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The Effects of Regulated Lake levels on Beaver in Voyageurs National Park, Minnesota

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THE EFFECTS OF REGULATED LAKE LEVELS ON BEAVER IN VOYAGEURS NATIONAL PARK, MINNESOTA

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NATIONAL PARK SERVICE - Midwest Region

Research/Resources Management Report MWR-11

Produced under Cooperative Agreements No. CA6000-4-8003 and CA6820-5-8036 for the U.S. Department of the Interior, National Park Service, Midwest Region, Omaha, Nebraska

U.S. Department of the Interior
National Park Service
Midwest Regional Office
1709 Jackson Street
Omaha, Nebraska 68102

July 1988

Citation:

Smith, Douglas W. and Rolf O. Peterson. 1988. The Effects of Regulated Lake Levels on Beaver in Voyageurs National Park, Minnesota. U.S. Department of the Interior, National Park Service, Research/Resources Management Report MWR-11. Midwest Regional Office, Omaha, Nebraska 68102. 84 pp.

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ACKNOWLEDGMENTS

My debt is great. The successful orchestration of this study was dependent on many individuals, and because in each case, with each person, I still feel a heart felt thanks, I would like to thank each one.

Without the deep friendship of, and help of my dear friend William T. Route, nothing we accomplished would have been as good. From gathering data in my absence, to always listening patiently to my ideas, his help was immeasurable, and he will always stand out in my mind as the one I was with during these formative years.

Rolf O. Peterson was my advisor, but first was a friend. Since first working for Dr. Peterson on Isle Royale until now, his incredible knowledge, patience, and support have been a constant source of inspiration to do the best job I possibly could under all circumstances- no matter what. Thank you for this opportunity- I will not forget it.

At Michigan Tech I received help from several individuals. First and foremost was Dr. Thomas Drummer. His hand with its statistical brilliance has been across most of these data, and they are worlds better for it. I will never be able to thank him enough. Masters of the main frame computer, Dave Strenski and Eric Jones saved me hundreds of hours of drudgery, and they helped me overcome computer illiteracy, which nowadays helps in all walks of life. Joanne Thurber and I trapped together one fall, and she helped with beaver work whenever she could, and I thank her. I am also grateful to Todd Sanger for his help with some of the statistical analyses.

The National Park Service funded this study, and to them we are eternally grateful. Just about everyone from Voyageurs National Park lent us a hand at some point. First to mind are Glen Cole and Larry Kallemeyn whose coordinating efforts, and voice for us at park headquarters was appreciated. Then there are the woods runners- Bruce Barrett, Stephen Maass, and Dr. Dennis Lagergren. Their deep enthusiasm for the woods and beavers supplied me with many enjoyable and enlightening moments. Jim Benedict and Lee Grim also talked with me, contributing much with their biological knowledge.

Everyone from the maintenance crew helped. Stub Horne I'll remember mostly for his advice. Clayton Stevens, Jimmy Larson, Bob Hagen, Roger Hanson, Keith Manninen, Rob Ecklund, Mike Pullar, and Billy Johnson helped in every way they could, and their friendship will always be held in high esteem. Lee

Evans, Chris Case, Raoul Lufberry and Sharon Kennedy often kept the project going with their help at the Sheriff's or by loaning equipment. Leon Wautress lifted my spirits many a late night at park headquarters, and I am grateful. The mechanics Craig Moe and Dave Crawford were indispensable, without them I would have had to walk.

The park Ranger staff was always willing to help and share information about the park with me. I spent a lot of time with Joe Cayou and Scott Evans and learned much, and appreciate Joe's help right up until the end. Without Scott, major portions of the study would have been left incomplete. I also thank Dave Seegert, Bruce Malloy, Roger Moder, and Steve Goodrich for their time with me in the field.

At park headquarters Audrey Harmening deserves special mention- she not only assisted, but her good cheer will not be easily forgotten. Marylin Larson and Mary Graves were always keeping an ear to the radio for me, and that was nice to know. Ron Erickson, Mike Braley, Sherry Stemm, Judy Wendt, Lynn Matson, Reed Christianson, and Dottie Anderson all helped and I am grateful.

Several people from the Minnesota DNR assisted with many aspects of the project, and gave us all the data they had collected on beavers over the years. Thank you Jim Schneeweis, Frank Swenson, Dick Laurette, Dave Keuhn, and Bill Berg. Game warden Lloyd Steen I cannot say enough about, few have been so enthusiastic to help.

Several other individuals lent critical help. John and Robin Fisher taught me surgical techniques and always supplied equipment when it was needed it, even though it took months to pay them. Wayne Hasbargen and Mary Maki were also helpful veterinarians from International Falls. Sound North- thank you for keeping the telemetry equipment going. Andy Levar was in the field often, and assisted when he could. Nancy Albrecht trapped and helped operate on beavers. Bruce Lupfer gathered vegetation data with me, and helped increase my appreciation of the natural world. Chris Mostad lent us his fishing homestead whenever asked. Tim Ahern and Bruce Fossum lent their artistic and medical help. Kaya Route drew figure 18 and Karen Keen sketched the cover drawing and figure 21, the report is much better with this artistic touch. Norm and Dave Seegert were helpful, and more than hospitable at their marina. Trappers Kelly and Bill Wilson, Mike Zupetz, Bob Burns, Lloyd Steen all helped by turning in tags from beavers they had trapped. Chuck Williams with the help of Howie Arch and Mike operated his mechanical portage for us anytime asked, as well as storing gasoline and warming me many times. To all these people we are thankful.

Finally, there are several people who live in and make the bush their life, their shared information with me about beavers was invaluable. Their daily contact with wildlife make these people incredible sources of knowledge, especially intuitive, thus contributing to our short term study in ways not possible by our methodology. Alan Kielczewski and his family, Marvin Smith and John Smith (thanks for the beaver carcasses), and Laverne Ovesen all contributed by relating their knowledge of beavers. The late Ed Nelson deserves special mention. My research needed inspiration, and Ed gave me that. His stories of beavers and the woods kept my mind clear as to why I was studying beavers. There are few jobs now where one can be their own person in the free outdoors, and no sacrifice is too much. Ed, I wish I was more like you. Thank you.

Lastly, my mother and father, Billie Elaine Smith and Ralston Fox Smith, who gave me the chance to evolve a deep and burning passion for everything wild. Their understanding and support of a son often broke and full of crazy ideas, let me experience and experiment with life in a go as you please style, enabling me to develop a sense of what I loved, and a knowledge of what I wanted to do about it.

ABSTRACT

Beavers in Voyageurs National Park were studied to determine the effects of a winter water drawdown of 2 meters (3 meters annually) behind hydroelectric dams. Several areas of differing environmental conditions were chosen for study based on water drawdown (present, slight, absent) and habitat conditions. Beaver lodges were counted from aircraft, and beavers were live trapped and radio implanted to examine the effects of drawdowns and vegetation on beaver distribution, abundance, mortality, and reproduction.

Active beaver lodge density was greatest on the drawdown lake Kabetogama, and was increasing at a higher rate on Kabetogama than on the slight drawdown lake Rainy. Beavers living in the drawdown environment abandoned their lodges overwinter, but stayed in the lodge vicinity. Food cache utilization and usage of aquatic vegetation was less in the drawdown areas. Above-ice foraging in winter and spring abandonment of the fall-winter homesite was more common in the drawdown environment. Family size and kit production were lower in the drawdown and poor habitat locations, and adult body size was less at the poor habitat location.

Costs to beavers living in the drawdown environment were estimated. Variability and low sample sizes obscured interpretations, but beavers living in the drawdown environment came through winter in poorer condition. Winter drawdown was hypothesized to interfere with reproductive behavior. Overwinter mortality was not widespread, but some did occur due to starvation. Springtime wolf predation due to low water levels was thought to be the major beaver mortality factor, but estimated not to exceed 25%. Beaver-forest relations were also discussed.

Management recommendations were to change water management to approximate a more natural fluctuation. Total yearly fluctuation should not exceed 1.5 meters, and winter drawdowns should not exceed 0.7 meters.

INTRODUCTION

Voyageurs National Park (VNP)(Fig. 1) was established in 1975 (act of Congress 16 U.S.C. 160), and partially or wholly contains four large lakes (Rainy, Kabetogama, Namakan, and Sandpoint) which comprise approximately 39% of the park's water area (Fig. 2). In addition, 26 inland lakes and hundreds of beaver ponds also occur within the park boundaries. Since the early 1900's the large lakes of Voyageurs have had their water levels regulated by three dams. Rainy Lake is controlled by a dam at International Falls, Minnesota/ Fort Frances, Ontario while the Namakan Reservoir lakes (Kabetogama, Namakan,and Sandpoint) are controlled by two dams located at the outlet of Namakan Lake at Kettle Falls/Squirrel Falls. Crane and Little Vermilion lakes are also part of the Namakan Reservoir, but they do not lie within the park. Rainy Lake has unnaturally stable water levels (1 meter yearly fluctuation), while the five upstream Namakan Reservoir lakes fluctuate at greater than natural levels (3 meter yearly fluctuation). These water levels and dams are managed for authorized purposes of power generation, navigation, flood control, pollution abatement, and fish propagation (Kallemeyn et al. 1988).

The present water management is under the control of the International Joint Commission (IJC), the organization responsible for managing waters shared by the United States and Canada since its formulation in 1909. Under the present water management system water levels are kept within a band of acceptable values for certain times of the year, called a rule curve (Fig. 3). The present rule curve encompasses a range of maximum and minimum values allowing some leeway in water levels. The general yearly pattern begins in June when high water is reached about a month after natural dates (mid-May), and remains largely stable throughout the summer. In September water levels gradually decline, continuing through the winter and reaching the lowest level from mid to late March (Fig. 3). Much of the yearly fluctuation (2 meters) occurs in winter.

Present water fluctuations are more regular, but have a greater magnitude as compared to mean natural values since 1914 (Flug 1986)(Fig. 3). The National Park Service is responsible for restoration and maintenance of natural objects and wildlife as established by directives from the Organic act (16 U.S.C. 1). Boise Cascade, the present owners of the dams, utilize the present water system for industrial purposes, which in turn is responsible for the employment of many people in the Fort Frances and International Falls area. Additionally, pollution

Figure 1. Study area, Voyageurs National Park, Minnesota.

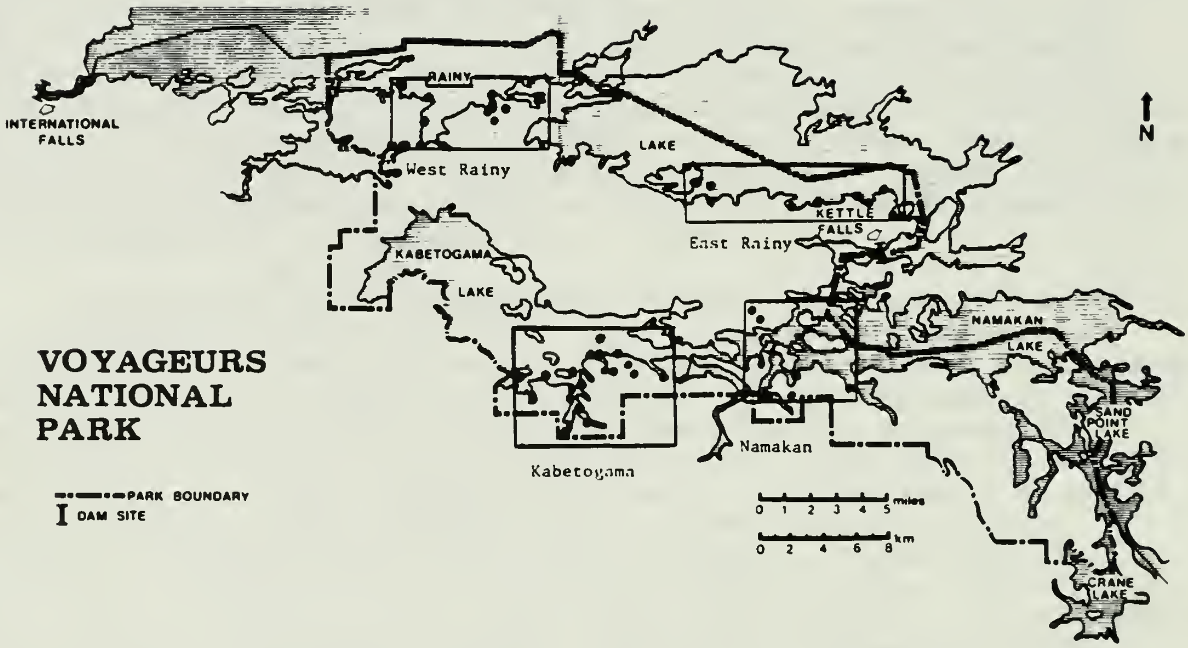

Figure 2. Voyageurs National Park, Minnesota. Boxes indicate study sites, dots represent beaver lodges that were trapped. Sampled inland lodges were associated with lake study sites.

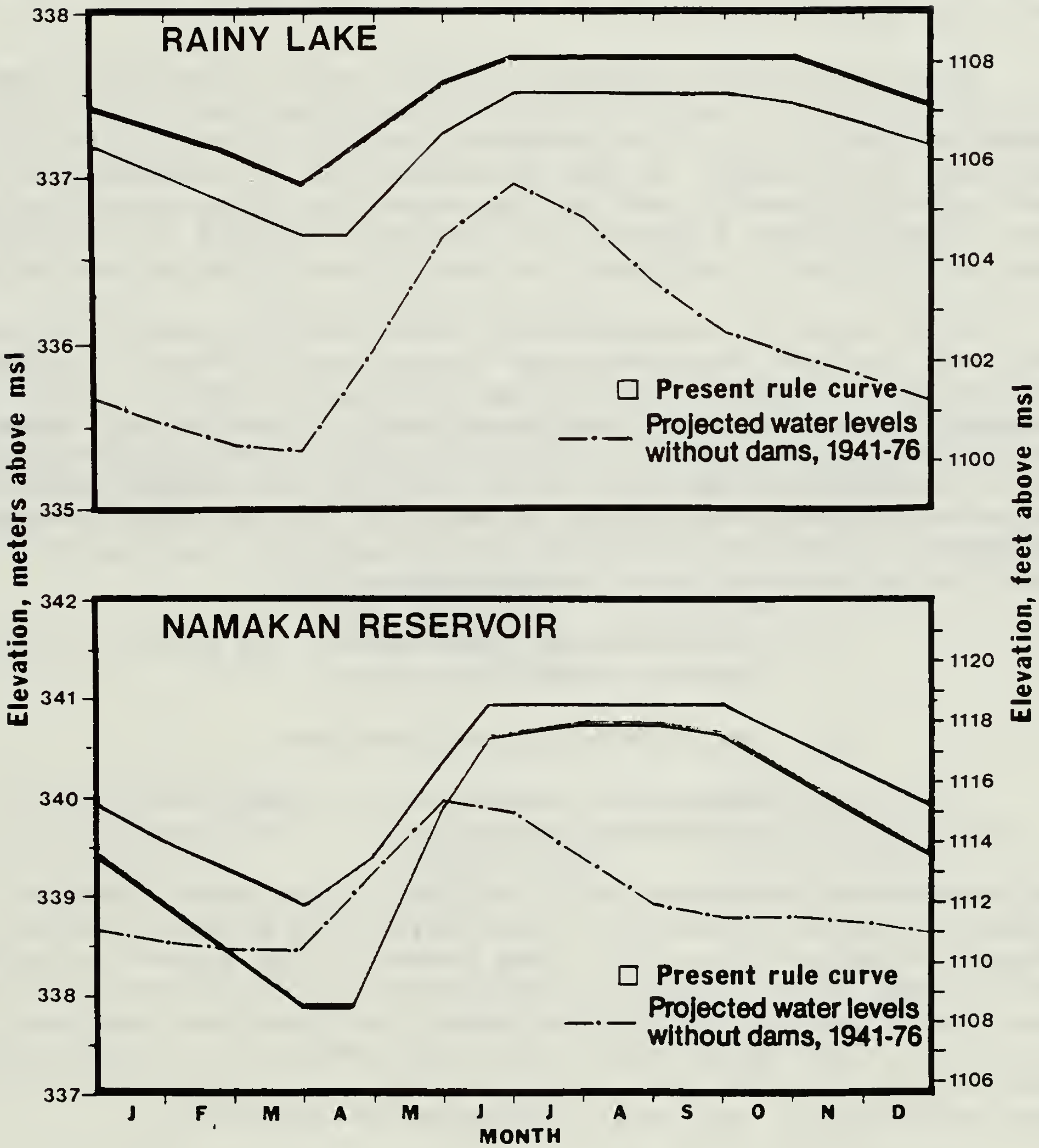

Figure 3. Rainy Lake and Namakan Reservoir water levels or "rule curves".

abatement and a resource industry (tourism, recreation) based on water levels in the major lakes and the Rainy River below are also major concerns.

Since the establishment of VNP, water management needs to be considered in light of the National Park Service (NPS) mandate. Central to this mandate, as described in the Scope of Work for this study, is the preservation of representative natural environments and native biota as integrated wholes. Thus, the NPS has a desire to know the impacts of drawdowns on the native biota, and how the conditions might be corrected.

This study of beavers from 1984-1987 is part of a larger research project to determine the effects of water drawdowns on the Voyageurs aquatic ecosystem (Kallemeyn 1983). Since other researchers have determined that highly fluctuating water levels are detrimental to beavers (Nixon and Ely 1969; Allen 1982; Courcelles and Nault 1984; Howard and Larson 1985), this beaver study was formulated to examine the effects of these unnatural drawdowns on the beaver population in the park. Specific objectives were to determine the:

(1) Distribution, abundance, and mortality of beavers within the park;

(2) Basic population dynamics;

(3) Overwinter behavior in relation to the water drawdowns.

The study was conducted as a natural experiment, examining five areas of beaver habitation with differing food and water characteristics (Fig. 4). Two areas in the severe drawdown environment were examined (Kabetogama Lake and Namakan Lake) as were two areas on Rainy Lake where the drawdown was less severe (Fig. 2). Two sites were chosen so areas of differing food quality within the same water regime could be sampled. The last area was inland, and was considered as a control.

Study design was focused on lake beaver populations, and accessible inland ponds exhibiting more stable water conditions. Many beaver ponds are found inland and this study does not report on conditions there in a detailed fashion, other than as is necessary to understand beaver population dynamics for the whole area.

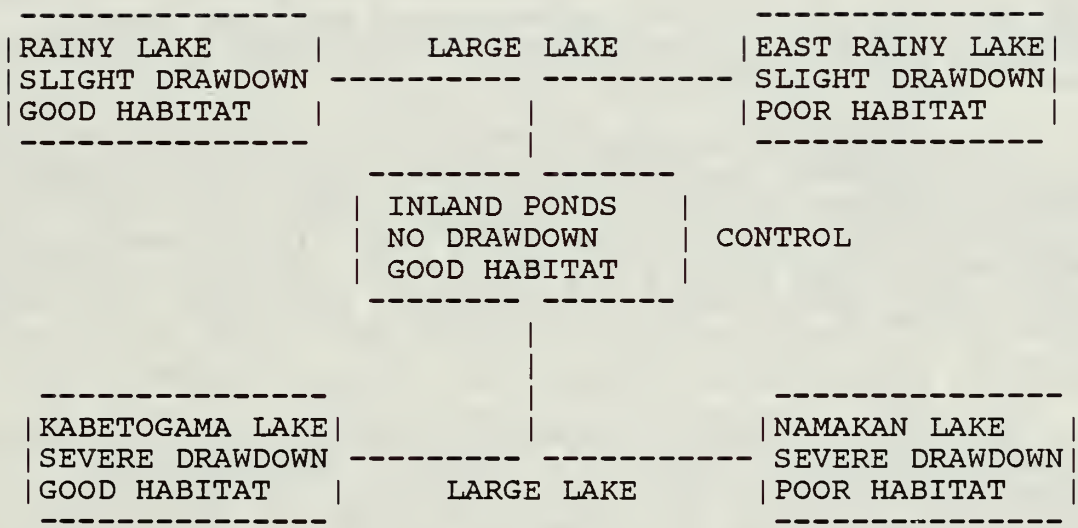

Figure 4. Beaver study experimental design. Beavers were sampled (live-trapping and radio implanted) in five areas of differing habitat and water conditions with an inland control to determine the water drawdown effects.

STUDY AREA

Voyageurs National Park, named by Sigurd F. Olson to commemorate the passage of the voyageurs through this region (Minnesota Volunteer 1971), tends east-west for 90 km along the U.S.- Ontario border in north central Minnesota (Fig. 2). The park's western boundary is approximately 18 km east of International Falls, MN(48 36' N, 93 25' W). Total area of the park is 88,628 ha, 34,400 of which is water. The rolling, lake-dominated topography is largely due to glaciation. The large lakes of the park are remnants from glacial Lake Agassiz, and the bedrock basins and natural rock sill outlets of the lakes are the result of glacial erosion (Bray 1977; Teller and Clayton 1983). Elevational differences are slight and range from approximately 335-420 meters above mean sea level. Abundant slow moving flowages and inland lakes have made this excellent habitat for beavers.

