0-315-03622-2

National Library of Canada — Bibliothèque nationale du Canada

Canadian Theses Division — Division des thèses canadiennes

Ottawa, Canada
K1A 0N4

51517

PERMISSION TO MICROFILM — AUTORISATION DE MICROFILMER

- Please print or type — Écrire en lettres moulées ou dactylographier

Full Name of Author — Nom complet de l'auteur

HELEN MAUREEN KERSHAW

Date of Birth — Date de naissance

12 MARCH 1981

Country of Birth — Lieu de naissance

CANADA

Permanent Address — Résidence fixe

120 Roxborough Dr
Sudbury Ontario
P3E 1J7

Title of Thesis — Titre de la thèse

Plant Community Characteristics of Prairie Creek, N.W.T.

University — Université

University of Alberta

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

MSc — Plant Ecology

Year this degree conferred — Année d'obtention de ce grade

SPRING 1981

Name of Supervisor — Nom du directeur de thèse

Date

May 13 1981

Signature

H. Maureen Kershaw

NL-91 (4/77)

THE UNIVERSITY OF ALBERTA

A STUDY OF THE PLANT COMMUNITY CHARACTERISTICS OF PRAIRIE CREEK ALLUVIAL FAN, NAHANNI NATIONAL PARK, N.W.T.

by

© H. MAUREEN KERSHAW

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

PLANT ECOLOGY

DEPARTMENT OF BOTANY

EDMONTON, ALBERTA

SPRING 1981

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR H. MAUREEN KERSHAW

TITLE OF THESIS A STUDY OF THE PLANT COMMUNITY CHARACTERISTICS OF PRAIRIE CREEK ALLUVIAL FAN, NAHANNI NATIONAL PARK, N.W.T.

DEGREE FOR WHICH THESIS WAS PRESENTED MASTER OF SCIENCE

YEAR THIS DEGREE GRANTED SPRING 1981

(Signed) H. T. Maureen Kershaw

PERMANENT ADDRESS:

120 Roxborough Dr

Sudbury, Ontario

P3E 1J7

DATED March 24, 1981

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled A STUDY OF THE PLANT COMMUNITY CHARACTERISTICS OF PRAIRIE CREEK ALLUVIAL FAN, NAHANNI NATIONAL PARK, N.W.T. submitted by H. MAUREEN KERSHAW in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in PLANT ECOLOGY.

Paul R. Gorham
Acting Supervisor
for L. C. Bliss

N. J. Dudas

Peter J. Achuff

Date February 4, 1981

ABSTRACT

The vascular flora and vegetation patterns for Prairie Creek alluvial fan, Nahanni National Park, N.W.T. were quantitatively and qualitatively described. A list of vascular species (192 species in 42 families) and a preliminary list of bryophytes and lichens was compiled.

The vegetation was classified into 16 plant community types based on cluster analysis and similarity matrices with the aid of aerial photographs. The greatest areal extent on the fan gravels was occupied by the *Dryas drummondii* community type and the *Arctostaphylos uva-ursi*/*Juniperus horizontalis*/Lichen community type. *Salix* and *Betula* species dominated the three scrub community types adjacent to active and abandoned channels. *Picea glauca* *Larix laricina* and *Populus balsamifera* were the three tree species found most frequently on both the fan gravels and the deep South Nahanni River levee silts and sands.

Vegetation patterns were related to fluvial processes and surficial deposits within a successional framework. Aerial photographs from 19[illegible]4 to 1977 were examined to document changes over time. Channel pattern, ice break-up, flood scars and surficial evidence for flooding were related to vegetation patterns. Three hundred tree cores and 38 cross-sections were examined to age major fire and flood events, to indicate growing conditions over time and space, and to assess the extent of carpenter ant damage.

Picea glauca seedlings and *Dryas drummondii* were the primary colonizers of denuded gravel sites. *Juniperus horizontalis*

Arctostaphylos uva-ursi and lichens became more prominent members of the gravel communities with a decrease in flood frequency and intensity. The formation of a shallow duff layer and a drop in the water table were accompanied by the establishment of a climax *Picea glauca*/*Rosa acicularis*/*Linnaea borealis* community type.

Salix interior and *Equisetum* pioneered the colonization of deep fine silt deposits, surviving successive depositional events. *Picea glauca* and *Populus balsamifera* invaded these communities with increasing distance from active flooding and scouring events. A climax community type of *Picea glauca*/*Rosa acicularis*/*Equisetum* was evident in areas of former heavy siltation.

Recommendations concerning the use of Prairie Creek alluvial fan for park visitation and interpreation are summarized.

ACKNOWLEDGEMENTS

I would like to thank my supervisor Dr. L. C. Bliss for his continuing advice and encouragement throughout the course of this study. Dr. P. Gorham is sincerely thanked for his encouraging assistance and time during the final stages of my thesis. Advice concerning vegetation sampling and analysis methods from Dr. G. LaRoi and Dr. E. Karlin is gratefully acknowledged. Special thanks are due Mr. J. Campbell for his assistance with computer programs and continual encouragement.

I am indebted to Dr. D. Pluth who provided facilities and materials to carry out soil analyses and spent time discussing soil sampling and analysis techniques. Thanks are due to Dr. M. Dudas who identified the components of a volcanic ash sample from the fan. Special thanks are due to both Dr. M. Dudas and Dr. P. Achoff who agreed to serve as replacement committee members and provided advice during the final stages of the thesis.

Several taxonomists generously aided in species identification and/or verification; lichens by Mr. A. H. Marsh, Mr. M. Ostafichuk, Mrs. M. See, and Mr. T. Ahti; bryophytes by Dr. W. Steere; Salices by Dr. G. Argus, Carices by Ms. M. Dumais, Mr. P. Lee and Dr. J. Hudson; vasculars by Dr. W. J. Cody. Dr. D. Vitt contributed useful background information on the bryophyte evidence for glacial refugia.

Special thanks are owed to Mr. A. H. Marsh, Mrs. L. Kershaw and my husband William who provided knowledgeable assistance and excellent company in the field. William has provided patient support and help throughout the project. Linda Kershaw assisted with soil analyses. Ms. P. Mortimer's help with the typing is gratefully acknowledged.

This project was feasible only with the advice and continual help of Dr. George Scotter of the Canadian Wildlife Service, Edmonton, who first introduced me to Prairie Creek fan and Nahanni National Park.

Financial support was provided through post-graduate NRC grant (1976-77), a graduate award from the Department of Botany (1978) and logistic support from Parks Canada. The co-operation of Park Superintendent Mr. E. Hiscock and Park Wardens Mr. Art Cochrin, R. Frey and Mr. Lu Comin is gratefully greatly appreciated.

TABLE OF CONTENTS

TABLE OF CONTENTS continued

TABLE OF CONTENTS continued

TABLE OF CONTENTS continued

TABLE OF CONTENTS continued

LIST OF TABLES

LIST OF TABLES continued

LIST OF FIGURES

LIST OF FIGURES continued

LIST OF FIGURES continued

LIST OF MAPS

LIST OF ABBREVIATIONS

Auu	*Arctostaphylos uva-ursi*
Bg	*Betula glandulosa*
Bp	*Betula papyrifera*
Bpu	*Betula pumila*
Ca	*Carex*
Cc	*Cornus canadensis*
Cs	*Cornus stolonifera*
Dd	*Dryas drummondii*
Ei	*Elymus innovatus*
Eq	*Equisetum*
Eq-a	*Equisetum arvense*
Eq-h	*Equisetum hyemale*
Eq-p	*Equisetum pratense*
Eq-v	*Equisetum variegatum*
F	Feathermoss
G	Gravel
Jc	*Juniperus communis*
Jh	*Juniperus horizontalis*
Lb	*Linnaea borealis*
Ll	*Larix laricina*
Pb	*Populus balsamifera*
Pf	*Potentilla fruticosa*
Pg	*Picea glauca*
Ra	*Rosa acicularis*
Sa	*Salix*
Sa-a	*Salix alaxensis*
Sa-ar	*Salix arbusculoides*
Sa-i	*Salix interior*
Sa-p	*Salix pseudomonticola*

I. INTRODUCTION

The effect of geomorphic processes on vegetation patterns has been emphasized by many authors including Heinselman (1970), Hack and Goodlett (1960), and Drury (1956). This is evident in floodplain zones where plant distribution is influenced by origin and development of surficial deposits. In turn, plant establishment contributes to physical and chemical characteristics of this medium, for example through enhancing soil stability (Gill 1972) and increasing soil fertility (Viereck 1970). Fluvial processes direct this parallel evolution of alluvial landscapes and associated biological systems. Plant community boundaries often coincide with frequency and depth of flooding (Gill 1972,1973).

Vegetation patterns and riparian succession were studied during the summer of 1976 and spring of 1977 on Prairie Creek alluvial fan, Northwest Territories. Its value as a study site is enhanced by several factors: active flooding of both Prairie Creek and the South Nahanni River modifies the fan surface; available aerial photographic coverage extends from 1934 to 1976; heath, scrub, woodland, savannah and forest cover types are represented. In addition, the fan's location within a national park facilitates ongoing research.

Study objectives were:

1. to identify and map surficial geomorphic features;
2. to delineate and map vegetation patterns;
3. to describe plant communities in terms of floristic composition, cover and physical site parameters;
4. to determine successional trends.

Aerial photographic interpretation and on-site field investigation were conducted to meet these objectives.

Similar studies have been completed along northern river and delta systems. Of special note are the studies by Bliss and Cantlon (1957) along the Colville River in northern Alaska and Viereck's (1970) documentation of soil development in relation to forest succession adjacent to the Chena River in interior Alaska. In northern Canada, comprehensive surveys of successional sequences associated with channel migration have been completed by Gill (1973) in the Mackenzie delta and by English (1979) for the Slave River delta. In Sweden, similar research has been carried out on a Lapland delta by Dahlskog (1966). Biophysical surveys in the Yukon and Northwest Territories (Hettinger et al. 1973, Douglas 1974) include general community descriptions for several fan systems. In western Alberta, Lulman (1975) has completed a study of alluvial fan Populus stands. Strang (1973) and others have noted the need for further successional studies in northern regions.

The geomorphology of alluvial fan systems has been documented by many researchers. Recent and past geomorphic work has focused on desert drainage systems of the western United States. Particle size distribution, slope, stratigraphy and climatic factors have been described and correlated. Studies by Beaty (1963, 1970), Blissenbach (1954), Bull (1960) and Hook (1968) are well known in this field. The occurrence of alluvial fans is less frequent in humid and cold regions. Leggett, Brown and Johnson's (1966) study of inactive alluvial fans near Aklavik is one of the few documentations for northern alluvial fan systems.

The Concept of Succession on Alluvial Fans

Odum (1971) defines succession as the orderly change in community composition, structure and function over time leading by stages to a stable self-perpetuating climax that is in dynamic equilibrium. On an alluvial fan these changes are triggered by fluvial processes. Seral progression can be monitored by changes in plant species present, and variation in relative mass or abundance of structural components (McCormick 1968).

Clements (1916) identified three phases leading to the development of the climax community: (1) nudation and colonization, (2) establishment, and (3) stabilization. An active alluvial fan surface is continually modified through erosion and deposition as it adjusts to the base level. Point bars and islands emerge within the stream bed. Multiple channels are scoured, then abandoned, across the floodplain. In some areas, overbank silt deposition buries established herb layers. These new surfaces are successfully colonized largely by species distributed by wind or water. Germination and establishment in these flood prone areas require tolerance to inundation, siltation and periodic drought. The success or continuation of species is dependent upon their ability to survive increased drought as the surfaces build up above the level of annual flooding. Stabilization is possible when this fluvial influence is minimal. With continual adjustment of the anastomosing channels, succession can be both progressive and regressive (Ludi 1930) on fan systems. Regressive succession can occur through the introduction of flood events in a formerly stable flood free community. Silt deposition can bury established forb layers and hinder tree growth by smothering established root systems.

Evidence for succession is often circumstantial based on casual observation, historical records, geological records, age series, areal relation or direct study of a site and experimentation over time (McCormick 1968). The most useful but least applied method is the direct long term observation of a site. The discussion of successional concepts on Prairie Creek fan was based on historical and geomorphological records, age series, and spatial changes in species composition.

