AN ASSESSMENT OF THE AGRICULTURAL POTENTIAL OF THE SLAVE RIVER LOWLANDS OF NORTHWEST TERRITORIES, CANADA.

BY

Northern Research Group

Research Station, Beaverlodge, Alberta and Associated Experimental Farms - Ft. Vermilion, Alberta and Prince George, B.C., Agriculture Canada.

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FOREWORD

This study was initiated at the request in 1964 by the then Department of Northern Affairs so that factual information would be made available on the productivity potential for agriculture of the Slave River Lowlands. This vast area of 810,000 ha (2 million acres) lying just north of 60 parallel in the Northwest Territories represents one of the last large tracts of land with agricultural potential in North America.

Initial arrangements for the project were made through officials of the department of Indian and Northern Affairs in Ft. Smith. To members of the Mackenzie Forest Service and the Territorial Fish and Game Branch, we owe our gratitude for their logistical support throughout the life of the study. To those two organizations, who so freely and on numerous occasions, gave their time and advice as well as unselfishly sharing their aircraft, tracked vehicles, cabins and boats, we offer our thanks.

This project has been a joint effort involving many colleagues and co-workers. The salinity determinations were undertaken at the Solonetzic Substation, Vegreville, Alberta. The Prairie Regional Office, Economics Branch, Regina, Saskatchewan carried out the economic interpretation of the data. Helpful advice in the field was provided by Research Directors, Research Co-ordinators and specialists in soil research.

The project was initiated by a visit to the area in 1967 and was activated in 1968. Peter Grant, the technician on this project spent three months of each of each of 6 years at Grand Detour. Thanks are due to Peter for his ability to cope with all situations: for collecting data sometimes under very trying conditions, having to battle against the elements, the mud and the insects; for his ability to keep machinery, tractors, mowers, outboard motors and the M.V. ARIN operating under primitive conditions and for maintaining his reporting schedule and data collection. The continuity he provided to this study was appreciated.

Finally we acknowledge a man whose vision of the north and whose expectation of the agricultural potential of the northern areas never faltered. It was through the interest, efforts and recommendations of Frank Nowasad that this study was borne. His untimely death in 1968 cut short this source of support and expertise which no doubt would have added immeasurably to this report.

Project Committee
W.L. Pringle, Leader
B. Siemens, Co-leader
A.M.F. Hennig, Soils
J.K. Wiens, Economics

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ASSESSMENT OF THE AGRICULTURAL POTENTIAL OF THE SLAVE RIVER LOWLANDS, NORTHWEST TERRITORY

Summary:

Between the years 1968 and 1974 the area known as Grand Detour on the Slave River was studied as a representative portion of the Slave River Lowlands. This report attempts to make an estimate of the total forage productivity of the area. It presents a number of alternatives for using this vast land surface taking into consideration the physical and economic constraints imposed by location and nature. Three separate plot areas were established to evaluate productivity of the most extensive soil types. For each of two meadow soils, Grand Detour and Taltson and a forested soil, Slave, the adaptability of forage crops and cereal crops plus the need for additional fertilizer was determined and the yield and quality of native meadows was studied. The best adapted forages are: smooth bromegrass, crested wheatgrass, reed canarygrass, meadow foxtail and alfalfa. Cereals were not able to survive the summer frosts and at no time matured ripe grain. The most limiting fertilizer element was nitrogen. Forage yield of native sedges and grasses ranged from 1000 - 5000 kg/ha ODW*. Native vegetation when cut continuously diminished in total yield but did not change appreciably in species composition. Yields varied greatly from year to year and from site to site. Most areas produced 1500 - 3000 kg/ha. The quality of native grass hay was lower than for the sedge hay. Protein levels dropped rapidly from a high of 15% in June to around 6.5% in late August. The only limiting element to livestock nutrition appeared to be phosphorus which was below 0.20% particularly in late cut forage both for native and cultivated species. The level of copper in native forages was also inadequate in many areas.

Climate of the area was recorded and found to vary widely from one year to the next, particularly for rainfall and soil temperature. Rainfall for the 3 month recording time varied from 9.09 cm in 1971 to 23.34 cm in 1973. Soil temperatures at 10 cm at no time exceeded 12°C on the meadow soils. Frost often remained in the ground until mid July in both forest and meadows. The productivity of the meadows was related to the water table throughout the year. The quality of surface water and subsurface water was related to the extent and severity of soil salinity in the area.

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* ODW Oven dry weight

In addition to the above statements, the following conclusions may be made from this study:

1. The stone-free, grass-sedge meadows cover extensive areas of the Slave River Lowlands.
2. The native grasses and sedges have a potential for grazing animals including beef cattle, horses and bison (full assessment of the potential will not be made until grazing experiments are carried out).
3. Native forage (sedge-grass) cut at the proper time would produce hay capable of wintering a beef cow herd.
4. Yields of brome-alfalfa are twice that of the native stands on the cultivatable areas.
5. Although time did not permit full assessment of longevity of alfalfa-brome stands, it is believed that it would equal that in the Peace River Region.
6. Current varieties of cereals did not mature at Grand Detour but need further testing at other locations within the lowland area.
7. Surface water needs to be controlled so as to bring about more equal distribution over parts of the lowland.
8. Certain soils (approximately 10%) have a tendency to become saline.
9. A small area (10,000 ha) mainly on ridges and adjacent to the Slave River has a potential for logging.
10. The area is free of noxious weeds, an advantage for the production of seed crops.

The Slave River Lowlands cover an area of 810,000 ha (2 million acres or 3,125 sq miles). It should be recognized that the meteorological data were collected from only one location during the seven year period. The limitations of this study relative to current knowledge in Agroclimatology should be pointed out as follows:

1. How the seven year period relates to the long term meteorological normals from adjacent established stations (Ft. Smith, Ft. Resolution, Hay River) has not been assessed, i.e. whether the 7 year period was colder or warmer than the long term normals.
2. The extent to which the agronomic information obtained at the single meteorological site relates to the whole region has not been assessed. This would be accomplished by an agroclimatic resource analysis of the region using statistical and mathematical models relating topographical, meteorological and agronomic information to map the region. Because the topography is fairly flat, the influence of low wet areas on the agroclimate should also be considered.

An addendum to this report incorporating the agroclimatic resource analysis and relevance to long term climatic normals will follow at a later date.

1. INTRODUCTION

1.1 Objectives

The large open and stone-free meadows of the Slave River Lowlands have aroused considerable interest in using these lands for agriculture and ranching. It is the primary objective of this report to present the research findings of the authors taken from the project from 1968 to 1974. In addition, these findings are related to earlier investigations. Based on these findings along with an economic analysis of the data, some proposals for use of this land are presented.

Several questions must be answered before a viable land use policy can be formulated. These questions pertain to climatic limitations, soil quality, adaptability of introduced plants, and the effects of several management techniques on the productivity and quality of native sedges and grasses.

1.2 Early History

Early explorers to the area were no doubt aware of the lowlands along the Slave River. However, they said little or nothing except that the area abounded in game and provided excellent beaver and muskrat trapping along the many stream channels.

The area has not been utilized extensively other than for trapping. Adjacent to the Slave River are various abandoned millsites which were active as recently as 1969 and as long ago as the 1920's. White spruce and balsam poplar were the raw material that brought the loggers to the area. Raup (1946), gave his impression of the area along the Slave River. He reported that from the river it appeared he was looking at a dense spruce forest of great aerial extent. He found, however, that the productive forests were limited to natural levees and eddy deposits and that a complicated and extensive system of wet meadows divides the forest into comparatively narrow strips. He also found that the levees were subject to destruction by the meandering of the rivers and by the silting up of the valley floors.

During the 1940's a winter road was put in from Ft. Smith to Ft. Resolution which was to some degree used by the military but was also used as a connecting link between the two communities. At this same time navigation was maintained on the Slave River. Channels were dredged and markers maintained. As late as 1969, barges plied up and down the river from Bell Rock connecting Ft. Smith with the Arctic.

1.2.1 1957 Survey

A reconnaisance survey of the area (Day and Leahey 1957) described the lowlands as 2,179,000 acres or 882,000 ha made up of nine soil series and four land types. They estimated on the basis of soil and topography that 73% of the area was suitable for some form of agriculture. Economic limitations, because of access, precluded any development at that time.

1.2.2 1965 Survey

In 1964 a request was made by the then, Department of Northern Affairs and National Resources to the Department of Agriculture for an evaluation of the potential for agriculture in the Slave River Lowlands. In 1965 a committee under F.S. Nowasad carried out a field survey in July and August. They concluded that: "Physical factors of soil and climate impose definite limitations on types of crops that can be grown successfully and on the yields that can be obtained. Available data indicate that forage crops and some cereal crops can be grown successfully and can provide the feed necessary for successful beef cattle production. The native vegetation can provide forage for cattle production but intensive cultivation of suitable forage mixtures and of grains will be necessary for full development of the area. The human population in the Northwest Territories is insufficient to provide a market for more than a small part of the potential production. Thus, cattle produced in the area would have to compete for markets with those produced in other areas of Canada. In view of the cost price squeeze being experienced by farmers in other parts of Canda, the prospect for financial success of a beef cattle enterprise in the lowlands is relatively low. Conversely, the possibility of settlers becoming a charge on the government is real. The committee cannot find a sound basis for recommending agricultural development of the Slave River Lowlands at the present time". One of the recommendations was to establish plots in the region to test the hardiness of pasture types of grass and to determine fertilizer response on forage crops.

The committee felt that a potential existed for livestock production and that many of the limitations of isolation, surpluses of agriculture produce elsewhere and economic problems in the Canadian farm sector can change with time.

1.2.3 Soil Report, 1972

As part of the 1965 survey the soils were studied in more detail, redescribed and more closely identified than was possible in the 1957 report. The field work culminated in a soil survey report (Day, 1972), which included soil maps of 1 inch to 1 mile that were derived from color aerial photographs flown in September 1966. Day described 23 soil types including 2,056,354 ac or 832,823 ha of which 18% is Class 3 land, 6% is Class 4 land, and 58% is Class 5 land (Table 1.2). This report covered all aspects of soil origin, classification and description. In addition, it included vegetation types and species lists. The soils information was used as the basis for this present report, therefore it will be quoted frequently.

An important question is the climatic limitation to crops, as well as the productivity and quality of the native vegetation. Before this land can be settled the question of crop adaptability and effect of use by haying or grazing on native "grasslands" has to be resolved.

2. DESCRIPTION OF THE AREA

2.1 Geographical and Geological

The Slave River Lowland is bounded on the south by the Northwest Territories - Alberta boundary, on the east by Taltson River, on the west by Little Buffalo River and on the north by Great Slave Lake. The north flowing Slave River roughly bisects this 2,056,354 acre (832,823 ha) area (Fig. 2.1).

The area west of the lowland is underlain by Middle Devonian rocks (map unit 9) that contains gypsum, salt, limestone, and breccia in their basal strata, and dolomite and limestone in their upper strata (Fig 2.2 after Day 1972).

Table 1.2 Extent of soil types and soil capability class in the Slave River Lowland (after Day 1972).

Soil or Land Type	Symbol	Total AC	%	Class	ha
Alluvium	A	66,238	3.22	7	22,826
Brule	B	54,926	2.67	4	22,245
Clewi	C	16,128	0.78	3	6,532
Desmarais	De	4,460	0.21	7	1,806
Ennuyeuse	En	4,172	0.20	7	1,690
Enterprise	Et	7,358	0.35	7	2,980
Eroded slopes	E	3,525	0.17	7	1,428
Fort Smith	F	104,937	5.10	5	42,499
Grand Detour	G	515,008	25.04	5	208,578
	Gp	55,514	2.69	6	22,483
Iche	I	7,322	0.35	5	2,965
Jean	Jn	145,081	7.05	5	58,758
Jerome	Jr	59,939	2.91	4	24,275
Little Buffalo	LB	77,094	3.74	3	31,223
Lobstick	L	274,334	13.34	5	111,105
	Lp	22,781	1.10	6	9,226
Matou	Ma	7,542	0.36	0	3,055
Norberta	N	56,117	2.72	5	22,727
	Np	4,181	0.20	6	1,693
Nyarling	Ny	7,163	0.34	0	2,901
Oracha	O	5,072	0.24	4	2,054
Resolution	R	30,143	1.46	7	12,208
Rocher	Ro	30,658	1.49	3	12,416
Rock outcrop		1,061	0.05	7	430
Slave	Sv	260,889	12.68	3	105,660
Sloughs	S	52,649	2.56	7	21,323
Taltson	T	89,255	4.34	5	36,148
	Tp	13,966	0.67	6	5,656
	Tv	8,478	0.41	7	3,434
Rivers and lakes		69,147	3.36	0	28,005
Urban		1,216	0.05	0	492
Total		2,056,354			832,823

	Class	Ac	%	Ha
Class totals	0	85,068	4.1	34,452
	3	384,769	18.7	155,831
	4	119,937	5.8	48,574
	5	1,192,054	58.0	482,782
	6	96,442	4.7	39,059
	7	178,084	8.7	72,124

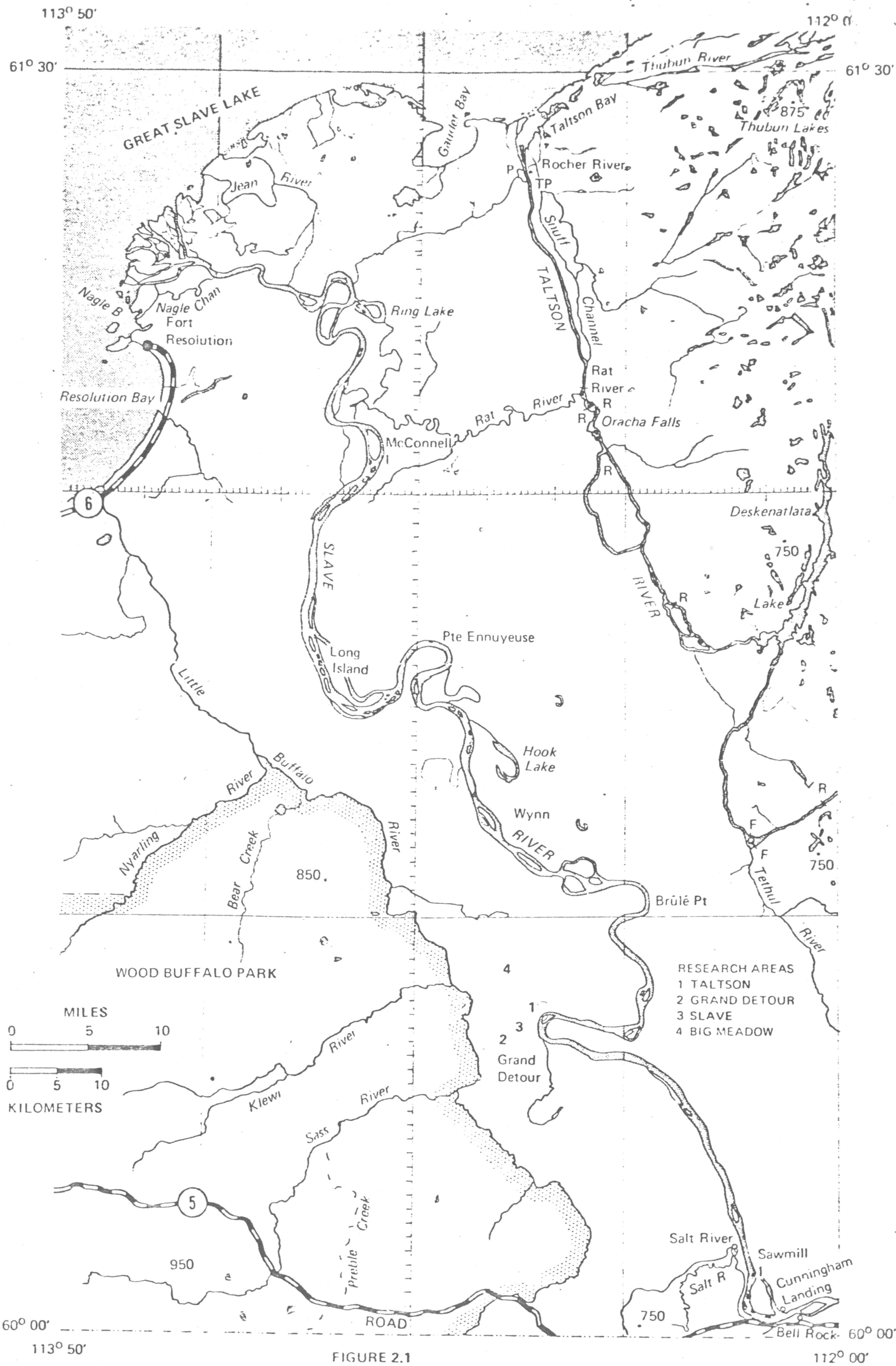


FIGURE 2.1
THE SLAVE RIVER LOWLANDS

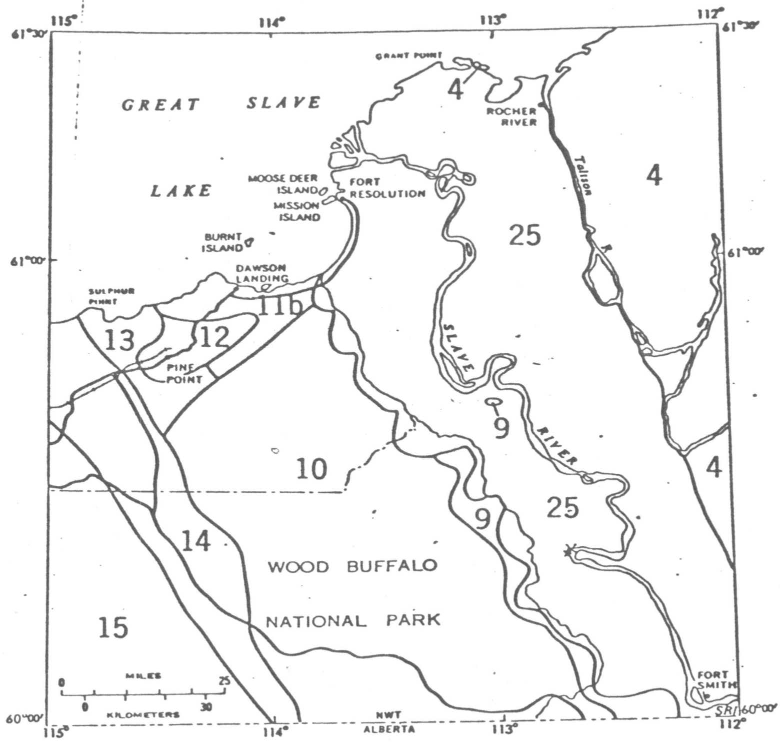


Fig. 2.2 Map of geological formations in the southwestern part of the Northwest Territories. (After Day 1972)

Age	*Map unit*	
Archaean	*4*	Granite, granodiorite, quartz diorite, gneiss, chloritized granite
Palaeozoic	*9*	Middle Devonian Gypsum, salt, limestone, breccia
	10	Middle Devonian Units 11-13 undifferentiated
	11b	Middle Devonian Pine Point formation Fine-grained vuggy dolomite
	12	Middle Devonian Presqu'ile formation Coarse-grained vuggy domomite
	13	Middle Devonian Fine-grained limestone and shale
	14	Middle Devonian Fine-grained limestone
	15	Upper Devonian Shale, limestone, sandstone
Cenozoic	*25*	Pleistocene and recent deposits

——— Map unit boundaries

Figure 2.3 Dry sedge meadow of the Slave River Lowlands, Tractor and trailer were the main mode of transportation to the project.

Several of the bedrock hills in the surveyed area are of this rock type. To the east of the area the rocks of the Shield Region (map unit 4) are mainly granites and granodiorites. Most of the bedrock outcrops on the eastern edge of the area are of the latter type. The unconsolidated sediments of the area have been assigned to Pleistocene and recent (Map unit 25).

The lowlands are in a state of dynamic change which often is accentuated by ice-jamming in the river with consequent flooding and ice damage to the river banks.

2.2 Vegetation

The desirable areas for native grazing and forage production on the lowlands are meadows. This term designates all vegetation types in which shrubs and trees form less than 10% of the total cover. Looman (unpublished report 1970), divides meadows into four types. However, they all grade one into the other and so there are intermediary forms and often it is difficult to categorize an area satisfactorily. The four main forms are: prairie, dry sedge meadow, wet sedge meadow, and saline meadows (Table 2.1). The last named must be considered as strictly saline areas and will be discussed fully later under salinity studies. Full species lists for all vegetation types after Day (1972) are presented in Tables 1-5. (Appendix)

2.2.1 Prairie

This is the least extensive type. It forms a narrow zone around the dry sedge meadow. It is well drained and the soil has a shallow 2 inch organic layer. This type is most susceptible to overuse and subsequent invasion by undesirable or increasing species.

2.2.2 Dry sedge meadow

This type may be flooded in the spring but not in summer. It is the most extensive of the meadow types occupying all the area between the wet sedge meadow and the bush. The soil is either Grand Detour or Taltson. Ninety percent of the vegetation is a mixture of *Carex atherodes* and *Calamagrostis inexpansa* (Figure 2.3).

2.2.3 Wet sedge meadow

Areas in this category have surface water most of the summer. The vegetation is made up of Scolochloa festucacea along with Carex atherodes and C. aquatalis with C. rostratata in the very wet places.

2.2.4 Saline meadows

The wet saline meadows are prevalent in the south western portion of the lowlands where water tables are high. Yields of sedges and grasses are low and in some areas Triglochin maritima, seaside arrowgrass (a Hydrocyanic acid poisonous lily) presents a hazard to grazing.

Table 2.1 Vegetation Types of Slave River Lowland (After Day 1972).

A.	Meadow	1.	Prairie
		2.	Dry sedge meadow
		3.	Wet sedge meadow
		4.	Saline meadows
B.	Brush	5.	Willow brush
		6.	Willow - aspen brush
		7.	Willow - dwarf birch brush
		8.	Willow - alder brush
C.	Forest	9.	Aspen - black poplar
		10.	Birch - aspen
		11.	White spruce - aspen
		12.	White spruce
		13.	Black poplar
		14.	Black spruce - dward birch
		15.	Black spruce - Labrador tea
		16.	White spruce - black spruce
		17.	Jack pine - aspen
		18.	Jack pine - white spruce
		19.	Jack pine

2.2.5 Brush and forest cover

2.2.5.1 Brush

Brush in the form of willows and aspen are invading and gradually replacing the dry sedge meadows and the prairie types. In later stages of invasion, shrubs other than willows become prevalent. The succession is usually from willow to aspen to spruce. Four types are recognized (Table 2.1).

2.2.5.2 Forest cover

Of the total 306,180 ha (756,000 acres) of forest surveyed along the Slave River, 179,172 ha (442,000 acres) have potential for forest production (Hirvonen 1968). They found that softwoods, spruce and pine occupy 26,263 ha (64,700 acres). This survey of saw timber done in 1950 and alter in 1958 indicated that 10,935 ha (27,000 acres), or four percent of the total area was stocked with saw timber. The estimate of total saw timber volume was 191 million board feet of which 164 million are in softwoods. They found the timber to be concentrated on the alluvial soils within one mile of the river. As a general trend, they observed that the tree size and volume are greatest on recent terraces. It was also noted that volume and tree size is less along the northern part compared to up river (further south). Observed were three strata of spruce saw timber: 180-200 yr old, d.b.h. (diameter breast high) 28-56 cm, height 23-29 m; 150 - 160 years old, d.b.h. 10-25 cm, 15 - 23 m high; less than 100 years old, d.b.h. 8-18 cm, 12 m high. The survey noted that permafrost is not uncommon in shaded areas under spruce stands (Hirvonen, 1958). The fact that the trees occupy the levees along the rivers gives the illusion of an extensive forest by an observer travelling in a boat on the Slave River. This location of the major forest stands along the Slave River is most unfortunate because the river is continually meandering and in so doing is effectively removing and wasting many of the best trees in the region. At Grand Detour where the west bank is being cut back the loss of land along with many fine old trees has exceeded 15 m in six years (Fig. 2.4).

Looman (unpublished report 1970) divides the forest into 11 types (Table 2.1).

2.3 Soils

2.3.1 General Description

Day (1972), describes the soils of the area in some detail. Development is generally weak as a result of the cool dry climate and youthful parent material. They are mainly of the Regosolie Order or the Eutric Order. Much of the area has been influenced by the ponding water in depressions where the soils are wet for much of the year. The soils that have been developed under conditions of excessive moisture are the Gleysols and Humic Gleysols which cover 51% of the area.

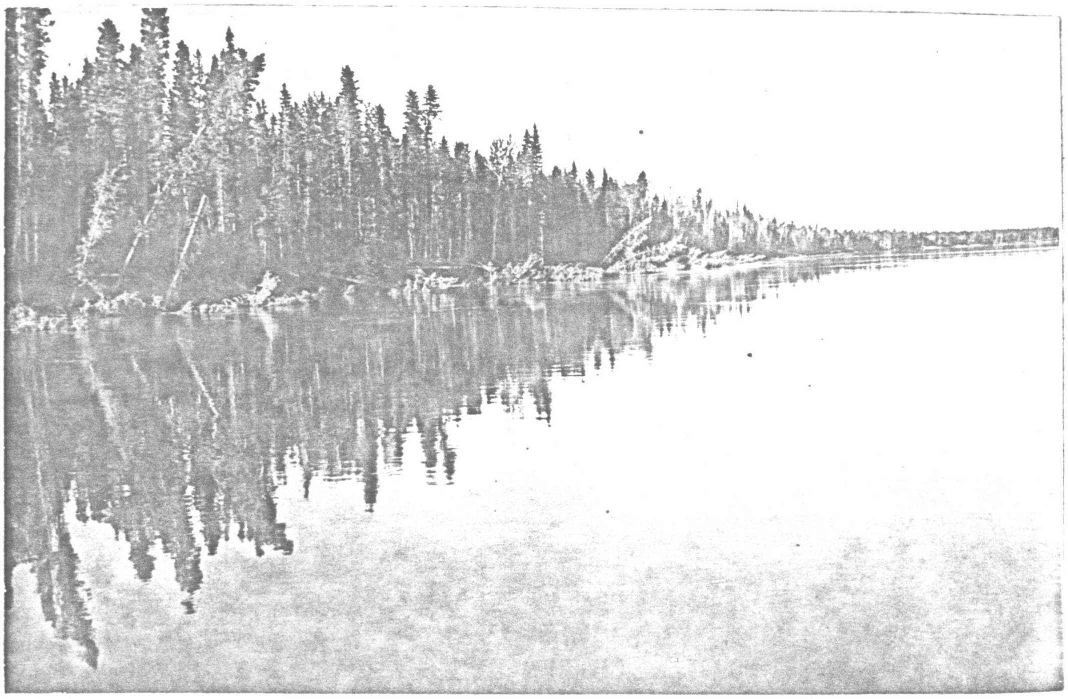


Figure 2.4 The Slave River at high water showing the extent of growth of white spruce and the loss caused by bank erosion.

2.3.2 Main Complexes

The main soils in the area compromise the Grand Detour complex which makes up the majority of the open meadows and is the largest in the lowlands being approximately 230,000 ha (570,000 acres). The second most important is the Taltson complex which is also a meadow type consisting of 41,000 ha (100,000 acres). The third most extensive is the Slave soil which is forested and comprises 105,000 ha (260,000 acres).

2.3.2.1 Grand Detour complex

The Grand Detour soils have developed on moderately fine calcareous lacustrine sediments that are underlain by fine sands. They are mainly Rego Humic Gleysols that may have more than 15 cm (6 inches) of peat on much of the surface, and have a black clayey mineral horizon over grayish calcereous clayey sediment that becomes mottled with depth. The depth to parent material averages 0.9 m (3 feet). The low content of organic matter in the parent material distinguishes these soils from the Taltson soils.