Precipitation is moderate (67.5 cm) and about 70% falls as rain, with mean yearly snowfall averaging 140 cm (Cole 1987; National Weather Service International Falls) The frost free season is 100-110 days. Summers are warm (18.6 C mean July temperature), and winters are very cold (-16.1 C mean January temperature), with temperature extremes from 36.6 C to -43.0 C (Cole 1987). Freeze-up usually occurs during the third week in November, with spring breakup around May 1 (Kallemeyn 1987).

The area is almost completely forested, and is classified as southern boreal, creating a mosaic of deciduous and coniferous habitats (Kurmis et al. 1986). Quaking aspen (Populus tremuloides) and paper birch (Betula papyrifera) are the dominate hardwood species with white spruce (Picea glauca) and balsam fir (Abies balsamea) as the dominant coniferous trees. White pine (Pinus strobus), red pine (Pinus resinosa), and jack pine (Pinus banksiana) occur in scattered pockets, the large pines (white and red) especially along the shorelines of the lakes. On drier, mineral soils the forest tends toward white spruce and balsam fir, while on wetter, peaty soils black spruce (Picea mariana) and white cedar (Thuja plicata) predominate. Historically, with a natural fire frequency, pines such as white and red, and large stands of jack pine were much more common (Heinselman 1973). Since then man-caused fires and logging have altered much of the original forest, and now seral species such as aspen and birch are widespread (Heinselman 1973; Cole 1979; Cole 1987) Finally, many shrub species exist in a variety of circumstances, willow (Salix sp.) and alder (Alnus sp.) on wetter sites, and dogwood (Cornus sp.)

and beaked hazel (Corylus sp.) on the drier sites. Kurmis et al.(1986) give a detailed analysis of plant associations in Voyageurs.

Logging operations began to remove the large pines from the midwestern lake states beginning in roughly 1830 (Swanholm 1978). This cutting activity reached the area now occupied by the park by approximately 1913, and most large pine were removed by 1929 (Nute 1950; Cole 1987). From 1930 to 1971 portions of the area were logged for pulpwood (VNP records). Since establishment as a park, no logging has occurred, and 92 inconsequential fires have been recorded, burning approximately 262 acres (VNP records).

Historic alteration of the forest had a significant impact on the fauna of the area, leading to a change in the major ungulates from moose (Alces alces) and woodland caribou (Rangifer tarandus) to white-tailed deer (Odocoileus virginianus)(Cole 1987). Market hunting for logging camps also contributed to the decline of large ungulates. Wolves (Canis lupus), the major beaver predator, and black bears (Ursus americanus), however, have always persisted in varying numbers (Cole 1987). There are currently about 20-30 wolves in 4-5 packs, and roughly 200 black bears (Cole 1987; Benedict 1987).

The northern location and abundant watercourses have made the area excellent habitat for many furbearers. Other than beavers, aquatic mammals such as mink (Mustela vison) and otter (Lutra canadensis) are common. Muskrats (Ondatra zibethicus) are also present and make use of the shallow weedy bays in the western portion of the park (Thurber and Peterson 1988). Other furbearers include coyote (Canis latrans), fox (Vulpes vulpes), fisher (Martes pennanti), marten (Martes americana), long-tailed and short-tailed weasels (Mustela frenatau and Mustela erminea), red squirrel (Tamiasciurus hudsonicus), snowshoe hare (Lepus americanus), and occasionally raccoons (Procyon lotor). Wolverines (Gulo luscus) were present, but have been absent or very rare since 1900 (Cole 1987). Lynx (Lynx canadensis) are also uncommon. Porcupines (Erethizon dorsatum) numbers are very low, and recently efforts were initiated to reintroduce them (Cole unpubl. data).

WATER FLUCTUATIONS DURING THE STUDY

Although water management on the large lakes of VNP was largely predictable, year to year variations did occur during our study (Fig. 5). Notable to beavers was the spring of 1985 when water levels rose unusually quickly. Also, the winter of 1986-87 was one of the driest in recent history and kept the lakes dewatered well into the summer.

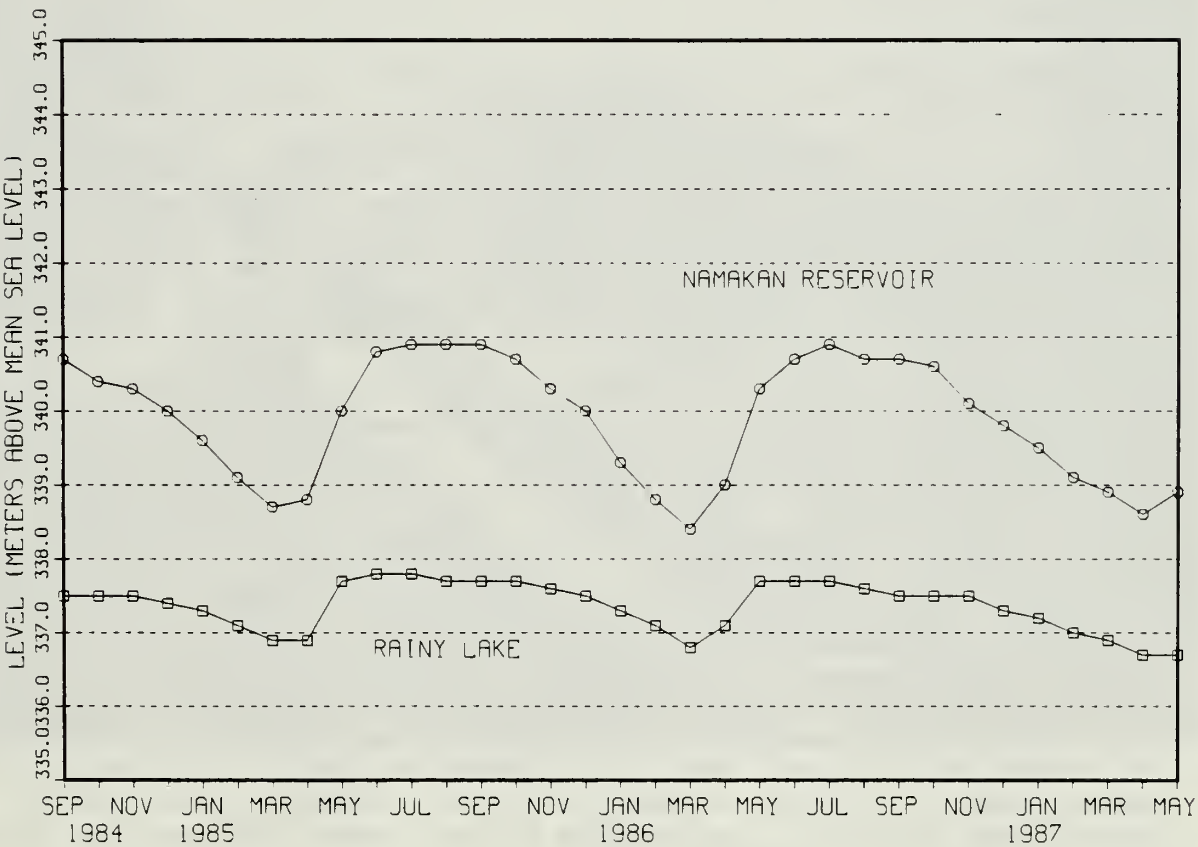

Figure 5. Mean monthly lake levels for Namakan Reservoir and Rainy Lake, September 1984- May 1987.

METHODS

Field studies of beavers were conducted in Voyageurs National Park from 9 September 1984 to 29 May 1987, with one brief visit during the fall of 1987. Fall live-trapping was usually conducted from early September through early November. The spring trapping period was shorter, usually only the month of May. All traps were checked daily either by motor boat or canoe.

TRAPPING

All beavers were captured and handled in Hancock live traps (Hancock Traps Co., Rt. 1 Box 38-2, Buffalo Gap, South Dakota 57722)(Fig. 6) baited with aspen, apple, or both, or caught in disguised sets without bait (Appendix I). Animals were handled and measured in burlap sacks without sedation. Measurements taken from each beaver included: weight, total length, zygomatic breadth, tail length and width, hind foot length, and sex. Each beaver was tagged with small numbered metal ear markers for future identification.

Movement, growth rate, and over-winter weight loss was determined from recaptures. Colony sizes, age ratios, and reproduction were calculated from live captures. Colony sizes were calculated two different ways:(1) uncorrectednumber of animals caught, and (2) corrected- number inferred from evening watches and assuming two adults if kits were present, although two adults may not have been captured. Litter size data represent kits trapped at a lodge in fall. Beaver age was estimated by three methods: (1) a regression curve plotting beaver weight vs. age (as determined from cementum layering and root closure (Van Nostrand and Stephenson 1964)) from beavers kill-trapped adjacent to Voyageurs, (2) measuring growth rates of known age beavers, and (3) cluster analysis using physical measurements from all animals handled. Method 1 was poorly correlated (r=0.12), so methods 2 and 3 were combined to obtain a best estimate of beaver age.

After these age categorizations beavers were analyzed three different ways: 1) physical measurements were compared statistically using two age classes (i.e. animals less than 10 kg (kits), and animals greater than 10 kg (adults)) separated by location; (2) yearlings were identified, and the age ratios of the different populations were compared statistically using three age classes and; (3) individual lodges were examined, and any additional adult-sized animals (besides the breeding pair) were assigned as 2-year-olds. Usually the largest two beaver were considered the breeding pair, with other individuals

Figure 6. Hancock live traps were used to capture beavers during the study (photo Billie E. Smith).

weighing between 16-19 kg and having a zygomatic breadth between 90-100 mm considered to be 2-year-olds.

Although no systematic sampling was conducted to determine parasites infesting beavers, it was common to encounter beetles in the fur while handling. Several were sent to the Oregon State University Entomology Department for identification (Dr. Gary Parsons).

RADIO TELEMETRY

Radio transmitters (Telonics Inc., 932 E. Impala Ave., Mesa, Arizona 85204) were surgically implanted in 26 beavers to identify mortality factors, and better document movements and behavior. Transmitters were equipped with activity/temperature sensors, and a continuously operating system (Fig. 7) recorded signals from 12 beavers through two winters. Other beavers were checked 2-3 times a week from September through May, and 1-2 times monthly from June through August. Most locations included date, time, location, temperature, activity, and position (in/out) relative to the lodge. Most tracking was from motorized vehicles (boats and snowmobiles), but occasionally a light aircraft was used.

With the exception of the initial surgical implants (John and Robin Fisher DVM, Vermilion Vet Clinic, Rt. 1 Box 366, Cook, MN 55723) all beaver surgery was done by Smith. Radios for adults (model 400L) were 95 x 33mm, weighing 85-90 gm (less than 1% of body weight). Kit(<10 kg) radios (model 200L) were 58 x 20mm, weighing 22-27 gm. Each beaver was sedated with an initial dose of 5 cc ketamine hydrochloride and 0.3 cc acepromazine maleate (Lancia et al. 1978). Time from initial drugging to the installation of the final stitch was approximately 2 hours, with actual surgery time usually under 1 hour. Specific surgical techniques were explained for otter by Melquist and Hornocker (1979), and beaver surgical implantations are similar. Beavers were cut ventrally, however, along the linnea alba, posterior to the rib cage- not along the dorso-ventral axis as performed in otters.

POPULATION DYNAMICS

Beaver population trends since about 1900 were constructed from aerial photos (Broschart et al. 1987) and trapper interviews. One aerial survey (Piper PA12 Supercub) of active beaver houses was flown over the entire park during the fall of 1984, and another survey of just the large lake (Rainy, Kabetogama, Namakan, and Sandpoint) shorelines was flown in the fall of 1986 (Fig. 8). During the first survey the entire park

Figure 7. A continuously operating system recorded signals from 12 radio-tagged beavers through two winters (1984-85; 1985-86) (photo D. W. Smith).

Figure 8. In late October beaver food cache's were almost completed and visible from aircraft. Two aerial surveys were conducted (1984 and 1986) to determine the number of active beaver lodges in Voyageurs National Park (photo D. W. Smith).

area was covered by flying in overlapping circles at an altitude of 800 to 1400 ft. In all cases where the observer was unsure the pilot circled back to confirm the sighting. In 1986, the inland portion of the park was not surveyed, and the overlapping circle flight pattern, at the same altitude as 1984, was used for the shorelines and islands of the large lakes. Mean lodge size obtained from live-trapping, and total lodge numbers from the aerial survey were combined to estimate total beaver population.

Information from aerial and ground examinations was used to determine the pattern of abandonment and re-occupation of lodges.

Beaver mortality was determined from radio-tagged animals, and by site checks at lodges overwinter. Additional estimates of beaver mortality were made by hiking exposed shorelines in the spring of 1987 recording wolf scats and their contents, and by noting other signs of overwinter mortality.

HABITAT ANALYSES

Five methods were used to quantify water and food conditions- four determined food resources, and one measured water conditions around lodges. Four methods were chosen to measure beaver food abundance because no one method alone was thought to adequately represent the situation. Habitat analyses focused on aspen abundance and utilization since aspen has been found to be the most important beaver food (Hall 1960; Jenkins and Busher 1979; Jenkins 1979). First, all freshly cut or downed trees around the beaver lodge were recorded for species, diameter at breast height (dbh), and distance from water. Then, within the areas identified around the lodge, systematic sampling (point center quarter method) was used to quantify the availability of aspen. Distances by water to feeding areas were also measured.

The last technique used in vegetation analyses was a measurement taken from color aerial photos (July 1981; scale 1:24,000) of deciduous volume and % deciduous cover around lodges. Volume was estimated by determining stocking density for 15 ft. crowns with a photo interpreters scale (National Agricultural Supply Co.) of 1:15,840 corrected by 5% when using photos of 1:24,000 scale. Tree height was determined using a parallax bar. Volumes were then calculated using a composite aerial volume table for northern Minnesota.

Forest type (coniferous or deciduous) was estimated from the photos by techniques described in Avery and Berlin (1985). A standard fixed area (400 m each side of the lodge and 100 m inland for lakeshore colonies; 100 m inland from the entire pond shoreline for interior colonies) was determined around beaver lodges from discussions of beaver foraging distances (Jenkins 1980; 1981). Total area for each forest type (each type computed as a % of total area) was determined with a computer digitizer.

Finally, water depths around lodges and food caches were measured three different times: in fall before the water drawdown began, mid-winter during severe drawdown conditions, and again in the spring, when the water was usually at its lowest level. Daily water drawdown information was secured from the Rainy Lake Board of Control, and integrated into analyses of beaver behavior and movements.

RESULTS

A total of 394 beavers were live-trapped in 60 colonies during three fall and spring trapping seasons. During the fall 291 beavers were captured, 29 of which were recaptured in another fall. In the spring 66 beavers were captured, 42 of these had been previously captured the preceding fall. Eight beavers were captured more than twice during different seasons. Total number of beavers captured but not recaptured was 323.

Only four dead beavers from within the park were examined: three were from trap mortalities, and one was found dead from natural causes. Fifteen dead beavers were examined from a trappers sample collected outside the park.

All data gathered on beavers within the park represent information gathered on an unexploited population. Trapping was prohibited after 1975 (excluding private lands) when Voyageurs became a national park. Park records indicate very little legal harvest on private lands and infrequent poaching activity.

POPULATION DYNAMICS

Present Population and Lodge Distribution

A total of 506 active beaver lodges or a density of 0.92 lodges/km2 were observed in an 1984 aerial survey of the entire park (Table 1). Inland lodges accounted for 391 of the total number of lodges. Lodge densities were slightly higher on the Namakan Reservoir lakes than they were on Rainy Lake. The 1986 aerial survey of just the large lake shorelines showed an increase in the number of lodges on all the lakes except Sand Point where the count was the same (Table 1). Fig. 9 summarizes beaver population trend in the park for the last 47 years.

Lodge size, Composition, Kit production and Sex ratios

Average beaver family size based on all data was 5.8 (Table 2). Beaver families were largest inland (mean=7.1 n=14) and on west Rainy Lake (mean=6.4 n=8). These differences are not statistically significant (Tukey's multiple range test), but when analyzed together these data show significance and suggest that east Rainy Lake (mean=4.4 n=10) and Kabetogama Lake (mean=4.8 n=16)) families are smaller ($p<0.03$).

Table 1. Active lodges per unit of shoreline.

Location	Year	Lodges	Ldgs/km	Ldgs/mi
Namakan Reservoir	1984	78	0.13	0.22
	1986	103	0.17	0.29
Kabetogama	1984	39	0.15	0.26
	1986	54	0.21	0.36
Namakan	1984	27	0.11	0.19
	1986	37	0.16	0.26
Sandpoint	1984	12	0.11	0.18
	1986	12	0.11	0.18
Rainy Lake	1984	37	0.10	0.17
	1986	46	0.12	0.21

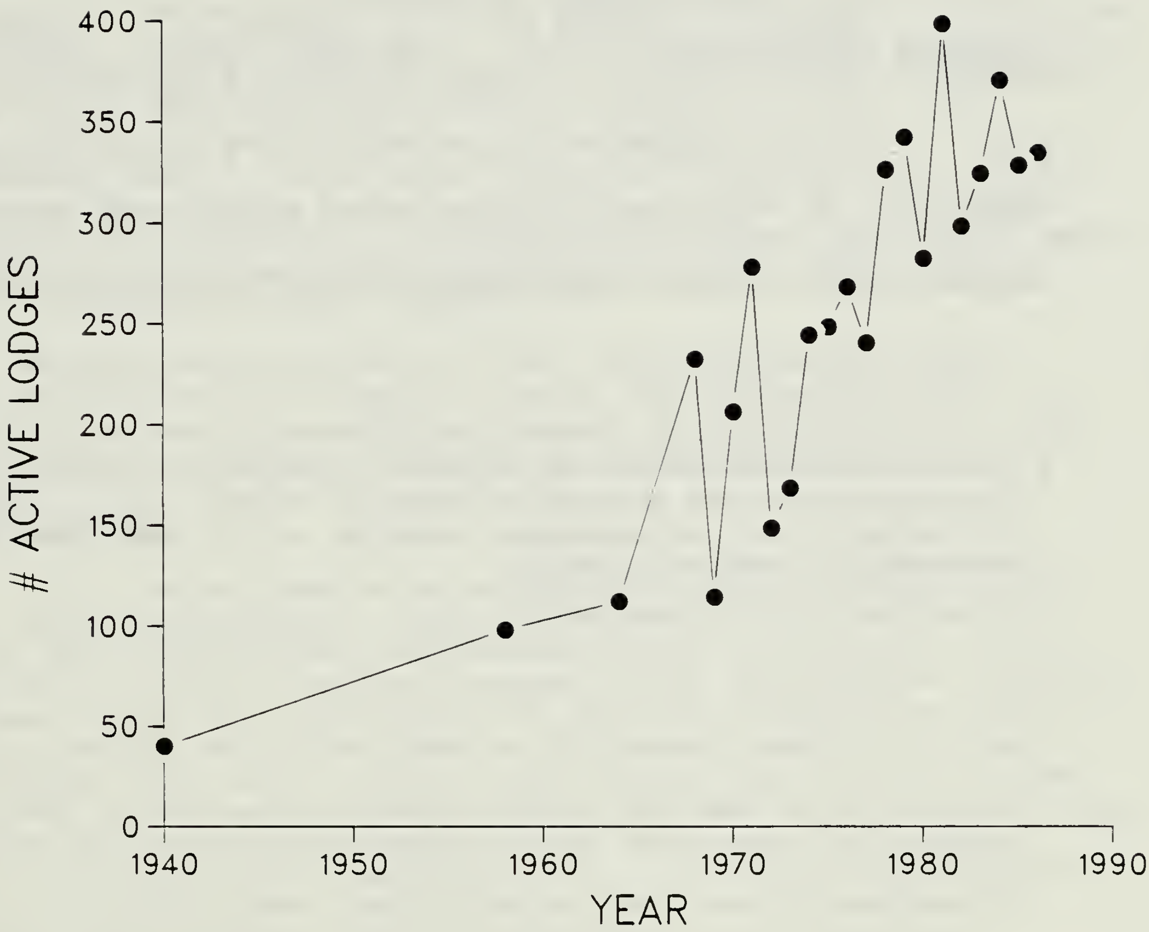

Figure 9. Number of active beaver lodges Kabetogama Peninsula, 1940-86.

Table 2. Colony size and kit production for live-trapped beaver lodges in Voyageurs National Park, Minnesota, 1984-87 (standard deviation in parenthesis)@.

