AUTUMN ACTIVITY, DIET AND PREY ABUNDANCE
FOR BATS (Chiroptera)
IN THE WEST ARM DEMONSTRATION FOREST
AND SURROUNDING AREA

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by

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ABSTRACT

I conducted field research on bats between September and November, 1993. Mist netting and insect trapping were attempted for 27 nights over a 6 week period. The purpose of the research was to study bat activity, diet and prey abundance during the autumn, a period of time rarely included in most studies. Twenty-one bats were caught representing 6 species including a fringed bat (Myotis thysasnodes), a species not originally thought to inhabit the area. Flight activity ceased between 6 and 10 October in most areas but bats were observed flying up until 1 November. I assume that bats began hibernation at that time or they migrated out of the study area. Forty-seven fecal pellets of 11 M. yumanensis were analyzed and the percent volume of each insect order was estimated. Diet included diptera (including chironomidae), lepidoptera, trichoptera, hemiptera/heteroptera, coleoptera and hymenoptera. Food availability was estimated by catching insects using a light/suction trap and was compared with diet. Food availability and diet were not correlated, indicating that bats were feeding selectively. As a second part of the study, I tested the detectability of QMC bat detectors under various canopy closures. Two trials were conducted in which 5 bat detectors were simultaneously placed under different canopy closures. There were differences in detectability under different canopy closures which may bias monitoring results in forest habitat.

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1.0 INTRODUCTION

Consideration of wildlife species as part of planning the harvesting of forests has become an important issue. Since harvesting will continue, data on habitat requirements of forest-dwelling animals are essential to allow us to minimize the impact of forest harvesting on these animals. Although some mammals have been well-studied (e.g./ deer - Harestad et al. 1982; bears - McLellan 1990), little is known about the ecology of non-game species such as bats. Most bat studies have focussed on bats in buildings and other human-made structures, so there is little information about bats in forest habitat (Milligan and Brigham 1993; Brigham 1991). Since bats are the second most diverse mammalian order in British Columbia and half of the bat species in the province are on the red list (endangered) or the blue list (threatened), it is crucial that we learn more about the ecology of these animals.

One comprehensive study on bats in the Nelson area began in 1992 and will continue for at least three years. The study was designed to gather information on distribution, abundance, diversity, roost site selection, foraging behaviour and diet of bats in the area. Field research for the study, like most studies in temperate areas, occurs during the summer months only.

Information about bats in the autumn is also valuable as it is at this time of year when bats acquire fat for hibernation or migration and mating occurs. An inability to overwinter is likely the major source of mortality in bats. At the same time, temperatures drop and insects become less abundant. Since most field research on bats occurs in the summer or at hibernacula sites in the winter, data on bats during the autumn period are scarce.

The following study was designed to supplement summer data by collecting information about activity patterns, diet, food availability, and the timing of hibernation and migration of local bat species in the Nelson area.

It is expected that at least 10 species of bats occur in the Interior Cedar-Hemlock (ICH) and Engleman Spruce-Subalpine Fir (ESSF) biogeoclimatic zones of the Nelson area (Nagorsen and Brigham 1993) including Big brown (*Eptesicus fuscus*), Silver-haired (*Lasionycteris noctivagans*), Townsend's big-eared (*Plecotus townsendii*), Hoary (*Lasiurus cinereus*), California (*Myotis californicus*), Western long-eared (*M. evotis*), Northern long-eared (*M. septentrionalis*), Little Brown (*M. lucifugus*), Long-legged (*M. volans*) and Yuma (*M. yumanensis*)

Seven of these species (all but *Plecotus townsendii*, *M. septentrionalis* and *Lasiurus cinereus*) have been confirmed in the area (Vonhoff and Grindal 1993). A fringed bat (*M. thysanodes*), not originally thought to reside in this area, was also caught in 1993. Western Small-footed bats (*Myotis ciliolabrum*) and Western Red bats (*Lasiurus blossevillii*) may also occur (Brigham, pers comm.).

The date of entry into hibernation or migration out of the study area by bats in the Nelson area is unkown. In British Columbia, bats arrive at hibernacula between September and November (Nagorsen and Brigham 1993). Bats in Kootenay National Park (a similar ecoregion) were observed flying under street lights as late as October 6th (Poll et al. 1984). Information about the timing of activity of bats may be useful when planning the harvesting of forests or future research on bats.

A second goal of this study was to examine the diet of bats in the Nelson area. Bats in B.C. eat a diverse variety of insects such as diptera, lepidoptera, coleoptera (Whitaker et al. 1977), trichoptera and ephemeroptera (Herd and Fenton 1983; Brigham et al. 1992). Bats may forage opportunistically, eating any insect they contact (Brigham et al. 1992; Fenton and Morris 1975). In this case, their diet would resemble the prey base available. Another theory suggests that bats are selective in their diet, eating prey of choice regardless of its abundance in the environment (Buchler 1976). This selectivity is may only be seasonal, occurring only when insects are abundant (Anthony and Kunz 1977). As prey density declines in the autumn, bats could beome less selective. This study was designed to examine diet and prey selection of bats in the Nelson area. By comparing the diet of bats (through fecal analysis) with prey availability, the degree of prey selectivity by bats can be determined.

The objectives of this study were:

1) to determine the species present in the West Arm Demonstration Forest (WADF) and surrounding area,
2) to determine when the beginning of hibernation or migration occurs in the study area,
3) to assess food abundance and the diet of bats in the autumn, and
4) to suggest future autumn bat research projects.

2.0 MATERIALS AND METHODS

The majority of this study was conducted in the ICH and ESSF biogeoclimatic zones in WADF and surrounding area. The WADF, a 14 500 ha forest, is located on the west arm of Kootenay Lake. I chose a total of 10 netting sites were chosen based on accessibility, previous success (summer research), liklihood of catching bats and elevation (Table 1). Most sites were south facing and between 579m and 1131m elevation.

Sites were classed as edge of forest, standing water, large creek, small creek, and flyway. Five sites were chosen at Redfish (Fig.1), three at Kokanee Creek (Fig.2 and 3), one at Sitkum Creek (Fig.4), and one at Grohman Narrows Provincial Park (Fig.5).

Bats were captured using nylon mist nets between 5.5m and 12.8m in length. Nets were set over standing water, under over-hanging trees, near creeks, and perpendicular to edges of clearcuts. Nets were opened at sunset and kept open for a minimum of two hours. Captured bats were weighed to the nearest 0.5 g. using a Pesola scale. Forearm, metacarpal, ear and wingspan was measured for each individual using dial calipers (Van Zyll de Jong 1985). Animals were kept in cloth bags for up to three hours after capture in order to collect fecal pellets for diet analysis.

Where possible, five fecal pellets from each bat were examined. For some bats, only one to four pellets were available. Due to time constraints, only pellets of M. yumanensis were analysed. A total of 47 pellets from 11 bats were analysed. Pellets were dissected in ethanol using a dissecting microscope under 500x magnification and the percentage volume of each recognizable insect order in each pellet was estimated to the nearest 5%. A single estimate for the diet of each bat was made.

Insects were sampled using a light/suction trap hung approximately 1.5m above the ground, 20 - 50m from the mist nets. The trap was turned on at sunset and left running for a minimum of 2 hours. Insects were stored in ethanol until being counted and identified to Order.

To provide consistency between trapping nights, the number of insects caught each night was scaled to 'insects per hour' by dividing the total number of insects caught by the number of hours the trap was active. Insects were identified to Order except those in Family chironomidae which were counted separately from other dipterans because of their easily identifiable features.

Diet was compared to trap captures using the Spearman rank correlation coefficient. When more than one bat was captured in a night, the average diet for that night was calculated.

Initially, bat activity was monitored using QMC Mini2bat detectors. It became apparent that these devices were not picking up bat echolocation calls through the forest canopy. Bat detectors transduce high frequency bat echolocation calls into sounds that can be heard by an unaided human ear. Although these devices have been proposed as a useful tool to determine bat presence, activity and distribution (Thomas et al., 1984), they may be limited in their use. Some limitations of bat detectors have been studied (Thomas et al. 1984; Downes 1982), but the validity of using these devices in the forest has not been investigated to my knowledge. Determining the limitations of bat detectors under canopy closure became an additional goal of this study.

Bat detectors were set at 40MHz, a frequency which is contained in the echolocation calls of most local species with the exception of <u>Lasiurus</u> <u>cinereus</u> and <u>Eptesicus</u> <u>fuscus</u> (Fenton et al. 1981). Detector output was recorded using small tape recorders operated at 120 cm/s. Detectors were placed 1 m above the ground and turned on at sunset for 90 minutes. Later, tapes were transcribed and passes and feeding buzzes were recorded. A pass was defined as a series of distinct echolocation calls produced by one bat flying above the recorder. A feeding buzz was defined as a series of indistinct echolocation calls emitted so close together that they appear to be one continuous sound. This buzz in indicative of an attack (Nagorsen and Brigham 1993).

