Province of British Columbia
Ministry of Agriculture and Food
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Agriculture Canada

THE MAXAN LAKE MULTI-LAND USE STUDY

A SUMMARY REVIEW

Project Number 271032

under the

Canada-British Columbia Subsidiary Agreement on

Agriculture and Rural Development

Compiled and Written by:

Allan O. McNeil
B.C. Ministry of Agriculture and Food

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This summary review of the Maxan Lake multi-land use study has been released for limited distribution by the Management Committee of the Agriculture and Rural Development Subsidiary Agreement, which funded the study, with the following comment:

The objective of the Maxan Lake multi-land use study was to examine the interaction between various forms of land use on an area having multi-use capacity. To this end, various studies were conducted to examine different aspects of this complex subject. The final report is a discussion document that summarizes these studies.

This report should be used with caution. The difficulties faced by the editor of this document included two principal problems with the actual level of multi-land use in the Maxan Lake area. First, while the site has a multi-use capacity, its agricultural and recreational potential are stated to be low and cattle numbers were purposely kept below normal stocking rates. Therefore, conclusions regarding the effect of cattle on seedlings and on other uses cannot be applied to normal range situations. Secondly, the area is said to have high wildlife potential, but only moose are studied; yet the moose population over the entire range was never more than 70 animals. No other wildlife species are studied or even mentioned.

ACKNOWLEDGEMENTS

This study was funded under the Agriculture and Rural Development Act (A.R.D.A.) during the years 1971 to 1976 and the Canada-British Columbia Agriculture and Rural Development Subsidiary Agreement (A.R.D.S.A.) during 1977 and 1978. The funds were provided under the direction of the B.C. Ministry of Agriculture and Food, Department of Regional Economic Expansion and Agriculture Canada.

It is recognized that many other federal and provincial government agencies contributed considerable time and man power to various parts of the Maxan Lake Multi-Land Use Study.

Portions of this report draw heavily on work done by the following people. Jim van Barneveld and Carol Thompson, Ministry of Environment, reported on the soils and vegetation aspects of the study. Dave King and Dennis Ableson, Ministry of Environment, reported on the wildlife and water quality areas, respectively, and R.D. Marsh, Ministry of Environment, discussed the climatological aspects of the study.

A NOTE ON THE UNITS OF MEASUREMENT

The reader will find portions of this study written in imperial units while other sections use metric units. This reflects the use of either the imperial or metric system, depending on the discipline, that occurred during the study period from 1971 to 1978. It was decided to report the study results using the units in which they were recorded to simplify production of this report.

Any of the later work and background material uses metric units.

EXECUTIVE SUMMARY

INTRODUCTION

The Maxan Lake Multi-Land Use Project was established in 1971 to study the interaction between various forms of land use on an area having a multi-use capacity in response to an ongoing concern with cattle and wildlife interactions and with a perceived need for increased domestic grazing. The Maxan Lake study area is located about 20 kilometers west of Burns Lake in a shallow valley at an elevation of about 775 meters with surrounding hills that reach 850 meters. The area is generally forested with mixed age stands of lodgepole pine and associated vegetation broken, in the valley bottom, with open meadows. Soils are generally alluvial or lacustrine in the valley bottom and glacial tills on the valley slopes.

The development plan formulated for the study laid out two main objectives. These were to observe, measure and document:

1) the interaction between resource users within an ecosystem; and

2) changes that will take place within the present ecosystem through the imposition of induced changes in land use.

To meet these objectives, four sub-projects were established. These were:

1) ecological inventory;
2) tree, grass and grazing study;
3) cattle - ungulate interaction; and
4) determination of carrying capacity and productivity of grazing site for beef cattle.

ECOLOGICAL INVENTORY

The first step in the Ecological Inventory was to gather information on the climatic, water, soils and vegetative conditions prior to the imposition of a land use on the study area. The second step involved monitoring the ecosystem affected by land uses, and thus; the objective, determining how a land use affects the ecosystem, would be met by comparing the data from before the start of land use with the data collected after use had begun. Work began in 1972 and is still continuing because some aspects of the inventory require monitoring over a long period of time.

The study area has a continental climate with long, cold winters, prolonged springs and fall periods and short, warm summers. Temperatures range from $-47^{\circ}C$ to $+32^{\circ}C$ and precipitation, relatively evenly distributed throughout the year, is greatest in December.

The temperatures on site are most extreme in the valley bottom and least variable under the forest canopy on the hillsides. Precipitation during the growing season averaged 213 mm, and annual precipitation averaged 483 mm. Growing degree days varied from 839 to 912, and killing frost free period (greater than $-2.2^{\circ}C$) varied from 60 to 98 days in the valley bottom, and on the forested hillside, from 150 to 156 days.

The area is drained by Foxy Creek, Crow Creek and Maxan Creek.

A variety of fishes inhabit the local streams including Rainbow trout, Dolly Varden char, Mountain whitefish and a variety of coarse fish.

Water quality studies showed pH levels remained relatively constant at 7.0 to 7.7, phosphorus concentration increased downstream, nitrogen levels remained constant and bacteriological levels were within the normal range of variability. Flow rates varied greatly in the two years they were monitored. For example, total discharge in 1975 was 46,200 acre feet, and in 1976, was 107,000 acre feet. Water temperatures varied from about $-1^{\circ}C$ to about $17^{\circ}C$ climbing in late May, peaking in July and dropping in September.

The seven different soil complexes mapped were generally alluvial or glacial tills. The alluvial soils varied in texture, were well sorted and subject to some flooding. The glacial tills were generally compact, of low permeability and poorly developed.

Vegetation varied by general soil type with lodgepole pine, white spruce, alpine fir and aspen growing on the hillsides and willow, alder, cottonwood along with a variety of grass and forb species growing on the valley floor.

An analysis of data collected concluded that grazing and browsing have an impact on species composition, and these activities altered the vegetation of the meadows.

<u>TREES, GRASS AND GRAZING STUDY</u> (Sub-Project II)

Sub-Project II was designed "to assess the effects of clearing, fertilization, grass seeding, lodgepole pine planting and grazing on tree regeneration and growth, forage production and soil properties" from an ecological point of view. The project was conducted on a simulated clear-cut located on the hillside to the east of Maxan Creek, and each of the treatments was laid out in a strip running uphill.

A floristic analysis was done to determine the effects of the treatments on vegetation. While it is still too early to draw definite conclusions, it was noted that grazing did not have a significant effect on vegetation composition (the area was only grazed for a short period). It was also noted that after five years while the plots all had similar species composition, different plots had different proportions of each species.

Biomass measurements were taken and those plots fertilized, seeded or planted showed the highest biomass (2) and the same plots also showed the highest organic matter content.

The forestry observations showed that mean annual increment (M.A.I.) varied between 53 and 73 cubic feet / acre / year in the original, overmature stands. The seedling count showed 797 seedlings / acre in the planted plots and 716 in the non-planted plants after five years, significantly above the 250 trees / acre considered 100 percent stocked.

Soil moisture and temperature data were collected at various times throughout the study period, but incomplete records, highly variable data and instrument difficulties caused the data to be of questionable quality. The levels of calcium, magnesium, potassium and phosphorus for the 0 - 6" depth were determined, and the results showed these elements to be at least adequate for grasses in the Prince George area. The Ca: Mg and K : Mg ratios were acceptable, increases in phosphorus on the surface horizons were noted after fertilization and the pH ranged from 5.5 to 7.0.

CATTLE - UNGULATE INTERACTION - (Sub-Project III)

Conducted with the Fish and Wildlife Branch, Ministry of Environment, the main objective of Sub-Project III was "to measure what change, if any, takes place under intensive grazing of cattle on:

1) the general ecology of the area; and
2) on the wintering capabilities for ungulates".

The sub-project was formulated due to concerns by Fish and Wildlife Branch biologists that cattle on Crown ranges were having a deterimental effect on wildlife habitat. The objectives were to be met by conducting browse and pellet count studies to determine winter carrying capacity for moose by grazing the area with cattle, by doing winter moose counts and by setting up two exclosures; one moose and cattle proof and the other cattle proof.

Moose sighting in the study area in summer were rare with the moose usually congregating in November and dispersing from mid-March to May as the snow pack disappeared. Winter use varied depending on the depth of snow pack with the heaviest and most restricted use occurring in the years with the deepest snow. The moose most frequented the swampier areas of the valley bottom using willow and other vegetation which grew there. The upland areas were used about 10% as much as the wet areas of the study site. Willow was the most frequently used browse species by moose.

In the harder winters, a greater degree of the available browse was used by moose than in the low snowfall years. The heavier use may have been due to the moose "yarding up" in one area.

There were no discernable differences between the degree of browsing of twinberry, willow, aspen or saskatoon between areas used by cattle and the cattle exclosure although moose browsing may have masked any effects due to cattle. It was noted that cattle tended to strip leaves from branches and remove tips, and they preferred black twinberry to willow. Browsing was much higher near salt blocks, but the overall effect was insignificant in relation to the total range area. Browsing by cattle increased as fall approached, and it was noted that later in the season a proximate analysis showed shrub nutrient constituents to be higher than the forage nutrient constituents. Dry matter digestibility (D.M.D.) analysis for willow ranged from 32.7% early in the year to 37% in July and to 20% the following February.

In a series of tests, removal of the tip and 20%, 40%, 60% and 80% of the shoot showed that up to 20% could be clipped with little effect on the total growth of the shoot. If a greater portion was removed, growth was reduced by about two thirds in that year.

The results show that the wet areas are most critical for moose, willow is the most important browse species, and moose tend to remain in these areas even though snow depths are reduced in the forest. Moose were felt to have a significant impact on their own habitat since the browse plants in the moose exclosure recovered and grew quickly once they were protected. As well, it was felt that cattle, at the moderate stocking rate used, had a minimal impact on moose habitat.

DETERMINATION OF CARRYING CAPACITY AND SITE PRODUCTIVITY FOR BEEF CATTLE - (Sub-Project IV)

The objective of Sub-Project IV was to provide basic information on the carrying capacity and productivity of forested and open meadow grazing sites in response to an apparent need for summer grazing for beef cattle in the area.

Nutrient analysis of shrub, forb and grass species; some yield data; annual grazing reports; annual and monthly cattle weights and a cattle grazing survey were recorded over the study period.

Nutrient analysis shows that levels of protein and other minerals would fall off in July or August - earlier than expected. This varied from site to site and species to species, but in general, nutrient levels would be below NRC guidelines before September 1. Protein levels varied greatly between and within species. Some shrubs showed variability in protein levels from 3.9 - 17.5 percent (rose) while some herbs ranged as high as 20.1%, grasses to 21.9% and legumes to 26.7% and 38.1%.

Cattle ranged the study area starting in 1973 for varying periods and at levels from 31 animal units (1973) to 66 animal units (1976). Reports on general cattle activity were kept and show that cattle avoided eating poisonous plants, there were no predator problems, as the cattle learned the area they would move up to three miles in a day, insect pests kept the cattle moving and may have affected weight gains, and the cattle stayed in the valley bottom as a rule. Two head were lost during the five year study period due, it was suspected, to poisoning by water hemlock.

Cattle weights were recorded for the study period and showed that cows, calves and yearlings all gained well in June with cows losing weight by September, yearlings leveling off and calves generally continuing to gain although not at the same rate per day as earlier in the summer. Season long average daily gains (A.D.G.) for cows varied from 1.35 to 2.21 lbs. / day, for calves from 1.84 to 2.57 lbs. / day and for yearlings from 1.63 to 2.41 lbs. / day.

The Cattle Grazing Survey showed that the cattle tended to bed down in the middle of the day when it was warm and sunny and also tended to move about less when it was raining or hot.

BEAVER SURVEY

The Beaver Survey was conducted to inventory beaver dams and lodges and estimate levels of activity of the animals because it was suspected that, over time, the building and breaking of dams would have a major effect on vegetation along the valley floor. The dams would flood several acres killing out trees and shrubs, open up the area, and once the dam was abandoned, leave a clear area in which a meadow would form. This would result in both forage for cattle and browse for moose.

ADVISORY COMMITTEE

M.G. Oswell	-	B.C. Ministry of Agriculture and Food
A. Bawtree	-	B.C. Ministry of Agriculture and Food
J.W. Awmack	-	B.C. Ministry of Agriculture and Food
J. van Barneveld	-	Soils - B.C. Ministry of Agriculture and Food
Phil van Mol	-	B.C. Ministry of Forests
G. Johnstone	-	B.C. Ministry of Agriculture and Food
R.M. Kohlert	-	Regional Economic Expansion
D. King	-	Fish and Wildlife
B. Marsh	-	Climatology - Secretariat
D. Blumenaur	-	B.C. Ministry of Agriculture and Food
A. McLean	-	Agriculture Canada

PROJECT MANAGER

Lee Bowd

MAXAN LAKE MULTI-LAND USE STUDY

A Summary Review

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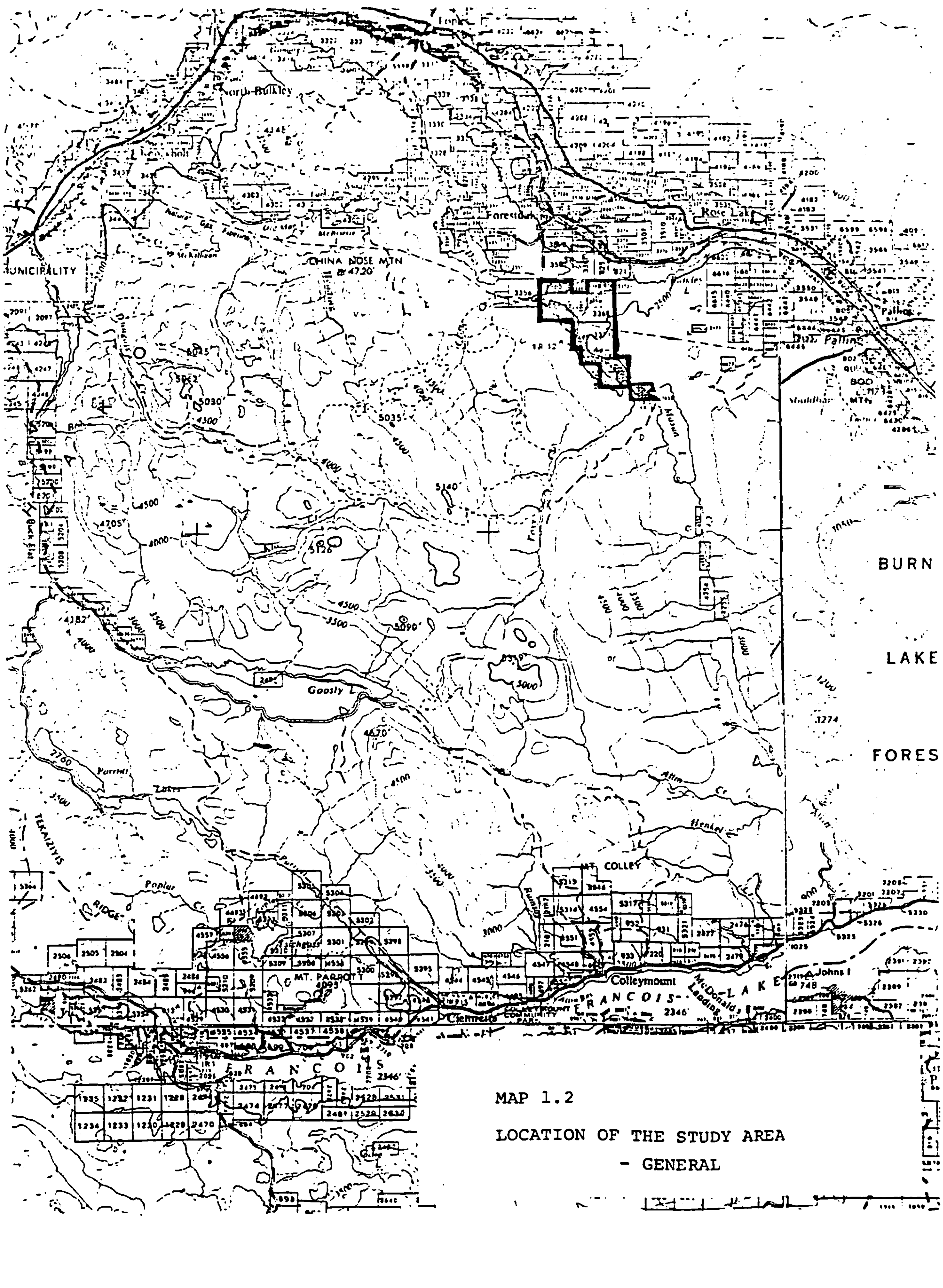


MAP 1.2

LOCATION OF THE STUDY AREA - GENERAL

MAXAN LAKE MULTI-LAND PROJECT

A SUMMARY REVIEW

1. INTRODUCTION

The Maxan Lake Multi-Land Use Project was established in 1981 to study the interaction between various forms of land use on an area having a multi-use capacity in response to an on-going concern with cattle and wildlife interactions and with a perceived need for increased domestic grazing.

1.1 DESCRIPTION OF STUDY AREA

1.11 General

The study area is located on the Nechako Plateau, an area characterized by low relief and flat to gently rolling landforms.

The plateau was heavily glaciated during the Fraser Glaciation (19,000 - 10,000 B.P.) and a thin sheet of ice covered most of the plateau resulting in drumlin-like ridges and grooves. This glacial action of picking up and then dropping bedrock and surficial materials resulted in a blanket of glacial till material over much of the region. This covering has greatly reduced the impact of local bedrock on soils.

Bedrock tends to be flat or gently dipping lava flows over older volcanic and sedimentary rocks. The types of volcanic rocks present (with the exception of granite) tend to weather to fine-grained minerals. Bedrock outcrops are not common. In addition to till deposits, lacustrine and fluvial deposits further reduced the influence of bedrock in the river valleys.

The vegetation of the Nechako Plateau is characteristic of the Sub-Boreal Spruce Biogeoclimatic Zone currently being described by the Ministry of Forests Research Branch. It is dominated by an upland coniferous forest consisting of the climatic climax species; white spruce (*Picea glauca*), and alpine fir (*Abies lasiocarpa*). These species occur as a mixture.

In areas of recent disturbance, lodgepole pine (*Pinus contorta*) and trembling aspen (*Populus tremuloides*) form widespread seral stands. Map 1.1 shows the project site location in British Columbia.

1.12

Specifically, Maxan Lake itself is located about 20 kilometers west of Burns Lake in a shallow valley characteristic of the area.

The valley floor is between 760 meters and 790 meters above sea level with surrounding hills reaching 850 meters. The valley is drained by Maxan Creek, which flows north through Maxan Lake eventually running into the Bulkley River system. Two major tributaries, Foxy and Crow Creeks, drain the area to the west of Maxan Creek.

The area is generally forested with stands of lodgepole pine of various ages and associated vegetation broken, in the valley bottom, with open meadows. Soils are generally alluvial or lacustrine in the valley bottom and glacial tills on the valley slopes.

Maxan Lake has a moderate to moderately low capability for agriculture and is considered a medium site for forest production. The valley bottom is considered Class 1 (very high capability) moose winter range and Class 3 and 4 (moderate to low capability) summer range for Mule and White tailed deer and elk. The Maxan Lake area has a moderately low rating for wilderness-oriented recreation, while the valley bottom has a low classification for recreation.

Map 1.2 shows the project site location in north western B.C.

1.2 HISTORY OF PROJECT

A committee representing Agriculture, Forestry, Fish and Wildlife, Lands and Parks at the provincial level was formed in 1970 in response to mounting local pressure on land resources. They were to consider the following:

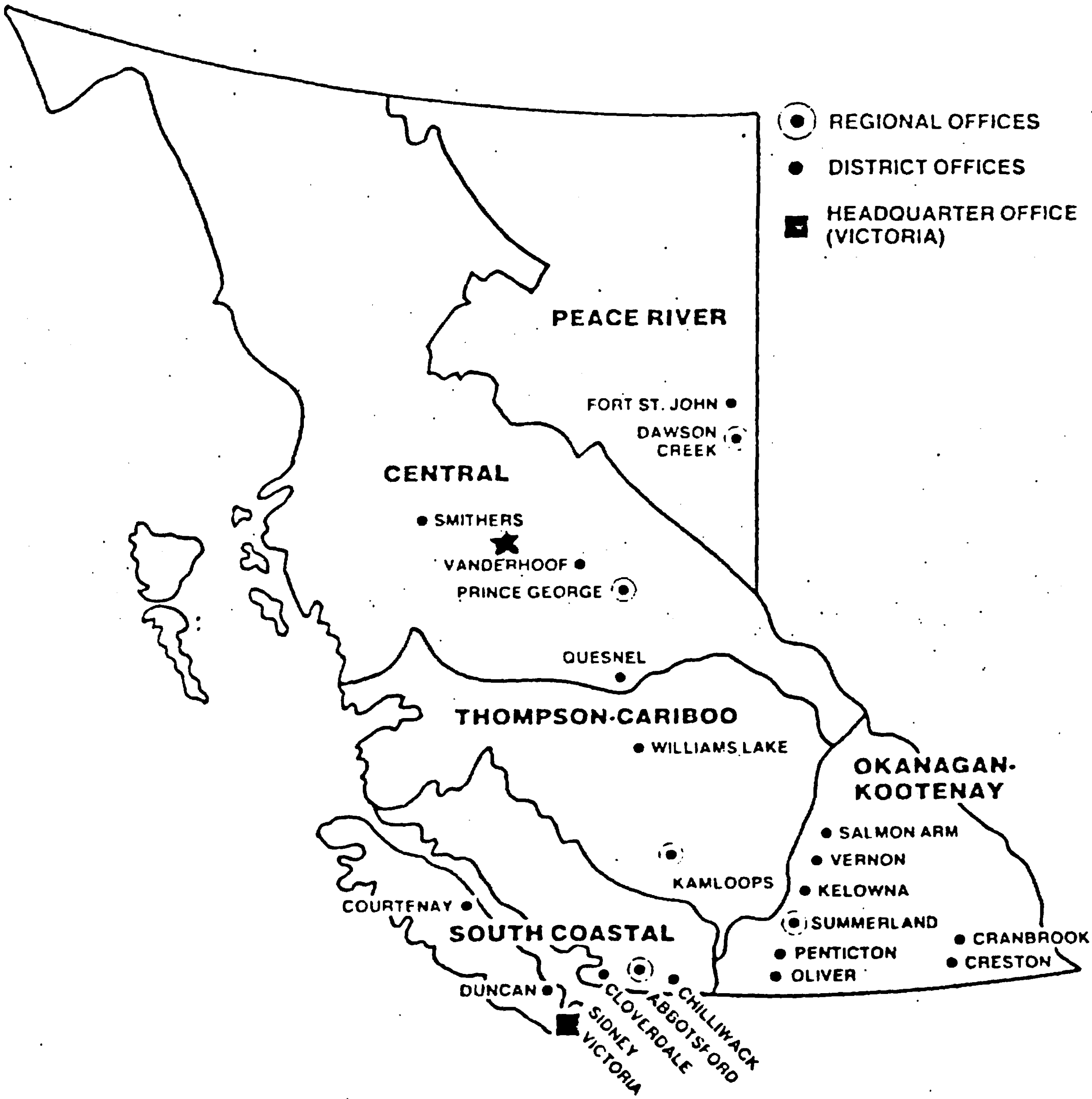
1) suitability of the area for a study of multi-purpose use of land in the Maxan area; and

2) suggest boundaries for such a study area if considered favourable. The area should contain a minimum of 2,000 acres including land with both grazing and timber potential.

Map. 1

Location of Study Area
General

Study Location - ✱



A field trip was made to Maxan Lake and an area including all surveyed lots south of District Lot 370, Range 5, Coast District including Indian Reserves 11, 11A and 12A was examined for suitability for a multiple land use project. This area was approximately 1,450 hectares of which roughly 560 ha was suitable for grazing with the remainder being dense Lodgepole pine forest.

Several land use functions were identified including range, recreation, wildlife and forestry. Concerns of each resource group were discussed and potential management practices and conflicts were recorded for the study.

The committee's recommendations were sent to the Director, Grazing Division, B.C. Forest Service, in November of 1970, indicating the site was suitable for a multi-land use study.

In the spring of 1971, the same committee was instructed by the Deputy Minister of Agriculture to prepare a project outline for a multi-land use study for submission to the Deputy Ministry's ARDA Committee for consideration for ARDA (Part I, Research) funding. The Deputy Minister indicated at the time that the project should be considered a "pilot action study" more than a pure, replicated, statistically sound research study.

1.3 THE DEVELOPMENT PLAN

A development plan was formulated to cover a four-year period (1972-1975) with two main objectives. These were to observe, measure and document:

1) the interaction between resource users within an ecosystem; and

2) changes that will take place within the present ecosystem through the imposition of induced changes in land use.

To achieve these objectives, a number of sub-projects were formulated. These were:

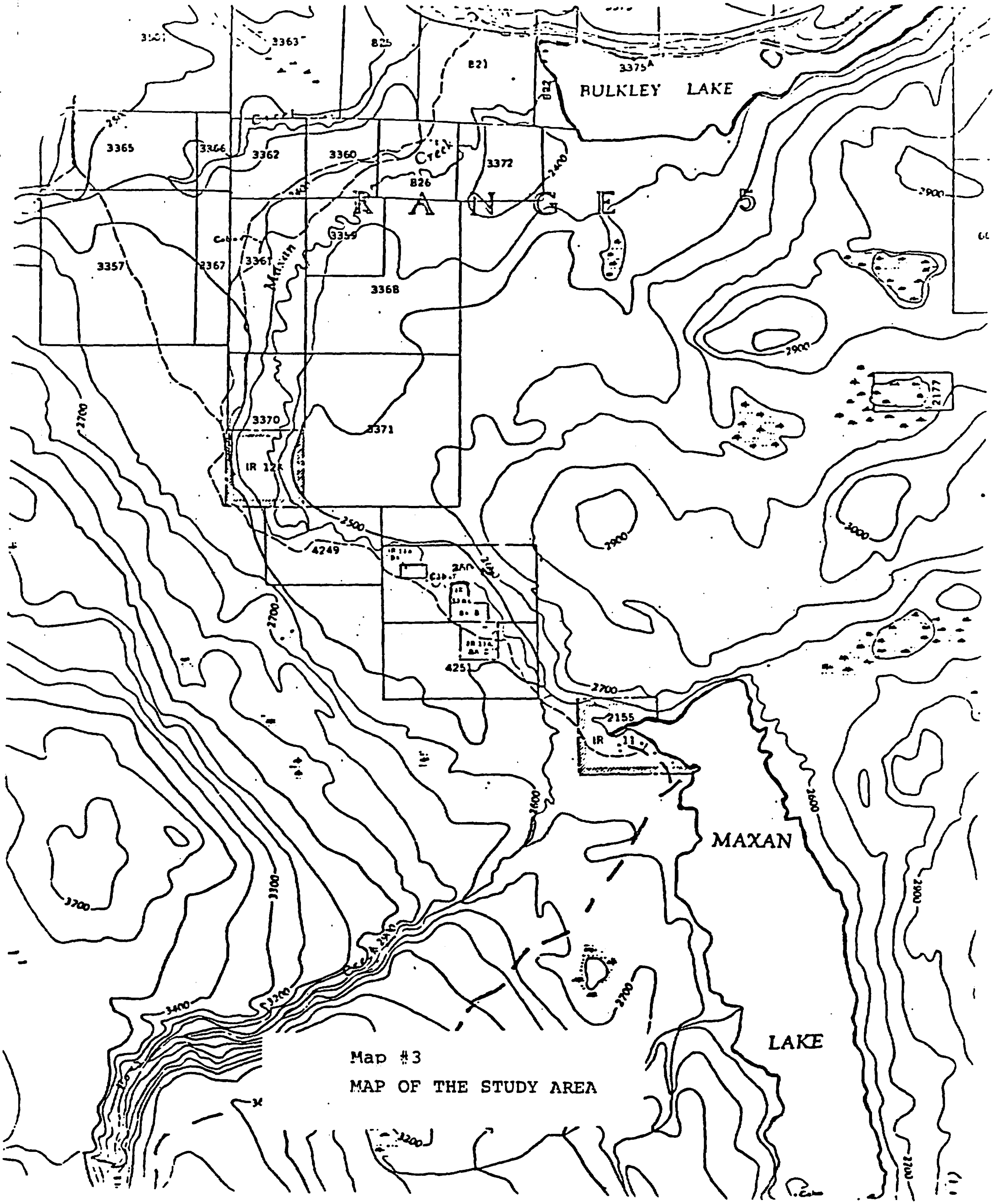
1) ecological inventory;

2) tree, grass and grazing study;

3) cattle - ungulate interaction; and

4) determination of carrying capacity and productivity of grazing site for beef cattle.

Map 1.3 shows the project site layout.



Map #3
MAP OF THE STUDY AREA

1.31 Ecological Inventory

Sub-Project I, the Ecological Inventory, was carried out in order to establish baseline information for measuring changes in the ecosystem resulting from the imposition of new land uses. This was a very broad inventory consisting of mapping, classifying and recording data on a number of resources. Observations were to be made each year of the project to determine what changes, if any, were occurring as a result of new land use patterns.

1.32 Grass, Tree and Grazing Study

Sub-Project 2 was designed to monitor interactions of grass, trees and cattle on a simulated clear-cut area, part of which had been logged and then burned in the spring of 1971. In 1972, a total of 72 acres were cleared, the piles burnt and the residue buried.

A variety of treatments were applied in strips sloping uphill, and test plots recording soils and vegetation data were established. Treatments included planting lodgepole pine, grass seeding, fertilizing and grazing in various combinations to monitor the results.

1.33 Cattle - Ungulate Interaction

Sub-Project 3 had two main objectives. These were "to measure what change, if any, takes place under intensive grazing of cattle on (1) the general ecology of the area; and (2) on the wintering capability for ungulates". This was to be done by conducting browse and pellet count studies to determine the carrying capacity for overwintering moose, by grazing the area with cattle, by doing winter moose counts and by setting up two exclosures. An 0.6 ha exclosure designed to keep out both moose and cattle was constructed of self supporting poles and a second exclosure designed to exclude only cattle was constructed of three stranded barbed wire with a top rail.

These exclosures allowed monitoring the effects of grazing and browsing combined, the effects of browsing only, and the effects of no grazing or browsing. This would allow an assessment of ungulate impact on the environment.

1.34 Determination of Carrying Capacity and Site Productivity for Beef Cattle

The objective of Sub-Project 4 was to provide basic information on the carrying capacity and productivity of forested and open meadow grazing sites. The data was to be obtained by using cattle from local ranchers to graze the area; by building fences, corrals and other livestock facilities; by recording cattle activity and by weighing cattle on and off pasture.

1.35 In addition to the four sub-projects described, a wilderness campsite was to be developed on Maxan Lake and its use, along with general recreation use of the valley, was to be monitored.

2. SUB-PROJECT I - ECOLOGICAL INVENTORY

The Ecological Inventory Sub-Project involved a two step process. The first step was to gather information on the climatic, water, soils and vegetative conditions prior to the imposition of a land use on the study area. Once this baseline information was gathered, the second step, that of monitoring the ecosystem affected by the land use, was carried out. Thus, the objective of determining how a land use affects the ecosystem, would be met by comparing the data from before imposition of a land use with the data collected after use has begun.

This very broad inventory consisted of monitoring and recording climatic data; monitoring and recording water quality and quantity data; surveying Maxan and Foxy Creeks and Maxan Lake; mapping and classifying soils; identifying ecosystems and listing grass, forb, shrub and tree species and determining and recording recreational use and potential for the study area.

Work on the ecological inventory began in 1972 with the establishment of some weather stations and initial soil sampling and water data collection. The plant species inventory began in 1973 along with further soils work and stream and lake inventories. Collection of information on each of the ecological components continued throughout the project with most agencies completing data collection in 1976 or 1977.

Results

Because of the complex nature of some sampling and analytical techniques used in the study, only the results are discussed in the summary review. As well, some aspects of the ecological inventory sub-project (especially vegetation and soils changes) requires monitoring over a long period of time to determine definitive trends.

Further information on methods of data collection and analysis may be obtained from the original reports (see page for a list of references).

2.1 CLIMATE

A report entitled "A Climatological Analysis of the Maxan Lake Project Area" was completed in 1979 from data collected between 1982 and 1976. The following comes from this report.

2.11 General

The northwest corner of the Interior Plateau has a climate that is continental in nature. The prevailing winds are from the west and the area is dominated by Maritime Polar air. These air masses generally precipitate moisture on the west slopes of the Coast Range resulting in drier and more thermally responsible formations. During the summer, Polar air moving from the north and east is warm and slightly moist, and during the winter, this Polar air is cold and dry.

Temperatures range from - 47°C to +32°C with relatively long, cold winters, prolonged spring and fall periods and short, warm summers. Freeze-free periods are generally short.