II. DESCRIPTION OF STUDY AREA

Location

Prairie Creek alluvial fan occurs within the southern portion of Nahanni National Park, Northwest Territories (Fig. 1). It is located at the confluence of Prairie Creek and the South Nahanni River approximately 150 air km WSW of Fort Simpson at 61 15' N Lat., 124 27' W Long. This feature is bounded by the sharp elevational gradients of eroded lake sediments to the west and north and the Nahanni Plateau to the east. The southern boundary is delimited by the South Nahanni River. The fan occupies an area of 607 ha (6.1 sq. km) within Deadmen Valley between First and Second Canyon. Maximum length and width reach 4.2 and 3.5 km respectively (Fig. 2).

Regional Geology

Nahanni National Park lies within the Mackenzie Mountain and Liard Plateau physiographic regions of the Western Cordillera (Bird 1972). The Mackenzie Mountain subdivision is composed of a northeast front arc of low wide mountains and plateaus known as the Canyon Ranges and the main body of rugged mountains to the southwest called the Backbone Ranges (Bostock 1948). The latter are characterized by north-trending thrust sheets and faulted flanks (Douglas 1970). The Liard Plateau consists of broad folding hills rising to 1370 m asl. (Bostock 1948). It is bounded on the north by the South Nahanni River and its tributary the Flat River.

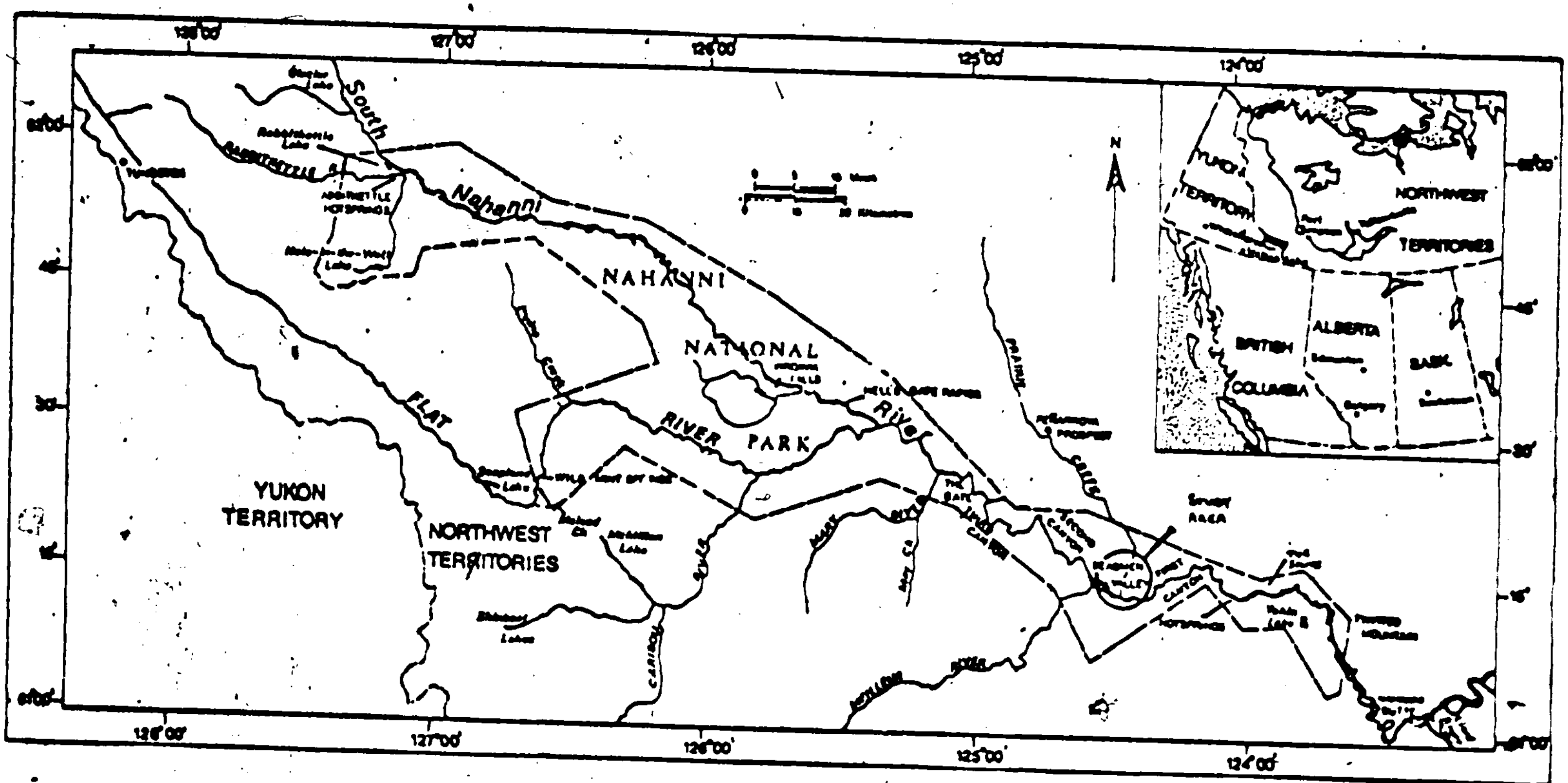


Fig. 1. Location of Prairie Creek alluvial fan, Nahanni National Park, N.W.T.

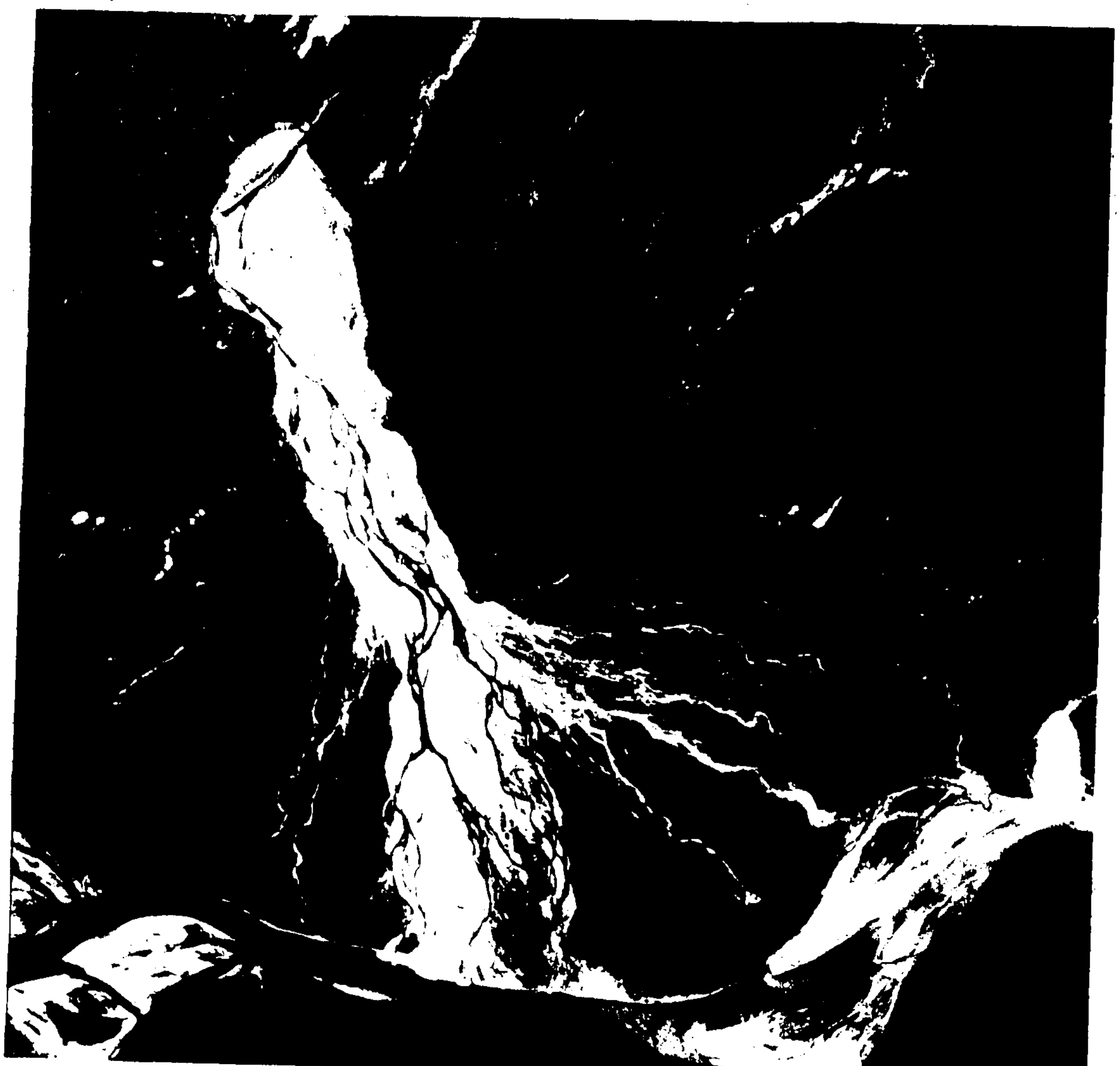


Fig. 2. 1974 aerial view of Prairie Creek alluvial fan, N.W.T. (Scale 1:63360).

Ford (1974) simplifies the geological history of Nahanni National Park into two major periods: 550 to 300 million yrs. B.P. and 110 million yrs ago to the present. During the Palaeozoic period (550 to 300 million yrs B.P.) the area within the current Park boundaries, including the Mackenzie Mountains, formed part of a shallow inland sea lying west of the Canadian Shield craton. Approximately 7000 m of Ordovician, Silurian, Devonian and Carboniferous sedimentary strata were formed on this shallow submarine platform (Dowling 1922, Dunbar 1952). The terriginous sandstones, shales, mudstones and siltstones were frequently impregnated with calcite, or dolomitic precipitates. Similarly, mud and sand mingled with the calcite.

The presence of limestones and dolomites infer tropical or sub-tropical temperatures. Trilobites and fossil corals are evident in the gravel lining the shores of the South Nahanni River (Scotter _et al_. 1971) and in rocks forming the rubble bed of many alluvial fans.

Ford (1974) comments that there is no record of sedimentation following the end of the Carboniferous period. It is speculated that the platform rocks were uplifted during the Triassic and early Jurassic periods and consequently exposed to degradation by erosion processes.

The second major period (110 million yrs. B.P. to the present) is characterized by deformation of the platform. Dunbar (1952) describes the formation of a geosyncline or trough along the present Rocky and Mackenzie Mountains which permitted the reentry of seas. Plate tectonic deformation of the area is thought to have followed this event during late Cretaceous times (Ford 1974). Sediments buckled and folded east of a batholithic intrusion which formed the high peaks of the Nahanni Arguilles and Cuillins of the Ragged Range and provided the source areas for the South Nahanni River (Fig. 3). The main ridges of the Mackenzie Mountains originated during this process of crustal compression. The folding continues to occur in the eastern half of the Park during the current Holocene period (Ford 1974).

Anticlines and synclines are the most common type of sedimentary folding found in the Park. Table 1 and Fig. 4 describe and locate the major geological units of Deadmen Valley as identified by Douglas and Norris (1960). Prairie Creek alluvial fan is located in the Deadmen Valley shale syncline (Unit 29), bordered by the Headless Range (Second Canyon) to the west and the Nahanni Plateau (First Canyon) to the east. Together these structures comprise the finest large fold structures of the Park (Ford 1974). The Deadmen Valley syncline is topped by Upper Devonian (340 million yrs. B.P., Strahler 1969) dark grey shales (Douglas and Norris 1960). West of Deadmen Valley the Headless Range pericline is dissected by the South Nahanni River which forms a 6.4 km long, 1200 m deep canyon. The Range is formed of the resistant rock Units 16, 20 and 22. Flat lying dolomites have been forced over steeply dipping limestones of the Nahanni Formation. Strata dip nearly vertically to the east of the thrust fault.