In order to determine the ability of bat detectors to pick-up echolocation calls through canopy closure, one bat detector was placed in the center of a gap (10 to12 m diameter) and four detectors were placed on the edge of the gap under various degrees of canopy closure . Bat detectors on the edge were no further than 14m from the center detector. This test was conducted independently at two sites on two separate nights.

To determine site characteristics for bat detectors placed randomly in the forest, eight 200m transect lines were conducted. Every 10 m, the canopy closure, height to canopy closure, proximity to gap and size of gap were estimated. Each stop was classified as potentially adequate to detect a bat based on knowledge from previous bat detector tests performed in this study.

3.0 RESULTS

3.1 Species Composition

A total of 21 bats representing 6 species were caught within a 3 week period, although netting was conducted over 6 weeks. Species caught include: Eptesicus fuscus, Lasionycteris noctivagans, Myotis yumanensis, M. lucifugus, M. volans, and M. thysanodes (Table 2). Thirteen M. yumanensis were caught making this species the most abundant. M. lucifugus was the second most abundant species with four individuals caught. One individual of each other species was caught.

The ratio of males to females caught was almost equal (11 female; 10 male). There was no change in the sex ratio of bats caught throughout the study period. Three juveniles were caught between September 17th and 19th and these were all M. yumanensis indicating that at least this species was reproductively active in 1993.

On average, M. yumanensis bat had a body mass of 6.9 g. (Table 2). Females had a mass of 6.7g and males 7.1g. M. lucifugus had an average mass of 5.8g. See Table 2 for a summary of measurements for each individual captured.

Of the 10 netting sites, bats were only caught at three sites. These sites were Busk Road, Kokanee Creek Park, and Redfish Spawning Channel (Fig. 6). Bats were observed at other sites but were not captured.

3.2 Timing of Hibernation/Migration in the Study Area

Flying bats were regularly observed until September 28th. After this date, the number of bats observed flying was reduced. Bat activity ceased at each site at different times (Figure 7). It was difficult to determine time of departure from sites that were not frequently visited. Therefore, only data from sites visited more than three times are included.

Bat activity ceased at Kokanee Creek Park and Busk Road by 6 October, at Redfish Spawning Channel by 8 October, and at Grohman Narrows by 10 October (Table 3). The latest bat activity was recorded at Redfish Clearcut on 1 November. After this date, daily minimum temperatures consistently dropped below 0°C (Fig. 8). Bats were caught at temperatures as low as 6°C (Table 3). Bats were observed flying at temperatures as low as 5°C.

3.3 Food Availability and Diet

The largest number of insects were caught at Busk Road and the fewest were caught at Redfish Clearcut (Table 4). The number of insects caught decreased over the study period in most sites but increased at Busk Road (Table 4). Flying insects were still present when bat activity ceased.

The majority of insects caught were dipterans (not including chironomidae), representing 92.0% of the total catch (Table 4). Chironomidae represented 5.2% of the catch, lepidoptera 1.9% and other Orders combined were 0.9%.

The diet of M. yumanensis included diptera, chironomidae, lepidoptera, trichoptera, hemiptera/heteroptera, coleoptera and hymenoptera (Table 5). The largest percent volume of insects in the diet were comprised of diptera at 57% followed by trichoptera at 17.5% and chironomidae at 10.5%. Diptera were found in the diet of 10 of 11 bats whose pellets I analyzed, chironomidae in the diet of 7, and lepidoptera in the diet of 6 (Table 6).

No correlations were found between diet and food abundance on the nights that were surveyed indicating that bats are selective in their diet rather than eating opportunistically (Fig. 9). These nights include 10 September (rs=.4620), 17 September (rs = .3744), 19 September (rs= .2386), 24 September (rs= .3339) and 28 September (rs=.3162). $p>0.05$ in all cases.

3.4 Bat Detectors

Bats were picked up by detectors located under gaps (crown closure < 5%) in both trials. No bats were picked up by bat detectors located under crown closures between 25% and 65% (Table 8).

Of the 100 sites surveyed in the transect lines, 17% were in gaps, 12% were on the edge of a gap, and 58% were more than 5m away from a gap (Table 9). Twenty-three percent of the sites were located in sites that were judged to be adequate to detect a bat.

Average canopy closure was 45% and average height to canopy closure was 7m (Table 9). Thirty-one percent of sites in the transect line had a canopy closure of 65%, and 79% of sites had canopy closures greater than 25% (Figure 13).

4.0 DISCUSSION

4.1 Species Composition

Unfortunately, the sample size of bats caught is too low to make any substantial conclusions about differences between species and sexes. However, some useful information can be drawn from my data.

M. yumanensis were the most abundant bats in the area. However, it must be noted that relative abundance could be influenced by different probability of capturing each species due to the placement of the nets and the height at which each species flies. It should also be noted that M. yumanensis and M. lucifugus were very difficult to distinguish from one another (Nagorsen and Brigham 1993).

The presence of M. thysanodes is significant since it was not originally thought to inhabit the area and it is on the provincial blue list. Before 1993, the range for this species in B.C. was thought to be contained within the Dry Interior Belt (Nagorsen and Brigham 1993). The confirmation of M. thysanodes as an inhabitant of the Nelson area indicates that this species is more widely distributed than previously thought. It also extends the range of this species into the ICH biogeoclimatic zone.

4.2 Timing of Hibernation/Migration in the Study Area

Although the date of 'disappearance' of bats indicates that activity has ceased, it is an assumption that this date also represents the date at which hibernation/migration occurs . The 'disappearance' of most bats appeared to fall around October 6th. This was also the date of the last sighting of a bat at Kootenay National Park (Poll et al. 1988). The similar dates may indicate that bats initiate hibernation/migration using photoperiod as a cue. Also, there was no obvious change in climate at this time (Fig. 8). The bats that ceased activity at this time were probably "small" bats such as Myotis spp. (Brigham, pers. comm.).

The bat observed at Redfish Clearcut on 1 November was thought to be Eptesicus fuscus because of its size and the known late departure for hibernation by this species (van Zyll de Jong 1985). It is possible that this bat remained active until 4 November because no field work was conducted between 1 and 4 November. The cue for hibernation might have been the drop in temperature to sub-zero temperatures which occured on 4 November (Fig. 8).

It is surprising that the latest bat activity was observed at Redfish Clearcut since it was one of the sites at the highest elevation and had the fewest insects. Since it was the only site located at the edge of a clearcut, it is possible that clearcut edges are the most important habitat types just before hibernation. Another possibility is that E. fuscus use edge habitat throughout the year and were the last species to leave (Vonhof and Grindal 1993).

4.3 Food Availability and Diet

With the exception of hymenoptera and hemiptera, the fecal contents from M. yumanensis were similar to those found in a previous study in the Okanagan (Brigham et al. 1992). M. yumanensis have been previously known to eat hymenoptera and hemiptera (Whitaker et al. 1977).

Bats did not appear to select areas based on food abundance. At Redfish Clearcut, which had the lowest food availability, bats were observed until the latest date. Bats were not as abundant at Busk Road which had high insect availability. This inconsistancy might be a result of the insect sampling method. At Busk Road, which had the highest insect catch, the trap was placed near a small creek where insects and bats were observed flying low. At Redfish

Clearcut, bats were flying high, indicating that the insect population might be concentrated above the forest canopy. The trap, however, was located 1.5m above the ground.

My results indicate that bats fed selectively throughout the study period. This feeding behaviour did not change, even at the end of September. This behaviour suggests that more than enough insects were available to satisfy the energy needs of the bats or that bats only caught the prey that they could detect.

4.4 Bat Detectors

Only two trials were completed to determine if bat detectors are capable of picking up bats through the forest canopy. However, these trials indicated that bat detectors may not be able to pick up bats through a forest canopy of as low as 25% crown closure. Further trials should be done so that more conclusive results can be drawn. If bat detectors are unable to pick up bats through crown closure, then detecting bats at any given site in the forest would depend on 5 factors:

i) presence of a bat
ii) canopy closure
iii) presence of a gap
iv) height of canopy closure
v) size of the gap

The first of these factors is, of course, what the detectors are used to find out. If the effects of the other influencing factors are known, the results could be interpreted accordingly.

It should be noted that the maximum detection distance is dependent on the intensity of the echolocation call and the rate of attenuation of sound in air. Since different species have different echolocation intensities (Fenton and

Fullard 1981) and higher frequencies attenuate more rapidly than lower frequencies, the maximum detection distance differs between species.

If the probability of picking up a bat through 100% crown closure is 0, and the probability of picking up a bat through 0% crown closure is 1, then perhaps there is a scaling system of probability that could be used between these two extremes. Intuition would expect that probabilities would be proportional to percent crown closure. Since the average crown closure as estimated by the transect lines was 45%, then the probability of detecting bats by placing a detector randomly in the forest would be low. This theory, however, remains to be tested rigorously.

