TAIGA BIOLOGICAL STATION
UNIVERSITY OF MANITOBA

Impact of Fire in the Taiga of Southeastern Manitoba on Wildlife, Vegetation, and Value to Resource Users.

by

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ABSTRACT

During the summer of 1982, trapping and vegetation surveys were carried out on permanent study plots within 6 of 7 different types of plant communities within the South-eastern Manitoba Taiga, which had been subjected to fire in May of 1980. A unique feature of this study area was the existence of an 8 year pre-fire data base. A total of 129 mammals, 123 of which are typified as "small mammals" were captured in 2100 trap nights. The number captured in each plant community were as follows: Jack Pine Ridge 19, Alder Jack Pine Ecotone 30, Alder Tamarack Bog 20, Jack Pine Sand Plain 5, Black Spruce Bog 5, Aspen Upland 21, Black Spruce Tamarack Bog 29. Pre-fire small mammal data for the permanent study plots were available, and up to ten years of data were used for comparative evaluation of fire effects. The effects of the fire vary according to the severity of the burn, but small mammal population numbers and biomass estimates for most plots increased the fall immediately after the burn, and then dropped in 1981. Specifically, <u>Clethrionomys</u> <u>gapperi</u> and <u>Peromyscus</u> <u>maniculatus</u> increased with the fire, and <u>Sorex</u> <u>cinereus</u> continued to fluctuate. Three growing seasons after the fire, population numbers and biomass estimates have declined, but are equal to or above

minimum pre-fire levels. The effects of fire on other local wildlife, such as ungulates, fur bearers, and birds are discussed briefly.

Current vegetation data were compared with pre-fire data and some basic post-fire reproductive strategies were observed. Pioneer or fugitive species with numerous light-weight wind-disseminated seeds, or those with long-lived seeds stored in soil seed banks, which grow and mature rapidly were present. Frugivores are also suspected to have been an agent of post-fire seed dispersal. Vegetative reproduction through root sprouting or suckering was a dominant strategy observed on some plots. Relatively slow growing, late maturing species with larger, heavier seeds were also observed, and these are expected eventually to regain their upper canopy status.

In an attempt to place a dollar value on the study area, the user's willingness to pay for benefits from use of the resources of the area, was combined with the potential attainable revenue from exploitation of local resources. The combined value is calculated to be in excess of $ 597,208.93. Interest in timber resources 80 years hence could present a conflict for land use management. It is recommended that the Taiga Biological Station study area be protected in its natural state, with controlled educational, research, traditional, and recreational activities permitted.

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INTRODUCTION

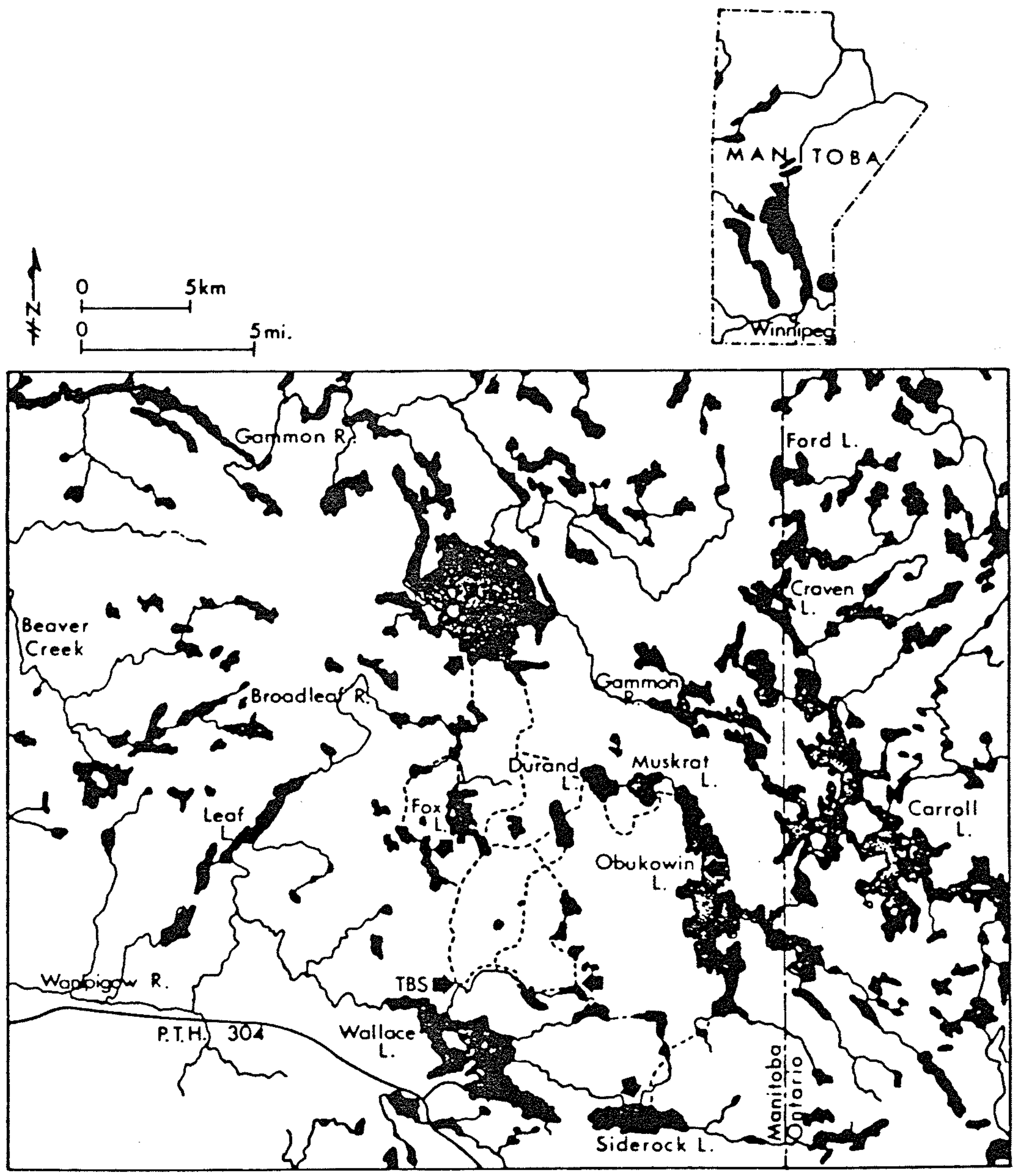
Resources of the Taiga (Boreal Forest) have been of use to indigenous man for food and shelter since prehistoric time. Only recently have these resources been utilized by settlers for domestic use, and later for export. Access costs to this largely remote area have inflated costs of production such that they may have been prohibitive to large scale industrial exploitation. Increasing demand for natural resources has instigated an interest in Boreal Forest resources such as timber, minerals, fish, and wildlife. Only through a comprehensive ecosystem approach to management can we prevent or at least minimize degradation of this area.

Fire is an intrinsic factor in the Taiga ecosystem and as such it merits examination. Early in this century forest fires became undesirable because of the "woeful waste" (Dwight 1918), and by 1930 fire suppression was widely used to allow ecological succession to proceed to a climax stage (Wright and Heinselman 1973). More recently man has reverted to the idea that fire is a valuable, and often essential factor in various ecosystems (White 1972, Viereck 1973, Wright and Heinselman 1973, Van Wagner and Methven 1980). The value of fire in taiga ecosystems is not well documented, or understood.

The Taiga Biological Station (TBS) was created in South-eastern Manitoba in 1973, by the University of Manitoba for the purpose of providing a site for biological research, teaching, and learning in a boreal setting. Studies associated with TBS have been conducted within an area that Stardom (1977) originally designated as an intensive study area for his research activities, (Figure 1) which commenced in 1970. The size of the study area (31337 ha.) was set to correspond with the home ranges of indigenous large boreal animals including the local woodland caribou (Rangifer tarandus caribou) herd. Studies on small mammals, larger wildlife, and vegetation have been relatively continuous since 1972. A fire in the spring of 1980 , which burned a total of 69,700 hectares (160,000 acres), was a cataclysmic event, but TBS continues to function as intended. Permanent study plots in use before and after the fire provide a valuable and unique opportunity to examine fire effects, since prefire data are available for comparison with post-fire data at identical locations.

Various groups have an interest in the resources of the area. Currently the University of Manitoba holds a cottage lease for the building site, but attempts are being made to secure a longer term lease in order to facilitate longer term research activities. Interest in timber extraction has declined sharply due to the fire, but other consumers such as trappers, hunters, and recreationists use the area.

Figure 1: The location of the Taiga Biological Station study area.



RESEARCH OBJECTIVES

The objective of the field portion of this study was to examine the post-fire rehabilitation of habitat for wildlife benefit, with particular reference to small mammal populations. To achieve this objective, efforts were expended (at TBS) in order to:

i) evaluate changes in small mammal populations over time, with the interjection of the 1980 fire, and

ii) assess vegetational changes in wildlife habitat due to fire.

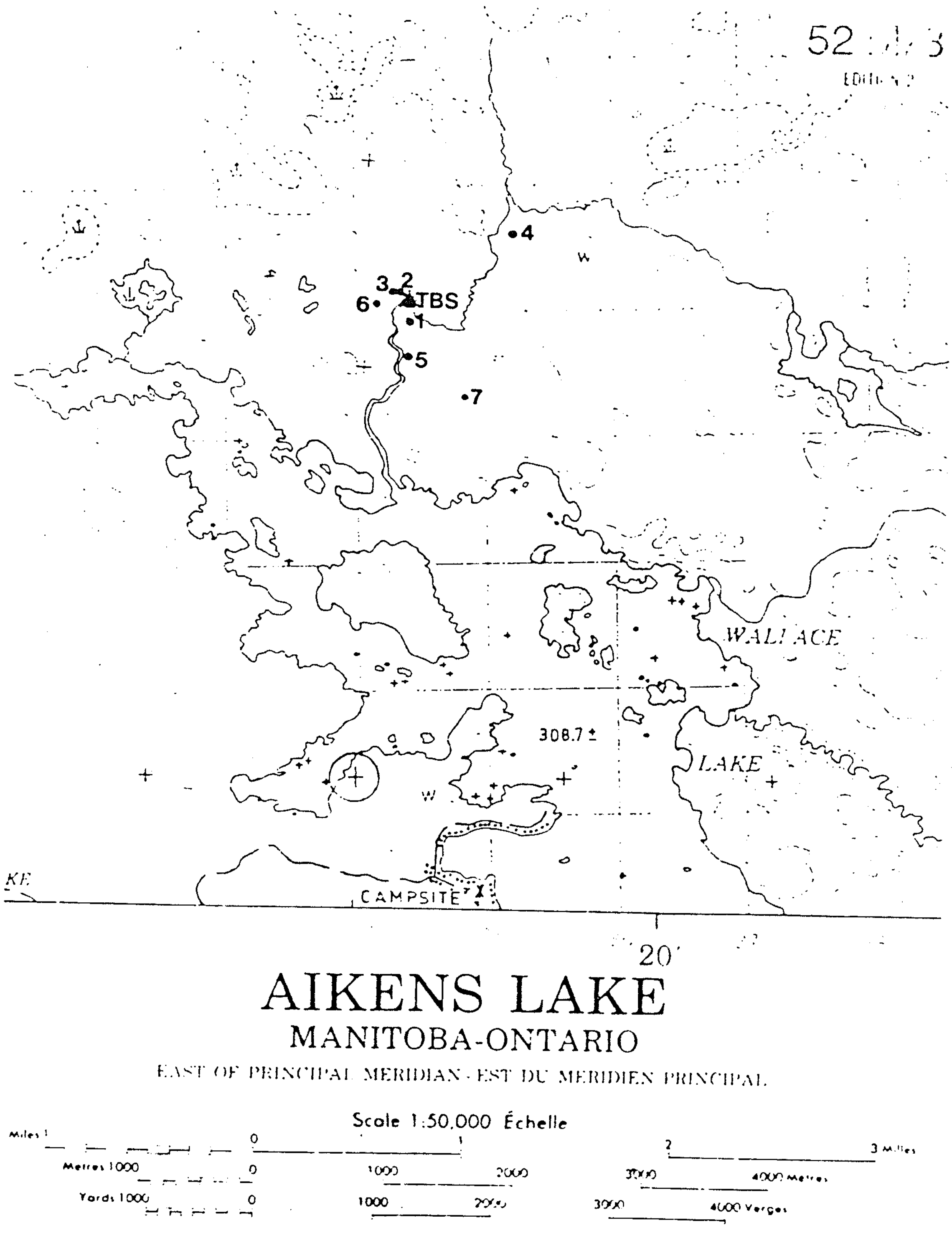
iii) A third objective was to consider management implications of fire in the portion of the taiga associated with TBS research interests. In particular the intention was to examine fire induced changes in the value of local resources to current and potential consumers of those resources.

METHODS

Study Area

All field work was carried out at TBS (51o 05'N lat., 95o2'W long) from 25 May to 3 September 1982. Permanent study plots (0.4 ha. or 1 acre) were established in 1972, 1973, and 1978 (Penny 1978, Raine unpubl. a), and have been in use almost continuously since that time, thus providing a sound data base before the fire (1980) for comparison with post-fire data. This feature is unique to the study area, in that the study plots were established before a fire. Seven different vegetation communities have been examined (Figure 2). Included were (1) Jack Pine Ridge, (2) Alder Jack Pine Ecotone, (3) Alder Tamarack Bog, (4) Jack Pine Sand Plain, (5) Black Spruce Bog, (6) Aspen Upland, and (7) Black Spruce Tamarack Bog. These communities represent the types of habitat found in the taiga, but sampling efforts do not reflect the actual proportions of each.

Figure 2: Illustration of the location of specific study plots within the study area.



Collection of data

Small mammals

As in previous years, the 1982 small mammal data were collected according to theremoval methods of Pruitt (1968). The square study plots, 0.4 ha in size, are subdivided by a 10 x 10 grid indicated by wooden markers approximately 6.5 meters apart. Axes are labelled 1 to 10 and A to J. One hundred Schuyler and Museum Special traps were placed alternately at stakes so that each was given equal presentation to the population being sampled. Traps were baited once, with a mixture of rolled oats, peanut butter, raisins, and bacon fat, and set for 3 nights. Traps were checked each morning and trapped mammals were placed in individual bags on which plot, grid co-ordinates, type of trap, and brief notes on the specific trap site were recorded. This information was later entered in the permanent TBS field catalogues along with measurements of total length, length of tail, hind foot, ear from notch and weight. Sex and reproductive state were also recorded, and skeletons were retained and donated to the Manitoba Museum of Man and Nature. Previous and current data were compared.

Habitat

Any study of changes in animal population must consider the possible changes in habitat. Vegetation is a habitat component most definitely affected by fire, hence an extensive vegetation survey was completed. All upper canopy trees within the plot grids were charted on site. Notation was made of the species and whether trees were live or dead was also indicated. The cover of young trees and shrubs greater than 1 meter high was also sketched, where applicable. Quadrat samples (1/4 m2 were used to estimate the percentages of ground cover vegetation. Unpublished data collected by Penny (1978) were used for pre-fire comparison.

Value to Users of the TBS Study Area

To assess the economic impact of the 1980 fire on the TBS study area, an attempt was made to define and quantify the interest(s) different users may have in the area. A modified Hotelling-Clawson model (Clawson and Knetch 1965) was used to assess the concept of value to users as it relates to the TBS study area and its intrinsic resources. Current and potential revenue accruing to traditional users was evaluated, as were the travel costs and other dollars spent in utilizing the area and its resources.

RESULTS AND DISCUSSION

A total of 129 mammals, of which 123 are typified as "small mammals", were captured during 2100 trap nights. Table 1 summarizes the number of each species captured in each habitat. The data for calculation of biomass estimates for three years prior to the fire and for post-fire years are available in the TBS field catalogue for comparison with 1982 data, and are found in Table 2.

Pre-fire (Penny 1978) and post-fire (1982) vegetation data collection methods were not identical, hence comparisons could be considered subjective. Systematic quadrat sampling was used by Penny (1978) while I chose to do random sampling. The most serious discrepancies in data comparisons would likely occur in plots on ecotones, where inadvertant selective sampling could be most frequent. This difference in methods limits quantitive analysis but a qualitative examination of results is valid.

Table 1: Small mammal snaptrap results, from 300 trapnights in each vegetation community

August 1982

Community	<u>Clethrionomys gapperi</u>	<u>Peromyscus maniculatus</u>	<u>Sorex cinereus</u>	<u>Blarina brevicauda</u>	<u>Glaucomys sabrinus</u>	<u>Tamiasciurus hudsonicus</u>	<u>Condylura cristata</u>	Total
Jack pine ridge	6	6	6	1				19
Alder Jackpine Ecotone	4	3	18	3	1		1	30
Alder Tamarack Bog	1	1	17	1				20
Jack pine Sand plain		4				1		5
Black Spruce Bog		2	3					5
Aspen Upland	3	7	7	1	3			21
Black Spruce Tamarack Bog	12		17					29
Total	26	23	68	6	4	1	1	129

Table 2: Biomass estimates from small mammal trap data, (grams)*

1977 Community	*Clethrionomys gapperi*	*Peromyscus maniculatus*	*Microtus pennsylvanicus*	*Sorex cinereus*	Other spp.	Total
Jack Pine ridge	126.1					126.2
Alder Jack pine Ecotone	124.7		17.8	6.4		148.9
Alder Tamarack Bog	277.4			14.4		291.8
Jack pine sand Plain	22.8					22.8
Black Spruce Bog	29.9					29.9
Aspen Upland	56.4					56.4
Total	637.4		17.8	20.8		676.0

1978 Community	*Clethrionomys gapperi*	*Peromyscus maniculatus*	*Microtus pennsylvanicus*	*Sorex cinereus*	Other spp.	Total
Jack pine ridge	86.7			18.8	201.8	307.3
Alder Jack pine Ecotone	144.1			39.4	291.7	475.2
Alder Tamarack Bog	198.2			30.4		228.6
Jack pine sand Plain	40.2					40.2
Black Spruce Bog	15.8					15.8
Aspen Upland	215.9			11.0	170.0	396.9
Black Spruce Tamarack Bog			69.4	11.6		81.0
Total	700.9		69.4	111.2	663.5	1545.0

*Missing values were estimated by the mean weight of the particular species in the applicable year.