Topography is level or gently undulating and the land surface is interrupted in places by sloughs, stream meanders, or lakes. Natural drainage is poor, but these soils are usually drained by midsummer, except in the lowest depressions where the peaty phases occur.

Vegetation is mainly sedges, grasses and rushes. Around the dryer edges of the meadows the grasses are dominant over the sedges and usually there are scattered clumps of willow and meadow herbs. In many areas trembling aspen, and willow are invading the meadows.

2.3.2.2 Taltson soil

The Taltson soils have developed on moderately fine textured calcareous alluvium that is rich in organic matter and is underlain by fine sands. They are Rego Humic Gleysols with peaty surface of about 15 cm (6 inches) over black mineral horizons that grade into dark gray calcareous alluvium.

Topography is level or very gently sloping. The land pattern is roughly parallel ridges separated by narrow depressions in which the Taltson soils occur. The soils are permeable and better drained than the Grand Detour soils.

Vegetation is dominantly sedges and grasses with forbs such as fireweed, marsh hedge nettle, mint and sweet coltsfoot.

2.3.2.3 Slave soils

The Slave soils have developed on moderately fine textured calcareous lacustrine sediments that are underlain by fine sands. They are Orthic Regosols which have a thin mat of moss under which the soil is dark grayish brown silty loam. Topography is gently sloping. The land pattern is that of low ridges between the Grand Detour meadows on which the Slave soils are present. These soils are well drained and tend to become droughty under cultivation.

Vegetation is mainly trembling aspen, white spruce, balsam poplar, willow and birch. The understory is soapberry, rose, fireweed and Canada reedgrass.

2.3.3. Other Soils

Some other soils in the lowlands are important because they cover large areas. The Lobstick soils extend over 110,970 ha (274,000 acres). They are Rego Gleysols that have developed on loamy calcareous lacustrine material and occupy troughs between ridges of sandier material. The topography is level and these soils are poorly drained. Vegetation consists mainly of dwarf birch and willow along with shrubby cinquefoil. The Fort Smith soils covering 42,525 ha (105,000 acres) have developed on sandy calcareous materials. They are Orthic Eutric Brunisols occurring on level to undulating land and are very permeable and droughty. Tree cover is mainly trembling aspen, jack pine and an understory of soapberry, rose and fireweed. The Brule soil covers 20,250 ha (50,000 acres). It is a Cumulic Regosol that has a thin layer of organic debris over dark grayish brown clay loam. It occurs on parallel ridges separated by Taltson meadows and has very good drainage. The Little Buffalo soil covers 31,185 ha (77,000 acres) and like the Brule is developed on loamy calcareous alluvium rich in organic matter. The Little Buffalo soil is lighter textured in the surface than the Brule. Both soils contain many buried organic layers and some are underlain by permafrost. Trees are trembling aspen, white spruce, balsam poplar, often of merchantable size. Shrubs are rose, soapberry, high bush cranberry and red osier dogwood.

Fifteen other soils of lesser importance have been described by Day (1972).

3. THE PROJECT

3.1 Terms of Reference

The initial date of request for study of the Slave River Lowlands was in 1964 which brought about the 1965 survey of soils and vegetation. This survey recognized a number of gaps with respect to productivity of the area and so the present study was undertaken beginning in 1967.

3.2 Objectives

The project initiated in 1967, had the objective of estimating the potential of the lowlands for the production of pasture, hay and feed grain and based on these to assess the potential for the commercial production of beef cattle. This objective was to be achieved by:

A. Determining the yield and nutritional adequacy of native palatable vegetation.
B. Determining the effect of clipping or grazing on native vegetation.
C. Determining to what extent introduced plants could improve forage production over the native species.
D. Determining if there are limiting nutrient deficiencies.
E. Relating plant response to environment.
F. Investigating the place of bison and other wildlife as an alternative to agricultural production to the extent of cooperating with wildlife officials.
G. Determining what factors could limit livestock production.

3.3 Initiating the Project

3.3.1 Preparations and equipment

In August 1967, an initial visit was made north from Fort Smith to the area known as Grand Detour on the Slave River by W. L. Pringle and B. Siemens. At that time it was decided to utilize the Warden's Cabin at Grand Detour as a headquarters. In March 1968, equipment was trucked in to the site over the winter road. A John Deere 1010 crawler tractor with blade, 2 two-bottom breaking plows, an Oliver 55 tractor, a two wheel trailer, disc, mower, harrows and all necessary small equipment and supplies needed to carry out plot seeding, cultivation and harvesting were laid down at the site.

In 1969 the M.V. ARIN, a 12 m (40 foot) motorized scow, was brought from Fort Simpson, for use as a floating living quarters (Figure 3.1). In summer access to Grand Detour from Fort Smith is by water. A 5m (16 foot) aluminum

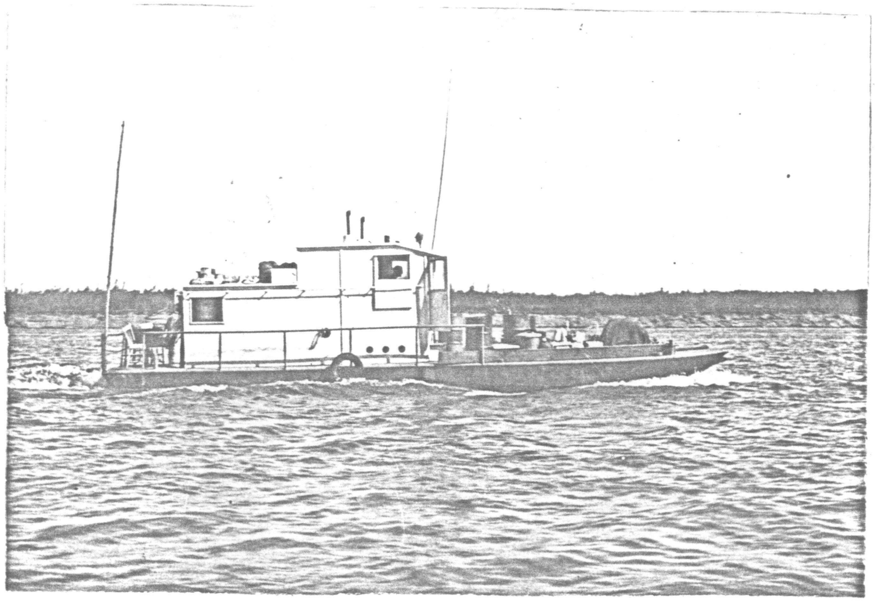


Figure 3.1 The M.V. ARIN used for transportation and as living quarters for the project.

Figure 4.1 The Taltson study area showing the extent of the plots in 1973. Individual plots are 5m long.

Crestliner boat with a 33 h.p. outboard motor was used weekly to obtain access to the Town. Mr. P. Grant was the resident technician for the full life of the project which was active for the three months: June July and August from 1968 to 1974. Most of the time he was alone on the site. A radio schedule with the McKenzie Forest Service was established as a safety feature and as a means of reporting weather from the area.

3.3.2 Allocation and preparation of test areas

Three areas were initially chosen for intensive study. They were selected on the basis of the prevalence of the particular soil type on the lowlands. In the spring of 1968, 1-acre blocks of land were plowed on the meadow sites and these were summer-fallowed during 1968 and 1969. Clearing of the 7-10 cm aspen on the wooded area was carried out in November, 1968 and the land was broken in 1969. At each of the three test areas a set of soil temperature probes at 5 depths was established. At Site 1, closest to the living quarters, a full weather station consisting of rain gauge, maximum and minimum thermometers, evaporimeters and anemometer was set up. A fourth site was set up in 1971.

Locations of the test areas are shown on map (Figure 2.1). Coordinates for Site 1 were 60° 22'N lat. 112° 42' W long.

4. STUDY SITES

4.1 Site 1

Taltson was only 460 m from the Slave River on a Taltson soil. It was a small meadow surrounded by willow and aspen. The soil is a rego humic gleysol with a tough peaty surface making it hard to plow and work down. This area was plowed and worked in 1968, summerfallowed in 1969 and seeded in July, 1969. The following year it was evident that the native sedges were taking over so the area was kept black during 1970 and was seeded again in 1971. This seeding was successful. Buffalo frequently wallowed in the area while it was being summerfallowed, hence it was fenced following seeding of the plots (Figure 4.1).

In 1974 the river rose to a high level during spring run off and because of ice jamming downstream overflowed its banks and inundated this site. It did not drain free until mid June.

4.2 Site 2

Grand Detour was 5 km southwest of the cabin. It was on an arm of a meadow that was about 60 ha in extent. The site was located on the north side of the meadow. The area was plowed and summerfallowed in 1968 and seeded in June 1969. The catch was good for all plots. The area was fenced to prevent bison from wallowing and plots were cut from 1970 to 1973. Fire burned the plots in 1972.

4.3 Site 3

Slave was 300 m north of Site 2 on a brown wooded soil. The area was treed by aspen (avg. 9 cm DBH, 9m high and 26 years old). This tree cover was cleared from a 0.4 ha area and the ground was plowed during 1969 (Figure 4.2). Roots were picked and the area was disced and summerfallowed in 1969 and the plots were seeded in 1970. A poor establishment was achieved for the legumes which were reseeded in 1971.

4.4 Site 4

Site 4 was established in 1971 on a large open meadow 11.3 km SW of the Grand Detour cabin. It was set up specifically to compare climate of a windswept area with that of a more enclosed site. The soil type was Grand Detour peaty phase which had standing water for most of the summer. Fertilizer and intensity of cutting trials were set up on this site. No cultivation was undertaken other than a late summer discing on which grass seed was scattered. This seeding was unsuccessful.

5. CLIMATE

5.1 Procedure

In any study to determine agricultural potential the climate of the area is of paramount importance. Because of this a weather station was set up one 460 m half mile west of the Slave River on a small meadow of 120 ha. This site was sheltered to the east and south by spruce forest. There were no trees or bushes over 4 m in height within 100 m of the weather site. The site was established in June 1968 and records were taken from it continuously for the months of June, July and August until 1974. A standard set of M.O.T. weather instruments were read at 0800 and 1700 hr each day while the operator was present. Records of maximum and minimum temperatures, rainfall, total km of

Figure 4.2 Clearing the Slave soil of light aspen tree cover using the small crawler tractor.

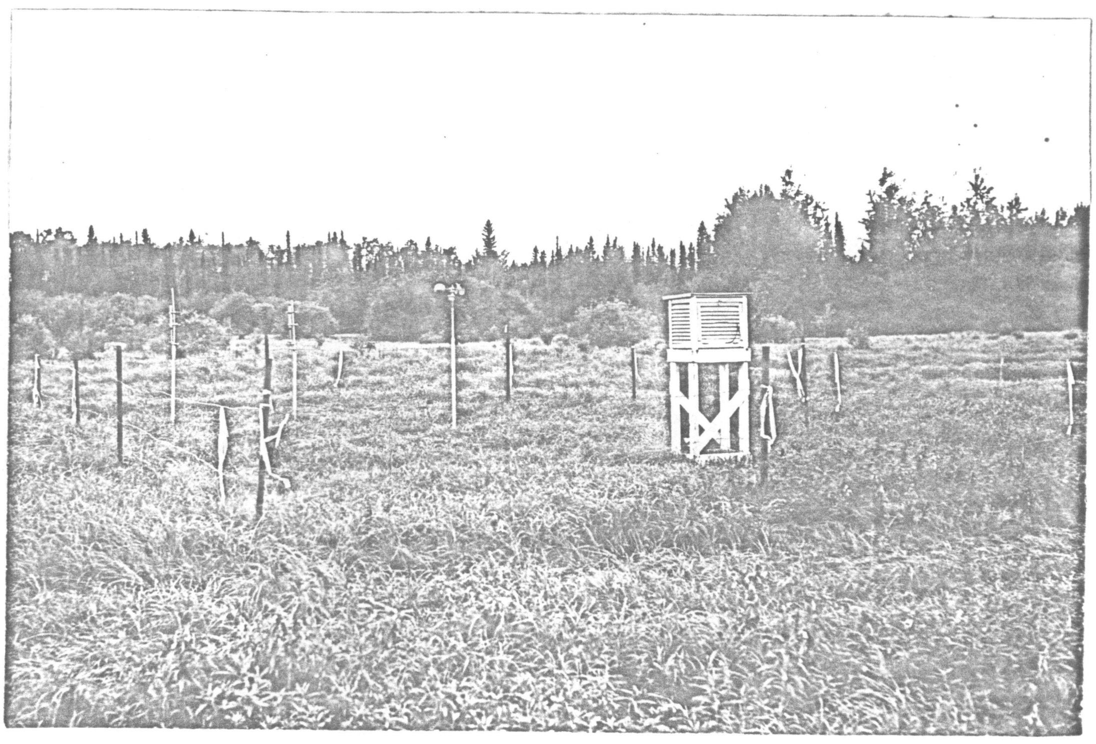


Figure 5.1 Weather Station on the Taltson area; the instruments were fenced to prevent disturbance by bison.

wind, evaporation, and soil temperatures at 5, 10, 15, 30, 45, 60 and 90 cm were made. The site was fenced with four strands of smooth wire which was hung with fluorescent surveyor's ribbon to discourage bison from disturbing the instruments (Figure 5.1).

It was soon realized that the weather instruments on Site 1 may be influenced by the close proximity of the trees and so a site on a larger open meadow with less chance of being influenced by adjacent bush was established in June 1971. This site was 300 m from any bush or tree and was set up in like manner to the first site. Records were read every third day and recording instruments were used to acquire temperatures because the site was 11 km (6 miles) from the living quarters. This site was also protected by a fence and surveyor's ribbon.

5.2 Description of equipment

Temperatures were taken using Casella maximum and minimum thermometers which were reset after each reading. These were checked against recording thermographs which were used also for records from the remote site and also on days when the operator was absent. These instruments were all housed in a standard Stevenson screen at 120 cm above the ground. Evaporation of distilled water was recorded from two black bellani plate evaporimeters which had 250 cc reservoirs, and were located at 120 cm above ground. Rainfall was recorded in standard M.O.T. rain gauges located 30 cm from ground level. Soil temperatures were recorded by Yellow Springs telethermometers from thermoprobes buried at specified depth and records started the following year. Contacts for thermoprobes were housed in ground level wooden boxes that were staked into the ground. Wind was recorded from Casella anemometers set 180 cm above ground surface.

5.3 Records 1968-74

Climate of the area affects the soil temperature, evapotranspiration and the heat units that are accumulated for any one growing season and so climate is most crucial in determining the type of crops that may be easily produced.

5.3.1 Taltson area (7 year)

At Site 1, air temperatures were taken twice a day for the three summer months for the period 1968-1974. There were only three years 1968, 1970, 1973 in which the temperature during July did not go below -2.2°C (killing frost). In 1972 temperatures dropped below -2.2°C on nine days during the summer months and four of those occurred in July. Wind is higher by 12-18% for June than for the other two months. However, this fluctuates markedly from year to year. It would appear that wind and precipitation combine to affect evaporation rather than temperature because the highest evaporation is during the month of June which also has the highest wind and the lowest rainfall. Amount of precipitation varies considerably from month to month and year to year. It is probably the greatest single factor in affecting yield from the native vegetation. The driest years (1969 and 1971) seemed to have very little June precipitation while the very wet year (1973) had three wet months in a row. A summary of all climatic data is presented in Table 5.1.

5.3.2 Big Meadow (Site 4)

A weather station at Site 4 on the Big Meadow was established in 1971. This was designed to record differences between a rather closed in meadow (Site 1) and a very open area (Site 4). Wind on the open site for the four years recorded is only about 4% greater in June and 13% greater in July and August than on the more sheltered site. Evaporation is increased only for the latter two months, air temperatures were only slightly greater during the months of June and August and rainfall was greater only in 1971 for Site 4 compared to Site 1. A summary of records taken for the years 1971-74 is given in Table 5.2. Blanks for June 1973 and August 1972 were the result of a faulty thermograph.

5.3.3 A comparison of climatic data from Grand Detour with adjacent locations

The daily mean, monthly high, monthly low and total monthly precipitation of each of the three months June, July and August for Grand Detour were compared for the years 1968-73 with similar records from the airports at Fort Smith, 56 km south, Fort Resolution 104 km north, and Hay River 185 km

Table 5.1 Weather Data - Grand Detour. Climatic Records.

		TALTSON MEADOW							
		1968	1969	1970	1971	1972	1973	1974	7 Year Average
Total km of Wind	June	2450	3769	4968	3568	4329	4070	3909	
	Ave/day	145	126	166	127	132	150	150	142
	July	3916	3429	3600	3333	4136	3088	4263	
	Ave/day	119	111	119	108	134	98	126	116
	August	2930	3843	4442	3872	3371	3080	3091	
	Ave/day	101	129	143	126	109	134	119	122
Soil Evaporation for the month cc.	June	859	1371	1304	1339	1202	1246	1061	1197
	July	1250	1301	1240	1152	1469	960	938	1187
	August	884	870	807	1052	1059	686	660	860
Air Temperatures °C									
Mean Max.	June	22.2	19.4	23.3	23.3	23.3	23.3	22.2	22.2
Mean Min.		3.9	1.1	6.7	3.9	6.1	6.1	6.1	5.0
Mean		12.8	10.0	15.0	13.3	14.4	15.0	17.2	13.9
Highest		28.3	27.8	33.3	30.6	30.0	28.9	28.9	29.4
Lowest		-6.7	-8.3	-2.2	-3.9	-3.9	-2.8	-6.1	-5.0
Mean Max.	July	21.1	24.4	24.4	23.9	22.8	22.8	22.8	23.3
Mean Min.		5.0	5.6	5.6	4.4	2.8	7.2	7.8	5.6
Mean		12.8	15.0	15.0	14.4	12.8	15.0	17.2	14.4
Highest		26.7	30.6	30.6	30.6	27.2	27.8	28.9	28.9
Lowest		-1.7	-2.8	-1.1	-2.2	-4.4	-1.1	-2.2	-2.2
Mean Max.	August	20.0	22.2	20.0	24.4	24.4	21.1	20.6	21.7
Mean Min.		3.3	6.1	6.7	4.4	4.4	5.0	4.4	5.0
Mean		11.7	14.4	13.3	14.4	14.4	12.8	16.1	13.9
Highest		26.7	31.1	27.8	31.1	31.1	28.9	31.1	29.4
Lowest		-1.7	-3.9	-3.9	-5.0	-5.0	-6.1	-6.1	-5.0
Rainfall (cm)	June	2.39	2.06	1.68	0.89	6.73	6.96	3.84	3.51
	July	7.19	3.25	3.18	4.37	.94	9.17	7.32	5.05
	August	1.19	4.17	10.52	3.84	5.87	6.91	3.12	5.08
	Total	10.77	9.47	15.37	9.10	13.54	23.34	14.27	13.69

Table 5.2 Weather Data - Grand Detour - Climatic Records

		BIG MEADOW				4 Year
		1971	1972	1973	1974	Average
Total km of Wind	June	3861	4244	3909	4126	
	Ave.	138	147	150	166	150
	July	3576	4560	4788	4606	
	Ave.	116	147	135	132	132
	Aug.	4299	4015	3703	3270	
	Ave.	135	129	161	126	138
Evaporation for the Month cc.	June	1490	1208	1136	945	1195
	July	1352	1470	1195	982	1250
	August	1250	1080	785	610	931
Air Temperatures °C						
Mean Max.	June	23.3	23.9	21.1	23.3	22.8
Mean Min.		5.0	6.1	6.1	6.7	6.1
Mean		14.4	15.0	13.3	17.8	15.0
Highest		31.1	30.0	28.9	29.4	30.0
Lowest		-3.9	-3.3	-4.4	-5.6	-4.4
Mean Max.	July	23.3	23.3	25.6	22.8	23.9
Mean Min.		3.9	.6	10.6	6.1	5.0
Mean		13.3	11.7	18.3	16.7	15.0
Highest		31.1	28.9	31.1	30.0	30.0
Lowest		-2.8	-4.4	-1.1	-2.2	-2.8
Mean Max.	August	23.9	NA*	21.1	20.6	21.7
Mean Min.		5.6	NA	6.1	3.3	5.0
Mean		14.4	NA	13.3	15.6	14.4
Highest		31.1	30.6	28.9	31.1	30.0
Lowest		-4.4	-6.1	-4.4	-6.1	-5.6
Rainfall (cm)	June	1.19	5.79	6.71	4.57	4.55
	July	6.48	.46	10.01	5.74	5.66
	August	6.58	5.46	6.10	3.76	5.46
	Total	14.25	11.71	22.81	14.07	15.70

* Data not available

Table 5.3 Comparison of daily mean, monthly high, and monthly low, (°C) for three settled locations and Grand Detour in Northwest Territories.

	Air Temperatures °C							
	1968	1969	1970	1971	1972	1973	1974	7 Year Average
Mean Monthly								
June								
Ft. Smith	12.8	11.1	15.6	15.0	15.0	15.6	14.4	14.4
Ft. Resolution	11.1	8.9	14.4	14.4	13.9	15.0	13.3	12.8
Hay River	10.6	10.0	14.4	13.3	12.2	13.3	13.9	12.8
Grand Detour	12.8	10.0	15.0	13.3	14.4	15.0	14.4	13.3
July								
Ft. Smith	13.3	15.6	16.7	15.6	15.0	17.2	15.6	15.6
Ft. Resolution	11.7	14.4	16.7	14.4	13.9	17.2	15.0	15.0
Hay River	13.3	15.6	16.7	15.6	15.6	17.8	15.0	15.6
Grand Detour	12.8	15.0	15.0	14.4	12.8	15.0	15.0	14.4
August								
Ft. Smith	12.2	14.4	13.9	15.6	15.6	14.4	12.2	13.9
Ft. Resolution	11.7	12.8	13.9	15.0	15.6	14.4	12.8	13.3
Hay River	12.8	13.3	13.9	16.1	15.6	13.9	12.8	13.9
Grand Detour	11.7	14.4	13.3	14.4	14.4	12.8	13.9	13.3
Monthly High								
June								
Ft. Smith	27.8	27.8	35.0	31.1	29.4	29.4	26.1	29.4
Ft. Resolution	26.1	25.6	28.9	26.1	28.9	28.3	27.2	27.2
Hay River	29.4	27.8	31.7	28.3	28.3	27.2	27.8	28.9
Grand Detour	28.3	27.8	33.3	30.6	30.0	28.9	28.9	29.4
July								
Ft. Smith	26.7	30.0	30.0	30.6	27.2	30.0	27.8	28.9
Ft. Resolution	24.4	28.9	28.3	26.7	27.2	29.4	26.7	27.2
Hay River	25.6	30.0	31.7	30.0	27.2	33.9	29.4	29.4
Grand Detour	26.7	30.6	30.6	30.6	27.2	27.8	28.9	28.9
August								
Ft. Smith	26.7	30.0	28.9	31.7	31.7	30.0	30.6	30.0
Ft. Resolution	26.1	24.4	28.3	31.1	28.3	27.8	28.9	27.8
Hay River	26.7	26.7	33.9	35.6	31.7	31.1	30.0	30.6
Grand Detour	26.7	31.1	27.8	31.1	31.1	28.9	31.1	29.4
Monthly Low								
June								
Ft. Smith	-2.2	-3.9	.6	1.7	.6	3.3	-3.9	- .6
Ft. Resolution	-3.3	-4.4	- .6	- .6	2.2	0	-2.2	-1.7
Hay River	-1.1	-1.1	1.7	2.8	1.7	1.1	1.7	1.1
Grand Detour	-6.7	-8.3	-2.2	-3.9	-3.9	-2.8	-6.1	-6.0
July								
Ft. Smith	0	- .6	3.3	1.7	1.1	4.4	5.6	2.2
Ft. Resolution	0	- .6	3.3	1.7	-.6	1.7	1.7	1.1
Hay River	2.8	4.4	7.2	7.2	2.2	6.7	5.0	5.0
Grand Detour	-1.7	-2.8	-1.1	-2.2	-4.4	- .6	-2.2	-2.2
August								
Ft. Smith	-2.2	0.6	0	0	0	-1.7	-2.8	-1.1
Ft. Resolution	-1.7	- .6	-1.1	0	-2.8	- .6	-2.2	-1.1
Hay River	1.7	2.8	1.7	5.0	3.9	0	.6	2.2
Grand Detour	-6.7	-3.9	-3.9	-5.0	-5.0	-6.1	-6.1	-5.0

northwest of our Taltson research site. Mean daily temperature for the month of June and for the seven year period was within 2 degrees between recording sites. Records from the Grand Detour location were between those of Fort Smith and Hay River. For July the spread was even less and August also had less than 2 degrees spread. The monthly highs for the four locations also showed little spread with the Grand Detour location being between the high and the low point for each of the three months. Monthly lows, however, showed Grand Detour to be at least 3^o below the next highest minimum for all three months. The records as presented in Table 5.3 clearly show that the lowland near Grand Detour suffers greater extremes of temperature than do the settled areas. The fact that Hay River has the lowest mean daily temperature of the four locations in June and the exact opposite for July and August may show the influence of the lake ice during the early part of the summer. Logically this should be true also for Fort Resolution but it records lower mean temperatures for July and August than either of the other locations. This would lead to the assumption that air drainage in the northern part of the Slave River could be causing these cooler temperatures. The calculated degree days above 5^oC for June, July and August (1969-1974) at Grand Detour were 244.8, 249.6 and 290.8 and for Fort Vermilion were 348.9, 397.0 and 339.0 respectively. It is readily seen that Grand Detour has a much lower degree day rating than has Fort Vermilion.

The monthly precipitation for the four locations indicate that Fort Smith and Grand Detour receive more rain than the two locations on Great Slave Lake for the three recording months. Records emphasize the great variability between years and between months in any one year. August appears to be the rainiest month most years. The driest summer was 1971 and the wettest was 1973 as shown in Table 5.4.

5.4 Soil Temperatures

Soil temperatures were taken at regular observation times at 4 sites. These temperatures taken at depths ranging from 5 to 90 cms were used to determine the time at which the rooting zone became active, the difference between sites, and the time frost was completely out of the ground. In some cases records were made every 3 days, in some instances they were taken

Table 5.4 Comparison of Summer Precipitation for Three Settled Locations and Grand Detour.

	Precipitation cm								Long
	1968	1969	1970	1971	1972	1973	1974	Average	Term
June									
Ft. Smith	4.32	1.98	1.45	.79	8.36	4.37	8.81	4.29	3.07
Ft. Resolution	3.00	1.80	1.45	.28	4.27	1.83	4.67	2.46	2.46
Hay River	2.21	1.78	1.42	.28	3.89	4.75	4.37	2.67	2.49
Grand Detour	2.39	2.06	1.68	.89	6.73	6.96	3.83	3.50	
July									
Ft. Smith	6.76	2.01	5.13	2.54	.53	14.91	6.30	5.44	5.33
Ft. Resolution	2.79	2.72	2.59	1.14	1.40	13.59	9.02	4.75	3.38
Hay River	7.06	1.40	1.73	3.73	1.19	6.63	4.45	3.73	4.22
Grand Detour	7.19	3.25	3.18	4.37	.94	9.17	7.31	5.05	
August									
Ft. Smith	4.06	5.89	7.49	2.16	8.05	6.40	4.34	5.49	3.45
Ft. Resolution	1.14	6.25	4.75	.58	6.07	7.77	3.68	4.32	3.45
Hay River	2.21	5.54	2.64	2.16	5.21	9.55	4.70	4.57	3.73
Grand Detour	1.19	4.17	10.52	3.84	5.87	6.91	3.12	5.10	
Summer Total									
Ft. Smith	15.14	9.88	14.07	5.49	16.94	25.68	19.46	15.21	11.86
Ft. Resolution	6.93	10.77	8.79	2.01	11.73	23.19	17.37	11.53	9.30
Hay River	11.48	8.71	5.79	6.17	10.29	20.93	13.51	13.51	110.44
Grand Detour	10.77	9.47	15.37	9.09	13.54	23.34	14.27	13.69	

weekly and averaged for the month. Cool soil temperatures prevail over the lowlands most of the year. A temperature of 5°C is usually reached near the end of May at the 15 cm depth. This temperature is considered threshold for root growth. Frost has been observed in the ground at 60 cm under sod up until July 5. Temperatures on the meadow soils over the observation period at 10 cm depth reached a high of 12.8°C in all but 1971 and 1974 on the Taltson site where the high was only 11.7°C. On the better drained Slave soil the high was 16.1°C. Average soil temperatures by the month for the four study sites are given in Table 5.5. Because soil temperatures during June 1974 were so much lower than the average they are recorded separately in brackets. It is difficult to explain these lower than normal soil temperatures in that the air temperatures for that year were close to the average. The average temperature for November 1973 at both Fort Smith and Fort Resolution was 2.8°C lower than the normal which would have increased the depth of frost in the soil. There did appear to be more than normal amounts of surface water and this could have had an insulating effect on the soil.