		Mean number of Beavers				
	# of	Total		Kits		2-year
Location	Ldgs	Uncorr	Corr	Uncorr	Corr	olds
Inland	14	7.1(2.3)	8.4(1.9)	3.1(1.5)	3.3(1.4)	0.6(1.1)
Kab	16	4.8(2.5)	5.1(2.7)	2.1(2.0)	2.1(2.0)	0.8(0.9)
W.Rainy	8	6.4(3.2)	6.6(3.2)	3.6(2.4)	3.8(2.5)	0.1(0.4)
E.Rainy	10	4.4(2.3)	4.6(2.4)	1.4(1.3)	1.6(1.6)	0.6(0.8)

@ Uncorrected refers to the number of animals actually caught. Corrected was the number of animals assumed to be present based on observations of untagged animals, or if kits were present, we assumed two adults present.

Family colonies (colonies with kits) compose all of the inland colonies trapped (n=14)(Appendix II). West Rainy has 75% (n=8), east Rainy 60% (n=10), and Kabetogama Lake has 63% (n=16) colonies with kits. Table 3 lists all the different family compositions encountered while trapping.

The average number of young produced per family across the park was 2.6, with west Rainy (3.6 kits/lodge) and inland (3.1 kits/lodge) the highest average per family (Table 2). The only areas which differed statistically were west Rainy (3.6 kits/lodge) and east Rainy (1.4 kits/lodge) ($p<0.03$). Kabetogama had 2.2 kits/lodge. When only lodges with kits were included the average number of kits per lodge is more equal across areas (inland=3.1; Kabetogama=3.3; west Rainy=4.8; east Rainy=2.3), and the overall average young per lodge is 3.3 (n=38; std.dev.=1.4195; range=1-7).

Beavers were difficult to sex, and good data on sex differences were not obtained until 1986 (Appendix III). Sixty-three adult beavers were sexed: 28 male:35 female, not significantly different from 50:50 (Chi-Square Test).

<u>Age Structure</u>

Only limited data were obtained on age structure of the park beaver population. Age was determined for beavers of known age (Van Nostrand and Stephenson 1964) trapped outside the park, but this did not produce a good correlation ($r=0.12$) between weight and age (Fig. 10). Cluster analyses of weights and zygomatic arch measurements did reveal some likely age groupings (Fig. 11), but too much overlap was found to allow accurate assignments in many cases. The best age estimator was determined by multiple recapture of known-age individuals (N=20; 13 kits and 7 yearlings)(Fig. 12). Kits caught during their first fall were unmistakable, and when subsequently caught they provided data on subsequent growth patterns.

When fall captured beavers were broken into three age classes (adults, yearlings, and kits) the population in general shows a preponderance of kits and adults (Table 4). Kabetogama Lake in 1984-85, and east Rainy Lake, however, do not conform to this general pattern. The proportion of kits was highest in all areas during 1986, especially inland and at west Rainy Lake.

Only 6 of 48 (13%) lodges analyzed had 2-year-olds present

Table 3. Sex and age class composition of Voyageurs National Park beavers 1984-87 (4 other lodges were incidentally trapped during an otter study).

COMPOSITION	NUMBER OF FAMILIES
One female	3
One 2 yr female and one yearling male	1
One 2 yr female and one 2 yr male	1
One male and one female(adult)	2
One male, one female, and kits	11
One male, one female, and yearlings	1
One male, one female, yearlings and kits	21
One male, one female, 2 yr old(s) yearlings, and kits	5
One male, one female, 2 yr, and kits	1
Pair(unknown sex), 2 yr, and yearling	1
Pair(unknown sex) and one yearling	1
One adult, one 2 yr, and one yearling	2
Yearling(s)	3
One 2 yr(unknown sex)	1
One 2 yr and kits	2
	56

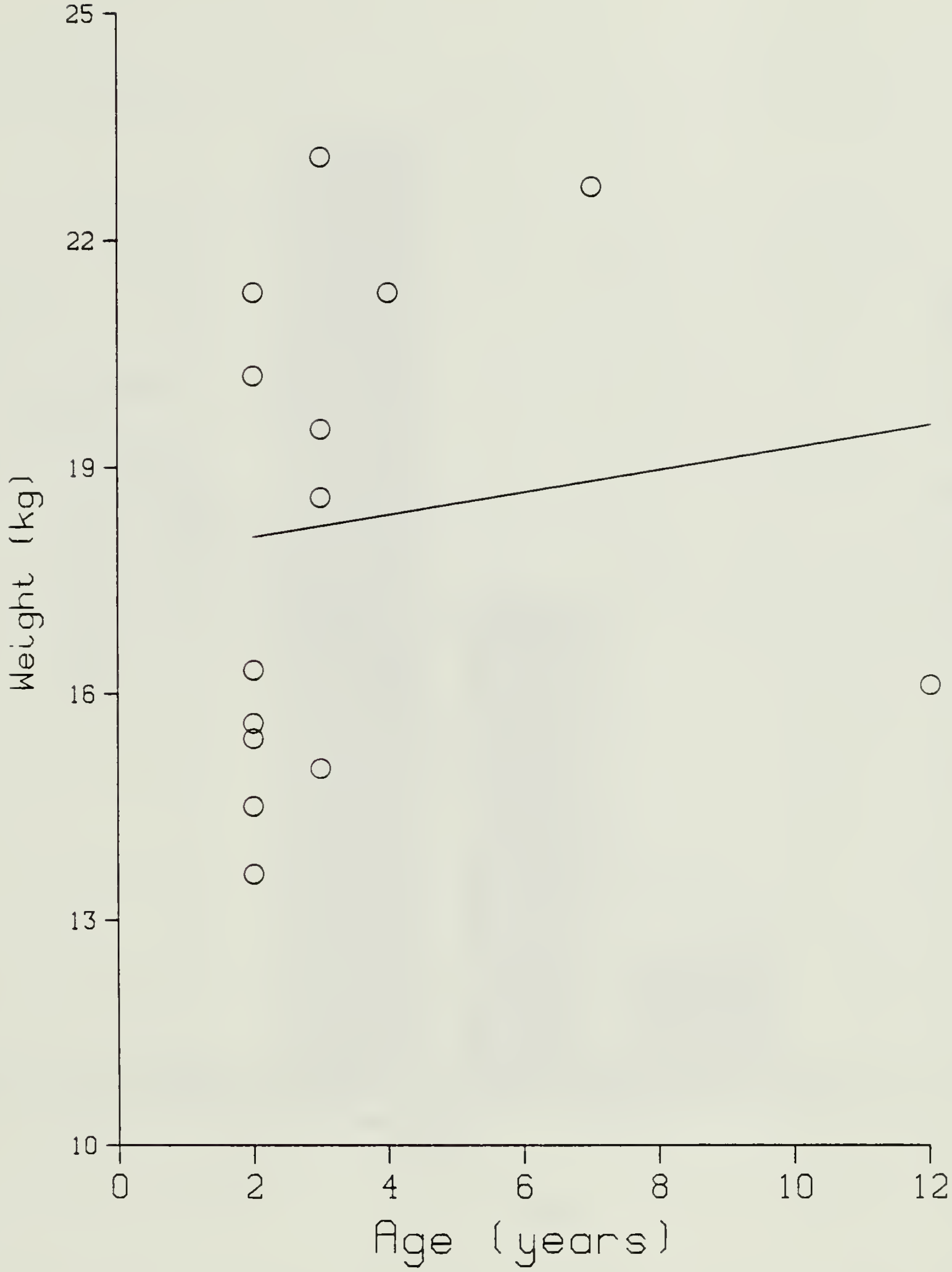

Figure 10. Weight-age regression of beavers kill trapped adjacent to Voyageurs National Park (r=0.12).

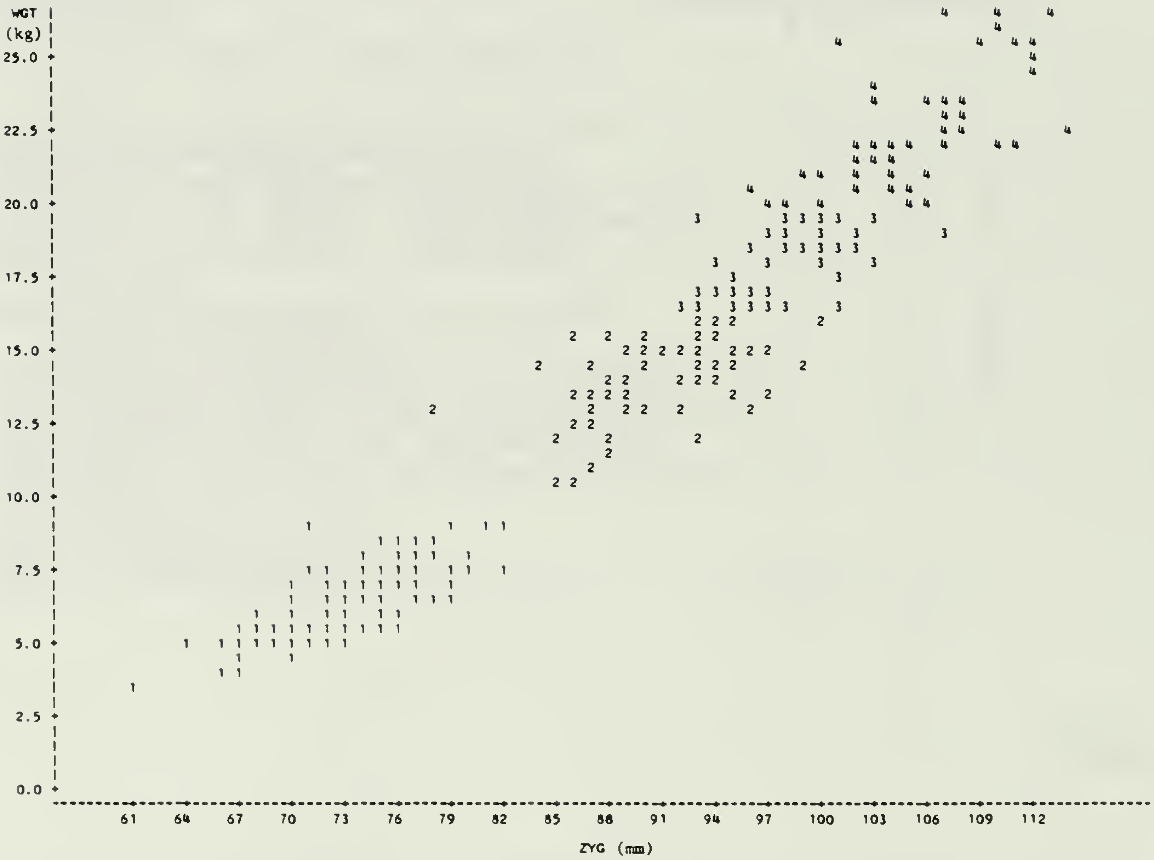

Figure 11. Cluster analysis of all beavers live-trapped in Voyageurs National Park, 1984-87 (1=kits, 2=yearling, 3=2-yr-old, 4=adults).

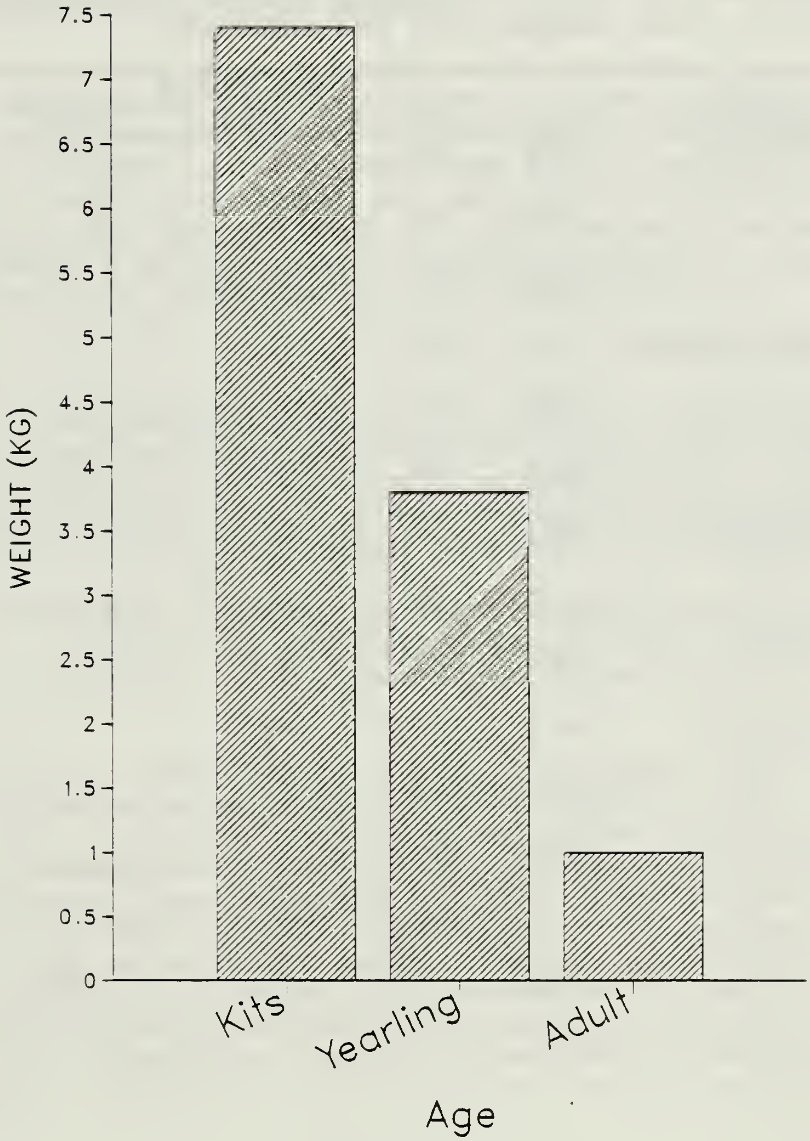

Figure 12. Weight gain of beavers captured at least twice (fall-fall) in Voyageurs National Park, 1984-87.

Table 4. Age ratios of live-trapped beavers, Voyageurs National Park, 1984-86. All numbers are percentages.

		Age Class		
Location	Year	Kit	Yearl.	Adult
Inland	1984	39	15	46
	1985	42	19	38
	1986	59	3	38
Kabetogama	1984	38	31	31
	1985	37	31	31
	1986	48	4	48
W.Rainy	1984	-	-	-
	1985	25	8	67
	1986	63	6	31
E.Rainy	1984	-	-	-
	1985	33	50	17
	1986	37	30	33
		n=124	n=55	n=-121
	average =	41%	18%	40%

in addition to a breeding pair (Table 4). Four of those 6 (67%) were inland lodges. Four lodges had one 2-year-old present, and two had three present.

No 2-year-olds were thought to be breeding in inland ponds. On Kabetogama Lake two pairs of 2-year-olds were breeding, and four groups with non-breeding 2-year-olds and no adults were trapped. No 2-year-olds were thought to have been breeding on west Rainy Lake, and only one other 2-year-old in a family colony was encountered. On east Rainy Lake we found one pair of breeding 2-year-olds, one non-breeding 2-year-old, and one 2-year-old in addition to the breeding pair.

Mortality

Of 26 instrumented animals, 5 signals (19%) were lost before the expected expiration date of the transmitter. Three of twelve signals (25%) were lost on Kabetogama, one on Rainy and one inland (14%). All of the signals but one (radio failed) were lost in the spring shortly after ice out.

Wolf sign was abundant on Kabetogama Lake shorelines in the spring. Remains of one beaver were found (freshly cleaned leg bone), and 47% of the scats encountered had beaver remains (n=17).

Two beavers that had been living together in a lodge that had no food cache were found dead in March of 1985. These beavers were living and constructing a food cache at another nearby site. They had moved to this lodge in late October when water levels at their original lodge fell below the lodge entrances. At the time of their death, both had been cutting trees on shore on top of 1 meter of snow. One beaver was found after a predator had fed on it (probably a fisher), and the other was observed dying and collected dead on top of the snow intact. This carcass was analyzed (National Wildlife Health Lab, Madison, Wisconsin), and cause of death was determined as starvation.

BEHAVIOR

Movements

Dispersal of radio-implanted beavers occurred in the spring at ice out, or when the edges of the lake became ice free allowing a beaver passage. Fifteen of 23 (3 beavers were not followed in the spring because of radio failure overwinter) beavers moved in the spring, 11 because of water drawdowns (lodge completely dewatered at the time of ice out). Nine of these 11 were from Kabetogama, and 2 were from west Rainy Lake. Of the remaining 4 beavers, 3 were from inland, and 1 was from Rainy Lake. The other radio-implanted beavers that were followed did not disperse.

Average distance moved by dispersing beaver was 14.3 km (n=11; range 1.6 km- 98.2 km). Excluding the two longest moves (24.0 km and 98.2 km) average distance moved was 3.9 km (n=9; range 1.6-7.0 km). One 11.4 kg female (weight at initial capture) originally captured and tagged during this study on September 1, 1985 moved from near Rabbit Island on east Rainy Lake to and then up the Pipestone River. She was captured 24.0 km from the initial capture site by a Canadian trapper (Bill Wilson) on April 18, 1986. The longest move was by a 10.6 kg male (weight at initial capture) from Daley Brook on Kabetogama Lake to Wolf Bay on Vermilion Lake. The straight line distance was 62.4 km, but the most likely route, which included several short overland crossings, and travel upstream was 98.2 km. The beaver, which was trapped and tagged on May 17, 1986, was caught on Vermilion Lake by trapper Mike Zupetz in November 1987.

Two beavers from different lodges dispersed to the same lodge 7.0 and 6.1 km away. They were re-caught together and remained together for a year. One other beaver moved inland 1.0 km to an already active lodge. A pair of beavers with a kit and a yearling moved back and forth between two lodges 0.4 km apart during the spring period when the water levels were at their lowest.

Eight colonies moved as a family for an average of 0.40 km (n=8; range 0.3 km- 0.9 km).

Lodge Site Abandonment and Re-occupation

Abandonment and re-occupation of lodges was highest on Kabetogama Lake. In 1984-85, 9 of 12 Kabetogama lodges were abandoned overwinter while 1 of 5 were abandoned during the same time period inland. Comparing lodge use in 1985-86 between areas, 13 of 15 lodges on Kabetogama Lake were abandoned or had been abandoned and re-occupied by another family in 1986. Two of five inland lodges and 4 of 13 Rainy Lake lodges had been abandoned or re-occupied. In the spring of 1987, 6 of 8 Kabetogama lodges that were active in the fall of 1986 were abandoned, and 7 of 16 Rainy Lake lodges were abandoned during the same time period. The two Kabetogama Lake families that did not abandon their lodge overwinter constructed dams by their lodge to hold water back, creating an inland like pond (Fig. 13). No inland beavers abandoned their lodges overwinter

Figure 13. Drawdown lake beavers often would construct dams to hold retreating water back, which in the spring resembled an inland beaver pond (photo D. W. Smith).

(n=5). Summarizing, Kabetogama Lake had a cumulative overwinter abandonment of 80% (n=35), Rainy Lake had a cumulative abandonment of 38% (n=29), and for inland colonies the cumulative abandonment rate was 20% (n=15).

In the fall of 1987 none of the lodges abandoned on Kabetogama Lake the previous spring had been re-occupied (n=6). One lodge within the study area that had been previously inactive became active for the first time during the study. Another house had the fourth beaver family in four years move into it.

There was also a higher density of inactive lodges on Kabetogama Lake (0.9 inactive lodges/ mile) compared to Rainy Lake (0.5 inactive lodges/mile). During the course of the study, many of these houses became re-occupied and some active houses became inactive.

A larger percentage of the Kabetogama Lake relocations were due to water drawdowns. Of 5 families and 4 individuals that were followed on Kabetogama Lake, we considered that 4 families and 1 individual moved because of water problemseither dry or flooded lodges in the spring. Inland, two families and two individuals moved for reasons not associated with water problems.

Most moves involved beavers re-occupying an old house (81%; n=26). In five cases beavers built a new house (two inland, two on Kabetogama Lake, and one on Rainy Lake), and one new house was the direct result of water drawdowns (i.e. water at the old house was too low).

Open Water Behavior

During the ice-free season radio-implanted beavers restricted their movements to the area around the lodge, and in the daytime were found inside of the lodge most of the time (88%; n=232). One pair of beavers followed to Daley Brook from Nebraska Bay lived the summer in several burrows before moving into an abandoned lodge for the winter.

