Energetically, movement beyond the food pile would not be worthwhile unless there were some benefit, such as better food, farther away.

I found beavers to have a pattern of intermittent activity over a fairly extended time period, tied with an occasional extended period of no activity. Bovet and Oertli (1974) and Potvin and Bovet (1975) found free-running circadian rhythms in beavers in southwestern Alberta and southern Quebec in winter. Lancia (1979) found a similar pattern in Massachusetts when there was no above-ice activity. The actograms, however, show a pattern of intermittent activity in January (Lancia, 1979) when temperatures were coldest and most closely approached temperatures in my study area. While Novakowski (1967) speculated that beavers would conserve energy in winter by activities such as huddling and dormancy, it may be that under very cold temperatures frequent activity is necessary in order to maintain body heat and lodge temperature. Frequent trips to the food pile accomplish this and maintain a constant energy supply in the beaver.

Above-ice activity was infrequent in the beavers I studied. In both 1987 and 1989 it occurred during periods when night-time temperatures did not fall much below freezing. Lancia (1980) recorded above-ice activity only at temperatures above -10°C, but with only minimal activity below 0°C, and Stephenson (1969) reported above-ice activity with milder temperatures. With *Castor fiber*, Semyonoff

(1953) found increasing activity with increasing temperature, with most activity occurring at $-5^{\circ}C$ or higher. Green (1936) cited one example of above ice activity at temperatures below $-18^{\circ}C$. Aleksiuk (1970) reported activity above the ice about 1 month before break-up, with the activity lasting about 1 week. Bovet and Oertli (1974) and Potvin and Bovet (1975) reported no above-ice activity. Above-ice activity would put beavers at greater risk from predators, and at cold temperatures would result in a high energy loss. Above-ice activity may be necessary to allow beavers to obtain fresher food, and may be an indicator of a low food supply under the ice. All signs of above-ice activity I found demonstrated food gathering by the beavers. Length of time with total ice cover and depth of snow cover will both affect ice thickness, which will in turn affect the per cent of the food pile available to the beaver.

DISPERSAL

Beavers have generally been thought to disperse at 2 years of age, but may move away as yearlings (Townsend, 1953) and yearlings may show a considerable tendency to wander (Beer, 1955). Both Bradt (1938) and Davis (1984) report that dispersal will not always occur, with some 2 year-olds remaining in the colony, but possibly in a separate burrow. There is little immigration by adults

(Beer, 1955). Bergerud and Miller (1977) found some adult dispersal, but much less than for the sub-adults, and male adults moved more than the females. I found only the sub-adults in my study moved away, but some of the ones I thought to be 2 year-olds returned to active colonies. Either my estimate of age was incorrect, or the beavers were staying longer than expected. Adults did not disperse, but I did not have a good sample of the adult population. Beavers might stay longer than two years if food is in good supply, or if they become involved in site maintenance or raising the kits. Early dispersal may result from a poor food supply.

The two known emigrants from my study area travelled at least 36 and 24 km including overland travel in the first case. Beer (1955 reports movement up to 80 km (stream distance), while Libby (1957) had only one beaver move farther than 9.6 km, but it moved 320 km (stream distance). Bergerud and Miller (1977) cited distances up to 40 km, with adult animals moving farther than sub-adults. Average distances moved are in the range of 10 to 15 km for non-transplanted beavers. Transplanted animals moved up to 237 km (Hibbard, 1958) and 48 km (Knudsen and Hale, 1965). Bradt (1938) and Knudsen and Hale (1965) both report frequent overland travel, especially in spring (Bradt, 1938). There is no theoretical limit on distance moved, but animals could be expected to settle wherever they first find a suitable place. Some beavers may also have an innate tendency to wander, and therefore do not settle early in the season. Overland travel would seem to be a dangerous business since the risk of predation is high and there is no guarantee of where the animal will find water again.

CONCLUSIONS

Beavers in the taiga of southeastern Manitoba inhabit much larger home ranges than is usual in reports in the literature. Overlapping of home ranges is common, and I found no direct evidence of territoriality. Dispersing beavers travelled much farther than the generally reported average dispersal distances. Winter movement under the ice is very limited. Temperatures at or near melting (0°C) are necessary before above-ice activity occurs.

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MANAGEMENT RECOMMENDATIONS

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The following recommendations are based on the data gathered in this study. These data were gathered from relatively few beavers and this must be considered when reviewing these recommendations. The extreme differences in many aspects of beaver ecology in my study, as compared to previous studies in other regions, indicate that care must be taken in extrapolating the recommendations to other regions. Further studies presently underway in the same region may result in these recommendations becoming outdated.

1. Beaver live-trapping should be undertaken in May, September and October to be most efficient.

2. Hancock traps are best for an area where definite beaver canals are not visible. Hancock traps are also more suitable for areas with steeper riverbanks.