Table 2 cont'd

1979 Community	Clethrionomys gapperi	Peromyscus maniculatus	Microtus pennsylvanicus	Sorex cinereus	Other spp.	Total
Jack pine ridge	182.3			29.5		211.8
Alder Jack pine Ecotone	125.2		42.0	27.3	57.2	251.7
Alder Tamarack Bog	54.2	14.9	67.2	22.6	50.4	209.3
Jack pine sand plain	27.2			15.9	22.6	65.7
Black Spruce Bog	18.6			17.6		36.2
Aspen Upland	276.2			13.1		289.3
Black Spruce Tamarack Bog	16.9	15.3	22.9	10.6		65.7
Total	700.6	30.2	132.1	136.6	130.2	1129.7

1980 Community	Clethrionomys gapperi	Peromyscus maniculatus	Microtus pennsylvanicus	Sorex cinereus	Other spp.	Total
Jack pine ridge	299.6	49.2		5.5	183.6	537.9
Alder Jack pine Ecotone	390.5	93.3	69.3	27.6	30.3	611.0
Alder Tamarack Bog	256.9		24.8	31.3	39.1	352.1
Jack pine Sand Plain	61.1	198.0		3.2	357.4	619.7
Black Spruce Bog						0.0
Aspen Upland	235.9	182.6	43.0	8.4		469.9
Black Spruce Tamarack Bog	196.1		57.9	8.6	206.1	468.7
Total	1440.1	532.1	195.0	84.6	816.5	2263.9

Table 2 cont'd

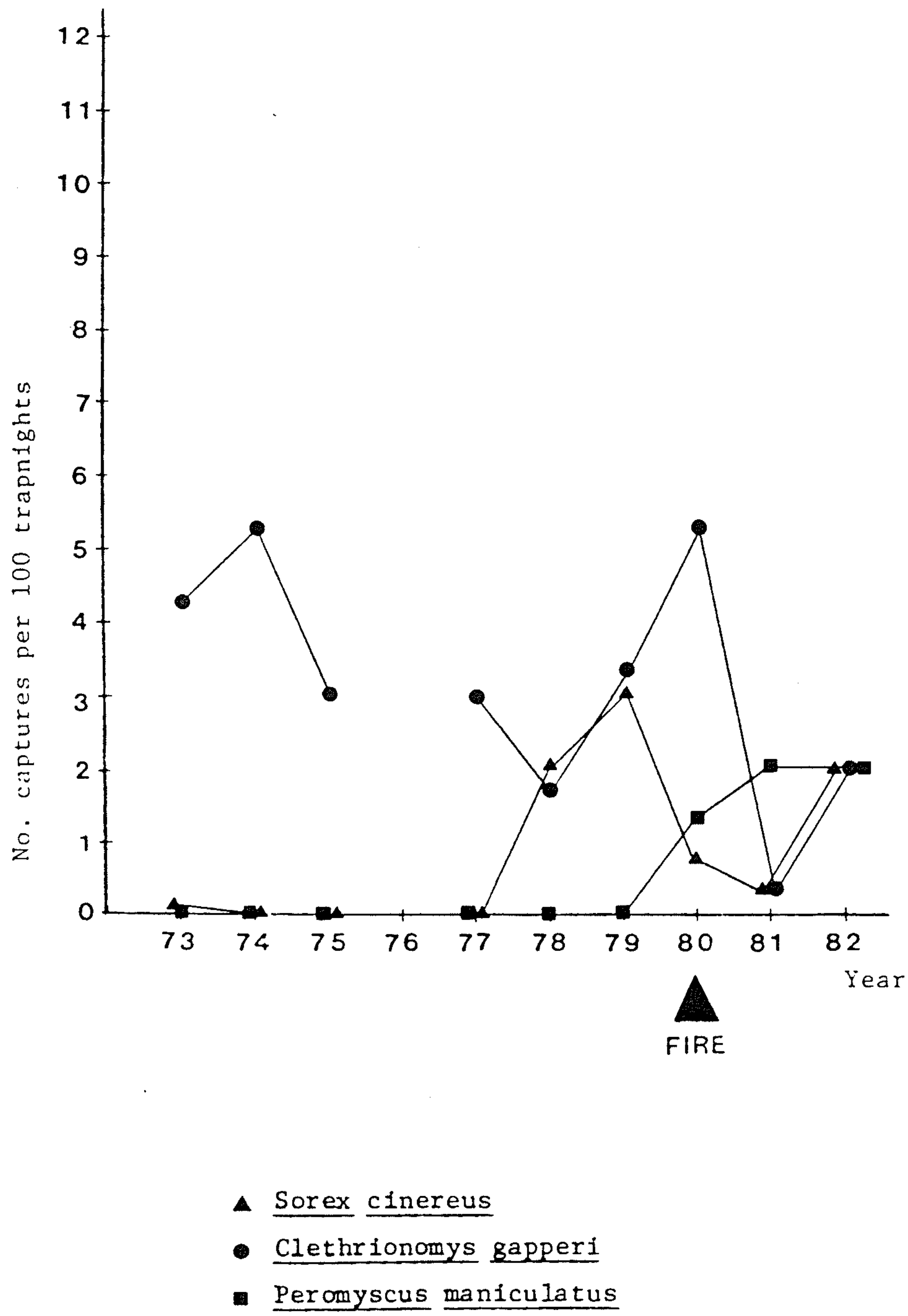
1981 Community	Clethrionomys gapperi	Peromyscus maniculatus	Microtus pennsylvanicus	Sorex cinereus	Other spp.	Total
Jack pine ridge	23.3	84.8		2.9		111.0
Alder Jack pine Ecotone	150.4	47.6		9.6		207.6
Alder Tamarack Bog	183.1			9.3		192.4
Jack pine sand Plain		126.4				126.4
Black Spruce Bog		29.4				29.4
Aspen Upland	no data available					
Black Spruce Tamarack Bog	no data available					
Total	356.8	288.2		21.8		666.8
1982 Community						
Jack pine ridge	160.4	101.2		23.6	19.5	304.7
Alder Jack pine Ecotone	108.7	60.2		66.1	188.0	423.0
Alder Tamarack Bog	17.3	10.6		61.9	18.9	108.7
Jack pine sand plain		75.9			214.6	290.5
Black Spruce Bog		27.4		10.0		37.4
Aspen Upland	63.0	115.7		24.7	358.9	562.3
Black Spruce Tamarack Bog	267.3			64.7		332.0
Total	626.7	391.0		241.0	799.9	2058.6

There was, and still is, a wide variation in physiographic and vegetative features of the specific study plots, which accounts for variation in fire behaviour, thus different plots were subjected to varying fire intensities. Therefore, the effects of fire differ for each plot, hence I will present and discuss the results from each plot separately.

Jack Pine Ridge

In 300 trap nights 19 small mammals were captured (Table 1). Figure 3 compares the number of captures for the three most common species for the ten year period (1973 to 1982) that this plot has been in use. *Clethrionomys gapperi* (Red-back Vole) numbers increased in the fall immediately after the fire, dropped to an all time low in 1981, then returned to the 1978 pre-fire level by 1982. *P. maniculatus* had not been trapped on this site prior to the fire. Seeds are reported to be the preferred food of *P. maniculatus* (Banfield 1974, Everett et. al. 1978, Vaughan 1979, Fox 1983), therefore the abundance of Jack Pine (*Pinus banksiana*) seeds released by the fire probably induced the species to invade the area. *C. gapperi* numbers for 1980 were not above those previously recorded (1974) and could be due to an upswing in the population, or to immigration. Wrigley (1975) reported small mammals survive major habitat destruction due to fire by taking refuge in narrow bands of

Figure 3: Jack Pine Ridge, number of captures per 100 trap nights, for the most common species

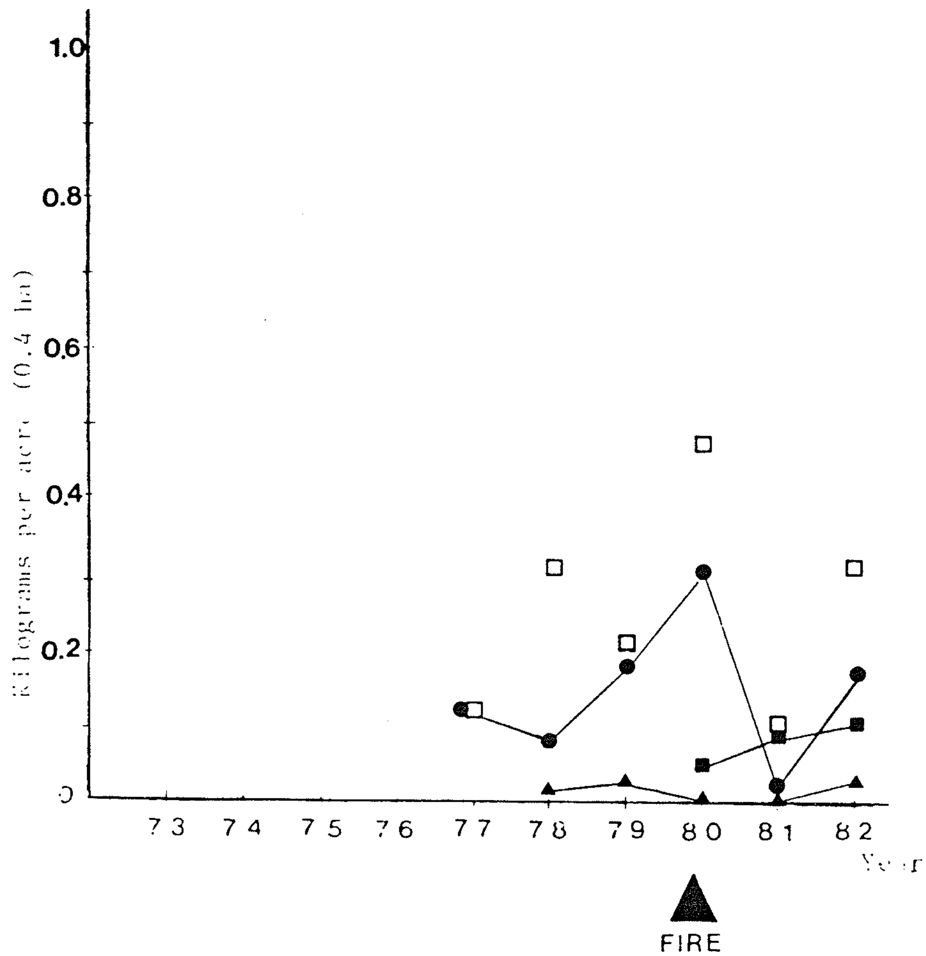


wet vegetation or cool burrows. The Black Spruce Bog adjacent to the Jack Pine Ridge plot was also subjected to a severe burn which left few if any food or cover resources available to any species. The fire occurred early enough in the 1980 season to allow regeneration of some vegetation. The low spots on the ridge would collect moisture and nutrients released by burning of organic matter. These factors would promote vigorous regrowth of vegetation. This new growth, available by the fall when trapping occurred, provides food for C. gapperi, an omnivore with herbivorous preferences (Banfield 1974). Sorex cinereus (Masked Shrew) numbers dropped in 1980 and again in 1981 but rebounded to pre-fire levels in 1982.

Small mammal biomass increased immediately after the fire, but declined sharply in the second post-fire year (Figure 4). P. maniculatus, which was not captured on this site prior to the fire, shows a continuous post-fire increase in biomass. Biomass estimates for C. gapperi and S. cinereus, three years after the fire, for the Jack Pine Ridge (Figure 4) are comparable to minimum pre-fire estimates.

Upper canopy, and young tree and shrub layer are illustrated by figures 5 and 5a. Trees burned beyond recognition are indicated by a question mark. Ground cover vegetation, summarized in Table 3, is found mostly in low spots on the ridge. Pre-fire data indicate this study plot

Figure 4: Jack Pine Ridge, comparison of small mammal biomass estimates obtained from trap data available to date.(300 trap nights)



▲ Sorex cinereus

● Clethriomonys gapperi

■ Peromyscus maniculatus

□ All species combined

Figure 5: Jack Pine Ridge -- Upper Canopy (UC)

5a: -- Young tree and shrub canopy (SC)

Live UC	Live SC	Dead	
●		○	Picea mariana
▲		△	Pinus banksiana
■	p	□	Populus tremuloides
S	s		Salix sp.

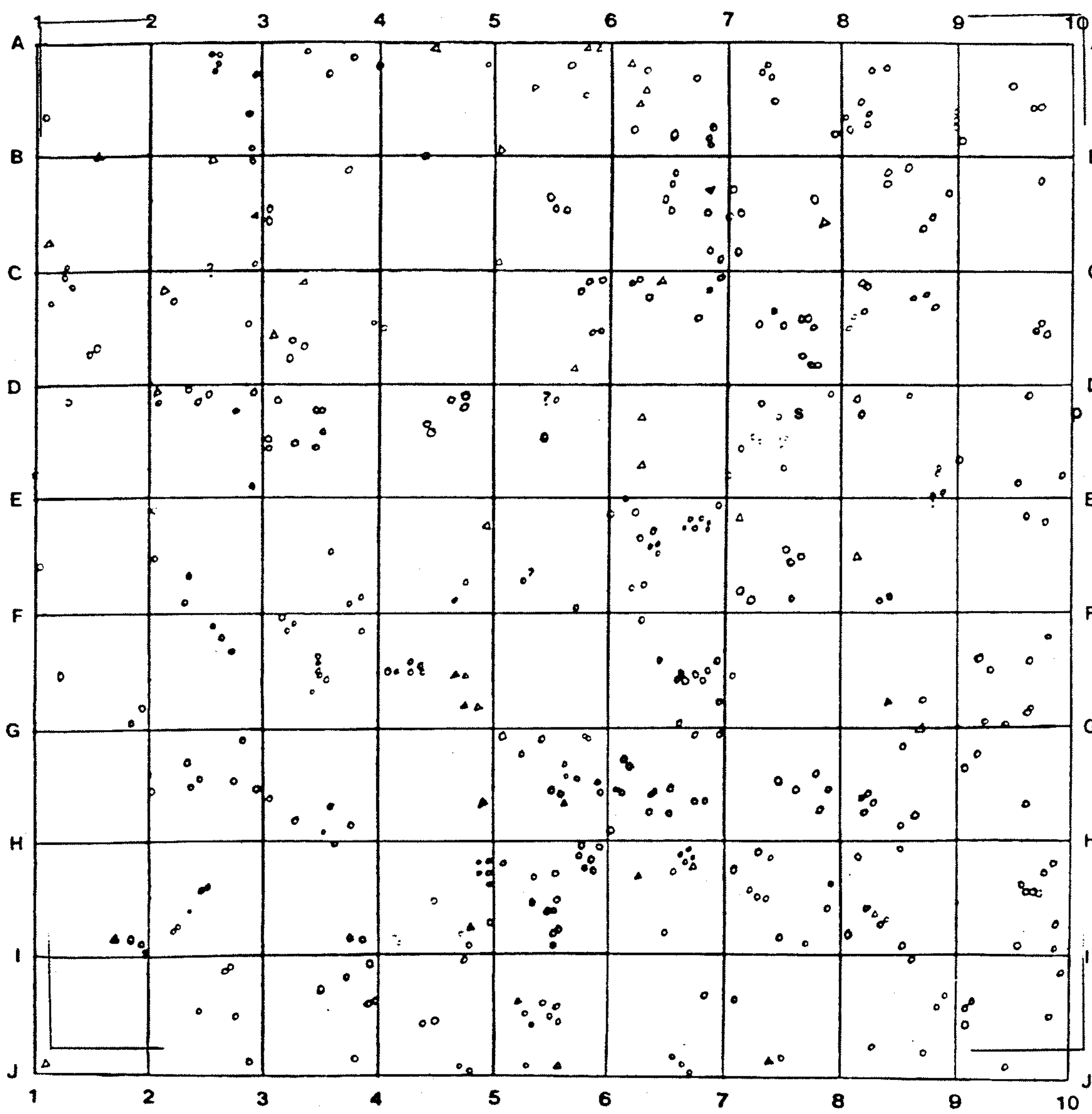

1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J
A B C D E F G H I J
1 2 3 4 5 6 7 8 9 10

Table 3: Jack Pine Ridge, ground cover vegetation determined from ¼ m^2 quadrats (n = 15)

Species	% Cover
Ceratadon purpureus	8.9
Aralia hispida	7.4
Epilobium angustifolium	4.1
Polytrichum sp.	2.1
Vaccinium spp. *	2.0
Populus tremuloides	1.7
Marchantia polymorpha	1.6
Polygonum cilinode	1.4
Pinus banksiana	1.1
Other species**	3.0
Litter	44.9
Fallen dead trees	3.3
Charcoal	2.3
Bare rock	15.5
Bare soil	0.7

* includes: V. augustifolium and/or V. myrtilloides

**includes: *Carex spp.* (2), *Picia mariana* (0.03%) *Ribes glandulosum*, *Rubus idaeus*, *Rubus chamaemorus*, *Ledum groenlandicum*, *Linnaea borealis*, *Chimaphila umbellata*.

had a fairly dense upper canopy of Pinus banksiana, Picea mariana, (Black spruce), and Picea glauca, (White spruce), all of which was lost in the fire. There was a shrub layer which covered approximately 5 percent of the plot, made up of Ledum groenlandicum, Arctostaphylos uva-ursi, Vaccinium sp., Diervilla lonicera, Juniperus sp., and Populus tremuloides. Currently V. angustifolium (and/or V. myrtillodes) and P. tremuloides cover 2.0, and 1.7 percent of the plot respectively. In 1976 herbaceous cover was less than 1 percent for each species, 4 percent of the plot was bare rock, 28 percent was litter, and about 70 percent of the ground cover is estimated to have been mosses and lichens. This contrasts with current data which indicate cover percentages of 15.5% bare rock, 48.2% litter, Ceratadon purpureus 8.9%, and other mosses 3.7%. Lichens and former bryophyte species are absent. Dominant post-fire colonizing species are C. purpureus, Epilobium angustifolium, and Polygonum cilinode.

Alder Jack Pine Ecotone

A total of 30 mammals (Table 1) were captured in 300 trap nights. The number of captures over a nine year period are compared in Figure 6, while Figure 7 shows small mammal biomass estimates since 1977.

The numbers of S. cinereus and Microtus pennsylvanicus (Meadow Vole) remained steady the fall after the fire. The third year after the fire (1982) S. cinereus numbers

Figure 6: Alder Jack Pine Ecotone, number of captures per 100 trap nights, for the most common species.