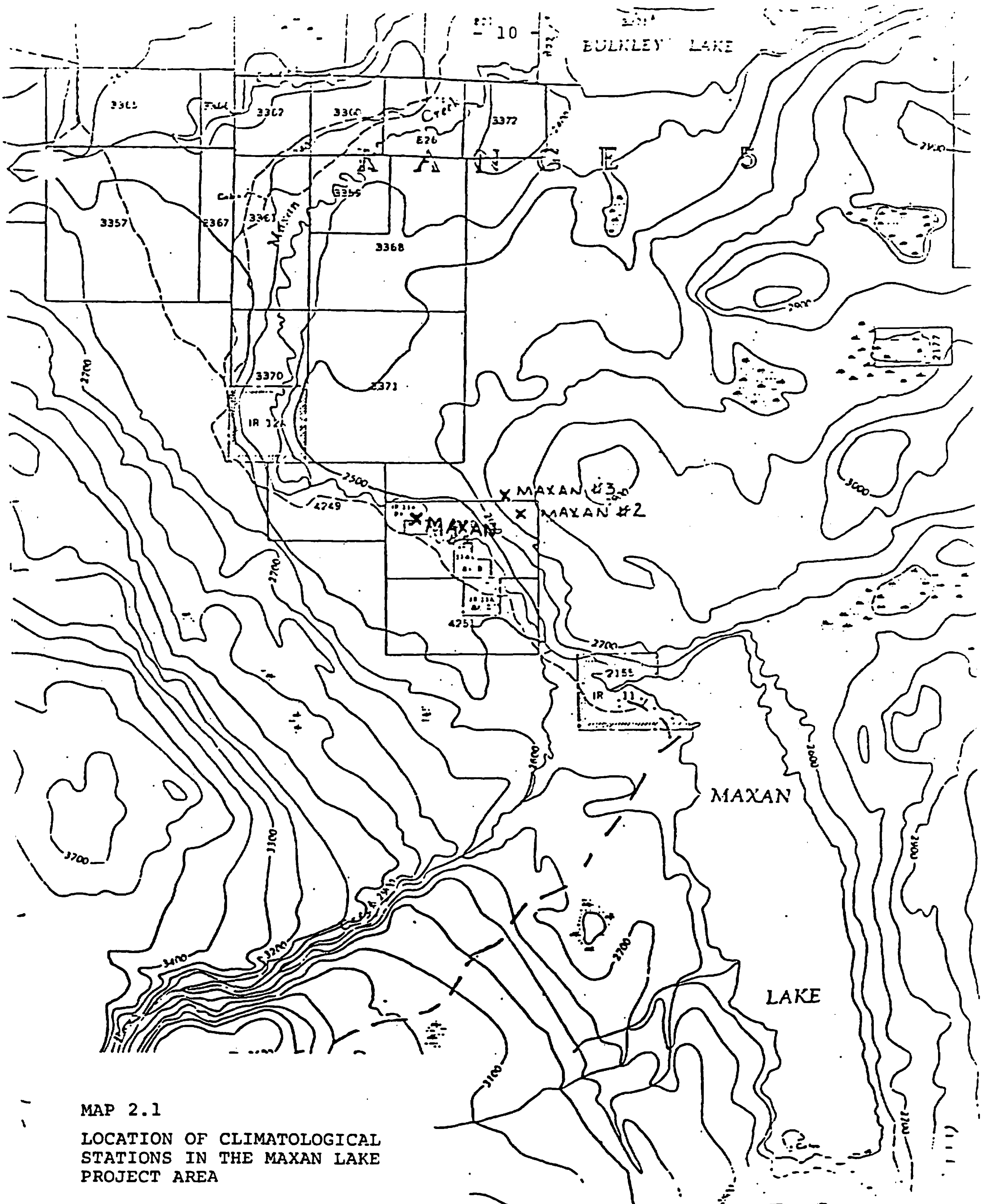
December is the wettest month with precipitation being relatively evenly distributed throughout the year. Forty-four percent of annual precipitation falls between May and September. Snow depths range from 0.5 to 1.0 meters at elevations below 900 meters with snow cover extending from mid-November through late April. Snow densities are low early in the year (0.174 g/cm^3 in January) and increase later in the year (0.264 g/cm^3 in April).

During the study period from 1972 to 1976, cool temperatures occurred in 1973 and 1976 and dry conditions occurred in 1974 and 1975.

2.12 Maxan Lake Study Area Observations

Three climatological stations were established within the study area; Maxan #1, established in October 1972 at 732 meters on the valley bottom; Maxan #2, established in May 1973 at 838 meters on a clear-cut; and Maxan #3, established in October 1974 at 869 meters within a Lodgepole pine forest (see Map 2.1).

Maximum and minimum temperatures, precipitation, snow depth, snow water equivalent and snow density data were recorded. As well, soil thermistors were installed at standard soil depths, but malfunctions, observation difficulties and trampling of leads resulted in inconsistent data. Attempts to measure surface temperature also failed.



MAP 2.1

LOCATION OF CLIMATOLOGICAL
STATIONS IN THE MAXAN LAKE
PROJECT AREA

From Marsh, R.D., 1979. A Climatological Analysis of the Maxan Lake Project Area. B.C. Ministry of Environment, Climate Branch, 29 pp.

Table 2.1

Maxan #1 Monthly Climate Data (1972-1977)

Date	Monthly Maximum Temp. (°C)	Monthly Minimum Temp. (°C)	Monthly Mean Temp. (°C)
Oct. 1972	6.6	-2.3	2.2
Nov.	1.2	-3.9	-1.4
Dec.	-9.0	-20.1	-14.6
Jan. 1973	-5.5	-16.4	-10.9
Feb.	-2.2	-15.6	-8.8
Mar.	4.3	-9.2	-2.4
Apr.	8.4	-5.3	1.6
May	13.9	-1.3	6.3
June	15.4	0.7	8.1
July	20.1	3.5	11.8
Aug.	19.3	2.6	10.9
Sept.	13.3	1.5	7.4
Oct.	6.8	-2.8	2.0
Nov.	-6.3	-14.3	-10.6
Dec.	-4.6	-13.7	-9.1
Jan. 1974	-10.2	-22.6	-16.4
Feb.	3.3	-12.6	-4.7
Mar.	4.3	-10.6	-3.1
Apr.	10.6	-3.0	3.8
May	13.3	0.1	6.7
June	17.2	2.1	9.6
July	18.8	3.8	11.3
Aug.	23.0	4.1	13.6
Sept.	19.1	2.4	10.7
Oct.	10.4	-1.4	4.5
Nov.	0.1	-9.2	-4.6
Dec.	-0.2	-10.5	-5.3
Jan. 1975	-4.8	-18.6	-11.7
Feb.	-5.4	-19.8	-12.6
Mar.	1.5	-12.4	-5.5
Apr.	8.4	-5.1	1.7
May	14.6	-0.2	7.2
June	16.3	3.8	10.1
July	21.9	6.4	14.2
Aug.	16.1	4.5	10.3
Sept.	17.1	0.1	8.6
Oct.	7.3	-1.8	2.7
Nov.	-2.3	-10.2	-6.3
Dec.	-4.1	-15.1	-9.6

(Cont'd)

Date	Monthly Maximum Temp. (°C)	Monthly Minimum Temp. (°C)	Monthly Mean Temp. (°C)
Jan. 1976	-5.1	-15.8	-10.5
Feb.	-1.9	-14.6	-8.3
Mar.	1.8	-11.5	-4.8
Apr.	8.6	-5.3	1.7
May	10.7	-2.3	4.2
June	15.2	3.3	9.2
July	17.1	5.0	11.0
Aug.	17.9	6.3	12.1
Sept.	16.4	3.2	9.8
Oct.	8.8	-1.7	3.6
Nov.	1.5	-6.0	-2.2
Dec.	-2.9	-10.3	-6.6
Jan. 1977	-6.3	-14.8	-10.6
Feb.	3.4	-9.4	-3.0
Mar.	4.2	-8.9	-2.3
Apr.	11.6	-3.7	3.9
May	13.2	-0.1	6.6
June	18.2	4.3	11.2
July	19.7	6.3	13.0
Aug.	23.6	6.2	14.8
Sept.	13.3	1.9	7.6
Oct.	7.9	-2.2	2.9
Nov.	-0.9	-12.2	-6.6
Dec.	-12.8	-21.9	-17.4

From Davis (1979)

Table 2.1(a)

Maxan #1 Monthly Climate Data (1972-1977)

Date	Solar Radiation (MJ m^{-2} mo^{-1})	Net Radiation (MJ m^{-2} mo^{-1})	Potential Evapotranspiration (mm mo^{-1})
Oct. 1972	204.84	6.13	1.38
Nov.	69.36	-26.82	---
Dec.	61.17	-90.88	---
Jan. 1973	75.78	-74.21	---
Feb.	145.04	-52.64	---
Mar.	256.30	52.07	9.78
Apr.	407.80	148.00	32.51
May	539.41	255.25	65.70
June	506.38	251.07	68.00
July	621.63	302.43	90.28
Aug.	M	M	M
Sept.	290.84	93.40	24.79
Oct.	166.62	14.07	3.14
Nov.	81.09	-49.27	---
Dec.	49.56	-57.73	---
Jan. 1974	77.90	-84.61	---
Feb.	144.92	-46.47	---
Mar.	255.43	51.11	9.33
Apr.	M	M	M
May	478.45	227.88	59.25
June	631.28	304.23	85.87
July	544.85	269.85	79.57
Aug.	M	M	M
Sept.	334.03	105.61	30.68
Oct.	159.80	18.21	4.42
Nov.	83.54	-46.22	---
Dec.	57.90	-72.65	---
Jan. 1975	84.66	-89.95	---
Feb.	168.09	-76.67	---
Mar.	275.54	47.37	7.77
Apr.	394.86	145.05	31.97
May	562.72	260.51	68.75
June	506.38	253.87	72.61
July	628.83	309.93	97.80
Aug.	384.57	177.76	51.11
Sept.	330.19	101.56	27.90
Oct.	161.84	15.86	3.62
Nov.	85.00	-49.78	---
Dec.	58.63	-79.06	---

(Cont'd)

Date	Solar Radiation ($MJ\ m^{-2}\ mo^{-1}$)	Net Radiation ($MJ\ m^{-2}\ mo^{-1}$)	Potential Evapotranspiration ($mm\ mo^{-1}$)
Jan. 1976	67.75	-59.94	---
Feb.	136.15	-45.33	---
Mar.	253.68	48.83	8.27
Apr.	433.67	154.37	34.03
May	502.42	233.17	56.04
June	496.93	248.77	69.46
July	522.05	260.10	76.10
Aug.	421.59	192.99	58.03
Sept.	311.95	100.31	28.46
Oct.	174.81	14.24	3.36
Nov.	85.98	-46.52	---
Dec.	52.10	-61.20	---
Jan. 1977	70.71	-65.13	---
Feb.	122.46	-28.99	---
Mar.	264.17	52.20	9.85
Apr.	444.45	160.91	38.29
May	549.67	254.55	65.99
June	581.79	286.70	84.33
July	546.05	273.02	83.85
Aug.	M	M	M
Sept.	277.40	91.52	24.44
Oct.	175.49	13.26	3.05
Nov.	M	M	M
Dec.	53.55	-75.01	---

Note: M denotes missing data

From Davis (1979)

2.13 Results

2.131 Temperature

Maxan #1, located on the valley floor, recorded the warmest monthly maximum temperatures with averages 0.7° C warmer than Maxan #2 on the clear-cut and 2.2° C warmer than Maxan #3 in the forest. Even though Maxan #2 probably received more surface heating, it is located on a hillside and is subject to greater air movement.

Conversely, Maxan #1 had the lowest mean monthly minimum temperatures on the three sites due to reduced ventilation and topography favouring pooling of cold air. Temperatures were 1.9° C cooler than Maxan #2 and 2.4° C cooler than Maxan #3. Maxan #2 sheds cold air downslope leaving warmer air on the site and the forest provides shelter from the local winds and also acts in a heat storage capacity.

The relative differences in mean monthly minimums and maximums between each site remained fairly constant throughout the year (see Table 2.1).

2.132 Precipitation

Average seasonal precipitation and average annual precipitation was about 213 mm and 483 mm respectively with higher sites recording slightly higher readings than the valley bottom.

Average snow densities and snow water equivalents are difficult to determine accurately due to the short term of the study, but results showed an average density of 0.21 g/cm^3 at Maxan #1 and 0.241 g/cm^3 at Maxan #2.

Precipitation data indicate that the valley floor is likely to receive less snow than the higher clear-cut. However, snow data indicated snow depths are greater in the valley bottom and snow equivalents are very similar, possibly due to faster metamorphosis and settling of snow at Maxan #2 as a result of site orientation and slope (see Tables 2.2 and 2.3).

2.133 Growing Degree Days

The southern oriented clear-cut site (Maxan #2) had the highest Growing Degree Days (GDD) of about 912. The forested site had a GDD of about 866 while the lowest GDD figure was recorded in the valley bottom (Maxan #1) at about 839.

Table 2.2

Monthly and Seasonal (May - September) Precipitation in Millimetres at Maxan #1 and Maxan #2 for Individual Years from 1973 - 1977 Inclusive.

Maxan #1	1973	1974	1975	1976	1977
May	3.6	24.7	15.2	33.8	24.9
June	41.5	15.2	32.3	52.3	29.2
July	11.9	26.2	15.0	65.6	82.8
August	44.8	3.3	64.0	54.4	28.4
September	81.9	53.9	9.9	32.3	82.6
May - September	183.7	123.3	136.4	238.3	247.9

Maxan #2	1973	1974	1975	1976	1977
May	23.5	27.4	22.5	13.9	6.7
June	44.7	20.7	32.6	90.4	55.0
July	33.8	37.5	29.0	49.4	57.5
August	36.2	3.8	77.5	68.8	36.5
September	24.1	47.7	12.2	28.2	77.4
May - September	162.3	137.1	173.8	250.7	233.0

From Marsh (1979)

Table 2.3

Snow Depth, Snow Water Equivalent, and Snow Density on Selected Dates at Maxan #1 Climatological Station

			Maxan #1		
Month	Day	Year	Depth (cm)	Water Eq. (mm)	Snow Density (gm/cm^3)
April	21	1974	44.5	127.0	.285
February	6	1975	54.9	83.8	.152
March	6	1975	67.2	102.9	.153
April	3	1975	57.9	114.3	.197
December	5	1975	63.0	119.4	.189
February	6	1976	86.1	208.3	.242
March	4	1976	95.5	228.6	.239
April	2	1976	80.8	266.7	.330
January	19	1977	54.9	96.5	.176
February	17	1977	54.6	119.4	.219
March	18	1977	50.0	128.3	.256
January	18	1978	62.0	125.0	.200
March	2	1978	58.4	155.0	.265
December	7	1978	23.2	36.0	.155

From March (1979)

Table 2.3(a)

Snow Depth, Snow Water Equivalent, and Snow Density on Selected Dates at Maxan #2 Climatological Station.

			Maxan #2		
Month	Day	Year	Depth (cm)	Water Eq. (mm)	Snow Density
April	21	1974			
Feb.	6	1975	51.8	88.9	.172
March	6	1975	60.3	86.4	.143
April	3	1975	52.3	142.2	.272
Dec.	5	1975			
Feb.	6	1976			
March	4	1976	87.4	228.6	.262
April	2	1976	70.9	264.2	.373
Jan.	19	1977	52.6	106.7	.203
Feb.	17	1977	52.1	110.5	.212
March	18	1977	45.7	128.3	.281
Jan.	18	1978	62.2	125.0	.201
March	2	1978	53.7	157.0	.292
Dec.	7	1978			

From Marsh (1979)

The GDD's recorded reflect the mean monthly temperatures. This is pronounced with regard to Maxan #1, which had the highest maximum temperatures, the lowest minimum temperatures and the greatest diurnal variation in temperatures of all three sites (see Tables 2.4, 2.5 and 2.6).

2.134 Freeze-Free Period

Freeze-free periods varied substantially from site to site and from year to year as shown in Table 2.4. Also, there is a substantial difference in the FFP (greater than 0.25°C) which varied between 2 and 55 days and Killing Frost Free Period (KFFP) of between 94 and 147 days. The forested site, Maxan #3, had a frost-free period of between 89 and 92 days and a KFFP of between 150 and 156 days.

Freeze-free periods of less than 25 days may occur in the valley bottom 50% of the time while an average FFP of 51 days is expected at Maxan #2 reflecting better air drainage and higher minimum temperatures. Maxan #3, the forested site, has an expected average FFP of about 59 days (see Tables 2.4, 2.5 and 2.6).

2.135 Potential Evapotranspiration (PET)

Potential evapotranspiration (moisture test into the atmosphere through evaporation from plant and soil surface) is greatest at Maxan #2 due to increased amounts of solar radiation on the southwest facing site. Between May and September, PET was 413.3 mm and 462.1 mm for Maxan #1 and Maxan #2 respectively.

2.136 Climatic Moisture Balance (CMB)

Between April and September, there is a Climatic Moisture Deficit at both Maxan #1 and Maxan #2 with a greater deficit at the latter due to the influence of increased solar radiation. The actual moisture deficit was partially compensated for in the valley bottom by high water tables and capillary action of water.

The accumulated Climatic Moisture Balance (the sum of normal monthly precipitation less monthly PET) for Maxan #1 was -172.0 mm and for Maxan #2 was -254.2 mm. The greatest moisture deficit occurred in June and July and was about -60 mm for Maxan #1 and 70 mm for Maxan #2.

2.137 Soil Moisture Balance

Assuming soils are at field capacity by the first of May and assuming that 160 mm of water can be held in the top 90 cm of soil, then it is possible to predict an "average" Soil Moisture Balance. A soil

Table 2.4

Predicted Longterm Average Temperatures (^{O}C) at Maxan #3 Climatological Station.

	Minimum	Maximum	Mean	Precipitation	Degree Days	Freeze Free Period
Jan.	-15.1	-10.1	-12.6			
Feb.	-11.0	-3.1	-7.1			
Mar.	-7.9	1.1	-3.6			
Apr.	-2.7	6.8	2.1			
May	1.0	12.4	6.7	-	73	
June	4.3	16.5	10.4	-	182	
July	6.1	18.7	12.4	-	249	
Aug.	5.9	18.4	12.2	-	243	
Sept.	3.3	13.4	8.3	-	119	
Oct.	0.1	6.5	3.3			
Nov.	-5.8	-2.8	-4.3			
Dec.	-11.8	-7.9	-9.9			
Annual	-2.8	5.8	1.5	-		59*
May-Sept.				-	866*	

*Denotes best available estimate. Subject to revision when statistics program run.

From Marsh (1979)

Table 2.5

Predicted Longterm Average Temperatures (°C) and Precipitation (mm) at Maxan #2 Climatological Station.

	Minimum	Maximum	Mean	Precipitation	Degree Days	Freeze Free Period
Jan.	-15.4	-8.2	-11.8			
Feb.	-11.5	-1.3	-6.4			
Mar.	-8.3	2.8	-2.8			
Apr.	-3.2	8.3	2.6			
May	0.4	13.7	7.1	34.2	85	
June	3.8	17.6	10.7	43.3	191	
July	5.4	19.8	12.6	55.5	256	
Aug.	5.3	19.5	12.4	42.1	249	
Sept.	2.7	14.6	8.7	38.3	131	
Oct.	-0.5	7.9	3.7			
Nov.	-6.3	-1.1	-3.7			
Dec.	-12.2	-6.1	-9.2			
Annual	-3.3	7.3	2.0	438.0		51*
May-Sept.				212.9	912*	

*Denotes best available estimate. Subject to revision when statistics program run.

From Marsh (1979)

Table 2.6

Predicted Longterm Average Temperature (°C) and Precipitation (mm) at Maxan #1 Climatological Station.

	Minimum	Maximum	Mean	Precipitation	Degree Days	Freeze Free Period
Jan.	-17.8	-7.3	-12.8			
Feb.	-14.1	-0.6	-7.3			
Mar.	-10.7	3.4	-3.6			
Apr.	-5.1	8.9	1.9			
May	-1.2	14.3	6.6	33.2	70	
June	2.3	18.2	10.2	41.6	176	
July	4.1	20.3	12.2	53.9	243	
Aug.	3.9	20.0	11.9	40.9	234	
Sept.	1.2	15.2	8.2	37.2	116	
Oct.	-2.2	8.6	3.2			
Nov.	-8.5	-0.3	-4.4			
Dec.	-14.9	-5.2	-10.1			
Annual	-5.3	8.0	1.4	469.0		<25*
May-Sept.				206.8	839*	

*Denotes best available estimate. Subject to revision when statistics program run.

From Marsh (1979)

moisture surplus occurs at Maxan #1 and #2 through May and June with the clear-cut becoming moisture deficient in early July and the valley bottom in mid July (see Table 2.7).

Rain during the growing season will not overcome the deficit so over-winter recharge of the soil is necessary for next year's growth.

2.2 WATER

2.21 Maxan Lake

Maxan Lake, located adjacent to the southeast corner of the project area, was surveyed on September 10th, 1973. The lake is approximately 6.4 kilometers long by 1.6 kilometers wide with a shoreline consisting of about 90% forest soil with a few, fine gravel beaches and some boulders and rock outcroppings.

The inlet, Maxan Creek, flows into the south end of the lake after meandering the last mile through flat bottom land. It averages 10 meters width and one meter in depth with a muck bottom broken occasionally with sandy patches. Beaver activity has resulted in flooded areas. The banks of the stream are made of loose material and are unstable. A second, smaller stream, located about halfway along the west side of the lake has a gravel bottom and is about 2 meters wide. It has good cover and at 30:70 pool to riffle ratio for the 150 mm of stream checked.

At the time the lake was examined, total dissolved solids were 77 ppm, the Secchi reading was 6.5 and the oxygen content of the water at the surface was 9 ppm.

Lake fauna collected included mountain whitefish (*Prosopium williamsoni*), coarse scale suckers (*Castostomas macrocheilus*), longnose suckers (*C. castostomus*), prickly sculpin (*Cottus asper*), redside shiner (*Richarsonius balteatus*), squawfish (*Ptychocheilus oregonese*), Peamouth chub (*Mylocheilus caurinum*), and rainbow trout (*Salmo gairdneri*).

Table 2.8 shows water temperature in relation to depth at the time of the study. The surface temperature was 13.8°C decreasing to 6.6°C on the bottom.

2.22 Foxy Creek

Foxy Creek, a major tributary of Maxan Creek, was surveyed on August 12, 1974. At the time of the survey, the average width was 4 m and average depth was about 24 cm with an estimated discharge of 10 c.f.s. and

Table 2.7

Average Monthly Precipitation (mm), Potential Evapotranspiration (mm), Climatic Moisture Balance (mm), Accumulated Climatic Moisture Balance (mm), and Soil Moisture Balance (mm) at Maxan #1 and Maxan #2

	Precip.	PET	*CMB	*Accum. CMB	Soil Moisture Balance
Maxan #1					
April	20.0	35.5			160.0
May	32.8	82.1	-49.3	-49.3	110.7
June	41.1	101.9	-60.8	-110.1	49.9
July	53.3	112.1	-58.8	-168.9	-8.9
Aug.	40.4	83.7	-43.3	-212.2	-52.2
Sept.	36.8	33.5	+3.3	-208.9	-48.9
Oct.	38.8	1.9	+36.9	-172.0	-12.0
Maxan #2					
April	20.5	43.9			160.0
May	29.2	87.5	-58.3	-58.3	101.7
June	36.6	104.9	-68.3	-116.6	33.4
July	47.2	117.9	-70.7	-187.3	-37.3
Aug.	35.8	98.6	-62.8	-250.1	-100.1
Sept.	32.5	53.2	-20.7	-270.8	-120.8
Oct.	40.0	23.4	+16.6	-254.2	-104.2

Precip. = precipitation
PET = potential evapotranspiration
CMB = climatic moisture balance
Accum. CMB = accumulated climatic moisture balance
Soil Moisture Balance: assumes 160 mm in soil May 1st

*Note: a negative CMB or Soil Moisture Balance indicates a deficit situation

Table 2.8

WATER TEMPERATURE VS. WATER DEPTH
OF MAXAN LAKE

(September 10, 1973)

Surface - 0 meters	13.8°C
1.5 meters	13.3°C
3.05 meters	13.1°C
4.5 meters	12.8°C
7.6 meters	12.6°C
9.1 meters	11.6°C
10.6 meters	9.8°C
11.2 meters	9.1°C
12.2 meters	8.2°C
13.1 meters	7.3°C
13.7 meters	7.3°C
15.2 meters (bottom)	6.6°C

water temperature of 12°C. The creek bottom was 60% rubble and 40% gravel. The banks were cut by the creek, had numerous sweepers and streamside cover consisted of grasses, deciduous shrubs, large cottonwoods and spruce.

Fauna included rainbow trout (Salmo gairdneri) about 12 cm long and Dolly Varden char (Salvelinus alpinus) from 10 to 12 cm long.

Foxy Creek is about 26 kilometers long rising out of a meadow at the 1,340 meter level, flowing east through semi-open spruce stands. About 5 kilometers from the source, Foxy Creek enters a steep rugged valley with numerous barriers that prevent fish from travelling further upstream. The lower portion of the creek, especially the last 5 kilometers, has good capability for spawning as the creek becomes wider with many cut banks and sand and gravel bars.

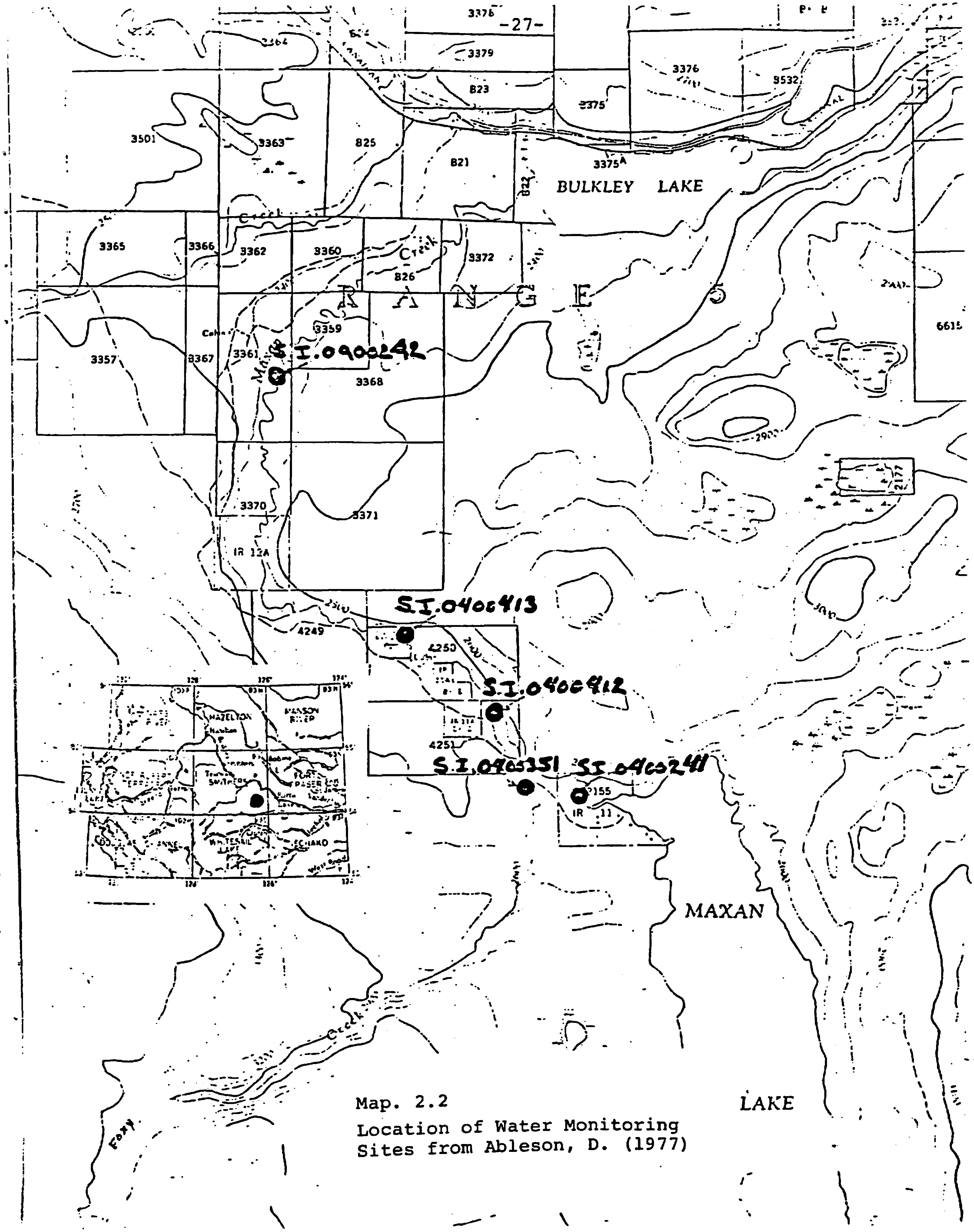
2.23 Water Quality Study

Water quality and quantity monitoring of Maxan and Foxy Creek was carried out in conjunction with other Maxan projects in an attempt to assess the effects of agricultural activity, specifically range utilization by cattle, on a watershed.

Three water quality stations were established on Maxan Creek in 1972 with two more being established in 1973. Sampling was carried out from 1972 through December 1975 with a series of replicate samples being collected at three sites in the spring of 1977 for the purpose of establishing confidence limits on all data collected (see Map 2.2).

"Single grab near surface samples" were collected monthly in rinsed plastic containers and chemical and biological analysis were conducted. As well, stream flow measurements were done daily for 1975 and 1976.

This information was compiled in the "Maxan Creek Water Quality Study - 1972 to 1975" by the Department of Environment, water Resources Service, Government of British Columbia, and a report written in December 1977.



Map. 2.2
Location of Water Monitoring Sites from Ableson, D. (1977)

2.231 Results

2.2311 Water Quality - Chemistry

The various nitrogen levels checked remained comparatively low throughout the study and readings were similar in both Maxan and Foxy Creeks. Ammonia nitrogen level ranged from 0.009 - 0.021 mg./l. while Kjeldahl nitrogen differences were slight with mean values ranging from 0.219 - 0.360 mg./l. Foxy Creek levels were lower with a mean 1.137 mg./l. Summer levels of nitrite/nitrate nitrogen levels approached the detectable analytical limits. Table 2.91(a), (b) and (c) show a breakdown of the data for Station 0400240 located downstream from the study area.

Phosphorus concentrations generally increased downstream due to additions from Foxy Creek and from surface runoff with maximum values being recorded during freshets.

As with phosphorus, residue levels increased downstream with the lowest readings occurring near the lake (Total Residue 66 - 86 mg./l.; non-filterable residue less than 1.0 - 9.0 mg./l.) and the highest readings at the lowest station (total residue 74 - 188 mg./l.; N.F. residue 1.0 - 100.0 mg./l.). Again, high readings occurred during the spring freshet.

In addition to Foxy Creek, over ground runoff plus ground water flows contributed to specific conductance levels which increased downstream. Foxy Creek had a mean reading of 102 Umhos/cm while the lake station had a mean reading of 74 Umhos/cm.

Organic carbon levels were diluted by the inflow of Foxy Creek, which generally had lower levels than the lake.

The lowest range of alkalinity levels (34.0 - 37.1 mg./l.) occurred at the lake station and levels increased as one moved downstream.

Dissolved potassium, a measure of the effects of upland disturbance on water quality, did not differ appreciably between stations.

Levels of pH remained comparatively constant, ranging from 7.0 to 7.7.

Table 2.9

MAXAN LAKE

WATER QUALITY STUDY

(1972 - 1975)

Station 0400242

Date of Sampling	pH	Total Residue (mg/L)	Non-Filt. Residue (mg/L)	Specific Conduct (umno/om)
13/12/72		94	5.0	
2/1/73		106	6.9	
15/1/73		86	3.2	
30/1/73		118	11.8	
14/2/73		82	2.1	
28/2/73		90	3.1	
14/3/73		94	1.6	
2/4/73		94	4.5	
16/4/73		104	13.5	
7/5/73		126	53.	
22/5/73		102	27.	
30/5/73		86	23.	
31/7/73		94	1.7	
2/9/73		96	3.1	
9/10/73		96	1.5	
31/10/73		102	3.4	
4/12/73		108	2.1	
7/1/74		188	101.	
30/1/74		86	3.	
4/3/74		88	10.	
1/4/74		96	4.	
6/5/74		144	50.	
4/6/74				
10/7/74		74	11.	
31/7/74		84	4.	
3/8/74		104	2.	
2/10/74		106	6.	
4/11/74		96	5.	
3/12/74				
4/2/75	7.0	90.	4.	
4/3/75	7.2	90.	2.	
1/4/75	7.4	90.	1.	
30/4/75	7.6	96.	14.	
29/5/75	7.3	86.	16.	
16/6/75	7.3	80.	8.	
7/7/75	7.4	80.		
21/7/75	7.4	78.		
11/8/75	7.3	92.	2.	
26/8/75	7.3	92.	6.	
9/9/75	7.5	84.		
9/10/75	7.3	100.	8.	
19/11/75	7.2	84.	10.	
10/12/75		90.	10.	

From Ableson (1977)

Table 2.9 (a)

MAXAN LAKE

WATER QUALITY STUDY

(1972 - 1975)

Station 0400242

Date of Sampling	Organic Carbon (mg/L)	Ammonia Nitrogen (mg/L)	NO_2/NO_3 Nitrogen (mg/L)
13/12/72	12.		0.07
2/1/73	13.		0.08
15/1/73	10.		0.08
30/1/73	14.		0.11
14/2/73	10.5		0.09
28/2/73	11.		0.15
14/3/73	10.		0.08
2/4/73	11.		0.03
16/4/73	12.		0.03
7/5/73	16.		0.10
22/5/73	14.		0.04
30/5/73	13.		0.07
31/7/73	8.		L0.02
2/9/73	5.		L0.03
9/10/73	14.		L0.03
31/10/73	6.		0.04
4/12/73	5.		0.03
7/1/74	14.		0.09
30/1/74	8.		0.10
4/3/74	7.		0.08
1/4/74	7.		0.03
6/5/74	11.		0.04
4/6/74	13.		
10/7/74			
31/7/74	9.		L0.025
3/8/74			
2/10/74	9.		L0.02
4/11/74	7.		L0.02
3/12/74			
4/2/75	8.		0.08
4/3/75	11.		0.07
1/4/75	5.		0.05
30/4/75	7.	.012	L0.025
29/5/75	11.	.013	L0.025
16/6/75	10.	.017	L0.025
7/7/75	9.	.011	L0.025
21/7/75	9.	.018	L0.025
11/8/75	6.	.011	L0.025
26/8/75	10.	.010	L0.025
9/9/75	9.	.014	L0.025
9/10/75	7.	.013	L0.025
19/11/75	8.	.019	.10
10/12/75			

From Ableson (1977)

Table 2.9 (b)

MAXAN LAKE

WATER QUALITY STUDY

(1972-1975)

Station 0400242

Date of Sampling	Total Kjeldahl (mg/L)	Ortho. Phosph. (mg/L)	Total Phosph. (mg/L)
13/12/72	0.33		.052
2/1/73	0.31		.060
15/1/73	0.15		.044
20/1/73	0.53		.072
14/2/73	0.37		.036
28/2/73	0.43		.037
14/3/73	0.27		.031
2/4/73	0.13		.044
16/4/73	0.07		.064
7/5/73	0.33		.104
22/5/73	0.42		.092
30/5/73	0.32		.077
31/7/73	0.13		.041
2/9/73	0.15		.041
9/10/73	0.17		.041
31/10/73	0.14		.042
4/12/73	0.20		.040
7/1/74	0.37		.275
30/1/74	0.29		.041
4/3/74	0.18		.037
1/4/74	0.15		.040
6/5/74	0.31		.122
4/6/74			
10/7/74			.052
31/7/74	0.27		.040
3/8/74			.028
2/10/74	0.94		.058
4/11/74	0.18		.047
3/12/74			
4/2/75			
4/3/75			
1/4/74	0.27		.033
30/4/75	0.38	.021	.050
29/5/75	0.35	.021	.100
16/6/75	0.22	.020	.050
7/7/75	0.25	.026	.054
21/7/75	0.16	.030	.051
11/8/75	0.17	.032	.050
26/8/75	0.18	.030	.050
9/9/75	0.29	.027	.074
9/10/75	0.06	.027	.049
19/11/75	0.32	.028	.051
10/12/75			.044

From Ableson (1977)

Table 2.9 (c)

MAXAN LAKE

WATER QUALITY STUDY

(1972 - 1975)

Station 0400242

Date of Sampling	Sodium (mg / L)	Potassium (mg / L)	Alkalinity (mg / L)
13/12/72			
2/1/73			
15/1/73			
20/1/73			
14/2/73			
28/2/73			
14/3/73			
2/4/73			
16/4/73			
7/5/73			
22/5/73			
30/5/73			
31/7/73			
2/9/73			
9/10/73			
31/10/73			
4/12/73			
7/1/74			
30/1/74			
4/3/74			
1/4/74			
6/5/74			
4/6/74			
10/7/74			
31/7/74			
3/8/74	3.5	1.5	
2/10/74	3.6	1.6	
4/11/74		1.1	
3/12/74	3.2		
4/2/75	3.2	1.2	
4/3/75	3.1	1.1	
1/4/75	3.3	1.1	
30/4/75	3.1	1.1	49.3
29/5/75	2.1	0.7	25.0
16/6/75	2.2	0.9	29.4
7/7/75	2.7	1.2	39.7
21/7/75	3.0	1.3	46.1
11/8/75	3.1	1.2	47.0
26/8/75	3.2	1.3	49.5
9/9/75	3.1	1.2	45.8
9/10/75	3.2	1.4	58.5
19/11/75	2.7	1.1	39.6
10/12/75	2.9	1.1	

From Ableson (1977)

2.2312 Water Quality - Bacteriology

Bacteriological levels were found to be within the normal range of variability of natural waters. Total coliform levels ranged from 2 to 33 MPN/100 ml. Fecal streptococci levels ranged from less than 2 to 35 MPN/100 ml. Table 2.10 shows a breakdown and the data for station 0400242 located downstream from the study site.