Using the criteria as laid down by FAO, UNESCO for soil climatic mapping the temperatures recorded at Grand Detour the area is Class 3, Cryoboreal, sub-class cold where the mean summer soil temperature at 50 cm is between 2.2° and 8.3°C. The growing season (days above 5°C) is 120-220 days and the growing degree days (over 5°C) are 555-1250. Wet soils in this class, may remain frozen for portions of the growing season and discontinuous or localized permafrost is generally found in organic soils within this category.

5.5 Effect of cultivation on soil temperatures

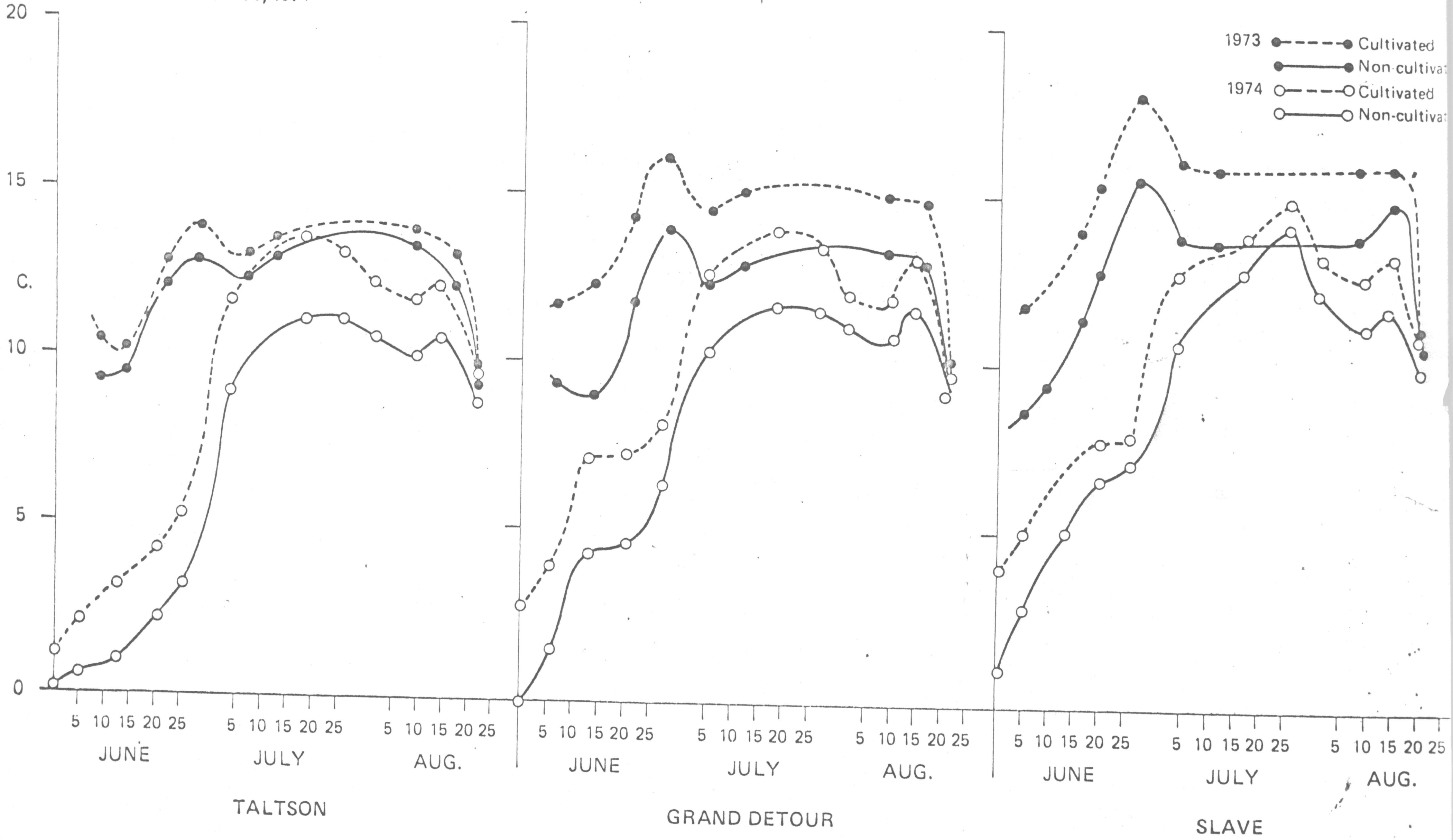
It was suspected that soil temperature is one factor that may be limiting plant growth. In 1973 and 1974 at 0830 hr, readings were taken weekly at 10 cm between cultivated but revegetated areas and native sod on the three study sites for the 3 summer months. It was found that the non-cultivated was cooler. The difference during June and July was 3-4°C diminishing to 1°C in late August. The largest differences occurred on the Slave and Grand Detour soil types in 1973 with the least on the Taltson soil (Fig. 5.2). In 1974 soil temperatures were very much lower than 1973 during June. This temperature spread between the native and cultivated areas in 1974 was

Table 5.5 Monthly Mean Soil Temperatures ^{o}C - Grand Detour

	Soil Depth cm						
	5	10	15	30	45	60	90
Taltson Site - Average 5 Years							
June - am	8.3 (2.8)*	8.3 (2.8)	7.2 (1.7)	5.6 (.6)	2.2	.6 (-3.0)	0 (-3.3)
pm	13.3 (7.2)	10.0 (5.6)	7.2 (3.9)	5.6 (2.2)	2.8	.6 (-1.7)	0 (-1.7)
July - am	10.0 (8.9	10.0 (8.9)	9.4 (8.3)	7.8 (6.7)	5.0	3.3 (2.2)	.6 (0)
pm	15.0 (11.7)	11.7 (10.0)	9.4 (8.3)	7.8 (6.7)	5.6	3.3 (2.2)	.6 (0)
August am	8.9 (8.9)	9.4 (8.9)	8.9 (8.3)	7.3 (7.2)	5.6	4.4 (3.3)	2.8 (1.1)
pm	13.3 (11.1)	11.1 (10.0)	9.4 (8.3)	7.8 (7.2)	5.6	3.9 (3.3)	2.2 (1.1)
Big Meadow - Average 3 Years (am)							
June	8.3 (4.4)	7.8 (3.9)	7.2 (3.3)	5.6 (2.2)	3.3 (.6)		
July	10.6 (10.0)	10.0 (10.0)	10.0 (10.0)	8.9 (8.9)	7.2 (7.2)		
August	10.6 (10.0)	11.1 (10.0)	10.6 (10.0)	9.4 (9.4)	8.9 (8.9)		
Slave - Average 3 Years (am)							
June	12.8 (4.4)	11.7 (4.4)	11.7 (3.9)	10.0 (2.8)	8.3 (1.1)		
July	13.9 (11.7)	13.3 (11.1)	13.3 (11.7)	12.8 (4.4)	11.1 (9.4)		
August	13.9 (10.0)	13.3 (10.0)	12.8 (10.0)	12.8 (10.0)	11.7 (9.4)		
Grand Detour - Average 3 Years (am)							
June	8.3 (3.9)	7.8 (3.3)	7.2 (3.3)	6.1 (2.2)	3.9 (0)	2.2	.6
July	10.6 (13.3)	10.0 (10.0)	9.4 (10.0)	8.9 (8.9)	7.2 (7.2)	6.1	3.3
August	21.1 (9.4)	11.1 (9.4)	11.1 (9.4)	10.6 (8.9)	10.6(8.8)	8.9	6.7

*Bracketed figures are for 1974

FIGURE 5.2 SOIL TEMPERATURES AT 10 cm.
COMPARISON OF NATIVE AND CULTIVATED SOIL AT THREE SITES
FOR 1973, 1974



greater for the Taltson soil than it was for the other two sites during July. Even though there was great fluctuation from one year to another, the important fact is that throughout the summer there is a temperature difference between cultivated and native sod of approximately 2°C which may range from 1°C to 5°C. Had the temperatures been taken on new cultivation showing bare ground instead of on areas that had been revegetated after cultivation, then the differences may have been very much wider.

6. STUDIES OF NATIVE VEGETATION

6.1 Effect of cutting intensity studies

6.1.1 1968 - 1970

Studies were begun on native vegetation on Sites 1 and 2 in 1968. A trial was carried out to determine the effect of frequency of cutting on yield and persistence of native species (Fig. 6.1). On one area of site 1, prior to establishing the plots, the aftermath was removed by mowing with a Mott harvester while on an adjacent area it was burned off before establishing the plots. Plots were cut once, twice and three times at various dates during the three summer months for three years. Yield from the plots are presented in Table 6.1. The drier Grand Detour site has greater fluctuation from year to year than the Taltson plot area. The high Coefficient of Variance on the plots indicates the very high degree of variability of the areas chosen. As may be seen the burning was a much harsher treatment than the mowing as reflected by the lower yields on the Taltson soil. The June only cut in most years is so low as to be impractical. The three times a season cutting regime adds nothing to the two cut system. It appears that the native forage requires at least 40 days in order to recover from an initial cutting. Under a practical haying system, it would seem that cutting once about mid July would offer the most effective system for making native hay.

Vegetative composition was recorded for the Taltson plots in 1968 and was re-run using a modified point count system in 1971. The figures show a certain fluctuation in crown cover with a general increase in forbs, mainly fireweed, buttercup, bedstraw and dandelion. Sedge was decreased and grass was increased by early mowing on the mowed areas. The accumulation of litter and the change in vegetative composition was not consistent with the treatments therefore the trends must be considered non-directional.

Figure 6.1 Frequency of cutting on sedge grass on a Taltson soil. The mower is removing one month regrowth.

In 1971 it was observed that the cut area was 10-15 cm shorter in growth than the adjacent untouched native stand. Samples were taken in August and revealed that:

	Plot area kg/ha	Not mowed kg/ha
Taltson	1137	2510
Grand Detour	936	2679

In each area almost twice as much forage was on the unmowed part. Some of the difference could have been due to old undergrowth but it was evident that mowing this type of vegetation reduces production the following year. This after effect of plant removal has been observed on other areas growing wet-land species (Corns & Schraa 1962).

6.1.2 1971-1973

Following these observations a trial was established on three vegetation types to see how resting or omitting a year or alternating harvest years would affect yield. Plots were cut for 4 years and old growth was removed as much as possible from the sample. Table 6.3 indicates the yields each year and the accumulated total for the 4 years.

The Taltson area was flooded hence the plots were not cut in 1974. That set of plots which consisted largely of Carex rostrata (beaked sedge) yielded heavier than the big meadow area which was mainly Whitetop grass or the Grand Detour area which was a mixture of grass and sedge (C. atherodes). It was noticeable that the Calmagrostis inexpansa had ample heads on the plots that had not been cut the previous year as compared to those that had been harvested the previous year where few heads occurred. Total yield was greatest for those plots that were cut every year. The greatest reduction in yield was recorded by continuous cutting on the drier Grand Detour site. On the very wet Taltson plot area, there was a negligible reduction. For haying on the meadows it would seem that they could be cut progressively year after year but the drier areas where yields are low would benefit from a rest every other year.

6.1.3 General observations

From all trials on native vegetation the salient observation is the wide fluctuation from one year to the next and this has serious implications to using

Table 6.1 Yield of native vegetation under various cutting intensities for two locations.

kg/ha

Taltson - Initially mowed

Cutting Regime	1968	1969	1970
June	562 f*	863 e	1467 b
June-July	1060 e	1004 de	1702 ab
June-July-August	1593 abc	1322 abcd	1595 b
June-August	1563 abcd	1679 ab	1871 ab
July	1749 ab	1436 abc	1892 ab
August	1787 a	1708 a	2042 a
SEx	138	114	128
CV%	20.0	17.4	14.5
$\bar{x}$	1385	1315	1762

Taltson - Initially burned

Cutting Regime	1968	1969	1970
June	279 f	675 d	1254 d
June-July	990 bcd	998 c	1403 bcd
June-July-August	964 bcde	1046 bc	1403 bcd
June-August	1224 abc	1232 abc	1531 abc
July	1452 a	1332 ab	1765 a
August	1266 ab	1354 a	1616 ab
SEx	97	84	74
CV%	19.0	15.2	10.0
$\bar{x}$	1029	1109	1495

Grand Detour area - Initially mowed

Cutting Regime	1968	1969	1970
June	1213 c	394 d	1021
June-July	1336 bc	510 c	1297
June-July-August	1671 abc	551 c	1233
June-August	1794 ab	569 abc	1318
July	1675 abc	692 ab	1425
August	1973 a	699 a	1254
SEx	147	38	55
CV%	18.2	13.6	8.7
$\bar{x}$	1610	569	1259

* Means followed by the same lower case letter are not significantly different (P=.05 Duncan's multiple range test).

the land for range or for relying on the area for a uniform supply of winter feed. This fluctuation in production cannot be tied directly to total summer rainfall but to July precipitation and lower than normal July temperatures. On open areas where the water table is within a few inches of the surface, moisture is not limiting production of native species.

Table 6.3 Yields of native vegetation as affected by deferred haying in kg/ha

Treat.	1971	1972	1973	1974	Total
Grand Detour (semi wet)					
1	3969			3573 a	7542 b
2		1248		3204 ab	4451 c
3			2503	2269 bc	4773 c
4	3969	1418		3431 a	8819 ab
5	4820	1361	1939	1844 c	9965 a
6	4376		2770	2212 bc	8612 ab
EX	17136	4026	7214	49599	132,490
x	4283	1342	1284	2755	7,360
Big Meadow (wet)					
1	3800			3573 a	7373 c
2		1673		3489 a	5161 d
3			2879	2779 b	5657 d
4	4055	2014		3166 ab	9235 ab
5	3205	1787	2056	2921 ab	9969 a
6	3262		2618	2892 ab	8772 b
EX	14322	5474	7552	18819	46166
x	3580	1825	2517	3137	7695
Taltson (very wet)					
1	5296			not cut	5296 c
2		3374		not cut	3374 d
3			5584	not cut	5584 c
4	6153	4112		not cut	10265 b
5	5586	4018	4946	not cut	14549 a
6	5842		4699	not cut	10540 b
EX	22875	11504	15229	not cut	49608
x	5719	3834	5076		8268

Yields in a column followed by the same lower case letter are not significantly different (P=0.05)

6.2 Fertilizer

6.2.1 N,P,K,S 1968-70

In order to ascertain if macro-nutrient deficiencies were present or if reasonable yield increase could be achieved a minus type fertilizer trial was laid down on two locations in June 1969. The plots at both sites were cut once each season in late July. The rates used were: 200 kg/ha each of N, P_2O_5, and K_2O with S at 40 kg/ha. Ammonium nitrate, treble super phosphate and muriate of potash along with flowers of sulphur were the sources of fertilizer elements.

Forage production showed significant response to N until the third year. There was no effect on yield from phosphorous, potash or sulphur. Yields on the Grand Detour soil fluctuated more from year to year than those from the Taltson soil and reflected the dry year of 1969. The uptake of P by the forage was increased 30% where it was applied (Table 6.4).

Table 6.4 Three year average yield of hay in kg/ha from an initial application of fertilizer on native forage.

(N, P_2O_5 and K_2O at 200 kg/ha each + S at 40 kg/ha)

	Taltson		Grand Detour	
Taltson Soil	O.D.W.	%P	O.D.W.	%P
NPKS	2337	0.26	2404	0.24
NPK	2330	0.25	2302	0.23
NP	2263	0.26	2304	0.24
N	2398	0.14	2286	0.17
P	1723	0.25	1313	0.26
Nil	1745	0.15	1318	0.17
1968	2145	0.27	3306	0.22
1969	1978	0.20	1067	0.22
1970	2304	0.18	1592	0.21

6.2.2 N rates 1971-74

Because N appeared to be the most limiting nutrient to growth on the native vegetation a N rate trial was established in June 1971 on three areas (Fig. 6.2):

1. On the west end of the Taltson meadow on a small area surrounded by willows which consisted of almost a pure stand of *Carex aquatilis* with a low percentage of *Calamagrostis inexpansa*.
2. On a Grand Detour soil SE of the study site which was made up of *Calamagrostis inexpansa* 50%, *Scolochloa festucacea* 20% and *Carex atherodes* 30%.
3. On the big meadow (wet Grand Detour soil) S of the weather site on an almost pure stand of *Scolochloa festucacea.*

Fertilizer was applied in June 1971 in the form of ammonium nitrate at rates from 0 to 300 kg per ha in 50 kg increments. A fall fertilization of 50 kg/ha was applied in September 1971 and 1973 to one half the plot. Plots were harvested in mid August for three successive years on the Taltson site and four years on the other two areas. In the first year of harvest the yield was taken for the plot as a whole, Hence, the same figure for each side of the split is recorded in 1971. In 1974 the Taltson plots were flooded and could not be cut. On all three areas nitrogen increased yields in the year of application. On the Taltson area maximum increase in yield was achieved by 100 kg of N per ha. On the Grand Detour area this was brought about by 250 kg of N per ha and on the Big Meadow 150 kg of N was the top producer in the initial year. Carry over effect was significant until the third year on the Taltson site with 200 kg of N while it was significant only to the third year on the Grand Detour site and then maximum yield was achieved only for the 300 kg rate of N. For the Big Meadow there were significant increases of forage into the fourth year with the maximum being attained by the highest rate of N.

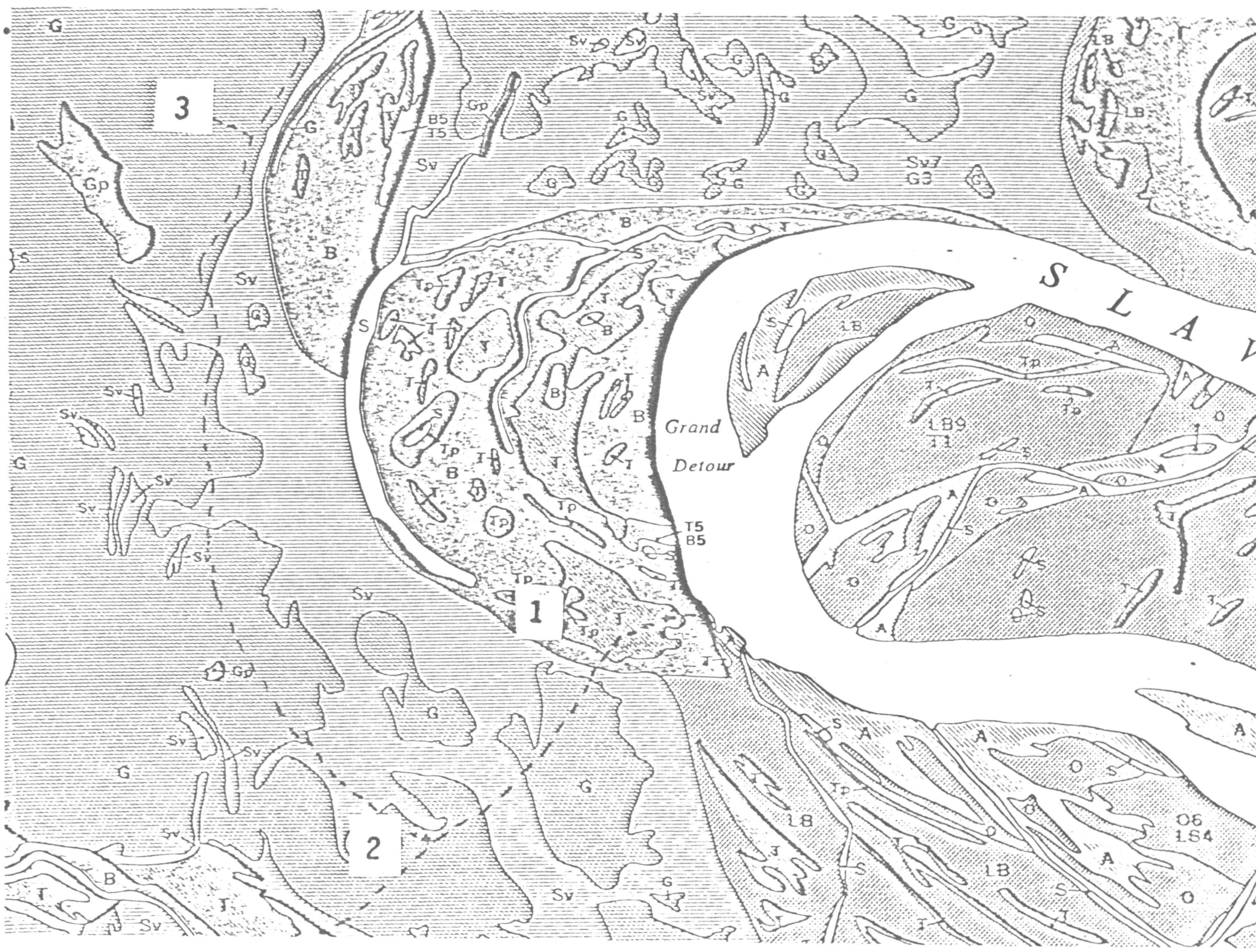


Fig. 6.2 Grand Detour area on Slave River N.W.T. showing location of fertilizer plot sites. 1 Taltson; 2 Grand Detour; 3 Big Meadow; in relation to soil type and distance from the River. (1 in = 1 mi) 1 cm = 0.63 km.

Table 6.5 Yield and percent protein of native grass-Taltson soil, 1971-1973.

	Plot No.	Trt.	kg/ha ODW 1971	kg/ha ODW 1972	kg/ha ODW 1973	kg/ha ODW Total	% Protein ODW 1971	% Protein ODW 1972	% Protein ODW 1973
	1	0	3176 h	3190 d	2992 b	9358 d	10.5 h	11.1 bc	9.4 a
	2	50	4082 d	3630 c	3286 b	10998 bc	11.2 f	10.5 c	9.2 a
	3	100	4519 a	3728 c	2911 b	11158 b	11.8 d	11.1 c	9.3 a
	4	150	3971 e	3787 bc	3317 b	11073 b	11.6 e	11.3 bc	9.3 a
	5	200	3856 f	4297 a	4186 a	12338 a	12.5 c	12.3 ab	10.1 a
	6	250	4252 c	4041 ab	3994 a	12287 a	13.2 a	13.3 a	10.6 a
	7	300	4395 b	4240 a	4219 a	12855 a	12.8 b	12.3 ab	11.3 a
	8	100 +S	3602 g	3814 bc	2806 b	10294 a	11.1 g	10.8 c	9.6 a
	Rate								
A	0	T	3948 a	3615 a	3465 a	11062 a	11.8 a	11.3 a	9.6 a
B	+50N		3948 a	4066 b	3463 a	11510 b	11.8 a	11.9 a	10.0 a

Means followed by the same letter are not significantly different P = .05.

T One half of each plot fertilized with 50 kg/ha of N in September 1971.

Table 6.6 Yield and percent protein of native grass - Grand Detour soil 1971-1974.

No.	Treat.	kg/ha 1971	kg/ha 1972	kg/ha 1973	kg/ha 1974	kg/ha Total	% Protein 1971	% Protein 1972	% Protein 1973	% Protein 1974
1	0	3487 h	1446 d	2174 f	2056 a	9,163 c	8.0 a	10.9 e	8.5 a	7.6 a
2	50	4055 g	1730 cd	2458 de	2353 a	10,597 bc	8.9 b	17.4 e	8.3 a	7.9 a
3	100	4366 f	1772 bcd	2414 e	2410 a	10,962 b	9.2 c	11.9 d	8.5 a	8.2 a
4	150	4817 b	2112 b	2587 cd	2510 a	12,027 ab	10.6 e	12.1 c	7.8 a	7.7 a
5	200	4764 c	2056 bc	2686 c	2197 a	11,703 ab	10.3 f	12.9 c	8.3 a	8.2 a
6	250	5191 a	2467 a	3000 b	2325 a	12,983 a	11.7 f	13.6 b	8.4 a	7.9 a
7	300	4735 d	2070 bc	2502 a	2212 a	12,519 a	11.8 h	15.3 a	8.8 a	8.2 a
8	100 + S	4384 e	1943 bc	2342 e	2028 a	10,695 bc	9.3 d	10.9 e	8.2 a	8.6 a
A[T]	0	4475 a	1832 a	2560 a	1818 a	10,685 a	10.0 a	11.8 a	8.5 a	7.9 a
B	+50 N	4475 a	2066 b	2730 b	2705 b	11,976 b	10.0 a	12.8 b	8.2 a	8.2 a

Means followed by the same letter are not significantly different (P = .05).

T - One half of each plot fertilized with 50 kg/ha of N in September 1971 and 1973.

Table 6.7 Yield and percent protein of native grass - Big Meadow Soil 1971-1974.

		kg/ha D.M.					% Protein			
No.	Treat.	1971	1972	1973	1974	Total	1971	1972	1973	1974
1	0	3033 h	2240 d	2389 de	3318 cd	10981 d	5.5 h	6.7 bc	7.6 c	5.9 a
2	50	3699 c	2694 bc	2864 c	3302 d	12560 c	6.4 f	6.3 c	7.5 c	5.6 a
3	100	3176 g	2438 cd	2379 e	3203 b	11198 d	7.3 d	7.1 bc	7.7 c	5.9 a
4	150	3947 a	2879 b	3045 b	3999 b	13868 b	6.9 e	6.8 bc	7.9 c	5.3 a
5	200	3772 b	2666 bc	2462 de	3601 bcd	12500 c	7.4 c	8.0 b	9.0 a	6.2 a
6	250	3431 f	2836 b	2856 c	3715 bc	12838 c	8.1 b	8.0 b	9.1 a	6.4 a
7	300	3630 d	3573 a	3522 a	4253 a	14978 a	8.3 a	8.5 a	8.4 b	6.4 a
8	100 + S	3517 e	2651 bc	2537 d	3346 cd	12164 c	6.3 g	6.4 c	7.6 c	5.4 a
A[T]	0	3540 a	2567 a	2635 a	3115 a	11864 a	7.0 a	7.1 a	8.0 a	5.1 a
B	+50	3540 a	2921 b	2878 b	4069 b	13407 b	7.0 a	7.3 a	8.2 a	6.7 b

Means followed by the same letter are not significantly different (P = .05).

T - One half of each plot fertilized with 50 kg/ha of N in September 1971 and 1973.