3. Live-trapping at cooler temperatures (5 – 15°C) may be more successful.

4. Implanted transmitters provide a better means of monitoring beavers than externally mounted transmitters.

5. The development of trapping methods that encourage related animals to occupy adjacent areas may increase the density of beavers because of a lack of territoriality.

6. Management of habitat for beavers must include areas well beyond the lodge area.

7. Many burnt areas produce an abundant supply of good beaver food, 5 to 8 years after fire. Beaver populations should be encouraged to colonize such burnt areas, because these become ideal beaver habitat.

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APPENDIX I

EFFECTS OF BEAVER ON THE REGENERATION OF VEGETATION AFTER FIRE

INTRODUCTION

Beavers' primary food of choice is generally recognized as Trembling Aspen (*Populus tremuloides*) (Hall, 1960; Brenner, 1962; Hall, 1972), but other foods may be selected (Jenkins, 1975). Herbaceous, non-woody vegetation may be chosen especially in summer (Bradt, 1938; Chabreck, 198; Brenner, 1962; Aleksiuk, 1970; Svendsen, 1980; Jenkins, 1981). Woody vegetation selected includes poplar (Bradt, 1938; Gese and Shadle, 1943; Brenner, 1962; Aleksiuk, 1970; Hall, 1972), willow (Bradt, 1938; Hall, 1960; Aleksiuk, 1970) and maple (Bradt, 1938). Other species are selected for lodge and dam construction such as conifers (Seton, 1909) and alders (Slough, 1978).

Authors disagree on the relationship of species selected to distance from the lodge. McGinley and Whitham (1985) argue a positive correlation while Belovsky (1984) found no relationship. Smaller treees may be harvested in general (Chabreck, 1958; Jenkins, 1980) and especially at increased distances inland (Jenkins, 1980; Pinkowski, 1983).

Beaver activity may affect the growth form of trees (McGinley and Whitham, 1985) and may promote decay (Chabreck, 1958). Alternatively, they may enhance forest diversity (Hall, 1972) and affect bog development (Rebertus, 1986).

While forest fires may be important in producing good beaver habitat (Patric and Webb, 1953), no studies have examined how beavers may affect forest development after a fire.

A long term study has been initiated which should demonstrate, over time, how beavers may affect forest regeneration after a fire.