2.2313 Discussion

The water quality study did not find any evidence of water quality deterioration that could be definitely attributed to the presence of range cattle or as a result of the application of fertilizers. Bacteriological results probably reflect little more than natural background levels, with total coliform contamination the result of surface runoff washing dead and decaying organic matter into the stream and fecal coliform and fecal streptococci contamination the result of beaver, livestock and other land animals.

Maxan Lake and Foxy Creek were found to be the most significant influences on the water course with natural impoundments with beaver activity suspected of exerting a lesser influence.

2.24 Water Quantity

Daily discharges and daily water levels were recorded for 1975 and 1976. Even though only two years were recorded there were considerable differences in flow rates reflecting the dry 1975 season and the wet 1976 season. The total discharge in 1975 was 46,200 acre feet with a mean discharge of 63.8 c.f.s. The maximum daily discharge was 607 c.f.s. on May 12 and the minimum daily discharge was 6.8 c.f.s. on March 10, with the highest recorded discharge being 648 c.f.s. at 21:00 P.S.T. on May 12. The daily water level (referenced to an assumed datum) recorded between May and December had a minimum reading of 5.2 feet on October 5 and a maximum reading of 8.64 feet on May 12 at 21:00 P.S.T.

Table 2.10

MAXAN LAKE

WATER QUALITY STUDY

(1972 - 1975)

MAXAN CREEK BACTERIOLOGICY RESULTS

Station 0400242

Sampling Date	Total Coliform (MPN)	Fecal Coliform (MPN)	Fecal Streptocc (MPN)
2/1/73		L2	
14/2/73		L2	
28/2/73		L2	
14/3/73		8.	
2/4/73		5.	
16/4/73		2.	
7/5/73		49.	
22/5/73		17.	
30/5/73		13.	
31/7/73		49.	
2/9/73		26.	
9/10/73		33.	
31/10/73		8.	
4/12/73		11.	
7/1/74		2.	
30/1/74		4.	
4/3/74		8.	
1/4/74		17.	
6/4/74		79.	
6/5/74		79.	
4/6/74		49.	
2/10/74		46.	
4/11/74		17.	
4/2/75		5.	
1/3/75		7.	
4/3/75		7.	
30/4/75		7.	
29/5/75		49.	
5/6/75	70	70.	L2
16/6/75		170.	
7/7/75	350	21.	5.
21/7/75	79	23.	11.
11/8/75	130	49.	7.0
26/8/75	240	41.	5.
9/9/75	130	79.	7.0
19/11/75		4.	

From Ableson (1977)

Table 2.10(a)

MAXAN LAKE

WATER QUALITY STUDY

(1972 - 1975)

MAXAN CREEK BACTERIOLOGY RESULTS

Sampling Date	Total Coliform (MPN)	Fecal Coliform (MPN)	Fecal Strept-OCC (MPN)
Station 0400412			
8/3/75		2.	
30/4/75		2.	
29/5/75		13.	
5/6/75	2	L2.	L2.
16/6/75		5.	
17/7/75	49	13.	L2.
21/7/75	130	22.	11.
26/8/75	79	22.	22.
9/9/75	11	4.	8.
19/11/75		7.	
Station 0400413			
8/3/75		5.	
30/4/75		2.	
29/5/75		17.	
5/6/75	2	2.	L2.
16/6/75		8.	
7/7/75	79	33.	L2.
21/7/75	79	46.	36.
11/8/75	79	17.	22.
11/8/75	49	33.	23.
26/8/75	79	8.	14.
9/9/75	22	8.	17.
19/11/75		6.	

From Ableson (1977)

The wet 1976 season had a mean discharge of 148 c.f.s. with a total discharge of 107,000 acre feet. The maximum daily discharge was 1,280 c.f.s. on May 6 with the highest reading being 1,300 c.f.s. at 21:16 on May 6 while the minimum daily discharge was 12.2 c.f.s. on March 30. Water levels for 1976 (based on an assumed reference datum) varied from a high of 10.26 feet on May 6 to a low of 5.47 feet on April 4.

Table 2.11(a),(b),(c) and (d) show a breakdown of the daily stream flows for 1975.

2.25 Water Temperature - Maxan Creek

Water temperatures were recorded monthly during 1973 and 1974 and the results presented graphically. Temperatures varied from below freezing (approximately -1°C) to about 17°C. Water temperatures climbed in late May, peaked in late July and dropped quickly in September.

2.26 Water Table Monitors

Four water table monitors were located within or adjacent to Indian Reserve 11A, Block A. This area is an open meadow with Maxan Creek flowing on one side and a small water course flowing on the other. The monitors indicated sub-surface water levels in relation to rooting depth in an area that could be subjected to spring flooding and summer droughts. (Monitor #1 was located in a wet sedge pond, #2 was dry, #3 was dry and #4 was also in a wet site).

The monitors were four four-inch perforated PVC pipes buried vertically in the ground. Intially established in November 1973 by hand, they were found to be too shallow and were re-established using a backhoe on November 14th, 1974.

A stream level gauge was established in 1974 to provide a comparison with subsurface elevations, but this was lost in the 1976 spring freshet and only one season's data is available.

Ground level was the 0 or baseline reading with below ground measurements being negative and above ground measurements being positive, as happened in the case of Monitor #4 when a beaver dam flooded the site.

The difference in height of ground surface for monitors #1, #3 and #4 is Monitor #3 235 cm higher than monitor #1 and #4 is 55.8 cm higher than #1.

Table 2.11(a)

WATER SURVEY OF CANADA STREAM FLOW
STATION #8EE-18
MAXAN CREEK AT BULKLEY LAKE
1975

(Daily Discharge in Cubic Feet/Second)

DAY	JAN	FEB	MAR
1	9.1	7.8	7.0
2	9.2	7.8	7.0
3	9.2	7.7	7.0
4	9.3	7.6	7.0
5	9.3	7.6	7.0
6	9.3	7.6	7.0
7	9.2	7.6	6.9
8	9.2	7.6	6.9
9	9.2	7.6	6.9
10	9.2	7.6	6.8
11	9.1	7.6	6.8
12	9.1	7.6	6.8
13	9.0	7.5	6.8
14	9.0	7.5	6.9
15	8.9	7.5	6.9
16	8.8	7.4	6.9
17	8.8	7.4	6.9
18	8.7	7.4	7.0
19	8.6	7.3	7.0
20	8.5	7.3	7.0
21	8.4	7.3	7.0
22	8.4	7.2	7.1
23	8.3	7.2	7.1
24	8.2	7.2	7.2
25	8.2	7.2	7.2
26	8.1	7.1	7.3
27	8.0	7.1	7.4
28	8.0	7.1	7.4
29	7.9		7.5
30	7.9		7.6
31	7.8		7.7
TOTAL:	269.9	208.4	219.0
MEAN	8.7	7.4	7.1
AC - FT	535.0	413.0	434.0
MAX	9.3	7.8	7.7
MIN	7.8	7.1	6.8

From Ableson (1977)

Table 2.11(b)

WATER SURVEY OF CANADA STREAM FLOW
STATION #8EE-18
MAXAN CREEK AT BULKLEY LAKE
1975

(Daily Discharge in Cubic Feet/Second)

DAY	APR	MAY	JUN
1	7.8	28.7	357.0
2	7.9	43.2	379.0
3	8.0	74.2	319.0
4	8.1	125.0	312.0
5	8.2	191.0	301.0
6	8.3	236.0	259.0
7	8.4	252.0	231.0
8	8.7	266.0	206.0
9	8.9	296.0	191.0
10	9.1	385.0	188.0
11	9.3	544.0	181.0
12	9.5	607.0	170.0
13	9.7	602.0	166.0
14	10.0	586.0	160.0
15	10.4	582.0	167.0
16	10.7	566.0	157.0
17	11.1	506.0	146.0
18	11.6	447.0	152.0
19	12.1	391.0	171.0
20	12.6	371.0	149.0
21	13.3	348.0	127.0
22	14.0	329.0	112.0
23	14.6	299.0	104.0
24	15.4	266.0	99.7
25	16.2	264.0	92.0
26	17.0	265.0	82.8
27	18.1	298.0	70.0
28	19.0	364.0	85.0
29	20.3	398.0	80.1
30	21.2	370.0	77.2
31		350.0	
TOTAL:	359.5	10,650.1	5,291.8
MEAN	12.0	344.0	176.0
AC - FT	713.0	21,100.0	10,500.0
MAX	21.2	607.0	379.0
MIN	7.8	28.7	70.0

From Ableson (1977)

Table 2.11(c)

WATER SUFVEY OF CANADA STREAM FLOW
STATION #8EE-18
MAXAN CREEK AT BULKLEY LAKE
1975

DAY	JUL	AUG	SEPT
1	70.5	10.1	39.4
2	63.4	11.6	34.8
3	59.4	13.1	29.7
4	54.0	15.9	27.5
5	48.7	19.0	30.5
6	44.1	16.2	28.6
7	37.4	17.8	24.2
8	36.8	21.4	21.1
9	36.4	18.5	18.8
10	33.8	20.3	17.3
11	29.2	21.2	15.9
12	21.8	19.3	14.8
13	15.4	15.6	13.8
14	11.7	13.9	12.8
15	13.0	12.9	12.0
16	13.7	13.6	13.0
17	17.8	19.3	13.6
18	28.1	23.5	13.1
19	27.0	22.2	12.4
20	25.7	18.9	11.6
21	22.3	17.1	10.6
22	20.9	16.6	10.0
23	18.2	15.4	9.7
24	16.1	15.0	9.4
25	13.6	17.0	8.8
26	14.4	19.9	8.6
27	13.7	42.9	8.6
28	13.4	46.5	8.8
29	12.8	46.6	9.8
30	11.5	47.8	10.0
31	10.7	44.3	
TOTAL:	856.5	673.4	499.2
MEAN	27.6	21.7	16.6
ACT - FT	1,700.0	1,340.0	990.0
MAX	70.5	47.8	39.4
MIN	10.7	10.1	8.6

From Ableson (1977)

Table 2.11(d)

WATER SURVEY OF CANADA STREAM FLOW
STATION #8EE-18
MAXAN CREEK AT BULKLEY LAKE
1975

(Daily Discharge in Cubic Feet/Second)

Day	Oct	Nov	Dec
1	9.5	41.7	54.0
2	8.9	40.0	52.0
3	8.5	49.2	50.0
4	8.3	46.4	48.2
5	8.1	45.6	46.9
6	8.7	41.8	45.8
7	9.3	44.6	44.5
8	9.1	40.3	43.4
9	10.3	36.2	42.5
10	10.8	31.6	41.0
11	13.6	34.1	40.0
12	13.8	43.7	39.2
13	12.6	59.2	38.5
14	12.9	68.0	37.8
15	31.2	75.9	37.5
16	32.7	77.6	37.0
17	26.9	118.0	36.5
18	24.5	230.0	36.2
19	23.6	266.0	36.0
20	23.6	238.0	36.0
21	20.2	192.0	35.7
22	16.8	145.0	35.7
23	16.3	100.0	35.6
24	15.4	83.0	35.5
25	15.3	77.0	35.5
26	14.8	71.0	35.5
27	14.4	57.0	35.4
28	13.8	63.0	35.3
29	13.9	60.0	35.2
30	13.2	57.0	35.0
31	24.5		34.5
TOTAL:	485.5	2,542.9	1,231.9
MEAN	15.7	84.8	39.7
ACT - FT	963.0	5,040.0	2,440.0
MAX	32.7	266.0	54.0
MIN	8.1	31.6	34.5

From Ableson (1977)

The data is contained in Table 2.12(a) and (b).

Records taken over a three-year period (1974-76) show the water table to be less than -1 meter very early in the year on drier sites and around -1 meter on the wetter sites by August. With rooting depths of most grasses and forbes ranging between 10 cm and 100 cm, some of the meadow sites would be moisture deficient later in the season.

2.3 SOILS

2.31 Introduction

In 1973, the soils of the Maxan Multi-Land Use Project area were mapped by N. Gough, B.C. Ministry of Agriculture and Food to provide initial data for the Ecological Inventory (Sub-Project I). The soils were then described and classified according to Cotic (1974).

As well as mapping, several permanent plots were set out in 1972 and 1973 from which soil and vegetation samples were collected. These plots were of two different designs:

1) a grid system with samples taken at coordinate points; and

2) a complex plot layout shown in Figure 2.1

Subsequent to the initial mapping of the soils, a number of factors were monitored on a periodic basis (see Table 3.1) to determine what changes, or variability if any, were occurring in the soils. These factors included soil moisture and temperature, profile sampling, mechanical analysis, moisture analysis at moisture equivalent and wilting point, bulk density, liquid and plastic limit and soil nutritional characteristics.

2.32 Soils of the Project Area

Mapping and classification revealed that most soils present in the study area were related to defined associations from nearby areas. The valley sides consist largely of soils of glacial till origin while soils of the valley bottom are lacustrine or fluvial in origin.

Barrett soils (see Map 2.3) developed on deep deposits of glacial till common to the region. Texturally, they are loam and sandy loams mixed with gravel, stones and cobbles and the soil has a very hard consistence. Due to compactness, permeability is slow although the soil is predominantly well to moderately well drained. The Barrett complex in the study area is an Orthic Gray Luvisol.

Table 2.12 (a)

Maxan Project

Water Table Monitor Data

Date	Monitor #1 cm	Monitor #2 cm
1975		
January 3	-60	Frozen
April 12	-73	Ice at 0
April 27	-148	-65
May 1	-143	-43
May 9	-155	-20
May 16	-163	-25
May 22	-160	-20
May 31	-155	-30
June 6	-158	-30
June 12	-125	+15
June 19	-118	-70
June 27	-110	+3
August 12	-125	-73
1976		
May 18	-28	
May 27	-63	
June 5	-63	
June 11	-59	
June 20	-64	
June 28	-68	
July 10	-84	
July 20	-64	
July 28	-67	

From Ableson (1977)

Table 2.12 (b)

Maxan Project

Water Table Monitor Data

Date	Monitor #3 Cm	Monitor #4 Cm	Maxan Creek Cm
1975			
January 3	-78	Frozen	
April 12	-53	Ice at 0	
April 27	-110	+83	
May 1	-108	+60	
May 9	-135	+60	+63
May 16	-150	+88	+85
May 22	-148	+80	+73
May 31	-140	+78	+63
June 6	-135	+78	+63
June 12	-143	+20	
June 19	-95	0	+28
June 27	-133	+10	+25
August 12	-228	-78	+23
1976			
May 18	-52		
May 27	-103		
June 5	-103		
June 11	-103		
June 20	-101		
June 28	-103		
July 10	-103		
July 20	-103		
July 28	-102		

From Ableson (1977)

The Babine association, found in the northwest corner of the study area, is a shallow lacustrine clay over glacial till. Again, it is an Orthic Gray Luvisol with silty clay loam to silt loam textures.

Crystal soils, found in association with the Barrett complex, developed on ablation till and are coarse textured gravelly or stoney-sandy loams and gravelly or stoney-loamy sands. It has a moderately rapid to rapid permeability and good to rapid drainage although variations are great. These soils are degraded and Orthic Dystric Brunisols.

The Stellako soil found along Maxan Creek is the product of erosion from surrounding lacustrine and till deposits. The texture varies greatly from gravelly through loamy sand to silt loam. These soils are usually subject to some flooding and may be imperfectly to very poorly drained close to the stream and well drained further away. Gleying and mottling are common in the Maxan Valley. The Stellako complex is an Orthic Regosol.

The Slug association, developed on alluvial fans, is found in the southern portion of the study area. The soil is gravelly-sandy or gravelly-sandy-loamy in texture and an Orthic Dystric Brunisol in development. These soils may be either well sorted or unsorted and are usually readily drained with moderate to rapid permeability.

Two previously undescribed associations (marked D and Da on the may) were also found in the study area running between the Stellako complex on the valley bottom and the Barrett complex on the hillside. These soils consist of up to twenty-four inches of a lacustrine veneer of silt-ooam to silty-clay loam textures overlying glacial materials of loamy sand to sandy texture. Described as Orthic Regosols, Gleyed Orthic Regosols and Gleysols, these associations show little soil development and the influence of a high water table is evident.

A complete description of those soils on which plots were established is contained in Appendix I.

2.33 Soil Nutrient Levels

A discussion on soil nutrition is contained in the Vegetation and Soil Report (van Barneveld et al 1980) indicates that there is adequate to high levels of Calcium, Magnesium, Potassium and Phosphorus in the first six inches of soil. As well, the Ca:Mg:K Ca:Mg and K:Mg all appeared to be satisfactory.

2.4 VEGETATION

2.41 Introduction

Using the soils information, representative of ecosystems were selected and vegetation data were collected beginning in 1973. This information would provide the base from which to measure:

1) succession of minor vegetation and trees; and
2) the effect of management techniques and forms of land use on the succession of a natural system.

The vegetation study was also designed "to serve as a pilot project for the establishment of permanent plots to monitor the effects of natural or man-caused disturbances" over longer periods of time.

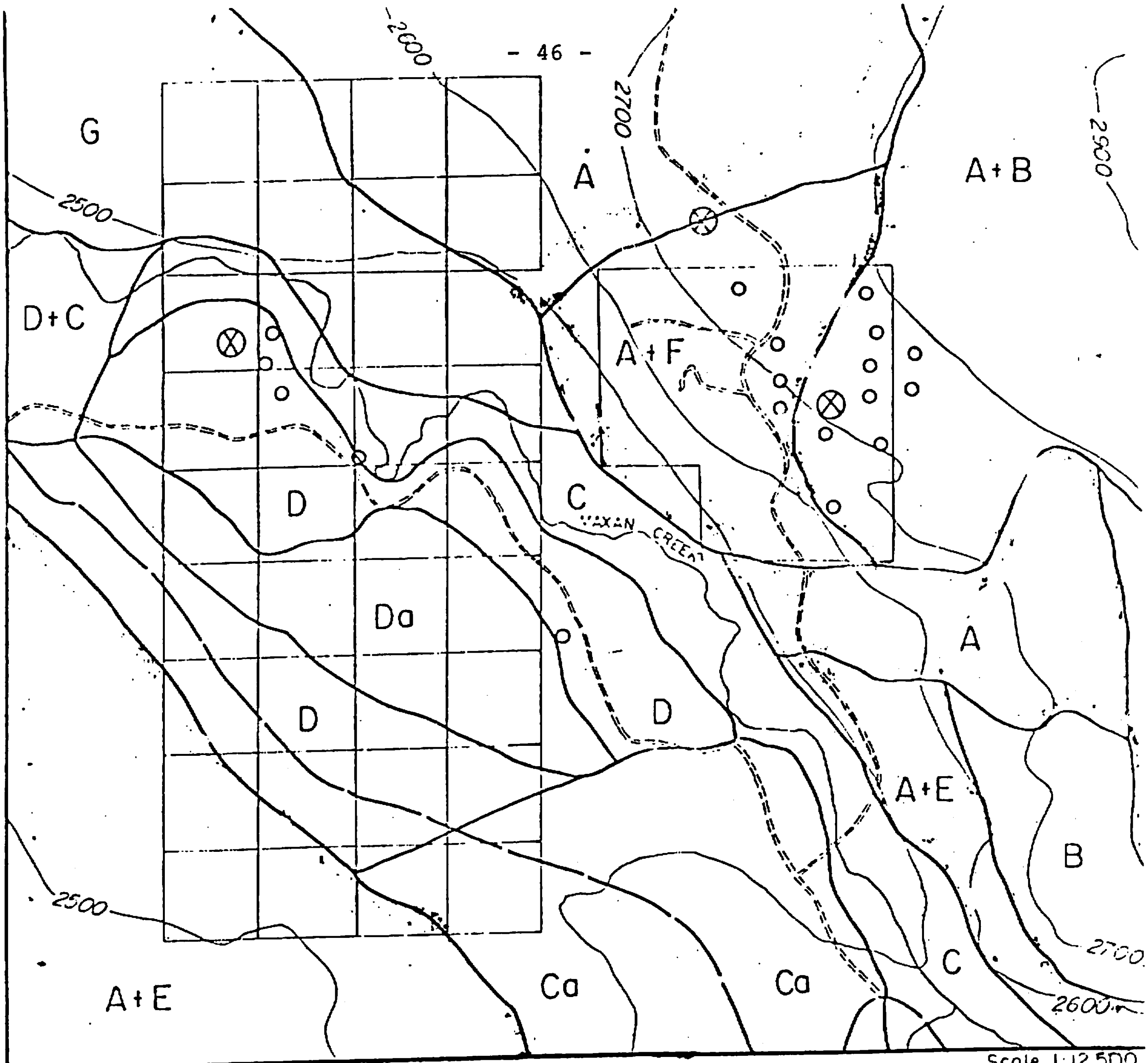
As the events the Vegetation Study was designed to monitor occur over a long time period, monitoring will continue on a periodic basis. Firm conclusions on the effects of man's management activities on the physical and biological components of the ecosystems cannot yet be drawn in all cases.

2.42 Vegetation by Soil Association

Vegetation in the study area is quite variable and will be discussed in relation to the soil type upon which it is found. The following information is taken from the Vegetation and Soil Report (van Barneveld et al 1980).

The Barrett soil complex is found on the upland portions of the study area. In its forested state, the vegetative canopy is dominated by overmature seral lodgepole pine (Pinus contorta var. latifolia) with scattered regeneration of white spruce (Picca glauca) and alpine fir (Abies lasiocarpa)

The only shrub found in the sub-canopy with any frequency is sitka mountain alder (Alnus viridis subsp. sinauta). Commonly occurring shrubs include birch-leaved spirea (Spiraea betulifolia subsp. lucida), high bush cranberry (Viburnum edule), western thimbleberry (Rubus parviflorus subsp. parviflorus), saskatoon (Amelanchier alnifolia), and twinberry honey-suckle (Lonicera involucrata). Common herbaceous species are Canadian bunchberry (Cornus canadensis), fireweed (Epilobium angustifolium), northern twinflower (Linnaea borealis), showy aster (Aster conspicuus) and cream coloured peavine (Lathyrus ochroleucus). Pleurozium moss (pleurozium schreberi) is often found on the forest floor.



Scale 1:12,500

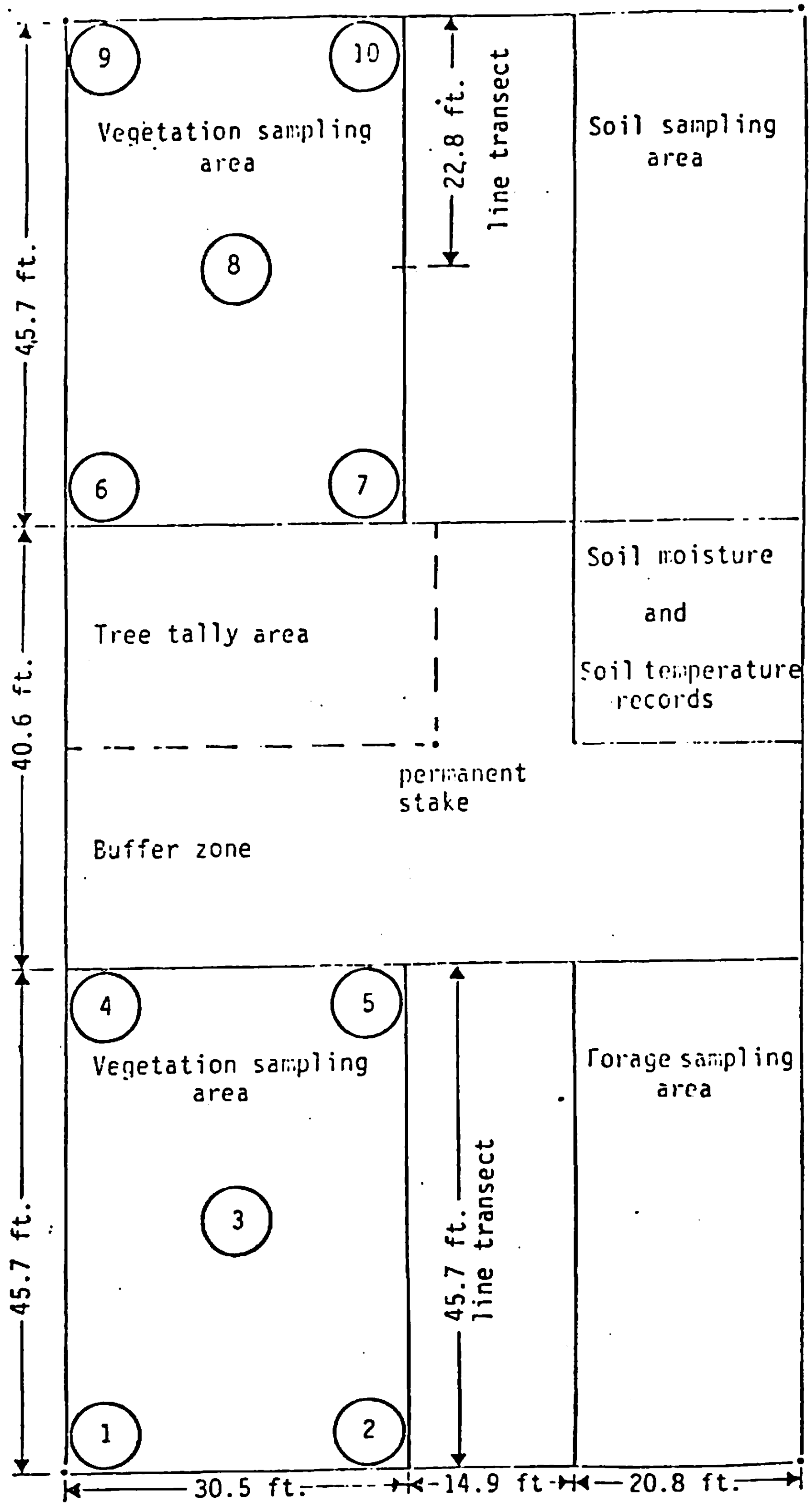
MAP KEY

- SOIL BOUNDARY
- SUBPROJECT G
- SUBPROJECT II
- CLIMATE STATIONS
- VEGETATION PLOTS
- TRAIL
- BULKLEY VALLEY INDUSTRIES ROAD

MAP SYMBOL	TEXTURE	LANDFORM	SOIL ASSOCIATION	SOIL SYMBOL	SOIL DEVELOPMENT
A	l-cl	Mb	Borrett	BA	O.GL
C	gs-gsl	F	Stellako	SL	O.R
Ca	gs-gsl	F	Slug	SG	O.DYB
D	sil-sicl/s	LV/F	—	—	O.R
Da	sil-sicl/s	LV/F	—	—	GL.R, G
E	gs-gsl	Mb	Crystal	CR	O.DYB
F	l-cl	Mv/R	—	—	O.DYB
G	sicl-sil	Lb/M	Bobine	BE	O.GL

From Soils and Vegetation Report (van Barneveld et al 1980)

Map 2.3 Soils of the Study Area



Scale 1" = 15.5'

Figure 2.1 VEGETATION-SOIL RESEARCH PLOT LAYOUT

From Soils and Vegetation Report (van Barneveld et al 1980)

A Crystal-Barrett soil complex is found on the upland areas of the western portion of the study area and has a tree canopy consisting of seral lodgepole pine and white spruce. The shrub layer has regenerating white spruce and alder (Alnus spp.), twinberry honeysuckle and rose.

Moving down the altitudinal gradient into the Babine soil complex, the forest canopy is again seral lodgepole pine mixed with white spruce. As well, trembling aspen (Populus tremuloides) occurs in the tree canopy. The shrub layer consists of soopolallie, rose and birch-leaved spirea. Herbs include showy aster, peavine, fireweed, bunchberry and blue-bead clintonia (Clintonia uniflora) with pleurozium moss sometimes forming a cover on the forest floor.

Three soil series are found on the valley floor.

The first, the Stellako association has a variety of plant communities depending on the water table level. In the wet areas, Maccall's willow (Salix maccalliana) and thin-leaved mountain alder (Alnus incana subsp. tenuifolia) occur in the shrub layer with a ground cover of fowl blue grass (Poa palustris). Drier areas have an overstory of black cottonwood (Populus balsamifera subsp. trichocarpa) with an understory of Scouler's willow (Salix scouleriana). Ground cover consists of blue-joint small reed grass (Calamagrostis canadensis). The driest sites in this association are dominated by white spruce with black cottonwood common. Red-osier dogwood (Cornus sericea subsp. sericea), twinberry, honeysuckle and rose are present. Again, blue-joint small reed grass is common at ground level.

The second soil association, the Slug, is dominated by white spruce with some lodgepole pine and trembling aspen occurring. White spruce is also regenerating in the shrub layer, which consists of willows (Salix spp.) and alder.

The last soil complex, referred to as "D" on the map (see page 46), may be split into two sites; forested and meadow areas; due to the variety of activities (logging, grazing, beaver ponding) that have occurred. The forested sites have an overstory of white spruce and lodgepole pine in a variety of seral stages in drier locations while trembling aspen and white spruce or trembling aspen are only found on the wetter, more productive spots. The meadow sites have three recognizable communities.

These sites are:

1) grasses and herb with Kentucky bluegrass (Poa pratensis) and dandelion (Taraxacum officinale) dominating;
2) grass, sedge and willow with bluejoint small reed grass, fowl blue grass, beaked sedge (Carex rostrata) and Bebb's willow (Salix bebbiana) dominating; and
3) sedge and willow with Bebb's willow, Maccall's willow, beaked sedge and Sitka sedge (Carex sitchensis) dominating.

An extensive plant species list may be found in Appendix 2 (from the Vegetation and Soils Report) edited by J. van Barneveld and compiled and written by C. Thompson).

2.43 Effects of Grazing and Browsing on Natural Meadows.

In 1973, plots were established in the meadowed and forested areas of the valley bottom that would be subject to grazing and browsing activities. The objective of this portion of the study was to "evaluate the result of grazing and/or browsing on selected types of vegetation" (van Barneveld et al 1980). The plots were established in a cottonwood stand, a young trembling aspen stand, the meadow and in an exclosure that excluded cattle. As well, a moose and cattle exclosure was established to monitor one area with no ungulate activity.

Species frequency, percent cover and biomass were measured from the plot areas which were established as described in the soils portion of this report (see Figure 2.1).

In order to estimate whether grazing or browsing had an impact on vegetation, the floristic data (percent cover) for 1973 or 1974 and 1978 was analyzed by computer. If the vegetation had not changed significantly over the duration of the project, the descriptions for each plot would remain in the same analysis grouping.

On the meadows, vegetation showed changes in species composition and percent cover. This resulted in the computer analysis yielding changes in analysis groupings from 1973 to 1978. From the analysis, it can be concluded that grazing and browsing have an impact on species composition and these activities altered the vegetaion on the meadow areas. As well, beaver activity may have had an effect as mentioned in Section 6.

A similar evaluation of the effects of man's management activities was done on a simulated clear-cut within the study area. As well as grazing, other activities such as clearing, planting trees, fertilization and grass seeding were conducted.

The results of these management techniques on a natural system are discussed under Sub-Project II - the Grass, Tree and Grazing Study.

3 TREES, GRASS AND GRAZING STUDY (SUB-PROJECT II)

3.1 Objectives

The tree, grass and grazing sub-project was conducted "to design a framework in order to evaluate the changes that occurred within the ecosystem as a result of various management and land use practices as they relate to vegetation and soils".

Sub-Project II was designed, therefore, "to assess the effects of clearing, fertilization, grass seeding, lodgepole pine planting and grazing on tree regeneration and growth, forage production and soil properties" from an ecosystem point of view.

3.2 Description of Area

Sub-Project II is located above Maxan Creek on a southwest slope at about 760 m elevation. The soils are Barrett complex compact glacial tills classified mainly as Orthic Gray Luvisols (see Section 2.3). Before logging, the vegetation canopy consisted of overmature seral lodgepole pine with some white spruce and alpine fir. The understory is described in Section 2.4 (Ecological Inventory - Vegetation).

A portion of the area was originally logged in 1968, and after, was partially burnt during cleanup operations. In November, 1972, the site was logged to simulate clear-cut conditions and the slash piled, burnt and the ash buried. During the fall of 1972 and spring of 1973, test plots were established, and in the summer of 1973, various treatments were applied.