Another possibiltiy of the effect of crown closure on detection of bats might be a detectable/non-detectable cut-off line at a certain crown closure. This possibility was supported by the trials. In this case, canopy closure would not be as important a factor as presence of a gap since data on bat activity would only be accurate if detectors were placed in gaps. Estimations from the transect line indicate that only 17% of random sites would be located in a gap, suggesting that only a small percentage of randomly placed detectors would be useful.

The height to canopy closure may influence ability to detect bats since it affects the amount of open sky that can be detected. If bat detectors can only pick up bats when aimed at open sky, the height to canopy closure might affect bat detection in the following way:

For the purpose of visualization, I assume that bat detectors have a range in the shape of a cone where the tip of the cone is the bat detector and the base of the cone is at the maximum distance that the loudest bat can be detected. The angle of range that detectors pick up is actually 120° (Downes 1982). The height to canopy closure could effect the detectable area of the bat detector

(Fig.10). In a similar manner, the size of gap could also have an effect (Fig.10). If the range detected was indeed in a cone shape, specific areas could easily be calculated using simple geometry.

Bats can be detected in the forest (Vonhoff and Grindal 1993; Thomas 1988). However, the number of bat passes recorded may be lower than the actual bat activity. The limitation of bat detectors should be further investigated because of the strong significance it has in past and present bat research. If detectors reveal only a small proportion of bats that are actually using forest habitat, bat activity would be vastly underestimated and the importance of forest habitat to bats could not be determined.

5.0 POTENTIAL FUTURE RESEARCH PROJECTS

5.1 Confirmation of Bat Species present

Research needs to be continued to determine which species are present in the Nelson (WADF) area. Of the expected species, 7 have been confirmed and 1 has been added. For species that are difficult to catch (ex. Lasiurus blossevillii, L. cinereus), broadband microphones could be used to confirm their presence. These devices record full echolocation calls so that species can be identified from their call without being captured.

5.2 Clearcut edges

The latest bat was observed at the edge of the clearcut on 1 November and bats were not observed at any of the other sites at this time. Research should be conducted to determine if clearcut edges are used more frequently at the end of the year or if this observation was a result of the small sample size. Detectors could be placed at several edges, several ponds and several forests throughout the year until November. The importance of edge habitat could then be determined.

5.3 Cue(s) for Hibernation/Migration

The specific data for hibernation/migration could be determined by recording bat departure dates for several years every the fall. Dates, weather conditions, lunar condtions, and food abundance could also be recorded each year and correlations between each of these factors and date of departure could then be made. If date of departure is consistent regardless of weather conditions, this timing would indicated that photoperiod is the cue for hibernation/migration.

5.4 Bat Detectors

More trials on the effects of canopy closure on bat detectors should be conducted. Ideally, these trials should be done in the summer months when many bats fly overhead during the night. The increased sample size would allow a test of the hypothesis that bat detectors are limited when used in the forest.

Further research into bat detectors could include determining exactly how much canopy closure, gap size and height to canopy closure affect detecting bats. Experimental trials could be done whereby only one of these factors was varied and the others were left constant. Indexes based on each of these factors could be developed so that data could be adjusted using information on the sites where detectors were placed.

The scaling factor for crown closure could be determined by conducting further trials using bat detectors placed under 0% crown closure in close proximity to those placed under varying degrees of crown closure. Trials could also be done by comparing detectors placed on the forest floor to those placed at the top of the canopy.

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TABLES

TABLES

Table 1: NETTING SITES.

Area	Site	Elevation (m)	Site Characteristics
Redfish	Clearcut	829	edge of forest
	Main Road	973	edge of forest/small creek
	Spawning Channel	579	standing water
	Powerline	707	edge of forest
	Long Beach Road	659	large creek/flyway
Kokanee	Busk Road	801	small creek/flyway
	Kokanee Creek Park	579	standing water
	Old Growth Trail	1131	large creek/standing water
Other	Sitkum	598	large creek/flyway
	Grohman Narrows	598	standing water

Table 2: SEX AND MORPHOMETRIC DATA FOR ALL BATS CAPTURED.

Bat #	site	date	Species	Sex	age	Mass	ear	forearm	3rd	4th	wing span	time caught	time of sunset
1	RFSC	Sept 10	M. yuma.	f	a	7.5	13.3	36.8				20:10	19:12
2	RFSC	Sept 10	M. yuma.	f	a	7.0	12.4	33.6				20:10	19:12
3	RFSC	Sept 10	M. yuma.	f	a	7.0	12.0	35.15				20:44	19:12
4	RFSC	Sept 10	M. lucif.	f	a	7.0	12.8	33.7				21:06	19:12
5	RFSC	Sept 10	M. yuma.	m	a	6.0	10.8	33.7				22:40	19:12
6	BUSK	Sept 13	M. lucif.	m	a	6.0	12.5	34.7	45.1	43.5		20:55	19:06
7	KCP	Sept 17	E. fuscus	m	a	16.5	12.8	42.6	40.5	39.4		20:00	18:57
8	KCP	Sept 17	M. yuma.	m	a	8.0	12.4	35.5	34.2	32.3		20:00	18:57
9	KCP	Sept 17	M. yuma.	f	a	6.5	10.0	36.1	33.9	32.2		21:00	18:57
10	KCP	Sept 17	M. yuma.	m	j	6.5	10.8	33.1	31.0	30.2		21:00	18:57
11	KCP	Sept 17	M. yuma.	m	j	7.0	9.8	35.4	33.8	33.3		21:00	18:57
12	KCP	Sept 17	M. volans	f	a	10.0	10.8	39.8	36.9	35.0		21:00	18:57
13	RFSC	Sept 19	M. yuma.	m	j	7.0	10.6	33.8	30.1	29.3	115.6	20:10	18:53
14	RFSC	Sept 19	M. yuma	m	a	8.0	10.4	34.7	33.1	30.9	116.9	20:15	18:53
15	KCP	Sept 24	M. lucif.	m	a	5.5	13.5	33.9	30.4	27.8	112.2	19:10	18:42
16	KCP	Sept 24	M. yuma.	f	a	7.0	10.4	34.4	30.6	29.1	126.25	19:10	18:42
17	KCP	Sept 24	M. thysan.	f	a	7.0	11.4	36.3	30.2	30.3	128.75	19:17	18:42
18	KCP	Sept 24	M. yuma.	f	a	7.0	11.2	35.4	29.7	29.2	124.6	19:19	18:42
19	KCP	Sept 24	L. noct.	f	a	13.5	10.2	39.6	36.3	34.1	133.7	20:14	18:42
20	BUSK	Sept 27	M. yuma.	m	a	4.5	10.0	31.4	31.9	29.0	116.3	19:00	18:35
21	RFSC	Sept 28	M. yuma.	f	a	5.0	13.0	33.7	29.8	29.7	117.45	19:00	18:33

(RFSC=Redfish Spawning Channels; KCP=Kokanee Creek Park; BUSK=Busk Road)

Table 3: BAT PRESENCE AND WEATHER DATA. Presence and absence of bats, temperature, and weather data for each site in the Nelson area between 7 September and 1 November, 1993.