East of Deadmen Valley, the Nahanni Plateau presents a good example of a denuded anticlinical dome. Unit 16 dolomites form the base of the dome. Units 20 and 22 (limestones) and Unit 29 (shale) formerly spanned across the full width of the dome (Douglas and Norris 1960). Erosion has stripped off the shales from the central and

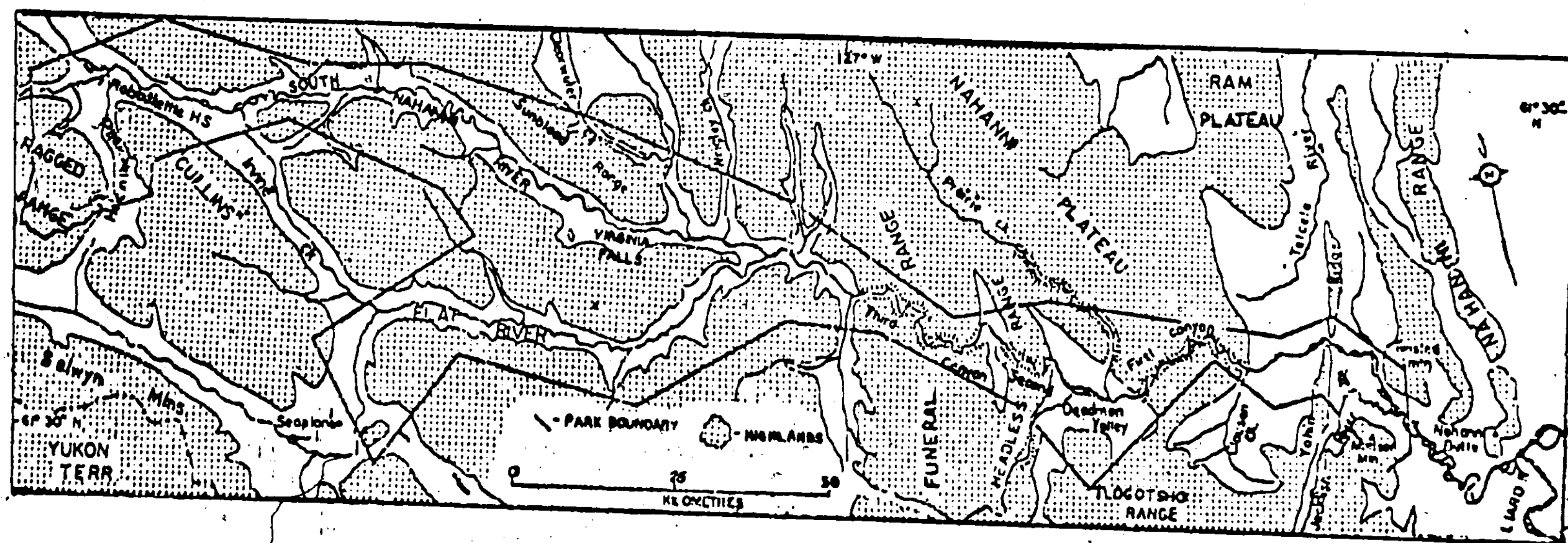


Fig. 3. Physiographic regions of Nahanni National Park.

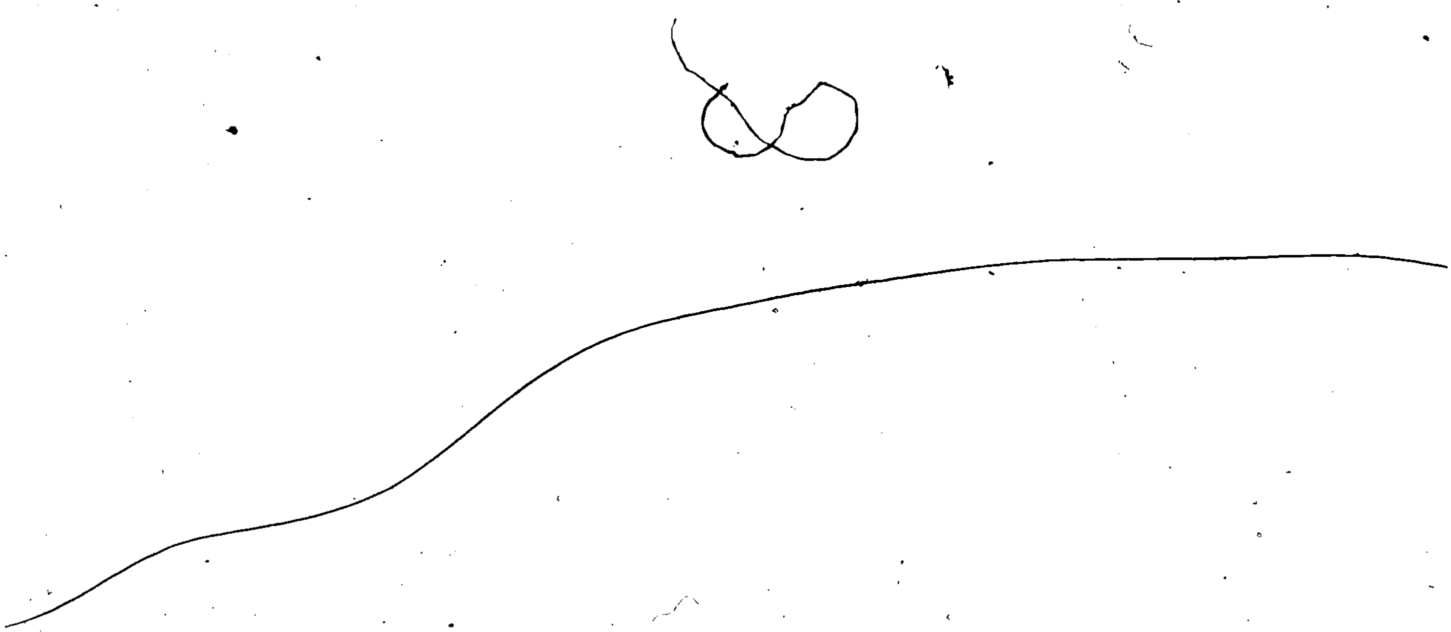


Fig. 4. Major geological units of Deadmen Valley (after Douglas and Norris 1960).

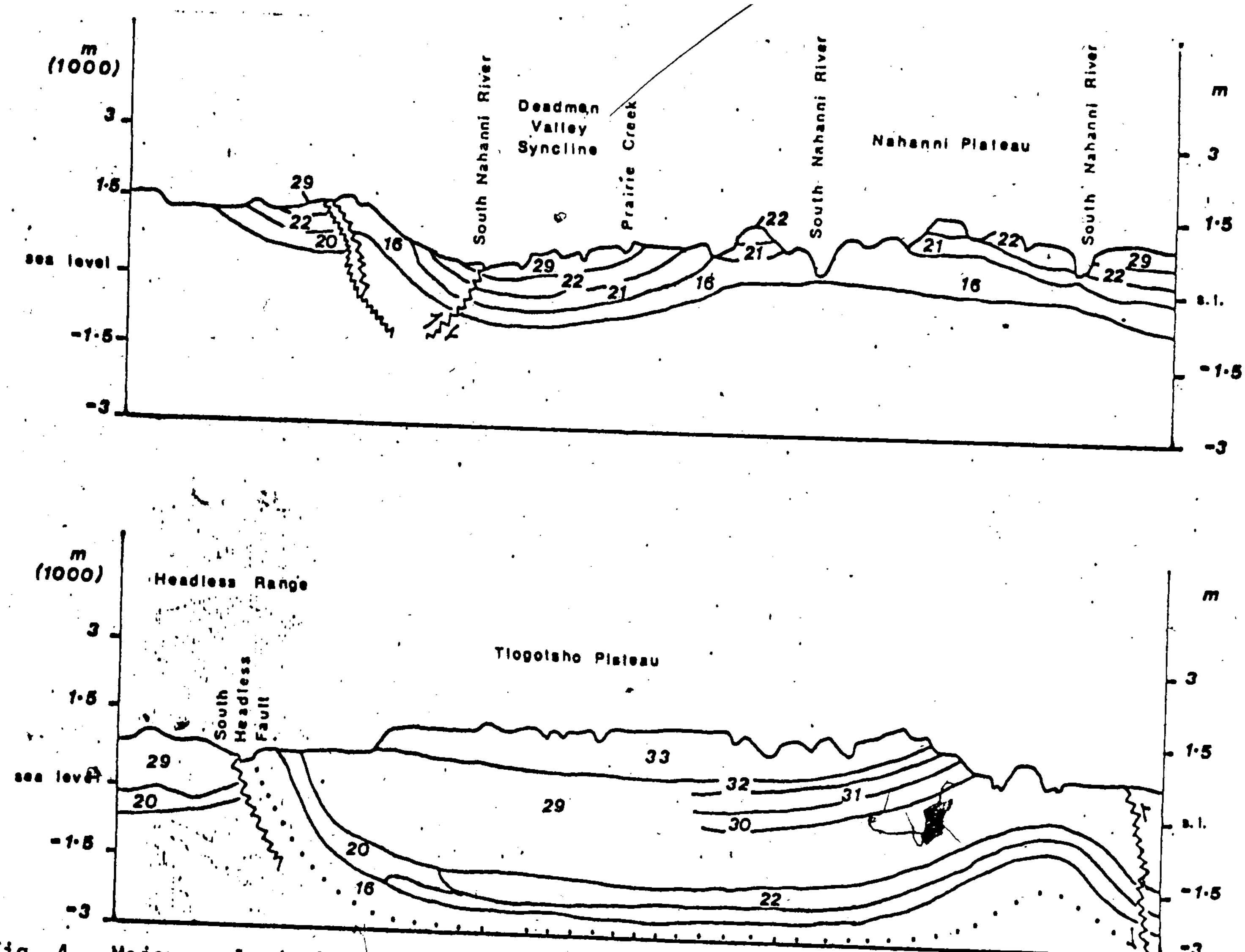


Fig. 4. Major geological units of Deadmen Valley (after Douglas and Norris 1960).

Table 1. Geological formations of Deadmen Valley (after Douglas and Norris 1960).

UNIT	MATERIAL	THICKNESS	WEATHERING	
16	dolomite	500-800m	pale grey, dark grey or brown banded	First Canyon upper 300m thinly bedded; support small crags interspersed with scree slopes Lower strata thicker, stronger, continuous cliffs. Prairie Creek Canyon tributary streams have been eroding the thin dolomite into a badland topography (rare in dolomites).
20 22	medium to massively bedded fossiliferous limestone	130-200m	uniform light grey with blue or silver tones	Greatest cliff formers among the sedimentary rocks of the Park. Both ends of First and Second Canyon where it dips downwards steeply to the South Nahanni River and below NAHANNI FORMATION: MIDDLE DEVONIAN AGE
29	dark shales with a few thin limestone or sandstone bands	900m+	periglacial processes mobilized deposits; sludge aprons of debris	Widespread but few lengthly exposures Very weak rock; scarce in alpine; mantled with forest in most areas below treeline Well developed on east flank of First Canyon Outcrop forms Deadmen Valley
33	sandstone mixed with shale and limestone at top	900-1200m		MATTSON FORMATION: upper layers
30	calcareous shale	39m		Carboniferous Age
32	shale and mudstone medium to thin bedded fossiliferous limestone with some sandstone, shale, dolomite	150 m		Lower layers All three strata always occur together in the Park; flat lying, form Tlogòtsho Plateau, a highly dissected table land

western portions. The limestones have been removed from the crest but rise in cliffs to 1200 m on the flanks. The South Nahanni River has cut a 19 m long, 1066 m deep canyon known as First Canyon through the Plateau. At the south end of the Nahanni Plateau Formation and Deadmen Valley syncline the massive sandstones (Unit 33) and Carboniferous shales (Units 30 and 32) of the Tlogotsho Plateau create a dissected broad saucer shaped tableland (Ford 1974, Douglas and Norris 1960). The strata have been lifted and tilted to the south.

Geomorphology and Glacial History

Geomorphology is concerned with the evolution and morphology of landforms (Davis 1909, Bloom 1969). Ford (1974, 1977) has examined the geomorphology and glacial history of Nahanni National Park. His studies suggest that the central portion of the Park, including Deadmen Valley, has never been submerged by glacial ice. No evidence was found by Ford for Laurentide ice penetration further west than the mouth of First Canyon; geomorphic features indicate that Cordilleran ice stagnated at a point upstream of Rabbitkettle Hotsprings (Fig. 5). For a more complete discussion of the glacial history of the Park see Ford (1974).