Winter Behavior

Beavers overwintering on Kabetogama Lake usually abandoned their lodges, but remained in the vicinity and used their lodges infrequently (Fig. 14). Abandonment followed the retreat of water from the lodges, and by January some of the lodges were completely dry, and little used. The timing of lodge abandonment ranged from shortly after freeze-up to one month

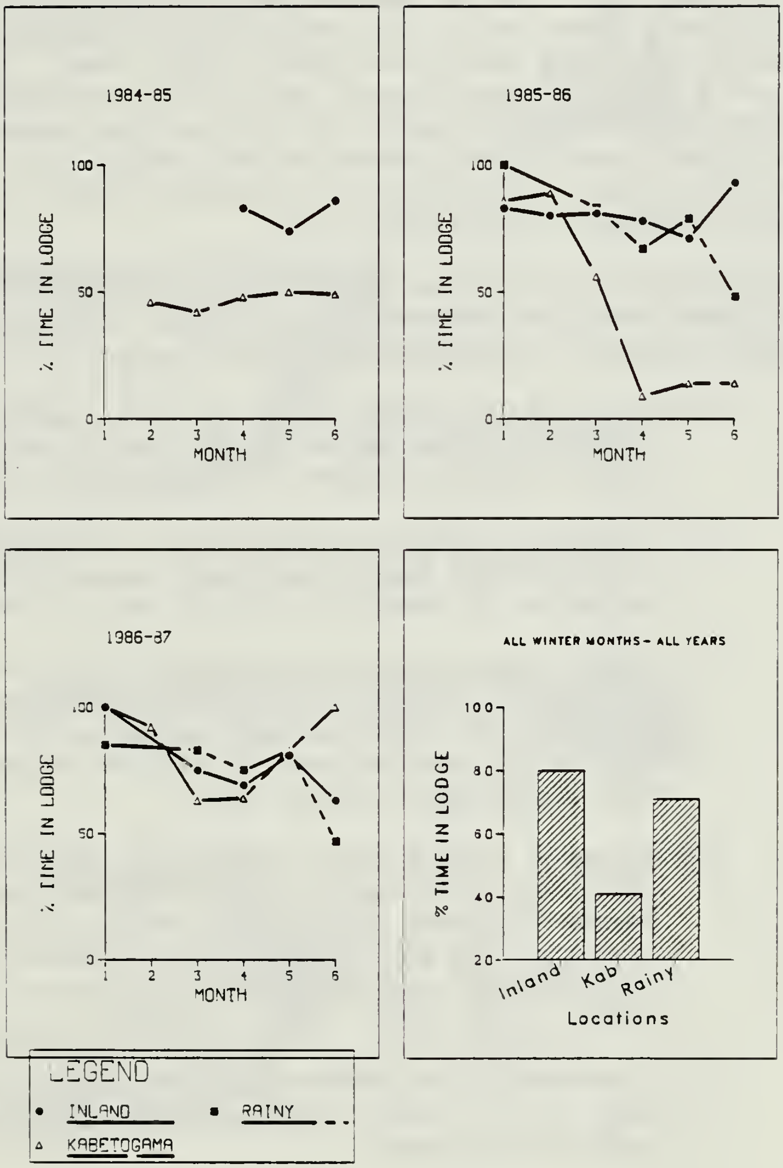

Figure 14. Locations of radio tagged beaver, Voyageurs National Park, winters 1984-85, 1985-86, 1986-87, and all winters combined (1=October, 2=November, 3=December, 4=January, 5=February, 6=March).

after freeze-up. Close examinations of 25 Kabetogama Lake lodges showed that lodge abandonment occurred in 88% of the cases during winter when the water was retreating. Overwinter abandonment did not occur on Rainy Lake (n=8), and only 23% (n=13) of inland lodges showed signs of overwinter abandonment (all cases where abandonment did occur was associated with lowered water levels and heavy otter activity). Beavers that did abandon their lodges made extensive use of air spaces created by hanging ice (Fig. 15).

The pattern of beaver existence during the overwinter drawdown was similar between all lodges. Events characterizing lodge abandonment on Kabetogama Lake were as follows:

1) The lodge became dry. By late April beaver lodges were found 10-500 meters from water (n=26; mean= 131; std.dev.= 141.6).

2) The food cache became dry. Dewatering would often make the food cache inaccessible because of sagging ice on top of bottom mud.

3) Canal construction beneath ice. As movements became restricted because of ice conditions beavers dug tunnels or canals in bottom mud to allow access around the lodge area (Fig. 16).

4) Beavers would then construct wood chip nests, commonly, but not always around the food cache (Figure 17). Rocks often would support sagging ice and create air spaces underneath that the beavers would also utilize as overwintering sites (Fig. 15).

5) These wood chip nests, sometimes numbering as many as 9, would replace the lodge as their activity center.

A typical winter lodge situation is diagrammed in Fig. 18.

The number and extent of usage of these alternate shelters outside the lodge was variable. Some beavers would use only a few shelters all winter while others would continue to abandon and create more shelters as the winter progressed.

Beaver response appeared to be highly site dependent. For example, inland beavers were radio-located inside the lodge most of the time (80%), and were never found to make wood chip

Figure 15. In early winter ice formed on top of water with no airspace. By late winter withdrawing water left air spaces between early winter ice and late winter water levels. After abandoning their lodges, beavers made extensive use of these air spaces (drawing Kaya Route).

Figure 16. After beaver lodges had become dewatered and ice was laying on the lake bottom, beavers dug canals to gain access to their cache and lodge (photo D. W. Smith).

Figure 17. Instead of overwintering inside of the lodge, beavers on dewatered Kabetogama Lake would spend more time in wood chip nests constructed and located in air spaces beneath the ice (photo D. W. Smith).

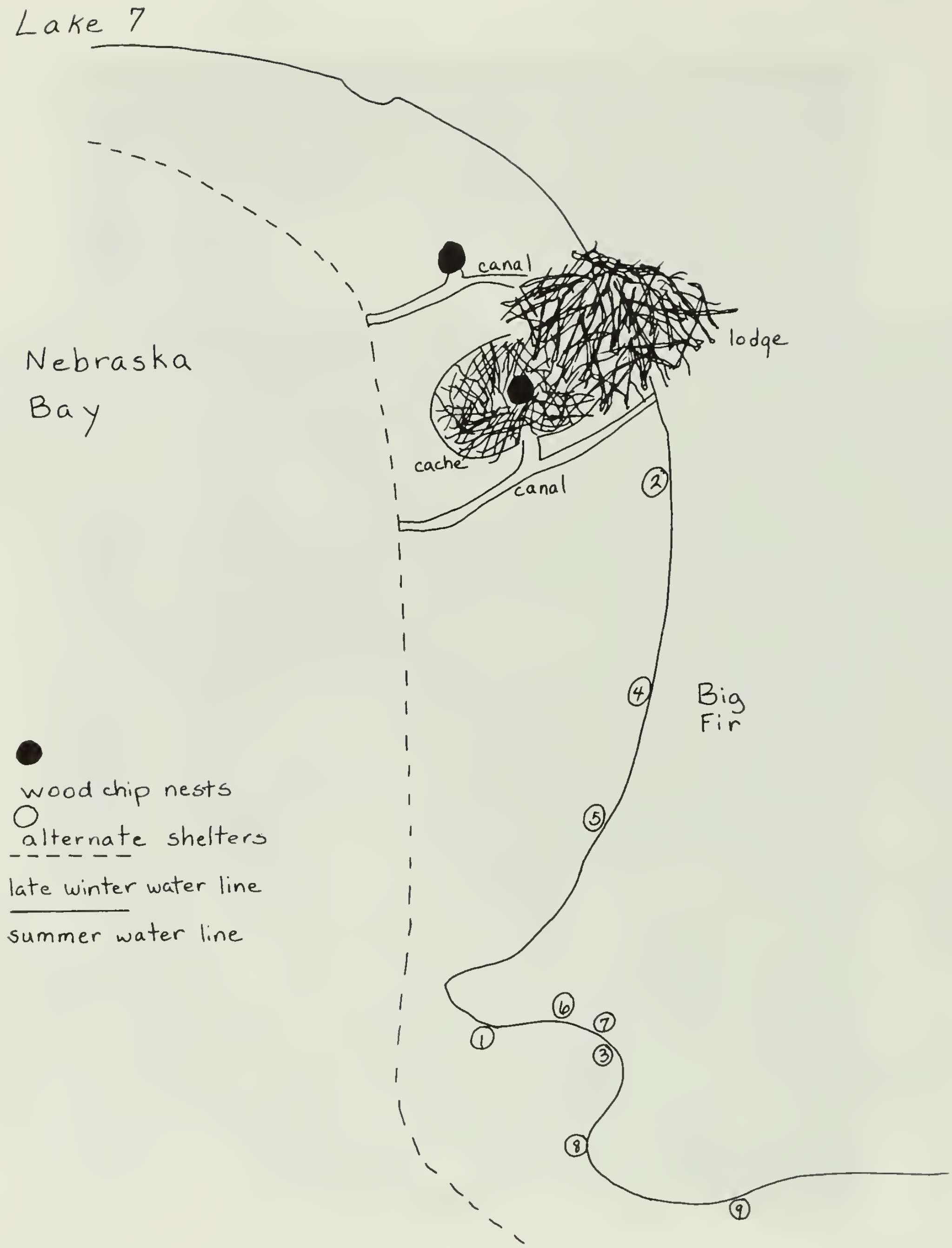

Figure 18. Diagrammatic representation of a typical beaver colony's (Lake 7) adjustment to declining water levels. Beaver dug canals and constructed wood chip nests near their cache, in addition to having a number of alternate shelters (numbered 1-9) that were used then abandoned as the water declined through winter (drawing Karen Keen).

nests. Radioed Kabetogama Lake beavers were located inside of their lodge 41% of the time, and constructed several wood chip nests (mean= 3.3; range= 1-9). Rainy Lake beavers were located inside their lodge 73% of the time, and only one wood chip nest was found. This, however, was during the winter of 1986-87 when Rainy Lake experienced a prolonged 1 m drawdown.

In addition to usage of sites around the lodge beneath the ice, some beavers would come above ice during winter to forage. The incidence of this was higher on Kabetogama Lake (six cases) than on either Rainy Lake or inland (one lodge each). In the one case on Rainy Lake the beavers were without a food cache.

As an example of a colony of beavers living on Kabetogama Lake, the Lake 6 colony used an alternate rock shelter 0.2 km from their lodge during October and November when water drawdowns began, but moved back to the vicinity of their lodge at freeze up. During the rest of the winter locations were not precise enough to determine the proportion of time spent outside of the lodge, but based on the evidence found in the spring (wood chip nests in the cache, and 7 sites known to be used during winter), beavers probably spent most of the winter outside their lodge.

Lake 7, another family of beavers living on Kabetogama, almost completely abandoned their lodge by January (located in the lodge 10% of the time), and had 9 alternate shelters. The lodge was located in western Nebraska Bay, a very shallow, sloping portion of the bay where the lodge was especially susceptible to dewatering.

Creek beavers on Kabetogama tributaries exhibited different behaviors based on the location of the lodge in the creek. All beavers overwintering on Daley Brook moved out of their lodges overwinter (located inside 20%), existing in alternate shelters. Another lodge on John's Creek (west Irwin bay) exhibited similar behavior. One beaver located in a lodge near the feeder creek into Bowman Bay was found only infrequently outside of the lodge (located inside 82%). The lodge was located in close proximity to the flowing part of the creek, preventing complete dewatering.

Two radio-implanted beavers (a kit and an adult) in Lake colony 23 behaved differently from other Kabetogama beavers. Most of the winter was spent inside of their lodge (83%). In the spring it was found that these beavers constructed a dam near their house during the winter to hold water around the house, thereby, creating a small pond similar to an inland situation. Lake 24, on Sphunge Island probably did something similar, but were not as successful as only a remnant portion of water was remaining in the spring, and the beavers were not located at the site.

PHYSICAL MEASUREMENTS

Beaver Sizes

Average adult beaver weight (greater than 10 kg) was 17.8 kg (n=156; range 10.5 kg- 26.5 kg). The average weight of kits (less than 10 kg) was 6.4 kg (n=131; range 3.5 -9.0 kg). Average adult zygomatic arch was 97.4mm (n=154; range 78mm-114mm); average kit zygomatic arch was 73.4mm (n=131; range 61mm- 82mm). Tables 5 and 6 summarize these findings by location and year. Beaver physical measurements (weight, zygomatic arch, total length, tail length and width, and hindfoot length)(Appendix IV) were compared by analysis of variance by location (inland- stable water, moderate habitat; Kabetogama Lake-water drawdown, good habitat; west Rainy Lake-1 meter drawdown, good habitat; and east Rainy Lake-1 meter drawdown, poor habitat (see results under Habitat Measurements)); age, year, and then were nested and tested for an interaction between the variables lodge (location), location*age, location*year, age*year, lodge*age(location), lodge*year(location), location*age*year, lodge*age*year(location).

The initial analysis for fall captures only found year (p<0.0117) and location (p<0.0312; n=278) to be significant, so years were analyzed separately. No differences were found between adults in 1984 and 1985, but east Rainy adults in 1986 (mean=16.5 kg, n=19) were significantly lighter than inland (mean=19.4 kg, n=12) and west Rainy Lake animals (mean=19.7 kg, n=19), but not from Kabetogama Lake (mean=18.7 kg, n=14) adults (p<0.0389 n=64) (Tukey's Multiple Range Test). Weights of Kabetogama Lake adults did not differ significantly from inland or west Rainy Lake beavers. Although east Rainy Lake adult beavers had the smallest zygomatic breadth measurement (n=94.8mm; mean value for all locations=97.4mm) this difference was not significantly different from other locations (Table 5).

Inland kits (mean=7.2 kg, n=44) were heavier than kits from all other locations (p<0.0014 n=127). Kabetogama Lake (mean= 6.3 kg, n=31) and west Rainy Lake (mean= 6.3 kg, n=36) kits were not significantly different from each other, but were significantly heavier than east Rainy Lake kits (mean=5.3 kg, n=16). Kit zygomatic arch measurements varied by lodge within location (P<0.0001), but did not differ by location.

Table 5. Average measurements by location of adult beavers caught in Voyageurs National Park, fall 1984-86. Standard deviation in parenthesis after mean, and sample size in parenthesis below mean.

YEAR PARAMETER	INLAND	KABETOGAMA	NAMAKAN	WEST RAINY	EAST RAINY
			ADULTS LOCATION		
1984					
WEIGHT(kg)	19.0(3.5) (25)	15.8(2.1) (8)	15.3(3.3) (10)	-	-
TOTLGTH(mm)	1088(68.0) (25)	1023(87.5) (8)	976(58.4) (10)	-	-
ZYG.(mm)	99(6.2) (24)	93(4.9) (8)	92(5.6) (10)	-	-
TAILLGTH(mm)	298(23.2) (24)	282(21.0) (8)	270(14.4) (10)	-	-
TAILWDTH(mm)	131(14.7) (24)	116(5.6) (8)	106(6.7) (10)	-	-
HIND FT.(mm)	181(8.7) (24)	175(7.9) (8)	171(6.5) (10	-	-
1985					
WEIGHT(kg)	18.1(3.7) (15)	16.9(4.2) (22)	19.7(3.6) (3)	17.8(2.8) (9)	15.1(2.4) (9)
TOTLGTH(mm)	1080(93.4) (15)	1030(97.2) (22)	1105(125.6) (3)	1046(44.3) (7)	968(35.7) (8)
ZYG.(mm)	98(7.5) (15)	97(7.9) (22)	99(7.5) (3)	97(9.2) (8)	94(3.4) (9)
TAILLGTH(mm)	289(24.1) (15)	270(27.9) (22)	315(31.2) (3)	275(30.2) (8)	266(20.2) (8)
TAILWDTH(mm)	130(14.2) (15)	120(18.3) (22)	132(20.7) (3)	132(12.7) (8)	122(13.8) (8)
HIND FT.(mm)	183(8.6) (15)	174(11.0) (22)	188(6.8) (3)	177(9.4) (9)	164(13.8) (8)
1986					
WEIGHT(kg)	19.4(3.5) (12)	18.7(3.6) (14)	-	19.7(4.3) (19)	16.5(3.8) (19)
TOTLGTH(mm)	1077(74.2) (12)	1072(57.1) (14)	-	1072(75.1) (19)	1009(68.6) (19)
ZYG.(mm)	100(7.9) (12)	101(6.7) (14)	-	100(7.6) (19)	95(7.1) (19)
TAILLGTH(mm)	286(15.6) (12)	286(16.1) (13)	-	289(27.1) (19)	269(20.8) (19)
TAILWDTH(mm)	138(12.5) (12)	129(15.2) (14)	-	140(15.6) (18)	127(11.6) (19)
HIND FT.(mm)	186(7.9) (14)	183(10.9) (14)	- -	178(11.3) (19)	174(11.8) (19)

Table 6. Average measurements by location of kit beavers caught in Voyageurs National Park, fall 1984-86. Standard deviation in parenthesis after mean, sample size in parenthesis below mean.

YEAR PARAMETER	KITS LOCATION INLAND	KABETOGAMA	NAMAKAN	WEST RAINY	EAST RAINY
1984					
WEIGHT(kg)	7.4(1.3)	6.4(0.7)	5.4(0.5)	-	-
	(16)	(5)	(6)		
TOTLGTH(mm)	774(78.0)	744(31.0)	740(50.0)	-	-
	(16)	(5)	(6)		
ZYG.(mm)	74(3.6)	73(1.7)	72(1.9)	-	-
	(16)	(5)	(6)		
TAILLGTH(mm)	214(10.8)	203(6.1)	211(5.9)	-	-
	(15)	(5)	(6)		
TAILWDTH(mm)	89(9.9)	75(1.3)	70(3.9)	-	-
	(15)	(5)	(6)		
HIND FT.(mm)	145(9.1)	137(7.0)	134(3.6)	-	-
	(16)	(5)	(6)		
1985					
WEIGHT(kg)	7.6(0.9)	5.6(0.8)	6.2(-)	7.7(0.9)	5.3(0.5)
	(11)	(13)	(1)	(3)	(2)
TOTLGTH(mm)	804(33.7)	727(45.9)	765(-)	805(44.4)	694(8.5)
	(11)	(13)	(1)	(3)	(2)
ZYG.(mm)	77(3.1)	71(2.8)	75(-)	78(0.6)	72(2.1)
	(11)	(13)	(1)	(3)	(2)
TAILLGTH(mm)	210(10.7)	195(9.8)	210(-)	222(17.6)	207(9.2)
	(11)	(13)	(1)	(3)	(2)
TAILWDTH(mm)	88(11.3)	73(5.9)	71(-)	86(4.6)	68(2.1)
	(11)	(13)	(1)	(3)	(2)
HIND FT.(mm)	147(8.9)	134(9.7)	140(-)	147(7.7)	131(5.7)
	(11)	(13)	(1)	(3)	(2)
1986					
WEIGHT(kg)	6.7(1.2)	7.1(0.7)	-	6.1(0.8)	5.2(1.3)
	(17)	(13)		(33)	(11)
TOTLGTH(mm)	759(49.0)	794(37.0)	-	756(46.0)	681(69.0)
	(17)	(13)		(33)	(11)
ZYG.(mm)	74(4.7)	76(3.0)	-	73(2.9)	69(5.7)
	(17)	(13)		(33)	(11)
TAILLGTH(mm)	199(20.4)	209(12.1)	-	209(17.3)	188(26.5)
	(17)	(13)		(33)	(11)
TAILWDTH(mm)	76(8.2)	133(177)	-	75(7.7)	69(6.7)
	(17)	(13)		(33)	(11)
HIND FT.(mm)	140(8.5)	143(5.9)	-	139(13.0)	125(9.5)
	(17)	(12)		(33)	(11)

Simultaneous growth in weight and zygomatic breadth is illustrated in Fig. 19. The regression line represents the mean growth rate of all beavers in the park; values above the line represent larger-than-average beavers, and values below represent smaller beavers. Collectively these data suggest (Table 7) that east Rainy Lake had a preponderance of small animals while west Rainy Lake supported larger-than-average animals ($p<0.045$; n=165; Chi-Square).

Weight Gain

Twenty-seven beavers were captured during two consecutive falls (Fig. 12). Small sample sizes precluded statistical comparisons between locations, so the data were pooled. Average weight gain for kits was 7.4 kg. (n=12, std. dev.=1.2092), yearlings 3.8 kg. (n=8, std. dev.=1.4263), and adults 1.0 kg. (n=7, std. dev.=1.7417).

Overwinter Weight Changes

Kit beavers always gained weight during winter, but gained less overwinter on Kabetogama Lake (1.0 kg; n=5; std. dev.=0.3732) than they did on Rainy Lake (2.1 kg; n=6; std. dev.=0.5431) or inland (2.1 kg; n=6; std. dev.=1.7422) (Fig. 20). On average, kits increased their body weight by 28%, Kabetogama Lake kits had the lowest % body weight gain (Kabetogama Lake=17%; inland=30%; Rainy Lake=35%). Average adult weight loss inland was -0.7 kg (-4%; n=10; std. dev.=11.8303), and -1.8 kg (-9%; n=8; std. dev.=12.0112) on Kabetogama (only one adult beaver was captured fall-spring on Rainy lake) (Fig. 21)(Appendix V). These differences were not significant at the 0.05 level between locations for either age class.