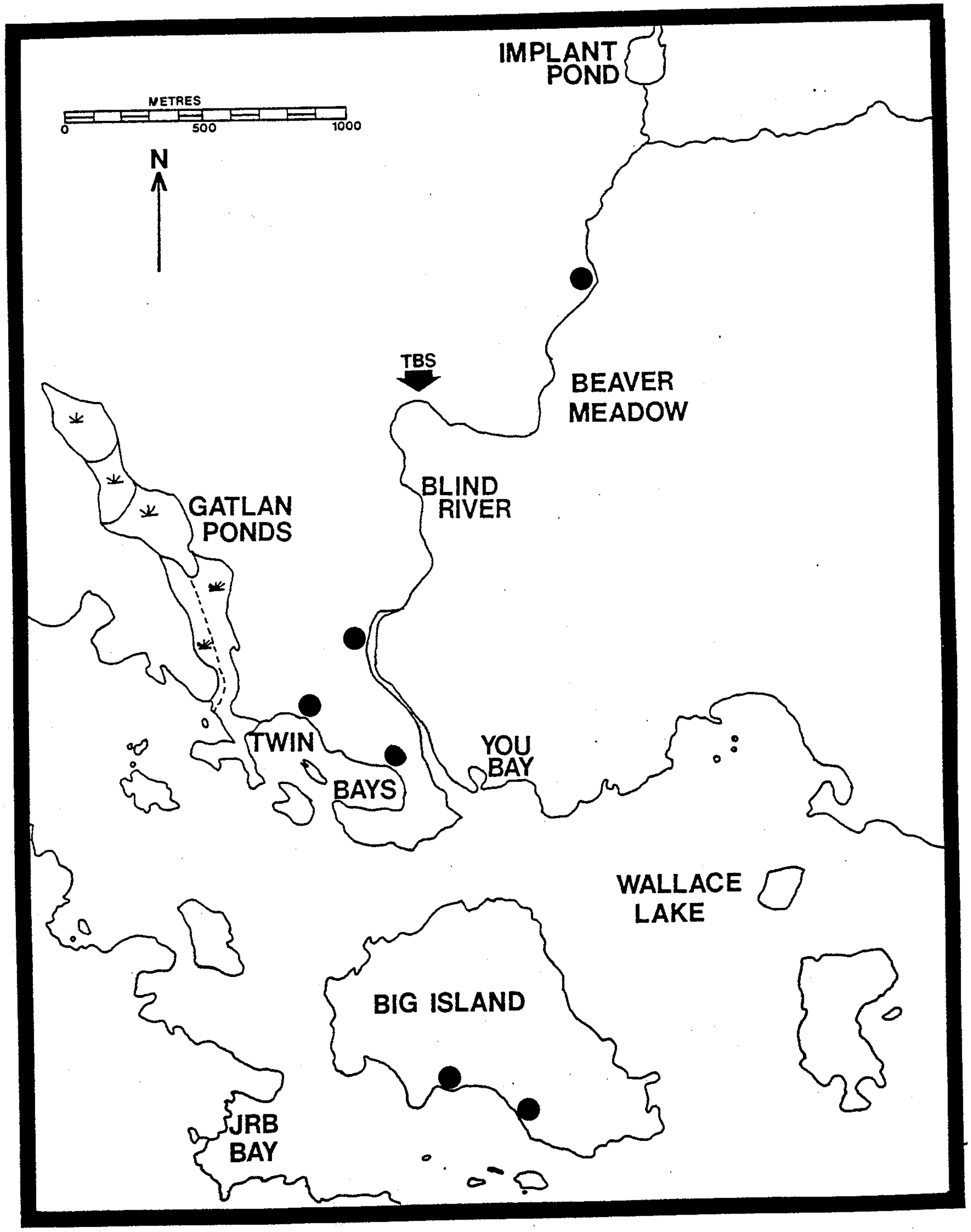
METHODS

Exclosures

I established six chain-link fence exclosures during the winter and early spring of 1988. The exclosures are each 4.32 m by 8.64 m, with the shorter edge parallel to the water's edge. Three of the exclosures are in bog areas, and three on upland, rocky ridge areas. All are in areas where beaver feeding activity has been noted. Two upland sites are on Big Island in the middle of Wallace Lake, and the other upland site is on the shore of a shallow bay on Wallace Lake. One bog site is on this same bay, another is situated along the Blind River, and the third is also along the Blind River, but in the beaver meadow (Figure 1).

In August, 1988, baseline vegetation data were collected from each exclosure and an adjacent control area. A line was run parallel to the long side of the plot, 1.66 m from the left side. Four 1 m quadrats were then placed along this line, 1 m apart, starting 0.82 m from the front edge of the plot. Within each quadrat, all species in the understory were recorded along with their per-cent cover and the average height of the plants of that species in that quadrat. For the overstory, percent cover was recorded for each species, and then for every member of the overstory originating in the quadrat, the height, diameter at the base

Figure 1. Location of beaver exclosure sites: ●.


IMPLANT POND
METRES
0
500
1000
N
TBS
BEAVER MEADOW
BLIND RIVER
GATLAN PONDS
TWIN BAYS
YOU BAY
WALLACE LAKE
BIG ISLAND
JRB BAY

and diameter at breast height were recorded. An estimate was also made of the percent cover of each overstory species for the entire plot, along with the average height of that species in the plot.

A control plot was analyzed adjacent to each exclosure. These areas have no restrictions on entry by beaver or other animals and are as similar as possible to their adjacent exclosures. For these areas, a line was run parallel to and 2 m from one long edge of the exclosure. The analysis was then carried out in the same manner as described for the exclosures. For the beaver meadow plot, it was not possible to run the line to the side, due to the winding of the river. As a result, it was placed parallel to and 2 m from the back short edge of the exclosure. It was ensured that the front edge of this line was the same distance from the water's edge as the front edge of the beaver meadow exclosure.

In addition, to verify the similarities of the exclosures and their adjacent controls, soil samples are being taken at two points in each exclosure and control area to be analyzed for components.

RESULTS

The initial data gathered from the plots are presented in raw form. This is a long term study that will only show significant changes over time. Data on the understory are given for each species in each quadrat, as average height of that species in the quadrat and percent cover of that species in the quadrat. Data on the overstory are given for each tree species. After the name of the species, the percent cover and average height of that species for the entire 8.64 by 4.32 m plot are given. The height (ht), diameter at breast height (dbh) and diameter at the base (dbas) are given for each quadrat. The percent cover of that species for each quadrat is given after the number of the quadrat. For stumps, data are listed for the height of the stump from the ground, the diameter of the base of the stump, and the number of stems, or new shoots coming out of the stump.