Glacial ice caused damming and backup of silt/clay laden meltwaters in the central unglaciated zone. Laurentide ice advancing from the east, blocked the South Nahanni River exit into the Mackenzie Lowlands, impounding the waters within the Mackenzie Mountains. Ice damming during the last Laurentide advance formed Glacial Lake Tetcela (Fig. 5) in Deadmen and Yohin valleys (Ford 1974). A deep

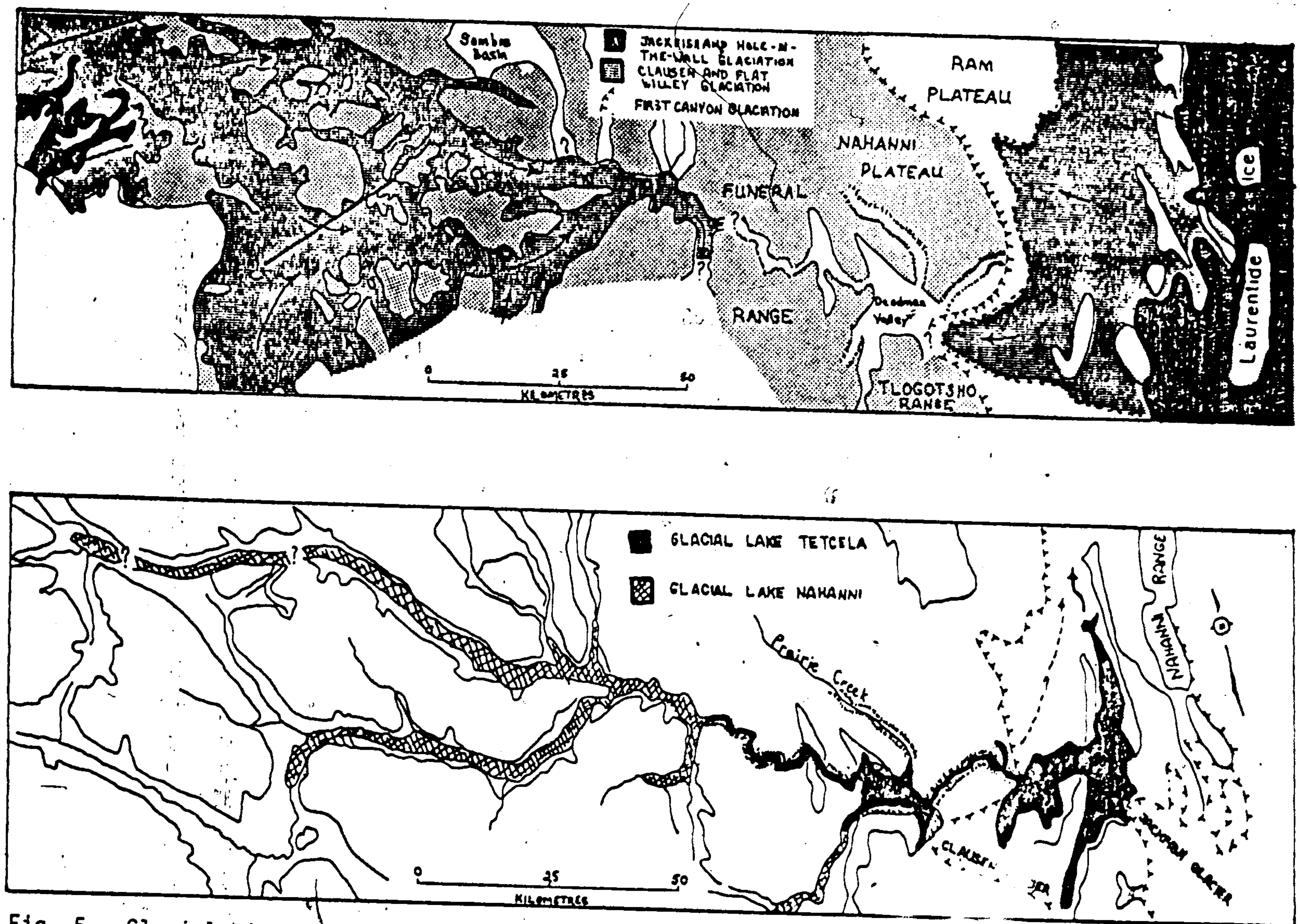


Fig. 5. Glacial history of Nahanni National Park (after Ford 19⁻⁵).

lacustrine bed formed from 213 to 610 m asl during the lake's 10,000 year life. The lake is thought to have drained 14,000 to 7,000 yrs. B.P. (Ford 1974). The remnants of the lake sediments can be seen as flat topped deposits rising 120 m above the South Nahanni River in Deadmen Valley (Ford 1974). These fine lacustrine sediments are underlain by coarse grained deposits of a palaeodelta. This delta formed where Prairie Creek entered Glacial Lake Tetcela.

A wedge shaped deltaic deposit at the eastern fan head has been eroded and exposed in vertical cross-section by the fluvial action of Prairie Creek (Fig. 6). This exposed material serves as a mineral lick for Dall sheep (Ovis dalli).

The surficial material on the slope of the western fan head consists of older lacustrine clay deposits with overlying deltaic sediments. Periodically this area is undermined by Prairie Creek flow during flood stages. The removal of material from the base of the slope combined with saturation of the clay results in massive rotational slumping (Fig. 7).

An alluvial fan forms where a constricted channel carrying a high sediment load enters a broader trunk valley. There is an abrupt decrease in gradient, and stream flow is no longer confined to a single channel (Ford 1974, Leopold et al. 1964). Stream competency as a result decreases and the coarse fraction of entrained material is deposited. A complex bedding pattern of rounded boulders, cobbles, pebbles and lenses of coarse sand and silt results from the migration of a braided channel network.

Fig. 6. Deltaic deposits at the eastern fan head used as a mineral lick by Dall Sheep (Ovis dalli).

Fig. 7. Rotational slump near fan [illegible]d, Prairie Creek, N.W.T.

COLOURED PICTURE

Prairie Creek alluvial fan conforms to this theoretical model of fan formation. Prairie Creek Valley is connected to the broad floodplain of Deadmen Valley by a narrow 9 m wide, 40 m deep cut through a limestone spur. This modern exit is underfit to the canyon. The former wider mouth is infilled by the palaeodeltaic sediments overtopped by lake sediments (Fig. 8). When Glacial Lake Tetcela drained and Prairie Creek commenced to downcut through the Lake bed, its course had migrated away from the original opening. The new channel cut through the limestone bedrock. The modern underfit is thought to be approximately 7,000 to 14,000 yr old (Ford 1974). Coarse gravel, silt and sand carried as bed and suspended load from upstream has been deposited, forming an ideal fan shaped feature that extends into Deadmen Valley. Multiple shallow surface and subsurface channels carry the flow on the fan in contrast to the deep single channel found upstream.

Ryder (1971) suggests that the presence of erodable material in the drainage basin is a prerequisite for fan formation. Unconsolidated lake sediments, the debris from a palaeodeltaic fan, rock glaciers and talus slopes have provided a variety of source rock to Prairie Creek fan.

Regional Soils

The soils of Nahanni National Park have not been studied and mapped in detail. Exploratory work has been completed only for a linear section between The Splits and the confluence of the Liard and South Nahanni rivers. Profile descriptions have also been recorded in site specific areas within the Park including Nahanni Hotsprings and

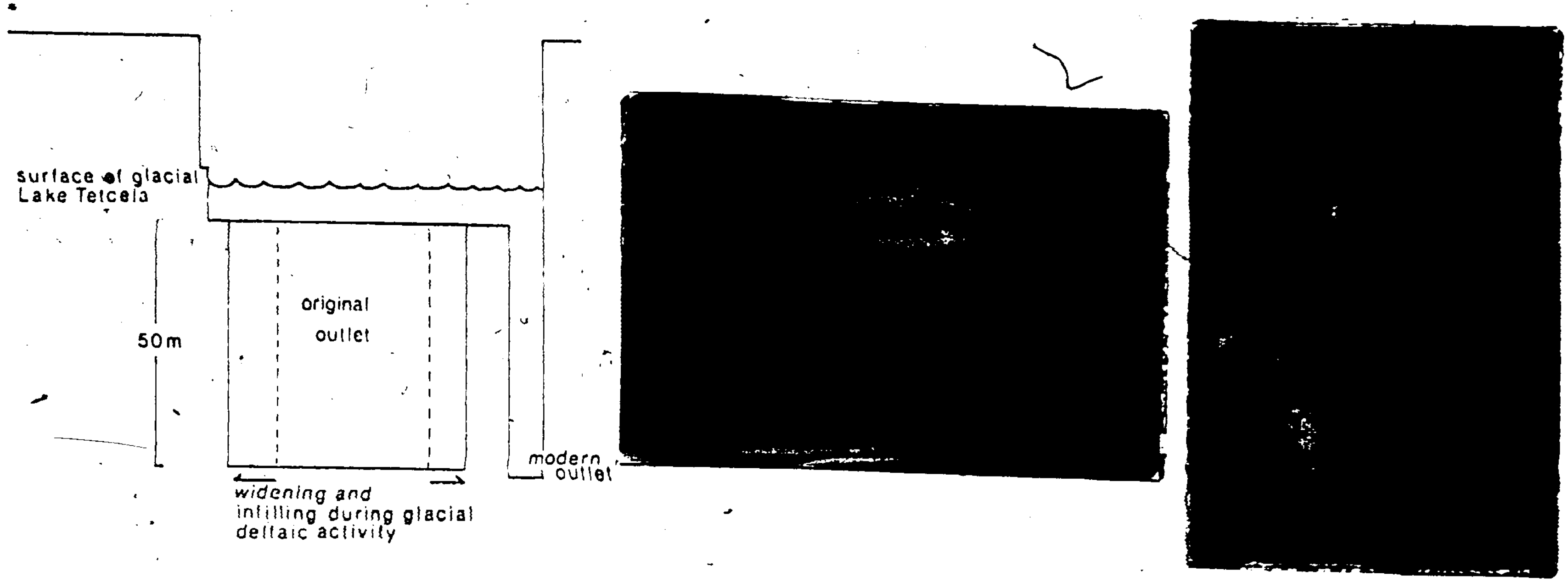


Fig. 8. Development of Prairie Creek gorge (after Ford 1974).

COLOURED PICTURE

Virginia Falls (Marsh and Scotter 1975).

An early description of soils was completed by Jeffrey (1964) in conjunction with a study of forest types in the Liard River Valley. He described soils belonging to the Podzolic, Organic, Brunisolic, Regosolic and Gleysolic orders along the lower reaches of the South Nahanni River.

Day (1966) mapped these soils in more detail during a reconnaissance survey of the Liard River Valley. Four of his soil series can be extended northwest to apply to the Deadmen Valley area; their descriptions are presented in Table 2. The Poplar Soil Series is located on terraces 12 to 23 m above the present river level. This series developed on alluvium deposited by a late post glacial stage of the Liard and South Nahanni rivers. The other three soil series formed on modern alluvial terraces less than 12 m above the present river level.

Tarnocai (1973) briefly discussed the soils of the lower South Nahanni River and Nahanni Range in his Mackenzie River soils report. He identified the dominance of Luvisols on well to imperfectly drained materials, and Brunisols on coarser deposits and at high elevations. Stony Orthic Eutric Brunisols and Cumulic Regosols have formed over sandy moderately calcareous alluvial deposits in the river valley (Clayton et al. 1977). Cryic Gleysols (Regosolic Turbic Cryosols) are restricted to poorly drained areas; Cryic Fibrisols (Terric Fibric Organic Cryosols) dominate the organic soils. Permafrost is discontinuous on poorly drained fine textured mineral soils and widespread on peatlands.

Table 2. Soil series of the lower South Nahanni River valley (after Day 1966).