3.3 Treatments

Six parallel treatment strips were laid out running downhill to prevent fertilizer contamination through runoff or sub-surface seepage. Each strip was subjected to slightly different treatments so that one strip would serve as a comparison control with respect to another. A "control" site was cleared above the treatment strips to assess the effects of simply clearing an area while another site was left in its original state. Finally, the strips were divided in two by a fence designed to provide grazed and ungrazed areas on the site.

Clearing, the initial treatment, was done to simulate clear-cut conditions, but cleanup was greater than normally would be carried out in the post harvest phase of logging.

Seeding was done between April 18th and June 28th, 1973 using a mixture of Climax timothy (20%), Creeping red fescue (20%), Rideau orchardgrass (20%), Alsike clover (10%) and Roamer alfalfa (10%) at a rate of 10 lbs. / acre.

Fertilizer (26-13-0 + 11% S) was applied at 100 lbs. / acre between July 27th and August 15th, 1973, with the goal of promoting rapid establishment of a seed mixture during a period of favourable moisture conditions.

In the spring of 1973, 15,600 lodgepole pine seedlings (1-0 stock) were planted with an 8 foot spacing between trees.

The final treatment, grazing was not applied until 1976 when 66 animal units grazed 25 acres on the eastern part of the site from July 28th to August 6th although some light grazing occurred from 1973 to 1975 when animals broke through the fence. In 1977, there was no grazing, and in 1978, the area was grazed, but no records were kept. Map 3.1 details what treatments were applied to each strip.

3.4 Data Collection

As mentioned, 13 test plots were established in 1972 and 1973 to facilitate data collection on the site. They were laid out so one plot would be grazed and one ungrazed for each of the treatment strips. The plot design is shown in Figure 2.1 while Map 3.1 shows plot locations and Table 3.1 shows the data collection plan.

Vegetation, forestry and soils data were recorded.

Information on vegetation included species frequency percent, cover (estimate and line intercept methods), biomass of understory and nutrient analysis of selected species was obtained. A variety of data were collected on the forestry aspect of the study. Tree tally for mean annual increment (MAI) was calculated for four selected plots to estimate forest productivity. Stem analysis was done by sectioning the trees into 2 foot lengths and counting the number of rings to estimate a growth curve for the plot. As well, the numbers and height growth for planted and naturally regenerated trees was determined. This was done to determine the "importance of distance to seed source, degree of seed release, regeneration rate and success under various treatment conditions" and to "permit a comparison between growth prior to the project and following the development".

3.5 Vegetation Results

3.51 Floristic Analysis

In an order to determine the effects of the various treatments listed previously on vegetation the vegetation cover for 1974 and 1978 was analysed by computer. If the vegetation component of the ecosystem had not changed significantly over the four years, then the descriptions for each plot would remain in the same analysis grouping.

The computer analysis shows that for Sub-Project II in 1974 the plots were divided between two description groupings. The 1978 analysis shows that the plots had generally been recategorized into a single analysis group. Although the study is ongoing and it may not be possible to draw final conclusions for some years, some preliminary results can be drawn from this floristic analysis. The first is that grazing did not have a significant effect on the composition of the vegetation once the other treatments had been carried out. The second conclusion is that after five years the plots were all similar in species regardless of their treatment although the proportions of each species varied widely.

3.52 Biomas

This section is taken directly from the <u>Soils and Vegetation Report.</u>

(a) Biomass following clearing

The biomass production per yd^2 for:

Table 3.1(a) LEGEND - DATA COLLECTION PLAN - SUB-PROJECT II AND GRID POINTS

<u>Treatments</u>

C - cleared
F - fertilized (100 lbs. / acre of 26-13-0 + sulfur)
S - grass mixture seeded* (broadcast at 10 lbs. / acre)
P - planted to lodgepole pine (2.0 at approximately 8 ft)
G - open to grazing
● - treatment lacking
\- - treatment not applicable

Table 3.1(a) continued ...

Frequency of Sampling

V	-	annually during project
XX	-	annually during project, then once every five years
▽ ▽	-	at start and finish of project
▼ ▼	-	once during project
^ ^	-	once every five years
-	-	biweekly in 1973

Code

8"	-	at an 8" depth
L-H	-	on the L-H horizon
Bm	-	on the Bm horizon

* Phleum pratense (common timothy)	20%
Festuca rubra (red fescue)	20%
Dactylis glomerata (orchardgrass)	20%
Bromus inermis (bromegrass)	20%
Trifolium hybridum (alsike clover)	10%
Medicago sativa (alfalfa)	10%

From Soils and Vegetation Report
(van Barneveld et al 1980)

Table 3.1(b)

Data Collection Plan
Sub-Project 11 Grid Points and the Meadows Plot

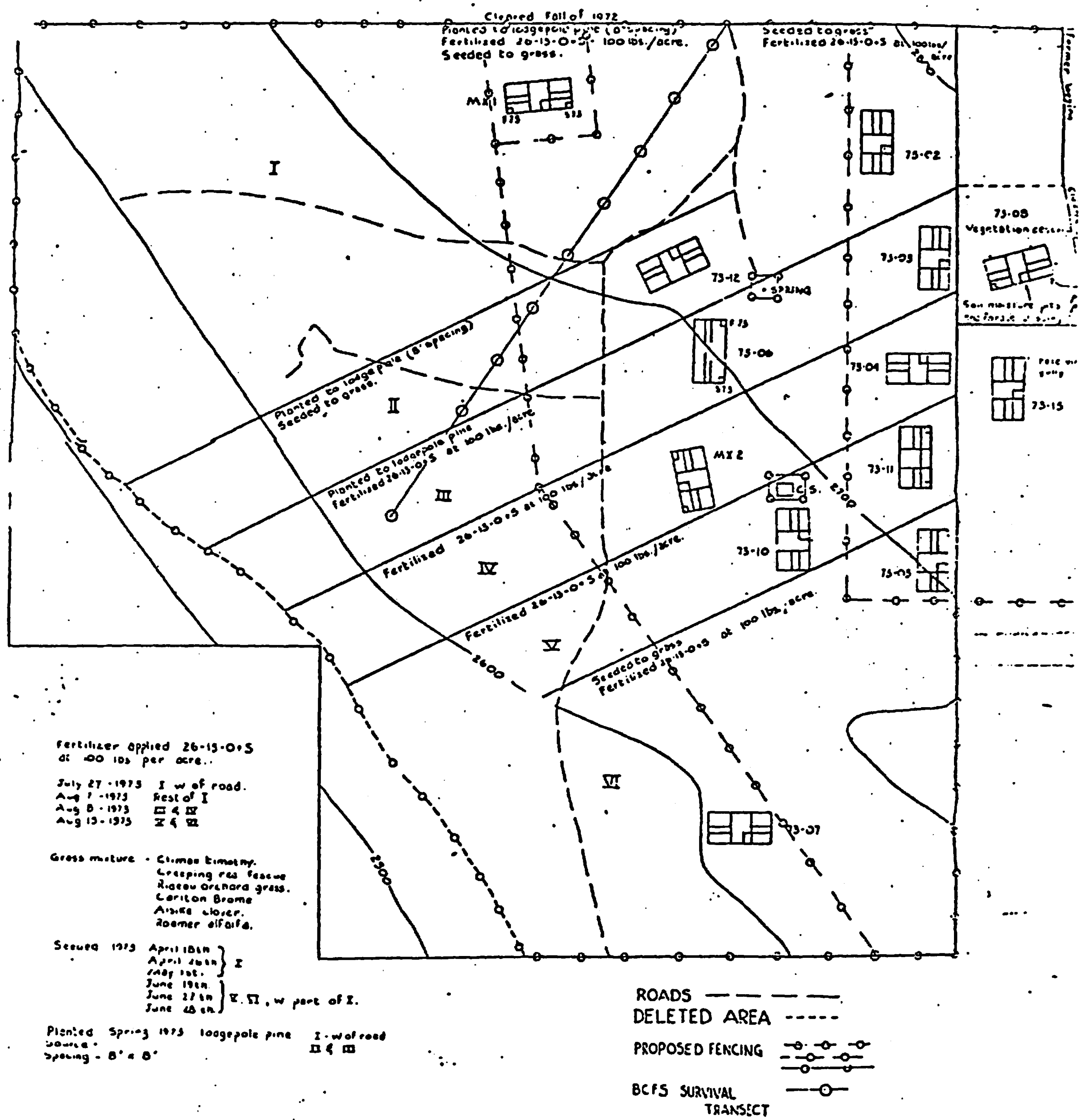
	SUBPROJECT 11													MEADOW PLOTS					Grid Points	
Treatment	....	C,......	C,F,S,P,.	C,F,S,...	C,..,S,P,G	C,F,..,P,.	C,F,..,P,G	C,F,.....	C,F,..,I,..G	C,F,.....	C,F,....,G	C,F,S,I,..	C,F,S,I,.G	-,-,-,-,G	-,-,-,-,G	-,-,-,-,G	-,-,-,-,G	-,-,-,-,-		
Data Type / Plot No.	73-13	73-08	MJ-1	73-02	71-12	73-03	73-06	73-04	MX-2	73-11	73-10	73-05	73-07	73-01	73-09	73-14	73-15	73-16	Select Grid Points	Grid Points
Vegetation																				
Species frequency (10 subplots)	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	v	v	v	v			
Species frequency (5 subplots)																			v	▽
Cover estimated	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	v	v	v	v		v	▽
Cover line intercept	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	v	v	v	v		v	▽
Biomass (1 yd² clipping)	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	v	v					
Forestry																				
Tree tally for M.A.I.	▼	▼	▼						▼											
Stem analysis: lodgepole pine	▼	▼	▼						▼											
Stem analysis: white spruce	▼	▼	▼						▼											
Seedling counts (10 subplots)	▼	v	v	v	v	v	v	v	v	v	v	v	v							
Regeneration counts (1/4 of 1/5 acre)	^	^	^	^	^	^	^	^	^	^	^	^	^							
Seedling height growth (10 subplots)	v	v	v	v	v	v	v	v	v	v	v	v	v							
Regeneration height growth (1/4 of 1/5 acre)	^	^	^	^	^	^	^	^	^	^	^	^	^							
Soil																				
Natural soil moisture at: 3½", 8", 14", 20"	△	△	△		△		△		△	△									▽	
Natural soil moisture at: 48"	△	△								△									▽	
Soil temperature at: 3½", 8", 14", 20"	△	△	△		△		△		△	△									▽	
Soil temperature at: 48"	△	△								△									▽	
Profile sampling at indicated depth a	xx	xx 1-1.5"	xx 1-1.5"		xx 0-1"		xx 1-6"		xx 5"	xx 0-5"										
b	xx	xx 0-2"	xx 0-1"		xx 2-6"		xx 6-10"		xx 0-6"	xx 2-6"										
c	xx	xx 9-15"	xx 1-3		xx 6-8"		xx 13-19"		xx 7-9"	xx 8-12"										
d	xx	xx 16-22"	xx 4-8"		xx 12-15"		xx 20-23"		xx 11-16"	xx 16-22"										
e	xx	xx 29-32"	xx 16-17"		xx 20-25"		xx 26-30"		xx 20-26"	xx 26-28"										
f	xx		xx 20-22"		xx 27-30"				xx 29"	xx 37-39"										
Profile description routine procedure	v	v	v		v		v		v	v									▼	
Parent material sampling																				▽
Chemistry and Physics: Mechanical analysis	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
Moisture tension: 15 bar (wilting point)	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
1/3 bar (moisture equiv.)	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
Bulk density: lab. procedure	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
Bulk density: field procedure	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
Atterberg limits: liquid limit	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
Atterberg limits: plastic limit	v ▼	v ▼	v ▼		v ▼		v ▼		v ▼	v ▼									▼	
Nutrition: Total Carbon	v	v	v		v		v		v	v									▽	
Total nitrogen (Kjeldahl)	v	v	v		v		v		v	v									▽	
Exchangeable cations	xx	xx	xx		xx		xx		xx	xx									▽	
Cation exchange capacity	xx	xx	xx		xx		xx		xx	xx									▽	
Fe & Al Pyrophosphate	v	v	v		v		v		v	v									▽	
Total phosphorous	xx	xx	xx		xx		xx		xx	xx									▽	
Available phosphorous	xx	xx	xx		xx		xx		xx	xx									▽	
Total sulphur	v	v	v		v		v		v	v									▽	
Available sulphur	v	v	v		v		v		v	v									▽	

From Soils and Vegetation Report
(van Barneveld et al 1980)

MAP 3.1

MAXAN LAKE PROJECT

- SUB PROJECT #2



From Soils and Vegetation Report
(van Barneveld et al 1980)

1976 - 1978 following clearing is presented below in Table 3.2. The total biomass for each year was calculated from dry weight measurements (in Appendix F.2).

Table 3.2 TOTAL ANNUAL BIOMASS

FOR SUB-PROJECT II FROM 1976 - 1978

Plot No.	Treatments[1]	Biomass (g/yd^2)		
		1976	1977	1978
73-13	.,.,.,.,.	13.9	16.3	51.6
73-08	C,.,.,.,.	33.5	35.5	71.0
MX-1	C,F,S,P,.	105.0	244.3	252.4
73-02	C,F,S,.,.	38.6	105.0	212.5
73-12	C,.,S,P,G	13.6	228.0	195.5
73-03	C,F,.,P,.	48.8	82.6	155.7
73-06	C,F,.,P,G	26.0	64.5	75.4
73-04	C,F,.,.,.	55.5	24.8	137.0
MX-2	C,F,.,.,G	62.1	147.0	208.7
73-11	C,F,.,.,.	38.1	115.1	95.5
73-10	C,F,.,.,G	39.2	55.6	184.8
73-05	C,F,S,.,.	73.1	62.6	279.6
73-07	C,F,S,.,G	59.7	118.8	127.0

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dot indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass mixture seeded, P - planted to lodgepole pine, G - open to grazing.

In general, the amount of biomass increased over time following clearing. Compared to the control plot (73-13), the treated plot totals are higher.

(b) Comparison of between plot biomass production:

i) General Effect of Treatments

Treatment plots compared to the control plot (73-08)

- the biomass of the treated plots exceeded that of the control plot

ii) Effect of Grazing

C,F,.,.,. (plots 73-04 and 73-11) compared to C,F,.,.,G (plots MX-2 and 73-10)

- the grazed plots showed an increase from 1976-1977, suggesting that grazing does not reduce forage production. The substantial biomass increase in plot MX-2 may be attributed to the fact that it is in a better position to receive moisture.

iii) Effect of Grass Seeding

C,F,.,.,. (plots 73-04 and 73-11) compared to C,F,S,.,. (plots 73-02 and 73-05)

- the seeded plots showed substantial increases in 1978. A higher value for plot 73-05 may be due to the fact that it is in a moister site (subhygric - Appendix A.1).

iv) Effects of Grazing on Seeded Sites

C,F,S,.,. (plots 73-02 and 73-05) compared to C,F,S,.,G (plot 73-07)

- the grazed plot shows lower values

v) Effects of Tree Planting

C,F,S,P,. (plot MX-1) compared to C,F,S,.,. (plots 73-05 and 73-02)

- in plot MX-1, the values seem to be levelling out by 1978. Perhaps, the lodgepole pine seedlings are competing better five years after planting, thereby, affecting understory growth.

vi) Effect of Fertilizer Application

C,F,S,P,. (plot MX-1) compared to C,.,S,P,G (plot 73-12)

- the value for 1976 for the unfertilized plots is the lowest for the treated plots except plot 73-08. Fertilizer will increase initial productivity.

(c) Biomass as it relates to organic matter

A singular value means there was only one sample.

Table 3.3

RANGE OF ORGANIC MATTER IN THE LFH HORIZON

Plot No.	Treatment[1]	
73-13	.,.,.,.	79.6
73-08	C,.,.,.	45.7-71.0
MX-1	C,F,S,P,.	76.2
73-12	C,.,S,P,G	55.8
73-06	C,F,.,P,G	31.4-41.3
MX-2	C,F,.,.,G	46.6-64.0
73-11	C,F,.,.,.	29.3-30.9

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dot indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass mixture seeded, P - planted to lodgepole pine, and G - open to grazing.

The control plots are relatively high in organic matter, but have low values for biomass. This could be for the following reasons:

1) plot 73-08 was cleared a year later than the other control plots, and no fertilizer or grass mixture was applied; and
2) plot 73-13 is under a treed canopy, which could reduce the amount of biomass produced.

In general in the remaining treated plots, the higher values of organic matter correlate to the higher amount of biomass.

(d) Biomass as it relates to percent cover estimations

A comparison between the two factors listed above was not feasible due to:

1) variation within the plot,
2) the differences in weight of the species, and
3) the fact that three dimensional measurements of the plants were not taken.

3.6 Forestry

The following section is taken directly from the Soils and Vegetation Report.

3.61 Tree Tally for Mean Annual Increment (M.A.I.)

The plots (73-13, 73-08, MX-1 and MX-2) chosen for M.A.I. determination were typically overstocked, and a considerable amount of natural thinning had occurred. The productivity of these stands was near maximum. The M.A.I.'s are: 57 cu ft/ac/yr for plot 73-13, 53 cu ft/ac/yr for plot 73-08, 73 cu ft/ac/yr for plot MX-1 and 60 cu ft/ac/yr for plot MX-2. The average capability of all the plots except MX-1 is class 4 (Forest Capability Maps, Terrestrial Studies Branch). Plot MX-1, which receives more moisture, has a higher capability than the better drained sites.

3.62 Stem Analysis for Lodgepole Pine and White spruce.

The results of the stem analysis for lodgepole pine and white spruce are depicted in Figure 3.1 to 3.6.

3.63 Stem Analysis Versus Seedling Height Growth

Although the seedlings are too young to meaningfully determine the slope of their growth curve (Figure 3.7), the observations thus far do not suggest any substantial deviation of growth patterns of the seedlings from those of the older generation of trees. This evidence must be presently considered unconclusive with regard to the impact of the treatments on the growth of the trees.

3.64 Seedling Counts

(a) Planted Seedlings Versus Natural Regeneration

The actual seedling counts for 1973-1978 are in Appendix 3. A tabulation of the seedling counts per acre is presented in Table 3.4.The planted stock could not be distinguished from the naturally regenerating seedlings of lodgepole pine.

After five years, the average number of seedlings per acre is 797 in the plots planted to lodgepole pine and 716 in the non-planted plots; this difference is not substantial. These results indicate that restocking by natural means leads to satisfactory rates of reforestation.

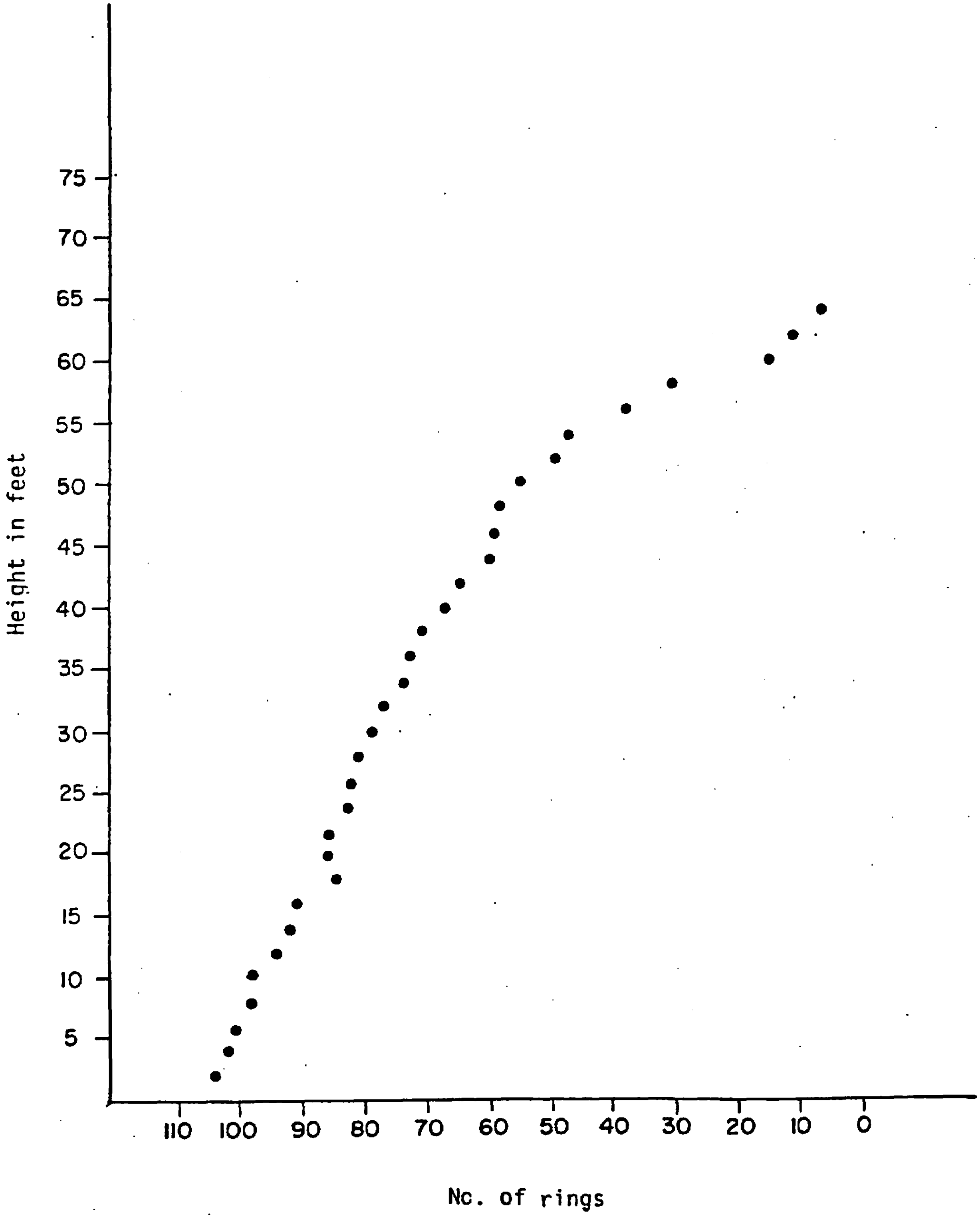


Figure 3.1 STEM ANALYSIS: RELATIONSHIP BETWEEN HEIGHT AND THE NUMBER OF ANNUAL RINGS FOR LODGEPOLE PINE IN PLOT 73-13

From Soils and Vegetation Report

(van Barneveld et al 1980)

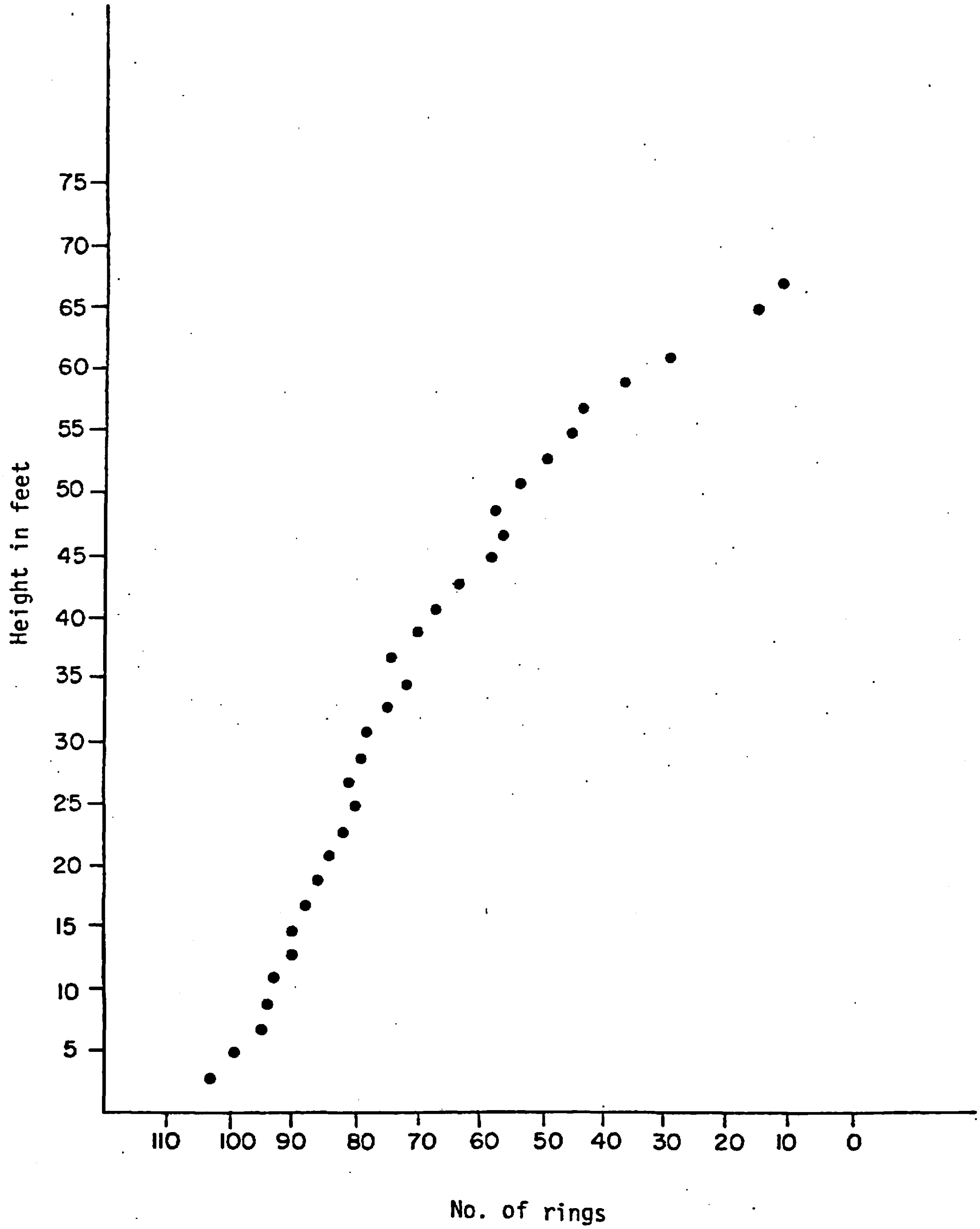


Figure 3.2 STEM ANALYSIS: RELATIONSHIP BETWEEN HEIGHT AND THE NUMBER OF ANNUAL RINGS FOR LODGEPOLE PINE IN PLOT 73-08

From Soils and Vegetation Report
(van Barneveld et al 1980)

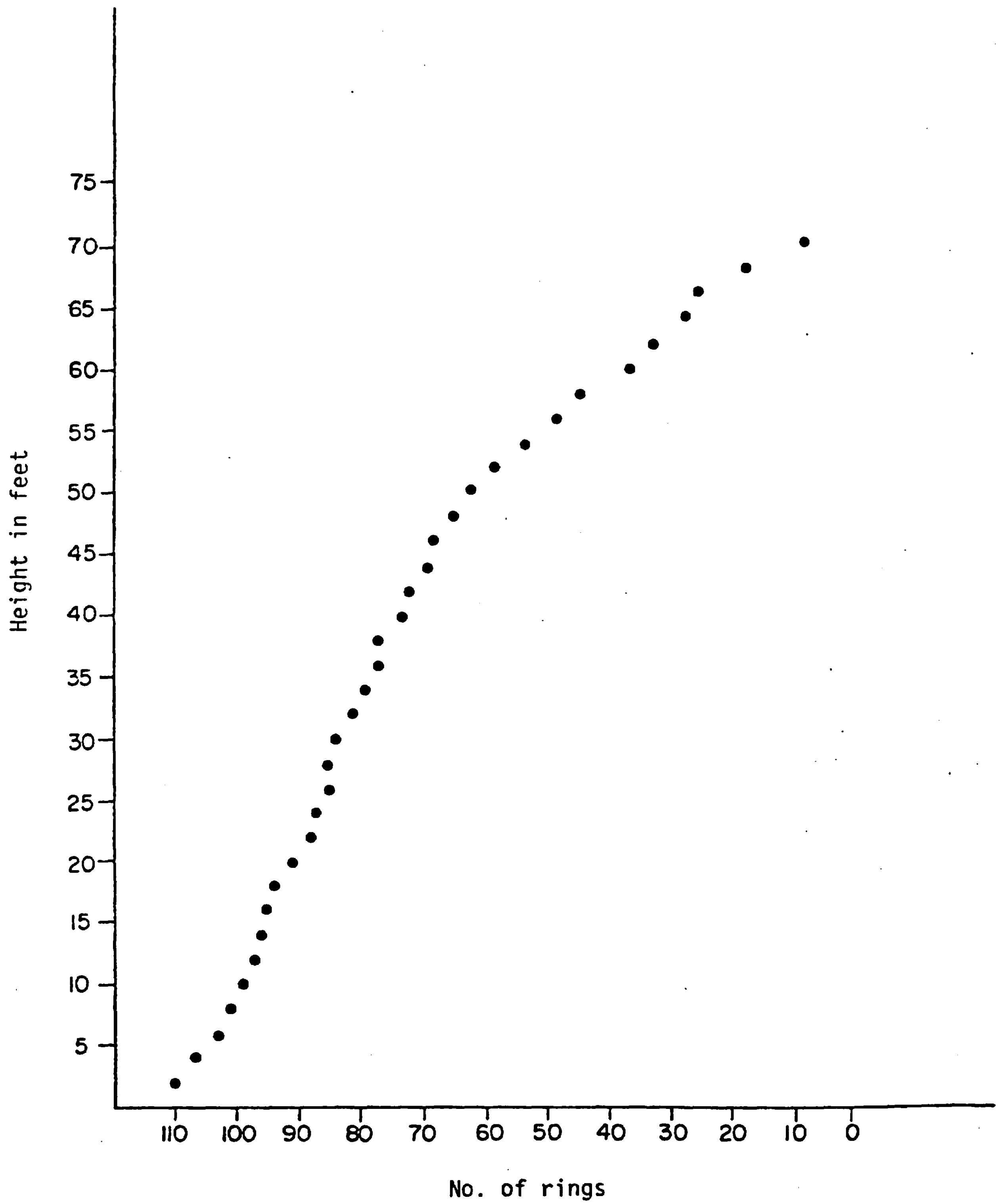


Figure 3.3 STEM ANALYSIS: RELATIONSHIP BETWEEN HEIGHT AND THE NUMBER OF ANNUAL RINGS FOR LODGEPOLE PINE IN PLOT MX-1

From Soils and Vegetation Report
(van Barneveld et al 1980)

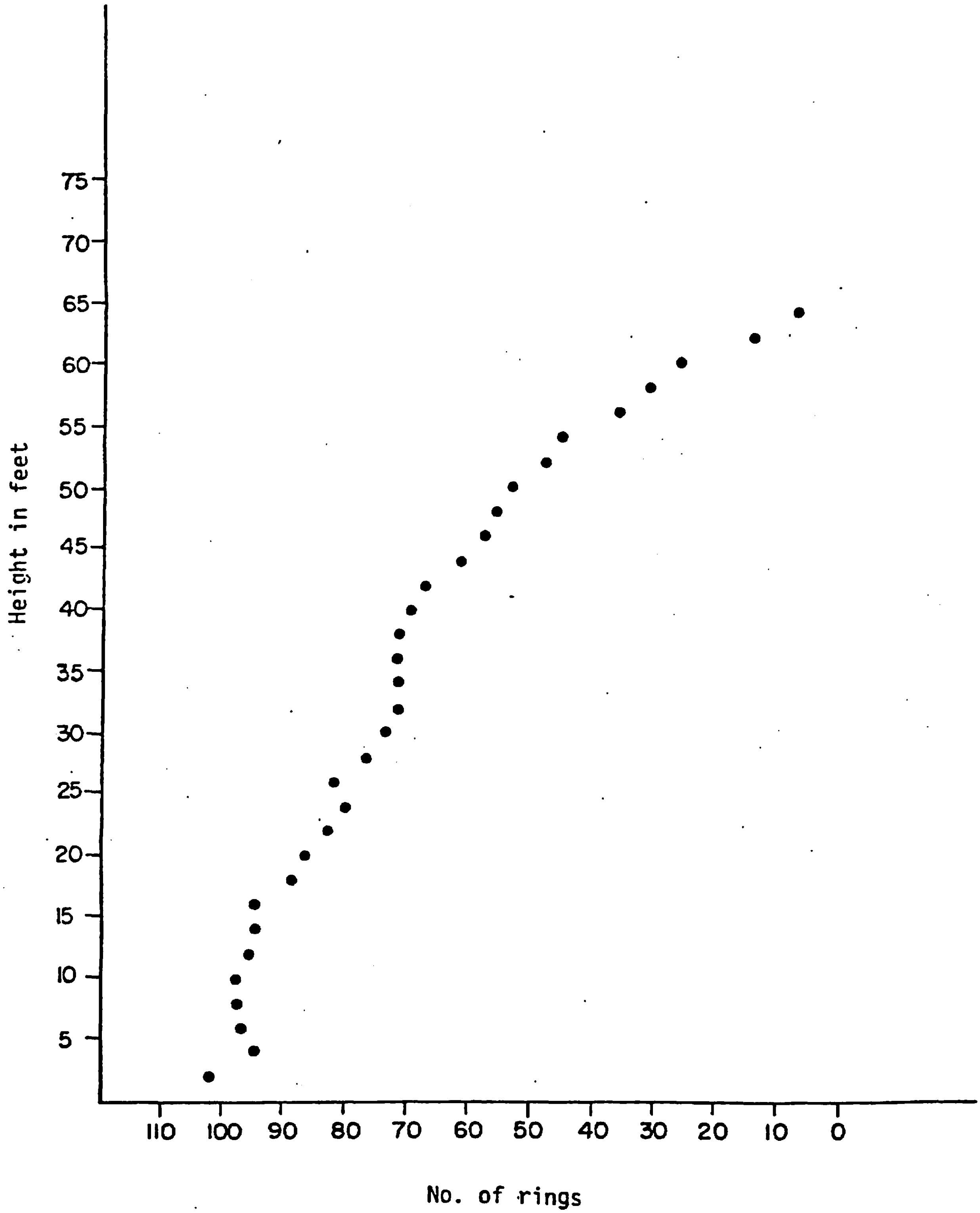


Figure 3.4 STEM ANALYSIS: RELATIONSHIP BETWEEN HEIGHT AND THE NUMBER OF ANNUAL RINGS FOR LODGEPOLE PINE IN PLOT MX-2

From Soils and Vegetation Report
(van Barneveld et al 1980)