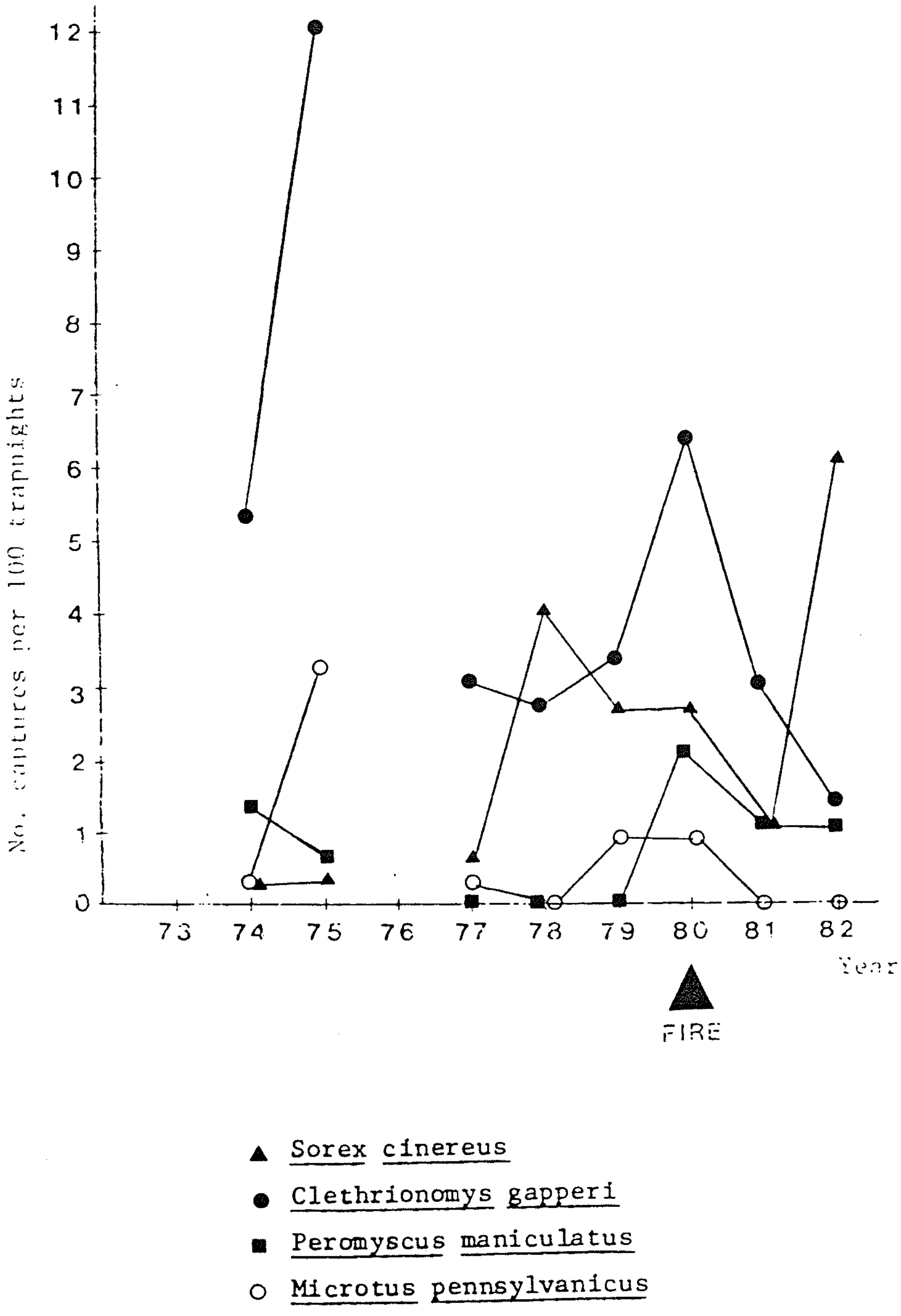
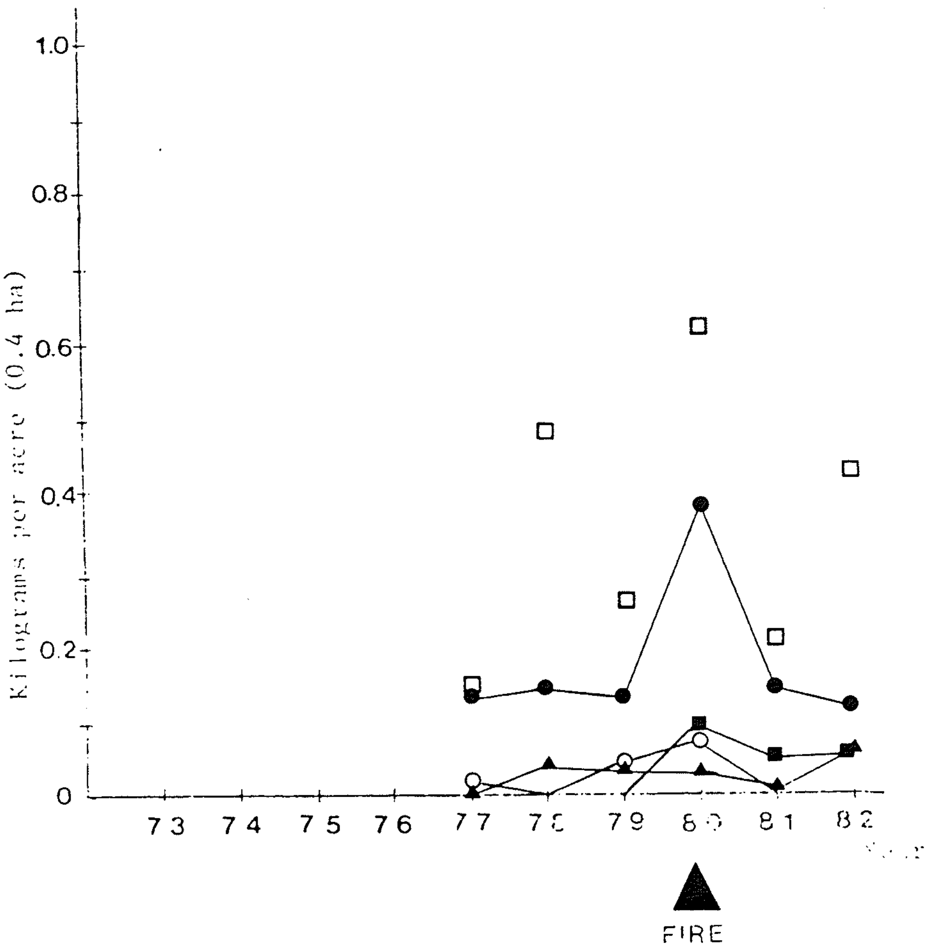


Figure 7: Alder Jack Pine Ecotone, comparison of small mammal biomass estimates obtained from trap data available to date (300 trap nights).



▲ Sorex cinereus

● Clethrionomys gapperi

■ Peromyscus maniculatus

○ Microtus pennsylvanicus

□ All species combined

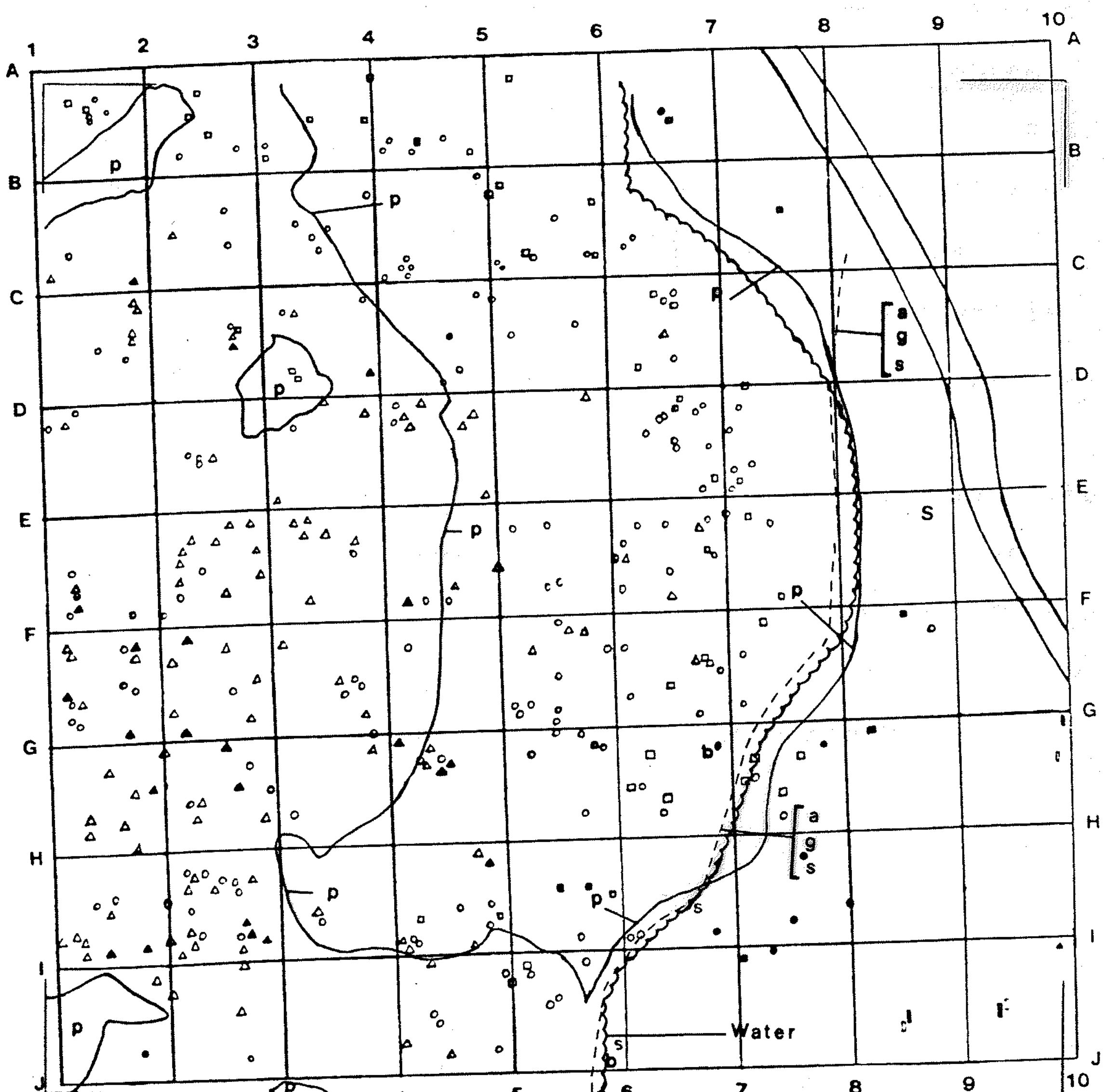
increased beyond previously recorded levels. Banfield (1974) indicates that populations of this species show marked fluctuations from year to year. M. pennsylvanicus has been absent from this plot since one year after the fire. P. maniculatus, which was absent from this plot from at least 1977, increased in number and in biomass immediately following the fire but one year later dropped back to minimum pre-fire levels and then showed a slight increase in biomass for 1982. C. gapperi numbers and biomass also increased immediately after the fire, but show a steady post-fire decrease leaving the current population below pre-fire minimum levels. Abundance of seeds and new growth again are postulated to be instigators in the increasing population of C. gapperi and P. maniculatus in the immediate post-fire season. Blarina brevicauda (Short-tailed Shrew) was captured twice on this plot. Four others were trapped on other plots and all sites were relatively wet, as is to be expected from reported habitat preferences (Banfield 1974, Kitchings and Levy, 1981, Fox 1983). Dueser and Shugart (1979) reported that B. brevicauda was frequently found on disturbed sites. During this study the moist fire sites and the Aikens Lake road proved to be the disturbed sites where this species was trapped.

Fire appears to have been less intense on this plot since a few upper canopy trees (Figure 8) have survived. The young tree and shrub layer (Figure 8a) along the edge of the

Figure 8: Alder Jack Pine Ecotone - Upper Canopy (UC)

8a: - Young tree and shrub canopy (SC)

Live		Dead	
UC	SC		
	a		*Alnus crispa*
	g		*Betula glandulosa*
B		b	*Betula papyrifera*
▮		▯	*Larix laricina*
●		○	*Picea mariana*
▲		△	*Pinus banksiana*
■	p	□	*Populus tremuloides*
S	s		*Salix sp.*



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Water

plot adjacent to the Alder Tamarack Bog plot was undoubtedly moist enough to resist serious fire damage. These species, and the Populus tremuloides and Diervilla lonicera (Table 4) on elevated areas of the plot are known to reproduce vegetatively from roots which have not been destroyed by fire (Wright and Heinselmann 1973, Carleton and Maycock 1980). Many herbaceous species are also common. Some of the wind disseminated "fugitive" species are Epilobium angustifolium and Petasites palmatus (Ahlgren 1960, 1974, Norum 1979, Johnson 1981). A residual seed bank likely accounts for some of the plants dependent on seeds for reproduction (Johnson pers. comm.) Animal dispersal is undoubtedly responsible for the presence of some species. Aralia nudicaulis berries were observed in bear scats adjacent to the Jack pine ridge plot. Small mammals often eat Polygonum spp., seeds (Johnson, Pruitt pers. comm.) A third reproductive strategy is illustrated by Jack Pine and Spruce which have larger, heavier seeds, relatively slow growth and delayed reproduction (Johnson and Rowe 1977).

Table 4: Alder Ridge Ecotone, ground cover vegetation determined from ¼ m^2 quadrats (m 41).

Species	% Cover
Ephilobium angustifolium	8.5
Sphagnum sp.	7.8
Other Bryophyts*	7.3
*Vaccinium sp.***	4.3
Diervilla lonicera	4.2
Rubus idaeus	3.8
Ledum groenlandicum	3.8
Cornus canadensis	2.8
Linnaea borealis	2.5
Clintonia borealis	2.2
Aralia nudicaulis	2.1
Fragaria virginiana	2.0
Polygonum cilinode	1.8
Viola sp.	1.7
Smilacina trifolia	1.6
Lichens	1.3
Maianthemum canadense	1.1
Petasites palmatus	1.0
Populus tremuloides (seedling)	1.0
Pinus banksiana	0.2
Picea sp.	0.1
Cyperaceae	5.6
Other species***	8.3
Litter	9.5
needle litter	6.1
fallen dead trees	1.7
charcoal	1.0
Tree root	1.9
Bare rock	2.5
Bare soil	0.7
Water	1.9

*includes: *Polytrichum sp.*, *Marchantia polymorpha*.

Table 4 cont'd

** includes: V. angustifolium, and V. myrtilloides.

*** includes: Vicia americana, Galium boreale, Rubus puvescens, V. caespitosum, V. vitis-idaea, Ribes triste, R. glandulosum R. oxyacanthoides, Equistem sp., Aralia hispida, Arctostaphylos uva-ursi, Campanula rotundifolia, Mitella nuda, Chimaphila umbellata, Pyrola minor, P. rotundifolia var americana, Trientalis borealis, Lycopodium spp., Alnus crispa (seedling), Betula gladulosa (seedling), Chamaedaphne calyculata, Potentilla parvifolia, Kalmia polifolia, Salix sp. (seedling), Geranium bicknellii, Oxycoccus microcarpus, Rhamus alnifolia, Rosa woodsii, Caltha palustris, Potentilla tridentata, Corydalis sempervirens.

Alder Tamarack Bog

Twenty small mammals were trapped during the 300 trap nights (Table 1). Figures 9 and 10 compare number of captures per 100 trap nights, and biomass estimates, respectively, of small mammal populations at this specific site for the years from which data are available. *C. gapperi* and *S. cinereus* populations show marked fluctuations in number and in biomass, with peaks for both species in 1980, however these are not the maxima recorded for either species. *C. gapperi* numbers and biomass show a steady post-fire decline. Fluctuations are normal for these two species (Banfield 1974) and no definite effects of the fire are apparent. Three *M. pennsylvanicus* were trapped on this plot in 1979, and one in 1980, but this species has not been captured on any of the study plots since the year of the fire. It is possible that this species was not able to withstand the post-fire competition for resources.

The 1982 biomass estimates for this plot (Figure 10) are below pre-fire values. This is most probably due to the *C. gapperi* component of the population which was at an all time low (Figure 9). *P. maniculatus*, a species rarely seen on this plot, prefers habitat conditions drier than those available within this plot (Banfield 1974). Because of their small size, the high number of *S. cinereus* captures does not inflate the biomass values.

Figure 9: Alder Tamarack Bog, number of captures per 100 trap nights for the most common species.

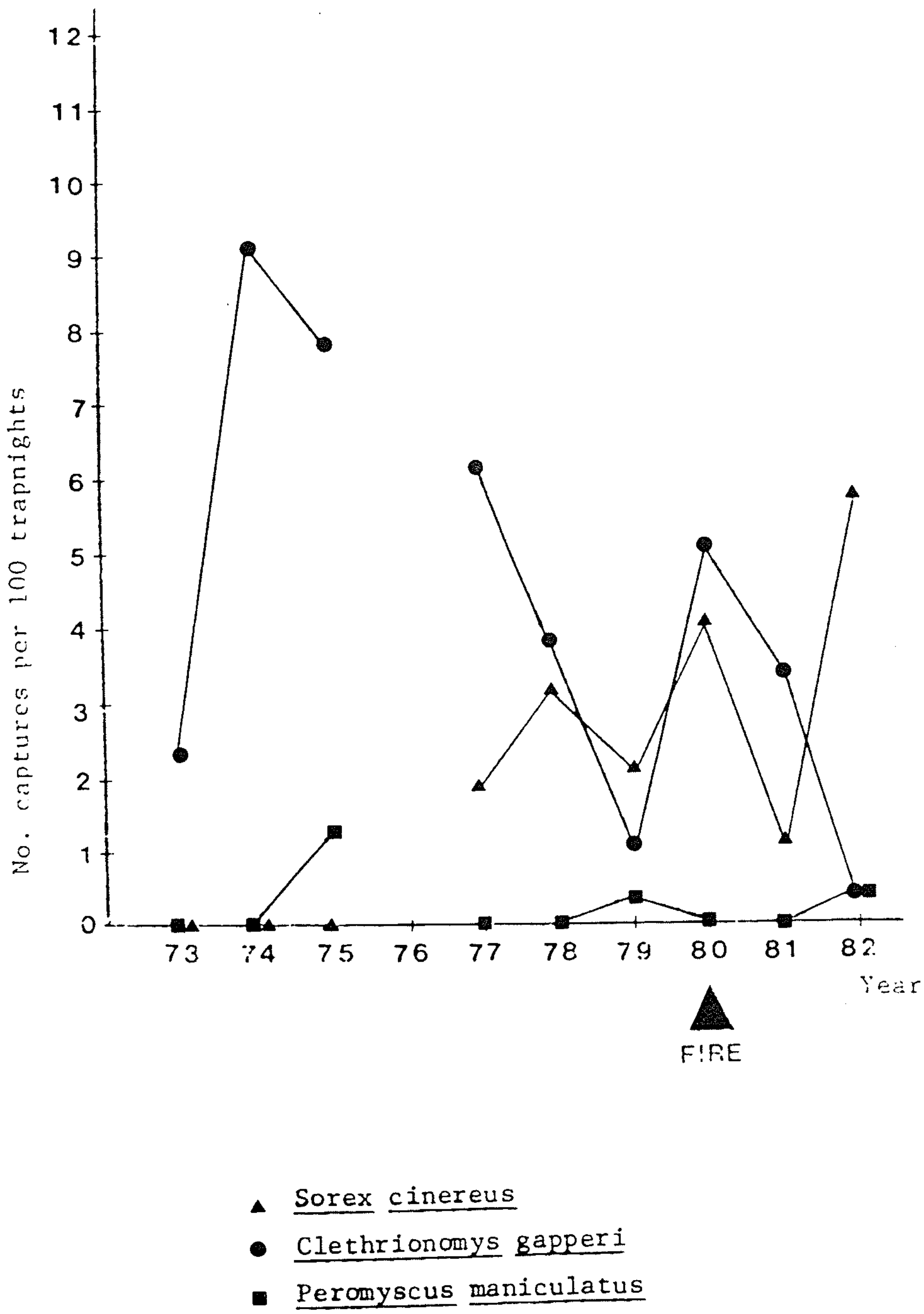
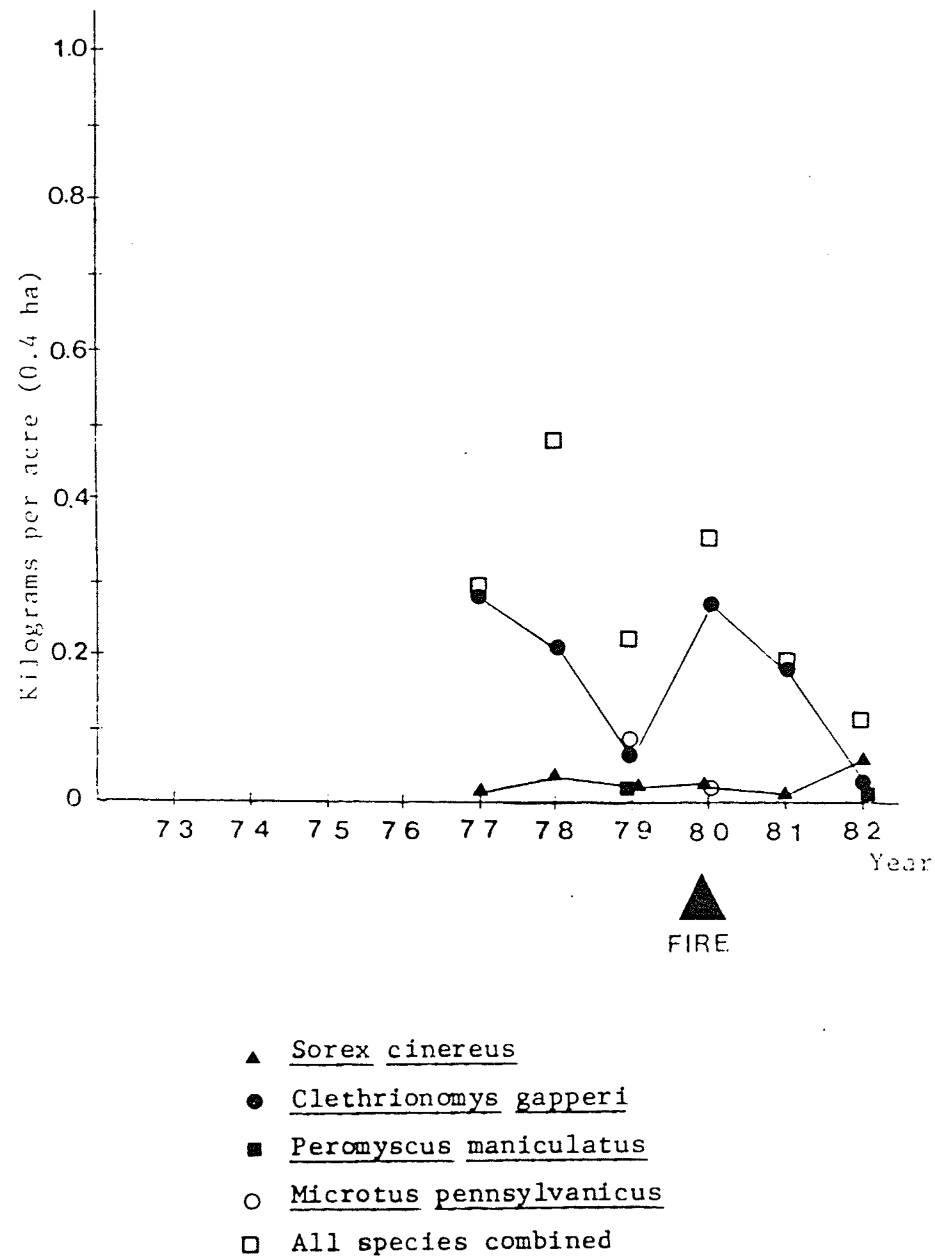


Figure 10: Alder Tamarack Bog, comparison of small mammal biomass estimates obtained from trap data available to date (300 trap nights).