SOIL SERIES LAND TYPE	SOIL TYPE	SOIL GROUP	SOIL MOISTURE CLASS	DOMINANT TOPOGRAPHY	STONINESS	SOIL PROFILE
Alluvium	sand to silty clay		moderately well drained to very poorly drained	level to hummocky	stone-free to slightly gravelly	greyish clacareous alluvium
Flett	clay loam and silty clay loam	Rego Humic Gleysol	poorly drained	level	stone-free	7.6 cm of peat over mottled dark-grey clay loam and silty clay over calcareous silty clay loam
Nahanni	loam	Orthic Regosol	well drained	level to irregularly gently sloping	stone-free	dark-grey calcareous loam
Poplar	loam and silty clay loam	Orthic Eutric Brunisol	well drained	level to gently sloping	stone-free	brown silty clay loam and loam grading into greyish calcareous loam and fine sandy loam

Regional Climate

The continental climate of the South Nahanni River watershed is characterized by long cold winters and short warm summers. A large part of the year the boundary between the Arctic and Pacific air masses lies over the watershed or a short distance east or west of it. Unstable and unpredictable meteorological conditions result from minor shifts in these weather systems (Addison 1974), compounded by regional interference from the Mackenzie and Selwyn Mountains, and local variability in relief and aspect.

Burns (1973) identified nine climatic zones for the Mackenzie Valley-Beaufort Sea Region. For a detailed discussion of regional climatic characteristics and controlling mechanisms for that area see Burns (1973). He divided Nahanni National Park into a northern Mountain zone and south-eastern Alpine (Forest-Tundra) zone. According to the Köeppen System of Classification, the Park is located in the snowy cold Dfc Subarctic climatic zone (Strahler 1969).

During the early summer months low pressure systems associated with the westerly winds, frequently generate storms and related cloudy conditions (Marsh and Scotter 1975). Showers, including thunderstorms, develop from orographic and thermal convection. Spring and autumn are short with variable temperatures and precipitation. Strong autumn chinook winds predictably precede the winter snow (Cochrane 1976 cited in Scotter and Henry 1977). Winter is predominantly sunny and clear, influenced by stable high pressure centres.

Continuous meteorological records are available from the nearby towns of Fort Simpson, Northwest Territories (62° N Lat., 122° W Long., elevation 130 m) and Watson Lake, Yukon Territory (60° N Lat., 129° W Long., elevation 690 m) located approximately 70 and 150 km from the study area. Partial records are available from Tungsten mine site (62° N Lat., 128° W Long., elevation 1143 m) and Little Doctor Lake (62° N Lat., 123° W Long., elevation 215m).

Table 3 summarizes mean monthly temperatures for 1976 and presents the 1941 to 1970 (inclusive) average monthly mean temperature for the four stations. The 1941 to 1970 average mean annual temperature ranges from -3° C at Watson Lake to -5° C at Tungsten. July is the warmest month with mean average temperatures of 12° C, 15° C and 16° C for Tungsten, Watson Lake and Fort Simpson respectively. Temperatures fall to a minimum in January with an average mean ranging from -23° C at Tungsten to -28° C at Fort Simpson (Environment Canada 1977).

Table 4 presents temperature extremes for the same sites. Maximum and minimum temperatures have varied from -59° C to +34° C in Watson Lake over the 30 year period.

Precipitation within the Park varies with elevation, slope exposure, orientation and terrain-modified wind regimes (Burns 1973). Average mean precipitation varies from 34 cm/yr. in Fort Simpson to 43 cm/yr. in Watson Lake. Precipitation is greatest during the summer months with a July 1976 maximum of 9.9 cm in Watson Lake (Table 5). The weakening and northward migration of the winter cyclone, increased evaporation, and influence of less stable atmospheric depressions contribute to this accelerated precipitation. In summer, convection in unstable air is a major contributor over higher terrain (Burns 1973).

Table 3. Monthly and annual mean temperatures (°C) for 1976 and 1941-70 for Fort Simpson, Watson Lake, Little Doctor Lake and Tungsten (Environment Canada 1977).

Station	J	F	M	A	M	J	J	A	S	O	N	D	annual	year
Fort Simpson NWT	-27	-25	-16	5	11	14	17	16	11	-1	-10	-24	-2	1976
	-28	-24	-14	-2	7	14	16	15	7	-2	-15	-24	-4	1941-70
Watson Lake Yukon	-20	-22	-12	1	7	11	13	13	8	1	-9	-21	-2	1976
	-26	-18	-11	-1	7	13	15	13	8	0	-13	-23	-3	1941-70
Little Cr. Lake NWT	-26	-25	-18	3	8	12	16	14	11	-1	-9	-24	-3	1976
Tungsten NWT	-18	-21	-14	-3	3	8	10	10	5	-5	-9	-17	-4	1976
	-23	-17	-13	-5	3	9	12	9	4	-4	-13	-19	-5	1941-70

Table 4. Thirty-year monthly mean minimum and mean maximum temperatures (°C) for Fort Simpson, Watson Lake, Little Doctor Lake and Tungsten, 1941-70 (Environment Canada 1977).

Station	J	F	M	A	M	J	J	A	S	O	N	D	absolute	
Fort Simpson NWT	-5	4	6	22	24	30	29	30	25	16	6	11	36	max.
	-43	-44	-1	-24	-2	1	8	3	-2	-13	-27	-40	-57	min.
Watson Lake Yukon	5	2	6	20	20	27	28	27	22	12	7	2	34	max.
	-51	-45	-41	-16	-3	-1	1	0	-5	-8	-27	-38	-59	min.
Little Dr. Lake NWT	10	8	7	20	22	30	28	29	24	17	13	12	ND	max.
	-43	-43	-39	-25	-5	-2	3	-56	-2	-6	-26	-40	ND	min.
Tungsten NWT	2	2	0	15	13	24	27	25	19	6	5	2	ND	max.
	-39	-41	ND	-18	-7	-2	-1	-2	-6	-21	-21	-38	ND	min.

Table 5. Thirty-year mean precipitation (1941-70) and 1976 total annual precipitation (cm) for Fort Simpson, Watson Lake, Little Doctor Lake and Tungsten (Environment Canada 1977).

Station	J	F	M	A	M	J	J	A	S	O	N	D	total	snow-fall	year
Fort Simpson NWT	2.1	2.7	2.4	0.4	2.6	1.5	9.3	9.2	0.9	1.5	0.8	1.1	34.5	200.4	1976
	1.4	1.4	1.1	1.5	3.1	3.9	6.0	4.8	3.1	2.7	3.0	2.3	34.3	138.0	1941-70
Watson Lake Yukon	5.4	4.4	1.3	2.0	4.2	7.8	9.9	5.9	3.8	1.8	1.1	4.3	51.8	269.0	1976
	3.5	2.8	2.4	1.8	2.3	4.9	5.3	4.5	4.3	3.5	3.8	4.1	43.2	227.3	1941-70
Little Dr. Lake NWT	1.8	2.7	6.0	2.8	1.5	2.6	9.7	9.5	1.7	1.9	0.8	1.4	42.2	271.8	1976
Tungsten NWT	2.4	1.6	1.5	ND	3.4	7.8	ND	4.6	5.4	5.7	3.5	2.3	ND	ND	1976

Minimum precipitation occurs during January and February.

Mean annual snowfall throughout the area varies widely year to year. Local variations also occur, influenced by wind redistribution, aspect, vegetation cover and winter chinooks (Burns 1973). Snowfall at Tungsten can exceed that at Fort Simpson by 50% (Addison 1974). Prairie Creek is geographically located between these two recording stations. Mean annual snow cover for the Prairie Creek fan area is estimated at 152.4 cm (Burns 1973). Minimum and maximum snow depths are 76.2 and 228.6 cm. In lowland areas the first snowfall occurs in late September-early October and lasts until late April or May. The highlands lose their permanent snow cover for July and August but can receive snow during any month.

Precipitation records must be accepted only as the best available estimate of total moisture reaching the ground. Daily records show a high frequency of small daily precipitation totals in both winter and summer. The light rain and snowfalls, often accompanied by wind, are difficult to assess. Measurements in winter are further complicated by the frequent presence of blowing snow which is difficult to separate from light windblown snowfalls, and by the long dark winter. Fort Simpson received less than 36 hr of sunshine in January 1976 with a 1941 to 1970 December average as low as 23 hr (Environment Canada 1977). Daylight in winter is restricted to 5 hr / day in January because of latitude. Maximum daylight of 16 hr / day occurs in June.

Regional Vegetation

The first botanical work within the South Nahanni River watershed is attributed to the vascular collections around Nahanni Butte by C.L. Crickmay in 1922 (Raup 1947). [illegible].S. Nowosad in 1944 (Jeffrey 1961), R.P. Hirvonen in 1955 (Hirvonen 1968), W.W. Jeffrey in 1959 (Jeffrey 1961, 1964), and W.J. Cody and K.W. Spicer in 1961 (Cody 1963) filed additional collections for this area. D.R. Flook was the first naturalist to collect in Deadmen Valley (Flook 1952). Scotter, Simmons (Scotter et al. 1971) and Cody (Scotter and Cody 1974), made extensive vascular collections throughout the Park including Deadmen Valley. W. Steere (1977, 1978) has collected and reported on the bryophytes of the area with citings from Deadmen Valley. Ahti completed a broad survey of the lichens in the Park in 1977. Additional collections of plants in the area are noted by Addison (1974).

A 1955 merchantable timber survey, based on 1947 to 1949 aerial photographic interpretation, was completed for the lower Liard River and the lower South Nahanni River up to Deadmen Valley (Hirvonen 1968). Jeffrey (1961, 1964) published a more detailed description of forest types along the lower Liard River. His inventory was based on landtypes and ecosystem types. The landtypes include mountain, terrace, ancient floodplain, intermediate floodplain, recent floodplain overlying ancient and recent floodplain. These latter five landtypes can be found in Deadmen Valley. Jeffrey's community studies extended up to the base of The Splits.

Scotter et al. (1971) and Addison (1974) generalize the forest types along the South Nahanni River. Populus balsamifera/Picea glauca stands with shrub layers of Rosa acicularis and Viburnum edule occur on fine alluvium along the main river. Populus tremuloides/Betula papyrifera with an understory of Alnus crispa and Rosa acicularis inhabit coarser material with associated stands of Picea mariana, Pinus banksiana or P. contorta. Betula papyrifera and Pinus species occupy the coarsest scree sites at the base of mountains. Regeneration following fire includes Populus tremuloides, Betula papyrifera, Picea mariana and P. glauca.

Throughout the Park treeline occurs at approximately 1190 m on south and west slopes and 1100 m on north and east slopes (Scotter and Cody 1974). The drier and warmer south slopes support Pinus banksiana and P. contorta with an Alnus crispa shrub understory at treeline. Picea mariana with an understory of Alnus and Ledum groenlandicum is the most common species at treeline on north slopes. In the Prairie Creek fan area Pinus contorta, Picea glauca, Betula papyrifera and Populus tremuloides form stands on the south slopes.

Poorly drained soils often underlain by clay loam are forested by scattered, stunted Picea mariana and Cladina stands. Scotter et al. (1971) and Addison (1974) cite moisture as the critical factor limiting tree size.

Alpine tundra is characterized by Dryas species, ericaceous shrubs, Carices and Graminoides.

A total of 544 taxa in 66 families of vascular plants has been reported for the Park (Addison 1974). Scotter and Cody (1974) list

483 taxa. Published plant distribution data for the Northwest Territories and the Yukon are restricted to inventory collections adjacent to the main roads and water routes. In Nahanni plant collecting has focused along the river. Range extensions have been noted by Scotter and Cody (1974) for both southerly vascular plants beyond their previously known range and northern species south of their documented range. The presence of a glacial refugium adjacent to First Canyon, proposed by Calder and Savile (1960) and identified by Ford (1974), and limited collecting can be cited as potential reasons for southern range extensions. The occurrence of hot springs (Patterson 1954, Arnold 1961, Scotter et al. 1971) and warm southern limestone exposures facilitate northern extensions.

Scotter and Cody (1974) list the phytogeographic affinities of 433 taxa of plants found in Nahanni within the Mackenzie Mountains (Zone 1 of Porsild and Cody 1968): "157 were circumpolar in distribution; 130 had more or less wide-ranging North American ranges; 80 were Amphi-Beringian; 34 were Cordilleran; 23 were endemic to the Alaska-Yukon-western Mackenzie region; 3 were Amphi-Atlantic; 5 were introduced from the Old World; and there was one hybrid." Raup (1947) also provides a detailed discussion of the phytogeographic affinities of plants collected in the Brintnell (Glacier) Lake area. His studies described plant community types for this area: forests, subalpine scrub, alpine communities, vegetation of alluvial and gravel deposits, and vegetation of stone and gravel lake beaches.