FIGURE 6.3 TALTSON

PROTEIN YIELD IN Kg PER ha

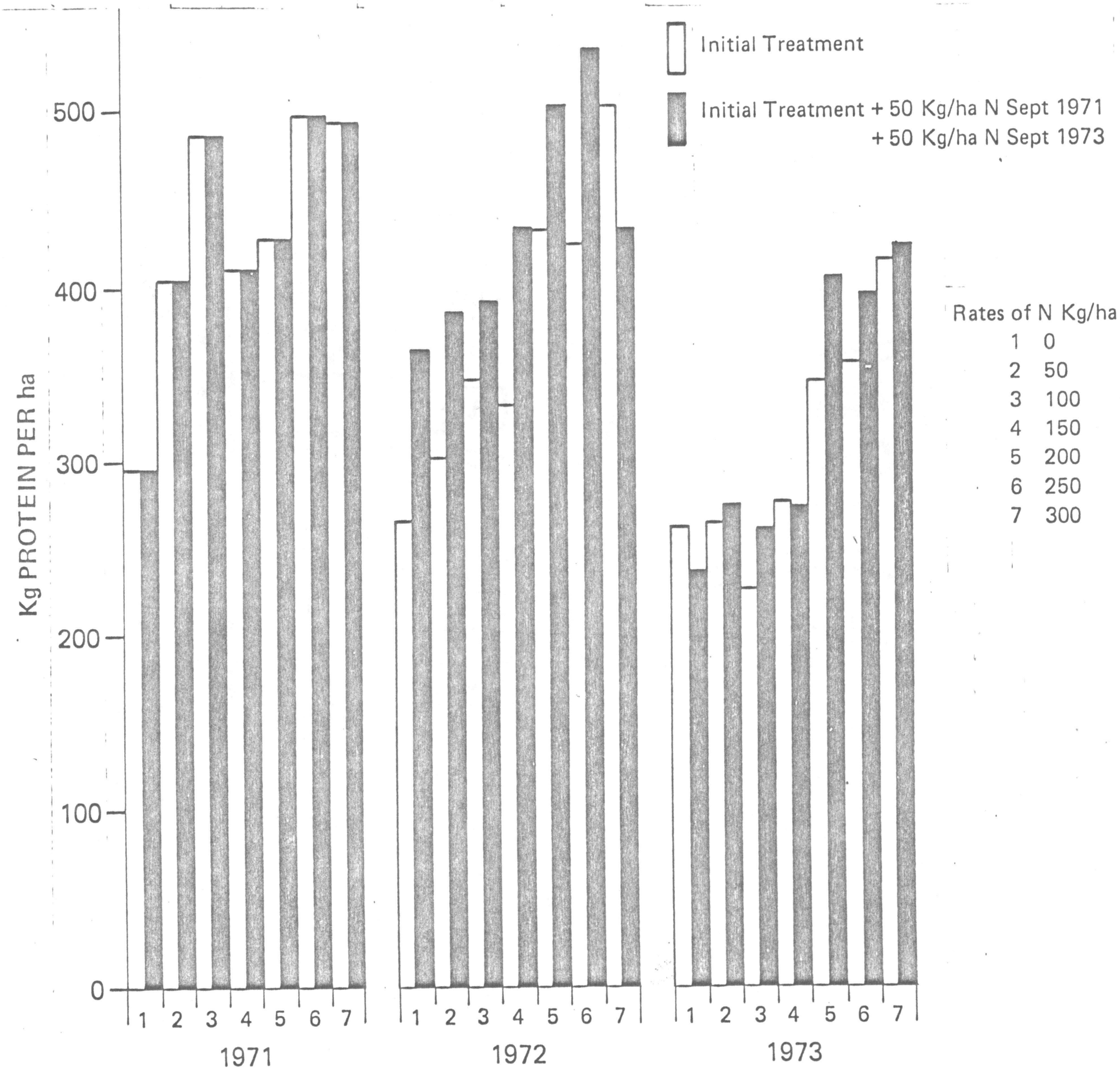


FIGURE 6.4 GRAND DETOUR SOIL

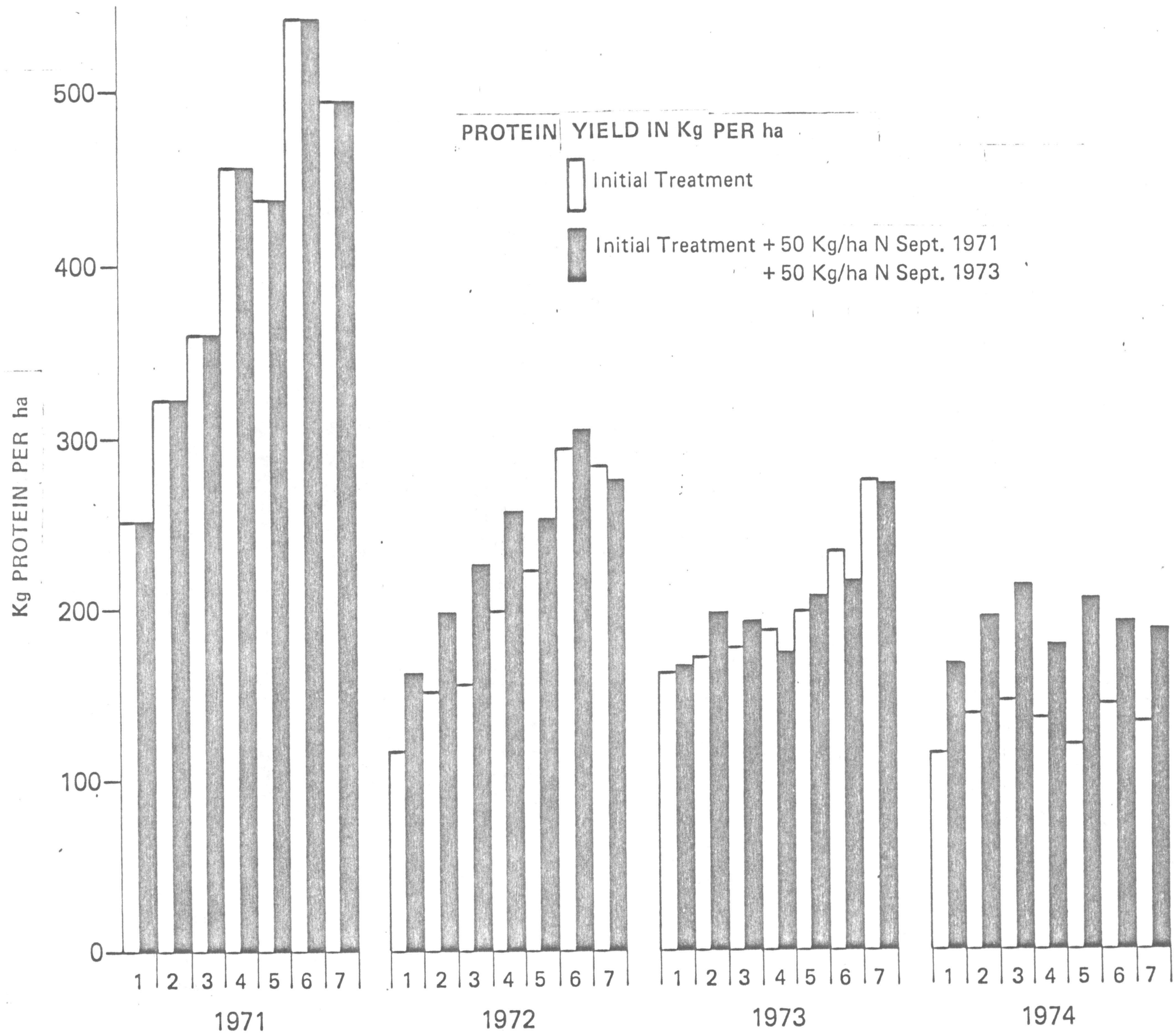
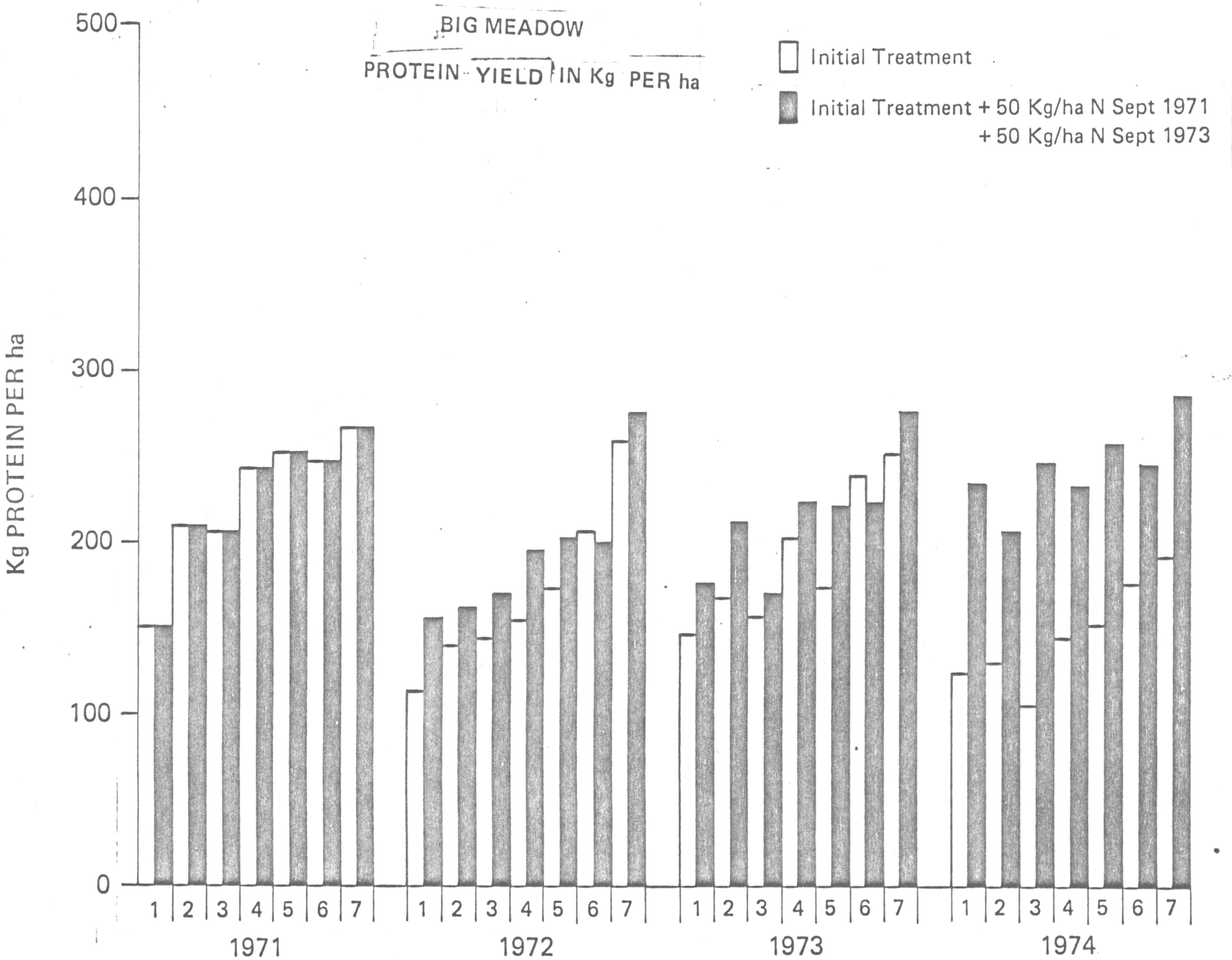


FIGURE 6.5

BIG MEADOW

PROTEIN YIELD IN Kg PER ha



On a total yield basis, the Taltson site (1) yielded almost as much in 3 years as the other two produced in 4 years. For the Grand Detour Site (2), maximum yield was produced by the application of 250 kg of nitrogen which would indicate this is the top of the fertilizer yield curve for a four year yield. On the Big Meadow site (3), the maximum yield was produced by the 300 kg rate which indicates that the maximum application had not been reached (Table 6.5 - 6.7). The forage with the best quality came from the Taltson area with the poorest quality in terms of protein coming from the Big Meadow. This would suggest that a pure sedge stand has better protein quality than a grass stand under the conditions described. For the Grand Detour and Taltson native forage it was shown that increasing rates of N fertilizer increased the protein content only up to the end of the second year following application, while for the wetter Big Meadow plots the effect lasted to the end of the third year (Tables 6.5-6.7).

Using the yield of dry matter and the % protein, the kg of protein per ha for each treatment was calculated. On the Taltson area it was seen that total yield dropped only slightly from 1971 to 1972 and from 1972 to 1973. It was also noticeable that the 100 kg rate of N gave almost as much protein as the two highest rates. The additional fall application of 50 kg per ha N produced increases for all but the highest rate of N, in the second year. Carry over of this added amount lasted into the third year only for the rates above 150 kg per ha (Figure 6.3).

On the Grand Detour area it was noticeable that the 1971 yield was nearly double that of the other three years. It was seen that quantity of protein was increased by initial application and by fall application up to 300 kg rate of N. By the third year the initial rates at 300 were showing a reasonable increase but the 50 kg fall application had been used up. By 1974 the initial rates were still showing small increases but the 1973 fall application was giving very substantial increases for all treatments (Fig. 6.4). For the Big Meadow, yields were somewhat lower in all years and the increases from initial rates of N were of less magnitude than on the other two sites. Very substantial increases in all treatments were affected by the 50 kg/ha of N applied in the fall of 1973 (Figure 6.5).

From the experiments carried out, it may be said that small yearly applications (50 kg per ha of N) are almost as effective as large single treatments of N which last only for three cutting seasons. It is also shown that N applications are more useful on stands of sedge or sedge grass mixtures as they respond more readily and show greater increases in protein content than do pure stands of native grass.

No significant difference was measured from the use of sulphur over the total yield for all three sites.

6.2.3 Economics of applying N

On the basis of the foregoing trials it is obvious that applications of N bring about substantial increases in both dry matter and levels of protein.

To determine if such a treatment could be used economically it becomes necessary to equate the treatment with the return.

It can be seen that 200 kg of N on the Taltson soil can, over three years give an increase of 2980 kg of dry matter (treatment 5 minus check yield). If a kg of dry matter is worth 2 cents, then the 200 kg of N have added 2980 x .02 = 59.60/ha to the value of the crop. This increase in value must then be compared to the going cost of N fertilizer. From this calculation the break even point is approximately 30 cents per kg of N. If, on the other hand, a kg of dry matter is valued at 1 cent of $10.00/t in the field then the 200 kg of N would have added 2980 x .01 = $29.80 to the value of the crop from one ha and the break even point is approximately 15 cents per kg of N.

In a similar fashion, the economics of other rates of application and yields from the various native stands may be looked at. On the basis of an increase in dry matter or total TDN plus an increase in total protein content and taking into account the reduced cost of haying a heavier standing crop the application of N fertilizer would still be questionable.

6.3 Quality of Native Vegetation

6.3.1 General vegetation 5 sites 3 dates (1968-70)

Samples for quality and chemical composition of native forage were taken at the end of June, July and August from 5 plant associations for three seasons. The following soil and major vegetation types were sampled.

1. Taltson soil, semi-wet, _Carex atherodes_, _Calamagrostis inexpansa_.
2. Taltson soil, wet, _Carex aquatilis_.
3. Grand Detour, dry _Calamagrostis canadensis_, _Agropyron trachycaulum_.
4. Grand Detour, semi wet, _Calamagrostis inexpansa_, _Carex atherodes_.
5. Grand Detour, very wet, _Scolochloa festucacea_, _Carex atherodes_.

The samples were over dried at 90°C and ground in a Wiley mill to pass a 1 mm screen. They were then analyzed for acid digestible fibre, (A.D.F.), by the method of Van Soest (1963). Protein was determined by the macrokjeldahl procedure and phosphorous by a modified vanadate ammonium molybdate method of Ward and Johnstron (1962). Ca, Mg. K., Zn, Mn and Cu were determined by atomic absorption spectrophotometry.

Analytical results for the five plant associations are presented in Table 6.8. The analysis shows a marked decrease in crude protein over the season. This decrease is less pronounced for the wetter associations than for the dry ones. It also appears that sedges have a higher protein level than the grasses and they maintain this better over the season. A.D.F. shows the opposite trend but parallels closely the degree of change indicated by protein levels. The data show that in 1969 more protein accrued in the forage than in either 1968 or 1970 and could possibly reflect the cool dry season. Phosphorous levels declined from June to August on all sites. The greatest degree of drop occurs on the wet sites between June and July and on the dry site between July and August. It seems that the Taltson soil is capable of mobilizing slightly more P than the Grand Detour area. Calcium content follows a similar pattern to P but increases over the season rather than decreasing. The Ca/P ratio is least early in the year and increases as the season progresses. It is greatest on the wet Grand Detour soils. Potash from the Taltson area is high, particularly in early cut forage. Zinc does not change with maturity of the vegetation but there does appear to be less in samples from the Grand Detour area as compared to those from Taltson area. Manganese shows a very high content especially from the wetter sites. Copper seems to be more available in the Taltson soil than on the Grand Detour soils and is present in the least amount on the drier associations. Drop in quantity of this element in the vegetation is very marked over the season.

Table 6.8 Average Chemical Composition of Native Vegetation from Specific areas at Grand Detour - 1968-70.

Site	Cut Date	%							ppm		
		A.D.F.	Protein	Ca	P	Ca/P	Mg	K	Zn	Mn	Cu
1. Taltson	June	27.3	15.3	.30	.32	1.1	.13	2.8	57	148	9.7
Semi-wet	July	28.8	12.5	.16	.44	2.7	.13	2.2	53	107	7.2
	Aug.	32.1	10.8	.15	.61	4.2	.13	1.8	66	144	4.7
2 Taltson	June	28.2	14.2	.22	.36	1.6	.13	2.4	33	234	10.7
Wet	July	29.1	11.4	.17	.48	2.8	.12	1.9	33	252	7.9
	Aug.	31.7	10.0	.14	.65	4.6	.12	1.5	32	351	3.9
3 Grand Detour	June	34.9	10.0	.21	.31	1.5	.13	1.2	29	101	2.5
Dry	July	35.5	8.7	.20	.36	1.8	.13	1.0	24	127	2.0
	Aug	38.4	6.5	.14	.41	3.0	.12	0.6	22	113	1.9
4 Grand Detour	June	32.0	12.2	.21	.31	1.5	.14	1.7	29	156	3.8
Semi-wet	July	36.0	9.4	.16	.38	2.3	.14	1.2	25	160	1.9
	Aug.	37.4	7.7	.11	.52	4.7	.15	0.8	30	184	1.7
5 Grand Detour	June	29.1	11.6	.16	.44	2.8	.11	1.9	41	241	6.4
Wet	July	32.3	10.0	.12	.52	4.3	.11	1.6	39	207	4.1
	Aug.	34.2	8.6	.10	.65	6.8	.11	1.0	38	250	2.1

6.3.2 Single species analysis

As a follow up to the analysis of mixed vegetation by zones, single species were collected at the end of June, July and August for the years 1972-1974. These species were taken from the same site each time and consisted of whole plants from crown to extremities. The following were selected:

1. Scolochloa festucacae - Whitetop, from Site 4 pathways.
2. Carex aquatilis - water sedge, fertilizer plot area on Taltson from pathways (not taken in 1974).
3. Carex atherodes - awned sedge, from east end of Taltson near clipping plots.
4. Calamagrostis inexpansa - northern reedgrass, Grand Detour clipping area.
5. Poa palustris - fowl meadowgrass, near fertilizer plots on Taltson meadow (1972 and 1973 only).
6. Vicia americana - American vetch, in forest edge north of Grand Detour plot area (1973 and 1974 only).
7. Calamagrostis canadensis - bluejoint, north of Grand Detour plot area (1974 only).

The same methods were used to analyze these samples as had been used on the 1968-70 samples with the exception that acid digestible detergent fibre was not determined. Results were somewhat similar to those found previously as regards the levels of nutrients and the change in % composition over the season (Table 6.9). Protein levels for sedges were highest in June and held their levels better than the grass. The native American vetch contained a surprising amount of protein and P which maintained itself well throughout the summer.

6.3.3 Evaluation and interpretation of chemical composition of native forage.

It is difficult to allocate specific levels of nutrients as being adequate or inadequate for beef cattle nutrition. It will depend upon the class of cattle, the time of year and the excess or deficiency of other elements. Goodrich, (1965) summarized requirements of minerals by several authors including NRC (1958). He lists levels that should meet all mineral requirements of cattle as follows:

Table 6.9 Chemical Composition of Forage Grand Detour 1972-74

	Month	% Protein	% Ca	% P	% Ca/p	% Mg	% K	P.P.M. Zn	P.P.M. Mn	P.P.M. Cu
Scolochloa	June	10.3	.135	.23	1.7	.11	1.76	29	91	4.5
festucacea	July	8.9	.064	.19	3.0	.09	0.86	19	56	1.2
(3 yrs)	Aug.	6.1	.058	.34	4.3	.14	0.57	28	114	1.1
Carex	June	13.1	.188	.37	2.0	.14	2.58	76	194	10.6
aquatilis	July	10.8	.166	.40	2.4	.13	2.29	84	241	7.6
(2 yrs)	Aug.	7.2	.128	.54	4.2	.13	1.77	70	227	3.0
Cares	June	14.4	.208	.37	1.8	.13	2.19	74	101	11.5
atherodes	July	10.6	.127	.41	3.2	.12	2.24	83	114	7.1
(3 year)	Aug.	8.9	.010	.49	4.9	.13	2.09	98	127	5.3
Calamagrostis	June	11.3	.194	.24	1.2	.11	1.34	16	133	1.8
inexpansa	July	9.0	.154	.30	1.9	.10	1.15	17	142	1.7
(3 yrs)	Aug.	7.4	.145	.38	2.6	.11	0.77	15	157	1.2
Poa	June	7.8	.203	.19	0.9	.10	1.70	46	50	2.8
palustris	July	7.2	.134	.17	1.3	.08	0.98	34	56	1.5
(2 yrs)	Aug.	5.6	.076	.18	2.4	.07	0.56	31	58	0.9
Vicia	June	24.5	.296	.76	2.6	.25	2.36	60	58	4.9
americana	July	20.4	.312	1.04	3.3	.24	2.32	57	32	8.5
(2 yrs)	Aug.	17.6	.216	1.22	5.6	.28	1.55	34	16	7.9
Calamagrostis	June	9.4	.138	.35	2.6	.08	1.10	50	174	3.1
canadensis	July	8.6	.128	.38	3.0	.08	0.91	48	241	1.4
(1 yr.)	Aug.									

Estimated mineral requirements of cattle:

	%		ppm
Calcium	0.30	Iron	75-100
Phosphorous	0.25	Manganese	20
Magnesium	0.10	Copper	6-10
Potassium	0.60	Cobalt	0.1-0.2
Sodium	0.15	Zinc	30-50
Chlorine	0.20	Molybdenum	1
Sulphur	0.15	Iodine	0.2-0.5
		Selenium	0.1

Phosphorous in a ration should be at least 0.18% (Nat. Ac. of Sci 1970). All samples analyzed with the exception of American vetch would be limiting in P content at hay cutting stage. Calcium requirements are just a little greater than P and the Ca/P ratio should not exceed 6:1. All collections contain adequate supplies of Ca. An exception is *Poa palustris* (Fowl meadowgrass) and this shows a decrease as the season progresses.

If the native stands were cut for hay during late July or August then this material would be marginal for protein, inadequate for P and marginal for Cu. In all other respects it would be adequate.

As individuals, the grasses whitetop and northern reedgrass, appear to lack adequate levels of Zn. Reynolds and Pringle in 1975, in the Hook Lake area, observed that bison removed only the upper 25% of the leaf of awned sedge and whitetop where forage was ample. This may be one way of assuring a higher protein diet.

If native vegetation was the main source of forage for a livestock enterprise, it would be necessary to supply P, supplemental protein, and a trace mineralized salt containing Cu and Zn.

7. CULTIVATED FORAGE

7.1 Forage Plant Adaptation Plots

Nurseries were seeded in Grand Detour and Taltson plot areas in 1969 and on the Slave area in 1970. These were single 6.1 m rows, 0.61 m apart. Thirty grasses and 11 legumes were included. These nurseries were observed annually in June to determine the winter kill and the earliness of growth and were evaluated again in August to record spread and seed set on the grasses and legumes on trial. On June 1, 1971 buffalo had grazed inside the fence on the Slave Soil plots. They seemed to prefer fescues, meadow foxtail, intermediate wheatgrass, timothy, slender wheatgrass, Kentucky bluegrass, Russian wildrye, Polar brome and Siberian wildrye. No legumes were utilized. Similar utilization by bison occurred in 1972. At that time they showed preference for the same species except that Fairway crested wheatgrass was heavily grazed and the smooth bromes were lightly grazed.

From the three nurseries the outstanding plants for adaptation on a short-lived basis were: Climax timothy, Chief intermediate wheatgrass, Revenue slender wheatgrass, Boreal creeping red fescue, Aurora alsike clover and Leo birdsfoot trefoil. On a long-lived basis the outstanding plants were: Fairway crested wheatgrass, meadow foxtail, Reed canarygrass, Russian wildrye, Carlton bromegrass and falcata alfalfa. Meadow foxtail has "seeded out" and now occurs over most of the plot areas. This seems to be a plant that can become established even under conditions of severe competition. All the better adapted grasses and legumes performed well giving high yields in all years observed (Figure 7.1).

7.2 Forage Variety Trials

Ten forage species of proven adaptability under northern conditions were selected and seeded into the three plot areas. These were broadcast on the Grand Detour site in 1969. The same trial was seeded in rows spread at 15.2 cm (6 inches) on the Slave soil in June 1970 and on the Taltson soil in June 1971. The Taltson seeding followed an unsuccessful attempt at broadcast seeding the area. Plots were cut using a sickle bar mower from July 10 to July 29 depending upon the year and the maturity of the forage. Samples were taken from which dry matter was determined and a small sample was retained for chemical analysis.

The Grand Detour plots gave surprisingly high first year yields. In the second year the alfalfa had diminished. Trefoil was almost killed out. Some of the grasses were suppressed and yields were much reduced. In the third year plots were destroyed by fire. In the fourth year, the alfalfa plots recovered and produced over 4,000 kg per ha. Only alfalfa, bromegrass, intermediate wheatgrass and meadow foxtail were worth cutting in that year.

Figure 7.1 The Taltson nursery August 1971, showing the amount of growth on Reptans creeping red fescue, meadow foxtail, Kentucky bluegrass, three bromegrasses and reed canary-grass listed from left to right.

Figure 7.2 Crested wheatgrass plot on Taltson soil August 6 showing regrowth in centre since cutting on July 16.

It was evident that one year of summerfallow was insufficient preparation allowing sedges and native grasses to become prevalent by the end of the third season. Best production on this area came from bromegrass and alfalfa, with intermediate wheatgrass yielding well in the first two years.

The Slave soil plots showed poor establishment because of crusting and baking of the soil surface. Once established, alfalfa gave the best yield followed by intermediate wheatgrass and bromegrass. Yields on this site were lower than the other two areas. Moisture seemed to be the limiting factor.

The Taltson plot area produced heavily in its first harvest year. Creeping red fescue, intermediate wheat and crested wheatgrass produced more than 4,000 kg per ha dry matter. In the second harvest the yields were just over 2,000 kg per ha with intermediate wheatgrass, bromegrass and crested wheatgrass having the greatest yields. In the third year, alfalfa, chrested wheatgrass (Figure 7.2), timothy and meadow foxtail all yielded better than 3,000 kg per ha.

All samples were analyzed for protein (Table 7.1). The areas were not fertilized, therefore the variability in total N in the forage was a reflection of the inherent fertility of the individual area. It showed that the Taltson soil produced forage of higher protein content than the other two locations. Understandably, the legumes were higher in total N than the grasses.

Figures for total dry matter production and total protein production are given in Table 7.2. They are on a one cut basis only and range from 4,700 kg/ha to less than 1,000 kg/ha. It should be noted that by August 31 there was good regrowth on all plots particularly the legumes. In the years 1970 and 1973 rainfall was ample following first harvest and aftermath was estimated to be in excess of 800 kg/ha of dry matter on the Taltson plots. This could have provided a second hay cut or could be grazed had livestock been available.