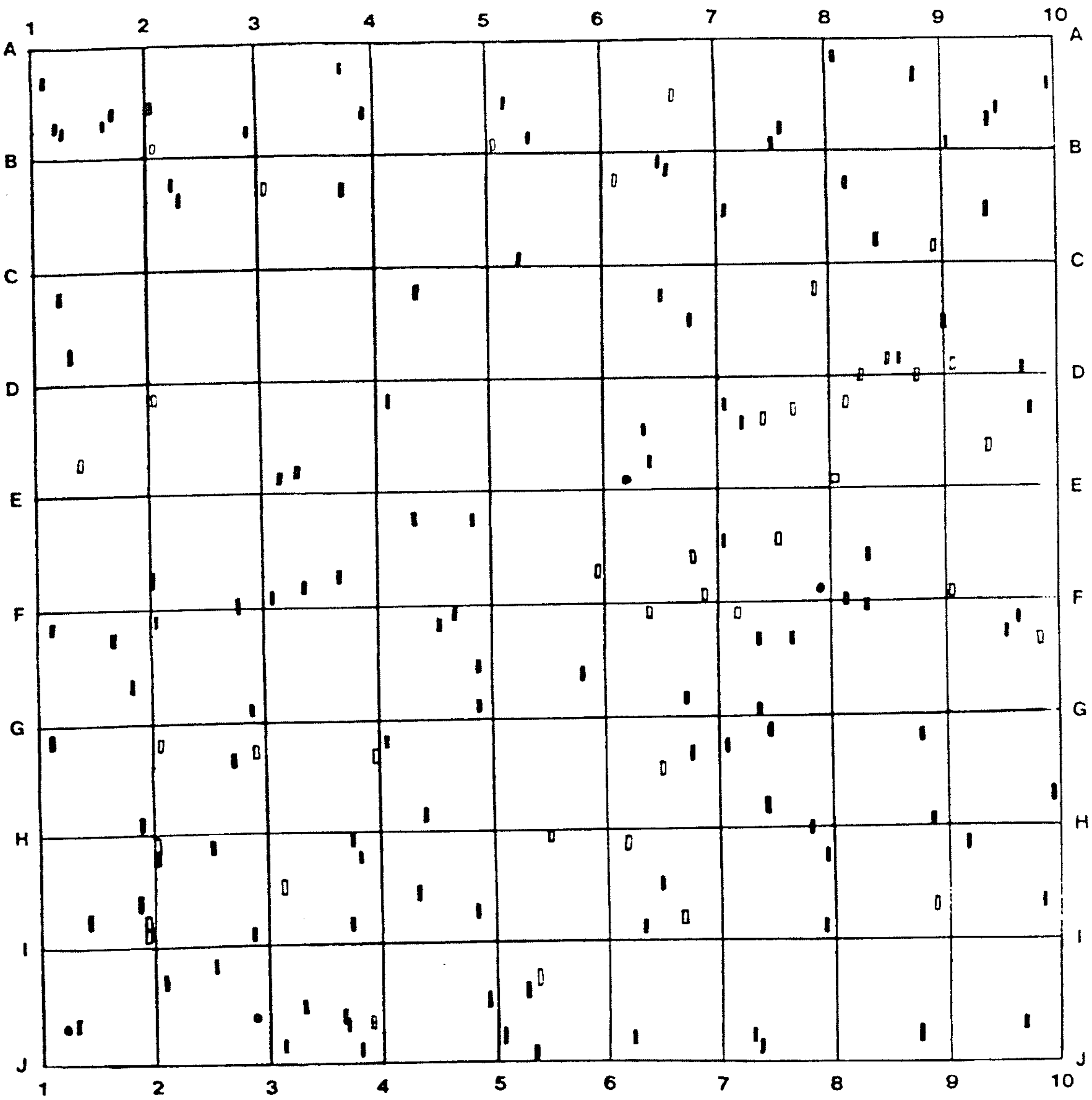
The upper canopy map is found in Figure 11. *Alnus crispa* and *Betula glandulosa* cover is dense and uniform throughout the plot. Table 5 lists the ground cover vegetation of which *Sphagnum sp.*, and *Ledum groenlandicum* are dominant.

There was no evidence visible in 1982 that this plot suffered fire damage. Comparison of vegetation data show relatively no change. The wet sphagnum/water substrate and late spring/early summer favourable moisture conditions would preclude fire in this type of habitat. This habitat undoubtedly provides valuable refuge from fire and its initial after effects.

Figure 11: Alder Tamarack Bog -- Upper Canopy

Live	Dead	
I	[	*Larix laricina*
o	o	*Picea mariana*

Note: The shrub layer on this plot consists of a dense uniform cover of *Alnus crispa* and *Betula glandulosa* extending over the entire plot.



1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J

Table 5: Alder Tamarack Bog, ground cover vegetation determined by ¼ m^2 quadrats (n = 14).

Species	% Cover
Sphagnum sp.	26.9
Ledum groenlandicum	21.7
Chamaedaphne calyculata	9.5
Smilacina trifolia	5.9
Carex spp. (3)	3.8
Lichen (s)	1.8
Viola spp. (2)	1.3
Trientalis borealis	1.0
Other spp.*	2.9
Litter	4.2
Needle litter	0.4
fallen dead trees	1.8
stump	1.4
Water	11.7

* includes: *Betula glandulosa*, *Potentilla palustris*, *Ribes glandulosum*, *Kalmia polifolia*, *Equisetum sp.*, *Oxycoccus microcarpus*.

Jack Pine Sand Plain

Only four *P. maniculatus* and one *Tamiasciurus hudsonicus* (Red Squirrel) were captured in 300 trap nights. Comparisons, over time, of the number captured, and biomass estimates are included in Figures 12 and 13, respectively. *P. maniculatus* captures for 1980 doubled the previously recorded maximum number, and biomass values increased accordingly,, but by 1982 numbers fell back to pre-fire levels. The increased availability of seed food due to the fire-release of Jack Pine seeds again accounts for high post-fire *P. maniculatus* populations. In the year of the fire *C. gapperi* and *S. cinereus* populations were similar to previous years, and have not been trapped on this site in post-fire years. Small mammal biomass estimates from 1982 are similar to before fire estimates, with *P. maniculatus* populations showing a continuous decline from the 1980 maximum. The *T. hudsonicus* captured on the edge of the study plot, adjacent to an unburned patch of forest, contributes to a three fold increase in biomass estimates when all species are combined. Cover resources are limited on this flat well drained plot with relatively uniform and sparse ground vegetation. This factor results in smaller populations of species dependent on cover for survival (Fox 1983).

The upper canopy map is shown in Figure 14 and the negligible young tree and shub canopy higher than 1 meter in

Figure 12: Jack Pine Sand Plain, number of captures per 100 trap nights for the most common species.

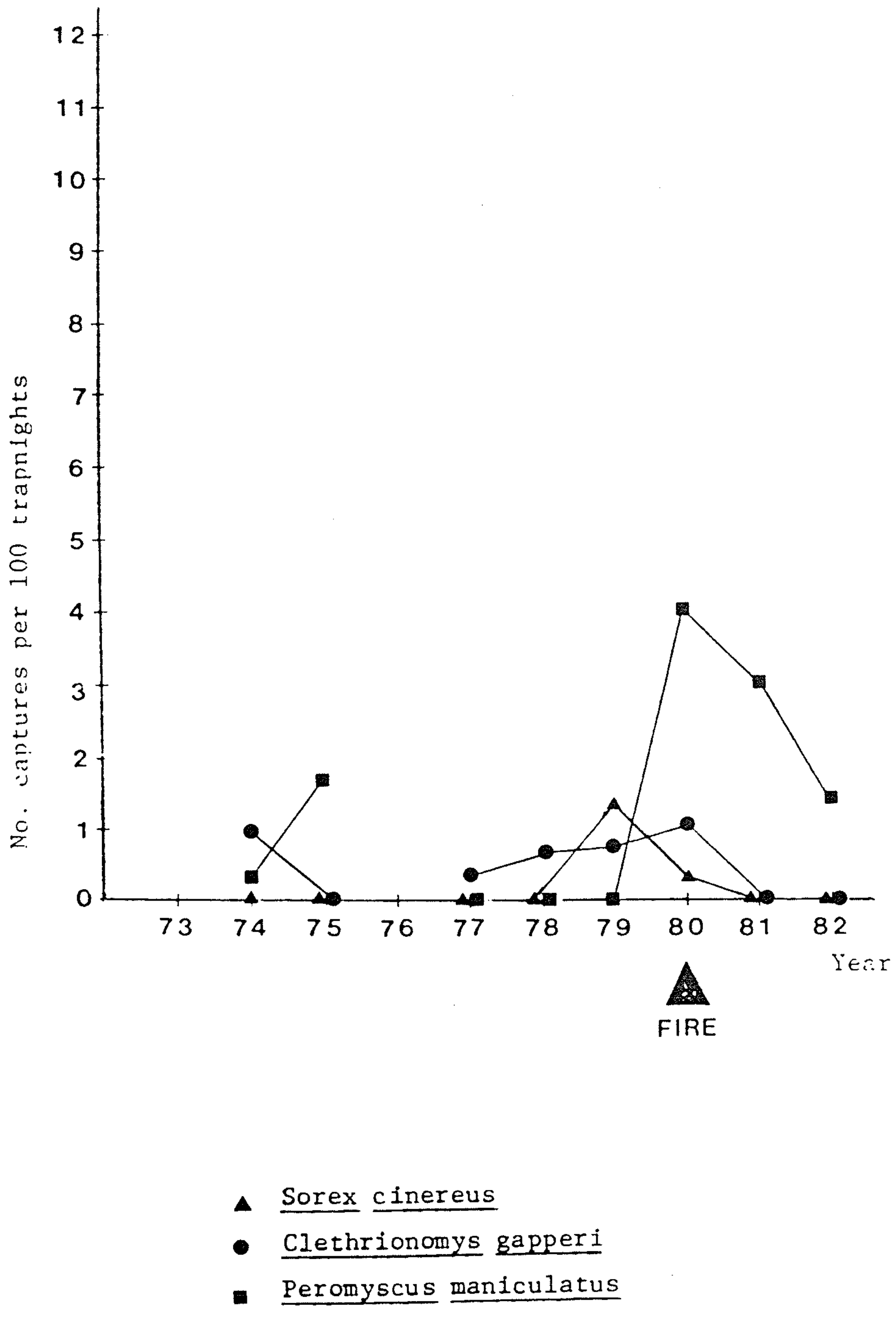
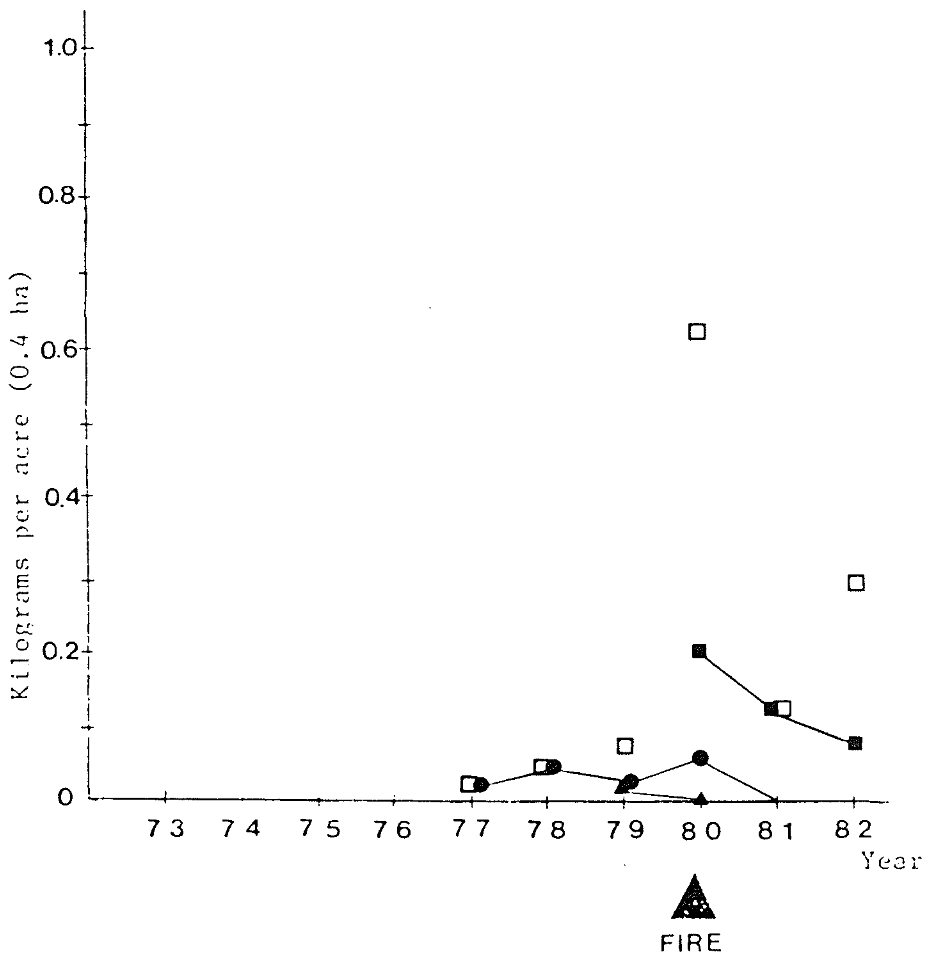


Figure 13: Jack Pine Sand Plain, comparison of small mammal biomass estimates obtained from trap data available to date (300 trap nights).



▲ *Sorex cinereus*

● *Clethrionomys gapperi*

■ *Peromyscus maniculatus*

□ All species combined

Figure 14: Jack Pine Sand Plain -- Upper Canopy (UC)

14a: -- Young tree and shrub canopy (SC)

Live		Dead	
UC	SC		
F		f	<u>Abies balsamea</u>
	a		<u>Alnus crispa</u>
▲		△	<u>Pinus banksiana</u>
●		○	<u>Picea mariana</u>

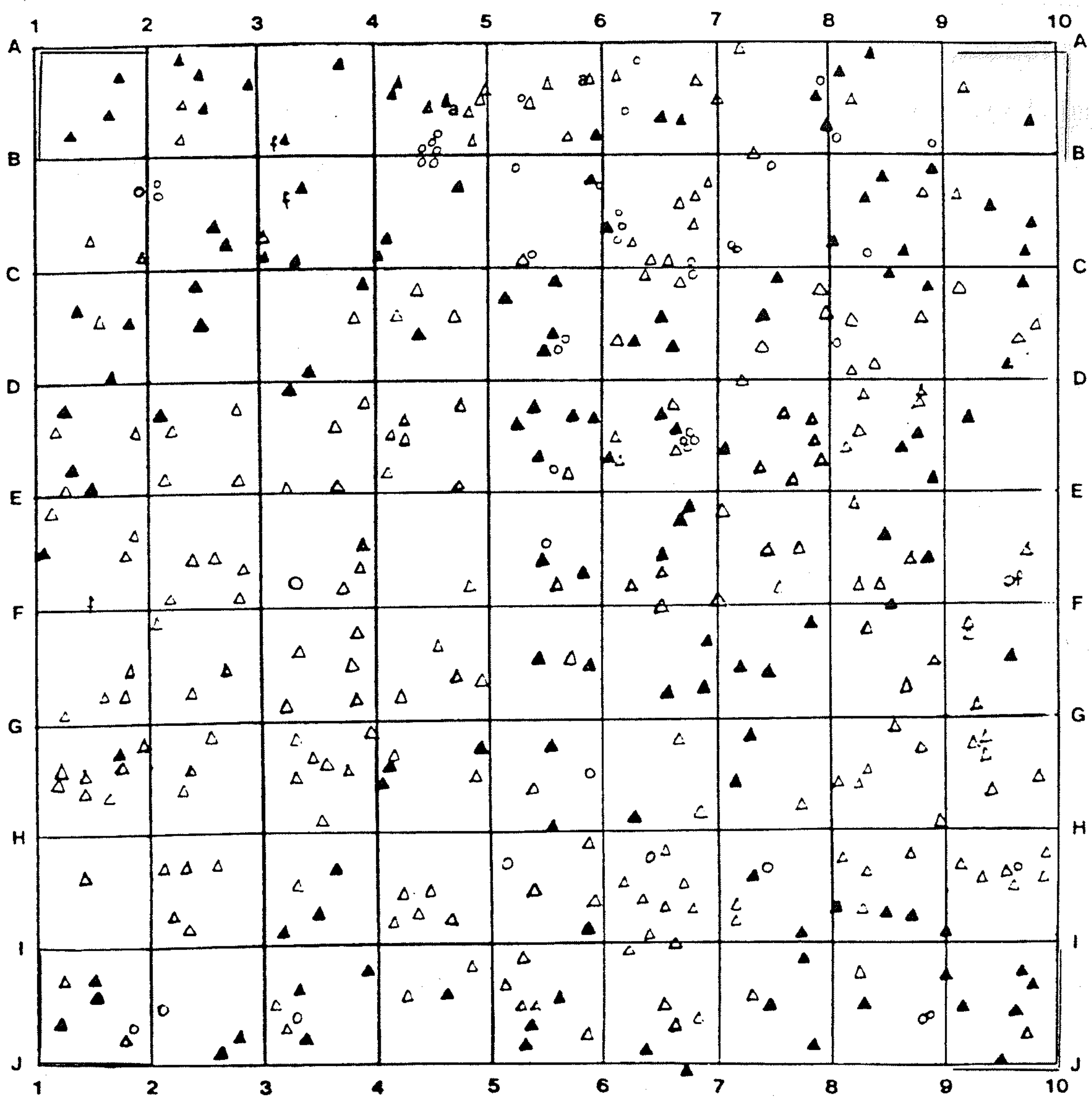

1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J

Figure 14a. About one third of the upper canopy survived the fire. There is a visible change in ground vegetation (Keleher pers. comm) in that lichens and most mosses are now absent. The only lichen species found in 1982 were on dead branches that appear to be post-fire additions to the litter. Table 6 summarizes the ground cover vegetation, with the residual *Vaccinium sp*. being dominant. *Apocynum sp*. and several other species were quite likely present before the fire. *V. vitis-idaea* and *Ledum groenlandicum* are pre-fire species not recorded in 1982.

Table 6: Jack Pine Sand Plain, ground cover vegetation determined from ¼ m^2 quadrats (n = 15)

Species	% Cover
*Vaccinium spp.**	17.5
Apocynum sp. (i)	3.5
Maianthemem canadense	3.2
Lichen (on litter)	2.5
Arctostaphylos uva-ursi	2.1
Carex sp.	1.4
Polytrichum sp.	1.0
Pinus banksiana	0.5
Other species**	1.9
Litter	8.1
Needle litter	32.7
fallen dead trees	6.3
charcoal	2.8
Bare Soil	15.9

* includes: *V. angustifolium* and/or *V. myrtilloides*.