The vegetation and habitat types for Deadmen Valley have been described by Scotter and Henry (1977) and Scotter and Kershaw (1978).

III. METHODS

Geomorphology

The geomorphology of the fan was described through aerial photographic interpretation of small scale 1975 stereo pairs (1:24,000) and large scale aerial photographs (1:2500) combined with field reconnaissance. Historical aerial photographic coverage from 1934, 1949, 1954, 1961, 1962, and 1974 provided additional insight into the history of erosional surfaces and fluvial erosion cycles. These trends are discussed in more detail under Results: Historical Aerial Photographic Record.

Geomorphic features were noted during the survey of plant communities in the area. Notes on slope, aspect, origin of the surface, relative age of the surface and recent geomorphic history of each community were taken. Species composition and the tree ring record were useful indicators of seepage zones, siltation and flood damage and direction. Major abandoned fluvial channels were traversed to identify the origin and termination of these surfaces. Depth to the gravel subsurface was also routinely checked. Depositional horizonation was described in fewer locations where the soil profile was examined. Clast size of gravel and boulder material was measured with calipers at spot locations within a 1 m^2 frame.

Soils

Soil Sampling

Seventeen $1m^2$ soil pits were excavated within and along the South Nahanni levee (Fig. 9). Thirteen additional pits were excavated on Prairie Creek fan. Pit depth extended from .3 m where extensive gravel deposits restricted digging, to 2 m in the floodplain silts. Profile descriptions were completed in the field according to the Canadian system of soil classification (Canadian Soil Survey Committee 1974). Notes were taken on horizon depth, texture, structure, consistency, colour and boundary form and distinctness. Root abundance, size class and orientation; presence of organic matter, ash and shells; observed moisture regime (saturated, moist or dry); and presence of carbonates (reaction to 1 N HCl) were described. Bulk samples were collected from each horizon or layer. Tree rooting patterns were examined and described. Extent and pattern of flood deposition were recorded.

On the open fan, gravels restricted the depth of excavation. No soil development was observed. Depth to gravel was recorded and surficial samples (0 to 20 cm) collected from the south-east corner of each plant sampling quadrat.

Soil samples were collected in aluminum tins, air dried and restored in the sealed tins. The dried soils were screened through a 2 mm sieve to remove the coarse fraction.

Soils from each horizon were analysed in the laboratory. In two cases where three pits were excavated in the same deposit, composite samples based on similarities in texture, colour and horizon

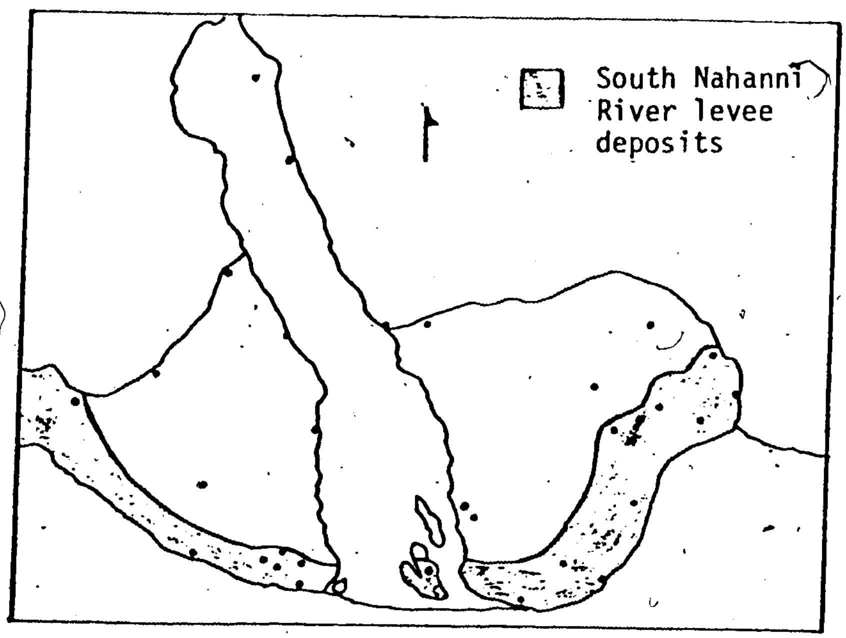


Fig. 9. Location of soil sampling excavations, Prairie Creek alluvial fan, N.W.T.

depth were analysed in the laboratory.[1] Samples collected along transects through non-forested areas were also combined based on similar depths to gravel, plant cover and distance from active flood channel.

The resistance of eight permanently installed thermistors at 10, 20, 30 and 60 cm depths was measured twice daily (0600 and 1800 h) by the Y.S.I. Telethermometer to obtain temperature profiles in two soil pits. One excavation was located beneath a closed *Picea glauca* forest on the South Nahanni River levee; the other was located beneath a *Juniperus horizontalis*/*Carex* heath community on the Prairie Creek floodplain. Thermistors were installed horizontally 10 cm into the undisturbed soil face and excavations refilled to minimize external influences.

Soil Analysis

Physical and chemical analyses done in triplicate on composite samples (<2 mm fraction) in the laboratory were:

1. dry and moist colour determinations under daylight using the Munsell colour chart (Munsell 1971);
2. mechanical texture analysis calculated by the hydrometer method (Bouyoucos 1936, Day 1965);
3. water retention of the soil at 1/3 and 15 bar tensions on ceramic moisture plates expressed as percent oven dry weight at 105 °C (Richards 1965);

---

1. e.g. Layer 0-15 cm silty sand in Pits 3, 4, and 14 were combined and analysis completed on the composite sample.

4. soil reaction measured with a Sargent glass electrode pH meter (Model PBL), using the 1:2 soil water slurry method (1:5 for organics) (Black 1965).

5. percent organic matter estimated by the Walkley Black wet oxidation method (Black 1965);
6. available phosphorus determined by the Olson Axely extraction method (Dickman and Bray 1940, McKeague 1976);
7. exchangeable potassium using ammonium acetate extraction and measured on an atomic absorption spectrophotometer (Chapman 1965, McKeague 1976);
8. percent calcite and dolomites were determined for two subsurface and two surface samples (n=3) from Prairie Creek and the South Nahanni River deposits on a Chittick Apparatus (Bascombe 1961).

Meteorological Observations

Air temperature and relative humidity were measured continuously from June 21, to September 17, 1976 by a Belfort No. 5-594 hygro-thermograph. The instrument was calibrated against a mercury thermometer and a sling psychrometer. The instruments were placed in a white painted louvered shelter installed at a height of 1.2 m in <u>Juniperus horizontalis</u>/<u>Carex</u> community centrally located near the toe of the fan.

Temperature and relative humidity are reported for 6 hr intervals seven days a week.

Standard weather bureau maximum and minimum thermometers were also placed in the shelter and read daily at 0600 and 1800 hr . Daily maximum and minimum temperatures are reported from these readings.

Precipitation was measured by one copper standard rain gauge and one Taylor 2701-M Clear Vu circular rain gauge. The unshielded gauges were located adjacent to the temperature sensing equipment on the gravel bar and near the louvered shelter. Data are presented as daily totals.

Wind speed and direction was measured at 1.2 m by a three cup anemometer. Daily maximum and minimum wind speeds and velocity for 6 hr intervals are reported from August 22 to September 12 as representative of wind velocities over the summer period.

Vegetation

Flora

Voucher collections of vascular taxa noted in the study area are deposited in the University of Alberta herbarium (ALTA). Partial collections have been placed in Ottawa (DAO), Salices in Ottawa (CAN) and Carices in Saskatoon (SASK). Nomenclature follows Hultén (1968) and Moss (1959) with the exception of Salices which are named according to Argus (1973).

Partial collections of bryophytes and lichens are deposited in the University of Alberta herbarium (ALTA); bryophytes in New York (NY) and lichens in Helsinki (H). Lichen nomenclature follows Hale and Culberson (1970). Mosses are named according to Crum *et al*. (1973);

liverworts after Stotler and Crandall-Stotler (1977).

Each vascular species was assigned to a geographic distribution type or province (Gleason and Cronquist 1964) using maps produced by Hultén (1968), Rowe (1972), Viereck and Little (1972) with additional distributional information gathered from Kershaw (1976) and Hitchcock and Cronquist (1973).

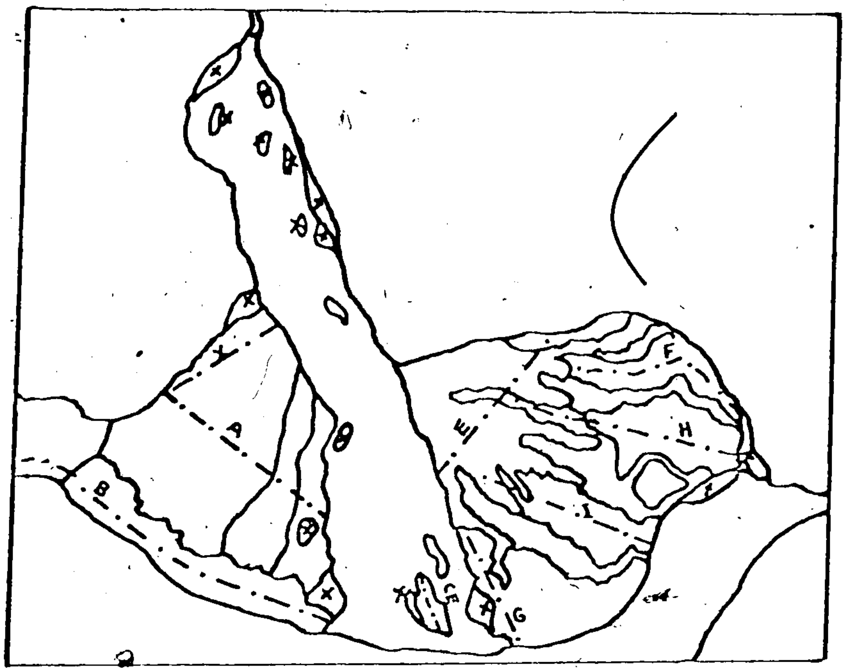
Species were also assigned to habitat preference types as indicated in Hultén (1968), Hitchcock and Cronquist (1973), Viereck and Little (1972) and Moss (1974). This assisted in determining species as indicators of physical site characteristics.

Community Sampling

The vegetation of Prairie Creek alluvial fan was initially divided into six structurally based units: forest, woodland, savannah, scrub, heath and barrens.[2] These units were delineated on a working field mosaic through aerial photographic interpretation of 1975 stereo pairs (Scale: 1:27,800) prior to the 1976 field season.

Nine line transects were mapped out on the 1975 stereo pairs (1:27,800) of the fan to bisect most of these structurally based units (Fig. 10). These were transferred to the field along compass lines beginning at an active water course edge and proceeding at approximately

2. Forests: very closely spaced (< 1 crown diameter apart) trees >8 m tall (Daubenmire 1968); Woodland: closely spaced (1-3 diameters apart trees > 5 m tall; Savannah: trees > 2 m in height widely scattered (> 3 crown diameters apart) over a continuous lichen or herb mat (Daubenmire 1968); scrub: tall shrubs (woody plants >1 m in height); Heath : dwarf shrubs < 1 m in height, herbs (plants that die back to the ground each year (Hanson 1962) and lichen mats; Barrens: < 10% vegetation cover.



Transect No. (←·→)	No. of 100 sq. m Quadrats
A	55
B	32
CE	13
E	13
F	14
G	8
H	10
I	15
X	7
	167
Additional Quadrats (×)	16
TOTAL	183

Fig. 10. Vegetation transects, Prairie Creek alluvial fan.

90 degree angles to the contour of overbank deposits. The transects provided a sampling framework to compare changes in plant species composition with predicted environmental gradients of flood frequency, silt depth and relative age of deposition. These three factors were significantly correlated plant-environment parameters in related northern riparian environments (Gill 1973, Viereck 1970, Dahlskog 1966).

One hundred and sixty-seven 10 x 10 m^2 quadrats were placed at 30 m intervals along eight transects and at 60 m intervals along a ninth transect (TRB) running through a less variable forest parallelling the South Nahanni River (Fig. 10). Along this transect additional 100 m^2 plots were placed at 30 and 60 m intervals north of the transect to form short branching transects designed to document variation across the South Nahanni River levee deposits.