Date	Site	Survey	Temp ('C)	% Cloud	Wind	Present?
27-Sep	Busk Road	mist-netted	14	0	none	y
6-Oct	Busk Road	mist-netted	15	100	none	n
16-Oct	Busk Road	bat detectors	8	100	slight	n
26-Sep	Grohman	mist-netted	11	0	none	y
29-Sep	Grohman	mist-netted	12	100	slight	y
10-Oct	Grohman	bat detectors				n
12-Oct	Grohman	mist-netted	11	25	none	n
7-Sep	Kokanee Creek	mist-netted	24	25		y
17-Sep	Kokanee Creek	mist-netted	7	0	slight	y
24-Sep	Kokanee Creek	mist-netted	11	100	slight	y
4-Oct	Kokanee Creek	mist-netted	10	0	none	y
6-Oct	Kokanee Creek	bat detectors	15	100	none	n
7-Oct	Kokanee Creek	mist-netted	7	25	none	n
7-Oct	Kokanee Creek	bat detectors	7	25	none	n
8-Oct	Kokanee Creek	bat detectors	11	0	none	n
9-Oct	Kokanee Creek	bat detectors				n
20-Oct	Kokanee Creek	bat detectors	5	25	slight	n
31-Oct	Kokanee Creek	bat detectors	7	25	slight	n
23-Sep	Long Beach Rd.	mist-netted	11	25	slight	y
7-Oct	Long Beach Rd.	bat detectors	7	25	none	n
19-Oct	Long Beach Rd.	bat detectors	7	0	slight	n
21-Sep	Redfish Main Rd.	mist-netted	6	0	slight	n
16-Sep	Old Growth Trail	mist-netted	6	100	slight	y
16-Oct	Old Growth Trail	bat detectors	8	100	slight	n
12-Sep	Clearcut	mist-netted	10	0		y
25-Sep	Clearcut	mist-netted	12	0	slight	y
9-Oct	Clearcut	bat detectors				n
14-Oct	Clearcut	mist-netted	9	100	slight	y
17-Oct	Clearcut	mist-netted	8	50	slight	y
19-Oct	Clearcut	bat detectors	7	0	slight	n
20-Oct	Clearcut	bat detectors	5	25	slight	n
27-Oct	Clearcut	bat detectors				n
31-Oct	Clearcut	bat detectors	7	25	slight	y
1-Nov	Clearcut	bat detectors	5	75	slight	y
4-Nov	Clearcut	bat detectors	3	100	none	n
11-Nov	Clearcut	bat detectors	2	0	slight	n
14-Nov	Clearcut	bat detectors	-1	25	slight	n
3-Oct	Powerline	mist-netted	9	0	slight	n
9-Sep	Spawning Channel	mist-netted	17	0		y
10-Sep	Spawning Channel	mist-netted	18	0		y
19-Sep	Spawning Channel	mist-netted	14	75	none	y
28-Sep	Spawning Channel	mist-netted	14	0	none	y
5-Oct	Spawning Channel	mist-netted	14	0	none	n
7-Oct	Spawning Channel	bat detectors	7	25	none	y
8-Oct	Spawning Channel	mist-netted	11	0	none	n
9-Oct	Spawning Channel	bat detectors				n
20-Oct	Spawning Channel	bat detectors	5	25	slight	n
27-Oct	Spawning Channel	bat detectors				n
31-Oct	Spawning Channel	bat detectors	7	25	slight	n
8-Sep	Sitkum	mist-netted	19	0		y
15-Sep	Sitkum	mist-netted	12	100	none	y
19-Sep	Sitkum	bat detectors	14	75	none	n
19-Oct	Sitkum	bat detectors	7	0	slight	n

Table 4: INSECTS CAUGHT PER HOUR FOR EACH TRAPPING NIGHT.

Site	Date	# Trap hours	Total	Dipt	Chir	Lepi	Tric	Hym	Hete	Homo	Thys
Busk Road	**Sep.7**	2.83	24.4	21.2	1.1	1.4	0.4	0.4			
Sitkum	**8**	3.00	66.7	64.3	0.7	1.3			0.3		
Long Beach	**9**	2.00	90.0	82.5	3.0	4.5					
Spawning Ch.	**10**	4.58	24.7	19.9	4.15	.7					
Clearcut	**12**	2.58	0.4	0.4							
Busk Road	**13**	4.00	10.0	8.8	0.5	0.5	0.3				
Old Growth	**16**	2.50	38.4	28.0	8.4	0.8	1.2				
Kokanee Cr.	**17**	3.17	11.0	10.7	0.3						
Spawning Ch.	**19**	3.83	21.7	20.9	0.5	0.3					
Main Road	**21**	2.92	6.2	6.2							
Long Beach	**23**	2.50	8.8	8.8							
Kokanee Cr.	**24**	3.16	13.3	11.1	1.6	0.6					
Clearcut	**25**	2.83	2.8	2.8							
Grohman	**26**	2.16	5.6	2.3	2.3	0.5			0.5		
Busk Road	**27**	2.83	78.4	72.8	3.2	0.7		1.0		0.4	
Spawning Ch.	**28**	3.67	12.0	10.9	0.8	0.3					
Grohman	**29**	2.16	28.7	20.8	6.5						
Powerline	**Oct. 3**	2.42	28.9	27.3	1.2	0.4					
Kokanee Cr.	**4**	3.16	6.0	6.0							
Spawning Ch.	**5**	3.16	20.6	19.9	0.6						
Busk Road	**6**	2.42	211.2	207.4	1.2	1.2		1.2			
Kokanee Cr.	**7**	3.08	5.5	5.2	0.3						
Spawning Ch.	**8**	2.58	5.8	5.0	0.8						
Grohman	**12**	2.83	2.5	1.8	0.4						0.4
Clearcut	**14**	2.08	1.9	1.9							
Clearcut	**17**	2.25	0.4	0.4							
Clearcut	**19**	1.58	0.0								
Kokanee Cr.	**20**	2.08	3.4	2.4	0.5	0.5					
Kokanee Cr.	**31**	2.50	0.8	0.8							
Total		80.86	728.5	670.5	38.1	13.7	1.9	2.6	0.8	0.4	0.4
Percent (%)				92.0	5.2	1.9	.26	.36	.11	0.05	0.05

(Dipt=Dipteran; Chir=Chironomid; Lepi=Lepidopteran; Tric=Trichopteran; Hym=Hymenopteran; Hete=Heteropteran; Homo=Homopteran; Thys=Thysanopteran)

Table 5: PERCENTAGE VOLUME OF EACH INSECT ORDER IN BAT FECAL PELLETS.

Bat #	% Dipt	% Chir	% Lepi	% Trich	% Hemi	% Col	% Hym
1	*100*						
2			*1.25*	*98.75*			
3	*28.75*	*71.25*					
5	*36.25*	*8.75*	*2.5*	*17.5*	*32.5*	*3.75*	
8	*87*	*12*					*1*
9	*76*	*6*	*3*			*8*	*7*
10	*78*	*4*			*11*	*2*	*5*
11	*39*		*1*	*60*			
13	*51*	*8*	*2*	*4*	*16*	*3*	*16*
16	*71*	*6*	*3*	*12*	*1*		*7*
21	*61.25*				*38.75*		
Avg.	*57.0*	*10.5*	*1.0*	*17.5*	*9.0*	*1.5*	*3.5*

(Dipt=Dipteran; Chir=Chironomidae; Lepi=Lepidopteran; Tric=Trichopteran; Hemi=Hemipteran; Col=Coleopteran; Hym=Hymenopteran)

Table 6: FREQUENCY OF INSECT ORDERS IN THE DIET OF MYOTIS YUMANENSIS.

Insect Order	# of Bats	Frequency
Dipteran	10	.91
Chironomidae	7	.64
Lepidopteran	6	.55
Trichopteran	5	.45
Hemipteran	5	.45
Coleopteran	4	.36
Hymenopteran	5	.45

Table 7: NUMBER OF BAT PASSES PICKED UP BY BAT DETECTORS.

	Canopy Closure						
Site	**< 5**	**25**	**35**	**45**	**55**	**60**	**65**
Sitkum	3	0	0		0		0
Redfish	1			0	0	0	0

n=number of bats heard

Table 8: CANOPY CLOSURE, PRESENCE OF GAP, AND DETECTABILITY OF BATS ON TRANSECT LINES.

Site	**average canopy closure (%)**	**average height to canopy closure (m)**	**in gap**	**on edge of gap**	**gap < 5 m away**	**gap > 5 m away**	**% of sites adequate to detect**
1	50	3	15%	15%	20%	50%	15%
2	50	4	15%	15%	5%	65%	25%
3	42	5	15%	15%	20%	50%	25%
4	38	12	30%	0%	15%	55%	30%
5	45	13	10%	15%	5%	70%	20%
all sites	45	7	17%	12%	13%	58%	23%