For either of the three soil types alfalfa and bromegrass seem to provide the steadiest forage production and the highest yield of crude protein for hay. As a grazing species meadow foxtail, crested wheatgrass or creeping red fescue would be well adapted. For sustained production, the grasses would require annual applications of N. Observations in mid-July 1975 and again in September 1976 showed that meadow foxtail and

Table 7.1 Forage Variety Trial - % Protein

		Grand Detour			Slave			Taltson		
		1970	1971	1973	1971	1972	1973	1972	1973	1974
1	Bromegrass, Manchar	5.06	5.11	7.60	6.34	6.18	8.01	8.20	9.07	6.25
2	Alfalfa, Rambler	13.41	13.25	12.45	9.59	16.50	14.24	14.02	14.80	14.90
3	Intermediate Wheatgrass, Chief	6.32	5.92	6.29	5.08	6.51	6.78	8.89	6.99	6.32
4	Crested Wheatgrass, Summit	6.42	7.36		5.05	6.74	6.70	9.19	7.07	6.42
5	Timothy, Climax	5.83	6.46		5.25	6.51	7.60	6.66	6.43	5.26
6	Alsike Clover, Aurora	12.16	13.60		12.03	14.04	12.84	13.03	16.53	13.84
7	Meadow Foxtail, Common	6.32	6.59	8.98	5.48	6.76	8.12	8.70	7.97	6.47
8	Reed Canarygrass, Frontier	9.28	7.06		5.37	7.03	11.51	8.17	8.71	6.51
9	Birdsfoot Trefoil, Leo	9.60			8.62			12.94	14.69	13.12
10	Creeping Red Fescue, Boreal	8.51	6.77		7.89	6.85	8.54	8.17	8.28	7.99

Table 7.2 Forage Variety Trial

a) Grand Detour Soil

Variety	kg/ha Dry Matter 1970	1971	1973	kg of Protein/ha 1970	1971	1973
Bromegrass, Manchar	5,049 a	2,166 a	1,606 b	256	111	113
Alfalfa, Rambler	4,558 ab	1,768 abcd	5,272 a	611	234	656
Intermediate wheatgrass, Chief	4,052 bc	2,020 abc	1,944 b	256	120	122
Crested wheatgrass, Summit	3,800 bcd	2,073 ab		244	152	
Timothy, Climax	3,707 bcd	1,169 f		216	75	
Alsike Clover, Aurora	3,228 cd	1,608 cde		392		
Meadow foxtail, Common	2,976 d	1,608 cde		188	105	85
Reed Canarygrass, Frontier	2,949 d	-		274		
Creeping Red Fescue, Boreal	2,883 d	1,210 ef		246	82	
Birdsfoot Trefoil, Leo	1,980 e	-		189		
x	3,519	1,703	2,444			
CV	16%	15%	15%			
SEX	286	128	180			
Date Cut	July 19	July 22	July 31			

b) Slave Soil

Variety	kg/ha Dry Matter 1971	1972	1973	kg of Protein/ha 1971	1972	1973
Bromegrass, Manchar	1,873 c	1,629 bc	1,272 cd	119	133	102
Alfalfa, Rambler	1,930 bc	2,657 a	2,936 a	185	372	418
Intermediate wheatgrass, Chief	2,445 b	1,789 b	1,776 bc	124	159	120
Crested wheatgrass, Summit	1,780 c	1,310 cd	1,364 cd	90	120	91
Timothy, Climax	1,820 c	1,612 bc	1,188 cde	95	108	90
Alsike Clover, Aurora	1,090 d	2,657 a	2,313 b	131	346	297
Meadow Foxtail, Common	1,501 cd	1,115 cd	1,077 de	82	96	87
Reed Canarygrass, Frontier	3,535a	1,381 bcd	631 e	189	113	73
Creeping Red Fescue, Boreal	1,036 d	992 d	778 de	82	81	66
Birdsfoot Trefoil, Leo	1,253 d	-	-	-	-	-
x	1,826	1,638	1,482			
CV	17%	17%	21%			
SE $\bar{x}$	158	167	178			
Date Cut	July 20	July 19	July 13			

Table 7.2 Forage Variety Trial (continued)

c) Taltson Soil

Variety	kg/ha Dry Matter 1972	kg/ha Dry Matter 1973	kg/ha Dry Matter 1974	kg Protein / ha 1972	kg Protein / ha 1973	kg Protein / ha 1974
Bromegrass, Manchar	4,344 ab*	2,795 ab	2,852 b	356	240	178
Alfalfa, Rambler	4,198 b	2,649 ab	3,521 ab	589	397	521
Intermediate wheatgrass	5,222 a	3,144 a	1,860 c	464	220	118
Crested wheatgrass, Summit	4,635 ab	2,743 ab	3,508 ab	426	203	225
Timothy, Climax	4,278 b	2,340 abc	3,880 a	285	160	204
Alsike Clover, Aurora	3,441 cd	943 d	3,401 ab	448	156	471
Meadow Foxtail, Common	3,149 de	2,476 abc	4,000 a	274	197	259
Reed Canarygrass, Frontier	4,143 bc	1,620 cd	1,807 c	339	137	118
Creeping Red Fescue, Boreal	5,355 a	2,381 abc	3,042 ab	437	205	243
Birdsfoot Trefoil, Leo	2,697 e	2,009 bc	1,674 c	349	295	220
$\bar{x}$	4,144	2,310	2,955			
CV T	11%	24%	20%			
SE $\bar{x}$ N	222	276	302			
Date Cut	July 18	July 10	July 16			

* means followed by the same lower case letter are not significantly different (P = .05).

T CV = coefficient of variability

N SE $\bar{x}$ = standard error of the mean

Figure 7.3 Cereals and oilseeds growing on the Taltson plot area, August 1970. These oats, wheat, flax and rapeseed (left to right) did not mature but were harvested for total dry matter.

reed canarygrass on both meadow locations were spreading into other plots indicating that they are two of the most aggressive plants in the test.

7.3 Cereal and Oilseed Trials

Barley, oats, wheat and flax were grown for the years 1970-72. They were planted in the first week of June in 21 cm rod rows but were not replicated (Figure 7.3). At no time did any of the plots mature and produce grain. In all instances summer frost prevented maturity. Plots were cut for green feed at the end of August and yields are reported in kg/ha dry matter (Table 7.3). In 1974, forage silage plots were put in but establishment was very poor because very little rain fell until July, therefore, they were not cut for yield. June precipitation is a limiting factor for production of annuals. Earlier seedings in late May would have little advantage because at that time soils are cold and germination is not likely on the two meadow areas until after June 1. This does not allow enough time for the grain to mature before a frost prevents full formation of the kernels. In 1972, a frost in mid July even eliminated the viability of crested wheatgrass seed. If cereals are used in the lowlands, it will be for hay or silage as production of grain would be virtually impossible in the majority of years using the current varieties.

Use of 100 kg per ha of 11-48-0 applied with the seed resulted in large increases in dry matter yield in barley and wheat and to a lesser extent for oats and flax. The largest increases were from the two meadow soils.

7.4 Fertilizer on brome-alfalfa

Factorial fertilizer trials using N and P at 100, 200 and 300 kg/ha and K in a blanket application at 100 kg/ha were applied one year after seeding.

Carlton bromegrass and Rambler alfalfa had been broadcast seeded on the Grand Detour site in 1969.and on stands that had been drilled with the legume at right angles to the grass in 15 cm rows on the Slave soil in 1970 and on the Taltson soil in 1971. The seeding rate was 6 kg/ha for the grass and 4 kg/ha for the legume which was inoculated with nitrogen AB type inoculant.

Table 7.3 Yield of Cereals & Oilseeds in kg/ha - dry matter averaged over 3 years.

		Grand Detour		Slave		Taltson		Avg. 3 sites	
		NF	F	NF	F	NF	F	NF	F
Barley -	Olli	2579	5294	4036	4003	3838	4902	4484	4733
	Gateway	2586	5344	3957	5033	3807	4994	3450	5135
	$\bar{x}$ Barley	2583	5319	2996	4519	3823	4948	3411	4928
Oats -	Abeqweit	4320	5215	3686	5927	3325	5014	3777	5385
	Random	6634	7002*	6080	5399	4834	7930	5849	6776
	Pendek	3907	5599	5990	2601	2409	3320	4102	3841
	$\bar{x}$ Oats	4954	5938	5252	4642	3522	5420	4576	5334
Wheat -	Garnet	2734	5736	4052	5048	2557	4560	3114	3605
Flax -	Noralta	3033	2794	2323	3167	2336	2314	3763	4780

NF - No fertilizer -- f-100 kg/ha11-48-0

* Random oats in 1971 produced an average of 6392 pounds of Dm and as this oat was only growin in 1971 and 1972, it pushed up the 3 year average on the Grand Detour soil. Similarly it produced heavily on the Taltson soil in 1971.

It is evident that crops respond to fertilizers only on the two meadow soils and not on the Slave type. It may be that moisture is limiting in that location.

The plots were harvested between July 15 and 20 each year using a Gravely mower. A chopped 500 gm sample was extracted from each cut and oven dried at 90°C which was used to calculate the oven dry yield of each plot. A sample of this oven dry material was ground in a Wiley mill to pass a 1 mm screen. P was determined by the ammonium molyhdate method, N by macrokeldjal and Ca using atomic absorption.

The dry matter yields, % N, % P, % Ca, Ca/P ratio and total protein per acre for each harvest year were calculated and summarized.

7.4.1 Taltson 1972-74

The Taltson plots gave the heaviest yield of hay for the three locations tested with a three year average of 4922 kg/ha. Forage crops on Taltson soil were the least responsive of the forages on three sites to added N but did appear to benefit from increasing rates of P (Table 7.4). The average yield of protein for the three years was not affected by the fertilizer treatments. The crude protein level of the forage averaged less than 10%. There did not appear to be any difference in yield of alfalfa across the plots as affected by fertilizer treatment. The Taltson area has a good growing potential with an apparent high inherent soil fertility, hence was not affected appreciably by the fertilizer treatments. The P content of the forage was increased by the application of P. The Ca/P ratio was greatest where no P was applied and least where a high rate of P was used. The unfertilized forage recorded an 8:1 ratio Ca/P as compared to an overall plot average of 6.6:1. These figures are high, therefore the hay from this area may require supplementation in the ration if it was the only source of feed. Since plots were cut in late July, a second cut was not taken for yield but it was estimated that 700 kg/ha was the regrowth in most years.

7.4.2 Grand Detour 1970-71, 73

This area was broadcast seeded on June 2, 1969. It was harrowed over to cover the seed. A reasonable establishment was achieved on a one year summerfallow. Plots were fertilized in June 1970. The Grand Detour forage plots had a lower total yield than the Taltson area with greater year to year fluctuation (Table 7.5). The plots were burned out in 1972 by an accidental fire but were cut again in 1973. Nitrogen was the limiting nutrient and this effect lasted through to the fourth year. The increases were not large, and the amount decreased over time.

Table 7.4 Average Yearly Yields and Quality from Taltson Factorial Fertilizer Plots on Brome-Alfalfa for Year 1972, 1973, 1974.

Treatment 1 = 100 kg/ha	Yield kg/ha	N%	P%	Ca%	Ca/P	Protein Yield kg/ha
NPK						
001	4083 d*	1.72 a	.098 c	.828 ab	8.00 ab	439 a
011	4588 bcd	1.59 ab	.104 bc	.820 abc	7.86 abc	465 a
021	4938 abc	1.55 ab	.114 bc	.826 abcd	7.24 abcd	484 a
031	5161 ab	1.49 ab	.110 bc	.782 ab	7.05 abcd	470 a
101	4817 abcd	1.43 b	.109 bc	.716 ab	6.70 abcd	431 a
111	4796 abcd	1.60 ab	.105 c	.916 a	8.36 a	476 a
121	5278 ab	1.55 ab	.115 bc	.803 ab	7.09 abcd	515 a
131	5157 ab	1.44 ab	.130 ab	.627 ab	4.62 cd	473 a
201	4284 cd	1.65 ab	.104 c	.906 a	8.52 a	453 a
211	5269 ab	1.50 ab	.100 c	.678 ab	6.70 abcd	487 a
221	5142 ab	1.53 ab	.116 bc	.678 ab	5.60 abcd	493 a
231	5592 a	1.41 b	.116 bc	.504 b	4.19 d	496 a
301	4498 bcd	1.63 ab	.096 c	.779 ab	7.68 abc	468 a
311	4939 abc	1.56 ab	.103 c	.637 ab	5.92 abcd	486 a
321	5182 ab	1.55 ab	.115 bc	.588 ab	5.06 bcd	518 a
331	5092 ab	1.62 ab	.140 a	.670 ab	4.64 cd	528 a
Maximum	7230					
Minimum	2635					
Mean	4022	1.50	.111	.735	6.58	480

* Means followed by the same letter do not differ significantly (P = 0.05).

Table 7.5 Average yearly yields and quality from Grand Detour factorial fertilizer plots on brome-alfalfa for years 1970, 1971, 1973.

Treatment NPK 1 = 100 kg/ha	Yield kg/ha	N%	P%	Ca%	Ca/P	Protein Yield kg/ha
001	2675 gh	1.23 bcde	.124 bcd	.646 a	5.10 a	202 ef
011	2612 h	1.13 de	.141 b	.526 abc	3.77 bcd	172 f
021	2978 efgh	1.15 de	.128 bcd	.546 abc	4.21 abcd	208 def
031	2910 fgh	1.19 cd	.144 ab	.553 abc	3.90 abcd	199 ef
101	3425 bcde	1.05 e	.114 d	.359 c	3.38 cd	226 def
111	3197 def	1.14 de	.128 bcd	.510 abc	4.11 abcd	219 def
121	3192 def	1.21 bcde	.139 bc	.540 abc	3.80 bcd	229 de
131	3150 ef	1.21 bcde	.138 bc	.628 ab	4.53 abc	228 de
201	3396 cdef	1.23 bcde	.118 cd	.579 abc	4.81 ab	262 cd
211	3806 abc	1.30 abcd	.127 bcd	.403 abc	3.55 bcd	308 bc
221	3795 abc	1.20 bcde	.128 bcd	.382 bc	3.35 cd	297 bc
231	3692 bcd	1.25 bcde	.144 ab	.413 abc	3.01 d	295 bc
301	3844 abc	1.42 ab	.129 bcd	.524 abc	4.18 abcd	343 ab
311	3911 ab	1.50 a	.129 bcd	.396 abc	2.97 d	376 a
321	4249 a	1.26 bcde	.129 bcd	.353 c	3.10 d	349 ab
331	3863 abc	1.41 abc	.162 a	.533 abc	3.53 bcd	341 ab
Maximum	7905					846
Minimum	1445					99
Mean	3418	1.28	.132	.493	3.83	266

* Means followed by the same letter do not differ significantly (P = 0.05).

Table 7.6 Average yearly yields and quality from Slave factorial fertilizer plots on brome-alfalfa for Years 1971, 1972, 1973, 1974.

Treatment 100 kg/ha NPK	Yield kg/ha	N%	P%	Ca%	Ca/P	Protein Yield kg/ha
001	2458 bcd*	1.62 b	.195 bcd	.567 bc	3.10 abcd	255 b
011	2164 d	1.73 ab	.191 cd	.636 abc	3.54 abc	233 b
021	3134 abc	1.77 ab	.198 abcd	.780 a	4.05 a	353 ab
031	2568 bcd	1.68 ab	.217 a	.727 ab	3.75 abc	276 b
101	2554 bcd	1.65 b	.194 bcd	.617 abc	3.33 abcd	271 b
111	2570 abcd	1.79 ab	.196 bcd	.632 abc	3.39 abc	284 ab
121	2521 bcd	1.65 ab	.187 d	.579 abc	3.17 abcd	264 b
131	2402 cd	1.74 ab	.205 abcd	.656 abc	3.26 abcd	262 b
201	2898 abcd	1.72 ab	.194 bcd	.584 abc	3.18 abcd	316 ab
211	2403 cd	1.78 ab	.201 abcd	.567 abc	2.86 cd	267 b
221	2925 abcd	1.85 ab	.207 abcd	.654 abc	3.26 abcd	342 ab
231	2612 abcd	1.85 ab	.215 ab	.667 abc	3.21 abcd	304 ab
301	2898 abcd	1.61 b	.198 abcd	.473 c	2.41 d	293 ab
311	2358 cd	1.78 ab	.193 cd	.558 bc	3.02 bcd	260 b
321	3362 a	1.91 ab	.211 abc	.675 abc	3.40 abc	405 a
331	3231 ab	1.96 a	.207 abc	.758 ab	3.86 ab	401 a
Maximum	5049	2.40	-			689
Minimum	1283	0.90				114
Mean	2691	1.75	.200	.633	3.16	299

* Means followed by the same letter do not significantly differ (P = 0.05).

The P content of the forage was very low in all years averaging less than .14%. Applying P increased the P content but did not bring it up to an optimum level (0.2%). Calcium also was low in the forage averaging less than 0.5%, Ca/P ratio averaged 3.7:1. Yield of protein was almost doubled by applying a high level of N (Table 7.5).

A second cut of forage was estimated to be 400 kg/ha in late August.

At the end of four years, there was very little alfalfa remaining in the plots which were then almost solid stands of bromegrass.

7.4.3 Slave 1971, '72, '73, '74

The Slave fertilizer plots produced the lowest yield of the three areas tested. This forested soil tended to be droughty which seriously hampered growth of the forages.

The four year average yield was 2,694 kg/ha with the high of 3,105 kg/ha in 1974.

Nitrogen appeared to give the greatest increase with little or no increase being added by the phosphorus (Table 7.6). Increases in dry matter were not significant after the second harvest year.

The yield of protein was affected only by the highest rate of N. The protein content of forage from this site was much higher than that from the gleysolic soils for each year.

The P content was reasonably high and was increased by the third and fourth level of additional P. The Ca/P ratio was low and was little affected by the fertilizer treatments.

Aftermath growth was estimated to be 400 kg/ha.

7.4.4 Discussion of N and P on yield and quality

On all three locations good stands of grass and legume were established. Even though there was some increase in yield following application of N and P, it must be recognized that the increases were small in comparison to the rates of fertilizer applied. The most responsive soil was the Grand Detour and the least responsive was Taltson which was also the most productive.

The nitrogen levels which were used to determine protein content (N x 6.25) were greatest for the forested Slave soil at 1.75%, for the Grand Detour 1.24% and for the Taltson 1.50%. Material with less than 1.3% nitrogen could be used only as a wintering maintenance ration for beef cattle.

During the first year following application of fertilizer on the Grand Detour soil N content of the forage was markedly increased, however, it did not reach the 15% protein level optimally found in a good quality alfalfa-brome hay (Morrison, 1956). The Ca levels are highest in the forage from the Taltson area which unfortunately has the lowest phosphate level thus creating an unfavourable Ca/P ratio. The Grand Detour forage has inadequate P content and a low Ca content which could result in an inadequate hay ration with respect to these two elements. In contrast to the two gleysolic soils, forage from the Slave plots contained almost an adequate supply of both Ca and P in a reasonable balance. It is speculated that plants on the peaty gleysols even though adequately supplied with P, were unable to absorb the element. A similar observation was made in Finland (Kaila, 1958).

On all three sites the alfalfa diminished and at the end of the fourth year, the stands were mainly bromegrass. The application of the fertilizer treatments did not appear to affect this change in species composition.

7.4.5 Nitrogen produced from inoculated alfalfa

Legumes on the two meadow plot areas were dug and analyzed for nitrogen production in July 1973 (Figure 7.4). The method used was the acetylene reduction assay of Paul, E. A. et al (1970).

Results of the assay are as follows:

Soil	Crop	Fixation mg/m^2 /hr
Grand Detour	Alfalfa, Rambler	0.01
	Alsike clover, Aurora	1.09
	Alfalfa, Falcata	0
	Red clover, Tammisto	0.85
Taltson	Alfalfa, Rambler	0.07
	Alsike clover, Aurora	0.60
	Birdsfoot trefoil, Leo	0.81
Slave	Native vetch (Vicia americana)	0.21

A reading of 1 $mg/m^2/hr$ is equivalent to about 45 kg/ha N/season. So it may be judged that alsike clover, red clover, and birdsfoot trefoil were the only plants imparting appreciable nitrogen to the soil. The alfalfa in all locations was so low as to be negligible. This suggests that the inoculum did not live and thrive at the time of seeding or that it dies

Figure 7.4 The acetylene reduction assay for nitrification of legumes being carried out in the field. The alfalfa was 4 years old and very vigorous.

Figure 7.5 Reed canarygrass showing better color and more heads where it is combined with alfalfa compared to a pure grass stand.

out in the interim years between seeding and the assay. Even so, on some locations where alfalfa was growing with or adjacent to grass there appeared to be a beneficial effect indicated by better color and vigor on the grass compared to the same plot where alfalfa was absent (Figure 7.5).

8. SOILS

8.1 Soil salinity

The Salt River plains, the existance of halophytic plants and salt encrustations on roadways attest to the fact that salts are present in larger than normal amounts (Figure 8.1). Day (1972), described a saline Taltson soil (TV) which is found just north of the Salt River and along the Little Buffalo River.

Early in the project it was noted that bison wallows were being revegetated by the halophyte glasswort (*Salicornia rubra*). It was felt that salts were being drawn to the surface by increased evaporation from the blackened puddled or wallowed areas.

In 1970, soils from each of the research sites was sampled down to 90 cm and each horizon was analyzed by the Alberta Dept. of Agriculture Soil and Feed Testing Laboratory, giving the results as found in Table 8.1. The Grand Detour soil indicated high salts EC (electrical conductivity) 4.5 mmhos/cm in the 12-18 cm layer. It also showed a high sodium content throughout the soil. Such salts definitely inhibit crop production, therefore further sampling was carried out in 1973 and 1974 to determine the extent, degree of salinity and types of salts present over the lowlands.

The fact that disturbance or cultivation of some areas increases salinity in the surface of the Grand Detour soil type is of great importance. Such disturbance could bring about solodization of the soil and a lowered capability for crop production (Figure 8.2).

On an area that had been scraped by a bulldozer in the process of burying bison killed by anthrax in 1964, the soil salt content was exceptionally high. The affected patch appeared to have spread beyond the part that had originally been disturbed (Figure 8.3). On that meadow the EC of the surface 10 cm of soil read 55 mmhos/cm where the black surface was devoid of any vegetation. Toward the edge of the black area grew glasswort on a soil of EC 29 mmhos/cm. Ringing the area was a fringe of wild barley on a soil of EC 9.1 mmhos/cm and out from this was the meadow proper supporting a typical stand of sedge and grass on a soil of EC 5.8 mmhos/cm.

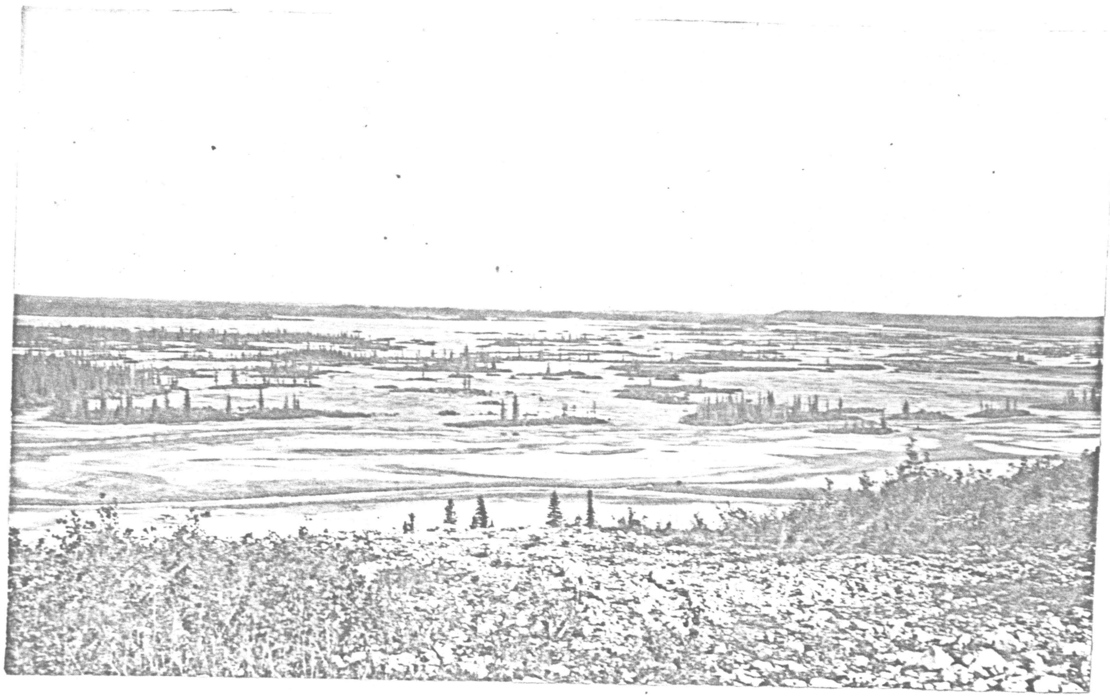


Figure 8.1 The Salt River plains showing saline accumulations in the areas west of Ft. Smith.

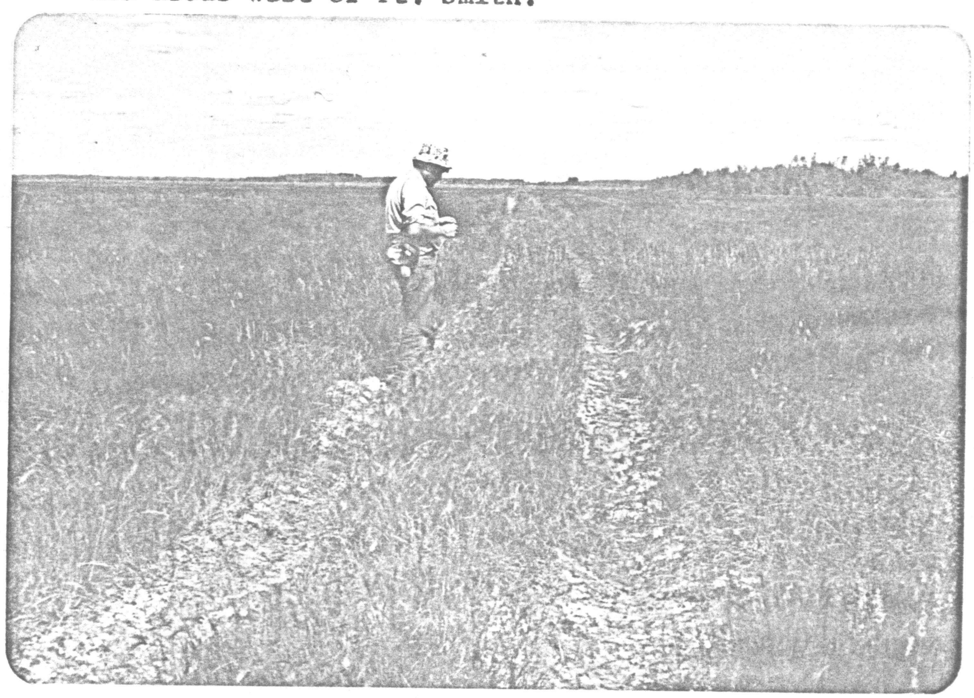


Figure 8.2 Salts appearing in Bombardier tracks north of Hook Lake. This indicates that disturbance will increase salinity in the surface soil.