** includes: *Cornus canadensis*, *Linnaea boreals*, *Potentilla tridentata*, *Chimaphila umbellata*, *Solidago sp.*, *Galium boreale*, *Graminae* (1 sp). *Campanula rotundifolia*, *Lycopodium sp*, *Cypripedium acaule*.

Black Spruce Bog

Productivity of this Plot is usually relatively low, and five small mammals were trapped in 1982. Current data with respect to number captured and biomass estimates are compared with past data in Figure 15 and 16 respectively. In the early 1970's the numbers of *C. gapperi* captured ranged from 3.3 to 5.3 per 100 trap nights, dropped dramatically by 1977, and this species has been absent since the fire. *P. maniculatus* is a post-fire invader and *S. cinereus* populations continue to fluctuate. The very intense fire and consequent loss of all vegetation on this site is assumed to be responsible for the lack of captures from 1980 trapping activities.

The *Picea mariana* growth habit allows fire access to all vegetation layers, hence destruction of the site was virtually complete despite expected favourable moisture conditions. Much of the *Sphagnum* substrate was burned and most of the remainder succumbed to intense heat. The upper canopy consists totally of charred Black Spruce remains (Figure 17). There are no shrubs over 1 meter in height, but the low shrub *Ledum groenlandicum* is the dominant vegetation as per Table 7. Trails along trap grids are evident and this compression of *Sphagnum* into low strips allowed survival of residual species. These areas also provide moisture conditions essential to current vegetation, most of which is composed of residual species. There is an

Figure 15: Black Spruce Bog, number of captures per 100 trap nights for the most common species.

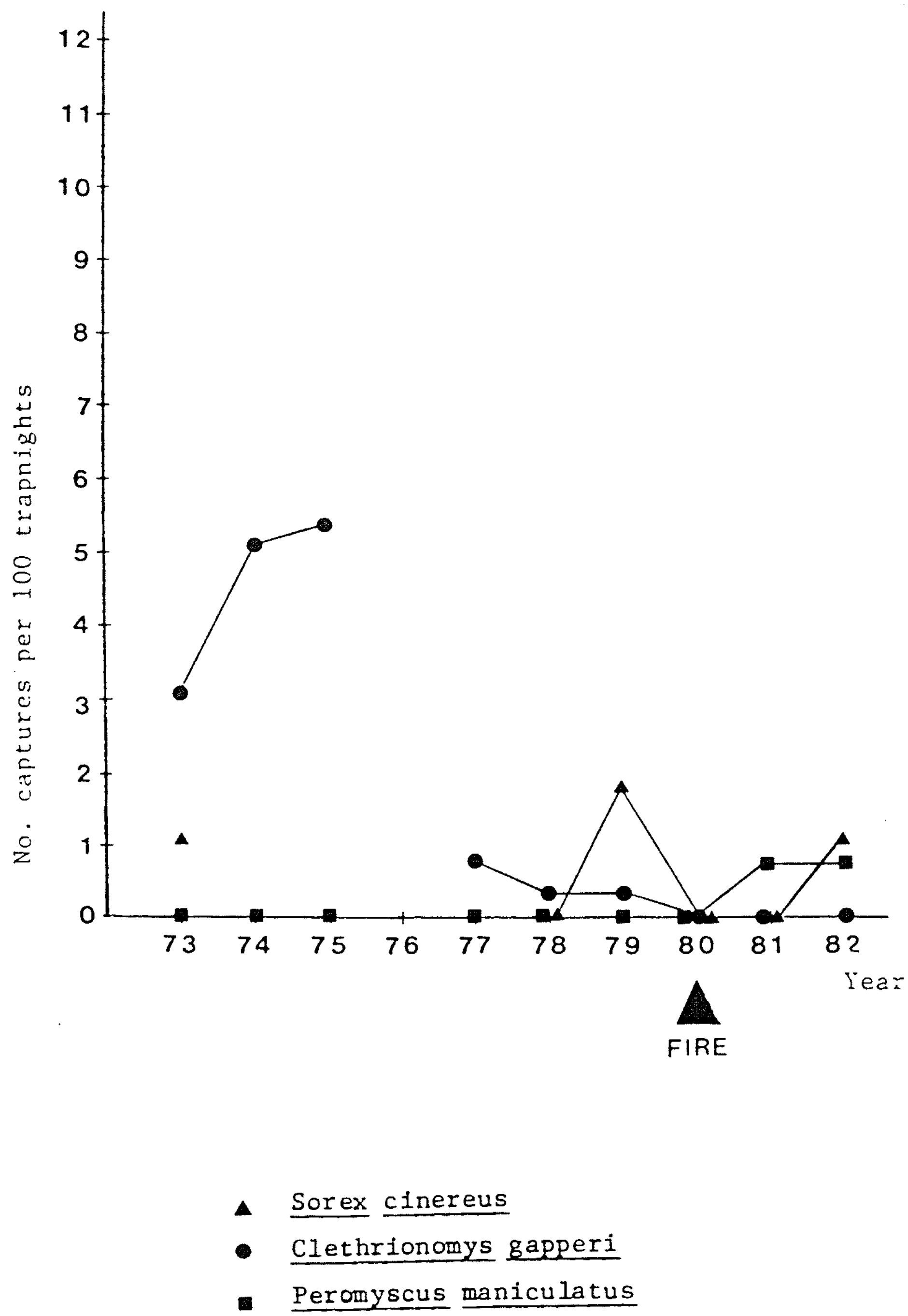
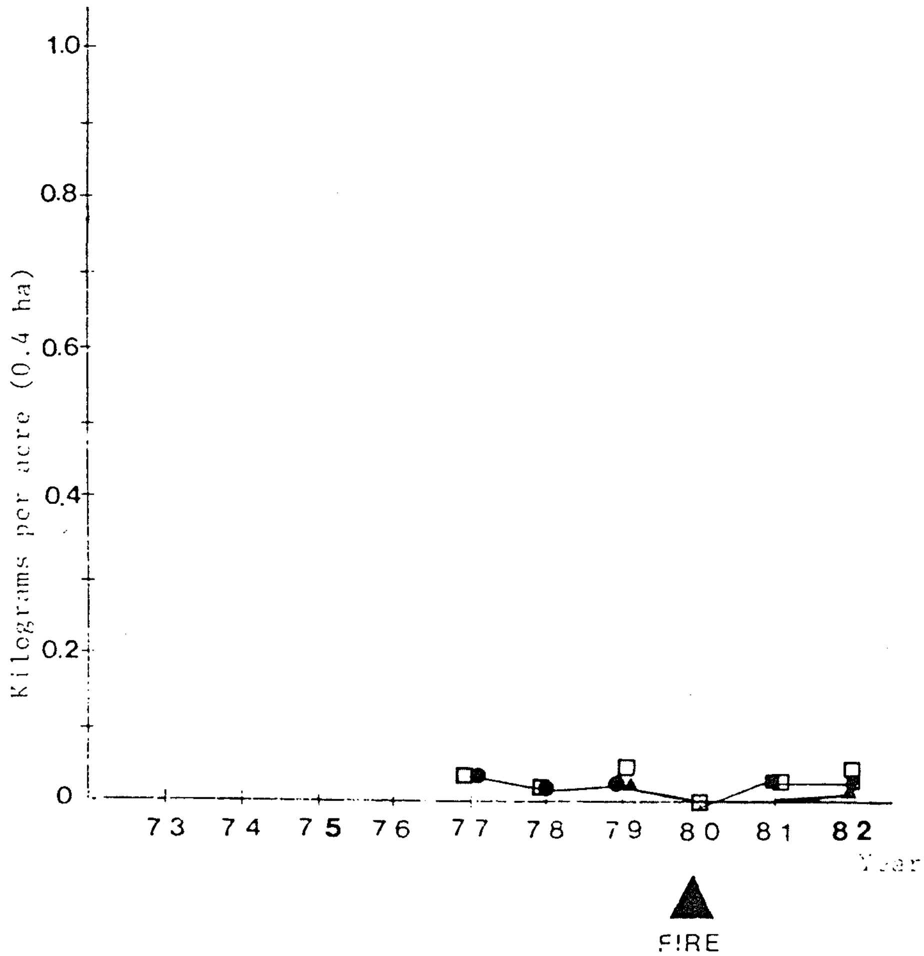


Figure 16: Black Spruce Bog, comparison of biomass estimates obtained from trap data.



▲ Sorex cinereus

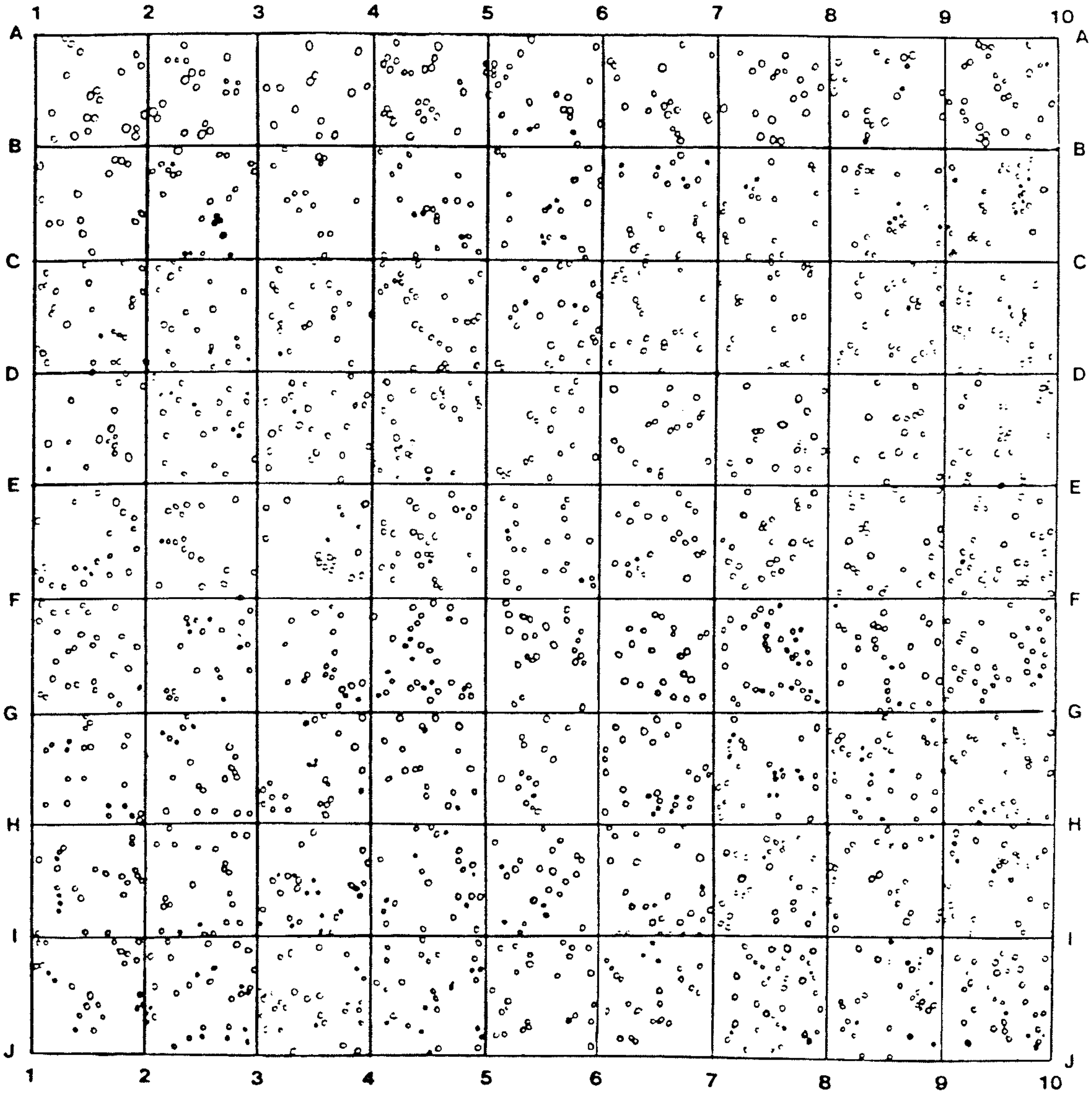
● Clethrionomys gapperi

■ Peromyscus maniculatus

□ All species combined

Figure 17: Black Spruce Bog -- Upper Canopy

Live	Dead	
●	○	*Picea mariana*



1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J

Table 7: Black Spruce Bog, ground cover vegetation determined by ¼ m^2 quadrats (n = 15).

Species	% Cover
Ledum groenlandicum	14.7
Smilacina trifolia	6.5
Sphagnum sp.	2.7
Marchantia polymorpha	2.0
Vaccinium vitis-idaea	1.3
Oxycoccus microcarpus	1.1
Populus tremuloides (seedlings)	0.8
Picea mariana (seedlings)	0.4
Other Bryophyta	6.5
(small brown moss 4.9 *Polytrichum* sp. 0.7)	
Other species*	1.8
Litter	1.6
fallen dead trees	3.1
charcoal (incl. burned sphagnum)	43.1
dense heat killed Sphagnum mat	15.1

* includes: *Epilobium angustifolium*, *Rubus chamaemorus*, *Chamaedaphne calyculata*, *Kalmia polifolia*, *Chimaphila umbellata*, *Rubus idaeus*, *Pinus banksiana*, *Eriophorum sp.*, "Mushroom" fungi,

approximate ten fold decrease in *Sphagnum sp.*, since the fire, and charcoal covers 43 percent of the ground.

Aspen Upland

Eighteen small mammals and three *Glaucomys sabrinus* (Flying Squirrel) were trapped, and these numbers are compared with nine other years data in Figure 18. As in several other plots *P. maniculatus* increased in number and therefore in biomass also, in the year of the fire, again likely due to seed availability. *C. gapperi* and *S. cinereus* populations fluctuate, with both species continuing a decrease before and after the fire. *S. cinereus* rebounded in 1982, 3 years after the fire. *Microtus pennsylvanicus* increased in 1980 but not in excess of the pre-fire maximum (1974), and again shows a post-fire absence.

Figure 19 shows 1982 biomass estimates to be greater than pre-fire estimates. Current estimates are similar to pre-fire values if *G. sabrinus* weights are excluded.

Upper canopy and young tree and shrub layer for the Aspen Upland plot are illustrated by Figures 20 and 20a. *Diervilla lonicera* is the most common ground vegetation followed by *Fragaria virginiana*. *Diervilla lonicera* and many of the species listed in Table 8 commonly reproduce vegetatively by root suckers, and this is presumed to have allowed for post-fire recovery. *Fragaria virginiana* may have been transported to the site by animals or a residual seed bank my have ensured recovery of this species.

Figure 18: Aspen Upland, number of captures per 100 trap nights for the most common species

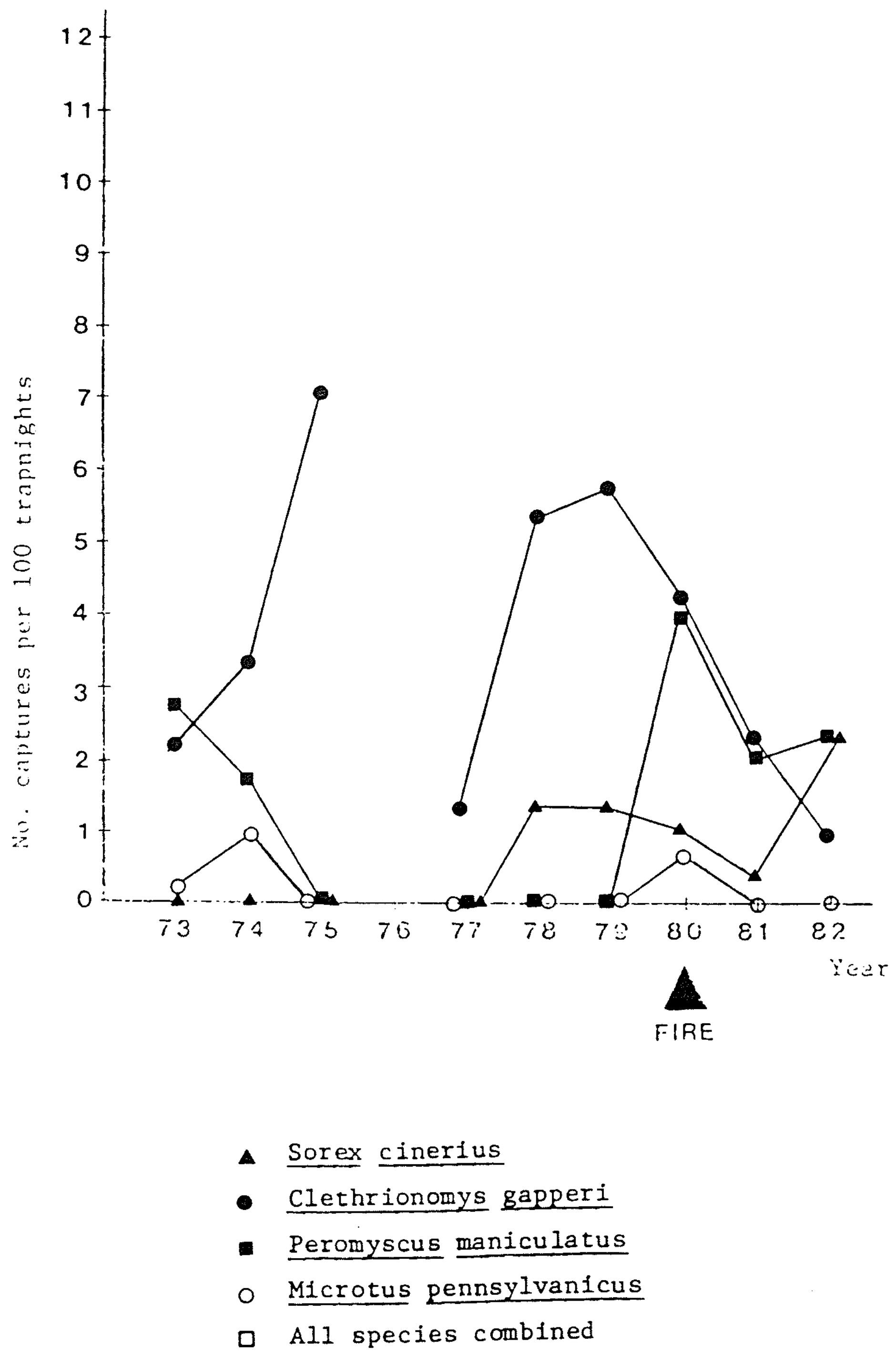


Figure 19: Aspen Upland, comparison of small mammal biomass estimates obtained from trap data available to date (300 trap nights).