Disease and Parasites

Two beaver ectoparasites were identified: Leptinillus validus (the beaver nest beetle), and Platypsyllus castoris (the beaver parasite beetle) (Parsons pers comm.).

HABITAT MEASUREMENTS

Cutting Activity

Average number of cut trees of all species at beaver lodges in the park was 84.5 (n=20; std. dev.=60.14), and aspen cut per lodge averaged 47.5 (n=20; std. dev.=35.92). Beavers cut a greater number of trees and aspen inland and on

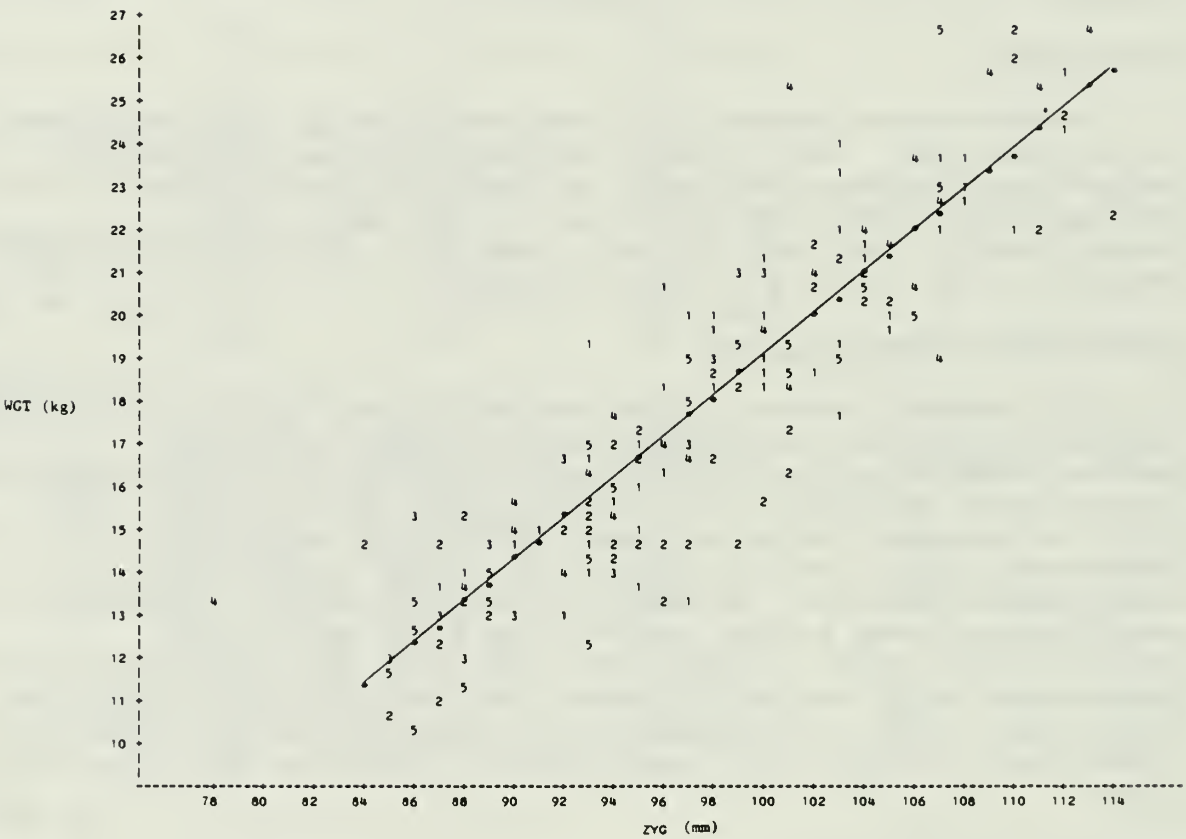

Figure 19. Relation between zygomatic arch and weight measurements of beavers in Voyageurs National Park. Solid line represents average. Numbers represent animals heavier or lighter than average, and identify location where beavers were captured (1=inland, 2=Kabetogama Lake, 3=Namakan Lake, 4=west Rainy Lake, 5=east Rainy Lake).

Table 7. Comparison of beaver size from 5 study sites with average size determined from relationship between weight and zygomatic arch measurements. Animals at the average were not counted.

	NUMBER OF BEAVERS BELOW AVG. SIZE	NUMBER OF BEAVERS ABOVE AVG. SIZE
INLAND	23	29
KAB.	24	20
NAMAKAN	4	9
W.RAINY	8	20
E.RAINY	18	10

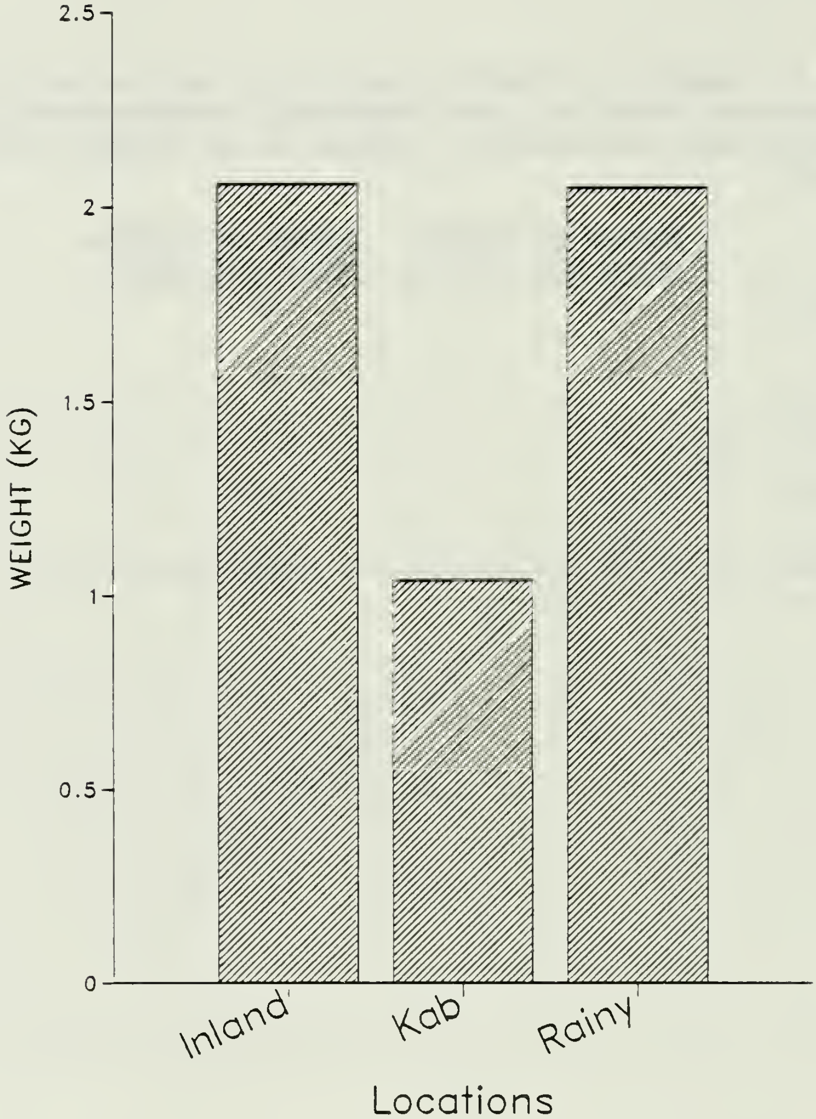

Figure 20. Mean overwinter weight gain of beaver kits in inland ponds (n=6), Kabetogama Lake (n=5), and west Rainy Lake (n=6), Voyageurs National Park.

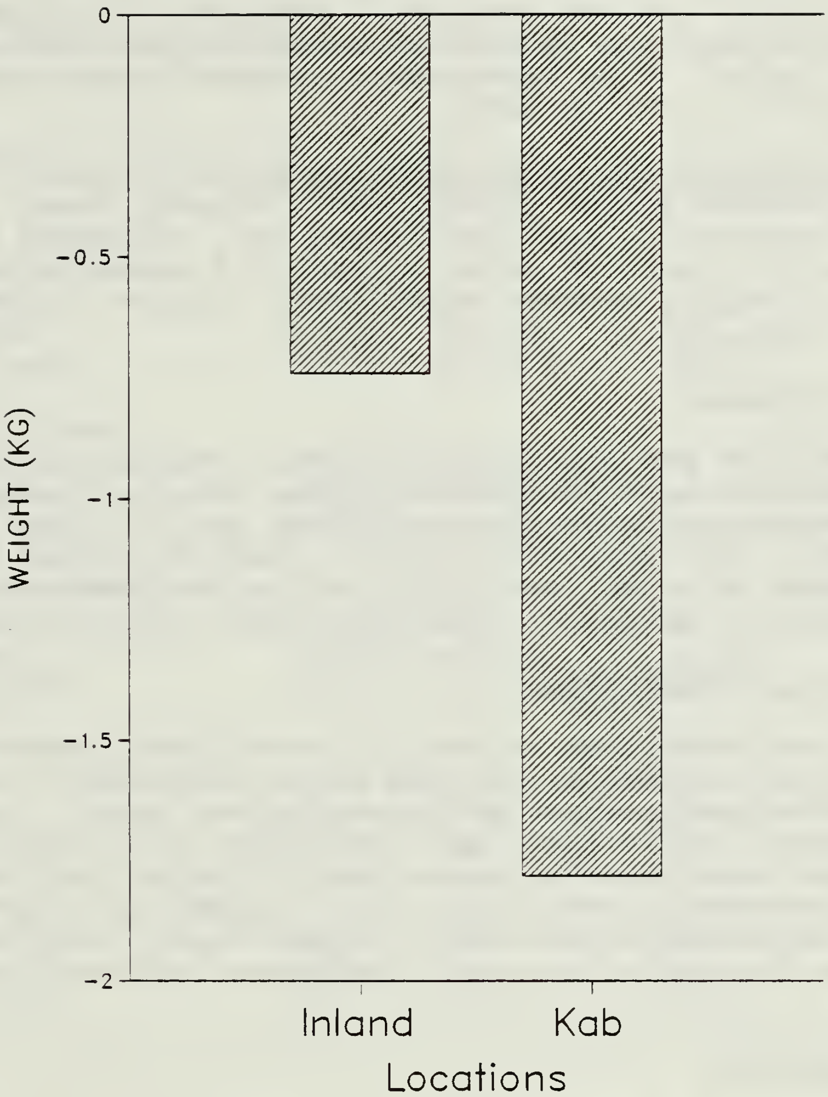

Figure 21. Mean overwinter weight loss of adult beaver in inland ponds (n=10) and Kabetogama Lake (n=8), Voyageurs National Park.

Kabetogama ($p<0.05$) than on west Rainy, and east Rainy (Table 8). These results are not completely comparable, because data was gathered during the fall on west Rainy first, followed by east Rainy, inland, then Kabetogama, thereby underestimating cutting activity on Rainy Lake.

Distance travelled to an aspen on shore averaged 25.7 meters and did not differ significantly between areas, except for inland compared to east Rainy ($p<0.05$). Distances travelled in the water to a cutting site averaged 195 meters and did not differ significantly between areas (n=19, range= 43-350)(Table 8).

Vegetation Analysis

Tree species availability and forest composition in areas of beaver cutting were determined by the point center quarter method. Average aspen density per lodge was 678.7/ha (range=0-3658, std. dev.=493.3, n=66). West Rainy had the densest stands of aspen ($p<0.0001$), while the other areas were not significantly different from each other (Table 8).

Aerial Photo Interpretation

Total deciduous tree volume (in cubic feet), and % deciduous cover as determined from aerial photograph interpretation was greatest at inland lodges (mean volume/acre=2404 cubic feet, mean deciduous cover=72%) followed by Kabetogama Lake (mean volume/acre=2234 cubic feet, mean deciduous cover=96%), west Rainy (mean volume/acre=2197 cubic feet, mean deciduous cover=75%), and east Rainy (mean volume/acre=1434 cubic feet, mean deciduous cover=42%) (Table 9).

Cache Utilization

The presence or absence of water overwinter had a significant effect on the utilization of the food cache (Fig. 22). Only 6% of the lodges with water all winter had part of their food cache remaining (n=18), while 78% of the lodges that did not have water overwinter had part of their cache left (n=9).

Water Measurements

By late September, Kabetogama Lake lodges had much less water (0.55 m; n=24) around their entrances than Rainy (0.95 m;

Table 8. Characteristics of vegetation associated with beaver lodges in Voyageurs National Park.

	Inland	Kabetogama	W.Rainy	E.Rainy
Number of lodges	4	4	5	5
Aspen density/ha				
mean	425	468	1106	420
range	0-1239	157-897	128-3658	0-1217
std.dev.	353.1	257.7	910.6	375.2
Number cut trees				
mean	173	103	52	59
range	83-314	73-183	11-113	15-128
std.dev.	123.5	45.4	42.7	45.3
Number cut aspen				
mean	67	68	35	32
range	21-115	32-148	11-70	4-67
std.dev.	47.0	49.7	25.1	25.4
Land distance (m) to A*				
mean	12	23	28	34
range	5-24	5-34	19-36	24-56
std.dev.	10.1	11.0	6.4	12.7
Water distance to site#				
mean	102	178	221	232
range	50-130	70-340	43-330	130-350
std.dev.	44.8	110.3	101.6	78.9

m meters
* Aspen
# Water distance to cutting site

Table 9. Aerial photography habitat analysis at selected beaver lodges in Voyageurs National Park. Total deciduous tree volume available per lodge, deciduous tree volume per lodge acre, total acres deciduous cover, and percent lodge area deciduous cover.

LOCATION	DECID. TREE VOLUME- TOTAL CUBIC FT.	DECID. TREE VOLUME- CUBIC FT./ACRE	ACRES DECID. COVER	% DECID. COVER
INLAND				
I-5	16,733	2,490	6.7	100
I-6	16,558	2,199	7.5	18
I-7	81,347	2,395	34.0	71
Alder	67,768	2,530	26.8	97
KABETOGAMA				
Daley	14,122	2,620	5.4	85
L-7	28,195	2,406	11.5	100
Deer	8,713	1,289	6.8	100
Sphunge	36,339	2,620	13.9	100
W.RAINY				
Sweet	8,363	2,230	3.8	46
Alder Crk.	26,965	2,568	10.5	100
540	29,448	2,420	12.2	100
Narrows	12,933	2,360	5.5	100
Channel	1,320	2,491	0.5	5
Wild	13,675	1,110	12.3	100
E.RAINY				
Lyman	0	0	0	0
Rock	0	0	0	0
Snow	21,615	2,620	8.3	63
Idle	31,833	2,620	12.2	65
Anderson	16,502	1,930	8.6	80

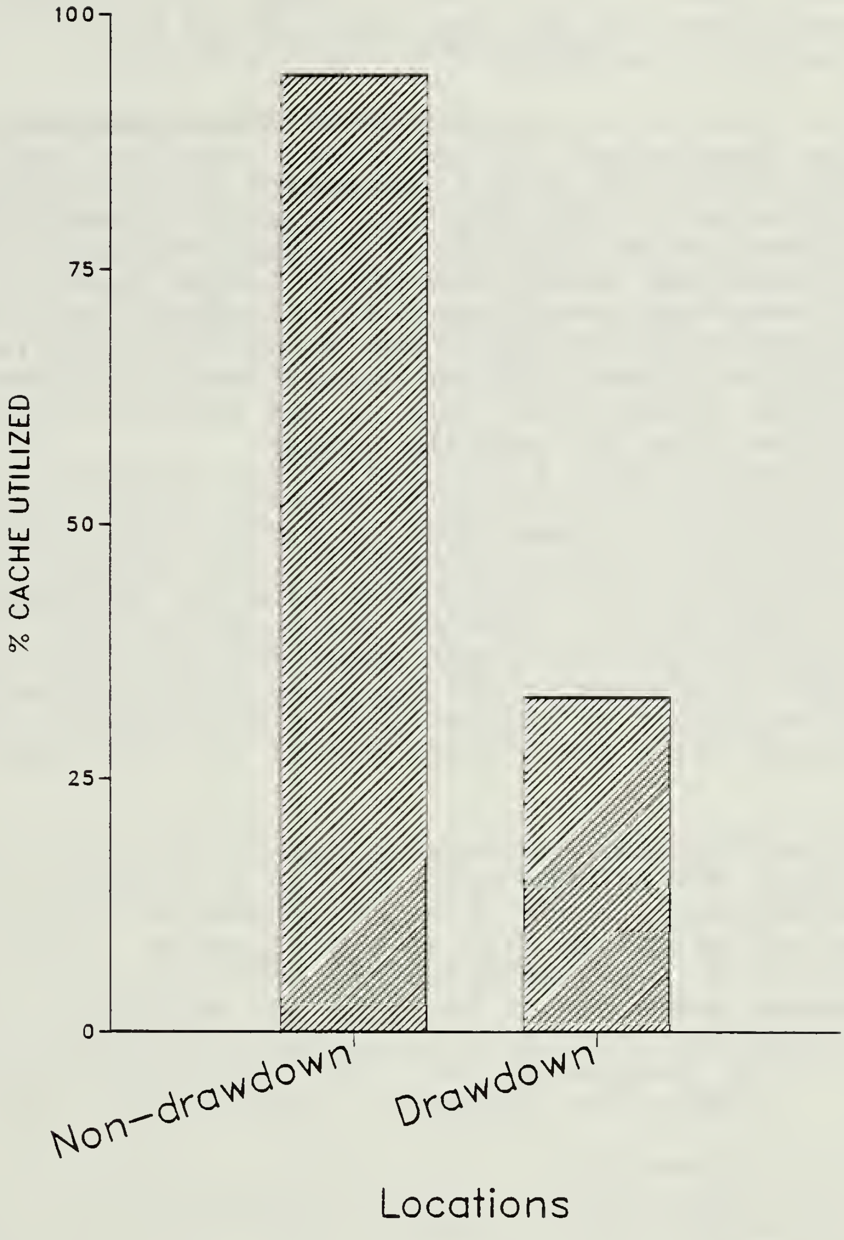

Figure 22. Percentage of beaver lodges where food cache was completely utilized. Rainy Lake and inland together represent non-drawdown; Kabetogama Lake represents drawdown.

n=28), and inland (1.09 m; n=21) lodges. Water depths around caches were approximately equal (Kab.=1.17 m n=48; Rainy=1.30 m n=37; inland=1.45 m n=35).

Total dewatering varied between Kabetogama lodges due to lodge site physiographic differences. Shallow lodges often had their food caches dry by mid- November, while water remained around others until early to late January. Most lodges, however, were dry by mid-winter (January-February). Mean water depth at this time around Kabetogama lodges was 1.77 mm (n=7), compared to 554 mm (n=5) around Rainy lodges, and 1138 mm (n=9) around inland lodges. Lodges were dry until water levels returned in the spring. In 1987 water levels did not return in the spring on either Rainy Lake or the Namakan Reservoir, and beaver lodges were dry into the summer.

DISCUSSION AND CONCLUSIONS

Historical Population Fluctuations

Reconstruction of historical beaver population trends in northern Minnesota is fairly accurate due to two major environmental disturbances, the fur trade and pine logging in the Lake States (Innis 1930; Swanholm 1978) which led to the virtual elimination of beaver in northern Minnesota. The present beaver population in northern Minnesota arose from a remnant population beginning in approximately 1900 (Stenlund 1985).

The fur industry (1630-1830) had a devastating continent wide effect on beaver numbers (Innis 1930; Sandoz 1964; Nute 1950; Lavender 1977). There is disagreement on whether it is possible to totally trap out beavers, but in any case beaver numbers throughout the Lake States area were extremely low until early into the twentieth century. In addition, almost immediately after the fur trade came the exploitation of the forests (Swanholm 1978; Stenlund 1985; Cole 1987). Then locally forest fires burned much of the country in Voyageurs and adjacent Ontario in the 1930's (Heinselman 1973; Stenlund 1985).

In many ways the forest alterations changed the forest to favor beaver population growth. The logging and fires converted much of Minnesota to seral aspen, ideal beaver food (Stenlund 1985). Examinations of 1940 aerial photos show only 40 beaver ponds present on the Kabetogama Peninsula (Broschart et al. 1987). Longtime residents of the area can remember seeing the first beaver ponds in the 1930's, and recall that their fathers rarely, if ever, trapped beavers prior to 1940 (L. Ovesen, A. Kielczewski, E. Nelson pers comm.).