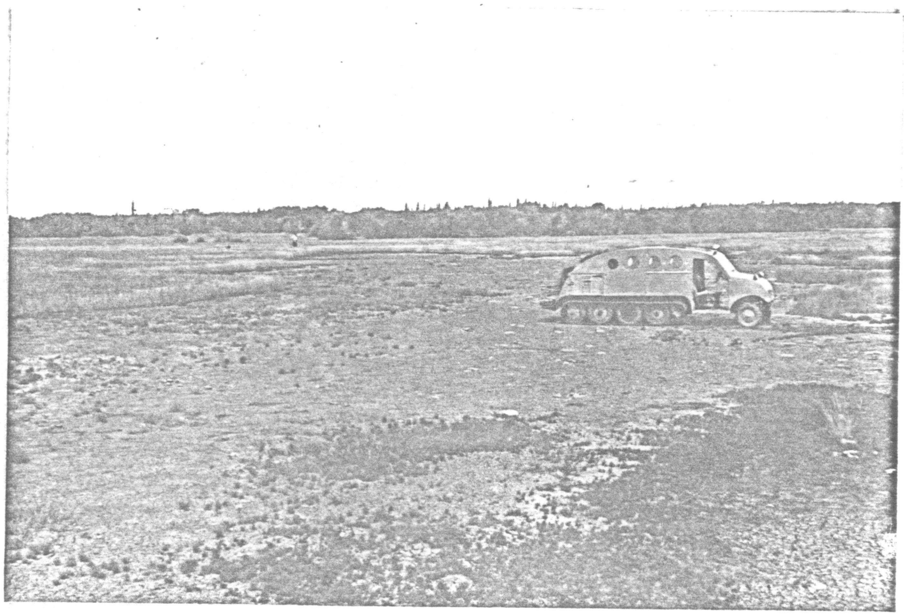


Figure 8.3 A saline patch near Grand Detour that has spread from a bison burial mound.

Table 8.1 Analyses* of soil profiles - Grand Detour, 1970.

Layer cm	N	P	K	Na	pH	mmhos	SO_4	S	Free Lime
Slave									
0-10	2	43	674	L+[T]	7.2	0.4		H	-
10-20	1	5	324	M-	8.2	0.6			-
20-30	2	1	268	H+	8.2	0.7			L+
30-40	2	1	233	H+	8.5	0.8			M+
40-90	1	0	295	H+	8.0	2.0	L		M-
Grand Detour									
0-10	2	8	833	M+	6.3	0.5		H+	-
10-20	1	0	685	H+	7.8	1.5	L-		L+
20-30	0	0	371	H+	7.9	4.5	M		M
30-40	1	0	310	H+	7.8	4.7	M		M-
40-90	0	1	363	H+	7.7	4.5	M+		L+
Taltson									
0-10	2	10	599	L	6.3	0.1		H	-
10-20	1	1	243	L	7.7	0.2			L+
20-30	1	2	177	L-	8.1	0.1			M
30-40	1	3	280	L-	7.8	0.2			-
40-90	0	6	347	L	7.3	0.2			-

* Analyzed by Alberta Dept. of Agriculture, Soil and Feed Testing Laboratory, Edmonton, Alberta

[T] L - Low; M - Medium; H - High

A more intensive salinity survey was carried out in 1973. On this survey 40 sites were sampled. In 1974, Dr. R. Cairns of the Solonetzic Soil Substation, Vegreville, Alberta, assisted and a further 15 sites were sampled.

Soils were sampled at 10 cm intervals to a depth of 30 cm. Some were taken from subsoil at 100 cm. The samples were dried and analyzed for: pH EC in mmhos/cm, SP (saturation percentage) and Meg/litre of extract of Na (sodium), K (Potassium), Ca (calcium), Mg (magnesium), S (sulphate) and Cl (chloride).

The problem was mainly on the Grand Detour soil so this type was sampled more fully than others. The procedure and results of the sampling were presented by Pringle et al (1975). It was generally observed that the wetter areas were higher in salts than the dryer ones. It was found that the Grand Detour soil type on the west side of the river had higher EC, more Na, Ca, Mg, SO_4, and Cl than a similar soil on the east side of the river.

There was great variability between sites for the same soil type. Grand Detour soil varied from a highly saline condition to one in which salts were very weakly present. Some of the Taltson soils showed moderate amounts of salinity and the one marked TV or ~~Taltson soils showed moderate amounts of salinity and the one marked TV or~~ Taltson saline indicated excessive sodium S and Cl. Samples from 275 cm depth at the three plot areas indicated that Grand Detour soil contained a reservoir of salts high in Na. A selected group of samples showing the chemistry of the various horizons at 10 cm intervals is presented in Table 8.2.

8.2 Soil Sampling

The soils of the Slave River Lowlands have been described in detail by Day (1972). It was felt, however, that the most prevalent and important soil types deserved a re-examination and preservation of reference profiles. In 1970 monoliths of soil profiles were taken of the Grand Detour, Taltson and Slave soils. In 1973, profiles were cut of the Little Buffalo (Figure 8.4), Brule, and a Grand Detour soil from Hook Lake (Figure 8.5).

These profiles were described as they were being dug.

Figure 8.4 Digging out the Little Buffalo soil profile. The bottom of the pit is on permafrost. Monoliths were taken in this manner from seven separate locations.

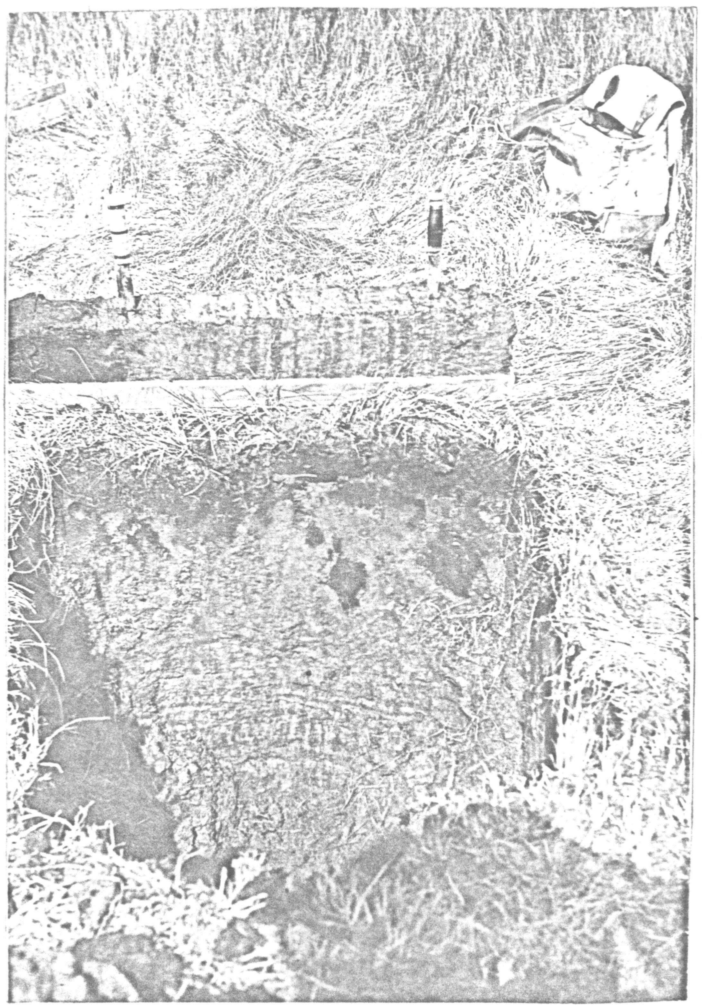


Figure 8.5 A Grand Detour soil profile extracted near Hook Lake corral showing the "tonguing of the black Ah layer into the gray Ck laye which lies above the varied mottled Ckg fi sandy loam.

For the most part, the soil descriptions agreed with those of Day (1972). By the very nature of the soil buildup through successive flooding of the river flats there are real differences in layering and in textures of the various layers therefore no two soils are exactly alike. Day (1972), stated that the main difference between Grand Detour and Taltson soils is the greater amount of organic matter in the clayey parent material in the latter soil. Our profiles seemed to indicate a greater degree of layering and a sandier subsoil in the Taltson as compared to the Grand Detour. It was evident, too, that a Grand Detour soil at Hook Lake was lighter textured in the CK horizon than those of Grand Detour. It was also interesting to note that during the digging of both the Little Buffalo and Brule soil profiles, permanently frozen ground was encountered at 70 cm.

9. WATER

9.1 River and Stream Water Quality

Quality of river and stream water is important in relationship to domestic use and irrigation.

Streams and water sources are being continuously monitored by the Water Quality Branch of the Inland Waters Directorate, Dept. of Environment. Water was collected in 1974 and analyzed by the Solonetzic Substation at Vegreville, Alberta. Table 9.1 shows the analyses for the water sampled during 1974. Of interest is the gradual drop in pH of the Slave River water from a high of 8.3 in May to a low of 7.1 in August. This occurs as well for the Salt River which also increases in conductivity over the season. This diluting effect is understandable, as the water flow diminishes, the concentration of salts will increase.

The Little Buffalo River flows along the west boundary of the lowlands and drains some of the meadows lying west of the Slave River. It also forms the boundary of Wood Buffalo Park. Inland Waters Branch, Water Quality Division, Department of the Environment, samples from this river both where it crosses Highway 5 near the Northwest Territories border and 150 km north where it crosses Highway 6 near Great Slave Lake. It is readily apparent that the concentration of salts increases on this stream from the southern sampling site to the northern sampling site. Table 9.2 indicates the range of measured water qualities for the period 1972-1973 at the two measuring points. For example, on June 7, 1973, water at the southern site had a

Table 9.1 Chemistry* of river waters from Slave River Lowlands, Northwest Territories, Canada 1974.

Site	Sample Date	pH	EC mmhos/cm	Sodium Absorption Ratio	Meq/l Soluble Cations			
					Na	K	Ca	Mg
Slave River								
Grand Detour	May 31	8.3	0.2	.50	.10	1.75	.58	.46
	June 26	7.9	0.3	.56	.08	1.50	.58	.55
	July 30	7.7	0.3	.52	.05	1.50	.41	.53
	Aug. 26	7.5	0.3	.32	.06	1.40	.41	.34
Ft. Smith	Aug. 7	7.1	0.3	.34	.06	1.60	.50	.33
Taltson River	June 26	8.1	0.1	.22	.06	.35	.08	.48
Landry Creek Hook Lake	July 4	8.2	0.3	.34	.06	1.50	.41	.35
Little Buffalo R. Hwy. 5	Aug. 7	7.2	1.0	.68	.05	4.54	1.15	.40
Salt R. Wood								
Buffalo Park	June 26	8.1	5.5	20.6	.09	5.7	5.75	0.15
Hwy. 5	Aug. 7	7.2	8.0	39.2	.15	27.0	2.10	10.3

* Analyses carried out at Vegreville, Solonetzic Substation, Agriculture Canada, 1974.

Table 9.2 Water analysis of the Little Buffalo River 1972-73.

	Highway 5 Low	Highway 5 High	Highway 6 Low	Highway 6 High
Temp. °C	0	17	0	10
pH	7.9	8.3	7.6	8.0
Turbidity	1.4	5.1	3.3	25.0
Electrical conductivity mmhos/cm	0.9	1.7	1.8	4.9
$CaCO_3$ meq/l	136	233	132	317
Total dissolved solids	334	1313	2205	3790
SO_4 meq/l	330	752	1113	1633
Cl meq/l	13.7	45.0	503	740
Hardness $CaCO_3$ meq/l	482	984	1446	2018
Calcium dissolved meq/l	152	304	527	652
Na meq/l	15.2	44.0	330	476
K meq/l	1.0	5.6	0	4.8

Records supplied by: Water Quality Division Inland Waters Branch
Department of Environment

conductivity of 0.85 mmhos/cm while on June 20 it was 2.75 mmhos/cm at the northern sample site. Total dissolved solids for the two sites showed a difference of 580 to 2205 for the same sampling dates. The Sass, Klewi and Nyarling Rivers that enter the Little Buffalo from the western escarpment may pick up salts from the underlying porous rock from the Karst Plateau.

9.2 Ground Water Quality

Perforated pipe wells 3 m deep were established at three locations in 1974. Samples were extracted and analyzed monthly. Water disappeared in the Taltson well in early June so only the May collection was made. Table 9.3 presents the analysis for the water samples. Water from a wet Grand Detour site (Big Meadow) had an EC of 4.5 reaching a high of 6.5 in July with a corresponding increase in Na. On the semi wet area, Grand Detour plot site, the EC was 3.0 in May, diminishing as the water table dropped to EC 1.6 in August with a corresponding drop in Na. Both conductivity and Na content of the Taltson water were very low.

9.3 Water Levels

Piezometers were installed at the three meadow sites to 5, 2.5 and 1.23 m depths and water levels were read during 1973 and 1974. Water levels in the 5 m piezometer closely paralleled that of the other two depths thus water level and water table are very similar. Because of this, records for the 5 m piezometers only are given in Table 9.4.

At the Taltson site water appeared in the tube only in 1973 when it rose to within 381 cm of the surface. This was a rise of 70 cm which represented a small rise relative to the other two sites. On the wet site a rise of 256 cm was recorded and on the semi wet area a rise of 161 cm was recorded for 1973. In 1974 the water rose 173 cm and 148 cm for the wet and semi wet areas respectively. It is of interest to see the sharp rise in water between July 11 and 19 in 1973 and between July 4 and 11 in 1974 at the time the frost disappeared from the soil. This corresponded with a disappearance of surface water on the wet site. Up to that time water appeared to move both up and down in the soil probably being affected by both evaporation and local precipitation.

Table 9.4 Chemical analysis of water samples from three open wells 1974.

	Date End of	pH	Electrical Conductivity mmhos/cm	Sodium Absorption Ratio	Meq/l in water			
					Na	K	Ca	Mg
Wet Grand Detour	May	6.9	4.5	3.16	12.40	.27	21.7	9.0
	June	7.3	5.0	3.46	14.40	.20	23.4	11.1
	July	7.2	6.5	4.78	23.40	.22	27.4	20.6
	August	7.4	5.5	2.67	12.80	.33	25.6	20.1
Semi-Wet Grand Detour	May	8.3	3.0	2.3	7.00	.79	10.7	7.8
	June	7.1	1.9	1.8	4.20	.48	7.0	3.4
	July	7.0	1.8	1.4	2.90	.48	5.4	3.0
	August	7.0	1.6	1.3	2.50	.69	5.0	3.0
Taltson	May	7.1	0.6	0.2	0.3	0.3	2.7	1.2

Table 9.5 Depth to water table in cm from 5 m piezometers 1973 and 1974.

	Grand Detour Wet		Grand Detour Semi-Wet		Taltson	
DATE	73	74	73	74	73	74
June 6	284	239	259	234	441	No
13	283	236	221	205	448	water
20	277	223	191	188	445	in
27	269	206	165	140	443	tube
July 4	220	183	146	137	442	
11	142	97*	107	76	436	
19	83*	66	98	66	418	
24	79	71	109	76	381	
Aug. 1	62	74	115	91	399	
8	51	76	124	104	391	
15	66	86	129	112	386	
21	28	66	127	101	385	

* Approximate date ice left the soil

10. BURNING OF NATIVE VEGETATION

10.1 History of Burning

Evidence of fire may be found on or adjacent to all meadows in the Lowlands. Burned stumps, charred branches and charcoal in the soil profile all provide ample proof that fire has played a significant part in the ecology of the vegetation types, particularly meadows, along the Slave River. When areas are not being utilized heavily by grazing animals, a large amount of fine leaves and stems accumulate on the surface of the soil. This provides flash fuel for fire through which flames may travel quickly.

10.2 Types of Burns

Casual observation indicates that there are three main types of burns. First, fire that burns over large areas of land where the main fuel is standing timber but where unburned tongues or stringers are left. Rowe (1974) claims these unburned areas may be the result of vagaries of wind changes or patterns of "spotting" ahead of fire fronts which lead to pulses of burning. He also claims that animals such as the varying hare by browsing and thus killing seedlings and saplings which could carry a ground fire help to form a stringer pattern. This type of burn is the most destructive because it covers the timber area and because it is normally the hottest type of burn. It may be a very hot ground fire or it may crown in which case it usually travels many miles. Normally a fire of this nature occurs during the heat of July or August after the ground has dried out when nights are relatively warm and humidity is very low.

Second, fires occurring in the spring which utilize the flash fuel built up either on the meadows or on meadow edges from previous year's growth. At this time frost is not out of the ground and soil is relatively wet. Such fires travel quickly where fuel is available but die when they hit heavy bush or low wet areas. At this time, days are normally very warm but nights are cool and humidity rises as the sun goes down. Such burns rarely last more than a day. They kill top growth only on well established deciduous trees such as aspen and willow by blistering the bark. Normally there is little or no damage to conifers, as the fire does not carry easily into the forest edge.

A fire of this type was started accidentally on June 4, 1972 on a plot area. The temperature during the day reached 23.3°C but dropped during the early morning of June 5 to -1.7°C. A wind of 32 km p.h. during the day dropped in the evening and the fire died under those conditions. The greatest damage done was to the willows at the edge of the meadow which had resprouted by the end of August. The fire virtually stopped when it reached the aspen or spruce forest. Burns of this nature could be used to remove old growth from the meadows and to slow up or eliminate willow and aspen invasion.

The third type of fire is that occurring on an open meadow in late summer usually from a lightening strike. This type can be serious if it reaches a forest edge. The meadow vegetation at this time is normally lush and green but the dry bottom can carry the fire and thus it consumes both the old and the new vegetation. In most instances rain follows and the fire is extinguished. This is unlike a lightening strike in the forest when a "sleeper" can be ignited and smoulder through the accompanying rain then burst forth when the humidity drops following the storm. A spot of 80 ha was burned in this manner on August 13, 1972 (Figure 10.1). Two weeks later 5 cm of green growth was evident on the burned stubble. The following year bison seemed to prefer grazing on this burned over area. A black ash at the soil surface was the only evidence that the area had suffered a recent burn.

10.3 Potential for Removing Brush

Ponding of spring run-off water is probably the prime reason for the existence of meadows. The water drowns out seedlings of woody growth and where it persists often kills mature willow and aspen. This process is frequently aided by the activity of beaver. Grasses and sedges thrive in the open areas. An accumulation of dry grasses provides fuel for fire which enlarges the meadows or at least slows down the encroachment of woody growth.

From observations of aspen and willow regeneration and invasion of meadows of the Slave River Lowlands, it appears that fire has played a forceful role in the past in forming the meadows and should not be over-

Figure 10.1 August burn on a meadow started by a lightning strike and extinguished by the following rainstorm.

looked as a vital force in maintaining open ground. Without periodic burning, the sedge grass meadows will gradually fill in and forest rather, than forage will become the dominant vegetation.

11. HAZARDS AND CONSTRAINTS TO LAND SETTLEMENT

Any condition that forces additional expenditure on the cost of producing an agricultural product, or provides a constraining influence on the enterprise which may eliminate the profit may be thought of as a hazard that must be fought against. The Slave River Lowland was looked at carefully by a team of experts in 1965. They reported that they could find no sound basis for recommending agricultural development of the Slave River Lowlands at that time (Stutt et al, 1969). The main constraints to development are those same factors that continually plague ranchers in many outlying areas of the west.

11.1 Climatic Fluctuation

The vagaries of climate do not at first seem to present a hazard, however, if you are expecting a normal winter and it turns into an exceptionally long winter, the rancher must be prepared for it. Therefore, a livestock enterprise has to gear for a minimum herd, or there must be a carry over of hay that can be saved for emergency situations. Spring storms at that latitude could be very hazardous to a cow herd that was calving.

11.2 Flooding

High water can be caused by ice jamming of the rivers during spring break-up and such conditions could be very hazardous to dwellings or farmsteads particularly if they were located close to the river. The rapid cutting of river banks could cause loss of land and would be a hazard which would be one further reason for building away from the river (Figure 13.1).

Because the land is exceptionally flat, spring flooding occurs generally which would cut off roads and lines of access for several weeks each year. This would cause some hardship and would require expensive roads if access was to be assured.

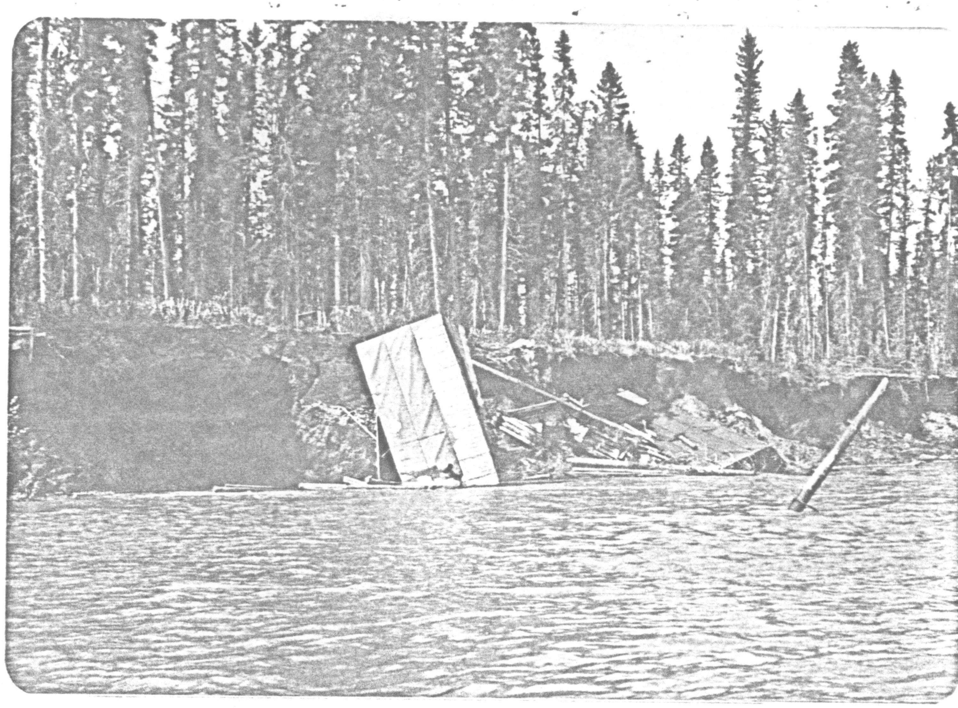


Figure 13.1 One of the hazards of building next to the river. In 1968 these cabins were 18 m from the river edge and in 1974 they are obliterated.

11.3 Disease

The area is inhabited by bison which suffer from a number of diseases common to domestic cattle. The most serious of these is anthrax which seems to break out during wet warm summers. It has been reported that from 1962 to 1971, 368 animals died at Hook Lake and 471 were killed by this disease around Grand Detour (Simmons 1975). There is an inoculation against anthrax but it must be undertaken annually.

Tuberculosis and brucellosis are both present. Each of these diseases has been recorded from bison with an average incidence of between 25-30% TB and slightly over 30% brucellosis in the Hook Lake and Grand Detour herds (Simmons 1975). The cure for TB and brucellosis is a test and slaughter program therefore as long as the wild herd could freely mix with domestic livestock, the losses would be such as to quickly put a livestock operator out of business. There is, of course, the additional hazard of the bison bulls breeding the domestic cows. Not only will this enhance the spread of disease but would bring about impossible or very difficult calving by the cows.

11.4 Predation

Wolves and bears are prevalent on the lowlands. Where there is a free ranging wild animal population, there are always large numbers of predators and scavengers.

In that the lowlands border Wood Buffalo Park, there will be a reservoir of predators living under full protection. These animals will infiltrate the lowlands or make forays from the park on the domestic animals on the lowlands. It must be recognized then that the predator situation will be more serious than is found in most areas and it will be much more difficult to control because of the proximity to a sanctuary.

11.5 Insects

The area abounds with insects. Because of the extensive areas of standing water, mosquitoes are a real menace to warm-blooded creatures. These pests emerge in late May and reach a peak in July, tapering off into late August. At times, they are so prevalent as to be unbearable. Mosquitoes on the lowlands are such that, work outdoors would be impossible if it were not for insect repellent.

Black flies are also very common and can be worrisome to both humans and animals. They are most abundant in late summer during the cool of the evening. The species Simulium venustum, the white-stockinged blackfly and Venustum vittatum,the silvery grey blackfly have both been identified from the Hook Lake area. It has been suggested that S. arcticum, a serious pest of cattle would most likely be present as well (Shemanchuk, 1975). Horse-flies appear in large numbers about mid July and last until mid August. These Tabanids swarm about anything that is moving and are capable of a vicious bite. They could be detrimental to horses.

On some areas, the clear-wing grasshopper, Camnula pelucida, becomes very prevalent in some years. In 1973, an outbreak was observed at Hook Lake on July 25. These insects were in epidemic proportions. At the time of observation, there were about 25 per square meter in buffalo wallows where they were laying their eggs.

Because this insect depends upon bare ground for its increase, then cultivation of land may have the effect of increasing its population.

The only detrimental effect of grasshoppers is their removal of palatable vegetation or their damage to crop and gardens. The fact that they can appear in plaque proportions in the area must be borne in mind so that land users are forewarned and may be prepared to exercise controls.

11.6 Isolation requiring transportation

Access to the lowlands is through Fort Smith. This town of 2700 is 1368 km N. of Edmonton.

An all weather road from Ft. Smith links up with the MacKenzie Highway at Hay River, 273 km to the north west. There is direct access to Edmonton by air through Pacific Western Airlines, approximately one hour flying time directly south.

When the area is opened for settlement, the means of access to Fort Smith will determine the degree of isolation of the individual holding.

The fact that Ft. Smith is such a long distance from large centres of population, means that the transportation of supplies and equipment to the area will be costly and conversely the shipment of farm products from the area will also add considerably to the cost of production.

The whole aspect of transportation is well covered by Stutt (1968), however, the costs since that time have more than doubled. Now the basic cost for transporting goods from Edmonton to Ft. Smith is $21 for 100 kg in 1000 kg lots, but may be reduced to $7.92 per 100 kg in 20 T truckloads (Grimshaw Trucking, September 1978).

12. PROSPECTS FOR AGRICULTURAL DEVELOPMENT

12.1 Productive potential

Productive potential of the lowlands for forage fluctuates greatly from year to year and from area to area depending largely upon the rainfall pattern for the growing season. In estimating the dry matter production, it must be recognized that plot yields are generally slightly higher than yields on a field scale basis. In judging large areas from a few small samples, the low estimate will be used so as not to give over-optimistic predictions. This is particularly true for forage quality as plots are handled quickly and are never subjected to the same degree of weathering as a hayed field.

In its agricultural development proposals of the lowlands, this report will only deal with the open or semi-open lands and will not take into account land clearing other than for homestead or brush control on meadow edges.

The attractiveness of the lowlands for agricultural settlement stems from the fact that the land is open and may be easily plowed and worked, or ostensibly, readily and safely grazed by domestic stock. The forested areas will provide some grazing but for the most part, summer feed for livestock will come from the myriads of small meadows that lie trapped between the tongues of forest and bush. The actual effect of predation, disease and insects will be determined only when livestock are using the area. In estimating carrying capacity, open areas only will be considered.

The aforementioned hazards and constraints to beef cattle production on the lowland must be taken into consideration when thinking of a productive potential for the area or of the economics of production.

It is for these reasons that calculations of productivity will be based on low figures for forage yield and on a maximum daily allowance of feed for each class of livestock. In addition, the maximum calf crop percentage is assessed to be 80%.

One further thought is that the pioneers to any area usually suffer the most from lack of proper infrastructure and little or no professional help. And, so early settlers to the area can expect to have lower than normal production and higher than normal losses from predation and disease.

12.1.1 Native forage.

Forage in the early part of the season may be as high as 15% protein and drop to a low of 6% in September which means that along with the use of browse, an adequate diet will be available throughout the grazing season. Trace mineral salt containing copper would be used. Native forage can be used as hay or as grazing. Many of the areas too wet for cultivation or too saline should be left in native forage and utilized in this manner. Where stands of native forage are used for hay, it would be advisable to cut and graze the same area in alternate years so as to maintain the productivity of the stand and retain the natural species composition.

The following estimates of forage yields based on plot research from various types of open meadows will be used to help determine a livestock potential for the lowlands.

Area	Yield kg/ha	%Protein
Taltson semi dry	2800	10
Taltson very wet	4000	12
Grand Detour dry	1500	9
Grand Detour semi wet	2000	8
Grand Detour wet	2400	6
Lobstick dry	1500	4
Lobstick wet	2000	8

12.1.2 Cultivated forage

Cultivated forage will gradually replace the native stands as the need for better quality hay is desired. Forage will be grown on Grand Detour soils which are low in total salts and on Taltson soils that offer large enough meadows to be effectively broken and cultivated. The main species that will be used as indicated by our trials will be smooth bromegrass and alfalfa or pure stands of alfalfa for hay. For pasturing, meadow foxtail and creeping red fescue may be used.