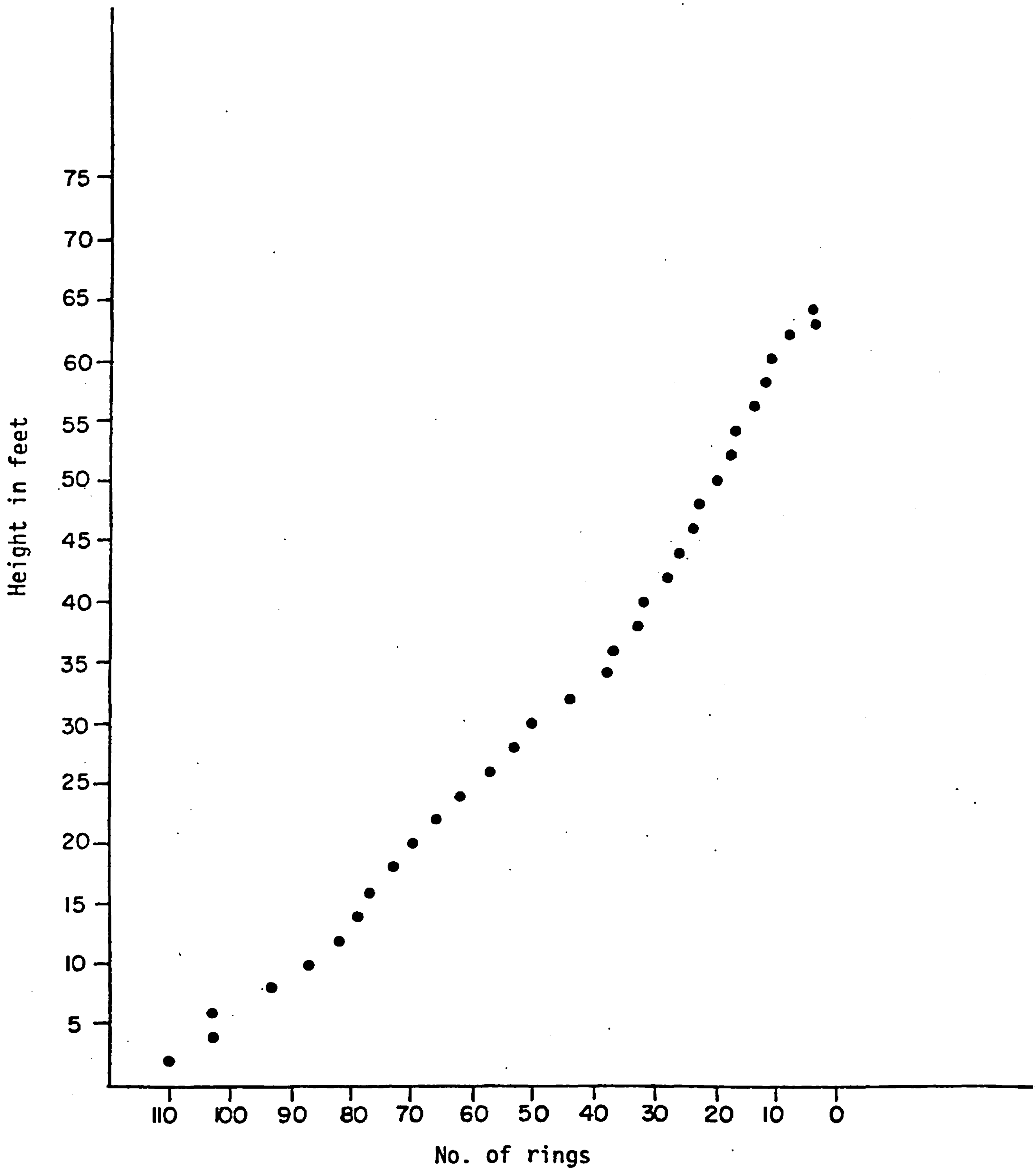


Figure 3.5 STEM ANALYSIS: RELATIONSHIP BETWEEN HEIGHT AND THE NUMBER OF ANNUAL RINGS FOR WHITE SPRUCE IN PLOT MX-1

From Soils and Vegetation Report
(van Barneveld et al 1980)

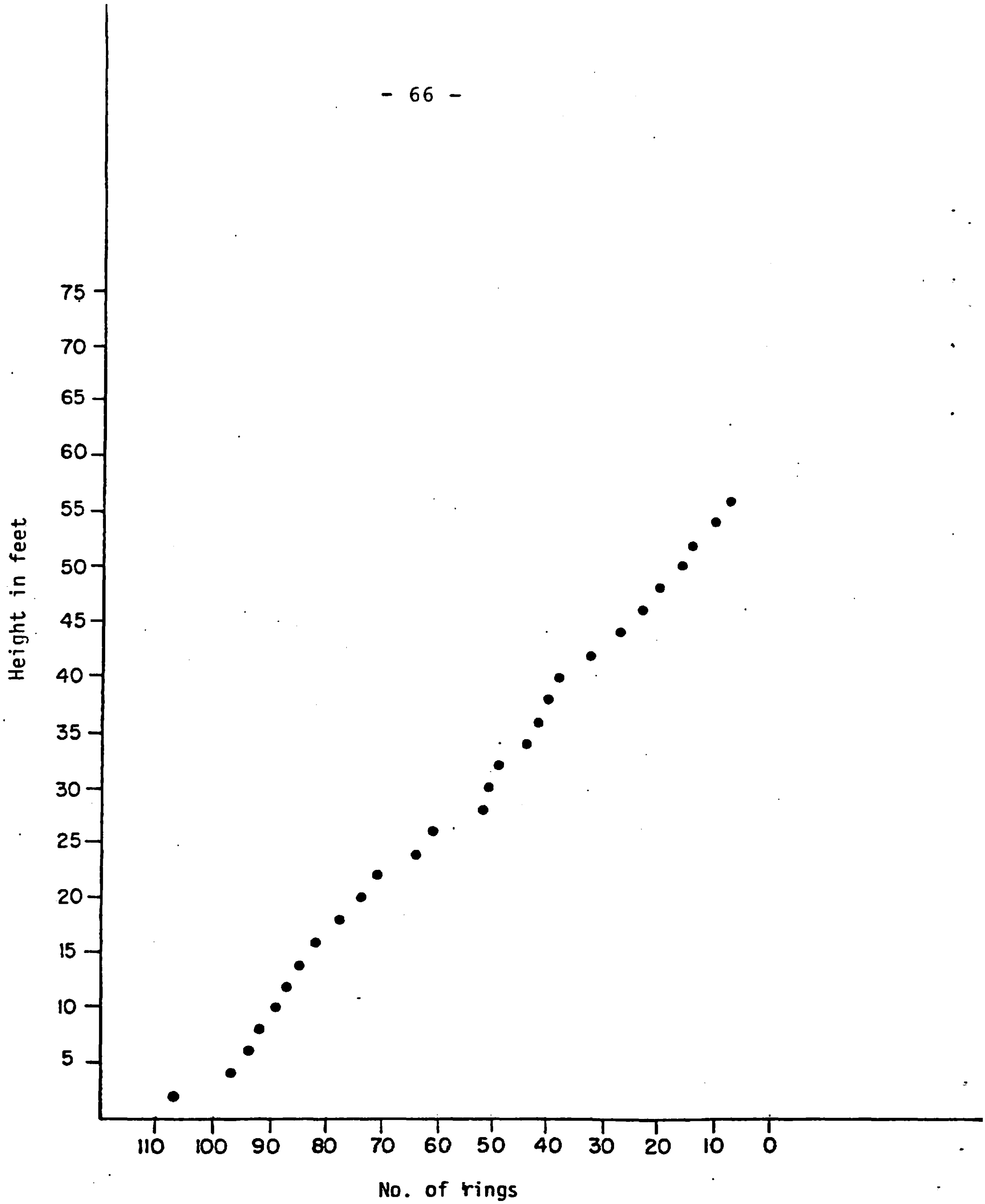


Figure 3.6 STEM ANALYSIS: RELATIONSHIP BETWEEN HEIGHT AND THE NUMBER OF ANNUAL RINGS FOR WHITE SPRUCE IN PLOT MX-2

From Soils and Vegetation Report
(van Barneveld et al 1980)

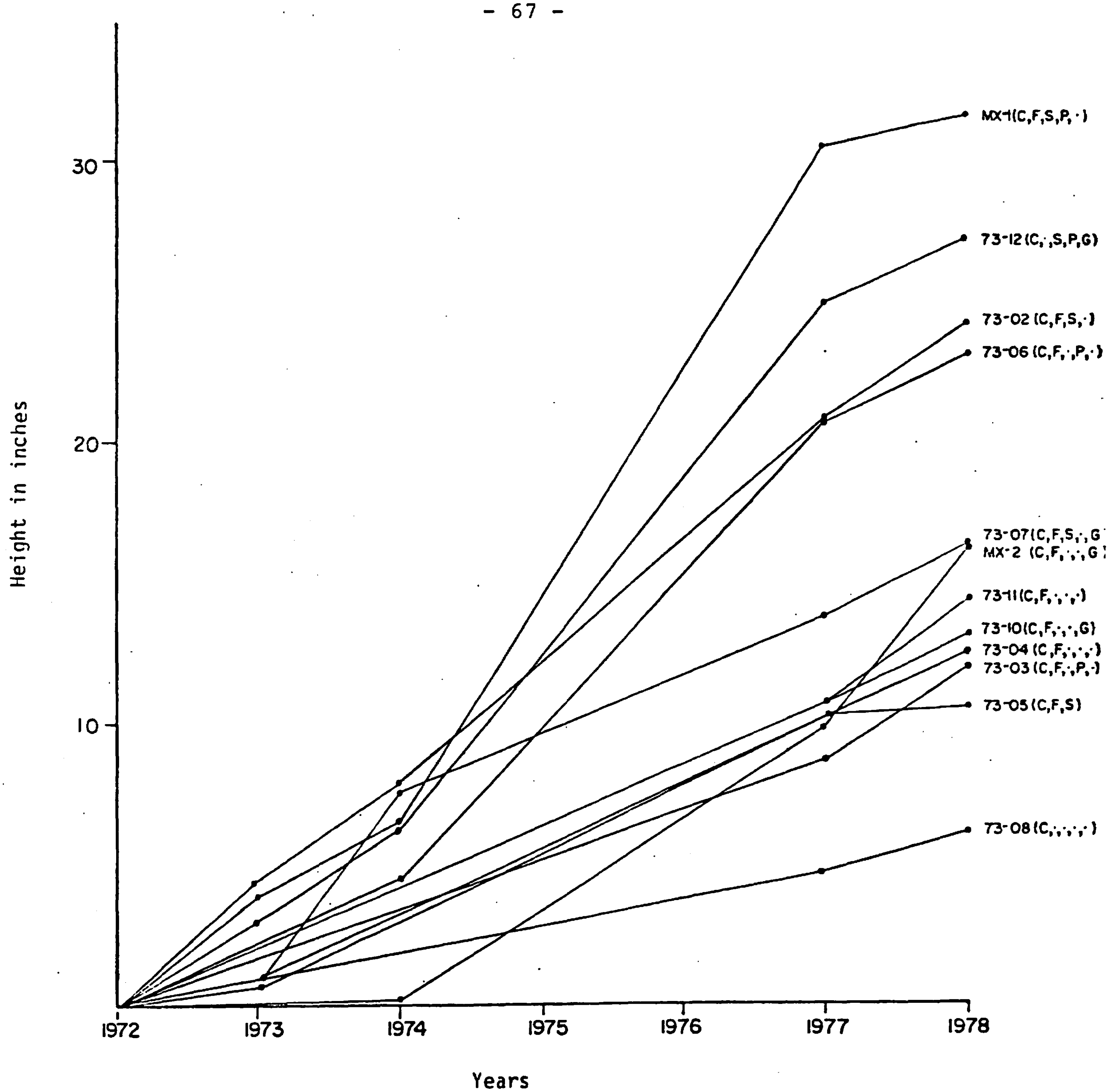


Figure 3.7

SEEDLING HEIGHT GROWTH

From Soils and Vegetation Report
(van Barneveld et al 1980)

Table 3.4

CALCULATED NUMBER OF SEEDLINGS PER ACRE FROM 1973-1978
FOR LODGEPOLE PINE AND WHITE SPRUCE

Plot No.	1973		1974		1975		1976		1977		1978
	IP	WS	IP	WS	IP	WS	IP	WS	IP	WS	IP
MX-1	835.9		785.2		911.88		886.6		937.2		987.87
73-12	785.2	126.7	809.5		987.87	101.32	607.9	50.6	937.2	126.7	962.54
73-03	---				1,114.52		430.6		1,114.5		1,139.85
73-06	962.5		1,012.0		1,646.45		1,899.7		1,798.4		2,001.07
73-08	---				---				1,189.1		3,546.2
73-02	50.6	50.6	50.6		126.7	50.6	75.9	25.3	101.32		151.98
73-04	25.3				202.6		430.6		582.59		1,165.18
MX-2	---		25.3		506.6		734.57		785.23		861.22
73-11	---				177.31		253.3		430.6		607.92
73-10	25.3				1,063.9		1,519.8		1,671.78		2,203.71
73-05	---				50.6		202.6		151.9		278.63
73-07	25.3		50.6				202.6		177.3		329.29

From Soils and Vegetation Report

The stocking rate is determined by the number of seedlings per acre. One hundred percent stocking by the 4 mil acre method means at least 250 trees/acre (Forestry Handbook for B.C. 1971). All plots with the exception of 73-02, 73-05 and 73-07, from the non-planted group; meet this requirement. Plot 73-02 and 73-07 are both located on very exposed positions in the landscape. The latter is located on a knoll and the former was placed on an upper slope position. The result of this exposure is a drying effect caused by prevailing winds and sun. This could possibly lead to a reduction in the number of seedlings per acre.

(b) Lodgepole Pine Seedlings Versus White Spruce Seedling Regeneration

The number of white spruce seedlings by natural regeneration is very low in comparison to natural regeneration of lodgepole pine. In moist areas with a cooler aspect, the generation of white spruce seedlings may be somewhat improved.

3.65 Seedling Height Growth

Figure 3.7 represents the average heights of lodgepole pine and white spruce seedlings from 1973 - 1978. The slope of these curves differ noticeably in response to the site conditions. Somewhat more rapid growth of MX-1 is thought to have resulted from better moisture conditions. Competition for moisture with the grasses does not seem to be responsible for reducing growth. The response to fertilizer application is inconclusive at this stage.

3.7 Soil Results

3.71 Natural Soil Moisture and Soil Temperature

The natural soil moisture and soil temperature data consist of the following:

i) for Sub-Project II - soil moisture - biweekly in 1973 and 1976 from May - September
- once in the fall of 1978.
Soil temperature - biweekly in 1973 from May - August.

ii) for Sub-Project G - soil moisture - once at the end of the summer in 1976 and 1978.
Soil temperature - once at the end of the summer in 1976 and 1978.

However, incomplete records, highly variable data and instrument difficulties render this data unsuitable for publication. The data are available by writing to Operations Manager, Terrestrial Studies Branch, B.C. Ministry of Environment.

3.72 Soil Nutrition

The concentration of the soil elements (calcium, magnesium, potassium and phosphorus) were calculated for the 0-6 in. depth. The findings were interpreted for general levels of nutrition based on element requirements for grasses of the Prince George area (Neufeld, Personal Communication). The level of the elements is shown in Table 3.5.

Table 3.5

GENERAL PLANT NUTRIENT ELEMENT LEVELS
ON THE SELECTED SITES FROM SUB-PROJECT II

Plot No.	Calcium	Magnesium	Potassium	Phosphorus
73-13	adequate	high	high	medium-high
73-08	adequate	medium	high	medium-high
MX-1	adequate	high	high	medium-high
73-12	adequate	high	high	medium-high
73-06	adequate	high	high	high
MX-2	adequate	high	high	high
73-11	adequate	medium-high	high	high

On the basis of the above interpretations, the levels of the elements found in the 0-6 inch depth of the area sampled do not demonstrate any deficiency.

"The ability of plants to get suitable amounts of an element is not solely dependent on the absolute amount of the element present, but is also dependent on the ratio of the elements present with regard to each other. It is therefore important to examine calcium, magnesium, potassium ratios carefully with due consideration given to the type of soil colloids and the kind of crop grown". (Cotic, 1974).

It has been widely accepted that soils having a Ca:Mg:K ratio of 65:10:5 of exchange capacity (which is roughly equivalent to a 13:2:1 ratio) is a satisfactory medium for plant growth (Osborne, Personal Communication). Where K/Mg ratios exceed 0.5, antagonistic effects of potassium on the uptake of magnesium may occur (Cotic, 1974).

Generally, the ratio of calcium, magnesium, potassium were in the accepted range. There was no indication from analysis of the soil horizons in the 0-12 cm depth that Ca:Mg or K:Mg ratios were unbalanced, and the potassium and magnesium levels appeared to be in a satisfactory range needing no corrective application of fertilizer.

Phosphorus is an important element in plant nutrition. Phosphorus levels were found to be below optimum levels, so in August 1973, thirteen pounds per acre of phosphorus were applied. A substantial increase of phosphorus in the surface horizons of the selected sites in Sub project II was detected.

Soil: phosphorus relationships are strongly governed by the pH of the soil. The pH range through which phosphorus is considered most soluble, and therefore more readily available to plants, is 5.5 to 7.0 (Cotic, 1974). This range of pH occurs in the "B" (except Bf) and "C" horizons. The pH is lower than 5.5 or acidic in the Ae and Bf horizons due to weathering and/or leaching.

"This causes some of the exchangeable bases to be lost and their place taken by aluminum and/or hydrogen. Their presence on exchange sites is indicated by low soil pH and the failure of plants to grow well on soils with low pH can be attributed chiefly to aluminum toxicity". (Cotic, 1974).

4.0 CATTLE - UNGULATE INTERACTION SUB-PROJECT III

4.1 Introduction

The Cattle-Ungulate Interaction Sub-Project of the Maxan Lake Multi-Land Use Study is detailed in the "Report of the Cattle-Ungulate Interaction Sub-Project of the Maxan Lake Multi-Land Use Study", which was compiled and written by Dave King, Regional Wildlife Biologist with the Fish and Wildlife Branch of the Ministry of Environment in Prince George. Much of the following information comes from this report. Sub-Project III was formulated because of concerns by Fish and Wildlife Branch biologists that cattle on Crown ranges were having a detrimental effect on wildlife habitat, especially ungulate habitat. The study area recognized "the Maxan Creek drainage as an important and heavily used moose winter range", and the Canada Land Inventory rating shows a capability for moose and deer of 60% 3W and 40% 2W with snow depths being the key limiting factor.

4.11 Objectives

Sub-Project III, the Cattle-Ungulate Interaction, had two main objectives. There were "to measure what change, if any, takes place under intensive grazing of cattle on:

1) the general ecology of the land; and
2) on the wintering capabilities for ungulates.

The objectives were to be met by conducting browse and pellet count studies to determine winter carrying capacity for moose by grazing the area with cattle, by doing winter moose counts and by setting up two exclosures; one moose and cattle proof, and the other, cattle proof.

More specifically this sub-project sought to determine "what effect, if any, do cattle have on game habitat" (King, 1983), and to more fully understand the first objective "to identify what effects moose were having on their own habitat".

4.12 Description of Study Area (1:250,000 Map of whole area)

With respect to ungulates, the study area was expanded somewhat to include the lower portions of Maxan Creek to Bulkley Lake, which are heavily used by moose in deep snow winters and wetland areas which extend up Maxan Creek from the south end of Maxan Lake. This area is used by overwintering moose in light snow years.

As well, the main study area was divided into three main plant communities which reflected the degree of use by moose. The first area is the upland or dry type consisting mostly of lodgepole pine stands and associated vegetation. The second area was the semi-wet habitat type consisting of aspen, cottonwood and cotton-wood spruce communities with associated vegetation. The willow communities made up the third or wet habitat type.

Table 4.1 shows the breakdown and acreages of the various plant communities which make up the three habitat types.

Table 4.1

The Main Plant Communities and Their Acreage in the Study Area and on the Private Land (Acreages estimated using a dot grid)

Plant Communities	Approximate Acreage (Acres)	
	Study Area	Private Land
A. Upland Types		
1. Lodgepole pine (including recent logging)	3135 (1270 ha.)	not calculated
2. Experimental Clearcut	80 (32 ha.)	not applicable
B. Aspen Type		
3. Aspen	190 (77 ha.)	150 (61 ha.)
C. Riparian Types		
4. Cottonwood and Cottonwood Spruce along Maxan Creek	340 (138 ha.)	90 (36 ha.)
5. Cottonwood-Spruce along Foxy Creek	75 (30 ha.)	not applicable
6. Willow	100 (40 ha.)	360 (146 ha.)
7. Farm meadows	100 (40 ha.)	250 (101 ha.)

Snow depths were of major interest, and these varied from year to year on the study site. The heavy snow years were 1973-1974 and 1975-1976 when depths of 125 cm were recorded on the study area and the last signs of snow left in the third week of May. The other years had lesser snow packs with snow usually leaving the study area by the 1st week in May. In the high snow pack years, plant growth was delayed which affected turnout dates for cattle.

4.13 Methodology

To estimate the number and distribution of moose in the enlarged study area, two methods were used. Counts were made from aircraft in mid to late winter each year, and the location and class of animal (if identifiable) were recorded. The data collected were not directly comparable due to variation in observers, type of aircraft, date and thoroughness of search.

The second method involved running browse and pellet count line transects east-west across the valley to cover each of the main habitat types. Most transects were run between Maxan Lake and IR 12A and two types were used. "In 1973, data were recorded continuously within 6.6 ft of the transect line and divided into plots 66 ft long. From 1974 to 1977, stations were established at 100 foot intervals with 3 plots per station 15 ft apart" on the transect line. Within each 100 square foot plot, browsed and unbrowsed shrubs, intensity of browsing and number of moose pellet groups were recorded.

To estimate shrub utilization by moose, the intensity of browsing was recorded using a modified form of the classification system described in the U.S. Department of Agriculture, Forest Service and Wildlife Surveyors Handbook. The system is laid out in Table 4.2

Table 4.2

Modified Browse Use Classification System

Class	Description
1	No browsing
2	Light browsing (twigs to 1/8" diameter and less than 50% of the available twigs browsed)
3	Moderate browsing (twigs to 1/4" diameter browsed and most available twigs of current years growth browsed)
4	Heavy browsing (shrubs hedged and twigs to ½" diameter browsed)
5	Very heavy (shrubs heavily hedged, branches broken and stripped, and branches over ½" diameter browsed)

from King (1983)

Data were recorded for each quadrant of each plot for 1974 through 1977.

Cattle used the area throughout the study period with the stocking rate selected because there had been little use in the last 15 years, access was restricted and the clear-cuts had not yet been made. Most forage was located along the valley floor. Use in 1973 was very light, 31 animal units (A.U.), and for the rest of the study period, was held around 65 A.U.'s for varying length of grazing season. Stocking rate was felt to be moderate.

Table 4.3

Details, Cattle Numbers and Use

	1973	1974	1975	1976	1977
No. of A.U.'s	31	57	65	66	64
Turnout Date	June 25	June 15	June 7	May 30	June 13
Removal Date	Sept. 7	Sept.15	Sept.12	Sept.16	Sept.15
Length of Season	74 days	92 days	96 days	108 days	95 days

For more information, see Section 5, Determination of Carrying Capacity and Site Productivity for Beef Cattle.

As another method of determining cattle ungulate interactions, two exclosure plots were established. The cattle exclosure was 3.2 acres in size and was designed to allow moose access to the plot while the second was 1.3 acres and was surrounded by a 10 foot pole fence which excluded both moose and cattle.

Both plots contained willow and black twinberry, along with lesser amounts of aspen, serviceberry and wild rose. The exclosures did not, unfortunately, exclude beaver, who removed most of the young aspen and some willow from the plots.

During the study period, an undergraduate thesis was done by Bonnie Mahan using data collected during field work conducted in 1975. The thesis Quality and Quantity of Browse on a Multi-Use Range in North Central B.C. with Respect to Cattle and Moose Interactions had three main purposes:

1) "to estimate the amount of browsing done by cattle;
2) to compare the utilization of browse, forbs and grasses; and
3) record the progressive change in nutrient value during this summer, particularly as it related to the changes in utilization by cattle and moose".

To meet these requirements, black twinberry and willow, the most frequently occurring shrub species in the study area used by both cattle and moose, were selected at 20 randomly located sites and individual twigs were marked and then observed through the summer quantity of browse produced and/or removed by cattle. Use was estimated by comparing the length of new growth remaining after browsing with the new growth on unbrowsed twigs on the same site and with selected controls. As well, the amount of growth that occurred after the twigs were browsed was recorded. In order to compare changes in nutrient value between forage and shrubs, samples of grasses (mainly Danthonia, Festuca and Agropyron spp.) and forbes (mainly Epilobium, Arnica and Fragaria spp.) were collected monthly and a proximate analysis done. Further sampling on selected species was done by Lee Bowd, Project Foreman, in 1976 and a proximate analysis on these samples was also done. Bowd also simulated browsing by clipping the terminal bud and 20%, 40%, 60% and 80% of new shoots of willow and twinberry on June 15th, June 30th, July 15th and July 30th, 1976. Subsequent growth was then measured.

4.2 Results

This section is taken directly from King (1983).

4.21 Distribution

Through the summer months (mid May to October of 1973-8), signs of moose were relatively scarce and actual sightings few in number in the Maxan Valley. Moose became more apparent with the arrival of snow in November with their numbers building to a maximum, probably in January or February. Spring thaw generally began in mid March, which was followed by a dispersal of moose from late March on through May. We have no information on where the moose came from or dispersed to in summer, but presumably it was to the surrounding upland forests.

Between winters, the degree to which the moose used the Maxan Valley varied considerably. What they used also varied. Table 4.4 shows the results of the winter counts using air craft. Almost all moose were along Maxan Creek in the willow, the cottonwood or cottonwood-spruce habitat types. A few were on aspen dominated slopes adjacent to Maxan Creek or Maxan Lake. None were seen in the lodgepole pine habitat types although a very few scattered tracks were observed. The pine types were searched extensively in January of 1973 and 1974. The total number observed in the entire study area in light snow winters was about 30 compared with at least 45 in the deep snow winters of 1973 - 1974 and 1975 - 1976.

In the high snow pack winters, the moose abandoned the winter range south (upstream) of Maxan Lake. About 30% of the moose counted in the valley remained south of the lake throughout the easy winter of 1972-1973.

Table 4.5 summarizes the line transect fecal pellet group surveys. Shown are day's use calculated per acre for each year and each habitat type. As the 1973 data included both old and new pellet groups, the calculated day's use per acre was cut in half on the basis of the ratio of old to new groups recorded on transect lines in subsequent years.

Table 4.4 Results of Aerial Moose Counts

Date	Bulkley Lake to 3 Km up Maxan Creek	3 Km To Maxan	Total For Maxan Lake to Bulkley Lake	Maxan Lake and Upstream of Lake	Percent Calves
1972-73 Winter					
1. Jan 11/73	- - -	8 m, 6 f, 4 c*	18*	3 m, 4 f, 3 c	33%
1973-74 Winter					
2. Jan 7/74	not surveyed	15 m, 18 f, 9 c, 1 Unc	43**	0	26%
3. Early Mar/74	19 Unc.	17 Unc	34	9 Unc	--
1974-75 Winter					
4. Feb 1/75	2 m, 10 f, 1 c	7 m, 6 f, 1 c	27	not surveyed	8%
5. Mar 25/75	7 Unc	4 Unc	11	7 Unc	--
1975-76 Winter					
6. Dec 18/75	- - -	19 Unc*	19*	12 Unc	--
7. Mar 17/76	3 f, 3 c, 5 Unc Ad	6 f, 7 c, 21 Unc Ad	45	1 Unc Ad	29%

Results of aerial moose counts in the Maxan Valley m = male, f = female, c = calf, Unc = unclassified, Ad = adult, * = count for Bulkley Lake to Maxan Lake, ** = Total is conservatively estimated to be 25% low as the lower 3 km of Maxan Creek was not surveyed.

Table 4.5 Moose Days Use Per Acre For Each Habitat Type (1973 to 1977)
NB 13 Pellet Groups = / days / use

	1973			1974			1975			1976			1977		
Habitat Type	# of pellet groups (b)	#of plots (a)	days use/ acre (c)	# of pellet groups	# of plots (d)	days use/ acre	# of pellet groups	#of plots (d)	days use/ acre	# of pellet groups	# of plots (d)	days use/ acre	# of pellet groups	#of plots (d)	days use / acre
Wet	127	42	(5.8)	83	67	(e) 41.5	11	59	6.25	31	54	19.23	23	60	12.85
Semi-Wet	136	90	(2.9)	19	138	4.61	13	201	2.17	14	108	4.34	13	167	2.61
Dry	20	35	(1.1)	4	129	1.04	3	99	1.02	1	48	0.70	1	87	0.39
Average # of days use/acre for year	283	167	(3.25)	106	334	(f) 10.63	27	359	2.52	46	220	7.00	37	314	3.95

(a) plot size was 871.2 square feet
(b) pellet group totals included both new and old Groups, so calculated Days Use/Acre (c) for 1973 was reduced by 50% based on data collected in other years.
(d) plot size was 100 square feet.
(e) due to sampling in a very high use area this figure is high as is the average (f) for the year.

In 1974 and 1976, the calculated day use per acre in the wet and semi-wet habitats for the preceding winter was about twice that of the other three winters.

The data shows a very strong preference by moose for the wetland willow habitat type. The semi-wet habitats received, on average, about 25% as much use/acre, and the dry upland habitat about 10% as much as the wet type. An attempt was made to estimate numbers of moose utilizing the study area over the course of the winter using this data. While the numbers calculated were of the same magnitude as those observed in the aerial counts, meaningful estimates were not possible. This was because actual length of use of the area each winter was not known; some animals moved into and others out of the area through the winter, and third, the small sample size in the dry habitat type relative to its acreage gave erratic results.

Tables 4.6 and 4.7 summarize the data collected on distribution of browse and on browsing by moose in the different years and in the three habitat types. Only willow, alder, immature aspen, saskatoon, viburnum mountain ash (*Sorbus sitchensis*), black twinberry and red-osier dogwood were treated as used or potential browse for moose. We excluded soopolallie as it is never used by moose although widespread in the dry habitats. We also excluded *Rubus*, *Vaccinium*, and *Ribes* species as they were generally snow covered and unavailable to moose in winter although utilized by cattle in summer.

About 40% of all plots in the wet habitat contained browse, 20% of those in the semi-wet habitat and only 6% of those in the dry habitat. Willow made up 95% of the browse in the wet, 80% in the semi-wet and about 50% in the dry habitats. Also, the willow in the wet habitat was somewhat more vigorous than in the semi-wet habitat, and in both, habitats occurred in much larger and more vigorous bushes than in the dry habitat.

4.22 Extent and Effects of Browsing

The degree of browsing is summarized by the form class results in Table 6. The data show that overall in the wet habitat most available growth from 1973 was consumed during the tough winter of 1973 - 1974. They also show in the low snowfall winters of 1972 - 1973, 1974 - 1975 and 1976 - 1977 that an average light browsing occurred. Generally, there was less browsing and less variation between years in the semi-wet and dry habitats. In two of the low snowfall winters, browsing in the semi-wet habitat was slightly greater than in the wet.

Table 4.6 Number of Plots Sampled for all Browse Species and Number with Willow
NB (1973 data is not directly comparable)

	1973	1974			1975			1976			1977		
Habitat Type	# of plots with browse	# of plots	# with browse (%)	# with willow (%)	# of plots	# with browse (%)	# with willow (%)	# of plots	# with browse (%)	# with willow (%)	# of plots	# with browse (%)	# with willow (%)
Wet	32	228	65 (28.5)	64 (28)	208	74 (35.6)	69 (33.2)	212	120 (56.6)	109 (51.4)	252	104 (41.3)	100 (39.7)
Semi-Wet	70	660	99 (15.0)	71 (10.8)	532	121 (22.7)	89 (16.7)	432	98 (22.7)	87 (20.1)	568	104 (18.3)	8 (14.7)
Dry	27	552	21 (3.8)	13 (2.4)	396	44 (11.1)	9 (2.3)	296	12 (4.1)	10 (3.4)	348	13 (3.7)	9 (2.6)

TABLE 4.7

AVERAGE FORM CLASS for All Browse Species Combined and for Willow Only (1974 - 1977)

Habitat Type	1973 All Browse	1973 Willow	1974 All Browse	1974 Willow	1975 All Browse	1975 Willow	1976 All Browse	1976 Willow	1977 All Browse	1977 Willow
Wet	1.97	--	3.00	3.03	1.89	1.90	2.49	2.57	1.83	1.85
Semi Wet	1.64	--	2.50	2.73	2.12	2.12	1.94	1.95	1.86	1.89
Dry	1.44	--	1.76	2.08	1.82	2.22	1.25	1.30	1.00	1.00

In the high snowfall winters of 1973-1974 and 1975-1976, the moose tended to "yard up", and in these "yards", browsed very heavily (Figure 4.9). Other willow patches located perhaps only a 100 yards away were not touched at all. In the areas of very heavy browsing, willow and other browse was heavily damaged with stems up to 3/4 inch (2 cm) diameter and 3 years old being consumed. An examination of willow and other browse species in 1974 indicated very heavy browsing had also occurred 2 winters earlier and about 5 years earlier. A check of weather records indicated the winters 1966-1967, 1967-1968 and 1971-1972 had had deep snow and it had lasted a long time.

We could discern no differences between degree of browsing of twinberry, willow, aspen or saskatoon between land cattle had access to and within the cattle exclosure area. Any summer browsing by cattle had been masked by moose browsing through the following winter. The browse within the moose exclosure area, however; grew with great vigor. The willow was adding about 2 feet (60 cm) to its height each year. Although not included in this report, linear measurements of new growth in the moose exclosure, in the cattle exclosure and on the open range were made and used to refine the degree of browsing, that is; the form classes.

Ms. Mahan found "there was considerable selective browsing by the cattle. Current year's (woody) growth was not utilized as such. Instead, (the cattle) tended to strip the leaves from the branches and nip off the tips. The twinberry was utilized by the cattle much more extensively than the willow. Plants moderately browsed were simulated to produce twigs from lateral buds remaining on the browsed twigs". In the vicinity of salt blocks and other high use areas, she found many of the browse species destroyed by trampling and rubbing. But she considered "this damage insignificant when viewed in relation to the total range area". The number of her 20 experimental browse sites in which the twinberry and willow shrubs were browsed and the average twig length eaten by cattle follows. (The following is a summary of Table 4.8 in Ms. Mahan's report).