ISLAND PLOT WEST - Exclosure - 5.5m from shoreline

UNDERSTORY

Species	Quadrat 1 ht	%	2 ht	%	3 ht	%	4 ht	%
Rosa acicularis	30	40	15	2	--	--	--	--
Rubus strigosus	35	5	8	1	15	1	5	1
Fragaria virginiana	5	5	5	1	5	2	--	--
Epilobium angustifolium	40	5	15	2	15	2	15	1
Linnaea borealis	2	5	--	--	--	--	--	--
Vicia americana	25	1	15	15	5	2	7	3
Dicranum fuscescens	1	50	1	15	1	10	1	60
Oryzopsis pungens	25	1	60	2	25	1	--	--
bare ground	--	30	--	70	--	80	--	35

OVERSTORY

Species: Populus tremuloides - 50% cover, ht avg 130cm

Quadrat 1 20%			2 2%			3 10%			4 50%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
52	---	.48	18	---	.19	35	---	.30	25	---	.30
82	---	.86	53	---	.33	28	---	.26	25	---	.37
130	---	1.57	40	---	.57	30	---	.58	25	---	.35
55	---	.60				10	---	.27	150	.27	1.79
74	---	.60				25	---	.18	180	.58	1.99
54	---	.56				98	---	.72	95	---	1.12
						40	---	.32			
						35	---	.26			
						110	---	.72			
						57	---	.46			
						85	---	.70			

STUMPS

Species: Populus tremuloides

Quadrat 3:

ht = 27 dbase = 5.33 number of stems = 8

ISLAND PLOT WEST - Control - 5.5m from shore

UNDERSTORY

Species	Quadrat 1 ht	1 %	2 ht	2 %	3 ht	3 %	4 ht	4 %
Rosa acicularis	40	5	--	--	--	--	--	--
Rubus strigosus	15	5	30	20	30	20	--	--
Fragaria virginiana	10	15	6	20	5	10	10	5
Epilobium angustifolium	60	5	35	5	50	2	20	5
Vicia americana	10	1	--	--	--	--	--	--
Dicranum fuscescens	1	50	1	35	1	20	1	15
Elymus innovatus	50	20	55	1	--	--	--	--
Cornus canadensis	5	1	5	1	--	--	--	--
Lathyrus ochroleucus	--	--	30	2	40	40	40	40
Agropyron repens	--	--	--	--	45	30	--	--
Cornus stolonifera	--	--	--	--	--	--	15	1
Agrostis alba	--	--	--	--	--	--	60	1
Dandelion	--	--	--	--	--	--	15	1
bare ground	--	20	--	20	--	10	--	35

OVERSTORY

Species: Populus tremuloides - 20% cover, avg ht 140 cm

Quadrat 1 10% ht	dbh	dbas	Quadrat 3 10% ht	dbh	dbas	Quadrat 4 40% ht	dbh	dbas
100	---	.68	80	---	.83	75	---	.48
46	---	.19	85	---	.88	60	---	.62
45	---	.25	55	---	.62	98	---	.95
51	---	.41				71	---	1.03
51	---	.47				89	---	.66
						115	---	1.40
						60	---	.37
						75	---	.55
						50	---	.24

quadrat 2 had no overstory

STUMPS

Species: Populus tremuloides

Quadrat 4:

ht = 28cm   dbase = 3.36 cm   number of stems = 7

ISLAND PLOT EAST - Exclosure - 15.2m from shore

UNDERSTORY

Species	Quadrat 1		Quadrat 2		Quadrat 3		Quadrat 4	
	ht	%	ht	%	ht	%	ht	%
Rosa acicularis	20	1	30	10	25	1	20	1
Epilobium angustifolium	35	1	10	1	--	--	25	1
Dicranum fuscescens	1	40	1	20	1	15	1	30
Vicia americana	--	--	10	1	5	1	--	--
Lathyrus ochroleucus	--	--	--	--	10	1	--	--
Cirsium arvense	--	--	--	--	--	--	15	1
Peltigera aphthosa	--	--	--	--	--	--	--	2
bare ground	--	60	--	75	--	85	--	70

OVERSTORY

Species: Populus tremuloides - 60% cover, 3.5m avg ht

Quadrat 1			Quadrat 2			Quadrat 3			Quadrat 4		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
7	---	.11	110	---	.68	70	---	.44	75	---	.80
5	---	.10				125	---	.73	200	1.14	2.21
35	---	.47				350	1.30	2.10	175	.64	1.46
130	---	1.54				105	---	.92			
290	1.69	2.47				55	---	.67			
400	1.75	2.44				220	.74	1.23			
						450	2.78	4.01			
						500	2.88	4.57			
						300	1.30	2.24			
						150	.35	1.43			

no stumps in any quadrats, but some within exclosure plot

ISLAND PLOT EAST - Control - 15.2 m from shore

UNDERSTORY

Species	Quadrat 1		Quadrat 2		Quadrat 3		Quadrat 5	
	ht	%	ht	%	ht	%	ht	%
Rosa acicularis	40	50	50	60	35	10	10	1
Epilobium angustifolium	60	1	--	--	--	--	10	1
Vicia americana	35	5	--	--	--	--	--	--
Dicranum fuscescens	-	5	1	20	1	20	--	5
Peltigera aphthosa	--	--	--	--	--	1	--	--
Lathyrus ochroleucus	--	--	--	--	--	--	40	10
Cirsium arvense	--	--	--	--	--	--	10	1
bare ground	--	90	--	80	--	80	--	90