FIGURES

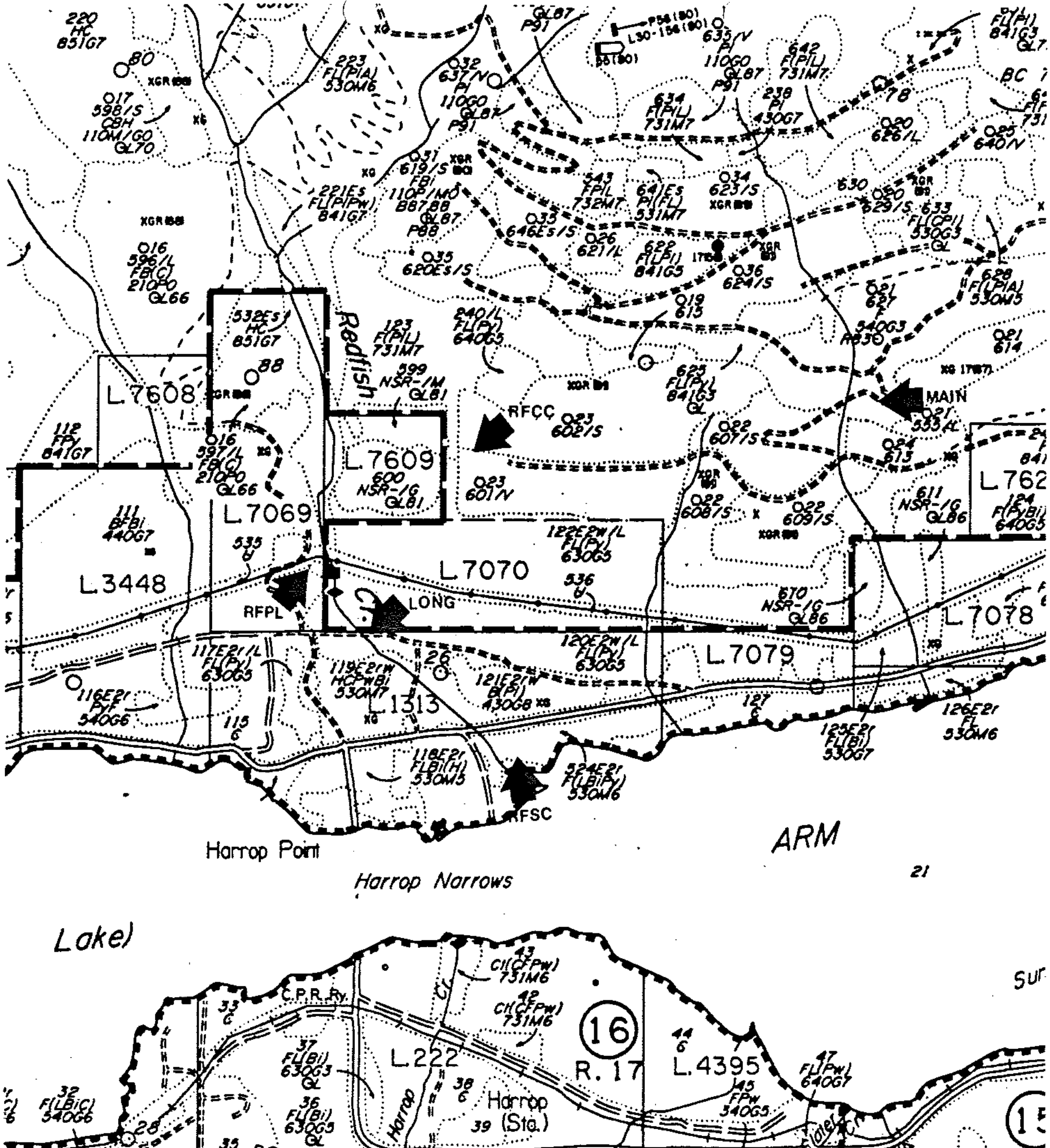

Figure 1: Redfish Sites (taken from 1:20 000 Forest Cover Map 82F065).
(RFCC=Redfish Clearcut; LONG=Long Beach Road; MAIN=Redfish Main Road; RFSC=Redfish Spawning Channels)

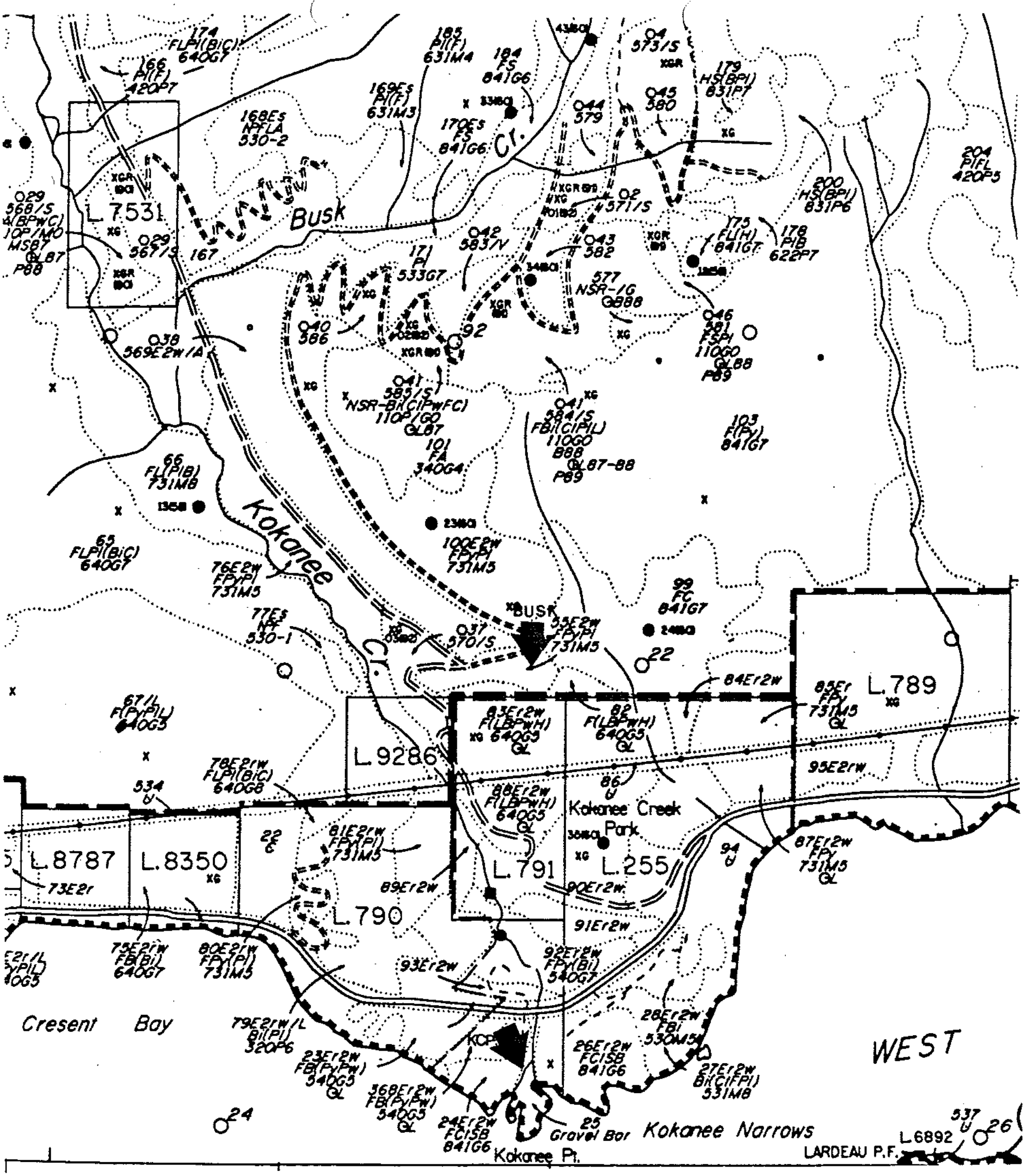

Figure 2: Kokanee Creek Sites (taken from 1:20 000 Forest Cover Map 82F065).
(BUSK=Busk Road; KCP=Kokanee Creek Park)