The following estimates of cultivated forage yields will be used to help determine the potential for hay from the lowlands.

Area	Yield kg/ha	% Protein
Grand Detour	2600	8.0
Taltson	4000	10.0

12.1.3 Other crops

It may be necessary to use cereals following breaking of the land so that the areas may be clean cultivated to eliminate regrowth of native sedges and grasses prior to establishing forage stands.

In this case, we could rely on 4500 kg/ha of dry matter which would make reasonable hay, or may be put up green as silage. Either oats or barley could be used for this purpose.

12.2 Estimated Requirements for Beef Cattle

In the northern area the grazing season is very short. Grass is just starting to green between May 15 and June 1. Aspens and willows are leafing out in the first week of June. From observations, it is evident that north of 60° latitude, grazing would last from June 1 to October 15 in most years. This gives an average grazing period of 135 days. It follows then that in most years feeding will be for 230 days. Nutrient allowances given by National Academy of Sciences (1970), for beef cattle are used to determine the feed requirements of various classes of livestock as follows:

	At Rest (Winter) kg DM/Day	%CP	Lactating or Growing (Summer) KG DM/Day
Cows 500 kg	7.6	6	10.5
Bulls 6-700 kg	10.7	10	11.6
Heifer yearlings	8.2	10	10.6
Heifer calves	5.4	11	
Steer calves	5.4	11	
Horses at rest	6.8	10	10

In view of the very long feed period, one way of maximizing feed efficiency would be to ship calves in the fall. This would result in a feed requirement for 100 cows calculated as follows:

Cows	100 x 7.6	=	760 kg
Bulls	5 x 10.7	=	54
Heifer yearlings	15 x 8.2	=	123
Heifer calves	15 x 5.4	=	81
Horses	5 x 6.8	=	35
Daily requirement			1053 Kg DM

It was decided to keep calves over winter and ship yearlings, then this system would have a 100 cow requirement per day calculated as follows:

Cows	100 x 7.6	=	760 kg
Bulls	5 x 10.7	=	54 kg
Heifer yearlings	15 x 8.2	=	123
Heifer calves	40 x 7.0	=	280
Steer calves	40 x 7.0	=	280
Horses	5 x 6.8	=	35
Daily requirement			1532 Kg DM

In that this is an extremely cold area, a safety factor of 10% is added to the allowance bringing the cow calf operation to 1158 Kg DM and the cow yearling operation to 1685 Kg DM for every 100 cows. If we look on the winter feed period as being 230 days, the feed needed per cow unit would be 2.7 T and 3.9 T for the cow calf and cow yearling operations respectively.

12.3 Estimated Livestock Potential

The livestock potential for the lowlands will be calculated on the basis of the amount of winter feed that can be produced. Open land types only will be used in the estimation and a percentage that can or should be cultivated will be arbitrarily set. The reason for discounting some areas would be the presence of salts in excessive amounts or the fact that the land is too wet. In the case of the Taltson soil, the areas may to be small or too isolated to bother with. We can estimate that approximately 30-50% of the open land would be suitable for cultivation following draining or damming as the case may require. If large areas of meadow soils were cultivated, particularly if summer-fallow was used as a means of preparing the land for cropping, there would be a danger of losing some of the top soil to wind erosion as it was noted that the soils when cultivated were very powdery and hence subject to blowing.

Estimate of arable area is:

Soil type	Total % arable	
Grand Detour	208,578 x 55	= 114,718 ha
Lobstick	111,105 x 45	= 50,000 ha
Taltson	36,148 x 33	= 11,929 ha

The Grand Detour and Lobstick soils are capable of producing 2.5 T per ha while the Taltson soil areas could produce about 4 T/ha. Production of hay would be:

114,718 x 2.5	= 286,795 t
50,000 x 2.5	= 125,000 t
11,929 x 4.0	= 47,716 t
	= 411,795 t

In addition to the cultivated land, a number of smaller Taltson meadows and some of the wetter Grand Detour and Lobstick meadows could be hayed in late summer. About 10% of the Grand Detour, 5% of the Lobstick and 20% of the Taltson areas would yield an additional hay supply of:

		%	T/ha		
G.D.	114,718 x	10 x	1.5	=	11208 t
Lob	50,000 x	5 x	1.5	=	3750 t
Tal	11,929 x	20 x	3.0	=	7157 t
		Total			22115 t

Total stored forage available for a winter feed supply is 411,795 + 22,115 = 433,910 T. This amount is capable of wintering 433,910 ÷ 2.7 = 160,707 cows if calves are not held over winter. If they are held and sold as yearlings, then this would be reduced to 433,910 - 3.9 = 111,259 cows.

12.4 Theoretical Production of the Lowlands

The total potential for the whole area is approximately 160,707 cows. With this number of cows and assuming an 80% calf crop and a need to retain 15 replacements for every 100 cows there could be 104,460 calves shipped from the area each year. In addition, 15% of the cows and bulls will be surplus and these will add an additional 24,106 animals as part of the overall production.

If calves are held over and sold as long yearlings, then there will be capacity for only 111,259 cows and from this there will be shipped 72,318 yearlings. In addition, there will be 16,688 cows and bulls.

If the first method is used and calves weigh 200 kg and cows 500 kg, then 32,945.0 T of animal will be shipped each year. If the second method using yearling steers which have attained a weight of 400 kg is followed, then 37,271 T of animals will be shipped each year.

Under the conditions described and on the basis of the calving success and the weights given, it would appear to be advantageous to winter over calves. In order to do this, a higher quality winter feed would be required than used to winter a straight cow herd.

By comparison, Stutt et al 1969, reported that the lowlands could support 300,000 head of cattle and market 100,000 per year. It should be re-iterated the present proposal does not include extensive land clearing of the Slave, Rocher, Brule or Little Buffalo soils. In addition, it witholds the saline soils from development.

This hypothetical approximation assumes that the whole lowland area would be under a similar type of management and that all land would be entirely utilized. This would not likely come about. However, the approximation of productivity suggested is reasonable and shows that the area is capable of becoming a source of wealth to the country. At conservative estimates and using today's prices, the returns from livestock as indicated in the foregoing approximation would exceed 20 million dollars a year. By using a figure of 1 man year for every 200 cows then we find we require a total of almost over 600 man years.

Beef cattle production north of 55° latitude has, in the past, been subjected to severe cost-price pressures. Predictions were that cattle production would increase and occupy an increasingly larger portion of the farming business. This has not been the case. Livestock production has tended to remain static or decrease over the past ten years. Beef production in the Peace River area of both B.C. and Alberta is undertaken mostly as a sideline to farming. Livestock utilize the waste places for range and the by-products of field crop and seed production. In the winter cattle must be fed and in most years this feed period lasts from October to the end of April. During these 6 - 7 months, up to 3 tons of hay must be stored for each animal unit kept on the farm. Herein lies the true cost of beef production in the northern area.

We can range cattle for between 3 and 4 months. However, early frosts and the nature of the forage drastically reduces the quality of the grazeable vegetation and cattle are barely able to maintain themselves on ranges in the fall.

13. ECONOMICS OF PRODUCTION

13.1 Transportation Costs

The area is geographically isolated and, compared to other agricultural areas, it is at a transportation disadvantage in the production of forage and feeder cattle. Transportation costs make most farm goods and services higher priced than in Alberta and Saskatchewan, while farm gate prices of forages and feeder cattle are lower for the same reason.

The potential demand for grass-fed beef in the Slave River Lowlands is limited. An earlier report** estimates beef requirements for the adjacent areas could be supplied by 2,100 animals and for the MacKenzie district by 4,900 animals. Thus, the local price of live cattle would be set at the export price level; that is, the Edmonton price less the cost of transportation. An alternative price, which could develop with a large feeder cattle production industry in the area, is the price paid in Ontario less air freight to that province. The Edmonton cattle price, less transportation costs, was used to evaluate the feeder cattle production potential for this area.

The development of road and rail facilities into the Territories in recent years has improved the transportation situation. However, farmers there are still forced to pay higher costs for most inputs, and to take lower prices for their products than farmers in the prairie provinces. The developing transportation system suggests that the area will never be on a main transportation route and that it is destined to remain at the far end of a branch of the MacKenzie River - Hay River - Peace River - Edmonton transportation artery.

General truck freight costs from Edmonton to Fort Smith in early 1976 were 14.4 cents per kg the cost per mile being slightly less than to Fort Vermilion. The cost per pound of transporting live cattle by truck cattle liner is estimated at 5.6 cents per kg for live cattle transported from Fort Smith to Edmonton

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** Report on the Potential of the Slave River Lowlands for Agricultural and the Feasibility of Developing a Viable Cattle Ranching Industry in the Area.

13.2 Production Costs

In addition to higher transportation costs, area farmers producing feeder cattle must contend with long, cold winters, high winter feed costs, short grazing seasons and such hazards as insects and disease. In the long run, insect and disease problems can probably be controlled through research and good management practices.

Cost data for field operations necessary for fodder production were based on 1974 Alberta consensus research** reports for the Peace River area in Alberta. These data have been adjusted to late 1975 price levels and increased by 10 percent as an estimate of added transportation costs for all inputs.

Production data were based on yields obtained from experimental plots. Livestock feed requirements in terms of minimum TDN and protein and maximum dry matter were based on N.R.C. standards. The winter energy feed requirements were adjusted upwards by 10 percent to take the harsh winter weather into account. The estimated daily feed requirements were checked out with the Animal Science Department of the University of Saskatchewan. It would be pointed out that these estimates are less than costs indicated by records taken from prairie farmers and less than farm estimates obtained to prepare the Alberta Consensus Research Reports.

13.3 Cattle Production

A series of farm budgets were generated to evaluate the potential of the Slave River Lowlands for feeder cattle production. The farm income would be derived from the sale of feeder calves, feeder yearlings, cull cows and bulls. These budgets were generated from a linear programming model, and they are presented as optimum farm budgets and optimum economic area production estimates for four different levels of cattle prices, two levels of calf crop (72 percent and 80 percent), and grazing seasons of different lengths.

** A Consensus of Costs and Returns, Alfalfa Production 200 Acres Grimshaw District, Alberta Agriculture, Marketing Division, Production Economics Branch, 75-1 APR/1974.

A Consensus of Costs and Returns, Alfalfa Production 70 Acres Fuller District, Alberta Agriculture, Marketing Division, Production Economics Branch, 78-1 APR/1974.

13.3.1 Assumptions and Inputs

The results are presented in summary form. The validity of these results depend on the realism of the coefficients** used in the model. The realism of these coefficients is based on the validity of some of the underlying assumptions, some of which have already been described. Others are:

1. The calendar year was divided into six feeding periods as follows:
   a) November to March is the winter feeding period. Although the energy requirements of cows will be somewhat greater in the colder months of January and February, it is assumed that an average daily energy intake for the five-month period will adequately estimate total winter feed requirements;
   b) April is considered separately. If calving is planned for late spring, then April could be included in the winter feeding period. However, to allow for somewhat earlier calving and the resulting change in feed intake, April has been set apart to allow for larger feed rations;
   c) May to mid-June is the period when the feed source can change and feed requirements for cows are increased because they are producing milk;
   d) Mid-June to mid-August is the period of active plant growth and large daily gains for calves and yearlings. Probably some cows also make gains;
   e) Mid-August to mid-September is the period when some plant growth takes place and is available for grazing along with plant growth from previous months, but the energy and protein qualities of this forage will be lower;
   f) Mid-September and October is the period when plant growth becomes negligible, but calves and yearlings can still make significant daily weight gains from aftermath grazing and browsing.
2. The cow herd is maintained by keeping 15 heifer calves per 100 cows each year for replacement. A mortality rate of two percent per year is assumed for all classes of animals.

** The detailed development of these coefficients is available in unpublished form.

3. The calf crop is estimated at 80 percent. Initially, it was estimated at 88 percent. However, Dr. C.M. Williams of the Animal Science Department, University of Saskatchewan, suggested calf crops of this magnitude were obtainable only on well-managed ranches in the prairie area of Western Canada. In the parkland area, calf crops were much lower and, in an area such as the Slave River Lowlands with short grazing seasons and long severe winters, Dr. Williams considered a 72 percent calf crop more realistic. These estimates result in a calf crop considerably lower than the Alberta consensus reports that assume a calf crop of 85 percent. The impact on farm income of a 72 percent calf crop was also calculated.
4. Types of cattle enterprises included in model:
   a) cow-calf, (spring calves),
   b) cow-yearling enterprise (With spring calves as base),
   c) fall calving - assumed not feasible since available feed does not have enough energy for lactating pregnant cows.
5. The non-feed costs of the cattle enterprise budget were based on farmer consensus in the Peace River agricultural area**. Ten percent was added to these costs to allow for additional transportation distribution costs.
6. Gross farm gate return from cattle was the estimated Edmonton price less transportation and selling costs. Four sets of cattle prices were used in the analysis. The first set was a 1976 projected price calculated from a 1955-75 regression model. For this set of prices, the Edmonton steer calf price was $49.93 per cwt. and the yearling steer price $37.30 per cwt. The other three sets of prices were derived demand prices for feeder cattle: (1) when the Edmonton slaughter steer price was 45 cents per pound live weight and feed grain prices were three cents per pound, (2) when the Edmonton slaughter steer price was 50 cents per pound live weight and feed grain prices were three cents per pound, and (3) when the Edmonton slaughter steer price was 55 cents per pound live weight and the feed grain prices were three cents per pound. The steer calf prices for these three price sets were $62, $72, and $83 per cwt., respectively, and yearling steer prices were $48, $55 and $67 in that order.

** H.R. Glasier, A Consensus of Costs and Returns for a 100 Beef Cow Operation in the Drayton Valley Evansburg Areas, Alberta Agriculture, 1974
R. Susko and L. Andruchow, A Consensus of Costs and Returns for a Cow-Calf Enterprise in the Athabasca Area, Alberta Agriculture, Marketing Division, Production Economics Branch, 61-26MAR/1975.

7. Field production was assumed at 90 percent of experimental plot yields in estimating hay yield, silage yield and pasture carrying capacity. To realize these yields, above average farm management is required. The possibility of growing grass-legume hay and pasture was not included in the model since production data was not available, but such forage has a higher yield per acre than alfalfa and grasses grown in separate fields.
8. Yields as mentioned above are based on short-run annual averages of three to five years, and they do not take into account variability in yield between years. Thus, the underlying assumption was that production from above average years can be carried forward to below average years without loss. Alternatively, this assumption suggests the cattle enterprise was flexible enough to expand or contract to compensate for the variation in production, i.e. variable rate of culling of breeding herd between years, selling yearlings in summer instead of fall, etc.
9. No locally-produced grains are available for feed because grain production in the area is not possible.
10. Feed grain was not costed as it was assumed that grain brought into the area could not compete with high quality roughage available locally for winter feeding of cows, bulls and replacement cattle.
11. Local cattle feed sources were:
    a) grain silage (soft dough stage)
    b) grain hay (soft dough stage)
    c) grass-alfalfa hay
    d) native hay
    e) summer pasture, and
    f) aftermath grazing
12. Land costs for improvements (clearing, breaking, fencing, water development) were amortized at nine percent interest for the life expectancy of each kind of improvement. A lease charge of 25 cents per acre was included as an additional land cost. It was implicitly assumed that the cost of developing the necessary community infrastructure would come from indirect taxes now included in the purchase of inputs. This study has not attempted to do a benefit-cost development analysis but only to examine the viability of a cattle enterprise in the area.

13. Labor requirements in hours were estimated for such operations as livestock care, fence maintenance, field operations, etc. These estimates were based on a combination of theoretical calculations and farmer consensus data. Labor input by the farm family was estimated at 1,800 hours per year. Labor requirements per cow-calf unit (not including feed production requirements) were estimated at 8.7 hours per year per unit, and the labor needed to raise the weaned calf to yearling level was estimated at 5.3 hours.

13.3.2 Labor and Management Return from Feeder Cattle Enterprise

In order to be viable, a livestock feeder cattle enterprise in the Slave River Lowlands will require a return to labor and management that is sufficient to cover basic living costs for the farm family plus enough savings to allow most of the investment capital to be refinanced from one generation to the next. The latter would require $733 per year for each $100,000 of capital (nine percent interest rate) above interest costs. The interest charges were included in the farm budgets.

Return to labor and management was not sufficient to sustain a viable cattle enterprise with feeder cattle prices based on projections to 1976 from the regression trend model. This was the case even when only the most economically suitable soils in the area were developed for production (Price set 1 in Table 1). When the calf crop rate was decreased to 72 percent, the return to labor and management was negative. (Price set 1 in Table 3).

Return to labor and management is highly sensitive to the price of cattle. At what price level is the return to labor and management high enough to sustain a viable cattle enterprise in the area? We assume that a return to labor and management of $12,000 is the minimum amount required for a viable feeder cattle production enterprise for this area.

With cattle price set 3, the return to labor and management would be nearly at this level for the 72 percent calf crop ($10,970) and above the level ($13,349) for the 80 percent calf crop level.

A feeder cattle production enterprise in the area could only be viable if it is large enough (at least a 100 cow herd), well capitalized, well managed and cattle prices are higher than have been historically experienced.

Table 13.1 Basic farm organization and income of optimum "Farm Unit" for four cattle price levels[1], Slave River Lowlands.

	- Price Set for Cattle -			
	2	3	4	5
	- acres -			
Land Use				
Improved Land				
Oat hay	24	24	20	22
Alfalfa hay	23	23	23	22
Crested wheat grass hay	233	233	233	233
Unimproved Land				
Pasture	161	161	161	161
Hay	151	151	152	148
Total	592	592	589	586
	- number of head -			
Livestock Enterprise				
Cows	110	110	110	122
Sales				
Calves	-	-	-	30
Yearlings	69	69	69	47
Cows	14	14	14	16
Return to Labor and Management (dollars)	1,109	8,446	13,349	17,575

1 80 percent calf crop.

2 Steer calf price $49.93 per cwt.; heifer calf price $41.28 per cwt.; yearling steer price $37.30 per cwt.; yearling heifer price $32.30 per cwt.; and cull cow price $22.94 per cwt. All prices gross at Edmonton.

3 Derived feeder cattle price from $45 per cwt. slaughter steer prices and three cents per pound for feed grain. The resulting steer calf price was $62 per cwt. and yearling steer price $48 per cwt.

4 Derived feeder cattle price from $50 per cwt. slaughter steer prices and three cents per pound for feed grain. The resulting steer calf price was $72 per cwt. and yearling steer price $55 per cwt.

5 Derived feeder cattle price from $55 per cwt. slaughter steer price and three cents per pound for feed grain. The resulting steer calf price was $83 per cwt. and yearling steer price $61 per cwt.

Table 13.2 Optimum area land use and production for four cattle price levels[1], Slave River Lowlands.

	- Price Set for Cattle -			
	2	3	4	5
	- acres -			
Land Use				
Improved Land				
Oat silage				
Oat hay	10,966	260,000	260,000	406,264
Alfalfa hay	9,332	150,000	150,000	3,736
Crested wheat grass hay	66,662	12,513	12,513	11,565
Unimproved Land				
Pasture	54,653	271,457	271,457	278,517
Hay	68,699	236,030	236,030	229,918
Total	338,505	930,000	930,000	930,000
	- number of head -			
Livestock Enterprise				
Cows	37,257	188,518	188,518	217,339
Sales				
Calves				53,326
Yearlings	23,323	118,013	118,013	84,327
Cows	4,843	24,507	24,507	28,254
Number of Units	342	1,797	1,797	1,887
Average Return to Labor and Management (dollars)	880	5,885	10,574	13,983
Average Return to Labor and Management per Cow Unit	8	56	101	121

1, 2, 3, 4, 5, See Table 1 for details.

Table 13.3 Basic farm organization and income of optimum "Farm Unit" for three cattle price levels[1], Slave River Lowlands.

	- Price Set for Cattle -			
	2	3	4	5
		- acres -		
Land Use				
Improved Land				
Oat hay	-	25	25	21
Alfalfa hay	-	22	22	22
Crested wheat grass hay	-	232	232	233
Unimproved Land				
Pasture	-	161	161	161
Hay	-	151	151	151
Total	-	591	591	588
		- number of head -		
Livestock Enterprise				
Cows	-	113	113	113
Sales				
Calves				
Yearlings	-	62	62	62
Cows	-	15	15	15
Return to Labor and Management (Dollars)	-	6,399	10,970	14,882

1 72 percent calf crop.

2, 3, 4, 5 See Table 1 for details.

Table 13.4 Optimum area land use and production for four cattle price levels[1], Slave River Lowlands.

	- Price Set for Cattle -			
	2	3	4	5
		- acres -		
Land Use				
Improved Land				
Oat hay	-	260,000	260,000	260,000
Alfalfa hay	-	150,000	150,000	150,000
Crested wheat grass hay	-	12,623	12,623	12,623
Unimproved Land				
Pasture	-	270,895	270,895	270,895
Hay	-	236,482	236,482	236,482
Total	-	930,000	930,000	930,000
		- number of head -		
Livestock Enterprise				
Cows	-	194,979	194,979	194,979
Sales				
Calves				
Yearlings	-	106,927	106,927	106,927
Cows	-	27,347	25,347	25,347
Number of Units	-	1,797	1,797	1,797
Average Return to Labor and Management (dollars)	-	3,941	8,314	12,054
Average Return to Labor and Management per Cow Unit	-	36	77	111

1 72 percent calf crop.

2, 3, 4, 5 See Table 1 for details.

Table 13.5 Summary of assumed viability of cattle interprise for four different sets of cattle prices and two levels of calf crops.

	- Price Set for Cattle -			
	2	3	4	5
	- assumed viability -			
80 Percent Calf Crop				
Most suitable soils	No	No	Yes	Yes
Area Average	No	No	Marginal	Yes
72 Percent Calf Crop				
Most suitable soils	No	No	Marginal	Yes
Area Average	No	No	No	Yes

2, 3, 4, 5 See Table 1 for details.

14. PROSPECTS FOR FREE RANGING HORSE PRODUCTION

We can range cattle for between 3 and 4 months. However, early frosts and the nature of the forage drastically reduces the quality of the grazeable vegetation and cattle are barely able to maintain themselves on ranges in the fall. Are we raising the right animal in our boreal forest zone? Should we not be raising an animal that has the capability of utilizing feed of less quality than is necessary for beef production? Should we be looking for a meat source that does not require "grain finishing in order to be acceptable"?

If it is desired to carry out a multiple use of the country for bison as big game and a domestic harvest, then some animal other than the bovine should be chosen. In Siberia, the horse has proven itself capable of wintering under northern conditions. V.M. Andreyev (1971) has described horse herding for meat in Yakutskaya ASSR. He indicates that horse herding, like reindeer herding, is based on natural food resources. It is well adapted to the severe conditions of Yakutskaya and most of the animals remain on pasture throughout the year, receiving additional feed only at difficult periods. Horse herding permits wider use of food resources in distant regions where cattle raising would be uneconomic. An average cost of producing horse meat on the Veekhoyankry State Farm from 1961-1966 was 63.8 rouples per centner (100 kg) while the cost of producing beef was 149.16 rouples per centner. Foals of Yakut horses gain 1 - 1.2 kg per day prior to weaning. Most critical periods is December to February and the spring wind time of March to April. There, herds consist of up to 11 mares for one stallion and the most rational herd structure is about 65% mares up to 62% of which will have foals at any one time. Their survival rate has been as high as 97%.

It has been pointed out that horses are susceptible to the same diseases as bison; tuberculosis, anthrax and brucellosis can infect horses, in addition, they are susceptible to equine infections anemia. They are affected by insects, mosquitoes, deer flies, etc., but appear to cope better than cattle when bothered by these pests. They are able to winter on feed of lower quality than the bovine so long as there is ample volume.

It is a gregarious animal and herds relatively easy so does not require fencing. The horse is intelligent and is powerful enough to overcome most predators including the timber wolf. One critical time of the year could be when snow depths become greater than 50 cm or when crusting of snow occurs. Where horses have "gone wild" they have multiplied and prospered so long as the habitat was suitable and a forage supply was available (Cook, C.W. 1975).

It has been reported and authenticated by the Territorial Fish and Game Branch that three horses survived near the Taltson River for at least ten years. These animals, two mares and a gelding, were spotted occasionally and were reported to be in very good condition. These animals are thought to be remnants of a group of 30 animals introduced to the area in the early 1950's. The "outfitter" that owned the herd reported that his animals had a hard time overwintering without supplemental rations. It is not known what condition his horses were in when they were turned out to the range.

Horses are in demand and will continue to be in demand for saddle and work stock, bucking horses and as a meat animal. This latter use is on the increase and could become a major enterprise for export markets. In the spring of 1978, meat horse buyers in Grande Prairie paid an average of 43 cents per pound and as high as 51 cents per pound for "good" animals. Competition for meat horses had forced up the price. It was reported by Alsask Processors, Edmonton, that they kill 90 animals a day and that 90% of the red meat is exported to Japan and Europe. A market for meat animals is definitely in place.

In order to attain a good return from the land, the product must be more than game animals. Therefore, in view of the above facts, it is suggested that a pilot project involving a small horse herd be established on the lowland with a view to determining the problems that might be encountered and the practical feasibility of producing horses on a semi-wild basis.

14.1 Requirements of Horses

The horse is a non-ruminant animal and unlike a cow it is not able to break down and assimilate roughage by pregastric fermentation. Thus, the cow is extremely efficient in utilizing the protein in its food. However, growth of a bovine is limited by the quality of the feed in that the rate of passage of food through the gut depends upon the rate of breakdown of materials in the rumen. The horse differs from ruminants in that the site of fermentation of cellulose is the enlarged colon and the large intestine and the site for extracting and assimilating protein is the simple stomach. For these reasons, the horse is less efficient than the ruminant in utilizing the protein in food. The horse, fortunately, has no mechanism imposing a limit on the rate of passage of material through the gut. By comparison the horse is able to pass material through its gut twice as fast as a cow (30-45 hours in a horse and 70-100 hours in a cow. (Bell, 1971)

It follows that if the horse is only two-thirds as efficient as the ruminant in extracting protein from forage but processes twice as much food in a given time, its rate of assimilation of protein per unit of time is four thirds of the ruminants' rate. Therefore, a horse is capable of supporting itself on a diet that is too low in protein to support a cow. The horse will paw through snow to reach its feed which is another advantage it has over the cow for use in Boreal areas.

Results of analysis of a few sedge grass samples taken in November, 1968 show a 5-6% protein level. This is minimal for beef cattle but could readily supply the needs of horses.

The Grain Grower (1970), suggests the following nutrient requirements of a 500 kg horse at various stages of production and growth.

	Hay Daily kg	Total Protein kg	TDN kg	Ca gm	P gm	Vit. A I.U.s 1000s
Maintenance	6.2	.4	3.1	11	11	8.3
Work - light	9.3	.4	4.6	12	12	8.3
- medium	10.8	.4	5.4	14	14	8.3
Pregnancy, last quarter	6.6	.5	3.3	16	15	23.3
Lactation	13.1	1.2	6.5	30	24	23.3
Growth, 180 kg, 6 mo	5.6	.50	2.8	15	12	3.3
272 kg, 14 mo	6.4	.45	3.2	14	12	5.0
454 kg, 24 mo	7.0	.40	3.5	13	12	6.7

Both Morrison (1956) and National Academy of Sciences (1973) suggest much higher levels of protein. They both indicate a need for about 10% crude protein levels in the feed with 0.33% calcium and 0.25% phosphorus for 500 kg mature horses at rest. There does appear to be some differences of opinion regarding requirements, however, as the horses in question will be kept at large and free to consume forage and libitum, including browse, then it is safe to accept the lower level of required nutrients.