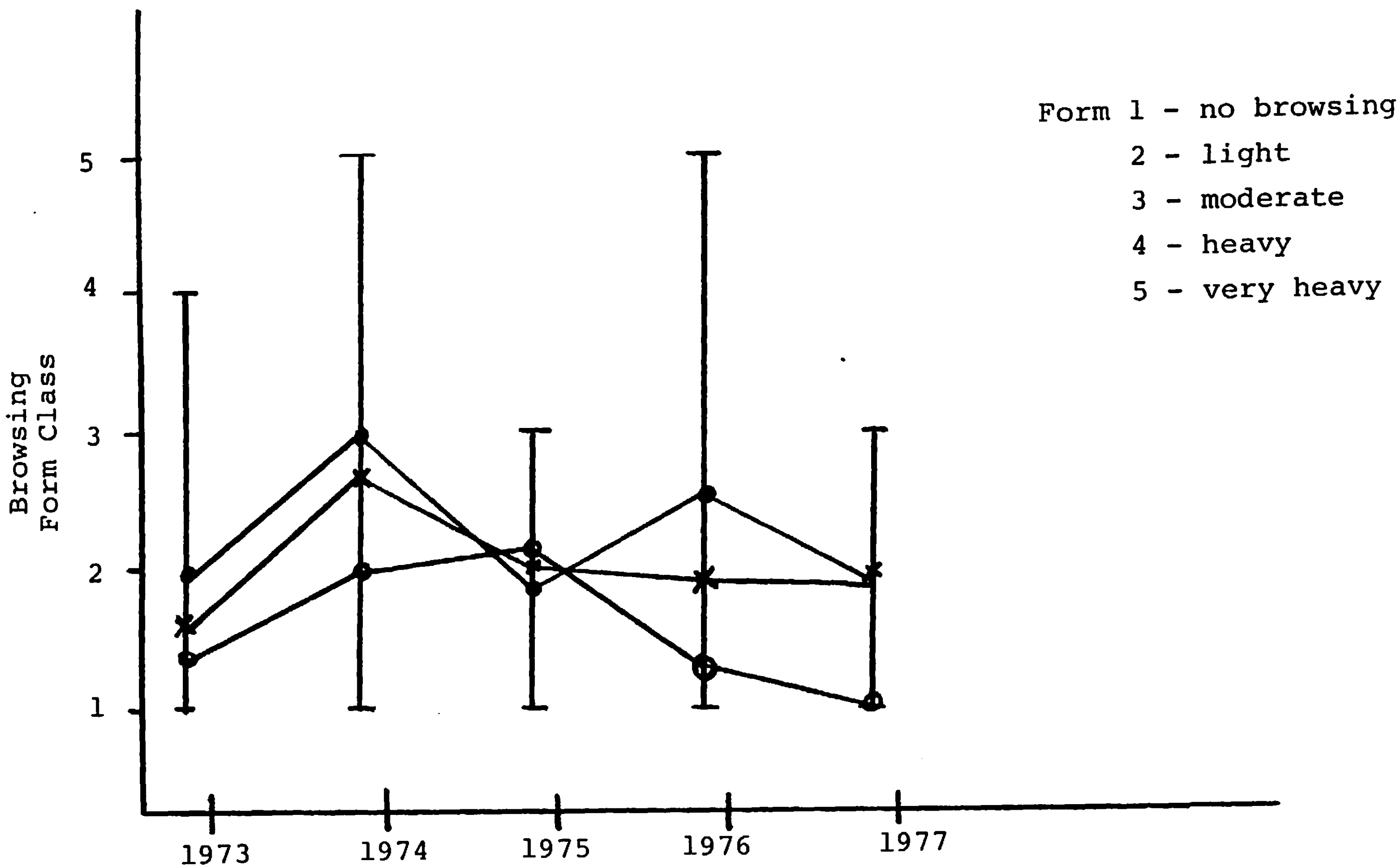
Clearly the degree of browsing increased in late summer with cattle appearing to prefer the black twinberry to willow. Cattle were also observed browsing on red-osier dogwood, saskatoon, rose, raspberry, aspen, highbush cranberry and blueberry.

TABLE 4.8

Amount of Twig Browsed

	June		July		August		September	
	No. Browsed	Av. Length Removed	No. Browsed	Av. Length Removed	No. Browsed	Av. Length Removed	No. Browsed	Av. Length Removed
Twinberry	1	8"	0	-	5	3.6"	12	5.8"
Willow	0	-	0	-	3	4.3"	5	5.9"

Figure 4.9 Average Browse form Classes for Willow in Each Habitat Type and Ranges in the Wet Type (vertical line)



4.23 Proximate Analysis

The proximate analysis results from Ms. Mahan's work are shown in Table 7. (Table 4.10 of Ms. Mahan's report). Lignum increased gradually in all forage from summer to winter although the relative increase in grass and forbs was greater than in the willow and twinberry. Ms. Mahan found the protein content declined from summer through to winter, but the rate of decline in grasses and forbs was greater than exhibited by the shrubs. "The cellulose and A.D.F. contents were significantly higher in the grass and forbs than any of the shrubs during late fall and winter months". The ash content declined in all forage from summer through winter with the level in shrubs always lower than in the grasses and forbs.

In 1976 - 1977, Lee Bowd collected additional samples of willow and twinberry for proximate analysis in the study area and at two other nearby locations. Table 4.11 gives the results for the study area for the same factors as determined in 1975 - 1976 by Ms. Mahan. (The data on other sites collected in 1976 - 1977 and on percentage of various minerals are available at the Ministry of Agriculture in Prince George). Differences existed between the two years. For example, the crude protein levels, in 1976 were twice those for 1975 for willow and twinberry. Ash contents were similar in the two years, but there were few similarities in either the absolute values or patterns of change through the year in A.D.F., cellulose and lignum. Obviously, more data needs to be collected.

4.24 Effects of Clipping

Growth of willows clipped at various times through the summer was compared with total growth as measured August 15th, 1976. Removal of the terminal bud or 20% of the new growth had little effect on the total growth regardless of month clipping occurred. However, when 40, 60 or 80 percent of the new growth was removed, further growth was reduced by about two thirds.

4.24 Discussion

Before addressing the question of the effects of cattle on moose use of the Maxan Valley, it is necessary to consider use of the valley by moose. This study showed that moose use to be related to two key factors: snow depth or winter severity and food supply.

Table 4.10

PROXIMATE ANALYSIS ON A DRY MATTER BASIS (%)

PROTEIN	FORAGE	FORBS	N.LEAF WILL.	B.LEAF WILL.	TWIN-BERRY	R.OSIER DOGWOOD	POP. TRIC.	POP. TREM.
June	19.5	12.3	14.2	14.5	15.0	14.8	11.2	11.5
July	20.1	13.2	11.2	15.3	10.1	9.6	12.8	13.6
August	9.3	10.2	11.5	15.9	10.6	6.8	14.4	17.2
September	6.1	9.8	10.7	14.1	8.6	5.6	13.8	15.2
November	7.4	8.3	7.8	8.3	4.7	4.9	8.6	9.1
January	3.5	4.8	9.3	10.1	5.2	5.1	7.8	8.9
A.D.F								
June	26.4	26.5	19.6	20.2	29.5	26.2	23.4	22.8
July	29.1	32.5	26.2	28.8	34.1	30.6	33.6	33.8
August	38.2	38.6	27.3	28.3	29.4	35.6	28.8	32.9
September	34.6	27.0	18.1	18.4	34.5	34.0	30.2	32.3
November	47.4	55.6	53.8	49.3	48.2	48.1	37.3	48.5
January	52.5	57.4	38.1	39.2	46.3	40.1	33.7	36.9
LIGNIN								
June	5.6	7.0	8.4	8.0	13.0	12.5	12.6	13.4
July	4.7	9.8	9.6	9.2	11.0	12.8	12.2	13.1
August	7.2	10.0	10.3	10.1	12.2	13.1	12.9	13.2
September	8.8	10.5	10.7	10.4	13.2	13.3	13.5	13.5
November	22.9	25.1	25.8	25.4	24.4	24.5	25.9	26.0
January	23.7	31.2	33.0	30.9	24.9	24.7	24.5	24.2
CELLULOSE								
June	20.8	19.5	11.2	12.2	16.5	13.7	11.8	9.4
July	24.4	22.7	16.6	19.6	23.1	17.8	21.4	20.7
August	31.0	28.6	17.0	18.2	17.2	22.5	15.9	19.7
September	25.8	16.5	7.4	8.0	21.3	20.7	17.0	18.8
November	24.5	30.5	28.0	23.9	23.7	23.7	11.4	22.5
January	28.8	26.2	5.1	8.3	21.4	15.4	9.2	12.7
ASH								
June	11.5	10.6	8.7	8.9	6.8	6.9	6.9	6.6
July	10.8	11.3	6.4	8.1	6.4	6.0	6.3	6.5
August	8.4	12.0	4.7	6.7	3.4	3.4	7.4	6.8
September	10.4	12.5	6.2	8.2	4.2	3.8	8.3	6.9
November	9.0	6.9	3.0	5.0	4.8	5.1	8.0	4.0
January	9.4	5.4	2.9	3.8	3.6	3.7	4.0	4.8

From Mahan (1976)

Table 4.1 Proximate Analysis Results from Samples Collected in 1976 by Lee Bowd

	Willow	Black Twinberry	Willow	Black Twinberry
	% Protein		% Cellulose	
June 17/76	31.0	27.9	17.0	13.6
26	25.8	20.6	22.6	17.8
July 14/76	23.7	13.6	13.0	19.7
30	17.3	12.6	20.7	19.7
Aug. 15/76	14.5	12.3	17.6	18.2
Oct. 15/76	9.2	4.4	25.8	28.2
Feb. 14/77	7.3	6.0	25.3	26.7
	% ADF		% Ash	
June 17/76	34.7	26.8	6.7	6.9
26	50.3	37.7	6.0	7.0
July 14/76	33.9	33.7	5.1	6.0
30	40.0	44.4	4.7	5.2
Aug. 15/76	38.9	36.8	3.9	7.0
Oct. 15/76	48.1	44.7	1.9	2.1
Feb. 14/77	47.7	44.7	1.96	2.8
	% Lignum		% DMD	
June 17.76	17.7	13.2	32.7	71.7
26	27.7	19.8	25.13	57.35
July 14/76	25.8	13.9	37.03	62.23
30	19.2	21.8	29.21	51.83
Aug. 15/76	21.2	18.4	22.79	43.56
Oct. 15/76	22.3	11.4	20.67	23.10
Feb. /77	22.5	18.0	19.54	33.04

Browse, particularly the key species, willow, occurred in all habitats in the study area. However, its frequency of occurrence in the dry upland pine type habitats of the flood plain. Moreover, the willow bushes in the dry habitats tended to be smaller, have less crown area and have much less new growth. The other winter browse species were much the same as the willow.

In winters with low snow depths, movement of moose was not greatly restricted. The moose travelled throughout all habitats and utilized the available browse relatively evenly within each habitat type and between habitat types. Also in the low snow winters, a much larger land area was used including the upper basin of the Maxan Valley south of Maxan Lake. But in winters with deep snow, the moose clearly concentrated into the open wetland habitats where food was most abundant. They did this even though snow depth under the closed canopy of the nearby upland forest was less. Within the wetland habitat, the moose tended to "yard up" resulting in uneven utilization of browse. In one site, the browse would be very heavily utilized with considerable damage to individual shrubs whereas an adjacent similar site may be untouched. In the heavily browsed locations, growth of two years and older was consumed and barking of larger stems occasionally occurred. Aspen trees were also debarked.

Research in Norway by Hjeljard et al (1982) with penned moose on the nutritive value and digestibility of Great willow (Salix caprea) and other browse showed the value of browse decreased with increasing twig diameter and age. They found the digestibility (in vitro dry matter disappearance - IVDMD) of Great willow to decrease from about 50% in twigs grown the previous summer to about 30% in older growth. They estimated the average daily intake of browse of 47% DMD (dry matter digestibility) for a 300 kg yearling moose would be 8.1 kg wet weight assuming a 20% weight loss occurred over winter. In vitro, digestion trials done in Alaska (Oldemeyer 1974) on willow (S. arbusculoides) gave a percent digestibility ranging from about 31 to 41%. This same paper contains extensive data on the nutritive value of browse with special reference to moose. Mahan did not calculate the DMD for her 1975 samples, but Bowd did so for those collected in 1976. He found a DMD of about 20%. If this value is for first year growth, then it suggests a yearling moose in the Maxan area would require considerably more food bulk than one in Norway.

Garaway and Coady (1974) in their review of the energy requirements for moose note that cold temperatures (to -40^{o}C) have no effect on basal metabolic rates. They estimate that a moose in winter requires 10 to 12,000 Kcal/day with the requirement somewhat higher in pregnant cows. Stewart et al (1977) estimated a 400 kg moose required 10,608 Kcal/day for maintenance energy in Saskatchewan.

In the Maxan study area, the moose were having a significant effect on their own habitat. The willow, twinberry, red-osier dogwood and seedling aspen in the moose exclosure plot were all heavily browsed and in varying states of apparent poor health at the time of construction of the protective fence. In the following years while they regained their health and have grown into vigorous shrubs or trees, those outside the exclosure have not. The impact of large herbivores on the ecological composition of their own habitats is well documented. The impact by moose on their own habitat has been documented by Hamilton (1947) in Sweden, in Ontario by Peterson, in Montana by Peek (1963) and in B.C. by Mitchell (1964) and in several other studies.

Overall, the impacts of the cattle on the moose winter range in the Maxan study area was minimal. The cattle were well managed and their numbers were low enough that there was never a shortage of forage. Some browsing of shrubs was noted during the study, but it was only extensive in the immediate area of salt blocks. We were able to detect any difference in the degree of browsing of shrubs between the cattle exclosure plot and the lands they frequented. In part, this may have been because moose had access to the cattle exclosure, however; even lower branches, only buried by snow when moose were present in large numbers, were not browsed to any appreciable degree. But cattle browsing did occur as was recorded by Ms. Mahan particularly in late summer. This was after the forage began to mature, dry out and its nutritive value dropped below that of the shrubs. A complete summary of nutritive changes of forage and shrubs and cattle weight gains is to be found in the main Maxan project's report.

The clipping trials done in 1976 by Bowd also indicated minor impact on shrubs provided only the growing tip of shoots was removed. However, if 40% or more of the shoot was removed, it has a severe impact on growth over the remainder of the growing season. The implication of these results is clear. On important moose winter range, cattle should be managed in a manner they browse key shrubs only lightly. If browsing becomes widespread and is removing more than 20% of the new growth, the cattle should be removed to a different range, but these results need confirmation through further tests.

4.25 Postscript

The author revisted the Maxan Valley on October 6, 1982, and made a quick visual assessment of areas where browse and fecal pellet groups were run and also of the moose enclosure. In the interim, the removal of the crosses, fences and increase in stocking numbers to 200 animal units. He noted that a large amount of willow had been broken down and the twinberry had disappeared in some areas with the effect that winter carrying capacity had been reduced.

5.0 DETERMINATION OF CARRYING CAPACITY AND SITE PRODUCTIVITY FOR BEEF CATTLE (Sub-Project IV)

The objective of Sub-Project IV was to provide basic information on the carrying capacity and productivity of forested and open meadow grazing sites. This was in response to an apparent need for summer grazing for beef cattle in the area.

Data was recorded on several grazing related parameters. Nutrient analysis was conducted on samples collected periodically throughout the study on shrub, forb and grass species. This information is presented in Section 5.1 and is taken from the Soils and Vegetation Report (van Barneveld et al 1980). As well, nutrient analysis of grasses and forbs are compared with selected browse species and presented in Table 3 in graph form from Mohan (1976) shown in the Section 4.23.

Grazing reports were presented annually during the project, and these are summarized by year along with the cattle weights listed by average daily gain on a monthly basis.

Finally, a cattle grazing survey was conducted during 1974 and 1975 by summer students who observed cattle activity on a daily basis.

5.1 Forage Nutrient Analysis

The following section is taken from the Soils and Vegetation Report (van Barneveld et al 1980), and the comments are based on samples taken from the permanent plots established on the simulated clear-cut site (Sub-Project II). For a plot map, see Map 5.

5.11 Seasonal Variation in Forage Quality

Table 5.1 summarizes the level of sufficiency for the various nutritive constitutives, monitored on this project, in comparison to the basic requirements for beef cattle. Comments were made using general descriptive terms - high and low. High refers to values that were well above the average requirements; low refers to borderline or deficient values.

The components considered are protein, calcium, phosphorus, magnesium, copper, zinc and manganese. Iron was not included due to high levels of contamination by soil; potassium and boron are considered to be at normally sufficient levels in the diet. As the forage samples were contaminated by soil, some manganese determinations were erroneous. This is indicated in table 5.1.

Only samples composed of one species and with a medium to high palatability were considered for analysis. Quantity of the species was not taken into consideration. Grazing preferences for cattle were obtained from McLean et al (1964) and the B.C. Forest Service. Mr. Rick Corbett (Personal Communication) provided his expertise in interpreting the NRC Macro Element Requirements Tables (Official Proceeding: Twelfth Annual Pacific N.W. Animal Nutrition Con., 1977) and the ARC (copper) tables (Agr. Research Council, 1965).

The comments were determined from limited data.

5.12 Forage Quality

Table 5.2 serves as a general index of forage quality. It includes annual forage production and forage quality - the basic nutritive constitutives. This latter part of the table serves to determine which component of the diet is deficient in response to senescence and succession of plants.

For forage quality, the nutritive components are protein, calcium, phosphorus, magnesium, copper, zinc and manganese. Iron was not included due to high levels of contamination; potassium and boron are considered to be at normally sufficient levels in the diet. As the forage samples were contaminated by soil, most manganese determinations were erroneous.

The AM and BM in the table represent above or at minimum requirements and below minimum requirements. The minimum requirement was obtained from the NRC tables (Official Proceeding: Twelfth Annual Pacific N.W. Animal Nutrition Con. 1977) and ARC (copper) tables (Agr. Research Council, 1965) for steers.

An animal's nutritional requirements change over the year relating to pregnancy, lactation and growth. The highest requirements refer to the most demanding stage in the annual cycle - early stages of lactation. Conversely, the lower requirements refer to the less demanding stages and usually correspond to the minimum requirements for growing animals.

Table 5.1 SEASONAL VARIATION IN FORAGE QUALITY

Plot No. and Treatment[1]	Chemical Component	Comments of Season Variations	Borderline Level Date
73-13 .,.,.,.,.	Protein	- generally very high in the palatable species	Sept 1
	Calcium	- generally the calcium levels are very high from early summer to fall	after Oct.
	Phosphorus	- in general, very high during the summer; decreasing towards fall	Aug 19
	Magnesium	- very high values	Sept 1
	Copper	- the values do not meet the basic requirements	-
	Zinc	- the values are very high; tend to decrease towards fall but the basic requirements are still fulfilled	after Oct
	Manganese	- the values exceeded the requirements for a pregnant or lactating cow	after Oct
73-08 C,.,.,.,.	Protein	- generally high in early spring and summer; decreasing towards the end of July; after August all values are below the basic requirements	July 9
	Calcium	- grass species: generally the values are below the average requirements for steer and lactating or pregnant cows - browse species: the values are high	- after Sept 1
	Phosphorus	- grass species: generally the values fulfill the average requirements - browse species: the values are high	Sept 1 after Sept

Table 5.1 (Cont'd)

Plot No. and Treatment[1]	Chemical Component	Comments of Season Variations	Borderline Level Date
	Magnesium	- grass species: generally the values meet only the requirements for a steer - browse species: the values are high	Aug 19 after Sept
	Copper	- the values are low	-
	Zinc	- grass species: generally the values are high - browse species: the basic requirements are fulfilled	after Sept after Sept
	Manganese	- contaminated sample	
MX-1 C,F,S,P,.	Protein	- generally the protein values are very high in the late spring; low values for July and Aug. were recorded; after Aug. the values are below what an animal requires	July 9
	Calcium	- in general, the values were low to very low after May; the value for the legume species is high	June 11
	Phosphorus	- generally the values begin relatively high in the spring and drop as the plants progress toward dormancy. Orchard grass has high values for this mineral component	July 26
	Magnesium	- generally the values meet only the requirements for a steer	after Oct 3
	Copper	- the values do not fulfill the basic requirements	-
	Zinc	- generally, the values are borderline to low with the exception of orchard grass	
	Manganese	- contaminated sample	

Table 5.1 (Cont'd)

Plot No. and Treatment[1]	Chemical Component	Comments of Season Variations	Borderline Level Date
73-06 C,F,.,P,G	Protein	- grass species: low to medium from June to July; after Aug. the values are below what an animal requires	Aug 19
		- browse and herb species: very high values for June to the latter part of July; the values are low in late summer and early fall	Aug 19
	Calcium	- grass species: fluctuating values from low to high	Aug 6
		- browse and herb species: generally the values are high	after Oct 3
	Phosphorus	- generally, the values are high during the spring and summer; towards the latter part of the summer the values drop below average with the exception of fireweed and orchard grass whose values remain high	Aug 6
	Magnesium	- grass species: the values meet the requirements for steer except, for orchard grass; its values meet the requirement for a lactating cow	Sept 1
		- browse and herb species: the values were very high during the summer months; decreasing in late summer and early fall	after Sept
	Copper	- the values are below the basic requirements	-
	Zinc	- generally the values meet the requirements	after Oct 3
	Manganese	- contaminated sample	-
73-11 C,F,.,.,.	Protein	- grass species: the values meet the requirements in the spring	July 9
		- browse and herb species: the values are high throughout the summer and becoming low in the fall	Sept 1
	Calcium	- generally the values are high	after Sept

Table 5.1 (Cont'd)

Plot No. and Treatment[1]	Chemical Component	Comments of Season Variations	Borderline Level Date
	Phosphorus	- grass species: the values are low after July - browse and herb species: generally the values are high	July 26
	Magnesium	- grass species: the values meet the requirements for a dry beef cow or a steer - browse and herb species: the values meet the requirements for a pregnant or lactating cow	Oct 3 after Sept
	Copper	- the values are low to very low	-
	Zinc	- grass species: generally, the values are borderline to low - browse and herb species: generally, the values meet the requirements	after Sept
	Manganese	- contaminated sample	

[1] Treatments are always listed in the following sequence C,F,S,P,G,. A dot indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass mixture seeded, P - planted to lodgepole pine, G - open to grazing.

5.13 Protein Values

In Table 5.3, the range of protein values (from 1976 to and including 1978) based on the chemical analysis of dried samples is presented. Factors affecting preference and palatability of species were not taken into consideration. A singular value represents one sample.

Table 5.2

FORAGE PRODUCTION (LBS/AC.) AND QUALITY FROM 1976-1978

Treatment[1]	Forage Production	1976	1977	1978
.,.,.,.,., (Plot 73-13)	Annual	123	145	459
	Forage Quality			
	Protein	BM	AM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	AM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	AM	AM	AM

Treatment	Forage Production	1976	1977	1978
C,.,.,.,., (Plot 73-08)	Annual	298	316	632
	Forage Quality			
	Protein	AM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

Treatment	Forage Production	1976	1977	1978
C,F,S,P,G (Plot MX-1)	Annual	935	2,174	2,246
	Forage Quality			
	Protein	BM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	BM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	BM	BM
	Manganese	contaminated sample		

Table 5.2 (Cont'd)

Treatment	Forage Production	1976	1977	1978
C,F,S,.,., (Plot 73-02)[2]	Annual	38.6	105.00	212.50
	Forage Quality			
	Protein	BM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	BM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

Treatment	Forage Production	1976	1977	1978
C,F,.,.,G (Plot MX-2)	Annual	553	1,308	1,857
	Forage Quality			
	Protein	AM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

Treatment	Forage Production	1976	1977	1978
C,F,.,.,., (Plot 73-11)	Annual	339	1,024	850
	Forage Quality			
	Protein	BM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

Table 5.2 (Cont'd)

Treatment	Forage Production	1976	1977	1978
C,F,.,.,G (Plot 73-10)[4]	Annual	39.2	55.6	184.8
	Forage Quality			
	Protein	BM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

Treatment	Forage Production	1976	1977	1978
C,F,S,.,., (Plot 73-05)	Annual	73.1	78.2	279.6
	Forage Quality			
	Protein	BM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

Treatment	Forage Production	1976	1977	1978
C,F,S,.,.G (Plot 73-07)	Annual	59.7	118.8	127.0
	Forage Quality			
	Protein	AM	BM	BM
	Calcium	AM	AM	AM
	Phosphorus	AM	BM	AM
	Magnesium	AM	AM	AM
	Copper	BM	BM	BM
	Zinc	AM	AM	AM
	Manganese	contaminated sample		

[1]Treatments are always listed in the following sequence - C,F,S,P,G. A dot indicates the treatment is lacking. The letters refer to: C-cleared, F-fertilized, S-grass mixtured seeded, P-planted to lodgepole pine, G-open to grazing.

[2]In 1978 bluejoint small reed grass was omitted from all calculations. In 1977 the protein value is low becuase there was insufficient sample to perform the test for herbs (No. 11).

[3]In 1978 herbs (No. 18) was omitted from all calculations.

[4]In 1977 the protein value is a low estimate because there was insufficient sample to perform the test for northern bedstraw (Galium boreale).

LIST OF PLANTS AND THEIR RANGE OF PROTEIN VALUES (%)

Common Name	Range of Protein Values
Tree Seedlings	
lodgepole pine (*Pinus contorta var. latifolia*)	5.6 - 6.1
trembling aspen (*Populus tremuloides*)	4.4 - 12.1
Shrubs	
alder (*Alnus spp.*)	10.6
American red raspberry (*Rubus idaeus subsp. melanolasius*)	6.8
birch-leaved spirea (*Spiraea betulifolia subsp. lucida*)	3.8 - 12.0
black blueberry (*Vaccinium membranaceum*)	5.6
saskatoon (*Amelanchier alnifolia*)	5.3 - 5.6
hardhack (*Spiraea douglasii*)	5.3
high bush cranberry (*Viburnum edule*)	5.1 - 10.2
roses (*Rosa spp.*)	3.9 - 17.5
willow (*Salix sp.*)	5.5
Scouler's willow (*Salix scouleriana*)	6.4
Sitka mountain alder (*Alnus viridis subsp. sinuata*)	14.5
soopolallie (*Shepherdia canadensis*)	10.2 - 15.2
twinberry honeysuckle (*Lonicera involucrata*)	3.9 - 15.8
western thimbleberry (*Rubus parviflorus subsp. parviflorus*)	11.4 - 16.5
Herbs	
arnica (*Arnica spp.*)	12.3 - 14.8
Aster (*Aster sp.*)	6.8 - 13.1
blue-bead clintonia (*Clintonia uniflora*)	9.7 - 14.0
blue-leaved wild strawberry (*Fragaria virginiana subsp. glauca*)	5.9 - 11.8
Canadian bunchberry (*Cornus canadensis*)	6.8 - 9.8
sedges (*Carex spp.*)	9.0

Common Name	Range of Protein Values
Herb's (Cont'd)	
Chamisso's arnica (*Arnica chamissonis*)	6.8
colt's-foot (*Petasites sp.*)	19.4 - 20.1
common dandelion (*Taraxacum officinale*)	7.8 - 17.3
cucumberroot twistedstalk (*Streptopus amplexifolius*)	15.5
Douglas' aster (*Aster subspicatus var. subspicatus*)	6.4 - 10.8
Douglas' water-hemlock (*Cicuta douglasii*)	14.0 - 14.4
dwarf blueberry (*Vaccinium caespitosum*)	9.2
dwarf red blackberry (*Rubus pubescens*)	10.3
willowherb (*Epilobium sp.*)	3.3 - 30.6
fireweed (*Epilobium angustifolium*)	2.0 - 19.2
strawberry (*Fragaria sp.*)	8.2 - 8.3
graceful cinquefoil (*Potentilla gracilis*)	9.5
nagoon berry (*Rubus arcticus*)	7.6
northern twinflower (*Linnaea borealis*)	5.0 - 6.1
palmate colt's-foot (*Petasites palmatus*)	6.9 - 11.3
penstemon (*Penstemon sp.*)	8.1
showy aster (*Aster conspicuus*)	4.9 - 12.0
Sitka burnet (*Sanquisorba canadensis subsp. latifolia*)	8.9 - 11.4
spirea (*Spiraea sp.*)	5.0 - 24.6
water avens (*Geum rivale*)	8.8
white hawkweed (*Hieracium albiflorum*)	5.5
yarrow (*Achillea millefolium*)	5.4 - 12.3
Grasses	
blue grass (*Poa sp.*)	9.1
bluejoint small reed grass (*Calamagrostis canadensis*)	4.4 - 10.9
brome grass (*Bromus sp.*)	3.8 - 5.3
small reed grass (*Calamagrostis sp.*)	2.4 - 8.7
common timothy (*Phleum pratense*)	1.3 - 15.8
fescue (*Festuca sp.*)	1.4 - 13.9
orchard grass (*Dactylis glomerata*)	2.8 - 21.9
pine grass (*Calamagrostis rubescens*)	3.6 - 7.6
red fescue (*Festuca rubra*)	3.5 - 4.8
rough-leaved rice grass (*Oryzopsis asperifolia*)	7.4
spike trisetum (*Trisetum spicatum*)	3.8

Common Name	Range of Protein Values
Legumes	
American vetch (Vicia americana)	18.6 - 38.1
cream-coloured peavine (Lathyrus ochroleucus)	7.1 - 17.4
peavine (Lathyrus sp.)	11.8 - 26.7
purple nevada peavine (Lathyrus nevadensis subsp. lanceolatus var. pilosellus)	15.7
white clover (Trifolium repens)	8.4

Management decisions must usually take into account many other facts. Therefore, decisions based solely on all the information presented here are likely to be unsatisfactory.

5.2 Grazing Reports

Prior to the establishment of the Maxan Lake Multi-Land Use Study, little, if any, grazing by domestic livestock had occurred in the study area. As part of the project, cattle first grazed the meadow sites in 1973. Since then, cattle have ranged the Maxan Creek Valley annually. Grazing reports were submitted from 1973 to 1976. As cattle had not used the area previously, turn out dates, periods of use and stocking rates varied greatly in an attempt to determine the best use for the area.

In 1973, 43 head of cattle, making up 31 Animal Units (A.U.) were turned out June 25th for a total of 74 days, being removed on September 9th. It was noted that the cattle avoided poisonous plants, and it appeared they would avoid eating larkspur if given an alternative. No large concentrations of water hemlock (Cicuta maculata L.) were evident. There was no evidence of stream bank damage as the cattle preferred to cross the creek on gravel bars. Occasionally, cattle were observed stripping leaves off of shrubs, but no damage to the shoots was noted. There were no predator problems. As this was the first year cattle used the project site, it was deliberately understocked and cattle were kept on the south portion of the study area. The cattle were weighed on and off the pasture.

A drift fence was built near I.R. 11A, Block A, to prevent the animals from moving north and the right-of-way was cleared along the north end of D.L. 3370 to allow future construction of a northern boundary fence.

The drift fence near I.R. HA split the project into two pastures. The north pasture contains about 280 acres covering I.R. 12A, D.L. 3370 and D.L. 4249, and the south block was the meadow areas running down to Maxan Lake. Later, in 1976, two blocks were fenced out of the south pasture and called Block A and Block B. Block A, 26.4 acres, encompassed I.R. 11A. Block A, while Block B was 28.4 acres, located near I.R. 11A Block B (van Barneveld et al 1980).

In 1974, 102 head (56 A.U.) were turned out from June 15th to September 15th - a period of 92 days. The fence built in 1973 split the study area into north and south pastures, and the cattle were rotated between them at monthly intervals. Weights were recorded when the cattle were turned out, when they were moved to a different pasture and when they were removed from the study area. Table 5.4 shows the periods of use and the rotation dates for the pastures in 1974.

The level of stocking used on the study site was set for the following reasons:

1) no clear-cuts,
2) range use was restricted to valley bottom,
3) little use in previous 15 years, and
4) restricted access

Table 5.4 PERIODS OF USE AND ROTATION DATES FOR THE NORTH AND SOUTH PASTURES - 1974 (from van Barneveld et al 1980)

Turned out on South Pasture	June 15 (weighed June 14)
Moved to North Pasture	July 16 (weighed July 15)
Moved to South Pasture	August 21 (weighed August 20)
Removed*	September 14 (weighed September 14)

*Only 88 of the 102 head could be found and weighed on September 14. The rest were removed later.

During the grazing season, one calf died, possibly from water hemlock poisoning.

During 1974, the cattle had developed more trails and pushed into fringe areas away from the creek. However, cattle tended to concentrate in the open meadow areas of the valley bottom. About the third week in August, the cattle began drifting apart in small groups.

No grazing was carried out on Sub-Project II during 1974.

Periodic browsing by cattle was noted with those individuals observed doing so only at one or two bushes or trees. Cattle took mostly leaves, although some shoots were consumed after which they went back to grazing. Most browsing occurred in August or September when the forage species had ripened.

At the 1974 stocking rate, it was felt that use of the northern area was about right for maintenance of existing species. Use on the south pasture was heavy enough that some changes in species composition would probably occur in subsequent years.

During the summer of 1974, the drift fence along the north end of D.L. 3370 was completed.

In 1975, 95 head comprising 65 A.U. were turned out from June 7th to September 12th, 215 A.U.M.'s use over 98 days. The north pasture was initially used with the cattle being weighed on June 6th and July 5th when they were moved to the south pasture.

They remained in the south pasture until August 5th, were weighed and then moved back to the north pasture. However, the cattle could not be held on the north pasture due to a greater abundance of forage on the south pasture and the cattle finding holes in or walking around the fence. A survey was done to see what forage sites the cattle frequented, and the results are presented in Table 5.5.

Table 5.5 FORAGE SITES USED BY CATTLE

1) High Use - Dry Meadow, Scattered Aspen, Scattered Willow
2) Medium Use - Wet Meadow, Dense Aspen, Aspen Willow
3) Low Use - Twin Berry, Aspen Spruce, Spruce Willow, Spruce, Pine

It was noted that cattle weight gains were down after September 1st and cattle started to wander. This suggests that cattle should be removed before this date or fed supplements. It was also suggested that cattle be first placed on pasture for a shorter initial period in the spring - say two weeks instead of the usual month. This was in reponse to the observation that the grazed pasture did not always recover sufficiently to provide forage taken in the season while the ungrazed pasture would get ahead of the cattle and ripen before it could be properly used.