The first beaver trapping season in Minnesota was not until 1939, but widespread poaching activity about ten years before signaled an increase in beaver numbers throughout the state (Stenlund 1985). Initially, the first beaver seasons were short (8-15 days), and had a limit (4-10 beavers). Then in 1954, season length increased (15-45 days), with various areas closed each year. Since 1977 seasons have become more liberal, staying open most of the year (October 27- April 30) with no limit. Recent management actions have curtailed the 1988 spring season (trapping closes February 28), but there is still no limit on the number of beavers that can be harvested.

Systematic sampling did not begin until 1958 when the

Minnesota Department of Natural Resources (MDNR) began flying aerial transects over large portions of the state . At first flights were sporadic, but in the last ten years they have been made on a regular basis. The Kabetogama Peninsula has for many years had the highest beaver densities of any area sampled by the state (MDNR unpublished data). Retired MDNR game warden Marvin Smith also verified high beaver population densities in the park during the 1960's and 70's. He indicated there was heavy trapping activity which resulted in the harvest of approximately 700-1000 beaver each year from the Kabetogama Peninsula. Fig. 9 summarizes beaver population trend in the park for the last 47 years.

Disease and Parasites

Two disease outbreaks have been recorded in the park beaver population during the last 35 years. In the early 1950's, a catastrophic outbreak of tuleramia swept the entire Great Lakes Region killing beaver in great numbers (Stenlund 1953; Lawrence et al. 1956). Thirty beaver were seen floating dead in one inland lake (Shoepack Lake) on the Kabetogama Peninsula (M. Smith, MDNR game warden pers. comm.). Another minor outbreak of tularemia occurred in late 1979, killing only small numbers of beavers (Schneeweis pers comm.).

Both of the two beaver ectoparasites identified, *Leptinillus validus* (the beaver nest beetle), and *Platypsyllus castoris* (the beaver parasite beetle) live on the skin, and feed on sloughing skin parts (Wood 1965).

Water Levels and Beaver Habitat

Allen (1982) summarized the important habitat factors for beavers. Food and water were identified as the most important habitat variables. Beavers need a stable, predictable water supply, and they need adequate aquatic and deciduous vegetation upon which to feed. When feeding beavers are considered choosy generalists (Jenkins and Busher 1979), and can subsist on a wide variety of foods. They will, however, grow larger, have more young, and attain higher densities on their preferred items (aspen, aquatics)(Hall 1960; Shelton 1966; Slough and Sadleir 1977; Hill 1982). Adequate water provides access to food, gives protection, and serves as a storage chamber for winter food (Slough 1978; Jenkins and Busher 1979).

Beavers either moved or perished, when these habitat conditions were not met. In the most extreme example, (reservoir filling and subsequent drawdown of up to 8 m) drought and flooding due to the construction of a hydroelectric dam caused beavers to leave their homesites and seek alternate dwelling places, but all apparently survived (Nault and Courcelles 1984). In Ohio, Henry and Bookhout (1970) found 2 of 8 beaver lodges were abandoned because of high and low water (flooded lodge and a nearly dry intermittent stream). Howard and Larson (1985) stated there is probably a relationship between water reliability and food availability. Few studies, however, document beaver mortality due to fluctuating water levels.

Our findings agree with this body of research. On Kabetogama Lake, where fluctuation is greatest, lodge abandonment in winter and relocation in spring was high because of dewatering, and in two cases because of spring flooding. Drawdown timing was crucial. Winter drawdowns prohibited access to stored food at a critical time of the year, causing beavers to leave their lodges. Since site relocation is not possible in winter, beavers were forced to subsist under poor conditions until the spring thaw. Nault and Courcelles (1984) stated that beavers adapted to water drawdowns, as long as the water was not frozen. After freeze up, trappers claimed that the beavers would not be able to adapt and would consequently die (Berkes 1983).

Winter Survival Strategies

Central to our study was an estimation of the costs incurred by beavers associated with the winter drawdown regime. Normal winter existence for beavers is largely confined to the lodge or its vicinity, with short trips to the food cache and longer periods of inactivity than in summer (Novakowski 1967; Aleksiuk and Cowan 1969b; Bovet and Oertli 1974; Potvin and Bovet 1975; Lancia et al. 1982). Aside from the food cache, aquatic vegetation and shoreline roots exposed underneath the ice (air spaces under the ice were called "sushinetz" by Semyonoff 1953) will provide beavers with winter foraging opportunities (Novakowski 1967; Northcott 1972; Howard and Larson 1985). Fat deposited in body reserves is also used by beavers in winter reducing the need to forage (Aleksiuk and Cowan 1969a).

Kabetogama Lake beavers were disrupted from this evolutionarily successful strategy. Dewatered shorelines with collapsed ice made winter food stores inaccessible, and allowed no foraging opportunities for aquatics and roots. This left Kabetogama Lake beavers with an insecure lodge and less food during the winter. Forced lodge abandonment prohibited close huddling behaviors (Coles 1967), and beavers resorted to wood chip nests which are much cooler than lodge environments (Coles

1967; Stephenson 1969). We believe these circumstances adversely affect beaver condition, as our data suggest greater adult weight loss and less weight gain of kits overwinter. Thus, excessive use of stored body fat and above-ice winter foraging are common survival strategies of Kabetogama Lake beaver.

Winter foraging has other costs. Vulnerability to predators while on land and in deep snow is high. Also, making trails, hauling sticks, and maintaining body heat outside of the lodge pose significant energetic costs.

The largest cost to beavers, however, is in the spring when they lose their protective ice cover, causing them to leave their winter homesites in search of other homesites. Our data and other wolf food habits studies from Voyageurs (Fisher 1975; Hardwig 1978) suggest high wolf predation on beavers at this time. Based on radiotracking this mortality may be as high as 25% of the population.

Payne (1984) suggests that beaver populations will stabilize or increase slightly at a 20-25% harvest level. Thus, it is unlikely that winter-spring beaver mortality exceeds 25% because the population is still increasing on the drawdown lakes. Payne (1984) also reported increased annual mortality after juveniles left the protection of the parent colony (a mortality rate from 0.04 to 0.40). His study was in Newfoundland where beaver predators were rare. With increased movements caused by water drawdowns, and with the presence of wolves, Kabetogama beavers were at an even greater risk of mortality.

Nault and Courcelles (1984) studied beavers under almost identical reservoir conditions in Quebec (summer high water-winter drawdown). They documented similar winter movements of beavers and found canals, wood chip nests, and above ice foraging. Their conclusions concur with ours that water drawdowns alone were not enough to increase beaver mortality, but increased mortality occurs as a result of greater exposure to predators (wolf and lynx).

Water Regulation Effects on Population Dynamics

When the dams on the lakes were constructed (1909 and 1914) the beaver population in northern Minnesota was low (Stenlund 1985). Since that time the beaver population in the area has increased steadily (Fig. 9) to its present very high level. It is presently the most dense in the state of Minnesota (0.9 ldgs/km2) (MDNR), and one of the most dense reported in North America (Jenkins and Busher 1979). Beaver lodge abundance was greatest along Kabetogama Lake shorelines, and the rate of population increase there was higher than on Rainy Lake. Thus, despite the water drawdowns, beavers have been able to increase in numbers, and will probably continue to do so in the park until aspen along the shoreline is depleted. Beaver mortality due to water drawdowns does occur (starvation, predation), but it is presently not sufficient to prevent population increases.

Differences in family sizes between lakes do suggest an environmental influence. Svendsen (1980) found a significant difference between family size in years and suggested that this was due to some unknown environmental influence. Beaver families were smaller on Kabetogama Lake and on east Rainy Lake. This also suggests an environmental influence, for these were the two areas of poorest habitat conditions (i.e. Kabetogama Lakefluctuating water levels; East Rainy Lake- poor food quality).

Additionally, there were differences in reproduction and lodge structure. Inland beavers always had kits, and had more 2-year-old beavers present with adults than any of the other areas sampled. This suggests greater colony stability, and a saturated population-colonies with 2-year-olds which have delayed dispersal (Novakowski 1967; Nordstrom 1972), or better survival to 2 years. Kabetogama Lake had more groups without kits (37%) than inland (0%) or west Rainy (25%)(east Rainy Lake had 40% without kits and this is probably due to poor habitat), and more 2-year-old size class beavers present in colonies with no adults present. This suggests instability and could represent a failure to reproduce because of water drawdown interference with normal reproductive behavior in February. Another explanation is that 2-year-olds are dispersing to Kabetogama Lake from inland and these pairs have not yet had an opportunity to breed. If this is true, then why is the same not true for west Rainy Lake where 75% of the trapped colonies were families with kits? Possibly, smaller lodges on Kabetogama Lake exist because frequent family movements expose groups to environmental vagaries, leading to mortality or group fragmentation. Finally, it should be pointed out that ages were provisional, based on estimated weight groupings, and size differences could be due to several factors (i.e. food).

Regardless of the age differences, kit production was lowest on Kabetogama Lake and east Rainy. Lower kit production on east Rainy was probably due to poor habitat, but this was not the case on Kabetogama Lake where food resources were considered excellent. When only the beaver lodges on

Kabetogama Lake that reproduced were examined, the number of young produced per lodge was comparable with the other lakes (3.4 kits/lodge). Thus, the lack of kits in lodges on Kabetogama Lake represents failure to breed, either because of young dispersing beaver settling on Kabetogama Lake, or disruption of normal breeding behavior by water drawdown.

We cannot reject either hypothesis based on our data, and more study would be required to answer this question. However, we support the breeding disruption hypothesis because west Rainy Lake is also excellent habitat, and the same immigration and reproduction should be occurring in this area as on Kabetogama Lake.

In support of this hypothesis, Courcelles (pers comm.) indicates that winter drawdowns may reduce female reproductive success by increasing energy expenditures through winter. Energy requirements for daily activities would be greater, diminishing breeding fitness.

Forest Community Affects

The lodge abandonment and subsequent relocation of beaver families has other significant ramifications. Water level fluctuations constantly dewater and re-flood beaver lodge sites creating a situation of frequent lodge abandonment and re-occupation. This reduces site fidelity on Kabetogama Lake and in these areas there are almost twice as many beaver lodges (this figure indicates both active and inactive houses) than on Rainy Lake. Many are inactive, but the movements of beavers, and the need for alternate sites of habitation on Kabetogama Lake are much greater. Beavers in many cases have been followed to inactive lodges that were already present, and in one case observed building a new lodge at the new, lower water line.

At the community level, the lack of beaver site fidelity because of water drawdowns may lengthen the lifespan of aspen stands near the lakeshore. Frequent beaver movements reduces browsing pressure on the vegetation around the lodge, thereby extending the potential period of site utilization by future beaver populations. Some lodge sites on Kabetogama Lake (Nebraska Bay, Daley Brook) still have aspen within one meter of the water, and in some places shoreline aspen is abundant. An example of this is colony site Lake 7 in Nebraska Bay (Fig. 18). Four families in four years occupied this lodge. Aspen supplies were excellent and in each case beavers cut aspen extensively. Each family, however, moved after winter leaving much aspen unharvested. Subsequently settling beavers would exert differential browsing pressure, either because of fewer family members, or cutting activities were centered in different shoreline areas because of a variety of areas from which to choose.

In contrast, monitored inland beaver colonies were also cutting aspen heavily on an annual basis, but in the same aspen stand year after year, and in some cases aspen supplies were beginning to show signs of depletion (I-4, I-6). Although no systematic sampling was conducted deep inland on the Kabetogama Peninsula, subjective examinations reveal that a similar situation exists. Aspen and other deciduous trees are severely depleted. We think this is from constant and long term usage at inland sites.

Brenner (1967) states that the size of a beaver colonies feeding range is a function of the interaction between the availability of food and water in relation to colony size. Kabetogama Lake, and very likely Rainy Lake, is an example of this phenomena. Beavers on Kabetogama Lake move from a lodge site before it becomes depleted of food, and only gradually after many successive occupations will shoreline aspen be reduced. Although Rainy Lake does not experience severe annual fluctuations like Kabetogama Lake, it will sporadically experience water fluctuations (as in spring 1987 where water levels were down by 1 meter) that could regulate beaver browsing pressure on shoreline forests.

MANAGEMENT RECOMMENDATIONS

Water drawdown timing is the critical concern for managing water levels to reduce impacts on beavers. Currently, high water levels are maintained throughout the summer with drawdowns beginning in late September. This has proved to be detrimental because placement of food caches begins in September and water level fluctuations after this time interfere with procurement of food from the winter cache. Beavers would benefit from a water fluctuation more similar to a natural regime: water gradually declining over the summer and reaching a more stable level by mid-September. Winter drawdowns should be minimized, which would provide sufficient access to winter food. With less of a drawdown, beavers would live inside their lodges through winter, remaining in better condition, and in the spring lodge relocations and subsequent predation would be lessened. The beaver population on Namakan Reservoir would likely increase faster and show greater site fidelity.

Annual water level fluctuations should average 1.5 meters or less. Overwinter drawdowns should not exceed 0.7 meters with a 0.5 meter upper limit preferable (Figure 23). In our study, water depths measured at lodge entrances in fall averaged about 1 meter. Since beavers need water in their lodge entrances all winter, a lowering of the water level by 0.5 meters would allow continued lodge use in most cases. It should be pointed out that high summer water levels may cause some beaver settlement in marginal areas, so even slight drawdowns will disturb these lodges. Thus, 0.7 m should be considered an upper limit since anything over this can cause disruption of normal winter existence. Food cache depth would be adequate, as winter food is normally stored in deeper water.

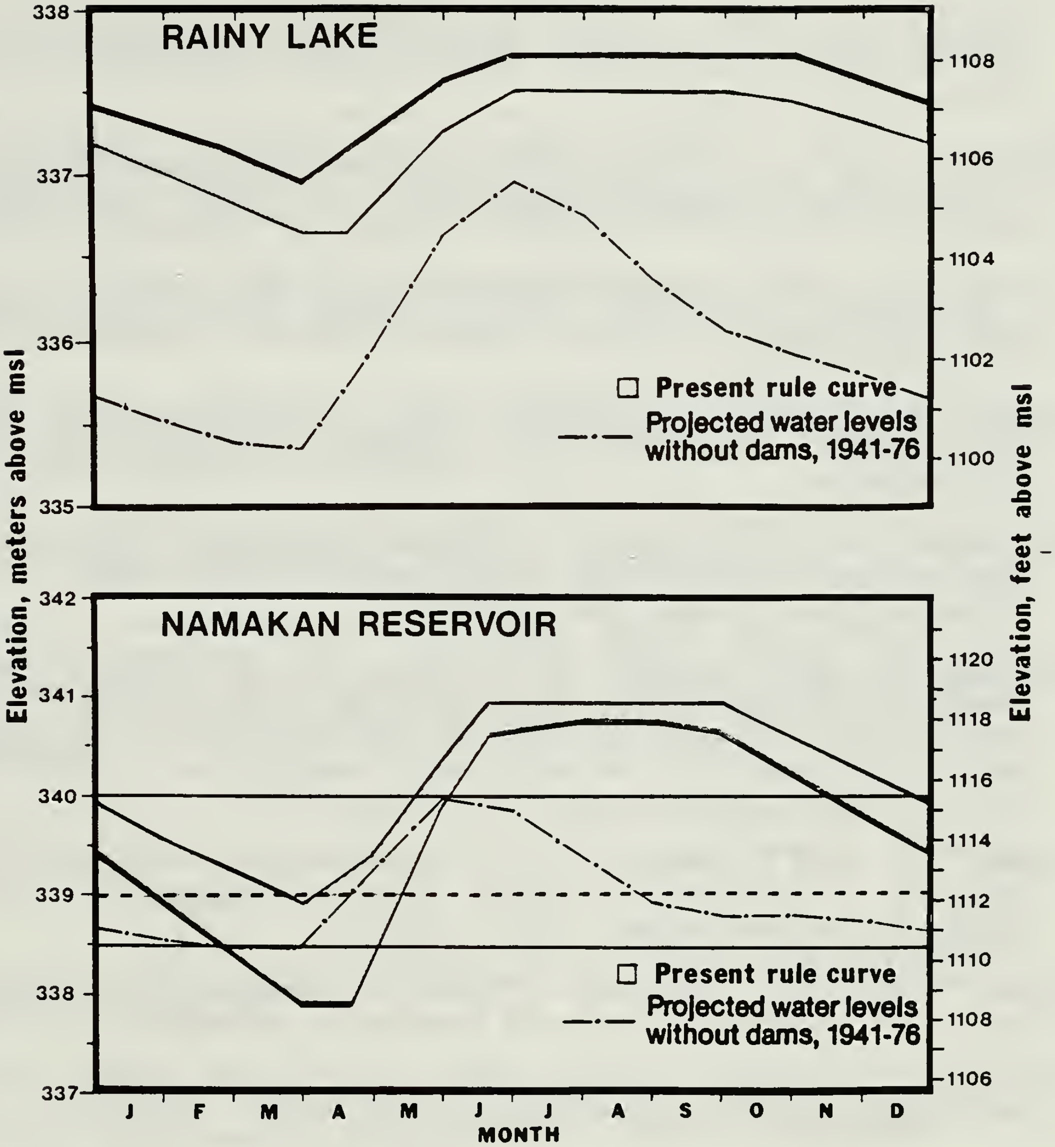

Figure 23. Recommended water fluctuations for Namakan Reservoir. Area between solid lines represents total recommended fluctuation, dashed line to lower solid line represents maximum recommended winter fluctuation.

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APPENDIX I

LIVE TRAPPING TECHNIQUES

All trapping was completed with Hancock live traps- which are ideal for capturing beavers unharmed (Fig. 6). Several different techniques can be used to capture beavers.

Once the jaws were separated and locked into the safe position, we would place the trap in the water, and secure the unsubmerged portion with a string to a stake driven into the ground. We then placed grass along the sides of the trap to focus the beaver's attention on the middle of the trap, thereby, ensuring proper positioning of the animal in the trap for capture. The grass was not used as disguise material. Freshly feathered aspen twigs were placed in the middle of the trap as bait. By placing one foot on the submerged portion of the trap, the trigger could be safely set without danger of accidental misfire.

Initially each lodge was trapped using sets baited with aspen, apple, or both. Later in the study we found aspen alone to be as effective as in combination with apples, but apples were not as effective as aspen alone. We were able to catch most of the beavers from a lodge with these baited sets.

Frequently, however, this method did not always capture all of the beavers in the lodge. Blind sets, similar in principal to the leg hold trap set, were then employed. The Hancock trap was placed in a position of beaver travel, and disguised, leaving the trigger set. Often these were set partly in water, but dry land sets were also made.

These sets were most successful in the fall on lodges where beavers were depositing mud for lodge repairs. Trail sets on land were only marginally successful, and observations of the beavers using these trails were often necessary for trap placement.

Springtime trapping was the most difficult because beavers were not working on their lodges, and were not feeding in predictable places on shore. Castor scent was most effective at this time of year, as it was also effective in the fall. We found it best to use castor as a last resort, however, for while it will usually catch a wary beaver, its success is short lived, possibly because of a waning response (kits excluded, they could be repeatedly captured on castor). We did not experiment with keeping different sexed castor glands seperate, but mixed several glands together.

APPENDIX II

INLAND LODGE SUMMARY

		SIZE		KITS		
YEAR	LODGE	UNCORR	CORR	UNCORR	CORR	2YR
1984	I2	9	9	2	2	3
1984	I4	8	10	2	4	3
1985	I4	10	11	3	3	
1986	I4	5	8	4	4	
1984	I5	5	6	2	2	1
1985	I5	4	5	2	2	
1986	I5	4	6	2	2	
1984	I6	8	10	3	3	
1985	I6	9	9	3	3	1
1986	I6	7	8	2	2	
1984	I7	9	10	7	7	
1985	I7	8	9	3	3	
1986	I7	4	6	4	4	
1986	I8	10	10	5	5	
TOTAL-	14	100	117	44	46	8
MEAN-		7.1	8.4	3.14	3.29	

APPENDIX II

KABETOGAMA LODGE SUMMARY

		SIZE		KITS		
YEAR	LODGE	UNCORR	CORR	UNCORR	CORR	2YR
1984	L6	4	4	2	2	2
1984	L7	5	6	3	3	2
1985	L7	8	9	5	5	
1986	L7	2	2	-	-	2
1984	L8	2	2	-	-	1
1985	L8	3	3	-	-	2
1985	L12	8	8	3	3	
1985	L13	3	4	2	2	
1985	L14	3	3	-	-	
1985	L15	6	7	3	3	
1985	L21	2	2	-	-	
1985	L29	8	8	6	6	
1986	L22	5	6	4	4	1
1986	L23	7	7	2	2	
1986	L24	9	9	4	4	
1986	L26	2	2	-	-	2
TOTAL-	16	77	83	34	34	12
MEAN-		4.8	5.1	2.1	2.1	

APPENDIX II

WEST RAINY LODGE SUMMARY

		SIZE		KITS		
YEAR	LODGE	UNCORR	CORR	UNCORR	CORR	2YR
1985	R6	3	3	0	0	-
1985	R7	2	2	0	0	-
1986	R7	4	5	3	3	-
1986	R8	9	9	6	6	1
1986	R9	10	10	6	6	-
1986	R17	7	7	5	5	-
1986	R18	6	6	4	4	-
1986	R19	10	11	5	6	-
TOTAL-	8	51	53	29	30	1
MEAN-		6.4	6.6	3.6	3.8	

APPENDIX II

EAST RAINY LODGE SUMMARY

		SIZE		KITS		
YEAR	LODGE	UNCORR	CORR	UNCORR	CORR	2YR
1985	R1	5	5	0	0	-
1986	R1	8	8	3	3	-
1985	R2	4	5	3	3	-
1985	R3	4	4	2	4	-
1986	R11	6	7	0	0	1
1985	R4	1	1	0	0	-
1986	R12	1	1	0	0	1
1986	R13	4	4	1	1	2
1986	R14	4	4	2	2	2
1986	R15	7	7	3	3	-
TOTAL-	10	44	46	14	16	6
MEAN-		4.4	4.6	1.4	1.6	

APPENDIX III

SEXING

All beavers were sexed by external or internal palpation for the os penis or baculum (Osborn 1955). The beaver was restrained inside the burlap sac and turned so the tail could be maneuvered outside of the bag. Then holding the beaver between the handler's legs the tail was lifted, exposing the cloaca. After, wetting the index finger, it was then placed into the cloaca to feel for the baculum.