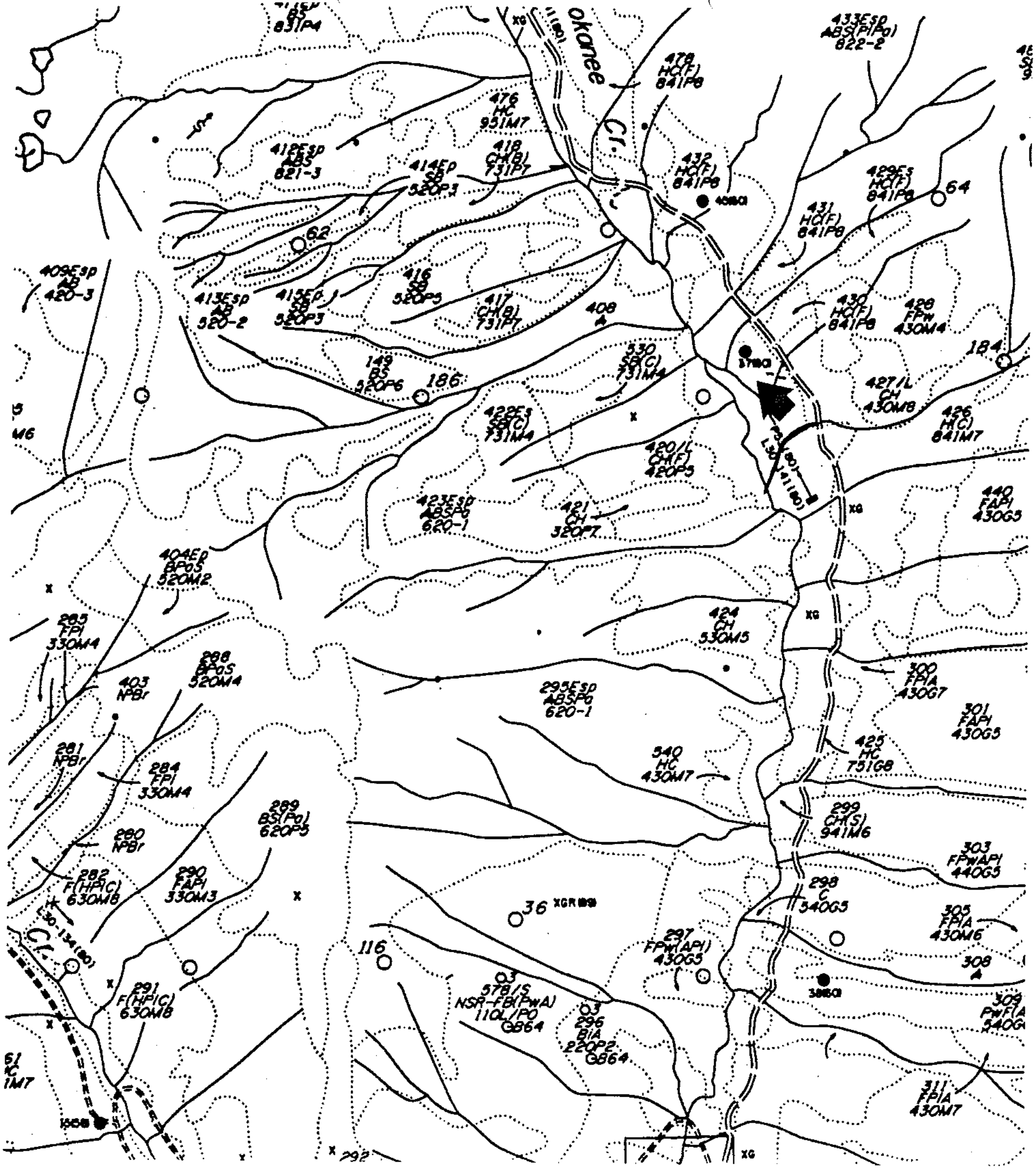

Figure 3: Old Growth Trail Site (taken from 1:20 000 Forest Cover Map (82F065).

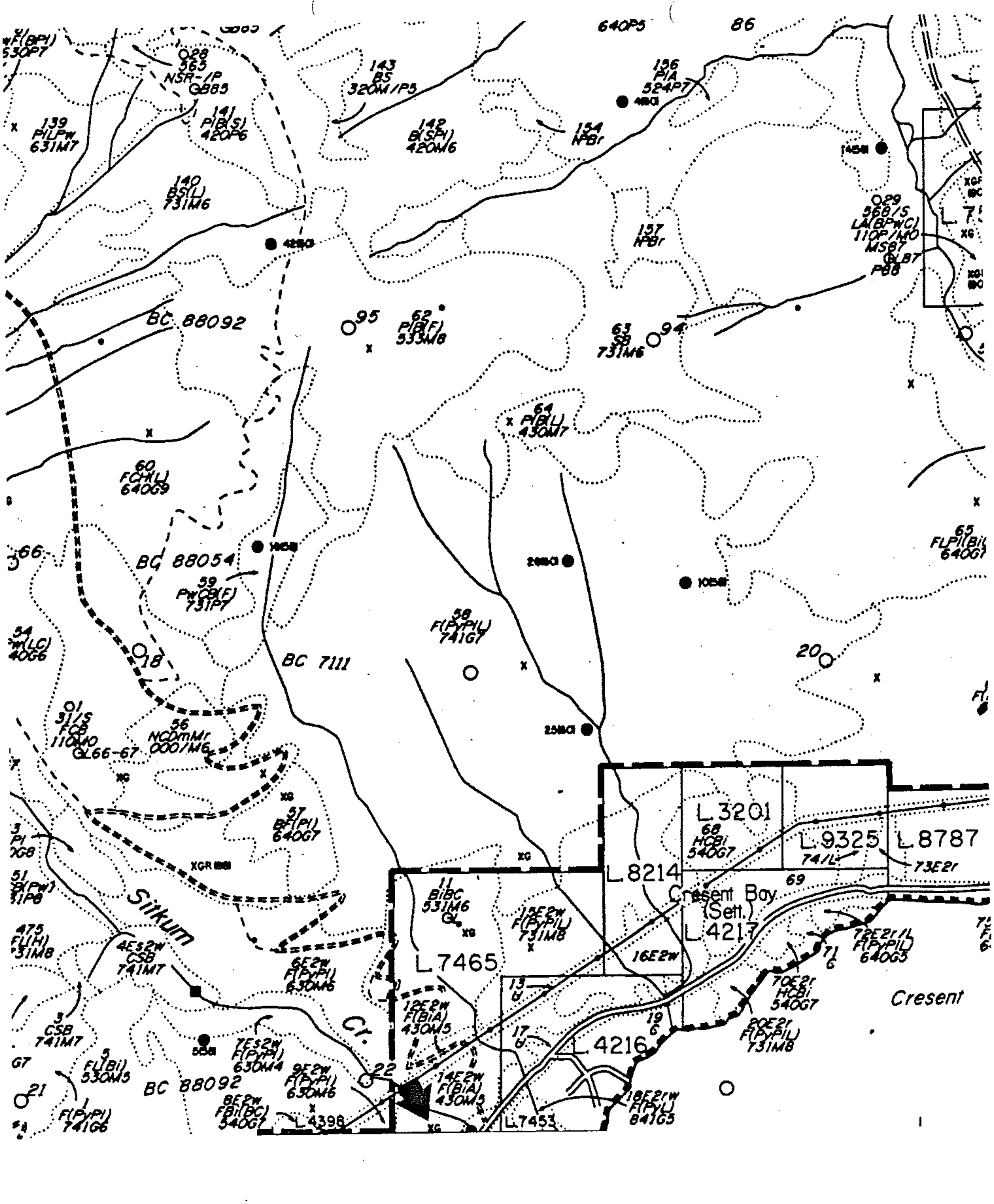

Figure 4: Sitkum Creek Site (taken from 1:20 000 Forest Cover Map 82F065).

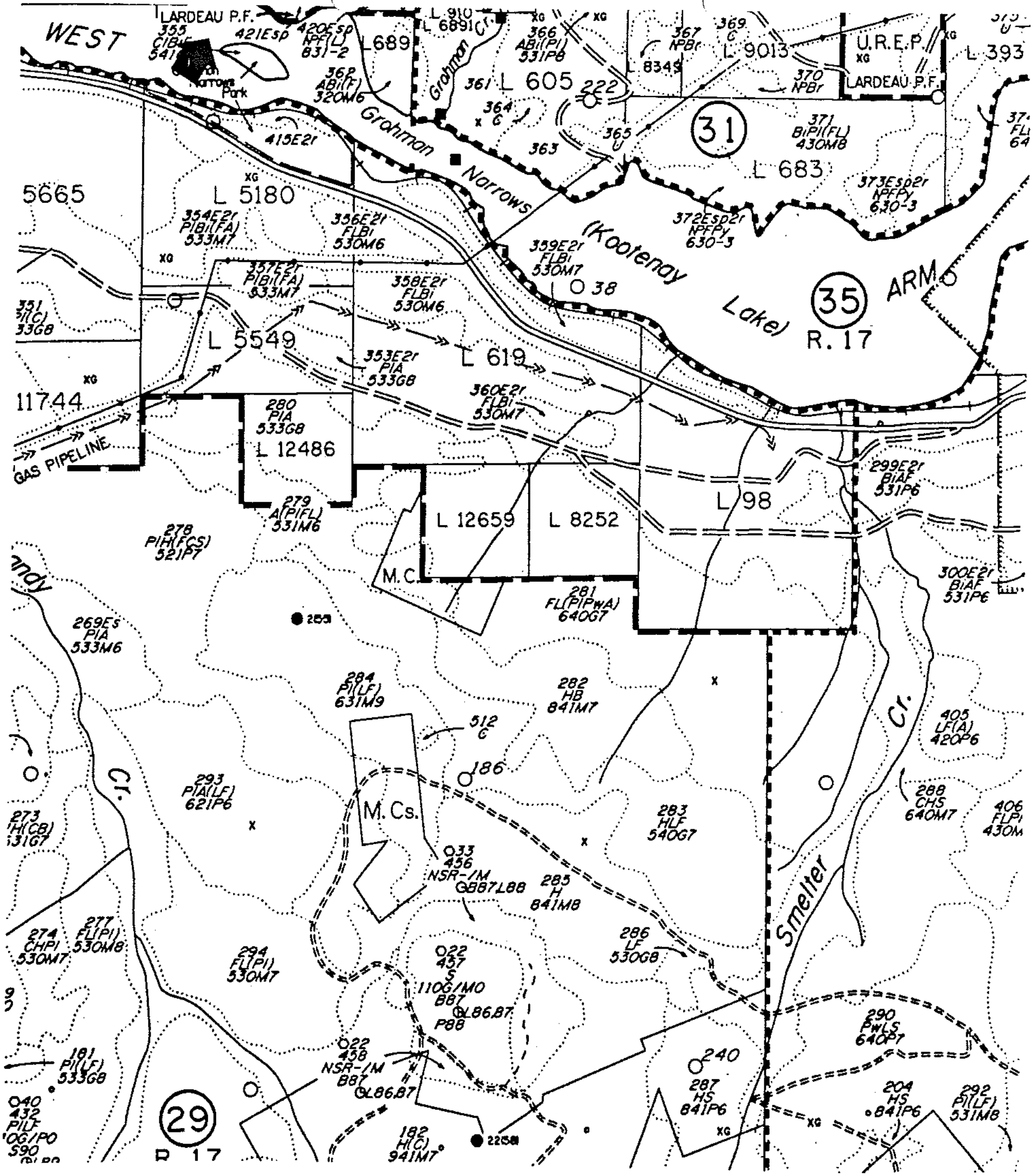

Figure 5: Grohman Narrows Site (taken from 1:20 000 Forest Cover Map 82F044).