OVERSTORY

Species: Populus tremuloides - 60% cover, 3.5 m average ht

Quadrat 1 50%			Quadrat 2 40%			Quadrat 3 30%			Quadrat 4 60%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
120	---	1.85	170	.59	1.40	350	2.98	4.10	220	.82	1.79
300	1.82	2.40	175	.68	1.69	500	3.05	4.38	400	2.49	3.13
80	---	1.40	100	---	1.08	180	.67	1.66	230	1.15	1.94
85	---	.63	170	.47	1.49	450	2.47	3.45	350	1.41	2.01
200	1.05	1.86	200	1.20	1.96				250	.89	1.58
150	.29	1.22							100	---	.93
220	1.67	2.21							300	1.46	1.94
160	.55	1.08							220	.92	1.33
350	2.24	3.43							170	.76	1.12

no stumps in quadrats, but stumps present in plot

BLIND RIVER PLOT - Exclosure - 1 m from water

UNDERSTORY

Species	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Ledum groenlandicum	30	30	45	30	50	70	60	70
Chamaedaphne calyculata	25	20	60	5	--	--	40	20
Myrica gale	45	20	80	20	--	--	--	--
Equisetum arvense	60	1	60	5	50	3	--	--
Calamagrostis canadensis	85	30	50	5	--	--	75	10
Carex leptalea	40	20	60	20	30	20	60	1
Sphagnum palustra	5	20	5	10	5	10	5	50
Salix pedicellaris		--	--	80	40	--	--	----
Dicranum fuscescens	--	--	1	20	1	30	--	--
Vaccinium oxycoccus	--	--	2	5	--	--	3	10
Polithicum sp.	--	--	--	--	2	10	--	--
Galium triflorum	--	--	--	--	5	1	--	--
Galium boreale	--	--	--	--	15	1	--	--
Rubus pubescens	--	--	--	--	--	--	10	10
Linnea borealis	--	--	--	--	--	--	5	20
Epilobium angustifolium	--	--	--	--	--	--	50	.1

OVERSTORY

Species: Alnus crispa - 40% cover, avg ht 2m

Quadrat 1 5%			2 30%			3 30%			4 5%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
140	.22	1.35	1	---	.73	none in plot			65	---	.53
			180	.81	1.56				80	---	.91
			250	.44	2.55				150	.45	1.57
			250	1.24	2.34						

Species: Betula glandulosa - 10% cover, avg ht 2m

Quadrat 3 - 50% cover

ht	dbh	dbas
220	.67	1.77
145	.18	.90
90	---	.56
200	.70	1.32

other quadrats - none in them

Species: Picea mariana - 5% cover, avg ht .3 m

Quadrat

3 5%			4 1%		
ht	dbh	dbas	ht	dbh	dbas
20	---	.19	20	---	.25
5	---	.07			
33	---	.33			
30	---	.33			

Stumps - none in quadrats, but some in plot

BLIND RIVER PLOT - Control - 1 m from shore

UNDERSTORY

Species	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Ledum groenlandicum	20	15	45	50	50	20	35	20
Chamaedaphne calyculata	50	10	40	20	35	20	--	--
Myrica gale	90	40	--	--	60	30	--	--
Carex lacustris	90	60	70	30	60	10	70	15
Sphagnum palustra	5	10	5	10	4	20	5	30
Epilobium angustifolium	--	--	50	1	15	1	50	5
Calamagrostis canadensis	--	--	80	20	40	10	55	10
Actea pachypodea	--	--	--	--	15	5	5	1
Polithicum sp.	--	--	--	--	--	--	3	20

OVERSTORY

Species: Alnus crispa - 40% cover, avg ht. = 2m

Quadrat

1 20%			2 30%			3 40%			4 20%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
none in plot			70	--	.80	65	---	.59	none in plot		
			240	1.20	1.40						
			250	1.47	2.67						
			150	.62	1.15						
			100	---	.83						
			120	--	.78						
			50	---	.62						

Species: Picea mariana - 5% cover, avg. ht. = 0.3m

Quadrat 4

ht	dbh	dbas
50	---	.80
90	---	.68
85	---	.81
55	---	.55
38	---	.34
40	---	.27

none in other quadrats

Species: Larix laricina - 2% cover, avg. ht. = 0.5m

STUMPS

Species: Alnus crispa

Quadrat 1			Quadrat 2		
ht	dbas	stems	ht	dbas	stems
9	.51	0	17	3.08	0
12	.50	0	23	.81	0
18	.66	0			