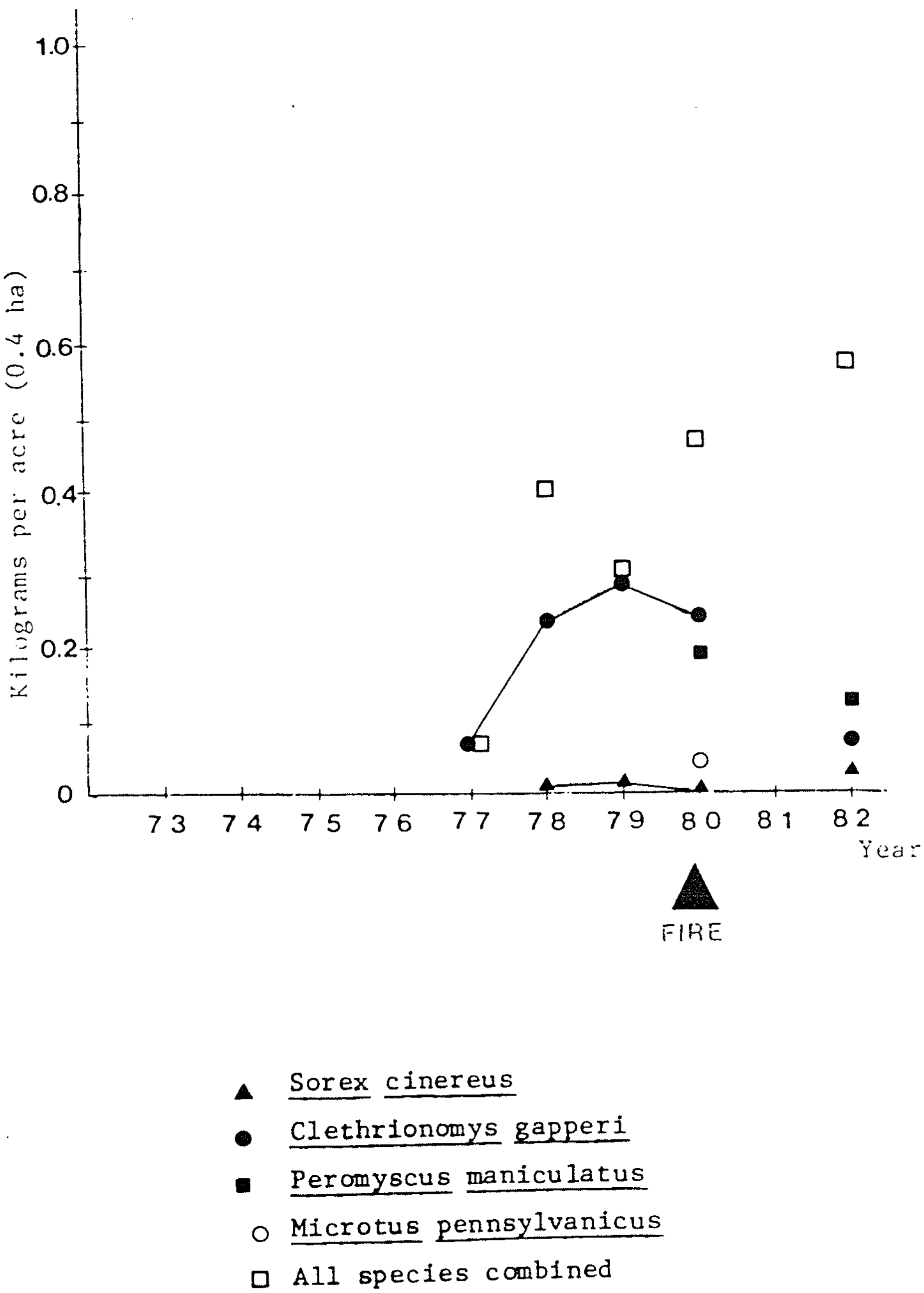
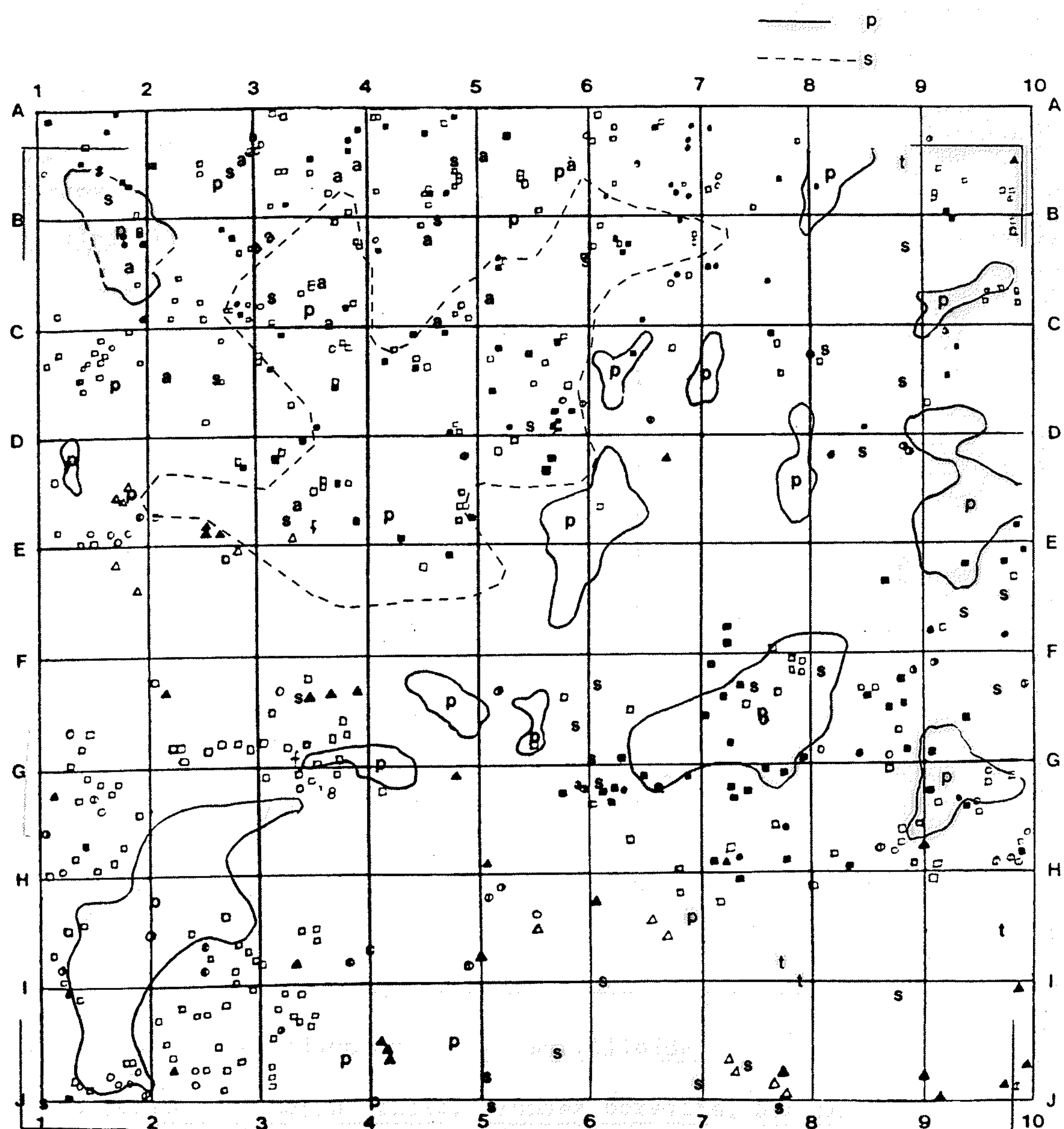


Figure 20: Aspen Upland -- Upper Canopy (UC)

20a: -- Young tree and shrub canopy (SC)

Live		Dead	
UC	SC		
F		f	*Abies balsamea*
	a		*Alnus crispa*
	t		*Amelanchier alnifolia*
◑		⦶	*Picea glauca*
○		○	*Picea mariana*
▲		△	*Pinus banksiana*
■	p	□	*Populus tremuloides*
S	s		*Salix sp.*



p
s
1 2 3 4 5 6 7 8 9 10
A B C D E F G H I J

Table 8: Aspen Upland, ground cover vegetation determined by ¼ m^2 quadrats (n = 15).

Species	% Cover
Diervilla lonicera	18.0
Fragaria virginiana	7.5
Lichen (mostly on rock)	6.5
Apocynum sp. (i)	3.6
Vaccinium spp.*	3.5
Potentilla tridentata	3.1
Vicia americana	2.9
Amelanchier alnifolia	2.3
Aster cordifolius	2.0
Apocynum sp. (ii)	1.9
Arctostaphylos uva-ursi	1.7
Other Bryophyta (incl. Polytrichum sp.)	1.7
Maianthemem canadense	1.6
Rubus ideaus	1.3
Aralia nudicaulis	1.2
Populus tremuloides	1.0
Graminae (6 sp)	5.9
Cyperaceae (1 sp)	3.7
Other spp.**	
Litter	13.7
Needle litter	5.6
charcoal	0.3
Water***	5.3
Bare rock	4.5

* includes: V. angustifolium and/or V. myrtilloides.

** includes: Campanala rotundifolia, Linnaea borealis, Sonchus sp., Vaccinium caespitosum, Trientalis boreale, Galium boreale, Pyrola sp., Rosa woodsii, Epilobium angustifolium, Polygonum cilinode, Solidago sp., Spirea alba, Geranium bicknellii.

*** Rain overnight prior to data collection may have inflated the percentage of ground covered with water.

This is the only plot examined that has significant lichen ground cover. Lichens were virtually all crustose, on rocks. It appears that the fire was intermittent over this area since ridges covered with crustose lichens escaped burning. Most species observed appear to be residual and post-fire differences are limited to changes in the upper canopy and charcoal.

Black Spruce Tamarack Bog

This plot was established in 1978 (by M. Raine) and data are only available for 4 years. The plot was not burned and served as a refuge from the fire's destructive influence. This is shown by the fact that *T. hudsonicus* and *G. sabrinus* were trapped on this plot in 1980, although vegetation on this plot differs from that of the preferred habitat for these two species of squirrels. Figure 21 compares the number of small mammals trapped for that time period, and biomass estimates are illustrated by Figure 22. *C. gapperi* showed a dramatic population increase in 1980, and increased again slightly in 1982. *S. cinereus* population estimates for 1982 are greater than 3 times those previously recorded. This moist plot with dense ground cover vegetation provides the preferred habitat for *C. gapperi* and *S. cinereus* (Banfield 1974). *P. maniculatus* has also been absent from this plot since the fire.

Figure 21: Black Spruce Tamarack Bog, number of captures per 100 trap nights for the most common species

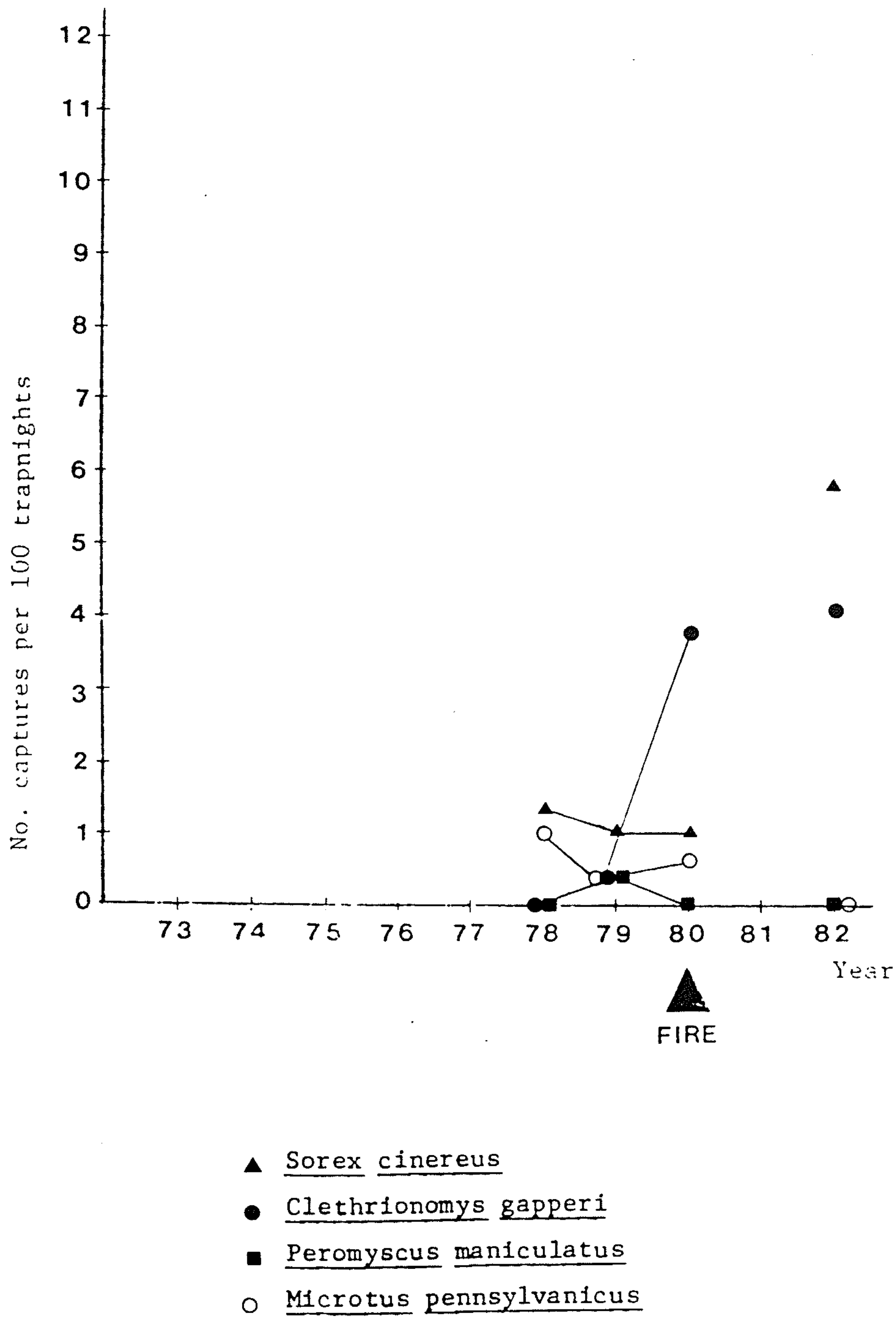
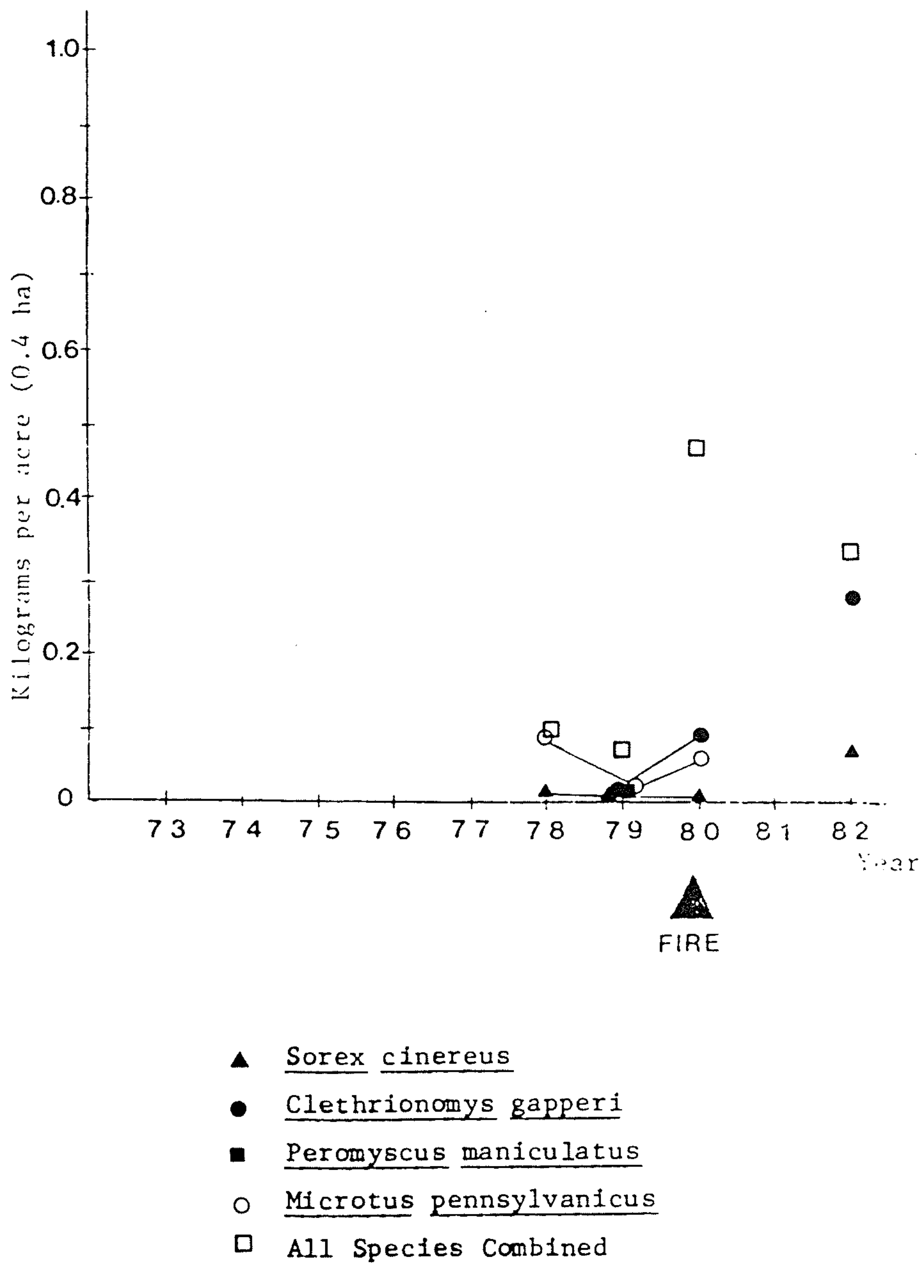


Figure 22: Black Spruce Tamarack Bog, comparison of small mammal biomass estimates obtained from trap data available to date (300 trap nights).



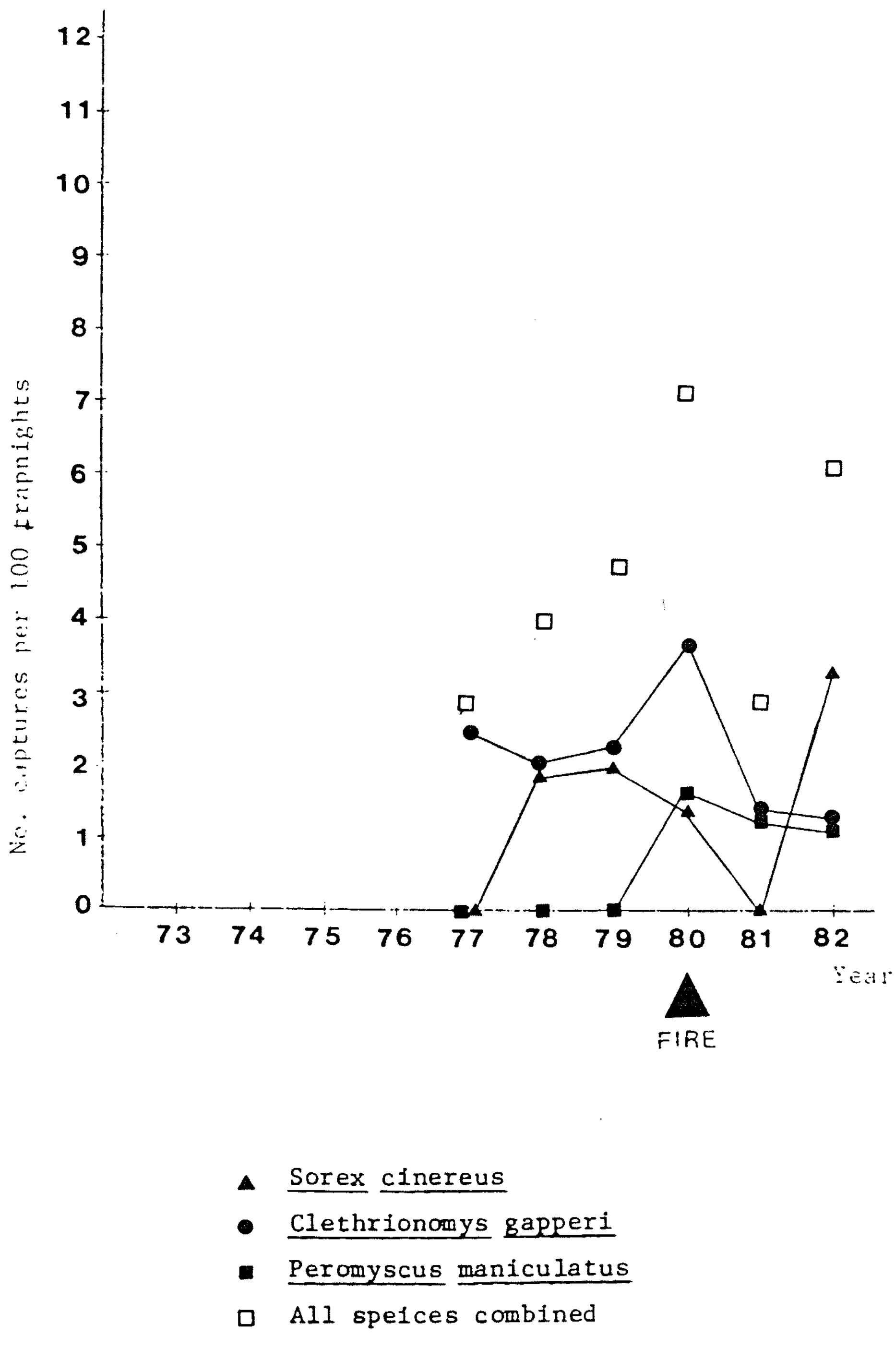
Biomass estimates for 1982 are above pre-fire values. *M. pennsylvanicus* was an important species in 1978 and occurred in 1979 and 1980 but was not recorded in 1982. Biomass data for 1981 are not available.