The phosphorus requirement is between 25 and 30 mg/kg body weight per day and the calcium requirement is 45 mg/kg body weight per day for mature horses (Nat. Academy of Sci. 1973). Analysis for most sedge grass forage in the lowlands is less than .12% for P late in the season and about 0.4% for Ca. This would mean that in order to assimilate P at 25 mg/kg of body weight/day a 500 kg horse would need to consume 10.4 kg of feed per day. It seems possible that one of the nutrients limiting horse production on the lowlands could be phosphorus.

14.2 Capacity for Horse Production

An average 500 kg horse will require 7.0 kg/day of feed in the winter and about 10 kg/day in the summer (Morrison 1956). If we consider winter to be 215 days and summer during which time the animals are sucking foals or putting on weight gains as 150 days, then the total forage needed year long is just over 3000 kg.

Horses appear to be more selective in their grazing than are cattle, therefore forage yields from the open areas as follows will be used:

Grand Detour 2, Lobstick 1.5 and Taltson 3.0 t/ha

The west side of the Slave River is capable of producing:

Grand Detour	94,172 ha x 2.0	=	188,344t
Lobstick	20,724 ha x 1.5	=	31,086t
Taltson	23,600 ha x 3.0	=	70,800t

This should be safety grazed at 60%. Therefore, the total usable forage resource is 174,138 T.

If it takes 3000 kg for one horse for one year, then 58,046 horses could be ranged on a sustained yield basis.

If it was desired to raise, at the same time, 5,000 bison and each animal required 5 t of forage/year, then the total horses would be cut back to 49,712.

On the east side of the Slave River, the production would be:

Grand Detour	113,556 ha x 2 =	227,112 t
Lobstick	79,723 ha x 1.5 =	119,584 t
Taltson	11,218 ha x 3 =	33,654 t
		380,350 t

Safe grazing is again 60% which would allow 228,210 t available. Each animal requires 3 t. Therefore, the capacity is for 76,070 horses.

If it was desired to run both the bison and horses we could produce 5,000 bison along with 67,736 horses.

If this system were applied to the whole area it would be capable of carrying 10,000 bison plus 117,448 horses.

14.3 A Theoretical Horse Production Schedule

Horses have a gestation period of 11 months which means that all mares will not foal every year. In the "wild" state a foal may be expected every 2 out of 3 years, therefore the increase is 66% each year. As with most animals, this could safely be cut back to about 60%. One half the increase will be male and the other half female, which amounts to a 30% increase each year. Losses of young animals will be about 10% and may even be 2% in the breeding mares. Under such conditions starting with 100 horses with 5 stallions and assuming that 2 year old geldings are sold and the young mares are bred to foal at 3 or 4 years of age, the herd size will be doubled every 4-5 years. At that rate of increase, an initial herd of 100 animals would take 16 years to reach 1,000 animals. During that time, approximately 925 geldings would be sold.

This schedule is strictly hypothetical in that information is not available on semi-wild horse production. The figures for rate of increase and loss even though theoretical, are if anything, on the side of minimum production.

The condition of the range would have to be watched closely to assure that local overgrazing accentuated by winter pawing did not become a problem. It is recommended that a pilot project be established on the lowlands in order to test this production schedule, to ascertain the problems that might be encountered and to evaluate the production both of individuals and as a herd.

Initially, the herd which should be between 30 and fifty mares with 3 or 4 stallions should have a caretaker who would live on the site chosen for the project. He would be responsible for production of native hay which would be used to ensure the survival of young animals through the winter. The decision as to the degree of management necessary for a large scale horse enterprise will have to come after several years of study. It will be necessary, however, to undertake a fall roundup during which time the animals will be culled, inoculations administered, weights taken, identification tags attached, branding and gelding of young horses will be carried out.

15. ALTERNATIVES FOR USING THE LOWLANDS

A number of alternatives are open for the future use of the S.R.L.L. No doubt there will continue to be a strong desire to use the land agriculturally. There will also continue to be a great deal of interest in preserving the land for bison and other wildlife.

The total lowlands represents an ecosystem that, at present, is relatively stable. The schematic diagram, Fig. 15.1, serves to show the various factors and how they are interrelated. On the left of the figure are the basic ecological conditions and superimposed upon these is the main influence fire. On the top of the diagram are the products of the environment, bison predators, furbearers, insects. Into this ecosystem comes man and his accompanying impacts through cultivation, inputs of labour, power, seed and fertilizer which produces a new product from the land, domestic livestock. Each of the natural products has a profound influence on each condition and each other product, and each, of course, has influence on and is influenced by the presence of man. As this presence becomes more pronounced the ecosystem changes and becomes more unbalanced. Overriding all these factors, and having little chance to change because of them, is the climate of the area represented here by the four main arrows: temperature, precipitation, day length and wind. It is logical to assume that pressure from man will rapidly change this diagram so that the natural outputs will gradually give way to man's domination. Already these forces are in progress with the drastic reduction in fires being one example.

SLAVE RIVER ECOSYSTEM

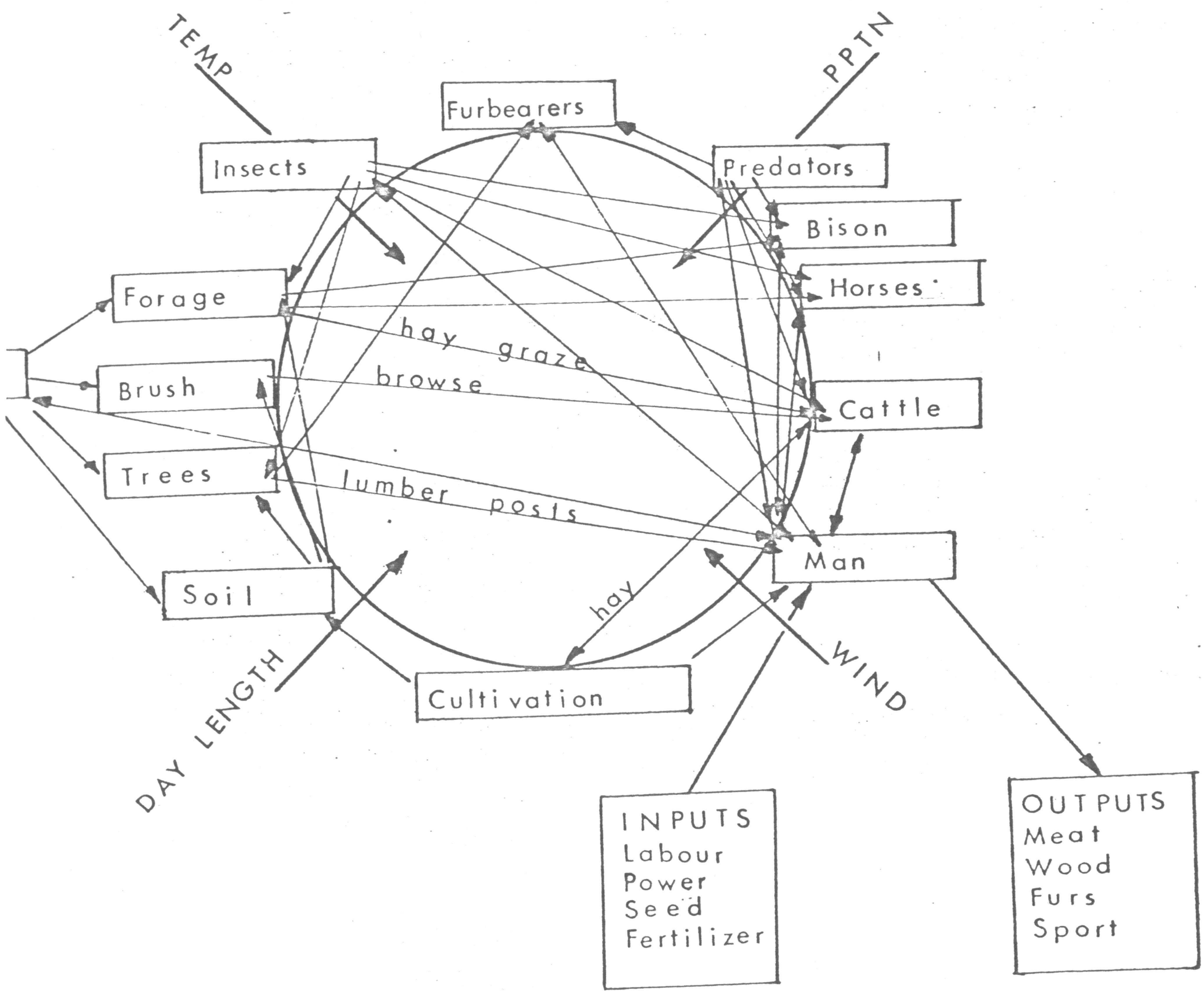

Figure 15.1

Gradually the needs of the people of Canada for living room, food and work opportunities with respect to this vast area, will have to be met. It is the **here and now** that we must concern ourselves with in this report. Therefore, any plan of action must be well considered so as to make the best use of the land at the least cost and with the least disturbance to the ecology.

This report has attempted to identify the physical aspects that could affect land use in the Slave River Lowlands. It cannot recommend how the area will be alienated, how it should be managed or who would be responsible for initiating a production scheme. Implementation of these needs fall to the policy makers.

In considering the use of this land, the governing thoughts must be the initial costs, the expected return, and the quality of life of the participants be they native or otherwise. In addition, the direction of development should take into consideration the need to conserve non-renewable energy. For example, a cow-calf operation requiring hay will expend far more energy than a free-ranging horse production unit. We must be looking at the situation that will be the order of the day twenty years from now. We must ask ourselves what will be the need for the products of this last frontier. I think we can safely say that the requirements of the few people of the southern portion of N.W.T. are not relative to the massive production that can be expected, if and when the Slave River Lowlands are being utilized effectively. To be efficient, it is essential that the area produce large quantities of one product. This will ensure a market for the commodity be it weaned calves or three year old horses.

The problem is that this production cannot be realized until the area becomes developed as production must start from zero and work up. If production was started without some direction then a number of different products would be produced and there would not be enough need to apply pressure for either processing or marketing, therefore each little enterprise would fail for lack of a concerted effort. It is only by having a large volume of a consistent and desirable product that an enterprise, under present conditions can become successful. A certain amount of diversification can come about later.

On the lowlands of the Slave River, a virtually unused forage resource exists. The 6 year study reported here indicates that some of the land may be improved to increase production and that much of the land has a potential by grazing animals in its present state. A number of hazards and constraints are recognized. Some of these are different or more serious than those encountered in other areas that are now developed agriculturally. However, if and when development progresses, these problems will gradually be overcome or circumvented. In order to achieve success and bring about efficient agricultural productivity from the area, a plan must be evolved and adhered to. This, then, is the next logical step in a process that started with the soil reconnaisance of 1959.

APPENDIX I

Species lists - Modified from Day (1972)

Table 1. Species occurring in Vegetation Type 1, Prairie.

Grasses:

Agropyron trachycaulum (Link) Malte
var. unilaterale (Cassidy) Malte
Agrostis scabra Willd.
Calamagrostis inexpansa A. Gray
Festuca brachyphylla Schultes
Poa interior Rydb.
Poa pratensis L.

Sedges and Rushes:
Carex aenea Fern.
Juncus balticus Willd.

Herbs:

Achillea lanulosa Nutt.
Androsace septentrionalis L.
var. puberulenta (Rydb.) Knuth
Anemone multifida Poir.
Anemone patens L.
var. Wolfgangiana (Bess.) Koch
Fragaria virginianum Duchesne
Galium boreale L.
Potentilla arguta Pursh.
Senecio pauperculus Michx.
Sisyrinchium montanum Greene
Stellaria longipes Goldie
Thalictrum venulosum Trel.
Vicia americana Muhl.
Viola adunca Sm.

In the South (Ft. Smith area) only:

Grasses and sedges:
Koeleria cristata (L.) Pers.
Muhlenbergia richardsonis (Trin.) Rydb.
Carex pensylvanica Lam.
var. digyna Börk.
Artemisia ludoviciana Nutt.
var. gnaphalodes (Nutt.) T. & G.
Aster pansus (Blake) Cronq.
Astragalus alpinus L.
Campanula rotundifolia L.
Geum triflorum Pursh
Hedysarum alpinum L.
var. americanum Michx.
Potentilla pensylvanica L.
Oxytropis splendens Dougl.
Solidago multiradiata Ait.
Solidago rigida L.

Grand Detour - Hook Lake area:

Carex atherodes Spreng.
Cirsium foliosum (Hook) D.C.
Cirsium drummondii T. & G.
Geum aleppicum Jacq.
Solidago canadensis L.
Erigeron lonchophyllus Hook.

Soils: Driest members of the Clewi (South) and Grand Detour catenas.

Table 2, Species occurring in the Meadows, Vegetation Types, 2, 3, 4 and 5.

In all Meadows:

Grasses:
Agropyron trachycaulum (Link) Malte
Beckmannia syzigachne (Steud.) Fern.
Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis inexpansa A. Gray
Calamagrostis neglecta (Ehrh.) Gaertn.
Phalaris arundinacea L.
Poa palustris L.
Scolochloa festucacea (Willd.) Link

Sedges and Rushes:
Carex aquatilis Wahl.
Carex atherodes Spreng.
Carex sp. 1
Carex sp. 2
Juncus balticus Willd.

Herbs:
Sium suave Walt.
Stachys palustris L.
Artemisia biennis Willd.

In 2, Dry Sedge Meadow:

Grasses:
Agrostis scabra Willd.
Deschampsia caespitosa (L.) Beauv.
Poa pratensis L.

Herbs:
Epilobium glandulosum Lehm.
var. adenocaulon (Hausskn.) Fern.
Geum aleppicum Jacq.
Scutellaria galericulata L.
var. pubescens Bentham
Senecio pauperculus Michx.
Senecio eremophilus Richards.

In V3, Wet Sedge Meadow:

Grasses and Rushes:
Cinna latifolia (Trev.) Griseb.
Glyceria grandis S. Wats.
Glyceria pulchella (Torr.) Trin.
Sparganium minimum (Hartm.) Fries
Typha latifolia L.

Herbs:
Bidens cernua L.
Cicuta mackenzieana Raup
Potentilla palustris
Petasites sagittatus (Pursh) A. Gray

In Saline Meadows only:

Grasses:
Hordeum jubatum L.
Puccinellia nuttalliana (Schultes) Hitchc.
Spartina gracilis Trin.

Herbs:

Glaux maritima L.
Plantago eriopoda Torr.
Salicornia rubra A. Nels.
Spergularia marina (L.) Griseb.
Suaeda depressa (Pursh) S. Wats.
Triglochin maritima L.

In 4, Saline Dry Meadow:

Agrostis scabra Willd.
Distichlis stricta (Torr.) Rydb.
Muhlenbergia richardsonis (Trin.) Rydb.
Senecio pauperculus Michx.
Erigeron lonchophyllus Hook.

In 5, Saline Wet Meadows:

Eleocharis palustris (L.) R. & S.
Scirpus americanus Pers.
Typha latifolia L.

Soils: 2 - Moderately to poorly drained members of the Clewi and Grand Detour
3 - Poorly drained Clewi and Grand Detour
4 and 5 - Moderately and poorly drained Saline Rego Gleysols.

Table 3. Species occurring in Vegetation Types 6, 7, 8 and 9: Brush.

In all Brush Types:

Salix bebbiana Sarg.
Salix glauca L.
Shepherdia canadensis (L.) Nutt.
Potentilla fruticosa L. (in south only)

In transitions to Woods:

Viburnum edule (Michx.) Raf.

Cornus stolonifer Michx.

In south on sand:

Elaeagnus commutata Bernh.

In south on loam:
Amelanchier alnifolia Nutt.

6. Willow Brush:

Salix candida Fluegge
Salix maccalliana Rowlee
Salix petiolaris Sm.
Salix planifolia Pursh

Ground cover:
Dry Sedge Meadow
Achillea sibirica Ledeb.
Aster ciliolatus Lindl.

7. Willow - Aspen Brush:

In addition to 6:
Populus tremuloides Michx.
Populus balsamifera L.
Picea glauca (Moench) Voss

Seedlings and saplings.

8. Willow - Ground Birch Brush:

Betula glandulosa Michx.
Salix myrtillifolia Anderss.
Salix serissima (Bailey) Fern.
Ground cover:
Transitional between
Dry Sedge Meadow and
Wet Sedge Meadow

9. Willow - Alder Brush:

Salix interior Rowlee
Salix serissima (Bailey) Fern.
Alnus tenuifolia Nutt.
Alnus crispa (Ait.) Pursh
Ground cover:
None, or more or less dense
Equisetum spp., interspersed
with some grasses and sedges
of the Meadows.

Table 4. Species occurring in the Pioneer Woods, 10 and 11.

Tree layer:
Populus tremuloides Michx. (D* in 10)
Populus balsamifera L.
Betula papyrifera Marsh (D in 11)
Betula occidentalis Hook.
Picea glauca (Moench) Voss
(seedlings and saplings)

Shrub Layer:
Rosa acicularis Lindl.
Sheperdia canadensis (L.) Nutt.
Salix bebbiana Sarg.
Cornus stolonifera Michx.
Viburnum edule (Michx.) Raf.
Amelanchier alnifolia Nutt.
Rubus idaeus L.
var. aculeatissimus Regel & Tiling
Ribes oxyacanthoides L.

Herb Layer:
Agropyron trachycaulum (Link) Malte
Agropyron trachycaulum (Link) Malte
var. unilaterale (Cassidy) Malte
Bromus ciliatus L.
Bromus pumpellianus Scribn.
Elymus innovatus Beal
Oryzopsis asperifolia Michx.
Poa pratensis L.
Aster ciliolatus Lindl.
Cornus canadensis L.
Delphinium glaucum S. Wats.
Epilobium angustifolium L.
Equisetum arvense L.
Fragaria virginiana Duch.
Galium boreale L.
Habenaria viridis (L.) R. Br.
var. bracteata (Willd.) Gray
Lathyrus ochroleucus Hook.
Mertensia paniculata (Ait.) G. Doh
Petasites palmatus (Ait.) A. Gray
Pyrola asarifolia Michx.
Vicia americana Muhl.

Ground cover very sparse:
Gladonia multiformis Merrill
Cladonia gracilis (L.) Willd.
Cladonis mitis Sandst.
Peltigera canina (L.) Wild.
var. albescens (Wahlb.) Thoms.

Soils: 10 is predominantly on Brown Wooded, Ft. Smith, Slave and Clewi.
11 on Jean, well drained to moderately drained members.

D* - Dense growth.

Table 5. Species occurring in Climax Woods, 13, 15, 16 and 20.

13. White Spruce Woods

Tree layer:
Picea glauca (Moench) Voss (D)
Populus tremuloides Michx.
Populus balsamifera L.
Betula popyrifera Marsh

Shrub layer (sparse):

Rosa acicularis Lindl.

Shepherdia canadensis (L.) Nutt.
Cornus stolonifera Michx.
Viburnum edule (Michx.) Raf.

15, 16. Black Spruce Woods

Tree layer:
Picea mariana (Mill.) BSP (D)
Larix laricina (DuRoi) K. Koch
(Picea glauca (Moench) Voss)

Shrub layer(Sparse):
Betula glandulosa Michx.(D in 15)
Ledum groelandicum Oeder (D in 16)
Salix myrtillifolia Anderss.
Salix glauca L.

20. Jack Pine Woods

Tree layer:
Pinus banksiana Lamb. (D)
Populus tremuloides Michx.
(Picea glauca (Moench) Voss)

Shrub layer (sparse):
Salix bebbiana Sarg.
Shepherdia canadensis (L.) Nutt.
Cornus stolonifera Michx.
Apocynum androsaemifolium L.

Herb layer in all types:
Arctostaphylos uva-ursi (L.) Spreng.
Cornus canadensis L.
Epilobium angustifolium L.
Fragaria virginiana Duch.
Geocaulon lividum (Richards.) Fern.
Habenaria viridis (L.) R. Br.
  var. bracteata (Willd.) A. Gray
Linnaea borealis L.
  var. americana (Forbes) Rehder
Pyrola secunda L.

In 13:
Agropyron trachycaulum (Link) Malte
Elymus innovatus Beal
Carex disperma Dew.
Carex trisperma Dew.
Actaea rubra (Ait.) Willd.
Calypso bulbosa (L.) Oakes
Corallorhiza trifida Chat.
Equisetum scirpoides Michx.
Goodyera repens (L.) R. Br.
Mitella nuda L.
Moneses uniflora (L.) A. Gray
Pyrola grandiflora Radius

In 15, 16:
Calamagrostis inexpansa A. Gray
Carex atherodes Spreng.
Carex capitata L.
Carex gynocrates Wormskj.
Arctostaphylos rubra (Rehd. & Wils.) Fern.
Equisetum scirpoides Michx.
Rubus acaulis Michx.
Rubus chamaemorus L.
Spiranthes romanzoffiana Cham.
Vaccinium vitis-idaea L.

In 20:
Calamagrostis purpurascens R. Br.
Carex aenea Fern.
Anemone mutifida Poir.
Anemone patens L.
  var. wolfgangiana (Bess.) Knuth
Antennaria sp.
Vaccinium myrtilloides Michx.

Ground cover, in all Woods, with abundance as indicated:

Mosses:
Aulacomnium palustre (15, 16, a)*
Diacranum rugosum
Hylocmium splendens (13, a)
Mnium sp. (15, a)
Pleurozium schreberi (13, a)
Polytrichum commune (13, a)
Polytichum juniperinum (20, a)
Ptilidium ciliare (13, a)
Ptilium crista-castrensis
Sphagnum spp. (16, a)
Tomenthypnum nitens(15, a)

Lichens:
Cladonia alpestris (16, a)
Cladonia amaurocraea
Cladonia deformis (15, 16, a)
Cladonia gracilis
  var. dilatata (20, a)
  var. elongata (13, 15, 16, a)
Cladonia mitis (20, a)
Cladonia multiformis
  var. simulata (15, 16, a)
  var. subascypha (20, a)
Cladonia rangiferina (16, a)
Cladonia uncialis (20, a)
Cladonia cristatella (20, a)
Cladonia cornuta (13, 16, a)
Cladonia cariosa (20, a)
Cladonia coccifera (20, a)
Cladonia squamosa (13, 16, a)
Cladonia verticillata (20, a)
Stereocaulon tomentosum (20, a)
Cetraria nivalis (16, a)
Cetraria islandica (20, 16, a)
Peltigera aphthosa variolosa (13, a)
Peligera canina albescens (16, a)
Peltigera canina spuria (20, 16, a)
Peltigera horizontalis
Peltigera malacea (13, a)
Peltigera polydactyla

Transitions between Pioneer Woods and Climax:

<u>12, White Spruce - Aspen</u>, is transitional between 10 or 11 and 13. The Shrub layer is better developed, the Herb layer contains species of 10 or 11, with several species of 13 lacking, the ground cover is usually less than 50%.

<u>14, Black Poplar</u>, is a transitional stage between 10 and 13, which has stagnated into virtually pure Black Poplar. The Shrub layer is very sparse; the Herb layer often dominated by Equisetum arvense, and the Ground cover lacking.

<u>18, Jack Pine</u> - Aspen, is transitional between 10 and 20; the Shrub layer is better developed than in 20; the Herb layer contains several species of 10, and the ground cover is sparse.

<u>17, White Spruce</u> - Black Spruce, and 19, Jack Pine - White Spruce, are transitional between 13 and 15, 16 and 20, respectively. Shrub and Herb layer and Ground cover are intermediate.

Soils: 13 is predominantly on well to moderately drained members of the Slave and Jean series.
15 and 16 are predominantly on moderately to poorly drained Gleysols and members of the Clewi and Grand Detour series.
20 is predominantly on well drained Ft. Smith soils, and gravel deposits.

a* - Abundant

REFERENCES

Bell, Richard A.V. 1971. A grazing ecosystem in the Serengeti. Scientific American. July 86 - 93.

Canada Dept. of Environment, 1973. Monthly record Meteorological Observations in Canada. Nov. 1973. Information Canada, Ottawa, Ontario.

Cook, Wayne C. 1975. Wild horses and burros: A new management problem Rangeman's Journal, S.R.M. Feb. Vol. 2, No. 1, Pp 19-21.

Corns, Wm. G. and R.A. Schraa, 1962. Seasonal productivity and chemical composition of march seed grass (Calamagrostis canadensis (Michx. Beauv.)) harvested periodically from fertilized and unfertilized native sod. Can. J. Plant Sci. 42: 651-659.

Day, J.H. 1972. Soils of the Slave River Lowland in the Northwest Territories. Soils Research Institute, Ottawa. Cat. No. A57-444/1972.

Day, J.H. and A. Leahey. 1957. Reconnaissance Soil Survey of the Slave River Lowland in the Northwest Territories of Canada. Experimental Farms Service, C.D.A., Ottawa.

Hirvonen, R.P. 1968. Report on the forest conditions in the Lower Slave River area Northwest Territories. Northern Surveys Report No. 4. Dept. of Forestry and Rural Development, Forest Management Institute, Ottawa, July 1968.

Goodrich, R.D. 1965. Factors affecting mineral requirements of fattening cattle. Proceedings of the 26th Minnesota Nutrition Conference, Univ. of Min.

Author Unknown - 1970. Horse feeds and feeding. Dec. issue (The Grain Grower: pages 460, 450.

Hirvonen, R.P. 1968. Report on Forest Conditions in the Lower Slave River Area Northwest Territories (No. 4). Forest Management Institute, Dept. of Forestry and Rural Development, Ottawa.

Kaila, A. 1958. Availability for plants of phosphorus in some virgin peat samples. J. Sci. Agr. Soc. Finland; 30, 133-142.

Lodge, R.W., J.B. Campbell, S. Smoliak and A. Johnson. 1971. Management of Western Range. C.D.A. Pub. 1425.

Morrison, F.B. 1956. Feeds and Feeding. 22nd ed. Morrison Pub. Co., Ithaca, N.Y.

National Academy of Sciences, 1970. Nutrient requirements of domestic animals, No. 4, Nutrient requirements of beef cattle, 4th ed. Washington, D.C.

National Academy of Sciences. 1973. Nutrient requirements of domestic animals, No. 6, Nutrient requirements of horses, 3rd revised edition. Washington, D.C.

Paul, E.H., R.I.A. Myers and W.A. Rice. 1971. Nitrogen fixation in grassland and associated cultivated ecosystems. Plant and Soil, Special Vol (?): 495-507.

Pringle, W.L., Cairns, R.R., Hennig, A.M.F. and Siemens, B. 1975. Salt status of some soils of the Slave River Lowlands in Canada's Northwest Territories. Can. J. Soil Sci. 55:399-406.

Raup, H.N. 1946. Phytogeographic studies in Athabasca - Slave Lake Region. Part II. J. of Arnold Arbor 27:1-85.

Rowe, J.S., J.L. Bergseeinsson, G.A. Padbury and R. Hermesh. 1974. Fire studies in the McKenzie Valley. INA Pub. No. QS-1567-000-EE-A1. Arctic Land Use Research Program, Northern Economic Development Branch, Dept. of Indian Affairs and Northern Development. Ottawa.

Simmons, N.M. 1975. Analysis of the utilization of meadows for bison range and agriculture in the McKenzie District N.W.T. Canadian Wildlife Service Progress Report, Feb.

Shemanchuk 1975. Letter from Lethbridge, Alta. Personal communication.

Stutt, R.A. 1968. An economic appraisal of proposed agricultural development and cattle ranching in the Slave River Lowlands, N.W.T. Economics Branch CDA, Ottawa.

Stutt, R.W., Day, J.H. and Rasmussen, K. 1969. Report on the potential of the Slave River Lowlands for agriculture and the feasibility of developing a viable cattle ranching industry in the area. Unpublished Report. Jan. 10, 1969. Ottawa.

Van Soest, P.J. 1963. Use of detergents in the analysis of fibrous feeds. II. A rapid method for the determination of fibre and lignin. J. Ass. Offic. Agri. Chem (J. of A.O.A.C. 46:829).

Ward, G.M. and F.B. Johnston, 1962. Chemical methods of plant analysis. Research Branch, C.D.A. Pub. 1064.