Later in the study we found better success with external palpation. A gentle grabbing action through the fur two to three inches anterior to the cloaca, would usually discern the presence or absence of the baculum.

APPENDIX IV

CAPTURE INFORMATION FOR EACH BEAVER HANDLED, 1984-87

#= number.

Tag= Tag number.

Date= Day-Month-Year.

Location= 1=inland; 2=Kabetogama Lake; 3=Namakan Lake; 4=West Rainy Lake; 5=East Rainy Lake.

Weight (kg).

Total length (mm).

Ear length (mm).

Hind foot length (mm).

Zygomatic breadth (mm).

Tail length (mm).

Tail width (mm).

Sex M=male; F=female.

Recapture= 1= yes, same year; 2=yes, not same year; 3= no.

APPENDIX IV

#	TAG	DATE	LOC	WGT	LGTH	EAR	HF	ZYG	TLL	TLW	SEX	RC
1	MLA101	09 SEP 84	1	13.00	940	22	175	92	259	109	M	3
2	MRA102	09 SEP 84	1	18.25	1079	20	190	96	329	138	F	3
3	PL826P	13 SEP 84	1	21.89	1114	28	170	107	294	148	F	3
4	PR0760	14 SEP 84	3	14.75	950	26	165	89	280	105	F	3
5	PR827P	14 SEP 84	3	12.15	939	29	173	88	259	95	F	1
6	PL251Y	14 SEP 84	1	7.65	794	24	148	75	199	80	F	3
7	DEAD	14 SEP 84	1	21.45	1155	30	190	104	295	145	F	3
8	PL702W	15 SEP 84	1	14.85	1000	27	177	95	280	125	F	3
9	PL703W	15 SEP 84	3	5.60	763	22	140	75	213	69	U	1
10	PR0770	15 SEP 84	3	5.60	696	25	132	70	201	67	U	1
11	PL525Y	15 SEP 84	3	6.10	804	20	132	73	214	72	U	1
12	PR253Y	16 SEP 84	3	13.10	959	24	162	90	246	105	M	3
13	PR404R	16 SEP 84	1	21.85	1191	25	173	110	301	140	F	3
14	PL405R	17 SEP 84	3	4.80	670	19	132	71	212	65	M	1
15	PL0780	17 SEP 84	1	22.10	1145	28	192	103	270	105	F	3
16	PL704W	17 SEP 84	3	20.85	1042	26	175	100	282	112	M	3
17	PR705W	18 SEP 84	3	5.35	768	21	135	72	218	76	F	1
18	PL254Y	19 SEP 84	3	12.10	935	20	171	85	265	109	F	3
19	PR828P	19 SEP 84	1	16.85	1029	23	190	95	294	122	F	3
20	PR255Y	19 SEP 84	1	19.35	1106	27	172	103	296	122	F	3
21	PR829P	19 SEP 84	3	15.35	994	24	176	86	264	104	F	3
22	PR406R	20 SEP 84	3	16.85	1049	24	171	97	294	110	F	1
23	PL830P	20 SEP 84	3	12.85	885	27	161	87	260	105	F	3
24	PR706W	21 SEP 84	1	6.85	817	23	152	76	217	85	F	3
25	PR256Y	21 SEP 84	3	13.85	944	22	172	94	264	95	F	3
26	PR0790	22 SEP 84	3	4.95	738	21	130	70	208	70	F	1
27	PR257Y	23 SEP 84	3	21.10	1062	25	182	99	282	116	F	3
28	PR831P	10 OCT 84	1	20.00	1163	28	185	100	328	127	F	3
29	PR0800	10 OCT 84	1	19.75	1130	27	182	105	330	130	M	3
30	PL707W	11 OCT 84	1	23.40	1145	30	192	103	315	154	M	3
31	PL0810	12 OCT 84	1	6.85	804	25	139	70	224	85	U	1
32	PR708W	12 OCT 84	1	20.00	1110	27	186	100	315	134	M	3
33	PR0830	13 OCT 84	2	17.25	1015	26	175	95	265	110	F	1
34	PR832P	14 OCT 84	2	7.40	761	24	143	75	206	74	U	1
35	PL833P	16 OCT 84	1	4.47	661	22	130	70	201	76	U	1
36	PL259Y	16 OCT 84	1	6.40	781	23	145	79	221	85	U	3
37	PR260Y	16 OCT 84	2	14.50	1035	31	173	95	270	113	F	3
38	PL408R	17 OCT 84	1	4.78	730	25	128	67	220	74	U	1
39	PR834P	17 OCT 84	2	15.50	1062	30	175	93	292	122	M	1
40	PR409R	17 OCT 84	2	14.45	1043	32	167	94	279	111	F	1
41	PL0840	18 OCT 84	2	6.35	715	23	140	75	195	74	U	1
42	PR410R	18 OCT 84	2	6.75	708	25	138	73	198	75	U	1
43	PR262Y	18 OCT 84	1	13.25	1005	27	175	97	290	118	F	3
44	PL411R	19 OCT 84	1	19.05	1162	32	192	100	327	123	F	3
45	PR835P	19 OCT 84	1	20.05	1045	31	185	98	334	138	F	3
46	PL712W	20 OCT 84	2	5.85	779	24	125	73	204	77	U	1
47	DEAD	11 OCT 84	1	24.30	1200	.	.	.	.	.	F	3
48	PL0850	22 OCT 84	1	23.60	1083	29	183	107	333	141	M	3
49	PL713W	22 OCT 84	2	5.55	755	21	140	71	210	76	U	3
50	PL264Y	25 OCT 84	2	16.80	843	30	179	95	263	116	M	3
51	MRA196	27 OCT 84	2	14.50	1005	32	173	84	265	115	M	3
52	MRA194	28 OCT 84	1	19.25	1110	27	182	93	310	133	M	3
53	MRA177	28 OCT 84	1	7.20	843	21	145	75	218	93	U	3
54	MRA103	28 OCT 84	1	20.00	1124	27	165	97	284	128	F	3
55	MRA195	28 OCT 84	1	8.10	771	26	151	76	221	92	U	3
56	MRA127	28 OCT 84	1	18.25	1022	27	184	98	282	136	M	3
57	MRA128	28 OCT 84	1	8.60	787	23	152	78	217	112	U	3
58	MRA176	29 OCT 84	1	7.15	793	23	137	76	213	88	F	1

59	MRL178	29 OCT 84	1	13.90	1039	27	168	93	259	111	U	3
60	MLA179	29 OCT 84	1	14.15	1017	26	175	88	282	125	M	3
61	MLA180	29 OCT 84	1	7.65	807	25	151	71	232	95	M	3
62	MLA181	29 OCT 84	1	7.70	765	23	147	72	205	90	M	3
63	MLA184	29 OCT 84	1	8.95	832	24	156	79	222	105	F	3
64	MLA185	30 OCT 84	2	13.40	1024	27	167	88	294	112	F	3
65	MLA192	30 OCT 84	2	20.00	1160	22	192	100	324	126	F	3
66	MLA186	30 OCT 84	1	8.10	812	23	135	78	202	89	F	3
67	MLA187	30 OCT 84	1	13.60	1005	28	170	87	285	119	F	3
68	MLA188	30 OCT 84	1	8.60	535	24	147	75	195	91	M	3
69	MLA189	30 OCT 84	1	8.85	845	25	160	71	.	.	F	3
70	MLA190	30 OCT 84	1	22.60	1090	33	193	108	280	169	M	3
71	MRA148	19 MAY 85	1	20.25	1180	.	197	102	330	140	F	3
72	MLA149	20 MAY 85	2	16.20	999	32	171	94	269	112	F	2
73	MLA179	21 MAY 85	1	14.25	1025	28	172	89	730	133	F	2
74	MRA150	21 MAY 85	1	24.00	1209	30	.	98	304	135	F	3
75	MRA113	29 AUG 85	5	4.85	712	.	123	73	192	66	U	3
76	MRA155	30 AUG 85	5	5.45	722	25	131	74	202	67	U	1
77	.	31 AUG 85	5	18.85	.	.	.	103	.	.	U	3
78	MRA171	31 AUG 85	5	19.30	1067	30	185	99	287	150	U	1
79	MLA161	31 AUG 85	5	22.95	1176	30	185	107	346	147	U	3
80	MLA164	31 AUG 85	5	5.45	690	24	128	76	200	67	U	3
81	MLA109	31 AUG 85	5	11.45	970	26	155	88	255	111	U	1
82	MRA120	31 AUG 85	5	12.20	946	.	165	93	256	121	U	3
83	MLA156	01 SEP 85	5	15.95	932	27	171	94	272	129	U	3
84	MRA111	01 SEP 85	5	5.60	700	.	135	70	200	69	U	1
85	MRA119	01 SEP 85	5	11.40	918	25	145	88	248	101	U	3
86	MRA115	01 SEP 85	5	10.45	853	26	142	86	223	100	M	3
87	MRA174	02 SEP 85	5	4.95	688	.	127	73	213	66	U	3
88	MRA158	05 SEP 85	5	13.35	882	24	162	89	242	116	U	3
89	MRA124	12 SEP 85	3	23.55	1250	32	193	107	350	151	F	3
90	MRA125	13 SEP 85	3	6.20	765	22	140	75	210	71	U	3
91	MLA167	13 SEP 85	1	19.85	1166	30	185	105	325	143	U	3
92	MRA122	14 SEP 85	2	5.70	718	22	144	74	206	71	U	1
93	MLA169	14 SEP 85	2	6.20	691	22	142	68	206	78	U	1
94	MRA331	14 SEP 85	2	5.50	743	22	116	70	193	73	U	1
95	MRA107	14 SEP 85	2	10.50	873	26	161	85	233	105	U	1
96	MLA450	15 SEP 85	2	6.30	664	20	130	70	184	76	U	3
97	MRA344	16 SEP 85	2	16.45	1189	22	180	101	259	122	F	3
98	MRA104	17 SEP 85	2	18.45	1052	29	181	99	259	110	F	3
99	MRA425	18 SEP 85	2	15.35	1056	33	180	88	286	113	M	3
100	MLA106	20 SEP 85	2	20.95	1095	22	182	104	295	145	F	3
101	MRA400	20 SEP 85	2	14.70	1035	20	165	87	275	107	F	3
102	MRA399	20 SEP 85	2	21.45	1049	25	178	103	274	145	U	3
103	MRA335	23 SEP 85	4	16.55	1012	25	169	.	270	132	U	3
104	MRA362	23 SEP 85	4	20.95	1120	32	178	102	290	137	M	3
105	MRA135	26 SEP 85	4	13.20	1057	22	165	78	287	112	U	3
106	MRA139	26 SEP 85	4	16.95	.	30	177	96	300	126	U	1
107	MRA447	27 SEP 85	4	7.85	820	27	145	78	220	87	U	1
108	MLA446	27 SEP 85	4	8.55	840	23	155	77	240	90	U	1
109	MRA136	28 SEP 85	4	16.55	1085	29	185	97	290	121	U	1
110	MRA444	29 SEP 85	4	18.95	1038	26	180	107	280	140	U	3
111	MLA442	01 OCT 85	4	19.65	1007	30	178	100	202	144	U	3
112	MRA474	01 OCT 85	4	21.90	.	28	193	104	260	152	U	3
113	MRA498	02 OCT 85	4	15.70	1002	26	164	90	297	122	U	3
114	MRA440	03 OCT 85	4	6.73	755	.	140	78	205	81	U	3
115	MRA398	22 SEP 85	1	18.70	970	25	175	102	270	135	U	3
116	MLA396	24 SEP 85	2	13.20	1013	25	150	96	233	100	U	1
117	MLA395	24 SEP 85	2	22.30	1130	33	190	114	270	144	U	1
118	MLA394	26 SEP 85	2	14.95	982	20	178	93	252	106	U	1
119	MLA322	01 OCT 85	2	21.70	1070	22	180	102	290	130	U	1
120	MLA370	29 SEP 85	1	24.25	1205	25	195	112	330	155	U	1
121	MRA409	05 OCT 85	2	5.30	764	23	125	68	194	75	U	1

122	MRA470	05 OCT 85	2	14.75	1038	.	167	97	267	114	U	1
123	MLA473	06 OCT 85	2	6.10	684	.	135	76	194	73	U	3
124	MRA196	06 OCT 85	2	19.00	1027	.	190	97	287	127	M	2
125	MRA410	07 OCT 85	1	7.00	821	.	150	79	216	87	U	3
126	MLA460	07 OCT 85	1	6.50	754	.	143	75	189	84	U	1
127	MLA499	07 OCT 85	2	6.80	787	.	145	76	217	80	U	1
128	MRA427	08 OCT 85	2	5.05	733	.	132	72	193	69	U	1
129	MLA481	09 OCT 85	2	12.40	898	.	161	87	258	110	U	1
130	PL0810	09 OCT 85	1	12.70	1012	.	173	95	272	121	U	2
131	MLA494	10 OCT 85	2	20.25	1093	.	180	104	293	126	U	1
132	MLA405	10 OCT 85	2	13.00	920	.	163	89	240	104	U	1
133	MRA496	10 OCT 85	2	18.55	1079	.	181	98	281	111	U	3
134	MRA176	10 OCT 85	1	14.10	994	.	174	89	264	110	U	2
135	MLA149	11 OCT 85	2	19.50	1038	.	176	100	270	126	U	2
136	MRA401	11 OCT 85	2	11.00	888	.	164	87	218	95	U	3
137	MRA462	11 OCT 85	2	14.85	962	.	166	92	267	110	U	3
138	MLA456	11 OCT 85	2	3.75	681	.	116	67	181	56	U	1
139	MLA469	11 OCT 85	2	26.00	1258	.	190	110	343	169	U	3
140	MRA490	11 OCT 85	1	6.75	767	.	130	72	201	82	U	1
141	MRA177	15 OCT 85	1	13.75	1035	.	170	84	260	117	U	2
142	MLA299	17 OCT 85	2	17.75	1035	.	176	96	300	120	M	2
143	MRA477	17 OCT 85	1	15.00	1061	.	182	91	288	115	U	3
144	MRA296	17 OCT 85	1	7.75	866	.	146	77	211	80	U	3
145	MLA257	17 OCT 85	1	14.50	983	.	176	90	253	119	U	1
146	MLA362	17 OCT 85	3	19.00	1035	29	180	98	305	135	U	3
147	MLA497	19 OCT 85	2	17.25	1082	.	184	102	297	120	F	2
148	MRA479	19 OCT 85	1	22.52	1140	.	180	108	260	133	F	1
149	MRA255	20 OCT 85	2	19.40	1010	.	180	101	265	115	F	2
150	MLA493	20 OCT 85	1	7.30	800	.	146	80	217	81	U	3
151	MLA413	20 OCT 85	2	20.40	1110	.	190	105	330	132	M	2
152	MLA489	21 OCT 85	2	5.80	790	.	142	72	200	76	U	1
153	MLA459	22 OCT 85	2	4.90	673	.	136	71	188	74	U	3
154	MLA265	23 OCT 85	2	5.70	789	.	136	71	194	75	U	3
155	MLA179	24 OCT 85	1	16.70	1072	.	187	99	302	142	M	2
156	MRA472	24 OCT 85	1	13.55	1020	.	179	95	290	105	U	3
157	MRA294	25 OCT 85	1	6.90	778	.	147	74	203	80	U	1
158	MRA418	25 OCT 85	2	5.50	730	.	139	72	190	75	U	3
159	MLA451	25 OCT 85	2	14.50	910	.	172	94	250	117	U	3
160	MRA373	18 OCT 85	2	14.75	1007	30	165	96	297	130	U	3
161	MRA381	18 OCT 85	3	16.50	1030	30	190	92	290	110	U	3
162	MLA235	31 OCT 85	1	15.50	969	.	184	94	269	137	F	3
163	MRA212	31 OCT 85	1	9.00	803	.	166	82	203	109	F	3
164	MRA228	01 NOV 85	1	15.00	1084	.	172	93	304	121	F	3
165	MLA383	01 NOV 85	1	7.75	784	.	141	77	214	76	U	1
166	MRA126	01 NOV 85	1	7.60	817	.	146	76	227	86	U	3
167	MRA203	01 NOV 85	1	15.70	978	.	176	90	267	124	F	3
168	MLA293	01 NOV 85	1	20.50	1167	.	195	96	287	137	M	3
169	MRA206	02 NOV 85	1	21.20	1130	.	200	100	310	136	M	3
170	MRA377	02 NOV 85	1	25.70	1116	.	192	112	286	165	M	2
171	MLA254	02 NOV 85	1	9.00	850	.	148	81	220	109	M	3
172	MLA181	03 NOV 85	1	14.30	935	.	113	89	255	124	M	2
173	MRA250	04 NOV 85	1	18.20	1110	.	188	100	300	133	M	3
174	MRA286	04 NOV 85	1	13.20	980	.	173	89	270	106	U	3
175	MRA291	04 NOV 85	1	23.50	1234	.	189	108	314	144	M	3
176	MRA251	04 NOV 85	1	8.30	805	.	156	76	205	92	F	3
177	MRA276	30 OCT 85	2	21.25	1060	.	191	103	300	136	U	3
178	MRA474	06 SEP 86	4	24.00	1045	.	.	108	265	158	F	2
179	MRB107	06 SEP 86	4	7.00	778	.	146	77	218	75	U	3
180	MRA475	06 SEP 86	4	19.00	1131	.	182	99	311	156	M	2
181	MRB104	06 SEP 86	4	5.75	760	.	135	72	210	76	U	3
182	MRB103	06 SEP 86	4	15.75	1057	.	173	93	307	135	M	1
183	MRB101	07 SEP 86	4	5.00	703	.	137	71	198	80	U	3
184	MRB149	07 SEP 86	4	6.10	787	.	139	75	227	80	U	3