No vegetation data were collected from this plot but it can be described as a moderately open bog with a *Sphagnum sp.*, substrate. Black Spruce and Tamarack provide a moderately open upper canopy while the shrub layer consists of *Betula glandulosa*, *Chamedaphne calyculata* and *Salix sp.* Other species on the plot include: Cyperaceae species, *Equisetum sp.*, *Oxycoccus microcarpous*, *Andromeda polifolia* and *Vaccinium vitis-idaea*.

All habitats combined

Data from all study plots were combined. The number of captures per 100 trap nights was calculated and these values are illustrated in Figure 23. *C. gapperi* and *P. maniculatus* increased in number in 1980 while *S. cinereus* showed a slight decline to give an overall increase in total number of all species combined. In 3 of the plots *P. maniculatus* was not trapped before the fire. All specific populations decreased in 1981. *S. cinereus* populations increased above previous records in 1982. while *C. gapperi* and *P. maniculatus* continued with a slight decrease in 1982. *C. gapperi* numbers are slightly below the pre-fire minimum record. The 1982 number of captures per 100 trap nights for all species combined was exceeded only by the 1980 value.

Figure 23: All habitats combined, number of captures per 100 trap nights for the commonest species.

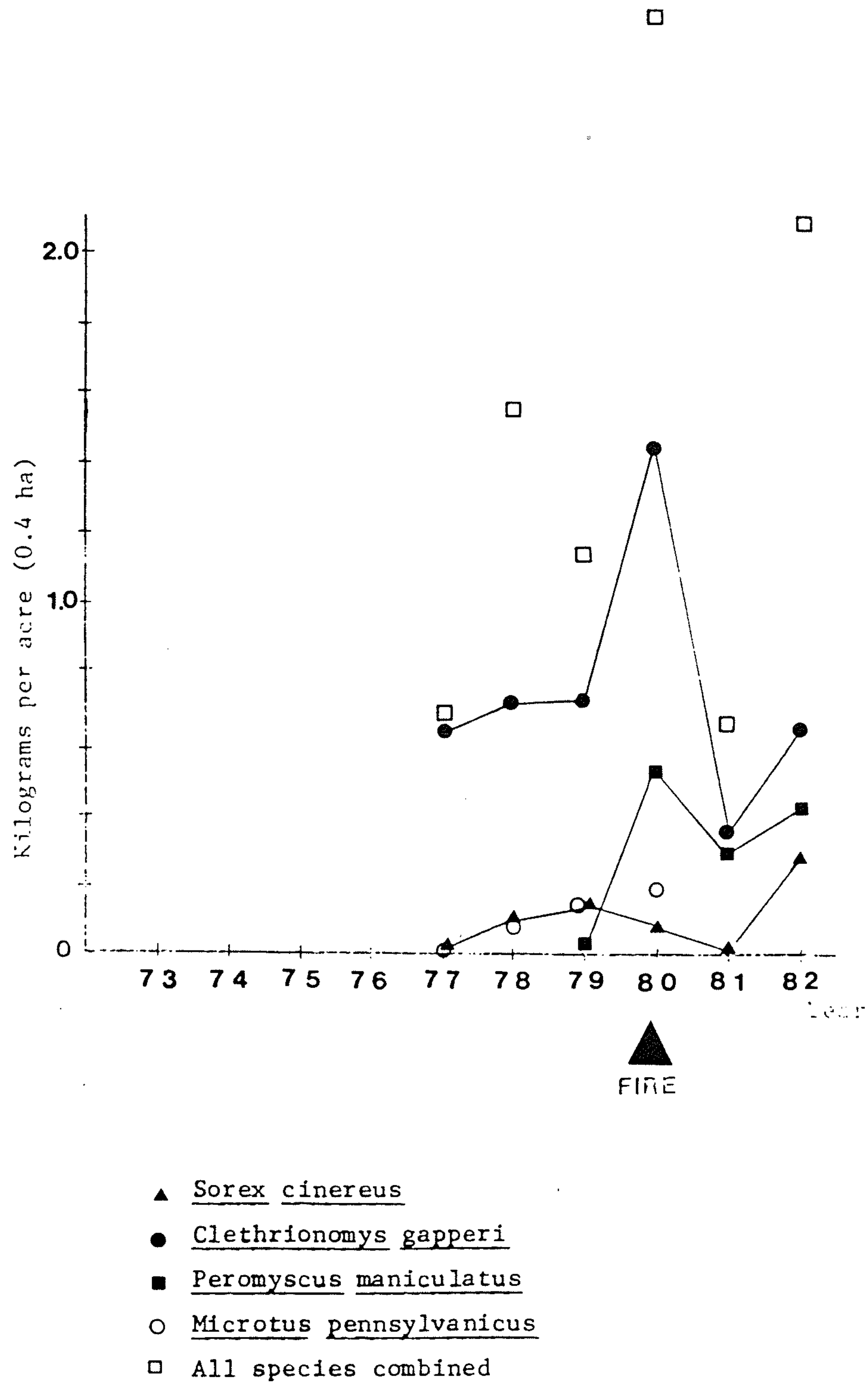


The combined small mammal biomass estimates are illustrated in Figure 24. 1982 biomass values for all habitats combined, S. cinereus, and P. maniculatus exceed pre-fire values. C. gapperi biomass was slightly less for 1982 than for 1978 and 1979 but was greater than the 1977 value.

Kayall (1968) indicates that burning either benefits small mammals or causes temporary declines in their populations. This study shows C. gapperi, P. maniculatus, and S. cinereus numbers and biomass increased with the fire, and despite a decline the following year the biomass of these species is at minimum pre-fire levels 3 growing seasons after the burn. From this study and other reports (Wrigley 1975, Kelsall et. al. 1977) it seems apparent that small mammals efficiently find refuge from the fire. Species composition shifts following the fire and most studies indicates that P. maniculatus assumes dominance during the initial recovery (Ahlgren 1966, Krefting and Ahlgren 1974, Kelsall 1977). In all habitats examined, (except on Jack Pine Sand Plain) C. gapperi was more abundant than P. maniculatus in 1980, and often in later years also.

Recovery of vegetation after a fire is dependent on the severity of the fire (Viereck and Dyrness 1979). My study provides further evidence of this in that more severely burned study plots had less dense and less diverse vegetation, while the converse is also true.

Figure 24: All habitats combined, comparison of small mammal biomass estimates obtained from trap data available to date. (2100 traps nights/year, except 1977 which was 1800 trap nights, and 1981 which was 1500 trap nights).



Conifer Regeneration

The frequency of conifer seedling regeneration is shown in Table 9. *Pinus banksiana* seedling frequency ranges from 0.0 to 3.2 per square meter. The frequency for plots in all habitats combined was 1.3 per square meter, but for just those where *Pinus banksiana* seedlings were observed, the frequency was 2.0 seedlings per square meter. *Picea mariana* seedling frequency ranged from 0.0 to 4.0 per square meter, and averages to 0.8 seedlings per square meter when all habitats were combined. For only those habitats where spruce seedlings were observed the average frequency per square meter was 1.5.

The restocking on these plots appears to be less than that for portions of the study area which were burned in 1976 (Johnson pers.comm.). Seed counts following the 1980 burn were higher than evidenced by restocking density (Pruitt, Johnson pers. comm.). Climatic conditions must have influenced seed germination and subsequent seedling establishment. Several authors have indicated that weather conditions influence the severity of a burn and fires are most destructive in dry seasons (Lutz 1956, Kiil and Grigel 1969, Scotter 1972, Rowe and Scotter 1973, Methven 1978, Quintillo 1978, Van Wagner 1979, White 1979). No rain was recorded for over 30 days prior to the 1980 fire and drought conditions persisted after the fire (Pruitt 1981).
Post-fire drought conditions, in the case of the 1980 fire,

Table 9: Density of seedlings (per m^2) estimated from frequency counts in $\frac{1}{4}$ m^2 quadrat samples

Habitat	No. of quadrats	Species *Pinus banksiana*	Species *Picea mariana*
Jack pine ridge	15	3.2	0.3
Alder jack pine ecotone	41	1.6	1.0
Alder tamarack bog	14	0	0
Jack pine sand plain	15	3.2	0
Black spruce bog	15	0*	4.0
Aspen upland	15	0	0
Black spruce tamarack bog	15	0	0

*_Pinus banksiana_ seedlings were observed on the study plot but did not occur in quadrat samples.

were probably the most influencial factor in reducing germination and seedling viability.

Effects of Fire on Other Wildlife

Fire is an influential factor in determining vegetation patterns in wildlife habitat, and thus affects wildlife populations. Fire effects can be immediate loss of life, food, and shelter, or long term effects resulting from changes in dynamic ecosystems. Herbivores are limited as fire controls the vegetational mosaic and influences the relative abundance of plant communities and successional stages. Carnivores are dependent on vegetation for cover and herbivores such as mice and voles for food therefore the vegetation mosaic created and maintained by fire is critical to their survival. Fire can also have an indirect influence on wildlife populations by altering snow cover characteristics which are an important factor in animal distribution (Pruitt 1959).

Quantitiative data are lacking for many of the relevant boreal animals, however the animal species observed within the study area used by persons associated with TBS, since the 1980 fire, are listed in Table 10. The impact of fire on wildlife constitutes a separate study for each species, hence, this report makes only brief and fairly general comments with respect to the consequences of fire to local wildlife other than the small mammals discussed previously.

TABLE 10: Other mammals observed in the study area since the 1980 fire. Sources include personal observations, TBS field catalogues, and Raine 1983.

Bat(s)	species not known
Black Bear	(*Ursus americanus*)
Weasel	(*Mustela sp.*)
Mink	(*Mustela vison*)
Marten	(*Martes americana*)
River Otter	(*Loutra canadensis*)
Fisher	(*Martes pennanti*)
Timber Wolf	(*Canis lupus*)
Red fox	(*Vulpes fulva*)
Lynx	(*Lynx canadensis*)
Chipmunk	(*Tamais/Eutamais*)
Beaver	(*Castor canadensis*)
Muskrat	(*Ondatra zibethica*)
Snowshoe Hare	(*Lepus americanus*)
Whitetail Dear	(*Odocoileus virginianus*)
Moose	(*Alces alces*)
Woodland Caribou	(*Rangifer tarandus*)

Ungulates

Woodland Caribou

There is general agreement that woodland caribou (*Rangifer tarandus caribou*) selectively feed on lichens when they are available during critical winter months, but the degree of dependence on lichens appears to vary with location. Fire destroys lichens and post-fire recovery of lichens is very slow. (Kelsall et.al. 1977, Vierick and Schandelmeier 1980). Caribou herds tend to avoid burned areas (Kelsall et.al. 1977, Stardom 1977, Darby 1979). Several authors have blamed the decline in caribou populations on the coincident increase in fire (Scotter 1971, Heinselman 1973, Pruitt, 1959, 1978) while others have questioned the association of caribou decline with fire (Johnson and Rowe 1975). There are also indications that optimal caribou habitat is to a certain degree fire dependent (Bergerud 1974, Darby 1977). Skoog (1968 c.f. Viereck & Schandelmeier 1980) suggested that fire caused a spatial shift in caribou populations in Alaska, but was not responsible for the overall population decline. There does not appear to be conclusive evidence as to the magnitude of fire effects on these animals in taiga ecosystems, and the effects can be expected to vary for each particular study area as well as according to individual fires.

Previous studies related to caribou at TBS before the 1980 fire confirm avoidance or limited use of burned areas depending on the season (Stardom 1977, Darby 1979). The number of caribou in the study area dropped dramatically following the 1980 fire, and have declined continuously until the present time when current use can best be described as sporadic (Pruitt pers.comm.) Results of an ongoing study of the Aikens-Wallace Lake caribou herd should provide very relevant information as to the effects of fire on caribou populations. It appears that the recent woodland caribou herd was utilizing unburned patches of the taiga (Decker pers.comm.). The long term impacts of the fire on the study area's carrying capacity for woodland caribou remain to be seen.

Moose

There is a concensus that moose (*Alces alces*) are present throughout the North American taiga and that moose browse is most abundant in early successional stands, therefore moose populations are expected to increase following a fire (Peterson 1955, Peek 1974, Kelsall et.al. 1977. Viereck and Schandelmeier 1980). Optimal moose habitat occurs between 11 and 30 years after burning and decreases in suitability as succession proceeds towards a climax stage (Kelsall et.al. 1977). Moose tracks in the vicinity of TBS were more frequent the first winter after the 1980 fire, but since there had been insufficient post-fire growth of browse to attract moose, Raine (1983) suggests that high track counts were due to increased travel facilitated by a thin snow cover. Decker (pers.comm.) reports that up to 14 moose are using the TBS study area which is a significant decrease in number from Stardom's (1977) minimum estimate of 66 for the same area.

Whitetail Deer

Only the southern fringes of the study area are frequented by (*Odocoileus virginianus dacotensis*) (Stardom 1977), due to the limiting, snow cover factor. Since the 1980 fire, Whitetail deer have not moved northward into the study area, but favorable snow conditions promoted by a mild winter could allow them to move into burned areas where forage plants are abundant. The migration of whitetail deer further into moose habitat increases the probability of occurrence of *Parelaphostrongylus tenuis*. Whitetail deer are a reservoir host for this parasite which is fatal to to moose and caribou when they ingest contaminated gastropods (Anderson 1972, 1975).

Fur Bearers

Marten (*Martes americana*) and fisher (*Martes pennanti*) are able to co-exist in the taiga, despite similar prey resources, because of temporal difference in habitat use in response to snow cover. Both species are absent from recent burns (Kelsall et.al. 1977, Raine 1982), but Raine also reported that two radio collared marten survived the 1980 burn at TBS. One was forced to, or chose to, move 60 km., eastward to ensure its survival. Fire affects marten and fisher by influencing availability of food and shelter, and their ability to travel (Koehler and Hornocker 1977, Raine 1980).

Raine (1983) analyzed track data collected from 1978 to 1982 at TBS and concluded that causes for differences in track counts could not be attributed to any one of several conflicting factors including fire. He suggests that either fire had no effect on fisher or marten populations or that populations were reduced in size but travelled greater distances for food because of more favourable snow conditions. Mink (Mustela vison), and otter (Loutra canadensis) populations were not affected by fire since their activities are restricted to water courses where fire effects are minimized. Lynx (Lynx canadensis) tracks decreased in number while the occurence of red fox (Vulpes fulva) increased , but data did not substantiate fire induced changes in populations (Raine 1983).

Some beaver (Castor canadensis) and Muskrat (Ondatra zibethica) habitat was burned in the 1980 fire, but, these two species are suited to early successional stages and therefore benefit from fire (Kelsall et.al. 1977, Viereck and Schandelmeier 1980). Results of a beaver survey done in 1982 indicated 1.1 beaver per square kilometer (Stardom pers..comm.).

Wolf (Canis lupus) populations are expected to react to the expected post- fire increase in moose populations and decrease in caribou population size (Kelsall et.al. 1977, Viereck and Schandelmeier 1980). Hill (1979) studied wolves at TBS and found that they were dependent on moose, beaver, and deer for food. It is expected that wolf populations will benefit from fire as the beaver and moose populations achieve their expected population increase.

Red Squirrel are expected to survive only in unburned areas where spruce cones are readily available for sustenance (Viereck and Schandemeier 1980).

Black bear (Ursus americanus) sign was ubiquitous during field work but actual sightings were not frequent. The Black bear diet consists of nearly 50% berries (Viereck and Schandelmeier 1980) so the present abundance of berries is a boon to bear populations.

Birds

Avian populations undergo a change in species composition following fire. Bird foraging strategy changes from tree searching to ground and bush foraging. A partial list of species observed since the 1980 fire is in Table 11. Common post-fire invader species are the White-throated Sparrow

Table 11: Partial list of birds observed in the study area since the 1980 fire. Sources include personal observations and TBS field catalogues.

Mallard	(Anas platyrhynchos)
Common Goldeneye	(Bucephala clangula)
Goshawk	(Accipiter gentilis)
Rough-legged Hawk	(Buteo lagopus)
Bald Eagle	(Haliacetus leucocephalus)
Sparrow Hawk	(Falco sparverius)
Spruce Grouse	(Canachites canadensis)
Herring Gull	(Larus argentatus)
Owl	(species not known)
Common Nighthawk	(Chordeiles minor)
Yellow -shafted Flicker	(Colaptes auratus)
Pileated Woodpecker	(Dryocopus pileatus)
Hairy Woodpecker	(Dendrocopos villosus)
Black-backed Three-toed Woodpecker	(Picoides arcticus)
Gray Jay	(Perisoreus canadensis)
Common Crow	(Corvus brachyrhynchos)
Black-capped Chickadee	(Parus aticapillus)
American Robin	(Turdus migratorius)
Hermit Thrush	(Hylocichla guttata)
Cedar Waxwing	(Bombycilla cedrorum)
Yellow Warbler	(Dendroica petechia)
Pine Grosbeak	(Pinicola enucleator)
Le Conte's Sparrow	(Passerherbulus caudacutus)
Slate-colored Junco	(Junco hyemalis)
White-throated Sparrow	(Zonotrichia albicollis)

(Zonotrichia albicollis), American Robin (Turdus migratorius). Dark-eyed Junco (Junco hyiemalis),and Woodpeckers (Apfelbaum and Haney 1980). These species were prevalent throughout the area covered for this study. White throated sparrows were occaisonally captured in small mammal traps as were a few green frogs.

An influx in woodpeckers is largely due to the high populations of insects inhabiting trees killed by fire. (Apfelbaum and Haney 1981). A Pileated Woodpecker (Dryocupus pileatus) was seen frequently in early summer (1982) at the TBS building site. The Black-backed Three-toed Woodpecker (Picoides arcticus) was the most common woodpecker observed during the 1982 field season but Yellow-Shafted Flickers (Colaptes auratus) were also seen.

Waterfowl generally benefit as fire opens up marshes (Ward 1968, Kelsall et.al. 1977). In years of drought, the taiga provides nesting habitat for waterfowl (Pospahala et.al. 1974) thus maintenance of marsh habitat can provide relief for waterfowl forced to look farther north for suitible nest sites.

Three Spruce Grouse (Canachites canadensis) were observed in the Jack Pine Alder ecotone plot. This species prefers mature conifer habitat and is not common in recently burned areas (Kelsall et.al. 1977).