The number of stems, diameter at 1.3 m from the ground (dbh) and height of each tree species within the 100 m^2 quadrats were recorded and plotted. From these data, density (stems/ha) and basal area (m^2/ha) were calculated for each species. Cores were extracted 20 cm up the bole from 2 trees of each species located in the plot. Samples for aging were taken from one tree of modal dbh and height and one of maximum dbh within each quadrat. Cores were stored in paper straws to minimize molding and aged under 10x power in the laboratory the following autumn. Three hundred samples were successfully aged. Few ages were determined for Populus balsamifera because of the high frequency of heart rot.

An index of vigour was assigned to each tree plotted: 1=<1% leaf/branch mortality; 2=1 to 30% leaf/branch mortality; 3=31 to 99% leaf/branch mortality. Damage from frost, desiccation, fire, carpenter ants, wind abrasion, flooding and other mechanical events were recorded. Thirty-eight sample discs were cut to age flood and fire events and to determine the extent of carpenter ant damage where such damage was present.

Species presence, height (of shrubs and herbs) and percentage cover of shrubs, herbs, bryophytes and lichens were also recorded in the 10 by 10 m square plots. Percent cover was visually estimated. It was recorded both as an absolute value and indexed using a modified Braun-Blanquet cover-abundance scale (Braun-Blanquet 1932, Mueller-Dombois and Ellenberg 1974):

Cover Class	Range (% Cover)	Midpoint (% Cover)
6	76-100	88
5	51- 75	63
4	26- 50	38
3	16- 25	20
2	5- 15	10
1	1- 5	3
+	1	0.5
R	single occurrence	-

Low cover values are best estimated with this scale. A large percentage of the species on the fan had very low cover, and were thus well represented by this system. The midpoint of each class was used in calculating mean cover values for use in synthesizing sampling data.

Total silt, gravel and litter cover were also estimated and recorded.

Two recorders made separate evaluations of the cover of the parameters to reduce human error/bias. Cover was selected as the most important indicator of a plant's abundance and biotic influence.

Other observations in the 100 m^2 quadrats included: phenological stage of vasculars, slope and aspect, geomorphic history (e.g. channel bar, scour...) soil surface texture and surface soil horizonation and texture (0-20 cm).

Sixteen additional 100 m^2 quadrats were centrally placed in geographically separated units (e.g. channel islands) identified on the aerial photographs which were larger than 100 m^2 in size but were not traversed by the transects. Data collection within these quadrats was identical to that in quadrats placed along the transects.

Each quadrat was moved $\pm$ 5 m from the 30 or 60 m point on the transect, where necessary, to avoid major discontinuities in physical site characteristics, plant composition and/or plant cover. Shrub, forb and bare areas were sampled earlier than forested units to minimize sampling error related to seasonal variation in species composition and cover.

The 100 m^2 plot size was chosen to permit comparison with other vegetation studies in Nahanni National Park including the field work completed on the fan by A.H. Marsh (Scotter and Kershaw 1978). Mueller-Dombois and Ellenberg (1974) noted that this is the most common plot size for trees and it is the common relevee size used in vegetation surveys in the boreal forest. The inconclusive and contradictory results from tests concerning quadrat shape (Morris 1973) were not thought to warrant using an alternative plot size or shape.

One m^2 plots were placed at 150 m intervals along four major dry channels to document colonization processes in abandoned stream beds. Two channels are still periodically flooded and two are abandoned stream beds. Percentage cover of plants by species, gravel, sand, silt and litter were recorded. These data were not subjected to any statistical analysis. Two species lists were made: those colonizing gravels and those surviving on silts and sands. Species not recorded within the quadrats but observed in the vicinity, were noted.

Vegetation Synthesis

Classification

Vascular species lists from 180 100 m^2 quadrats distributed over the fan were collated into a species by quadrat table by a subprogram of the Cornell CEP 20C (Twinspan) program (Gauch 1975). The three quadrats omitted had less than four species. Twinspan through a rejiterative reordering process ordered those quadrats with species listed in the upper half of the table towards the left, and those quadrats with species listed in the lower half of the table towards the right. Those species which occurred in most quadrats were placed centrally on the table.

A synthesis table (Mueller-Dombois and Ellenberg 1974, p 177) was formed from this species-quadrat table. The centrally located species present in 15 to 100% of the quadrats whose distribution was not restricted to similar groups of quadrats as other species were defined as the constant species. Those species present in only one quadrat were grouped together as the rare species. The list of remaining species were identified as the differential species. These were present in 7 to 33% of the quadrats and their distribution was concentrated in similar groupings of quadrats as some other species (Mueller Dombois and Ellenberg 1974).

Nine quadrat groupings were identified from this differential table. Other quadrat characteristics of lichen and bryophyte cover; tree height, age and density; surface texture, slope and depth to gravel; and presence or absence of flooding were examined. Similarities and differences within each grouping were noted.

The same sampling data were subjected to Cluster analysis, a classification technique. General discussions of classification techniques are presented in Grieg-Smith (1964), Whittaker (1973) and Mueller-Dombois and Ellenberg (1974).

In this study the Clustan 1C program (Wishart 1975), a modification of Ward's cluster analysis technique, was used to analyse the same quadrats from the fan. Ward (1963) developed a cluster analysis program which is a sequential agglomerative technique which forms non-overlapping clusters within a hierarchy. Clusters, whose fusion yields the least increase in the error sum of squares, are combined to yield minimum-variance spherical clusters. After each fusion of two such clusters a new distance matrix is calculated using the newly formed groups.

The modified Clustan 1C program (Wishart 1975) minimizes information losses often associated with groupings based on similarity criteria (Ward 1963). The distance matrix for the stands to be clustered is based on the squared Euclidian distance between the stands. Sneath and Sokal (1973) define this index between two factors j and k in an n-dimensional space as:

$$d = \left(\sum_{j=1}^{n} \left(X_{ij} - X_{jk} \right)^2 \right)^{1/2}$$

Midpoints of the Braun-Blanquet scaled cover values were used. Distance matrices were also calculated for binary (species presence-absence) data in each quadrat.

Results were plotted as a dendrogram. A vertical scale coefficient was provided by multiplying by two, the error sum of squares which initiated fusion at each level. Individual quadrats were listed on the horizontal axis.

Other quadrat observations (tree species densities, age, height distribution; bryophyte and lichen cover; and physical parameters including soil texture, depth to gravel, topography and presence or absence of flooding) for the quadrat groupings at various cluster levels in the dendrogram were examined to identify if and at what point on the dendrogram these groups could represent concrete community types (recurring plant assemblages with similar species composition, physiognomy and habitat, Mueller Dombois and Ellenberg 1974). Divisions at various stages in the dendrogram were studied to see if groupings reflected quadrats with similar total plant cover, dominant species composition, major growth forms and/or physical site characteristics. Cluster composition was compared to quadrat groupings noted on the synthesis table.

From this information a classification scheme for the alluvial fan was prepared. It established community groups based on quadrat groupings of similar vegetation structure (Dansereau 1957) defined by growth form stratification and coverage; subgroups described by dominant growth forms of major strata and community types defined by dominant species by strata.

The locations of quadrats were plotted on the aerial photograph of the fan. Communities delineated through aerial photographic interpretation were described by the characteristics of quadrats falling within their boundaries. Where more than one quadrat fell within a photographically interpreted unit, average cover values were calculated by dividing the sum of cover values for each species present, by the number of quadrats located within that community. Similarly, percent frequency for each species was calculated by the number of times it occurred, divided by the number of quadrats in the community.

The following spring (1977) boundaries and general characteristics were rechecked. Additional tree cores were taken where this information was not available.

A final map of plant communities was prepared (Map 1).

Indirect Ordination

Bray-Curtis (1957) and Reciprocal Averaging (Hill 1973) indirect ordination techniques were used to quantify observed gradation of species composition with environmental gradients. The same data as used in Cluster analysis (vascular species recorded in 180, 100 m^2 quadrats) was used in the ordinations. Ordination graphically arranges samples along a continuum. The axes of indirect ordination represent differences in species composition among samples. In direct ordination, measured environmental parameters (e.g. soil moisture, elevation) are scaled. Indirect ordination, the method used in this study, is most useful when environmental transitions are unclear (Whittaker and Gauch 1973) or not easily measured along a continuum.

Bray-Curtis ordination is the most frequently used indirect ordination technique. This method plots sample points (communities, stands, quadrats) along an axis based on similarities of the samples to two chosen end points. The subjective choice of end points is a major disadvantage of this method. To reduce this subjectivity, end points for the x-axis were chosen from similarity matrices, using the criteria of 1) great dissimilarity between the two stands and 2) some similarity with other stands.

Similarity matrices, using midpoints from the cover-abundance scale, were constructed for the vascular data from the 180 100 m^2 quadrats sampled on the fan. Additional matrices were constructed for the quadrats along each transect for ordination of plots along individual transects.

Three similarity indices were used in the analyses: coefficient of community (CC), percent similarity (PS), and euclidean distance (ED).

$$CC(A,B) = \frac{200w}{a+b}$$

where w = total no. of species in stands A and B
b = no. of species in stand A
a = no. of species in stand B

$$PS\ (A,B) = \frac{200x}{c+d}$$

where x = lesser cover values for species common to both stands
c = species cover values in stand A
d = species cover values in stand B

$$[illegible] \sqrt{\sum_{i=1}^{I} \left(Pi_A - Pi_B\right)^2}$$

where Pi_A = abundance/cover of species i in plot A
Pi_B = abundance/cover of species i in plot B
I = no. of species

Coefficient of community and percent similarity are the most frequently used similarity indices in ordinations (Gauch and Whittaker 1977). In this study coefficient of community displayed the best stand separation for the composite sample data for the entire fan and was used in the presentation of this ordination. Percent similarity was more useful in the analysis of individual transects. This index is recommended for use in Bray-Curtis ordinations by Gauch (1971).

A quantitative modification of Sorensen's coefficient of community (Sorensen 1948) was used as the index of similarity (IS). This index presented by Motyka <u>et al</u>. (1950) and often referred to as percent similarity (PS), is calculated by:

$$PS\ (A,B) = \frac{200x}{(c+d)}$$

where c = species cover values in stand A
d = species cover values in stand B
x = lesser cover values for species common to both stands

Similarity values were computed when stands were grouped into community types.

Reciprocal averaging developed by Hill (1973) provided a second indirect ordination technique used in this study. It is an indirect weighted average procedure, using successive approximates to produce species and stand ordinations (Hill 1973, Gauch et al. 1977). This procedure avoids subjectively choosing end points, the major weakness of the Bray-Curtis technique. As in Bray-Curtis ordinations, a low level of distortion is maintained even at high levels of B-diversity (Cottam et.al. 1973). Floristic differences among sample plots on the fan were substantial, justifying consideration of this property.

Reciprocal averaging is most effective in revealing the major direction of sample variation in response to the environment. Weaker or secondary gradients are often obscured by distortion (Hill 1973). This was found to apply to the Prairie Creek fan data. Patterns represented by secondary and tertiary axes were compressed close to the primary axis and were thus rejected as less valuable than Bray-Curtis ordination for presenting secondary axes of variation. The primary axis distribution from reciprocal averaging and a Bray-Curtis ordination using the end points suggested by the reciprocal averaging process were compared. The patterns were similar in terms of the ordering of quadrats however reciprocal averaging provided a more even spread. Ordination results were therefore presented based on a reciprocal averaging display of the x or primary axis of variation and a Bray-Curtis presentation of the y or secondary axis. End points for this secondary axis were chosen based on great dissimilarity with the two end points of the x axis yet some similarity to the other stands, as outlined in Mueller-Dombois and Ellenberg (1974).

Stand groups, corresponding to clusters from cluster analysis (Ward 1963) of the composite data, were delineated on the ordination field to suggest trends and relationships among these groups.

Bray-Curtis and reciprocal averaging were used to examine gradients along individual transects. The ordination of stands along transect TRC-E are presented to represent the value of using smaller units to understand species groupings along environmental gradients on Prairie Creek fan. Stand characteristics and species tolerances along the ordination axes are summarized.