<u>TWIN BAYS EAST</u> - Exclosure - 4.8 m from shore

UNDERSTORY

<u>Species</u>	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Chamaedaphne calyculata	80	70	65	50	60	50	75	2
Myrica gale	60	40	60	20	65	20	90	40
Carex lacustris	125	25	125	5	110	5	125	10
Sphagnum palustra	3	10	1	20	3	50	2	10
Galium triflorum	---	---	2	1	--	--	--	--
Ledum groenlandicum	---	---	---	--	35	30	60	10
Spirea alba1	---	---	----	--	65	10	100	2
Calamagrostis canadensis	---	---	----	--	70	5	105	35
Polygonum amphibium	---	---	---	---	---	--	60	5
Lycopus uniflorus	---	---	---	---	---	--	10	1
Trientalis borealis	---	---	---	---	---	--	10	1

OVERSTORY

Species: Betula glandulosa - 40% cover, avg ht = 1m

Quadrat 1 1%			Quadrat 2 50%			Quadrat 3 5%			Quadrat 4		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
80	--	.50	120	---	1.33	180	.19	1.11	none in plot		
40	--	.23	155	.29	1.32						
			170	.40	1.33						
			110	---	.93						
			140	.25	1.19						
			170	.51	1.21						
			150	.28	1.08						
			100	---	.90						

Species: Amelanchier sanguinea - 10% cover, avg ht 1.5m

Quadrat 3 5% cover

other quadrats none in plot or overhanging

Species: Alnus crispa - 30% cover, avg ht 1.3m

Quadrat 3 5%			Quadrat 4 40%		
ht	dbh	dbas	ht	dbh	dbas
none in plot			190	.77	1.23
			200	.79	1.63
			120	---	1.97
			130	---	1.18

other quadrats - none in plot

Species: Betula papyrifera - 10% cover, avg ht = 1.5 m

Quadrat 4

ht	dbh	dbas
140	.25	.86
60	---	.43
80	---	.53

other quadrats - none in plot

Species: Populus tremuloides - 2% cover, avg. ht. 5 m

Stumps - present in plot, but none in quadrats

TWIN BAYS EAST - Control - 4.8 m from shore

UNDERSTORY

Species	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Chamaedaphne calyculata	45	15	50	5	50	25	--	--
Myrica gale	60	30	60	50	80	30	50	20
Carex lacustris	110	50	130	30	---	--	---	--
Spirea alba	---	--	40	5	140	10	155	2
Sphagnum palustra	---	--	2	10	3	10	4	10
Ledum groenlandicum	---	--	---	--	40	50	35	30
Trientalis borealis	---	--	---	--	3	1	5	1
Calamagrostis canadensis	---	--	---	--	55	2	---	--
Fragaria virginiana	---	--	---	--	---	--	15	2

OVERSTORY

Species: Betula glandulosa - 50% cover, 1.0 avg ht

Quadrat 1 20%			2 50%			3			4		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
110	---	.87	80	---	.49	none	in plot		none	in plot	
			170	.28	.69						
			200	.82	1.95						
			165	.33	.94						
			155	.25	1.17						
			190	.51	1.00						
			150	.19	.99						
			140	.16	.95						
			70	---	.38						
			155	.34	1.20						
			20	---	.19						
			150	.17	.99						
			165	.42	1.46						
			60	---	.86						
			210	.82	1.69						
			190	.53	1.33						
			37	---	.41						
			50	---	.38						

Species: Alnus crispa - 20% cover, avg ht 2m

Quadrat 3 10%			Quadrat 4 40%		
ht	dh	dbas	ht	dbh	dbas
none in plot			25	---	.27
			10	---	.15
			8	---	.10
			18	---	.16

other quadrats - none in plots

Species: Amelanchier sanguinea - 10% cover, 1.5 m avg ht

Quadrat 4 - 20%

ht	dbh	dbas
75	---	.59
85	---	.61
120	---	.78
155	.30	1.10
135	---	1.08
50	---	.41

other quadrats - none in plot

Species: Populus tremuloides - 5% cover, avg ht 3m

Quadrat 3 - 5% - none in plot

Stumps - present, but not in any quadrats

TWIN BAYS WEST - Exclosure - 10m from shore

UNDERSTORY

Species	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Fragaria virginiana	10	20	5	2	--	--	--	--
Cornus canadensis	10	5	--	--	3	1	--	--
Lathyrus ochroleucus	20	2	60	2	50	10	30	5
Epilobium angustifolium	70	1	95	1	65	1	--	--
Equisetum arvense	35	5	15	5	30	5	45	2
Galium triflorum	5	1	--	--	2	1	20	1
Rubus strigosus	15	3	30	1	30	2	2	1
Ribes glandulosum	25	2	20	2	--	--	--	--
Dicranum fuscescens	1	10	1	10	1	10	1	10
bare ground	--	40	--	70	--	40	--	80
Rosa acicularis	--	--	20	5	--	--	--	--
Vicia americana	--	--	15	10	--	--	--	--
Aralia nudicaulis	---	--	30	10	--	--	--	--
Viola renifolia	--	--	--	--	2	5	--	--
Viola pensylvanica	--	--	--	--	5	1	--	--
Solidago hispida	--	--	--	--	5	1	--	--
Urtica droica	--	--	--	--	20	10	35	5
Polytrichum commune	--	--	--	--	2	20	--	--