Forage production in 1975 was good due to the cool, wet weather and cattle distribution was considered good with considerable use being made of open coniferous areas aided by riding and salting.

In 1976, 6 animal units were turned out May 30th and were on pasture until September 15th, 112 days. The area supported 219 A.U.M.'s use. The grazing rotation is listed in Table 5.6.

Table 5.6 GRAZING ROTATION - 1976
(from Van Barneveld et al, 1980)

May 30 - June 15 (Approx.)	- Blocks A and B on south pasture
June 15 - July 28	- North pasture (Block I.R. 12A - 10.7 ac)
July 28 - August 6	- East side Sub-Project 2 - simulated clear-cut
August 7 - August 11	- West Side Sub-Project 2 - simulated clear-cut
August 11 - September 1	- Meadow Block B-1.2 A.U.M./ac
September 1 - September 19 (approx.)	- Meadow Block A-1.18 A.U.M./ac

In 1976, the simulated clear-cut area (Sub-Project II) was used for about two weeks, from July 28 to August 11. Distribution over the clear-cut was good with stocking rates of .5 A.U.M.'s/acre and 0.34 A.U.M.'s/acre. While cattle were on the clear-cut site, some damage to tree seedlings was observed as a result of either trampling or being run over by equipment. It was noted that the trees appeared very susceptible to bark slippage or peeling, possibly due to the abnormally wet conditions. While the wet, cool climate conditions favoured abundant forage growth and forage analysis samples of cured hay and grass silage indicated a nutrient level adequate for satisfactory growth, the cattle did not do well (see next section on ADG). It was mentioned that pasture management may have been largely responsible although intake of the lush forage may have also been a problem.

Up until 1976, the cattle had been moved between two large pastures and considerable difficulty was experienced gathering the cattle late in the season. The two fenced areas, Blocks A and B, plus the fenced clear-cut site allowed the cattle to be controlled for the last seven weeks of the grazing period. The cattle were restricted to the open meadows from mid August on to minimize browsing as well as prevent cattle from scattering, and a difference was noted on the level of browsing inside the small blocks compared with outside the blocks.

One cow was lost, again thought to be due to water hemlock poisoning although the carcass had been cleaned by a bear.

As well in 1976, there were problems with 19 open cows when pregnancy tested after leaving the pasture. Thirty four percent of the 56 cows were open after the grazing season, and while no specific reason could be found, there are several possible factors including separation from the bulls on pasture, late or missed cycling due to poor winter nutrition, a history of poor breeding, possible infections or calving problems. It was later found that some of the open cows were pregnant, but there was still reason for concern.

Two clear-cut blocks, logged by Northwood Pulp Ltd., were seeded and partially fertilized in 1976. The seed mix was 50% Chinook orchardgrass, 25% Alsike clover and 25% Carlton bromegrass applied at 4 lbs/acre to about 313 acres. 34-0-0 fertilizer at 100 lbs/acre was applied to about half of the seeding.

No grazing report was made for 1977 although periods of use and weights were recorded. Sixty four A.U.'s were put on range that year. Period of use is shown in Table 5.7.

Table 5.7 Grazing Rotation - 1977
(from van Barneveld et al 1980)

June 5 - June 13	- Block B on south pasture
June 13 - June 20	- Block A on south pasture
June 20 - June 25	- I.R. 12A and the north pasture
June 25 - July 22	- Outside the fenced meadows on the south pasture
July 22 - August 6	- Blocks A and B on south pasture
August 6 - August 24	- North pasture
August 24 - September 15	- Blocks A and B on south pasture

After 1978, the area was grazed by 200 animal units from about June 20 to September 15 using most of the valley as one unit under a Forest Service grazing permit.

Some general observations were made in the reports that are worth noting. Behaviour of cattle was affected by insects, and it was felt that this would in turn affect weight gains because the animals couldn't rest due to constant harassment by the pests. Also, the animals tended to stay in the natural openings to catch what wind would be available. When the clear-cuts were put in and seeded, the cattle moved into them and concentrated on the orchardgrass contained in the mix.

It was also noted that salt did not hold cattle in one area to any great extent. The cattle would stay near the salt for a day and then leave for perhaps a week returning once they became salt hungry. They would move two or three miles in a day.

Cattle also avoided Foxy Creek, on the south end of the study area, until later in the season. This area didn't get as much sunlight as other parts of the study area, and although it is not known why they avoided this area, lack of sunlight could have been a factor.

5.3 Cattle Weights

Weights were recorded on and off the pasture in 1973 and approximately monthly from 1974 to 1977. Figure 5.1 gives an estimate of the beef produced in pounds on the Maxan Lake Study area. Over the five years that weights were recorded, roughly 81,000 lbs. of beef was produced on the study area.

Table 5.12 gives a breakdown of periods of use, animal units, an estimate of beef produced and animal losses by year.

Table 5.4 SUMMARY OF GRAZING EVENTS

	1973	1974	1975	1976	1977
Turnout Date	June 25	June 15	June 7	May 30	June 13
Takeoff Date	Sept. 7	Sept. 15	Sept. 12	Sept. 16	Sept. 15
Animal Units	31	56.5	65	66	64
Grazing Period	74 days	92 days	96 days	108 days	95 days
Animal Unit Months	75	112	208	238	204
Beef Produced	8,762#	18,050#	19,900#	17,800#	16,800#
Animal Losses*		1 calf		1 cow	

*Poisoning suspected in both cases

Since on and off dates, time between weigh days, number of weighings and total time on pasture varied from year to year only a portion of the weight data was used in the following analysis. Information from 1973 was not used because only on and off weights were recorded. Also, some weigh day results were not used from 1974, 1975, and 1976 because they were not consistent for all classes of animals, were collected after the cattle left the pasture or were not collected on a monthly basis. The conclusions that follow are based on the results of four weights recorded in each of the four years allowing for a more uniform comparison.

The weigh dates and periods for each year are shown in Table 5.8. All values reported are least square means.

Tables 5.9, 5.10, and 5.11 show the corrected average daily gains (A.D.G.) of cows, calves and yearlings.

In the following analysis of cattle weights obtained from the Maxan Lake study area, it is assumed that all animals received similar treatments while on pasture and cattle from each farm received similar treatments while at home.

The data were analysed using the Statistical Analysis System (SAS) General Linear Models Procedure (GLM) to obtain an analysis of variance, orthogonal contrasts and least square means. The GLM procedure takes into account the unbalanced experimental design resulting from the varied number of cows, calves and yearlings on pasture in each of the four years. The data was blocked in the analysis by farms (2), year (4) and class of animal (3).

The analysis shows the difference in initial weights between farms were significant ($p < .01$) while those recorded in later periods were not significantly different ($p < .01$). It was felt that the level of management between farms differed and the turnout weights on range reflect this. As the season progressed, compensatory gain is evidenced and the weights of cattle from each farm became more alike. Further support is given to compensatory gain since the A.D.G. recorded in the first period is significantly different (p .01) between farms with the farm having the lightest cattle showing the highest gain. A.D.G. in later period is not significantly different (p .05) between farms.

All weights and A.D.G's were significantly different (p .01) between years. A number of factors could cause this result including the level of management used and the weather of a particular year. An orthogonal contrast between the years 1974 (a year when the cattle used two large pastures) and 1976 (when the cattle were confined to small pastures) shows overall A.D.G.'s in the intensively managed year to be greater than overall A.D.G.'s (p .01) in the year cattle management was more extensive.

While this is the case for overall A.D.G., there are fluctuations in the period A.D.G. A.D.G. is greater (p .01) in 1974 in the first and second periods while it is greater (p. 01) in 1976 in the last period. In 1976, cattle were closely controlled for the last nine weeks. During this wet year, growth continued longer than usual and cattle had better forage to use that had not been previously used. In the first half of the 1976 season, cattle were confined in two large areas, but could not wander in search of better forage as they could in 1974. Cattle numbers were also greater in 1976, and this, coupled with greater control, resulted in a higher stocking rate per unit area. Thus, cattle had more competition for food in 1976, but by conserving feed in the wet year, they had better quality feed to go onto and did better than in 1974 when the preferred feed had all been consumed or was dried out. It would appear that more intensive management and conservation of selected later maturing species can result in greater overall A.D.G.'s.

Another contrast was done to compare wetter years (1975 and 1976) with drier years (1973 and 1977). Again A.D.G. was significantly greater (p .01) for the wet versus dry years.

As would be expected, the weights and A.D.G. between classes of animals (cows, calves and yearlings) were all significantly different (p .01). Further comparisons of class performance were made by running an orthogonal contrast between cows and calves and calves and yearlings. The contrasts show that cow and calf A.D.G.'s were not significantly different (p .05) in the first period, but the calves performed better (p .01) later on in the summer. This reflects the initial gains by cows when first placed on pasture. A.D.G. then falls off while the calf continues to gain at much the same rate. The comparison of calves and yearlings shows no significant difference (p .05) in A.D.G. in the first and second periods or over the whole season, but there is a significant difference (p .05) in A.D.G. in period 3 when yearling weight gains fall off. While calf gains do drop slightly, they continue to perform much better than cows and yearlings late into the year.

The analysis of variance bears out the expected drop in cow A.D.G. later in the season, shows that the yearling A.D.G. can drop significantly and confirms that calves tend to do well throughout the entire period on range.

Figure 5.2 shows the corrected cumulative average weight gain of cows, calves and yearlings over the grazing season for the years 1974 and 1976.

As can be seen from the tables, cows generally do best in the first month on pasture and then ADG drops off with cows actually losing weight later in the season in some years. Unlike cows, the calves gain much more consistently over the period on pasture and never actually lost weight while on pasture.

Like cows, the calves generally had the highest ADG in June and lowest in September. Yearling ADG was somewhat more variable than cow ADG, and in some years, yearlings actually lost weight later in the season.

5.4 Cattle Grazing Survey

Data collected during 1974 and 1975 by summer students who noted weather conditions, time, cattle location, length of observation period, types of plants being used and some records of individual habits.

Time and length of observation period varied greatly as did the individual animals being studied, so little more than trends can be determined from the survey records. Generally, animals were observed between 9:00 and 11:00 a.m. with observations occurring as early as 5:00 a.m. and as late as 6:30 p.m. Because of the size and forested nature of the pastures, the cattle could spread out and an individual would not necessarily be observed on a daily basis.

As may be expected, the cattle tended to bed down in the middle of the day when it was warm and sunny and also tended to move about less when it was overcast and rainy. Grazing was noted during the middle of the day under scattered cloud, overcast or cool conditions.

Cattle were noted using dandelion (Taraxacum officinale), fireweed (Epilobium angustifolium), meadowrue (Thalictrum spp. L.) and peavine (Lathyrus spp.) throughout the grazing season as well as grasses, sedges and other forbes. Some individual browsing was noted.

TABLE 5.8

Dates of Weigh Days and Days on Pasture
Used in Corrected Data

YEAR	WEIGH PERIOD (Date and Day)							
	Date	Day	Date	Day	Date	Day	Date	Day
1974	June 15	1	July 15	30	Aug. 20	67	Sept. 14	102
1975	June 7	1	July 5	28	Aug. 5	59	Sept. 2	87
1976	May 29	1	July 28	59	Aug. 11	73	Sept. 16	109
1977	June 13	1	July 22	40	Aug. 24	73	Sept. 16	96

TABLE 5.9

Average Daily Gain (A.D.G.) of Cows by Weigh Period
(corrected by least square means)

YEAR	WEIGH PERIOD			
	1	2	3	Season Long
1974	4.08	1.46	-0.20	1.63
1975	2.65	2.45	1.56	2.21
1976	3.56	-0.82	-0.20	1.74
1977	1.24	2.76	-0.49	1.35

TABLE 5.10

Average Daily Gains (A.D.G.) of Calves by Weigh Period
(corrected by least square means)

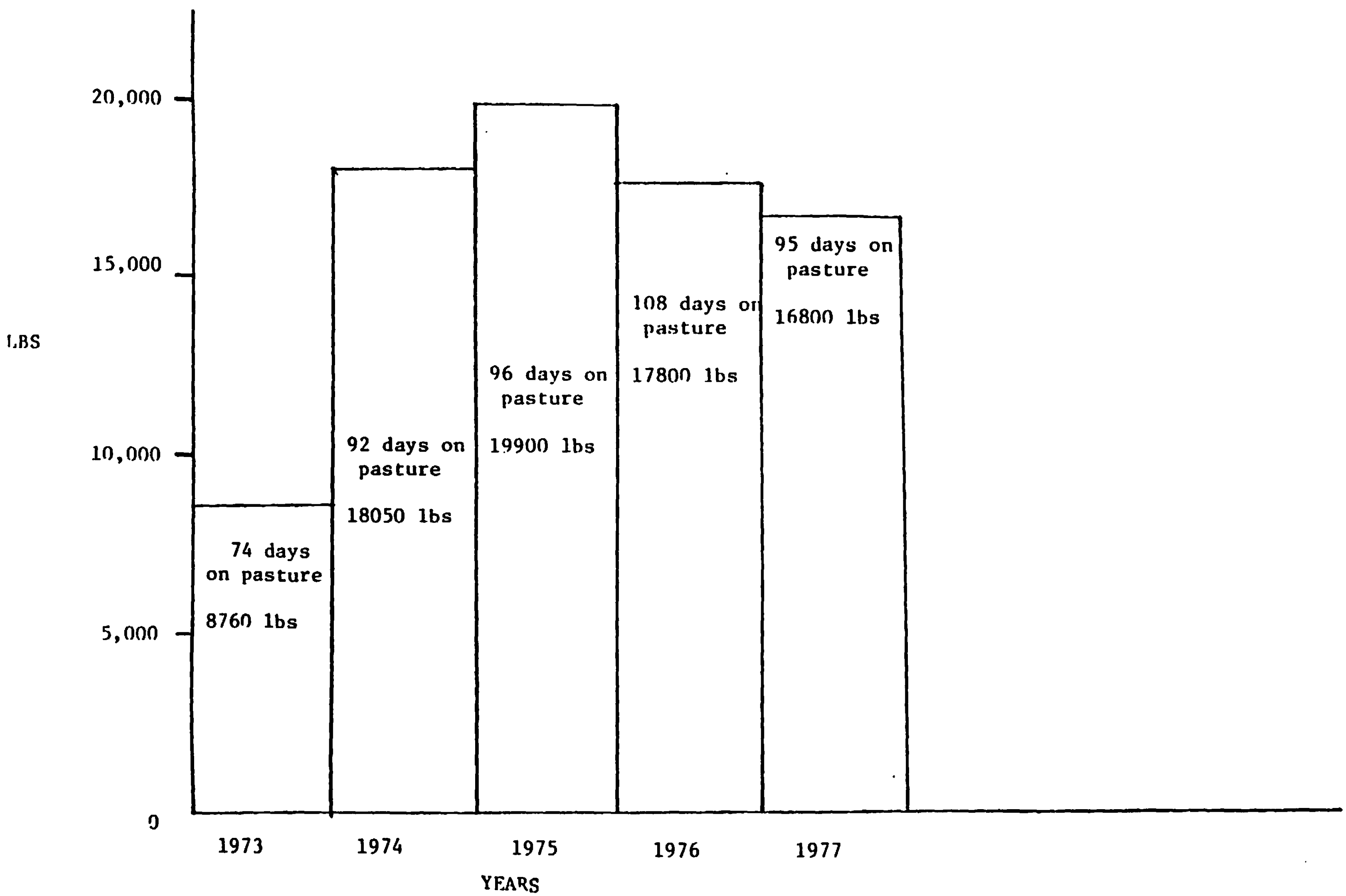
YEAR	WEIGH PERIOD 1	2	3	Season Long
1974	3.28	2.32	0.77	2.06
1975	2.61	2.53	2.60	2.57
1976	2.16	1.68	1.38	1.84
1977	2.12	2.35	1.92	2.16

TABLE 5.11

Average Daily Gains (A.D.G.) of Yearlings by Weigh Period
(corrected by least square means)

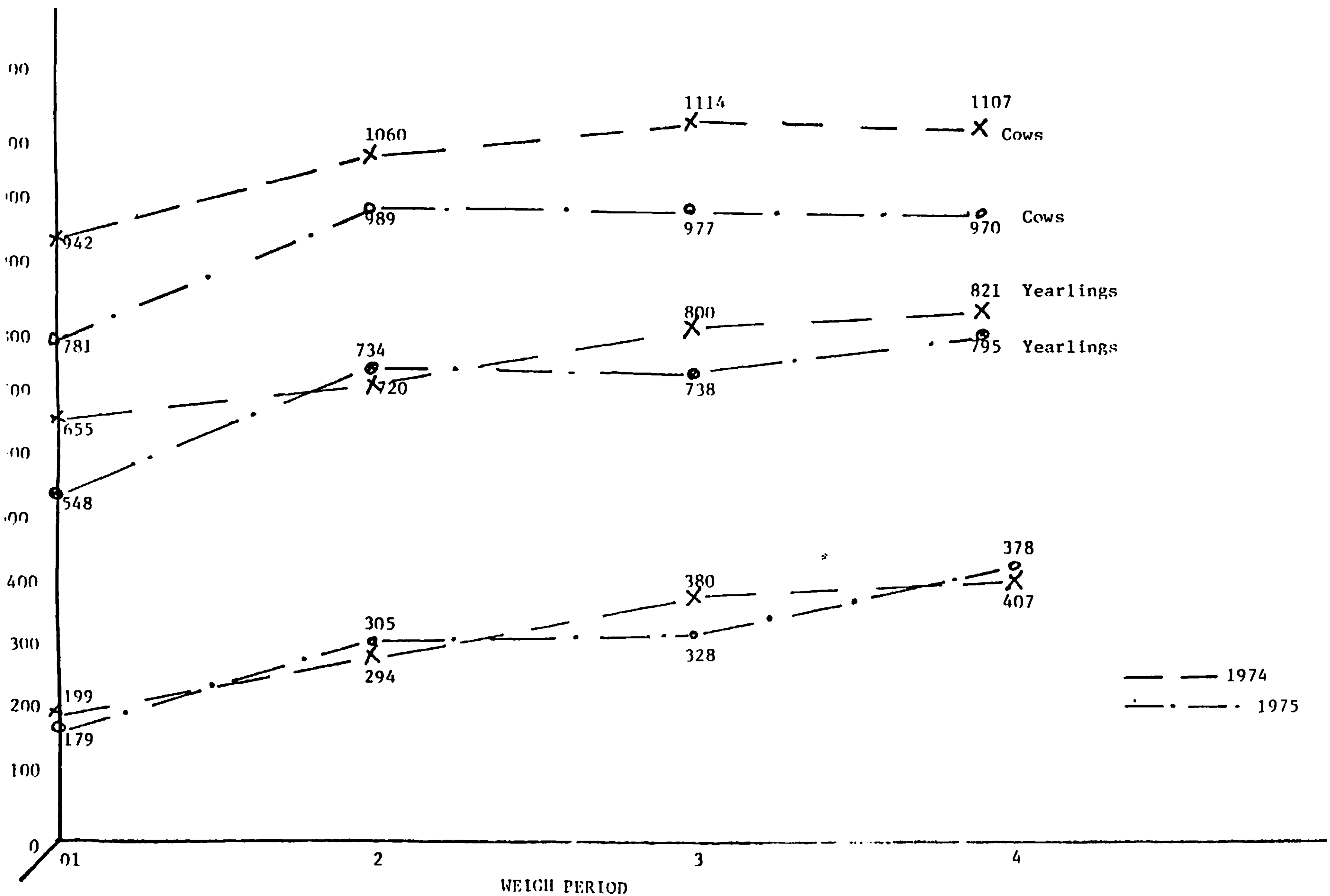
YEAR	WEIGH PERIOD 1	2	3	Season Long
1974	2.22	2.16	0.60	1.63
1975	2.41	2.60	2.59	2.41
1976	3.24	0.23	1.58	2.28
1977	2.14	2.92	0.27	1.93

Figure 5.1 POUNDS OF BEEF PRODUCED ON THE MAXAN LAKE STUDY AREA BY YEAR*



*Approximate Figures Calculated From A.D.G. Figures

Figure 5.2 CUMULATIVE WEIGHT GAINS OVER GRAZING SEASON (lbs)
(corrected weights using Least Square Means)



6.0 Beaver Study

After observing beaver activity along Maxan Creek for a season, it was suspected that over the long term beaver could have a major impact on vegetation and land forms on the valley floor. Observations of beaver activity were taken in August and November 1974. These observations show about 9 separate beaver lodge complexes in the study area with about half living near the main stream and the remainder in ponds resulting from damming small tributaries or side channels. Generally, the lodges were substantial structures about 15 - 20 ft high (with 5 to 10 ft out of the water) and 20 - 40 ft across. The age of the various lodges varied from fairly new to old and possibly abandoned. The dams were up to several hundred feed in length, but were only about 3' high. Usually 3 - 4 acres were flooded although one area of 20 acres was noted and the ponds were about 3 - 5' deep. The beaver living along the main stem of Maxan Creek would dam up a side channel and several small ponds would result. Adjacent vegetation generally included willow, aspen, sedges with spruce and pine growing on upland areas away from the inundated lowlands. A considerable amount of beaver activity was noted with well developed trails and channels and aspen being cut for food. A review of the air photos of the study area shows open areas free of trees that correspond with the areas flooded by beaver dams.

It was felt, and this inventory further suggests, that the beaver affected the vegetation by drowning out dominant tree species which, in combination with food harvesting, opened up the canopy for production of low grazing species. As well, the inundated areas would support willow and other riparian species along the banks of the ponds. This vegetation could then be used by moose for winter feed. As well, flooded areas would increase water tables in adjacent areas allowing different plant species to grow. Once the beaver had consumed all the feed adjacent to their lodges and abandoned them, these areas would drain and open areas would result. Succession would result with a grass-forb and then shrub seral stage occurring which would further change the on-site vegetation. It was felt that the dams and subsequent changes in vegetation benefited livestock, but many areas were inaccessible.

The concept of beaver affecting the valley floor is an area that may require further research since the inventory is not an indepth study.

7. Interactions, Results and Conclusions

While the nature of the study, the design and the long time period needed to gather data about ecological factors made it difficult to draw conclusions, some initial results may be discussed.

It appears that competition between trees and grass are minimal after the first few years of growth and that planting of grass may benefit tree production through increased organic matter in the soil. Also, sites that were planted to trees show much better growth and stocking than unplanted areas. This would suggest planting may reduce the cycle period.

Although cattle did not spend a lot of time on the clear-cut site, minimal damage occurred to the seedlings. In order to assess cattle-tree interaction more fully, cattle would have to have spent more time on the clear-cut.

At the stocking rates used in the study, there appears to be little conflict between cattle and moose with regard to winter browse. Cattle tended to strip leaves from portions of the shrub that would be buried and unavailable to moose in the winter when they did browse and browsing by cattle usually occurred later in the season when the palatability of forages was lower than shrubs. This suggests that cattle and moose can coexist at moderate stocking rates if the cattle receive adequate management in the latter part of the grazing season. There is some question that at much heavier stocking rates cattle could affect moose winter browse.

Finally, the Maxan valley produced a respectable amount of saleable beef over the study period with weight gains being excellent early in the season. Calves on the cow did quite well throughout the season while yearlings did not gain well or lost weight later in the season. This suggests that the valley would make good quality summer range for cows and calves and that season long weight gains may be increased if overall herd management is carefully addressed.

Recommendations for Future Projects

When the concept for the Maxan Lake Multi-Land Use Study was first considered in 1970 and later when the project was operational, there was no previous experience to draw on for guidance in project management. This was a pioneering study. As such, one of the most important points to discuss deals, not with the actual data collected, but with recommendations on the approach to project design and management.

Prior to the start of a new project, the concerns which are being addressed must be carefully thought out and the questions to be answered clearly defined. The best way to accomplish this would be to develop a working plan which thoroughly discusses the goals of the study, questions to be answered, hypothesis to be tested, methodology of carrying out the research and the method of statistical analysis and interpretation of results.

To expand on these points, it is important that the goals set to answer the questions of interest be thought out and recorded to ensure that the data collected will actually lead to an answer to the question asked.

A sound experimental design, laid out in advance, will ensure project goals will be met. A sound design has the added value that data collection and interpretation of results becomes straight forward and a methodology for data collection is in place before work begins. A design does not need to be complicated and in the types of projects similar to the Maxan study, should not be complicated. Further, the study should be laid out so that projects are replicated. Replication allows for three very important considerations when interpreting data. First of all it is possible to estimate the variability of the data collected. Is the data collected consistent? Will it provide detailed enough information to answer the question? Is there unexplained variability in the data that was not taken into account when the project methodology was laid out? Secondly, replication will allow for statistical analysis of the data. This analysis allows one to ascertain the reliability and applicability of the data interpreted.

Final conclusions within the degrees of uncertainty defined by the analysis, may be made and the questions asked will be answered. Finally, replication and subsequent analysis serves as a check on the thoroughness of the project working plan and on the clarity questions asked.

When dealing with a study the size of Maxan, it is most efficient to break the project into smaller subsections that answer separate questions. These sub-projects must relate to each other in a meaningful way, must be set up so data for each can be gathered independently and must be laid out in the working plan beforehand so that all data collected is used. If it appears that a sub-project will not provide useful data for answering the overall questions posed in the study, it should be carefully rethought or dropped entirely from the working plan before the project has started.

Further to the idea of a comprehensive approach once the questions have been asked, the design and working plan laid down and data collection underway, no new sub-projects should be added to the study. This may lead to overcommitment of staff time reducing their ability to gather data for the most important question - the one originally asked. As well, a new sub-project may inadvertently nullify other work being done by laying the sub-project out over work already being done. By sticking to approved working plan, the questions that have been asked and are important enough to devote staff and money to will be answer conclusively.

Direction for a project with the size and scope of the Maxan Study must come from several areas of expertise. The steering committee should be just large enough to provide the required expertise and must have a hand in developing the working plan and be available for on-site supervision. This committee must also have the foresight and ability to resist the urge to add and drop incidental or peripheral sub-projects. Adding or dropping projects detracts from the important work being done, and if the project is dropped, it indicates clearly that the initial questions and methodology were not clearly thought out and resources were inefficiently used.

The overall project must have a full-time supervisor who is under the direction of the steering committee. It is extremely important that this on-site supervisor have a level of knowledge requisite with the scope of the study and have the knowledge, ability and authority to ask questions about goals, to see data collection and analysis through and to ensure that the working plan is followed. The supervisor must play an integral part in the data collection, analysis and final report.

By following these recommendations, projects that are undertaken will answer the questions asked in a conclusive manner making the best use of staff time and resources.

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APPENDIX I
SOIL SURVEY DATA ON SOILS IN THE MAXAN LAKE STUDY AREA

A great deal of soils data was collected during the study period, some of which is reproduced in this appendix. Survey information covered the Babine, Barrett, Stellako, D-Type (see text), Crystal and Slug soil series. Further data is available from the Resource Analysis Branch, Ministry of Environment, Victoria, B.C.

The following is from the Vegetation & Soil Report (edited by J. Van Barneveld and compiled and written by Carol Thompson).

Introduction to Appendix I

"Profile description - the soil profiles were described according to the field reconnaissance practices in use with the Soil Unit of the Terrestrial Studies Branch 1973-1978.

The descriptions serve
- to relate the soils of the area to the soil associations previously described by Cotic (1973)
- to characterize the soils of the study area
- to obtain an understanding of the ecological processes that are in effect (nutrient and moisture budgets)

Chemistry and Physics - the following specific tests were applied only to distinct horizons or depths. These are shown in Table 3.1. Appendix D lists the analytical methods used.

Mechanical analysis - is the determination of the various amounts of the different separates in a soil sample (Glossary of Terms in Soil Science 1976). This determination aids in the identification of the Bf and Bt horizons.

Moisture tension - was calculated for 15 bar and 1/3 bar. Fifteen bar moisture tension corresponds to the permanent wilting point of a plant. This is the point at which the plant can no longer remove appreciable quantities of water or the water remaining in the soil at this point is unavailable to plants in quantities or at a rate to maintain turgidity of the plant (Salisbury and Ross, 1969). The amount of water left in the soil at this point will vary considerably with the texture of the soil.

One third bar moisture tension corresponds to moisture equivalent. This is approximately the same constant as field capacity which is reached when the soil is containing its full complement of capillary water.

Bulk density - is the mass of dry soil per unit volume (Glossary of Terms in Soil Science, 1976). This constant is a measure of the compactness of the soil which is used in engineering. Also it supplies a measure of the amount of pore space available for root growth and moisture content.

Atterberg limits - describes soil consistency. These limits are expressed in terms of a liquid limit and a plastic limit which express the water content of a soil at these points (Hough, 1957). These measurements relate to the danger of destruction of soils and creek banks by trampling

Nutrition:

Total carbon - the percentage of organic carbon is used to define mineral horizons and layers (e.g. Bf, Bhf, Ah, Bh) (Canada Soil Survey Committee, 1978).

Total nitrogen - originally, this test was conducted to monitor and determine the effects of nitrogen fertilizer through the soil profile over a period of time.

Exchangeable cations - provides an indication of the fertility of the soil.

Cation exchange capacity - provides an indication of the ability of the soil to retain plant nutrients, which is important in soil management and determination of ecosystem sensitivity.

Fe and Al Pyrophosphate - is used to define mineral horizons and layers - Bf, Bgf, Bh and Bfj (CSSC, 1978)

Phosphorus:

Total and available - value of the measure of fertility of the soil.

Sulphur:

total and available - value of the measure of fertility of the soil.

SOIL: PROJECT: Barrett	NTS: 93L 8	RESOURCE ANALYSIS BRANCH MINISTRY OF ENVIRONMENT VICTORIA, B.C.	SUMMARY DATE: September 16/81 Page: 01

Date of Survey: 78 Surveyor: Kelowna, B.C.M.A. & R.A.B.
Sampling Purpose: Research

Project Code: V-1

Location

Latitude (N): 54 20 30
Longitude (W): 126 08 00

Classification

Orthic Dystric Brunisol (1978) Barrett

Parent Material & Landform

Profile Description

Horizon-Depth (In.)	Thickness	Colour 1	Texture
A EJ	0 - 1	10.OYR3.0/4.0 Matrix Moist 10.OYR6.0/3.0 Matrix Dry	Silt Loam
B M	1 - 8	10.OYR3.0/5.0 Matrix Moist 10.OYR6.0/3.0 Matrix Dry	Sandy Loam
BC	8 - 15	10.OYR3.5/3.0 Matrix Moist 10.OYR6.0/2.0 Matrix Dry	Loam
C	15 -	10.OYR3.5/3.0 Matrix Moist 10.OYR5.5/2.0 Matrix Dry	Loam

Physical & Chemical Data

Horizon	Depth (In.)	Sample # Lab Sample #	PH 1 Sample State	PH 1 Method	PH 1 Value	PH 2 Sample State	PH 2 Method	PH 2 Value	Organic Carbon %	Nitrogen %
A EJ	0 - 1	782038	2	1	5.2	2	4	4.5	1.56	.11
B M	1 - 8	782039	2	1	5.7	2	4	4.9	.62	.11
BC	8 - 15	782040	2	1	6.1	2	4	5.3	.26	.06
C	15 -	782041	2	1	6.2	2	4	5.4	.38	.05

Horizon	Depth (In.)	Exchangeable Cations Buff. (ME/100G)				C.E.C.	Extractable FE (%)		Extractable AL (%)		
		CA	MG	NA	K	DETERMINED	METHOD	RESULT	METHOD	RESULT	P1 PPM.
A EJ	0 - 1	3.42	.88	.05	.38	15.0					113.5
B M	1 - 8	3.28	.96	.11	.45	10.5	3	.2	3	.1	112.8
BC	8 - 15	4.98	1.48	.05	.35	9.6					6.6
C	15 -	6.94	2.02	.05	.35	12.4					4.3

Horizon	Depth (In.)		Moisture Status			Atterburg Limits		Part. Size Analy. (% Passing)				
		S PPM.	1/10 Bar.	1/3 Bar.	15 Bar.	Plastic Limit	Liquid Limit	63.5 MM	32 MM	16 MM	8 MM	#4
A EJ	0 - 1	.3	28.2	22.1	8.7							
B M	1 - 8	.2	27.3	19.6	6.5							
BC	8 - 15	.5	19.8	15.6	5.6							
C	15 -	.3	19.5	16.6	7.4	17.0	19.5	10.00	98.90	85.20	72.80	65.30

Horizon-Depth (In.)		Part. Size Analy. (% Passing) #7	#10	#18	#35	#60	#120	#200	#230	Particle Size (%) Total Sand	50-2 U Silt	2U Clay Total
A EJ	0 - 1									39	49	12
B M	1 - 8									52	37	11
BC	8 - 15									50	40	10
C	15 -	58.20	52.60	47.10	42.10	37.00	31.80	28.30	27.50	48	38	14

Extractable FE, AL, MN (%)
Methods, Code:

1...Oxalate Extractable
2...Dithionite Extractable
3...Pyrophosphate Extractable

PH Methods, Codes:

1...H20 1:1
2...H20 1:5
3...H20 Saturation
4...CACL2
5...KCL

Horizon-Depth (In.)		Part. Size Analy. (% Passing)					Particle Size (%)		
		#35	#60	#120	#200	#230	Total Sand	50-2 U Silt	2U Clay Total
B M	-						15	67	18
BC	-						82	13	5
C	-	30.30	9.70	3.20	1.00	.80	84	15	1

Extractable FE, AL, MN (%)
Methods, Code:

1...Oxalate Extractable
2...Dithionite Extractable
3...Pyrophosphate Extractable

PH Methods, Codes:

1...H20 1:1
2...H20 1:5
3...H20 Saturation
4...CACL2
5...KCL
6...NAF

A H	2 - 0	782022	2	1	5.9	2	4	5.5	21.50	.89
C	0 - 14	782023	2	1	6.4	2	4	5.7	.57	.03
II C	14 -	782024	2	1	6.7	2	4	6.0	.24	.04

Horizon-Depth (In.)		Exchangeable Cations Buff. (ME/100G)				C.E.C.			Moisture Status		
		CA	MG	NA	K	DETERMINED	P1 PPM	5 PPM	1/10 BAR.	1/3 BAR.	15 BAR.
A H	2 - 0	51.25	17.49	.35	1.04	114.3	39.7	4.9			85.7
C	0 - 14	17.74	8.61	.23	.51	29.2	20.7	.6	39.8	34.0	16.8
11 C	14 -	9.80	4.58	.16	.25	15.0	6.0	.9	24.0	17.5	9.1

Horizon-Depth (In.)		Part. Size Analy. (% Passing)											
		63.5 MM	32 MM	16 MM	8 MM	#4	#7	#10	#18	#35	#60	#120	#200
A H	2 - 0												
C	0 - 14												
11 C	14 -	10.00	98.70	92.00	85.80	82.30	79.90	77.80	73.20	68.50	61.90	53.30	46.50

Horizon-Depth (In.)		Part. Size Analysis (% Passing)	Particle Size (%)		
		#230	Total Sand	50-2 U Silt	2U Clay Total
A H	2 - 0				
C	0 - 14		1	70	29
11 C	14 -	45.10	57	28	15

Ph Methods, Codes

1...H20 1:1
2...H20 1:5
3...H20 Saturation
4...CACL2
5...KCL
6...NAF

SOIL:
PROJECT: Stellako NTS: 93L 8

RESOURCE ANALYSIS BRANCH
MINISTRY OF ENVIRONMENT
VICTORIA, B.C.