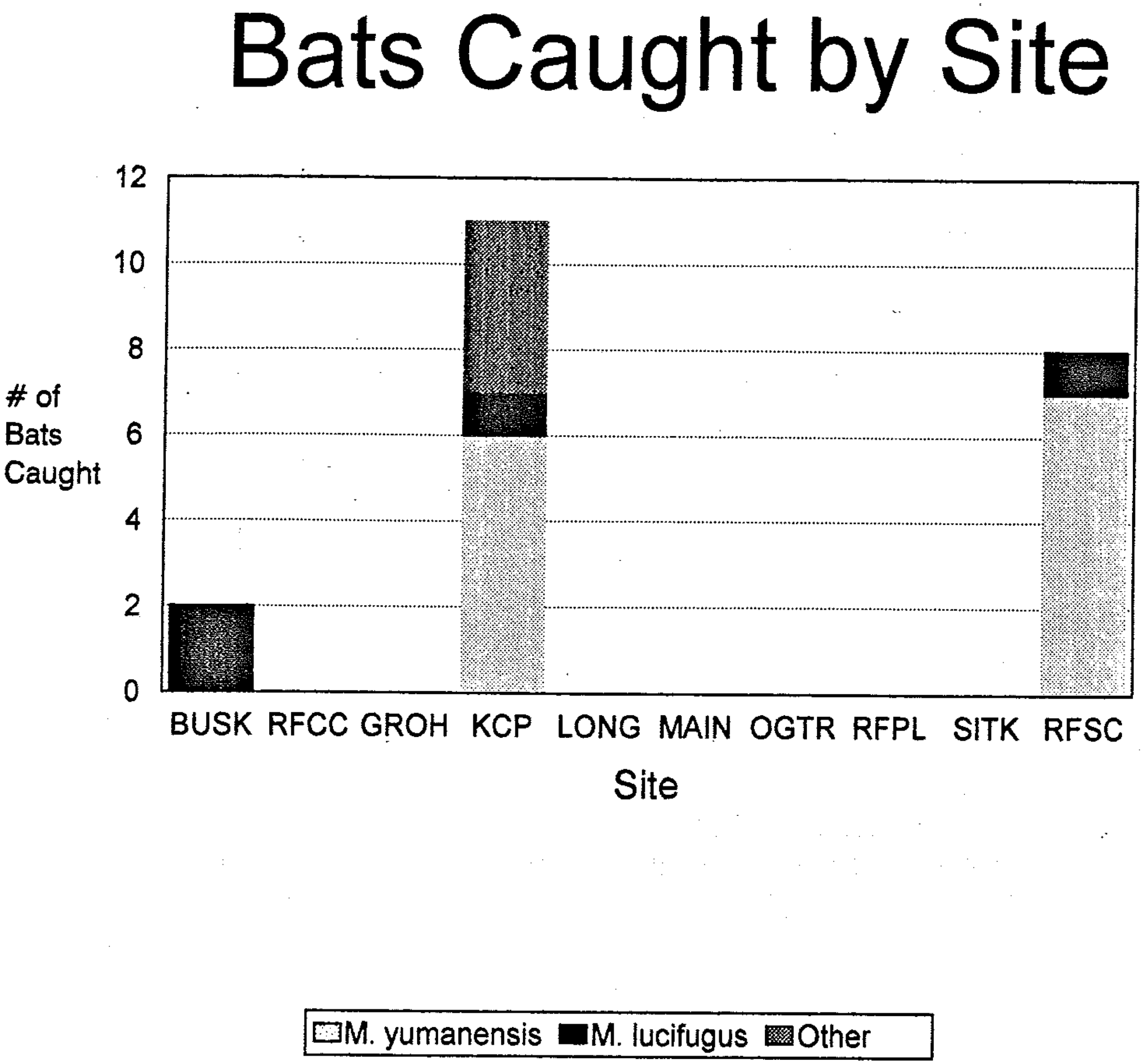

Figure 6: Bat captures at each netting site in the Nelson area. The number of bats caught represent all captures between September 7 and 28, 1993. (BUSK=Busk Rd.; RFCC= Redfish Clearcut; GROH= Grohman Narrows; KCP= Kokanee Creek Park; LONG= Long Beach Road; MAIN= Redfish Main Road; OGTR= Old Growth Trail; RFPL= Redfish Powerline; SITK= Sitkum Creek; RFSC= Redfish Spawning Channel)

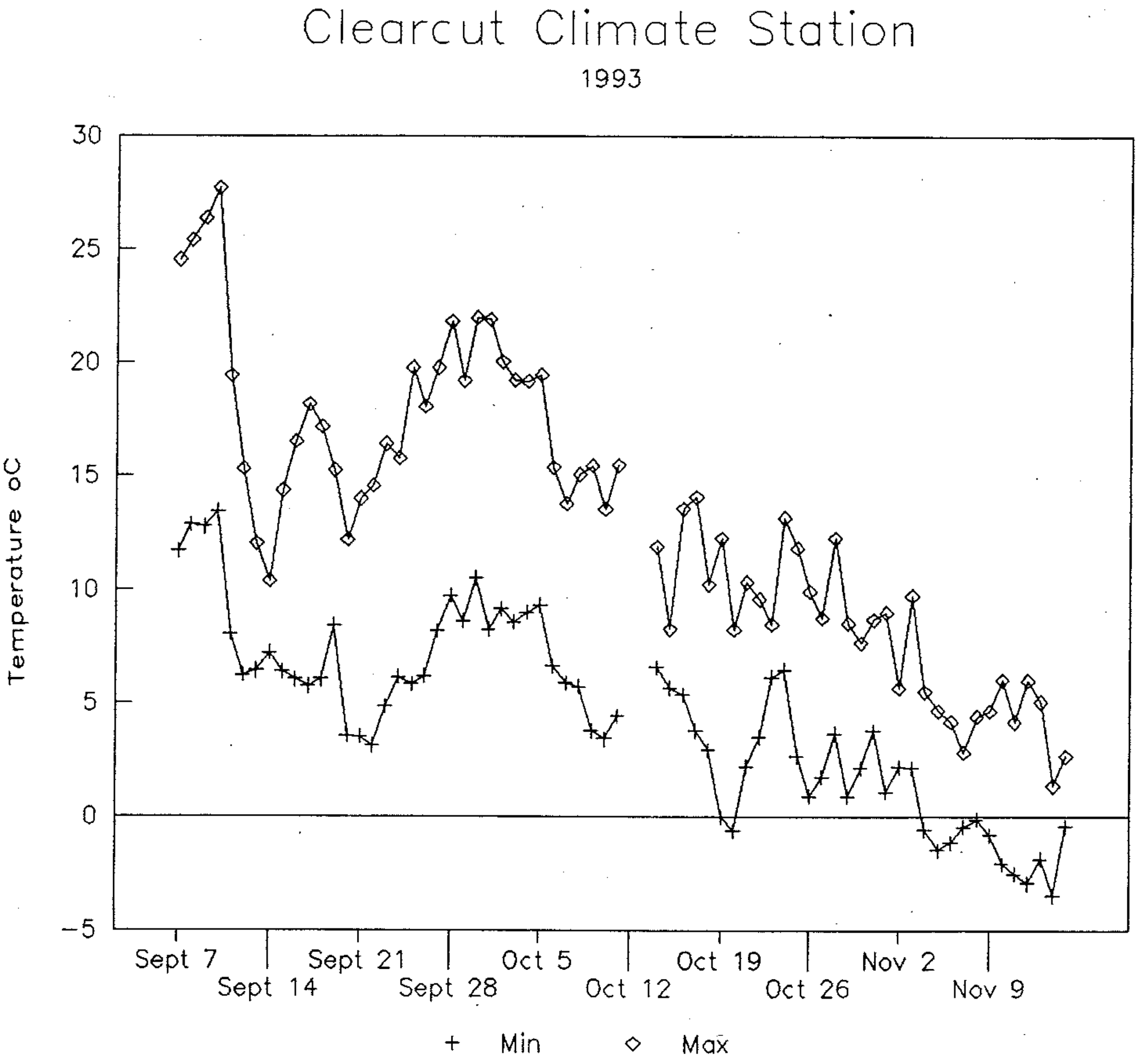

Figure 8: Daily maximum and minimum temperatures as recorded from the "Seed Tree" Clearcut Climate Station. This raw data is courtesy of Forest Sciences Section, Ministry of Forests, Nelson Region and has not been edited. The Climate station is located within 1 km of the Clearcut netting site.