OVERSTORY

Species: Populus tremuloides - 30% cover, avg ht 3m

Quadrat 1 30%			4 20%		
ht	dbh	dbas	ht	dbh	dbas
180	.54	1.15	150	.45	1.85
350	1.92	2.59	220	.79	1.70
150	.30	1.24			
350	1.58	2.32			

other quadrats - none in plot

Species: Populus balsamifera - 30% cover avg ht 3 m

Quadrat 1 30%			Quadrat 2 80%			Quadrat 3 80%			Quadrat 4 60%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
140	.38	1.36	250	1.18	1.84	60	---	.58	400	2.5	3.84
30	--	.27	130	---	1.06	350	2.33	3.76	8	---	.14
						220	1.02	2.41			

Species: Picea mariana - 1% cover, avg ht .3m

Quadrat 1 1%			Quadrat 2 5%			Quadrat 3			Quadrat 4 1%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
25	---	.26	35	---	.52	none in plot			18	---	.17
			50	---	.49						

Species: Pinus banksiana - 5% cover, avg ht 1m

Quadrat 1 5%			Quadrat 3 2%		
ht	dbh	dbas	ht	dbh	dbas
90	---	.98	none in plot		
26	---	.25			

Species: Betula papyrifera - 5% cover, avg ht 1 m

Quadrat 2 - 5% cover

ht	dbh	dbas
230	.99	1.83

Stumps - none in quadrats, but some in plot

TWIN BAYS WEST - Control - 10 m from shore

UNDERSTORY

Species	Quadrat 1 ht	1 %	2 ht	2 %	3 ht	3 %	4 ht	4 %
Fragaria virginiana	15	30	15	20	15	10	10	1
Equisetum arvense	25	20	30	10	25	10	30	5
Galium triflorum	20	5	--	---	--	--	5	2
Rubus strigosus	15	20	35	20	15	10	--	--
Urtica droica	20	5	20	10	20	10	30	5
Vicia americana	60	20	75	10	--	--	--	--
Cirsium arvense	75	5	25	5	40	2	--	--
Aster ciliolatus	15	2	20	20	10	5	10	5
Dicranum fuscescens	1	10	1	15	1	10	1	20
Agropyron repens	45	5	--	---	30	1	15	1
Epilobium angustifolium	---	--	80	5	--	--	--	--
Viola pensylvanica	---	--	10	10	5	10	--	--
bare ground	---	--	10	20	--	50	--	30
Lathyrus ochroleucus	---	--	--	---	25	10	30	10
Cornus canadensis	---	--	--	--	--	--	10	5
Ribes glandulosa	---	--	--	--	--	--	20	.1
Petasites palmatus	---	--	--	--	--	--	15	10

OVERSTORY

Species: Populus tremuloides - 50% cover, average ht 3m

quadrat 1 5% ht	dbh	dbas	2 40% ht	dbh	dbas	3 60% ht	dbh	dbas	4 60% ht	dbh	dbas
none	in plot		300	2.25	3.08	140	.19	1.26	400	2.59	3.43
			200	1.10	2.02	230	1.06	1.87	80	----	.70
			100	----	.98	350	2.19	3.05	60	----	.62
			170	.34	1.05	100	---	1.08	450	3.47	5.11
			70	---	.79	60	----	.46			
						40	----	.25			
						300	1.89	2.34			
						60	---	.49			

Species: Populus balsamifera - 20% cover, ht avg 3 m

Quadrat 1 5% ht	dbh	dbas	2 ht	dbh	dbas	3 ht	dbh	dbas	4 ht	dbh	dbas
none	in plot		none	in plot		none	in plot		none	in plot	

Species: Pinus banksiana - 10 % cover, avg ht 1 m

Quadrat 1 10%			Quadrat 2 5%			Quadrat 3 5%			Quadrat 4		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
190	1.33	2.91	none in plot			90	---	1.01	none in plot		

Species: Picea mariana - 5% cover, avg ht 0.5m

Quadrat 1 5%			Quadrat 4 5%		
ht	dbh	dbas	ht	dbh	dbas
43	---	.57	20	---	.18
28	---	.29	15	---	.19
28	---	.51	25	---	.32
			10	---	.08