SUMMARY DATE:
September 16/81
Page 01

Date of Survey: 08 73 Surveyor: Kelowna, B.C.M.A. & R.A.B.
Sampling Purpose: Research

Project Code: IV-5

Location		Classification
Latitude (N):	54 20 59	
Longitude (W):	126 09 30	Orthic Regosol (1978) Stellako

Parent Material & Landform

Profile Description

Horizontal	Thickness Depth (In.)	Colour I	Texture
A H	2 - 0		
C	0 - 14	10.OYR3.0/3.0 Matrix Moist 10.OYR4.0/4.0 Matrix Dry	Silty Clay Loam
11 C	14 -	10.OYR3.0/3.0 Matrix Moist 10.OYR5.5/2.0 Matrix Dry	Sandy Loam

Physical & Chemical Data

Horizon-Depth (In.)	Sample # Lab Sample #	PH 1 Sample State	Method	PH 2 Value	Organic Carbon %	Nitrogen %

Physical & Chemical Data

		Sample #	PH 1			PH 2				
Horizon-Depth (In.)		Lab Sample #	Sample State	Method	Value	Sample State	Method	Value	Organic Carbon %	Nitrogen %
I C	-	76 953	2	1	6.6	2	4	5.8	.62	.08
II C	-	76 954	2	1	6.9	2	4	6.0	.28	.03

		Exchangeable Cations Buff.(ME/100G)				C.E.C.			Moisture Status	
Horizon-Depth (In.)		CA	MG	NA	K	DETERMINED	P1 PPM.	S PPM.	1/3 BAR.	15 BAR.
I C	-	14,85	8.16	.19	.37	24.4	22.2	1.8	31.8	13.1
II C	-	9.10	4.30	.14	.17	13.8		.8		

		Part. Size Analy. (% Passing)						Particle Size (%)		
Horizon-Depth (In.)		#10	#25	#45	#60	#120	#200	Total Sand	50-2 U Silt	2U Clay Total
I C	-							4	67	29
II C	-	98.40	87.40	75.50	65.00	47.80				

PH Methods, Codes:

1...H20 1:1
2...H20 1:5
3...H20 Saturation
4...CACL2
5...KCL
6...NAF

SOIL:
PROJECT: "D" NTS: 93L 8

RESOURCE ANALYSIS BRANCH
MINISTRY OF ENVIRONMENT
VICTORIA, B.C.

SUMMARY DATE:
September 16/81
Page: 01

Date of Survey: 08 78 Surveyor: Kelowna, B.C.M.A. & R.A.B.
Sampling Purpose: Research

Project Code: 11-4

Location

Latitude (N): 54 20 57
Longitude (W): 126 09

Classification

Gleyed Sombric Brunisol (1978) D-type series

Parent Material & Landform

Profile Description

Horizon-Depth (In.)	Thickness	Colour I	Texture
LFH	1 - 0		
A P	0 - 4	10.OYR3.0/2.0 Matrix Moist 10.OYR4.0/2.0 Matrix Dry	Silt Loam
B MG	4 - 10	10.OYR3.5/5.0 Matrix Moist 10.OYR5.5/3.0 Matrix Dry	Silt Loam
BC G	10 - 21	10.OYR3.0/6.0 Matrix Moist 10.OYR5.0/4.0 Matrix Dry	Silt Loam
C G	21 -	10.OYR3.0/3.0 Matrix Moist 2.5YR4.0/4.0 Matrix Dry	Sandy Loam

Physical & Chemical Data

		Sample # PH 1				PH 2				
Horizon-Depth	(In.)	Lab Sample #	Sample State	Method	Value	Sample State	Method	Value	Organic Carbon %	Nitrogen %
LFH	1 - 0	782042	2	1	5.4	2	4	5.1	4.64	.53
A P	0 - 4	782043	2	1	6.0	2	4	5.5	1.67	.18
B MG	4 - 10	782044	2	1	6.5	2	4	5.9	1.13	.12
BC G	10 - 21	782045	2	1	6.6	2	4	6.0	.28	.04

		Exchangeable Cations Buff. (ME/100G)					C.E.C.	Extractable FE (%)		Extractable AL(%)
Horizon-Depth	(In.)	CA	MG	NA	K	DETERMINED	METHOD	RESULT	METHOD	RESULT	P1 PPM.
LFH	1 - 0	17.76	6.52	.20	.71	35.2					2.9
A P	0 - 4	16.21	6.90	.24	.35	29.8	3	.3	3	.1	5.0
B MG	4 - 10	17.00	7.73	,27	.29	29.8					3.8
BC G	10 - 21	7.87	3.97	.11	.26	14.6					6.0

			Moisture Status			Part. Size Analy. (%Passing)							
Horizon-Depth	(In.)	S PPM.	1/10 Bar.	1/3 Bar.	15 Bar.	63.5 MM	32 MM	16 MM	8 MM	#4	#7	#10	#18
LFH	1 - 0	7.0	62.6	44.2	31.3								
A P	0 - 4	1.3	59.0	38.8	16.1								
B MG	4 - 10	.4	51.5	36.7	15.1								
BC G	10 - 21	.7	14.6	9.8	6.4	10.00	91.70	76.80	58.30	47.70	39.80	35.00	34.70
C G	21 -												

Horizon-Depth (In.)		Part. Size Analy. (% Passing) #35	#60	#120	#200	#230	Particle Size (%) Total Sand	50-2 U Silt	2U Clay Total
LFH	1 - 0						6	66	28
A P	0 - 4						2	78	20
B MG	4 - 10						3	76	21
BC G	10 - 21	27.20	18.10	13.70	12.00	11.70	63	31	6

Extractable FE, AL, Mn (%) PH Methods, Codes:

SOIL: PROJECT: Crystal	NTS: 93L 8	RESOURCE ANALYSIS BRANCH MINISTRY OF ENVIRONMENT VICTORIA, B.C.	SUMMARY DATE: September 16/81 Page 01

Date of Survey: 08 78 Surveyor: Kelowna, B.C.M.A. & R.A.B.
Sample Purpose: Research
Project Code: 1 - 10

Location		Classification
Latitude (N):	54 19 30	
Longitude (W):	126 09 00	Orthic Gray Luvisol (1978)

Parent Material & Landform

Profile Description

Horizon-Depth (In.)	Thickness	Colour I	Texture
A E1	0 - 6	10.OYR4.0/3.0 Matrix Moist 10.OYR6.0/2.5 Matrix Dry	Silt Loam
A E2	6 - 15	10.OYR4.0/4.0 Matrix Moist 10.OYR6.0/2.5 Matrix Dry	Silt Loam
B T1	15 - 21	10.OYR3.0/3.5 Matrix Moist 10.OYR6.0/3.0 Matrix Dry	Silt Loam
B T2	21 - 25	10.OYR3.0/3.0 Matrix Moist 10.OYR6.0/3.0 Matrix Dry	Silt Loam

BC	25 -	10.OYR3.0/3.0 Matrix Moist 10.OYR6.5/3.0 Matrix Dry	Silt Loam

Physical & Chemical Data

Horizon-Depth (In.)		Sample # Lab Sample #	PH 1 Sample State	Method	Value	PH 2 Sample State	Method	Value	Organic Carbon %	Nitrogen %
A E1	0 - 6	782017	2	1	6.3	2	4	5.7	1.76	.09
A E2	6 - 15	782018	2	1	6.7	2	4	6.0	.29	.03
B T1	15 - 21	782019	2	1	6.8	2	4	6.1	.31	.04
B T2	21 - 25	782020	2	1	6.9	2	4	6.2	.36	.04
BC	25 -	782021	2	1	6.9	2	4	6.2	.33	.06

Horizon-Depth (In.)		Exchangeable Cations Buff. (ME/100G) CA	MG	NA	K	C.E.C. DETERMINED	P1 PPM.	S PPM.	Moisture Status 1/10 BAR.	1/3 BAR.	15 BAR.
A E1	0 - 6	14.79	6.21	.09	.57	25.4	30.6	1.7	32.6	25.6	12.4
A E2	6 - 15	11.03	4.41	.12	.37	17.7	9.0	1.6	27.8	22.3	10.0
B T1	15 - 21	12.03	5.10	.15	.37	19.4	4.9	.6	34.4	25.9	10.6
B T2	21 - 25	12.89	5.62	.16	.35	20.1	3.8	.7	37.3	30.0	11.3
BC	25 -	12.67	5.62	.16	.34	20.4	3.2	.3	38.3	31.7	9.1

Horizon-Depth (In.)		Atterburg Limits Plastic Limit	Liquid Limit	Particle Size (%) Total Sand	50-2 U Silt	2U Clay Total
A E1	0 - 6			28	57	15
A E2	6 - 15			35	52	13
B T1	15 - 21			14	68	18
B T2	21 - 25			5	75	20
BC	25 -	23.3	29.7	3	77	20

PH Methods, Codes:

1...H20 1:1
2...H20 1:5
3...H20 Saturation
4...CACL2
5...KCL
6...NAF

Physical & Chemical Data

Horizon-Depth (In.)		Sample # Lab Sample #	PH 1 Sample State	Method	Value	PH 2 Sample State	Method	Value	Organic Carbon %	Nitrogen %
A E	-	76 938	2	1	6.6	2	4	5.6	.47	.03
	-	76 939	2	1	6.7	2	4	5.7	.52	.04
B T	-	76 940	2	1	6.9	2	4	6.0	.41	.04

Horizon-Depth (In.)		Exchangeable Cations Buff. (ME/100G) CA	MG	NA	K	C.E.C. DETERMINED	P1 PPM.	Particle Size (%) Total Sand	5- 2 U Silt	2U Clay Total	.2U Clay Total
A E	-	8.66	3.69	.16	.22	16.5	65.1	22	67	11	3
	-	13.48	6.27	.20	.45	23.8	11.4				
B T	-	12.10	6.50	.23	.23	20.3	3.2	4	75	21	10

PH Methods, Codes:

1...H20 1:1
2...H20 1:5
3...H20 Saturation
4...CACL2
5...KCL
6...NAF

SOIL: PROJECT: Slug	NTS: 93L 8	RESOURCE ANALYSIS BRANCH MINISTRY OF ENVIRONMENT VICTORIA, B.C.	SUMMARY DATE: Sept. 16/81 Page: 01

Date of Survey: 08 78 Surveyor: Kelowna, B.C.M.A. & R.A.B.
Sampling Purpose: Research

Project Code: 11-8

Location		Classification
Latitude (N):	54 19 15	
Longitude (W):	126 09 00	Orthic Gray Luvisol (1978) Slug

Parent Material & Landform

Profile Description

Horizon	Thickness Depth (In)	Colour I	Texture
A E	0 - 6	10.OYR3.5/3.0 Matrix Moist 10.OYR4.5/4.0 Matrix Dry	Silt Loam
B T	6 - 12	10.OYR3.0/4.0 Matrix Moist 10.OY-3.0/3.0 Matrix Dry	Loamy Sand
BC	12 - 20	10.OYR3.0/3.0 Matrix Moist 10.OYR5.5/3.0 Matrix Dry	Loam
C	20 -	10.OYR3.0/3.0 Matrix Moist 10.OYR5.5/3.5 Matrix Dry	

Physical & Chemical Data

Horizon-Depth (In.)		Sample # Lab Sample #	PH 1 Sample State	Method	Value	PH 2 Sample State	Method	Value	Organic Carbon %	Nitrogen %
A E	0 - 6	782025	2	1	5.9	2	4	5.2	.90	.14
B T	6 - 12	782026	2	1	6.2	2	4	5.6	.31	.03
BC	12 - 20	782027	2	1	6.4	2	4	5.7	.24	.03
C	20 -	782028	2	1	6.5	2	4	5.8	.28	.03

Horizon-Depth (In.)		Exchangeable Cations Buff.(ME/100G) CA	MG	NA	K	C.E.C. DETERMINED	P1 PPM	S PPM	Moisture Status 1/10 Bar.	1/3 Bar.	16 Bar.
A E	0 - 6	10.69	3.15	.10	.65	22.1	236.0	.7	33.1	30.3	11.5
B T	6 - 12	0.96	3.44	.09	.44	22.6	36.9	.8	13.9	9.8	7.0
BC	12 - 20	11.73	3.97	.10	.42	18.7	26.9	.6	26.1	17.0	8.2
C	20 -	12.74	4.36	.11	.43	19-6	29.5	.4	29.6	19.7	8.8

Horizon-Depth (In.)		Part Size Analy. (% Passing) 32 MM	16 MM	8 MM	#4	#7	#10	#35	#60	#120	#200	#230
A E	0 - 6											
B T	6 - 12											
B C	12 - 20											
C	20 -	10.00	98.80	99.70	99.70	99.70	99.70	99.50	79.40	37.70	23.70	21.20

Horizon-Depth (In.)		Particle Size (%) Total Sand	50-2 U Silt	2U Clay Total	.2U Clay Total
A E	0 - 6	31	55	14	5
B T	6 - 12	80	14	6	4
BC	12 - 20	51	39	10	4
C	20 -	49	41	10	2

PH Methods, Codes

1...H20 1:1

2...H20 1:5

3...H20 Saturation

4...CACL2

5...KCL

Appendix 2

PLANT SPECIES LIST

The following species are the vascular plants, mosses and lichens which were identified within the project. Vascular plant nomenclature follows Taylor, R.L., and MacBryde, B. (1977). Botanical nomenclature of the mosses is after Crum, Steere, and Anderson (1973); that of the lichens is after Hale and Culberson (1970).

Problems in making identifications to the specific level in some taxonomically difficult genera, or when less significant ecological differences exist between certain closely-related species have resulted in the grouping of some species by genus.

E.1 LIST OF VASCULAR PLANT SPECIES

Tree Species

Botanical Name	Common Name
Abies lasiocarpa var. lasiocarpa	alpine fir
Picea glauca	white spruce
Pinus contorta var. latifolia	lodgepole pine
Populus tremuloides	trembling aspen
Populus balsamifera subsp. trichocarpa	black cottonwood

Shrub Species

Botanical Name	Common Name
Alnus incana subsp. tenuifolia	thin-leaved mountain alder
Alnus viridis subsp. sinuata	Sitka mountain alder
Amelanchier alnifolia	saskatoon
Cornus sericea subsp. sericea	common red-osier dogwood
Juniperus communis	juniper
Ledum groenlandicum	common Labrador tea
Lonicera ciliosa	western trumpet honeysuckle
Lonicera involucrata	twinberry honeysuckle
Ribes bracteosum	stink current
Ribes cereum	squaw current
Ribes hudsonianum	northern black current
Ribes irriguum	Idaho black gooseberry

Shrub Species Cont...

Ribes lacustre	black swamp gooseberry
Ribes laxiflorum	trailing black current
Ribes spp.	currants, gooseberries
Ribes viscosissimum var. viscossissimum	sticky currant
Rosa acicularis subsp. sayi	prickly rose
Rosa gymnocarpa	baldhip rose
Rosa nutkana	Nootka rose
Rosa spp.	roses
Rosa woodsii	Wood's rose
Rubus idaeus subsp. melanolasius	American red raspberry
Rubus parviflorus subsp. parviflorus	western thimbleberry
Salix bebbiana	Bebb's willow
Salix exigua	coyote willow
Salix lasiandra	Pacific willow
Salix maccalliana	Maccall's willow
Salix scouleriana	Scouler's willow
Salix spp.	willows
Sambucus racemosa	American elder
Sheperdia canadensis	soopolallie
Sorbus sitchensis	Sitka mountain ash
Spiraea betulifolia subsp. lucida	birch-leaved spirea
Spiraea douglasii	hardback
Symphoricarpos albus	common snowberry
Vaccinium membranaceum	black blueberry
Viburnum edule	high bush cranberry

Herb and Dwarf Shrub Species

Botanical Name	Common Name
Achillea millefolium	yarrow
Actaea rubra	red baneberry
Agoseris aurantiaca var. aurantiaca	orange false dandelion
Agropyron dasystachyum var. dasystachyum	northern wheat grass
Agropyron pauciflorum	slender wheat grass
Agropyron repens	quack grass
Agropyron spicatum	bluebunch wheat grass
Agropyron spp.	wheat grasses
Agrostis exarata	spike grass
Agrostis gigantea	redtop
Agrostis scabra	hair bent grass
Agrostis spp.	bent grasses

Herb and Dwarf Shrub Species Cont....

Botanical Name	Common Name
Anaphalis margaritacea	common pearly everlasting
Anemone drummondii	Drummond's anemone
Anemone multifida	Pacific anemone
Anemone spp.	anemones, windflowers
Angelica spp.	angelicas
Antennaria microphylla	rosy pussytoes
Antennaria neglecta	field pussytoes
Antennaria parvifolia	Nuttall's pussytoes
Antennaria racemosa	racemose pussytoes
Antennaria spp.	pussytoes
Aquilegia formosa subsp. formosa	Sitka columbine
Arabis holboellii	Holboell's rock cress
Arabis supp.	rock cresses
Aralia nudicaulis	wild sarsaparilla
Arctium minus	lesser burdock
Arctostaphylos uva-ursi	kinnikinnick
Arenaria spp.	sandworts
Arnica chamissonis	Chamisso's arnica
Arnica cordifolia	heart-leaved arnica
Arnica latifolia	broad-leaved arnica
Arnica spp.	arnicas
Aruncus dioicus	sylvan goat's-beard
Aster conspicuus	showy aster
Aster modestus	great northern aster
Aster spp.	asters
Aster subspicatus var. subspicatus	Douglas' aster
Avena spp.	oats
Botrychium boreale subsp. obtusilobum	northern grape fern
Botrychium lanceolatum var. lanceolatum	lance-leaved grape fern
Botrychium lunaria	moonwort
Botrychium spp.	grape ferns
Bromus ciliatus	fringed brome grass
Bromus inermis	brome grass
Bromus mollis	soft brome grass
Bromus spp.	brome grass
Bromus vulgaris var. bulgaris	Columbia brome grass
Calamagrostis canadensis	bluejoint small reed grass
Calamagrostis inexpansa	northern small reed grass
Calamagrostis rubescens	pine grass
Calypso bulbosa	fairyslipper
Capsella bursa-pastoris	common shepherd's-purse

Herb and Dwarf Shrub Species Cont...

Botanical Name	Common Name
Carex concinna	low northern sedge
Carex concinnoides	northwestern sedge
Carex disperma	soft-leaved sedge
Carex leptalea	bristle-stalked sedge
Carex macloviana	thick-headed sedge
Carex rossii	Ross' sedge
Carex rostrata	beaked sedge
Carex sitchensis	Sitka sedge
Carex spp.	sedges
Castilleja miniata	common red Indian paintbrush
Castilleja spp.	Indian paintbrushes
Cerastium arvense	field chickweed
Cerastium spp.	chickweeds
Chrysosplenium tetrandrum	northern golden saxifrage
Cicuta douglasii	Douglas' water-hemlock
Cinna latifolia	wood reed grass
Circaea alpina	alpine enchanter's-nightshade
Clematis occidentalis subsp. grosseserrata	western blue clematis
Clintonia uniflora	blue-bead clintonia
Collinsia parviflora	small-flowered blue-eyed Mary
Collinsia sp.	blue-eyed Mary
Collomia linearis	narrow-leaved collomia
Coptis spp.	goldthreads
Corallorhiza maculata	coralroot
Corallorhiza trifida	yellow coralroot
Cornus canadensis	Canadian bunchberry
Crepis spp.	hawk's-beards
Cystopteris fragilis	fragile fern
Dactylis glomerata	orchard grass
Danthonia californica	California oat grass
Danthonia spicata	poverty oat grass
Delphinium glaucum	glaucous delphinium
Delphinium spp.	delphiniums
Disporum trachycarpum	rough-fruited fairybells
Dryopteris assimilis	spiny shield fern
Elymus glaucus	blue wild rye grass
Elymus innovatus var. innovatus	fuzzy-spiked wild rye grass
Epilobium angustifolium	fireweed
Epilobium ciliatum	purple-leaved willowherb
Epilobium latifolium subsp. latifolium	broad-leaved willowherb
Equisetum arvense	common horsetail
Equisetum hyemale subsp. affine	scouring-rush
Equisetum palustre	marsh horsetale
Equisetum scirpoides	dwarf scouring-rush
Equisetum spp.	horsetails, scouring-rushes
Equisetum sylvaticum	wood horsetail

Herb and Dwarf Shrub Species Cont...

Bontanical	Common Name
Festuca occidentalis	western fescue
Festuca rubra	red fescue
Festuca saximontana	Rocky Mountain fescue
Festuca spp.	fescues
Fragaria vesca	wood strawberry
Fragaria virginiana subsp. glauca	blue-leaved strawberry
Fritillaria lanceolata	chocolate lily
Galium boreale	northern bedstraw
Galium trifidum subsp. trifidum	interior small bedstraw
Galium triflorum	sweet-scented bedstraw
Gentianella amarella subsp. acuta	northern gentian
Geocaulon lividum	northern red-fruited commandra
Geranium bicknellii	Bicknell's crane's-bill
Geranium richardsonii	Richardson's crane's-bill
Geranium spp.	crane's-bill
Geranium viscosissimum	sticky purple crane's-bill
Geum macrophyllum var. macrophyllum	large-leaved avens
Geum rivale	water avens
Glyceria striata	fowl manna grass
Goodyera oblongifolia	large-leaved rattlesnake orchid
Gymnocarpium dryopteris var. disjunctum	oak fern
Heracleum sphondylium subsp. montanum	common cow-parsnip
Hieracium albertinum	western hawkweed
Hieracium albiflorum	white hawkweed
Hieracium canadense	hound's-tongue hawkweed
Hierochloe odorata subsp. hirta	common sweet grass
Juncus spp.	rushes
Lathyrus nevadensis subsp. lanceolatus var. pilosellus	purple Nevada peavine
Lathyrus ochroleucus	cream-coloured peavine
Lathyrus sp.	peavine
Linnaea borealis	northern twinflower
Listera convallarioides	broad-leaved twayblade
Lupinus spp.	lupines
Luzula sp.	wood-rushes
Lycopodium annotinum	stiff club-moss
Lycopodium clavatum	running club-moss
Lycopodium complanatum	ground cedar

Herb and Dwarf Shrub Species Cont....

Botanical Name	Common Name
Machaeranthera canescens	hoary tansyaster
Medicago lupulina	black medic
Medicago sativa	alfalfa
Medicago spp.	medics
Melampyrum lineare var. lineare	narrow-leaved cow-wheat
Melilotus spp.	sweet-clovers
Mentha arvensis subsp. borealis	field mint
Minuartia tenella	slender sandwort
Mitella nuda	common mitrewort
Moehringia spp.	sandworts
Moneses uniflora	one-flowered wintergreen
Muhlenbergia spp.	muhlenbergias
Myosotis spp.	forget-me-nots
Orthilia secunda	one-sided wintergreen
Oryzopsis asperifolia	rough-leaved rice grass
Oryzopsis exigua	little rice grass
Oryzopsis pungens	short-awned rice grass
Osmorhiza chilensis	mountain sweetcicely
Penstemon confertus	yellow penstemon
Penstemon procerus	slender blue penstemon
Penstemon spp.	beardtongues, penstemons
Petasites frigidus	Arctic colt's-foot
Petasites palmatus	palmate colt's-foot
Petasites sagittatus	arrow-leaved colt's-foot
Petasites spp.	colt's-feet
Phleum pratense	common timothy
Phlox sp.	phlox
Plantago patagonica	woolly plantain
Plantago spp.	plantains
Platanthera obtusata	one-leaved rein orchid
Platanthera orbiculata	large round-leaved rein orchid
Poa palustris	fowl blue grass
Poa pratensis	Kentucky blue grass
Poa spp.	blue grasses
Polemonium pulcherrimum	showy Jacob's-ladder
Polemonium spp.	Jacob's-ladders
Polygonum sp.	knotweed, smartweed
Potentilla arguta	white cinquefoil
Potentilla gracilis	graceful cinquefoil
Potentilla norvegica	rough cinquefoil
Potentilla sp.	cinquefoil
Prenanthes alata	western rattlesnakeroot
Pyrola asarifolia	common pink pyrola
Pyrola chlorantha	green pyrola
Pyrola minor	lesser pyrola

Herb and Dwarf Shrub Species con't.

Botanical Name	Common Name
Ranunculus aquatilis	common water crowfoot
Ranunculus eschscholtzii	subalpine buttercup
Ranunculus gmelinii	Gmelin's buttercup
Ranunculus hyperboreus subsp. hyperboreus	far-northern buttercup
Ranunculus occidentalis subsp. occidentalis	western buttercup
Ranunculus repens	creeping buttercup
Ranunculus sp.	buttercup, crowfoot
Rhinanthus minor	yellow rattle
Rubus arcticus	nagoon berry
Rubus pubescens	dwarf red blackberry
Rubus spp.	docks, sorrels
Sanguisorba canadensis subsp. latifolia	Sitka burnet
Satureja douglasii	yerba buena
Senecio pseudaureus	western golden ragwort
Senecio triangularis	arrow-leaved ragwort
Sisyrinchium spp.	blue-eyed-grass
Sium suave	hemlock water-parsnip
Smilacina racemosa	false Solomon's-seal
Smilacina stellata	star-flowered false Solomon's-seal
Solidago canadensis	goldenrod
Solidago spp.	goldenrods
Spiranthes romanzoffiana	hooded ladies'-tresses
Sporobolus spp.	dropseeds
Stachys palustris subsp. pilosa	swamp hedge-nettle
Stellaria spp.	starworts
Stipa comata	needle-and-thread grass
Stipa richardsonii	Richardson's needle grass
Stipa sp.	needle grass
Streptopus amplexifolius	cucumberroot twistedstalk
Streptopus spp.	twistedstalks
Taraxacum officinale	common dandelion
Thalictrum occidentale	western meadow-rue
Tiarella trifoliata	trifoliate-leaved foamflower
Tiarella unifoliata	unifoliate-leaved foamflower
Trifolium hybridum	alsike clover
Trifolium macrocephalum	big-headed clover
Trifolium pratense	red clover
Trifolium repens	white clover
Trifolium spp.	clovers
Tristetum cernuum subsp. canescens	nodding trisetum
Trisetum spicatum	spike trisetum
Trisetum spp.	trisetum

E.2 LIST OF BRYOPHYTE SPECIES

Moss Species

Botanical Name

Aulacomnium androgynum
Aulacomnium palustre
Brachythecium spp.
Bryum spp.
Cratoneuron filicinum
Dicranum fuscescens
Dicranum polysetum
Dicranum scoparium
Dicranum spp.
Dicranum tauricum
Drepanocladus Uncinatus
Hylocomium splendens
Mnium blyttii
Mnium glabrescens
Mnium insigne
Mnium spp.
Pleurozium schreberi
Pogonatum spp.
Polytrichum juniperinum
Polytrichum spp.
Ptillium crista-castrensis
Rhytidiadelphus spp.
Rhytidiadelphus triquetrus
Rhytidiopsis robusta
Sphagnum spp.
Tomenthypnum nitens

E.3 LIST OF LICHEN SPECIES

Lichen Species

Cladina rangiferina
Cladonia spp.
Peltigera spp.

Herb and Dwarf Shrub Species Cont'd...

Botanical Name	Common Name
Urtica dioica subsp. gracilis var. lyallii	Lyall's American stinging nettle
Vaccinium caespitosum	dwarf blueberry
Vaccinium vitis-idaea subsp. minus	mountain cranberry
Valeriana dioica subsp. sylvatica	marsh valerian
Veronica americana	American speedwell
Veronica spp.	speedwells
Vicia americana	American vetch
Viola adunca subsp. adunca	early blue violet
Viola orbiculata	evergreen yellow violet
Viola renifolia	kidney-leaved violet
Viola spp.	violets

A.1 PHYSICAL DATA

The physical characteristics for Subproject II and the Meadow Plots are listed below

ADDITIONAL SITE CHARACTERISTICS FOR
SUBPROJECT II AND THE MEADOW PLOTS

Plot No.	Treatment[1]	Aspect	Slope (%)	Elevation Approx-imated (ft)	Site Position-Macro	Site Position-Meso	Site Surface Shape	Micro-topography	Site Position Moisture	Ecological Moisture Regime	Nutrient Regime	Exposure Type	Soil Drainage
73-13	.,.,.,.,.	SW	5	2760	upper slope	level	straight	mod. mounded	normal	mesic	mesotrophic	N/A	mod.[2] well-well drained
73-08	C,.,.,.,.	E	0-15	2780	upper slope	level	straight	slightly mounded	normal	mesic	mesotrophic	N/A	well drained
MX-1	C,F,S,P,.	W	5	2700	middle slope	level	straight	micro mounded	normal	mesic	mesotrophic	N/A	mod. well drained
73-02	C,F,S,.,.	W	0-15	2740	middle slope	upper	convex	micro mounded	shedding	submesic	mesotrophic	N/A	mod. well-well drained
73-12	C,.,S,P,G	Var.	0-15	2710	middle slope	level	straight	micro mounded	normal	mesic	mesotrophic	N/A	well drained
73-03	C,F,.,P,.	SSW	0-15	2750	middle slope	upper	convex	micro mounded	shedding	submesic	mesotrophic	N/A	mod. well-well drained
73-06	C,F,.,P,G	SSE	0-10	2700	middle slope	middle slope	concave	slightly mounded	receiving	subhygric	mesotrophic	N/A	well drained
73-04	C,F,.,.,.	SW	0-10	2730	middle slope	middle slope	straight	slightly mounded	normal	mesic	mesotrophic	N/A	well drained
MX-2	C,F,.,.,G	SSW	11	2700	middle slope	depression	concave	slightly mounded	receiving	subhygric	mesotrophic	N/A	well drained
73-11	C,F,.,.,.	SW	0-15	2730	middle slope	middle	convex	mod. mounded	normal	mesic	mesotrophic	N/A	well drained

Appendix 3

The data seedling counts for 1973-1978 are presented below. lP and wS represent lodgepole pine and white spruce respectively. Planted refers to the treatment applied to the plot. The planted stock could not be distinguished from the naturally regenerating seedlings of lodgepole pine.

H.2 ACTUAL SEEDLING COUNTS

NUMBER OF SEEDLINGS PER .2 ACRE PLOT FROM 1973-1978 FOR LODGEPOLE PINE AND WHITE SPRUCE

Plot Number and Treatment[1]	1973		1974		1975		1976		1977		1978	
	lP[2]	wS[3]	lP	wS	lP	wS	lP	wS	lP	wS	lP	wS
Planted												
MX-1 C,F,S,P,.	33		31		36		34		37		39	
73-12 C,.,S,P,G	31	5	32		39	4	24	2	37	5	38	
73-03 C,F,.,F,.					44		17		44		45	
73-06 C,F,.,P,G	38		40		65		75		71		79	
Non-planted												
73-08 C,.,.,.,.									47		140	
73-02 C,F,S,.,.	2	2	2		5	2	3	1	4		6	
73-04 C,F,.,.,.	1				8		17		23		46	
MX-2 C,F,.,.,.			1		20		29		31		34	
73-11 C,F,.,.,.					7		10		17		24	
73-10 C,F,.,.,.	1				42		60		66		87	
73-05 C,F,S,.,.					2		8		6		11	
73-07 C,F,S,.,G	1		2				8		7		13	

[1]The treatments are always listed in the following sequence - C,F,S,P,G. A dot indicates the treatments is lacking. The letters refer to: C - cleared, F - fertilized, S - grass mixture seeded, P - planted to lodgepole pine, G - open to grazing.

[2]lP - lodgepole pine (Pinus contorta var. latifolia)

[3]wS - white spruce (Picea glauca)

Plot No.	Treatment[1]	Aspect	Slope (%)	Elevation-Approximated (ft)	Site Position-Macro	Site Position-Meso	Site Surface Shape	Micro-topography	Site Position - Moisture	Ecological Moisture Regime	Nutrient Regime	Exposure Type	Soil Drainage
73-10	C,F,.,.,G	SW	0-20	2680	middle slope	crest	convex	slightly mounded	shedding	submesic	mesotrophic	N/A	mod. well-well drained
73-05	C,F,S,.,.	S	5-30	2700	middle slope	lower	concave	micro-mounded	receiving	subhygric	mesotrophic	N/A	well drained
73-07	C,F,S,.,G	SW	0-10	2620	lower slope	crest	convex	micro-mounded	shedding	submexic	mesotrophic	N/A	mod. well-well drained
73-01	.,.,.,.,G	none	0	2500	valley floor	level	straight	smooth	normal	hygric	submeso-trophic	cold air drainage	well drained
73-09	.,.,.,.,G	none	0	2500	valley floor	level	straight	smooth	normal	hygric	submeso-trophic	cold air drainage	well drained
73-14	.,.,.,.,G	none	0	2500	valley floor	level	straight	smooth	normal	subhygric	permeso-trophic	cold air drainage	imp.[4] drained
73-15	.,.,.,.,.	none	0	2500	valley floor	level	straight	smooth	normal	subhygric	permeso-trophic	cold air drainage	mod. well - well drained
73-16	.,.,.,.,G	none	0	2500	valley floor	level	straight	smooth	normal	subhygric	permeso-trophic	cold air drainage	mod. well-well drained

[1] The treatments are always listed in the following sequence - C,F,S,P,G. A dot indicates the treatment is lacking. The letters refer to: C - cleared, F - fertilized, S - grass mixture seeded, P - planned to lodgepole pine, G - open to grazing.

[2] mod. - moderately

[3] var. - variable

[4] imp. - imperfectly

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