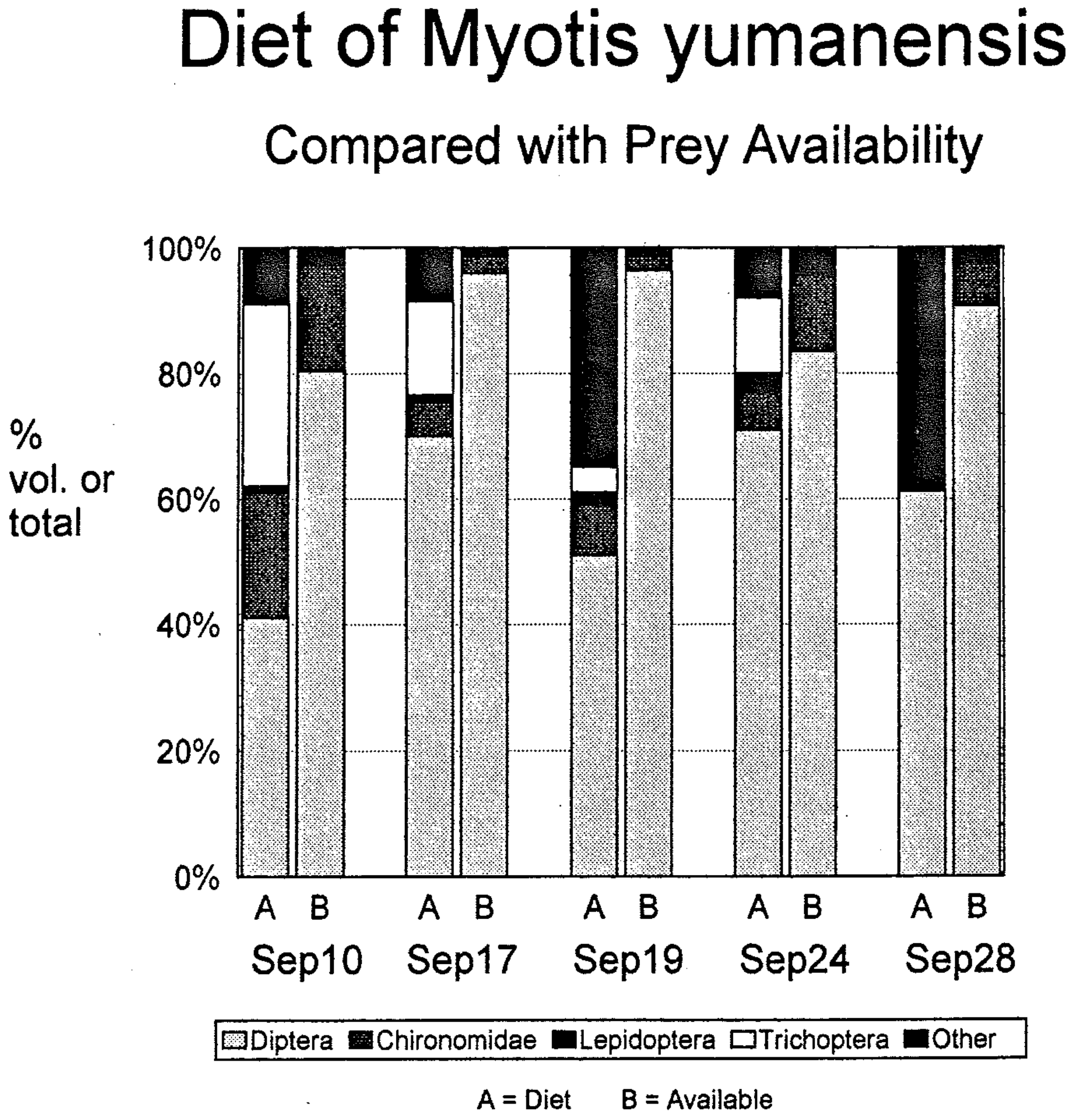

Figure 9: Diet of Myotis yumanensis compared with prey available. Diet (A) was determined by estimating the percent volume of each insect order in fecal pellets. The average of all bats caught in one night was calculated to give a single estimate for diet for that night. Prey availability (B) was assessed by catching insects using a light/suction trap.

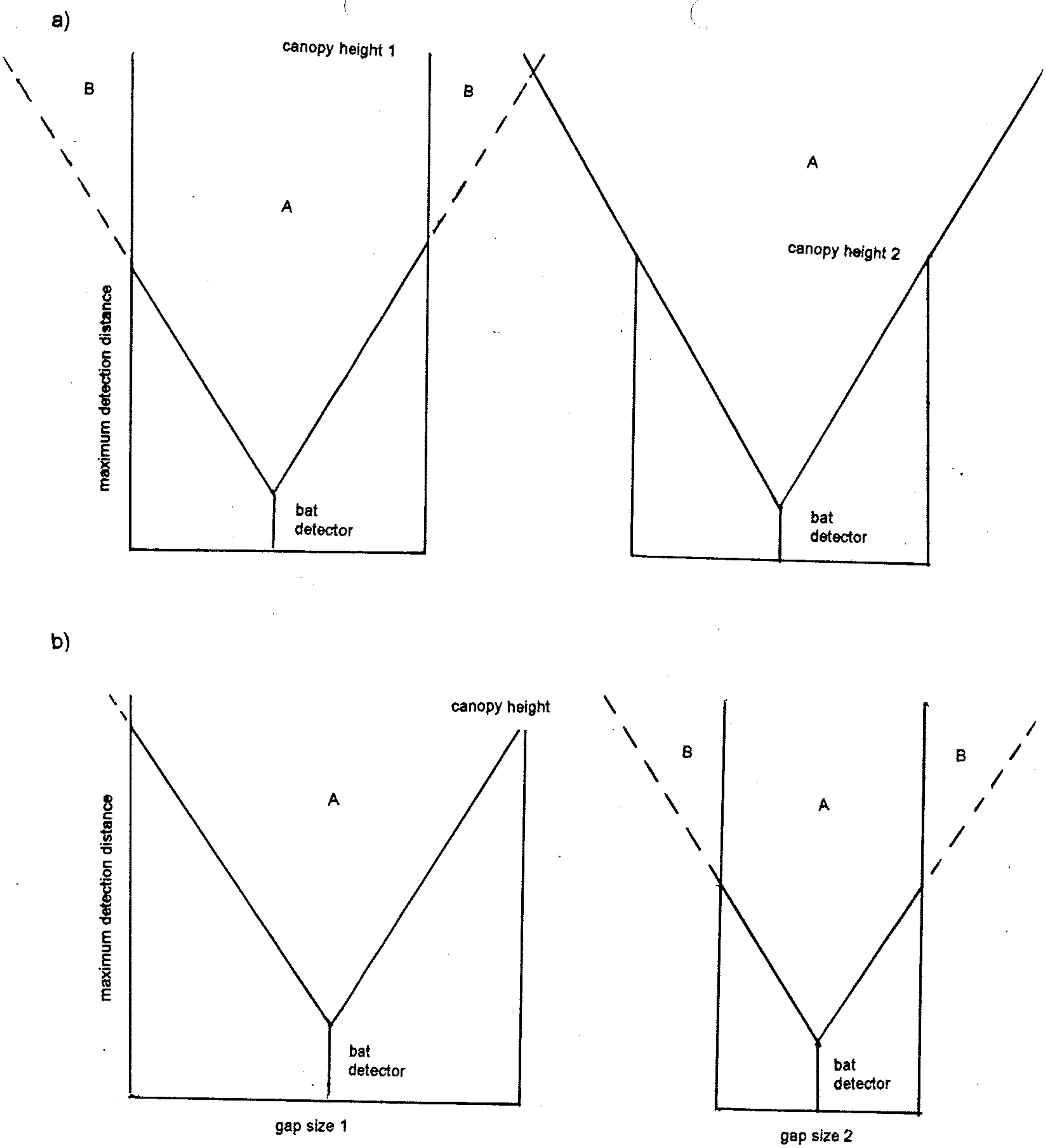

Figure 10: The potential effects of a) canopy height and b) gap size on the area censused by bat detectors. A= detectable area. B= non-detectable area.