Value of the TBS Study Area to Current and Potential Users

The perception of the effects of fire within an ecosystem depends on the particular values which reflect man's interests that are influenced by fire. This segment of this study only considers the net benefits that the study area provides to its users The actual expenditure incurred in order to use the resources of the area is used as a measure of value. The value of an object to an individual may arise from different sources or uses of the object, hence how persons rate various sources of wildlife or other resource values is used as a measure of importance (King 1979). In this value judgement it is assumed that the benefits must be at least equal to the cost or users of that particular commodity would go elsewhere, i.e. find a substitute. Substitution possibilities presented by other areas within the North American taiga will not be discussed.

Bounds have been placed on the extent of this evaluation, and some arbitrary limitations have been set. Time constraints did not allow for a comprehensive statistically valid survey of the value(s) to current and potential users of the study area and its intrinsic resources. Details of arbitrarily set limits and assumptions used in subsequent calculations are appended.

Traditional use of the area has included trapping, fishing, and harvesting of wild rice (*Zizania aquatica*).

Biological research activities and recreational pursuits within the area have been compatible with traditional use, but a conflict arose when the timber industry showed an interest in the local wood resources. The destructive nature of extractive industries such as timber cutting and mining have a deleterious effect on the appeal of natural or wilderness ecosystems to other users (Stankey 1973, Hendee and Berge 1974, Stankey and Baden 1977, Benson and Ullrich 1981).

Timber

The total value of timber lost in the 1980 fire was estimated at \$ 13.5 million. The 156,355 cords of wood in the TBS study area was valued at \$ 30 per cord (1978 \$) for a gross value of \$ 4,690,650 (Pruitt 1978). Using Pruitt's calculation of extraction costs gives a maximum net value of \$ 352,083. Fire has squelched timber industry interest in the area, but 80 years hence it is quite probable that their interest will resurface.

The inherent value(s) to users with compatible interests in the study area are delineated in Table 12, and calculation details are appended. The user's willingness to pay for use of the area and its resources, based on the annual estimated expenditure, is combined with the annual income attainable from resources in the area to yield an estimated net yearly value of \$ 597,208.93. This figure is an

TABLE 12: Value of Resources intrinsic to the Taiga Biological Station study area, based on annual expenditures and/ or income of compatible alternative users.

Type of use		Value ($Cdn)
Recreation		$ 459,884.75
- Sport Fishing	$ 308,642.75	
- Canoe route	151,242.00	
Education		48,798.33
University of Manitoba	38,546.83	
Museum of Man and Nature	9,231.50	
Wilderness Corps	1,020.00	
Wild rice harvest		48,230.85
Potential fur harvest		21,545.00
Prospecting*		18,750.00
Total Estimated Annual Value		597,208.93

*This value is based on one full time prospector earning $75.00 per day.

underestimate since the value of the area, to some users such as owners of private fishing camps and unorganized canoeing groups, was not included in this evaluation.

Recreation

The recreational use of the area involves the largest expenditure, and this figure does not include all recreational activities in the area. Hunting data for the area do not exist, nor do data with respect to winter activities such as snowmobile travel and winter camping, which are known to occur. The American Boy Scouts have had groups canoeing in the area since 1972, and were able to avoid cancelling their activities during the 1980 fire (Bridges pers.comm.). The Wilderness Corps have had an average of 40 persons use the canoe route each year. The sport fishing industry is comprised of fly-in camps serving approximately 570 visitors per year. Travel costs associated with recreational use of the study area have been based on some arbitary limits which are defined in Appendix E.

Wilderness recreational activities are largely dependent on maintenance of an undisturbed setting. Because of development of resources, the supply of true wilderness areas is diminishing, and at the same time demand it is increasing (Clawson 1972, Krutilla and Fisher 1975). There is no substitute for wilderness (Hendee and Berge 1974, Krutilla and Fisher 1975), and user satisfaction decreases as the evidence of human encroachment increases (Stankey 1973, Hendee and Berdge 1974, Stankey and Baden 1977, Benson and Ullrich 1981). For these reasons timber cutting is not considered to be compatible with existing or potential wilderness recreational endeavors.

Education and Reasearch

It is imperative that the status quo stage of development be maintained if the area is to retain its value for educational purposes.The TBS study area provides an ideal situation in which to examine natural boreal ecosystems and their biotic components. The University of Manitoba's Taiga Biological Station is the only North American field station of its kind located in a taiga setting, and as such has a distinct and valuable function. The presence of TBS has allowed for continuous research activities, and therefore the establishment of a sound data base with which to make comparisons and deliberate management decisions. Seven graduate research projects have been completed within the TBS study area . Research sponsored by other institutions is also active at TBS. Dr. K.L. Johnson is currently studying post-fire succession, as well as the reproductive strategy of *Geranium bicknellii*. A variety of floral and faunal topics including woodland caribou, moose, wolves, fisher, marten, small mammals, and terrestrial invertebrates have been and continue to be examined.

Currently the only two credit courses to take advantage of the field station facilities are Mammalogy and Boreal Ecology, but TBS offers the opportunity for many other ecologically oriented credit or non-credit courses to be implemented. The Manitoba Museum of Man and Nature personnel use articles and ideas from the TBS study area for exhibit gallery construction, thus serving a public information purpose. The station also has international recognition, in that researchers from various parts of Europe have visited TBS. TBS has a formal agreement exchange agreement with Värriö Subarctic Research Station of the University of Helsinki, Finland.

The generosity of the many organizations and individuals who donated time, money, and goods towards post-fire reconstruction of TBS facilities is indicative of the value these persons place on the station. The University of Manitoba contributed $6,500, and other donations brought the total to $ 16,500. Several persons volunteered approximately 100 man days labor in construction of replacement buildings. Even at the minimum wage rate the labor would be valued at more than $ 2,500.

The TBS site offers an excellent opportunity to examine the long term effects of fire on taiga ecosystems. There appears to be a dearth of information relevant to fire in the North American taiga, and there often appears to be conflict in information and/or hypotheses presented. The ecological impacts of fire on an ecosystem and processes affecting that ecosystem differ spatially and temporally. The natural dynamic state of taiga ecosystems must first be fully understood before the full impact of fire on this ecosystem can be adequately assessed. Once the influence of fire on the ecological factors of an area has been comprehensively evaluated, it is relevant to consider other associated facets which may be influenced directly by the fire or indirectly through ecological changes resulting from the fire.

Wild Rice Harvest

The harvest of wild rice in the study area provides a substantial source of income to local residents, and relief to persons suffering from chronic unemployment. Fire would not affect this endeavor unless immediate access was limited by an actual fire. It is also feasible that fire induced changes in nutrient cycles could affect growth.

Fur Harvest

The potential for harvest of furs provides opportunities to trappers but the current harvest is well below its potential (Stardom pers. comm.). Access to taiga areas for trapping is relatively difficult, and since the fire virtually all trails have become obstructed. In order to reestablish trapping activities it will be necessary to clear trails and construct trap sites. These activities will entail a tremendous expenditure of effort before any profit can be realized. Bill Conley the local trapper/prospector indicates that he intends to reestablish his trap lines.

Prospecting

Fire has facilitated prospecting activity in the area. Removal of duff and concurrent exposure of previously forested ridges improves prospecting conditions. The proximity of the San Antonio gold mine at Bissett has fuelled the interest of mining concerns, therefore claim stakes are common in the study area.

Value to Compatible Users

The yearly value of the study area ($ 597,208.93) to compatible alternative resource users exceeds the pre-fire value of the local timber resources ($ 352,083). Inflation will increase the value of the timber as it regenerates, but the value to other users will also increase concurrently. The cutting rotation is approximately 80 years (Shipley pers. comm.), therefore it will be at least that long before the value of the timber resources of the study area are maximized. In the mean time, benefits accruing to current resource users will have multiplied. The present value of net benefits to compatible users 80 years hence, using a 6 % real discount rate, is calculated to be $ 63,182,310. Wood cutting operations in the study area would adversely affect current resource use and therefore depreciate the value of benefits.

The TBS study area has a value just in the fact that it exists. The intangible value of the study area as a natural entity is very difficult to define. Non-users of the local resources also place a value on the study area in that they benefit from just knowing that natural ecosystems exist. It also provides a natural "control" system for comparison with industrial or natural activity elsewhere in the taiga.

SUMMARY AND CONCLUSIONS

Effects of Fire on Wildlife Habitat

1. The wide variation in physiographic and vegetative features of the specific study plots accounts for differences in fire behavior and fire intensity, thus subsequent fire effects differ for each habitat examined.
2. Vegetative reproduction of residual species, through root sprouting or suckering was the dominant post-fire reproductive strategy observed on some plots.
3. Fugitive species with light weight wind disseminated seed were also common.
4. Evidence suggests that a viable soil seed bank permitted post-fire vegetation recovery.
5. Frugivores are likely agents of dispersal which promote post-fire recolonization of species such as *Fragaria virginiana*.
6. Regeneration of former upper canopy species such as Jack pine and Black spruce is occurring, with the Jack pine showing most vigor.
7. Lichen and feather mosses are now virtually absent from burned areas.

Effects of Fire on Wildlife

8. A sufficient number of animals appeared to have found refuge from the fire and its aftermath in unburned habitats such as the many semi-open black spruce-tamarack bogs, to provide a source for post-fire recolonization.
9. Those species, such as Red Squirrels and Spruce Grouse, which prefer mature conifer stands, were observed only in unburned patches or in areas adjacent to the same.
10. *Clethrionomys gapperi* numbers and biomass increased following the fire, declined one year later, and are currently showing an increase on some sites, but have not yet reached pre-fire maximum levels. This species has attained minimum pre-fire levels which should sustain the population.
11. The lush post-fire growth of colonizer or fugitive plant species is considered to be responsible for the 1980 increase in *C. gapperi* populations.
12. *P. maniculatus* increased both in number and in biomass immediately following the fire, but declined one year later. Two years later the number captured dropped slightly while biomass increased.
13. *P. maniculatus* post-fire invasion of some sites and increase on others was associated with the abundant supply of seeds as a food resource.

14. Fluctuations of <u>Sorex cinereus</u> populations cannot be attributed to the fire in this instance.
15. <u>M</u>. <u>pennsylvanicus</u> has been absent from trap captures since the year of the fire.
16. Woodland caribou populations show a continuous post-fire decline and recent caribou use of the area has been sporadic.
17. It is expected that the moose populations will increase but there has not been sufficient time for optimal moose habitat to develop.
18. The potential for Whitetail deer invasion of the study area, especially if favorable snow conditions occur, raises the hazardous risk of <u>Parelaphostrongylus tenuis</u> infection of caribou and moose populations.
19. Effects of fire vary for different fur bearing species. Fisher, Marten, and Red Squirrels avoid burned areas. Beaver, Muskrats, and Black Bears benefit from early successional stages of vegetation development. Mink and Otter are affected minimally since their activities are restricted to water courses where fire effects are minimized.
20. Wolf populations will likely react positively to a post-fire increase in beaver populations and the expected increase in moose numbers.

21. Bird populations undergo a post-fire change in species composition. Ground and bush foragers, such as the Whitethroated Sparrow were common as were woodpeckers. Invasion of woodpeckers is due to the high populations of insects inhabiting fire killed trees.

<u>Value of the TBS Study Area to Users</u>

22. The value of the TBS study area to compatible users was calculated to be in excess of $ 597,208.93.
23. A conflict in land use is probable 80 years hence when the local wood resources again become attractive to the timber industry.
24. The value to compatible users will depreciate if timber cutting is allowed. In particular, if the natural state of the local taiga ecosystem was lost or modified, the inherent educational and research benefits would be foregone. Timber cutting would also curtail a portion of the local recreational activity.
25. The Taiga Biological Station can play a very valuable role as a natural control system for comparison with man's activities elsewhere in the taiga.
26. Preservation of a part of the natural taiga setting, as part of our natural heritage, is recognized as preferable if not essential.

27. Current use of the TBS study area appears to be compatible with natural ecosystem dynamics, however much remains unknown. Continued research in this study area will ensure a better knowledge of these natural dynamic ecosystems.

RECOMMENDATIONS

1. It is recommended that the Taiga Biological Station study area be protected in its natural state, with controlled educational, research, traditional, and recreational activities permitted.
2. Only by continuous monitoring and evaluation of biotic communities, and their associated physical parameters, can changes resulting from an impacting force such as fire, provide reliable knowledge with respect to the effects of the same. The TBS location is ideal for studying the dynamics of taiga ecosystems. A ten year data base already exists, and is constantly expanding. The value of the Taiga Biological Station must be recognized by ensuring indefinite continuation of reasearch activity. A long term agreement with the Province of Manitoba would provide this security.
3. Traditional, recreational, and other current uses of the area can be continued, but must be monitored in order to ensure that use is compatible with natural ecosystem dynamics.

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Appendix A

EDUCATION AND RESEARCH EXPENDITURES

Calculation of expenditures by University of Manitoba personnel associated with reasearch and teaching at TBS, (Information for years prior to 1976/1977 is not readily available).

Grants held by researchers associated with the University of Manitoba	Year	Expenditures
	1982/1983	$ 24,544.08
	1981/1982	17,289.87
	1980/1981	17,874.91
	1979/1980	8,727.02
	1978/1979	12,090.87
	1977/1978	15,316.94
	1976/1977	15,990.46
Other University of Manitoba accounts		3,700.00
Manitoba Environmental Council S.T.E.P. project (No.19-16)	1983	4,142.91
Yearly average		$ 17,096.58

Department of Zoology expenditures since 1977/78

Miscellaneous Capital Costs $ 3,000

Courses - operating budget

22:457 $ 3,160.92

22:733

Yearly Average $ 130.00

Summary of average yearly expenditures associated with research and teaching at the Taiga Biological Station.

Source of Expenditure	Calculated yearly average Expenditure
Grants for research at TBS	$ 17,096.58
Credit courses at University of Manitoba	1,256.82
Salaries for University of Manitoba personnel	20,193.43
Museum of Man and Nature	9,231.50
Wilderness Corps Natural History Day	1,020.00
Total annual expenditure estimate	$ 39,566.83

Estimates of expenditures, salaries, and cost to the wilderness corps were based on Granting Agency University Accounts -Receivables, and personal communications with Dr. W.O. Pruitt Jr., G. Keleher, L.S. Lowry, Dr. K.L. Johnson, and H. Cunningham.

Appendix B

FUR HARVEST

The estimated average potential annual fur harvest for the TBS study area (Stardom pers. comm.)

Species	Harvestable Number	Price * $ 1982	Total
Beaver	100	17.00	$ 1700.00
Bear	5	37.00	185.00
Coyote	5	79.00	395.00
Ermine	500	2.00	1000.00
Fisher	25	155.00	3875.00
Red Fox	25	63.00	1575.00
Lynx	25	306.00	7650.00
Marten	5	39.00	195.00
Mink	80	34.00	2720.00
Muskrat	100	3.00	300.00
Otter	10	44.00	440.00
Squirrel	500	1.70	850.00
Timber Wolf	5	132.00	660.00
Potential Yearly Revenue			$ 21,545.00

* Dominion Sudac average 1981-1982 price for Manitoba fur.

Note: Using an estimated production cost of 31.4% (Cable et.al. 1976), the potential average annual net income from fur harvest for the TBS study area is calculated to be $ 14,779.87.

Appendix C

WILD RICE HARVEST

Income from Wild Rice (*Zizania aquatica*) harvested from the TBS study area (Thorvaldson pers. comm.)

Seven leases are held within the study area, but only five were producing in 1982. Total reported production was 4868 kilograms (10,818 pounds). Calculations using the 1982 price of $ 2.47 per kg., ($ 1.11 /lb.), yields revenue of $ 12,007.98 for 1982.

The five year average production is calculated at 18424 kilograms (40,943 pounds), and using the 10 year average price of $1.224 per pound gives an estimated average annual revenue of $ 50,769.32.

Production costs are estimated to be approximately 5% thus a net average revenue of $ 48,230.85 accrues to lease holders in the study area.

Appendix D

MANITOBA MUSEUM OF MAN AND NATURE EXPENDITURES IN CONJUNCTIONWITH USE OF THE TBS STUDY AREA

(Information provided by Dr. K. Johnson)

Salaries		
Curators (n=1.5)	$ 19,200	
Assistant Curators (n=1.5)	12,500	
		$ 31,700
Transportation		
Automobile ($.17/km.)	1,392	
Gas (Van and Boat)	960	
Airfare (to Obukowin Lake)	600	
		2,952
Materials and Supplies		
$ 200 per trip		3,200
Total expenditure		$ 37,852
Average yearly expenditure		$ 9,231.50

Note: These costs are based on 16 trips of 5 days duration, i.e. 2 trips each year for the last 8 years, and are in 1982 dollars.

Appendix E

VALUE TO RECREATIONAL USERS

Calculation of user values based on the users willingness to pay in order to be able to make use of the area.

CANOE ROUTE

AMERICAN BOY SCOUTS

This calculation is based on the following information received from C.S. Bridges (pers. comm.) who co-ordinates their use of the canoe route which circumnavigates the study area.

- 300 persons per year use the route
- cost to the ABS association is estimated to be $ 20 (U.S. $) per day which is currently equivalent to $ 24.60 in Canadian dollars.
- each trip lasts 10 days
- maximum group size is 9
- users pay their own transportation costs to Bissett, and they come from all over the United States, as far away as Houston Texas.

To estimate the transportation costs to Bissett, I calculated the average cost for automobile and for commercial air transport, for the most distant users (from Houston) and for users from the closest U.S. location which I arbitrarily chose to be Grand Forks, North Dakota.

<u>Automobile Transport</u>

(assuming all travel in one vehicle)

Houston to Bissett (return)		
5346 km. at $ .20 per km.	$ 1,069.20	
accomodations and meals for 6 days (2 campsites @ $5 and $90 for food for 9 persons)	600.00	
Total Cost for 9		$ 1,669.20
Grand Forks to Bissett (return)		
936 km. at $ .20 per km.	$ 187.20	
accomodations and meals for 2 days (a/a)	200.00	
Total Cost for 9		$ 387.20

<u>Commercial Air Carrier</u>

Houston to Winnipeg		
Frontier Airlines @ $ 560 for 9 persons	$ 5,040.00	
plus auto transport to Bissett		
470 km. at $ .20 per km.	94.00	
Total Cost for 9		$ 5,134.00
Grand Forks to Winnipeg		
North West Airlines @ $ 87.20 for 9 persons	$ 784.80	

plus auto transport to Bissett

(a/a)	94.00		
	Total Cost for 9	$	878.80
Average travel cost for a group of 9 persons		$	2,017.30
Average travel cost per person		$	224.14

Estimated cost per individual user is calculated to be

$ 424.14

(10 days @ $24.60 + $ 224.14 travel costs)

Therefore, the total value of the study area to the 300 American Boy Scout users is estimated to be $ 127,242.00 annually.

Wilderness Corps

Approximately 40 persons use the canoe route each year. Using the average daily operating cost of $ 1020 gives an estimated user cost of $ 10200 per year assuming the trip takes 10 days. Data with respect to other canoeists who use the route are not available. The total value to known users of the specified canoe route is estimated to be $ 137,442 per annum.

FISHING OUTCAMPS

Information used in calculating this estimate was received from R. Munroe of Wallace Lake Lodge, G. Lavergne of Aikens Lake Lodge, and L. Ross of Pine Island Lodge. I respect the confidentiality of this information and will not include specific details in this document. Travel Costs for persons using sport fishing camps (fly-in)

assuming half of the fishermen are from Winnipeg, and allowing 3 persons per vehicle their cost to Bissett is estimated to be

470 km. at $.20 per km. x (285/3) = $ 8930.00

-assuming other fishermen are from Minneapolis and travel via to Winnipeg, and by automobile to Bissett,

Northwest Orient airfare

Minneapolis to Winnipeg	$ 164.15
plus auto transport to Bissett	
470 km at $.20/km, 3 to a vehicle	33.13
	195.48
Estimated total for 285 persons	$ 55711.80

Total estimated costs for fishermen from the U. S. assuming that the average cost to user is the cost for persons travelling from Minneapolis is $ 64,641.80