STUMPS

Species: Populus tremuloides

Quadrat 2			Quadrat 3			Quadrat 4		
ht	dbas	stems	ht	dbas	stems	ht	dbas	stems
17	3.82	2	30	2.39	1	15	3.40	2
			10	3.39	3			
			18	2.94	0			

<u>BEAVER MEADOW PLOT</u> - Exclosure - 4m from river

UNDERSTORY

Species	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Calamagrostis canadensis	100	100	100	100	100	60	100	75
Ribes hirtellum	25	15	45	5	20	3	40	15
Spirea alba	20	5	65	10	85	25	80	15
Equisetum arvense	20	1	---	---	40	1	--	--
Rubus strigosus	25	2	---	---	65	15	65	5
Urtica droica	---	---	75	5	95	1	--	--
Ribes triste	---	---	----	--	20	5	--	--
Carex lacustris	---	---	----	--	140	2	150	25
Carex trisperma	---	---	----	---	20	2	---	--
Galium triflorum	---	---	---	---	---	---	20	1
Mentha arvensis	---	---	---	---	---	---	20	2

OVERSTORY

Species: Alnus crispa - 60% cover, ht avg 2.5 m

Quadrat

1 10%			2 70%			3 80%			4 10%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
none	in plot		9	---	.15	55	---	.56	none	in plot	
			30	---	.17	23	---	.14			
			6	---	.39	300	2.19	4.18			
			42	---	.26						
			350	2.67	4.48						

Stumps - none in quadrats, but some in plot

BEAVER MEADOW PLOT - Control - 4m from river

UNDERSTORY

Species	Quadrat 1		2		3		4	
	ht	%	ht	%	ht	%	ht	%
Calamagrostis canadensis	120	100	120	100	120	100	120	100
Ribes hirtellum	40	2	---	---	35	15	---	---
Impatiens capensis	25	35	---	---	---	---	---	---
Spirea alba	35	1	---	---	---	---	90	10
Fragaria virginiana	5	5	---	---	---	---	---	---
Galium triflorum	10	1	----	--	---	---	---	---
Viola renifolia	2	5	---	---	---	---	---	---
Carex lacustris	---	---	100	1	100	10	120	5
Lysimachia thyrsifolia	---	---	25	2	---	---	---	---
Rubus strigosus	---	---	---	--	25	2	70	2
Salix sp. (cf. spyrifolia)	---	---	---	---	50	1	---	---
Equisetum arvense	---	---	---	---	---	---	35	1

OVERSTORY

Species: Alnus crispa - 50% cover, 2.5 m avg ht

Quadrat

1 30%			2 50%			3 10%			4 40%		
ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas	ht	dbh	dbas
200	.80	3.27	none	in plot		none	in plot		none	in plot	
325	1.78	3.31									

Species: Salix amygaloides - 5% cover, avg ht 1.5 m

Quadrat 1 10%

ht	dbh	dbas
140	.31	1.38

STUMPS

Species: Alnus crispa

Quadrat 1

ht	dbas	stems
37	1.78	0
7	1.54	0
73	2.43	0 (branch)

Species: Salix amygaloides

Quadrat 3

ht	dbas	stems
22	1.73	0
20	4.39	0
17	1.0	0
23	1.88	0
20	1.78	0
23	2.07	0
19	1.36	0
20	1.89	0
15	2.20	0
13	1.48	0
18	1.76	0
24	1.79	0

DISCUSSION

Data will be collected each year and analyzed to determine changes.

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APPENDIX II

TABLE OF MEASUREMENTS AND WEIGHTS OF, ALL BEAVERS USED IN THIS STUDY, AT TIME OF INITIAL CAPTURE

Table 1. Summary of measurements gathered for each beaver captured.

BEAVER #	WEIGHT (kg)	LENGTH (mm)	TAIL LENGTH (mm)	HF (mm)	EFN (mm)	TAIL CIRCUMF.	
						BASE (mm)	WIDEST (mm)
1829	7.7	750	280	n/a	n/a	n/a	n/a
1830	19.1	1120	420	180	n/a	230	n/a
1834-35	10.0	930	310	130	27	146	n/a
1844-45	19.55	1230	385	185	32	221	n/a
1846-47	9.5	895	280	150	22	170	n/a
1838-41	17.7	1000	330	170	50	179	n/a
1842-43	12.3	972	362	152	23	153	n/a
1848-50	13.2	952	287	160	22	158	n/a
B280-81	9.1	930	305	149	n/a	150	n/a
B286-87	10.45	977	328	177	30	160	241
B276-77	11.4	950	310	152	30	150	230
1836-37	12.3	985	300	172	30	165	222
B282-83	12.3	980	322	158	33	160	265
B288-89	11.4	1010	345	149	35	183	245
B296	15.0	1075	300	175	33	199	236
B434-37	11.8	953	321	175	29	160	240
B294-95	11.4	940	325	173	28	151	218