185	MRB151	07	SEP	86	4	21.75	1113	.	195	102	323	147	F	3
186	MRB148	07	SEP	86	4	6.25	810	.	141	73	210	66	U	3
187	MRB147	07	SEP	86	4	7.50	823	.	161	74	223	81	U	3
188	MLB145	07	SEP	86	4	25.25	1185	.	192	111	325	153	F	3
189	MRB144	07	SEP	86	4	6.25	793	.	142	72	223	71	U	3
190	MRB143	07	SEP	86	4	4.75	700	.	115	69	190	70	U	3
191	MLB141	08	SEP	86	4	6.25	768	.	135	72	200	75	U	3
192	MRB140	08	SEP	86	4	5.80	747	.	130	70	177	69	U	3
193	MRB139	08	SEP	86	4	7.00	771	.	135	77	216	83	U	3
194	MLB138	08	SEP	86	4	18.40	1040	.	180	101	300	135	M	3
195	MLB137	08	SEP	86	4	6.30	745	.	145	74	205	66	U	3
196	MRB136	09	SEP	86	4	5.60	765	.	136	72	200	66	U	3
197	MRB135	09	SEP	86	4	6.25	799	.	142	75	214	76	U	3
198	MRB134	09	SEP	86	4	6.20	745	.	137	72	200	77	U	3
199	MRB133	09	SEP	86	4	6.90	730	.	138	74	220	86	U	3
200	MRB131	09	SEP	86	4	5.50	700	.	127	72	195	74	U	3
201	MRB130	10	SEP	86	4	6.80	808	.	151	74	223	75	U	3
202	MRB129	10	SEP	86	4	7.25	770	.	147	74	220	83	U	3
203	MRB127	10	SEP	86	4	6.90	823	.	150	74	243	86	U	3
204	MRB126	11	SEP	86	4	6.25	790	.	141	74	220	73	U	3
205	MRB152	11	SEP	86	4	21.75	1065	.	179	105	285	152	M	3
206	MRB153	11	SEP	86	4	7.50	824	.	136	77	234	86	U	3
207	MRA440	12	SEP	86	4	14.25	995	.	175	96	285	120	F	2
208	MRB155	13	SEP	86	4	20.75	1145	.	162	106	295	138	F	3
209	MRB156	14	SEP	86	4	6.70	765	.	138	78	225	88	U	3
210	MRB157	14	SEP	86	4	22.50	1161	.	178	107	301	148	F	3
211	MRB158	14	SEP	86	4	23.50	1085	.	185	106	310	160	F	3
212	MRB159	14	SEP	86	4	7.00	849	.	145	76	249	88	U	3
213	MRB160	15	SEP	86	4	5.75	735	.	130	70	200	76	U	3
214	MRB161	15	SEP	86	1	7.00	796	.	146	76	206	75	U	3
215	MRB162	15	SEP	86	1	6.50	756	.	145	77	216	80	U	3
216	MRB163	15	SEP	86	1	6.75	748	.	135	74	198	89	U	3
217	MRB165	16	SEP	86	4	6.00	740	.	133	75	220	80	U	3
218	MRB166	17	SEP	86	1	19.50	1065	.	175	98	275	137	F	3
219	MRB167	17	SEP	86	1	16.00	1043	.	183	95	273	125	M	3
220	MRB168	17	SEP	86	4	25.50	1080	.	182	109	210	160	F	3
221	MRB178	18	SEP	86	4	6.00	742	.	192	72	192	73	U	3
222	MRB193	18	SEP	86	1	24.00	1105	.	184	103	290	147	F	3
223	MRB180	18	SEP	86	1	18.25	1078	.	182	96	293	136	M	3
224	MRB187	20	SEP	86	4	15.00	1005	.	172	90	285	.	F	3
225	MLB195	21	SEP	86	4	14.00	980	.	170	92	270	124	M	3
226	MRB190	21	SEP	86	4	4.75	680	.	127	67	193	64	U	3
227	MRB175	21	SEP	86	1	6.75	811	.	140	76	213	77	U	3
228	MRB191	21	SEP	86	1	16.70	964	.	180	93	274	130	F	3
229	MRB174	22	SEP	86	1	23.00	1085	.	195	108	275	160	F	3
230	MRB177	22	SEP	86	1	18.70	1125	.	192	100	295	135	F	3
231	MRB182	23	SEP	86	4	16.25	1003	.	173	93	278	130	F	3
232	MRB181	23	SEP	86	4	5.00	680	.	127	67	195	65	U	3
233	MRB198	23	SEP	86	4	4.80	700	.	124	68	185	66	U	3
234	MRB188	23	SEP	86	1	6.90	796	.	132	73	201	73	U	3
235	MRB105	24	SEP	86	4	15.25	1060	.	178	94	290	116	M	3
236	MRB185	24	SEP	86	4	5.50	741	.	130	73	191	62	U	3
237	MRB000	24	SEP	86	1	25.60	1241	.	195	112	301	161	M	3
238	MRB189	25	SEP	86	4	26.50	1233	.	195	113	313	140	F	3
239	MRB176	25	SEP	86	4	5.30	684	.	130	68	184	63	U	3
240	MRB186	26	SEP	86	5	15.00	1016	.	170	90	256	128	F	1
241	MRB170	26	SEP	86	5	26.50	1110	.	205	107	320	150	M	3
242	MRA316	26	SEP	86	5	4.80	606	.	120	64	176	64	U	1
243	MLA365	26	SEP	86	5	17.00	1052	.	175	93	282	128	M	1
244	MRB171	27	SEP	86	5	13.15	973	.	165	89	253	117	F	3
245	MRA155	27	SEP	86	5	13.25	956	.	165	93	256	115	F	2
246	MRB184	27	SEP	86	5	14.70	1023	.	180	94	273	125	F	3
247	MRB172	27	SEP	86	5	12.50	880	.	151	86	240	118	M	1

248	MRB192	28	SEP	86	5	14.25	945	.	172	93	260	122	M	1
249	MRB199	28	SEP	86	5	19.00	1047	.	180	97	272	131	M	1
250	MRA111	28	SEP	86	5	13.80	984	.	178	90	264	123	F	2
251	MRB200	28	SEP	86	5	18.50	1043	.	172	101	273	135	M	1
252	MRB276	28	SEP	86	5	14.00	912	.	166	89	252	107	M	3
253	MRB225	28	SEP	86	5	5.00	661	.	125	68	191	65	U	1
254	MRB224	28	SEP	86	5	6.50	727	.	134	75	207	78	U	1
255	MRB223	29	SEP	86	5	20.75	1063	.	194	104	273	147	F	1
256	MRB222	29	SEP	86	5	3.50	591	.	112	61	146	61	U	1
257	MRB277	29	SEP	86	5	18.00	1075	.	173	97	255	127	M	3
258	MRB201	29	SEP	86	5	13.40	940	.	173	86	260	120	M	3
259	MRB250	29	SEP	86	5	18.75	1060	.	173	102	310	123	F	1
260	MRB275	29	SEP	86	5	7.50	746	.	137	74	216	73	U	1
261	MRB249	30	SEP	86	5	5.25	721	.	126	69	201	72	U	1
262	MRB300	01	OCT	86	5	3.80	593	.	118	66	163	65	U	1
263	MRB274	01	OCT	86	5	3.70	619	.	110	61	149	62	U	1
264	MRB248	03	OCT	86	5	4.80	742	.	128	66	182	62	U	1
265	MRB247	05	OCT	86	5	6.40	702	.	133	72	212	77	U	3
266	MRB221	05	OCT	86	5	15.70	1047	.	178	94	267	120	F	1
267	MRB299	05	OCT	86	5	11.75	927	.	157	85	257	122	M	3
268	MRB298	06	OCT	86	5	6.40	780	.	137	78	220	77	U	3
269	MRB246	06	OCT	86	5	19.25	1058	.	182	101	278	136	F	3
270	MRB220	09	OCT	86	5	20.00	1077	.	175	106	287	146	F	3
271	MRB245	11	OCT	86	5	10.90	916	.	171	87	241	112	M	3
272	MRB244	14	OCT	86	1	8.50	846	.	152	77	226	90	U	3
273	MRB243	14	OCT	86	1	4.90	686	.	131	64	166	60	U	3
274	MRB241	14	OCT	86	2	7.75	780	.	145	76	200	78	U	1
275	MRB242	14	OCT	86	2	7.75	777	.	137	74	197	80	U	1
276	MRB239	14	OCT	86	2	7.75	785	.	147	76	215	85	U	1
277	MRB297	15	OCT	86	2	17.00	1030	.	190	94	295	120	F	1
278	MRB296	15	OCT	86	2	7.30	826	.	144	75	201	82	U	1
279	MRB295	15	OCT	86	2	6.60	763	.	143	75	198	82	U	3
280	MRB238	15	OCT	86	1	7.80	802	.	142	76	202	75	U	1
281	MRB294	15	OCT	86	1	5.00	690	.	132	67	170	63	U	1
282	MRB273	16	OCT	86	1	4.50	687	.	127	67	167	69	U	1
283	MRB293	16	OCT	86	2	7.25	770	.	150	79	215	75	U	1
284	MRB119	16	OCT	86	2	17.30	1077	.	192	99	277	115	F	2
285	MLB272	16	OCT	86	2	14.50	1042	.	183	99	.	113	F	1
286	MRB271	17	OCT	86	1	5.25	720	.	126	67	160	67	U	3
287	MRA427	20	OCT	86	2	13.00	907	.	170	98	247	102	M	2
288	MRA490	20	OCT	86	1	15.25	1029	.	173	87	259	115	M	2
289	MRB279	21	OCT	86	2	17.25	1040	.	190	101	290	112	F	1
290	MRA479	21	OCT	86	1	24.10	1070	.	200	107	245	134	F	2
291	MRA294	22	OCT	86	1	17.00	1103	.	183	91	263	115	F	2
292	MRA401	22	OCT	86	2	16.00	1012	.	180	93	242	120	F	2
293	MRB268	22	OCT	86	2	26.50	1178	.	200	110	298	160	F	3
294	MRB267	24	OCT	86	2	16.75	1015	.	177	93	280	130	F	3
295	MRB266	24	OCT	86	2	7.10	807	.	139	77	197	89	U	3
296	MRB219	25	OCT	86	2	6.60	893	.	140	78	213	86	U	1
297	MLA451	25	OCT	86	2	20.75	1064	.	192	98	274	140	F	2
298	MRB218	25	OCT	86	2	18.25	1069	.	170	98	289	129	M	1
299	MLA215	25	OCT	86	2	16.50	1045	.	171	98	280	120	F	1
300	MRB111	25	OCT	86	1	14.00	974	.	178	95	274	120	F	2
301	MRA177	26	OCT	86	1	17.25	1029	.	190	94	279	130	F	2
302	MRB236	26	OCT	86	2	24.80	1140	.	190	112	280	155	F	3
303	MRB235	27	OCT	86	2	16.25	996	.	173	93	266	125	F	1
304	MRB228	28	OCT	86	2	20.25	1058	.	175	105	273	120	F	1
305	MRB254	28	OCT	86	1	8.25	776	.	150	77	216	80	U	3
306	MRB258	28	OCT	86	1	7.80	738	.	141	80	218	80	U	3
307	MRB229	28	OCT	86	1	6.50	742	.	138	74	212	80	U	1
308	MRB203	29	OCT	86	1	7.00	714	.	144	77	209	79	U	3
309	MRB207	30	OCT	86	2	7.30	800	.	150	79	210	90	U	3
310	MRB234	30	OCT	86	2	7.50	780	.	148	82	200	95	U	3

311	MRB233	30 OCT 86	2	22.00	1129	.	200	111	324	150	F	3
312	MRB282	30 OCT 86	1	21.75	1155	.	200	104	325	140	M	1
313	MRA216	30 OCT 86	1	13.50	995	.	167	88	265	110	M	2
314	MRB286	31 OCT 86	1	8.00	800	.	153	78	200	84	U	3
315	MRB230	31 OCT 86	1	17.75	1052	.	188	103	277	127	M	3
316	MRB211	01 NOV 86	2	7.40	821	.	141	77	211	80	U	3
317	MRB202	01 NOV 86	2	20.50	1127	.	192	102	287	120	F	3
318	MRB226	02 NOV 86	1	6.90	802	.	147	74	202	76	U	3
319	DEAD	25 OCT 86	2	15.25	1010	.	170	93	260	130	U	3
320	MLA473	18 OCT 86	2	13.00	908	.	157	94	238	108	M	2
321	MRA384	18 OCT 86	2	5.75	760	.	130	70	240	720	U	3
322	MRA320	16 OCT 86	2	5.75	757	.	.	73	217	80	U	3
323	MRA284	06 OCT 86	1	17.00	1021	.	175	95	291	142	M	2
324	MRA321	28 SEP 86	1	16.25	1005	.	178	96	275	128	M	3
325	MRA277	11 SEP 86	1	14.75	1010	.	180	93	280	125	M	3
326	MRA208	01 NOV 86	2	15.80	1125	.	175	100	295	122	F	3
327	MRA245	19 SEP 86	4	19.25	1032	.	185	99	282	132	M	3
328	MRA284	23 SEP 86	4	17.75	1038	.	185	94	288	141	M	3
329	MRA356	26 SEP 86	4	25.25	1140	.	188	101	310	170	M	3
330	MRA366	06 OCT 86	4	16.50	960	.	160	95	270	130	M	3
331	MRA392	10 OCT 86	4	13.75	980	.	155	88	250	111	F	3
332	MRA274	12 OCT 86	4	6.00	708	.	140	70	198	78	U	3
333	MRA150	11 MAY 86	1	21.60	.	.	192	103	294	134	M	2
334	PL082P	11 MAY 86	2	15.30	1014	.	174	103	279	110	F	2
335	MRA294	12 MAY 86	1	10.25	955	.	162	85	240	91	F	2
336	MRA268	14 MAY 86	1	14.25	945	.	177	94	265	112	M	2
337	MRA427	14 MAY 86	2	6.30	822	.	146	78	222	76	U	2
338	MRB122	14 MAY 86	2	15.15	1021	.	177	97	266	122	M	3
339	MRB121	15 MAY 86	2	16.00	1004	.	172	100	284	120	F	3
340	MRA250	16 MAY 86	1	16.00	1053	.	194	101	298	136	M	2
341	MLA299	16 MAY 86	2	15.80	1011	.	173	98	291	105	M	2
342	MLA499	16 MAY 86	2	7.75	804	.	145	83	234	80	U	2
343	MLA497	16 MAY 86	2	18.50	1025	.	185	109	295	116	F	2
344	MRA201	07 MAY 86	2	13.50	1108	.	180	97	278	120	M	3
345	MRA209	14 MAY 86	1	26.50	1166	.	180	112	306	150	M	3
346	MRA490	17 MAY 86	1	9.75	878	.	155	85	228	88	M	2
347	MRA291	17 MAY 86	1	24.00	1046	.	186	106	306	138	M	2
348	MRA479	17 MAY 86	1	23.25	1093	.	183	108	263	129	F	2
349	MRB115	17 MAY 86	2	10.60	937	.	166	88	257	88	M	3
350	MRB114	19 MAY 86	2	8.20	854	.	146	83	234	87	U	3
351	MRA401	20 MAY 86	2	11.00	922	.	166	89	222	95	F	2
352	MRA331	20 MAY 86	2	7.00	828	.	146	77	203	76	U	2
353	MRB112	20 MAY 86	1	19.00	1262	.	185	103	322	120	F	3
354	MRB111	21 MAY 86	1	9.80	909	.	159	87	239	89	U	3
355	MLA179	21 MAY 86	1	17.10	1061	.	183	99	293	137	M	2
356	MRA344	21 MAY 86	2	14.75	969	.	176	102	254	120	F	2
357	MLA466	09 APR 86	2	20.75	1070	.	.	105	290	145	U	3
358	MRA298	09 APR 86	2	9.75	925	.	165	85	255	100	U	3
359	MLA295	10 APR 86	2	23.00	1140	.	195	.	320	140	F	3
360	MLA256	11 APR 86	2	9.50	870	.	165	84	240	105	U	3
361	MLA296	12 APR 86	2	9.75	850	.	170	83	240	100	M	3
362	MLA261	12 APR 86	2	9.25	860	.	168	81	240	100	M	3
363	MLA267	12 APR 86	2	10.25	865	.	164	84	240	101	F	3
364	MLA415	13 APR 86	2	9.50	865	.	169	85	255	108	M	3
365	MRA201	07 MAY 86	2	13.50	1108	.	180	97	278	120	M	3
366	MRB109	23 MAY 86	1	9.25	877	.	163	82	227	87	U	2
367	MLA493	12 MAY 87	1	15.25	1075	.	182	96	285	115	F	2
368	MRB239	12 MAY 87	2	8.75	845	.	166	82	230	92	U	2
369	MRB293	14 MAY 87	2	7.75	821	.	162	83	231	82	U	2
370	MRB230	15 MAY 87	1	15.50	1070	.	180	101	290	125	F	2
371	MRB258	16 MAY 87	1	7.80	823	.	155	84	233	81	U	2
372	MLA383	17 MAY 87	1	11.75	962	.	185	92	262	101	U	2
373	MLA460	17 MAY 87	1	14.60	996	.	187	102	256	122	F	2

374	MLB272	18	MAY	87	2	11.75	955	.	190	94	275	100	U	2
375	MRB282	18	MAY	87	1	17.25	1250	.	202	108	370	133	M	2
376	MRB210	18	MAY	87	1	9.10	848	.	158	85	238	91	U	3
377	MLB209	19	MAY	87	1	11.75	962	.	182	90	262	107	U	2
378	MRB286	19	MAY	87	1	8.25	843	.	160	81	233	87	U	2
379	MRA490	19	MAY	87	1	14.50	1030	.	175	96	270	110	M	2
380	MRB268	20	MAY	87	2	20.75	1123	.	193	109	293	140	M	2
381	MRA294	21	MAY	87	1	16.75	1128	.	185	97	278	115	F	2
382	MRB257	24	MAY	87	4	7.75	825	.	154	79	225	92	U	3
383	MRB255	24	MAY	87	4	8.25	895	.	163	81	220	85	U	3
384	MRB176	25	MAY	87	4	7.70	781	.	157	79	221	78	U	2
385	MRB185	26	MAY	87	4	8.20	851	.	156	84	221	80	U	2
386	MRB198	26	MAY	87	4	6.50	835	.	160	78	225	70	U	2
387	MRB147	26	MAY	87	4	9.00	886	.	165	83	236	90	U	2
388	MRB163	26	MAY	87	1	11.00	935	.	164	87	235	104	M	2
389	MRB279	27	MAY	87	4	18.00	1114	.	180	100	294	143	F	3
390	MRB181	27	MAY	87	4	6.50	806	.	161	81	226	78	U	2
391	MLB213	28	MAY	87	4	17.00	1038	.	.	107	288	110	F	3
392	MRB474	28	MAY	87	4	22.25	1057	.	195	111	267	143	M	2
393	MRB129	28	MAY	87	4	9.75	908	.	173	87	248	94	U	2
394	MRA107	23	MAY	86	2	11.25	909	.	170	89	239	104	M	2

APPENDIX V

Overwinter weight changes- Rainy Lake beavers.

YEAR	FALL WT.	SPRING WT.	FALL-SPRING DIFF.	AGE
1986-87	5.3	7.7	2.4	KIT
1986-87	5.5	8.2	2.7	KIT
1986-87	4.8	6.5	1.7	KIT
1986-87	7.5	9.0	1.5	KIT
1986-87	5.0	6.5	1.5	KIT
1986-87	7.25	9.75	2.5	KIT
1986-87	24.0	22.5	-1.5	AD
			1.5	

APPENDIX V

Overwinter weight changes- Kabetogama Lake beavers.

YEAR	FALL WT.	SPRING WT.	FALL-SPRING DIFF.	AGE
1985-86	5.05	6.3	1.25	KIT
1985-86	6.8	7.75	0.95	KIT
1985-86	5.5	7.0	1.5	KIT
1986-87	7.75	8.75	1.0	KIT
1986-87	7.25	7.75	0.5	KIT
1985-86	11.0	11.0	0	AD
1985-86	10.5	11.25	0.75	AD
1986-87	14.5	11.75	-2.75	AD
1985-86	17.75	15.8	-1.95	AD
1985-86	17.25	18.5	1.25	AD
1985-86	16.45	14.75	-1.70	AD
1985-86	19.40	15.30	-4.10	AD
1986-87	26.5	20.75	-5.75	AD
	12.7	12.1	-0.70	

APPENDIX V

Overwinter weight changes- Inland beavers.

YEAR	FALL WT.	SPRING WT.	FALL-SPRING DIFF.	AGE
1985-86	6.90	10.25	3.35	KIT
1985-86	6.75	9.75	3.00	KIT
1985-86	7.75	9.25	1.5	KIT
1986-87	7.8	7.8	0	KIT
1986-87	8.0	8.25	0.25	KIT
1986-87	6.75	11.0	4.25	KIT
1985-86	14.15	14.25	0.10	AD
1986-87	13.5	11.75	-1.75	AD
1986-87	15.25	14.5	-0.75	AD
1985-86	14.15	17.1	2.95	AD
1985-86	18.2	16.0	-2.2	AD
1986-87	17.75	15.5	-2.25	AD
1986-87	17.0	16.75	-0.25	AD
1985-86	23.5	24.0	0.5	AD
1985-86	22.52	23.25	0.73	AD
1986-87	21.75	17.25	-4.5	AD
	13.86	14.17	0.31	

MIDWEST REGION

The National Park Service's Midwest Region covers 33 park units located in 10 states in the Great Plains and Great Lakes area (Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Michigan, Illinois, Indiana, and Ohio). The physical and biological diversity of the Region is reflected in the variety of research conducted in the parks. Current research subjects range from a survey of prairie vegetation in several small parks to the ecology of boreal forests at Voyageurs; from threatened plants in a number of parks to endangered wolves at Isle Royale; from hydrology of springs at Ozark to air pollution at Indiana Dunes; and from recreational boating use patterns on the Lower Saint Croix to hiking and campground use at Isle Royale. For more information on the National Park Service's Midwest Regional science program, please write:

Regional Chief Scientist
National Park Service
Midwest Regional Office
1709 Jackson Street
Omaha, Nebraska 68102

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