All calculations were computed at the University of Alberta Computing Centre on an Amdahl 470 computer. The Cornell Ecology Programs assembled by Gauch (1971, 1975) were used for ordination: CEP 4 (Bray-Curtis Ordination), CEP 5 (Resemblance or Distance Matrix) and CEP 20C (Reciprocal Averaging, 3 axes).

Dendrological Data

Dendrological information was used to age stands, fires and floods, and to detect changes in growing conditions. Results from tree ring analyses were incorporated into the discussion of community types.

Previous forest fires were detected by the presence of charred wood fragments, fire scarred trunks, charcoal in the soil or the presence of even aged stands. Fire history techniques are discussed more fully by Heinselman (1977), Frissnell (1973), Spurr (1954) and Tande (1979).

Scars caused by mechanical abrasion including flood damage, windfall and snapped branches were distinguished from fire scars by their location on the tree and irregular outline. Porcupine girdling was distinct with its "square patch" outline and shredded bark. Selected scars from the fan were sectioned and sanded. Tree age and date of damage was assessed by counting annual growth rings beneath a zoom stereo microscope at low (6-12X) magnification.

IV. RESULTS

Geomorphology

The geomorphic character of Prairie Creek fan is graphically summarized in Fig. 11. A descriptive explanation of the major features is presented below.

The active core area of Prairie Creek alluvial fan is characterized by stream anabranches separated by gravel/boulder shoals. These branching and rejoining channels are variable in depth and width forming a sinuous but not a simple meandering pattern (Walker 1976). The channel floor is formed from a coarse gravel/boulder lag deposit. Gravel and coarse sand above this lag deposit are transported through the system as bedload. A large percentage of the finer silts and clays remain in suspension. Infrequently clay combines with gravel to form mudballs. These were observed to form along the northwestern fan shore, downstream from the clay exposure.

Clast size (long axis) is a useful indicator of depositional slope. An abundance of boulder-size clasts suggests a slope of 10 m/km or more; cobble-sized clasts indicate a slope greater than 3 m/km (Boothroyd 1972).

The upper fan region of Prairie Creek is characterized by large clast size (10 cm up to 1.2m), a steep slope (> 10 m/km), a confined floodplain and upper flow regime conditions even at low flow stages. Stream depth varied from 30 cm to 1.3 m during low flow in 1976. It

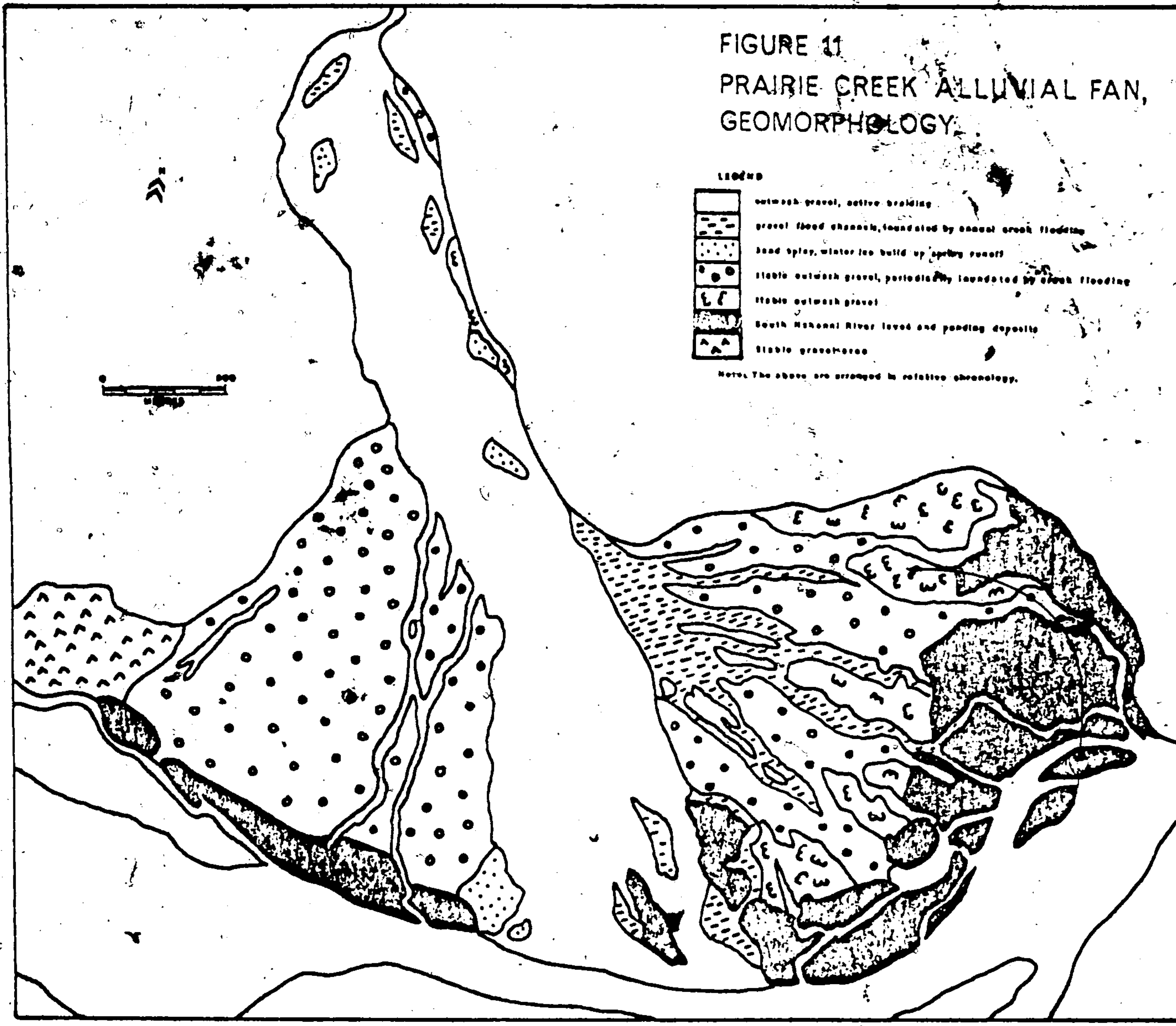


FIGURE 11
PRAIRIE CREEK ALLUVIAL FAN, GEOMORPHOLOGY

is both confined between steep unstable gravel banks and unconfined on a broad gently sloping gravel deposit. Under upper flow regime conditions, the stream overflows across the floodplain and channel bars as sheet flow with subsequent non-selective deposition of the coarser fraction. The bars are consequently formed of poorly-sorted, imbricated gravels. A sand matrix was infrequently present in the actively scoured region. This is similar to the findings of Williams and Rust (1969) on the Donjek River in Alaska. Vegetated channel bars were frequently mantled in sand. Dune features formed on these sparsely vegetated surfaces. Wave-rippled sandy pool beds with Populus balsamifera seedlings were also present near the fan head.

In the mid-fan area, clast size decreased to gravel and coarse sand. Horizontal bedding was visible in channel bars. Slipfaces were present on both point and longitudinal bars. The channel width/depth ratio increased as flow was dispersed among many channels across a broad gravel floodplain. Sand and silt deposits were more common here. Channels were actively eroding the western fan.

The toe of the fan displayed further decrease in slope and clast size, and increase in the number of distributaries carrying flow. Similar decreases in clast size have been documented on other alluvial and outwash fans (Boothroyd 1972, Bull 1960, Blissenbach 1954).

During high flow this gravel area is submerged by flood waters actively scouring the gravel surface. Flotsam including uprooted trees, serve as further scouring agents. The gravel/boulder bed is activated and undergoes active siltation. The geometry and configuration of channel beds and flow patterns vary following each major flood event.

Abrasion and erosion are too severe for successful plant establishment.

West of the active gravel area, an older surface of slightly higher elevation supports a low shrub and herb cover. This area is scarred by the braided pattern of abandoned channels. No age was determined for the dates of abandonment of most of these channels; many are outlined by linear groves of Picea glauca. A single scour channel adjacent to the NW slope was formed between 1954 and 1964 as indicated by the aerial photographic record. It was rescoured during a major flood in 1972 (Scotter pers. comm. 1978). Channels and bars of varying depths, sinuosity and vegetation cover characterize this western fan. The gravel subsurface fluvial forms are mantled by as much as 15 cm of desiccated soil.

An exception to this mantling pattern occurs in the lower south-east corner of the west fan, where loose recent silts and sands up to 1 m in depth are splayed on the surface. River ice was observed over this area in April, 1977. It is thought to have stagnated and melted in situ during recent years. Silt and sand would be released from the melting ice. No active scour features were evident in 1976. No soil development was observed in this area of the fan.

In 1976, three gravel channels, largely devoid of plant cover, were observed to carry flow during two major flood events on Prairie Creek. The flow in the central channels of the west fan served as surface overflow. In contrast, the far western scour channel originated through subsurface seepage. This channel was also unique in its pattern of dispersed linear scour pools near the toe of the fan, none of which formed a surface junction with the South Nahanni River. Three headward scour pools near the toe of the fan were also observed to fill through subsurface flow following heavy rain. The pattern of subsurface flow was not examined in detail.

The eastern portion of the Prairie Creek fan-surface is dominated by the presence of many overflow channels which are active during spring and early summer. In contrast to the west fan, there is a more abundant tree cover and greater annual tree growth as indicated in the tree ring record; these conditions suggest that subsurface seepage is more plentiful or closer to the surface. Seepage is contributed by drainage from the adjacent slopes and by Prairie Creek. Gravels lie from 1 to 15 cm below the surface on the open heath area; they lie buried beneath 5 cm to >2.5 m in the forested sites.

A muddy perennial channel and an intermittent gravel channel flow through the lower eastern portion of the alluvial fan. Subsurface flow provides their source. Beaver (Castor canadensis) have built dams and huts on the silt laden channel. A Carex rostrata/C. atherodes sedge meadow with interspersed fallen decaying trees has formed over the silty clay muck base of the ponded water. This meadow was visible on the earliest 1934 aerial photographic record.

The South Nahanni River forms a braided pattern through Deadmen Valley, constricted into a straight reach along the toe of the outbuilding fan. This valley existed as a distinct lowland, separating First and Second Canyons prior to glacial rebound and uplift which commenced between one to two million y B.P. (early Quaternary) (Ford 1974). It has shifted north to form a channel abutting the lacustrine bluffs resulting in a series of rotational slumps upstream from the fan. The location of channels and bars shift annually.

The South Nahanni River has formed a narrow levee along the west fan that supports a stand of tall Picea glauca. Stratified deposits of coarse and fine silts, loams, clay loams and organic materials overlie gravel in the upper 1 to 1.5 m of the levee. Tree roots are buried up to 1 m, binding the soil along the eroded cutbank of the western fan. Recent overbank flows are evident from surface and near-surface silt deposits, rafted debris, and flood marks on tree boles. Overbank flow is associated with flooding following major rain storms and spring breakup. Ice dams blocking the entrance of First Canyon cause backup of ice and debris laden waters onto levee vegetation. Minor blockage was observed during May, 1977. Two major scour pools were also observed along the west fan levee maintained by both Prairie Creek subsurface flow and erosion by the South Nahanni River.

The levee of the South Nahanni River is not as clearly defined in the east; it extends over the fan gravels in a broad tapering deposit and reaches a maximum depth at the eroded scarp shoreline. This deposit is also stratified into layers of buried organics, silt and silty clay loams. No headward erosion scour pools were observed along the shore.

Historical Aerial Photographic Record

The historical aerial photographic coverage of Prairie Creek alluvial fan was examined for 1934, 1949, 1961, 1974, 1975 and 1976. From these photographs, changes in geomorphic features and vegetational patterns from 1934 to 1976 were mapped. This information extended the temporal data base which assisted in interpreting the successional status of plant communities observed in 1976. Variation in scale and quality of photographs, season, stage of the river and the scope of this paper, limit the discussion of variation over time to major removal or extension of the land base and to visible changes in plant community structure. In the 1934 photographs groundwater discharge could be detected at the surface along the toe of the west fan and centrally along the east fan (Fig. 12). Continuous flow is carried by multiple channels on the east fan, east of the central island. Extensive gravel areas provide evidence for channel migration and active flooding in much of this area. This supports the hypothesis that moisture provided from throughflow contributes to the improved growth observed in cores of <u>Picea glauca</u> and <u>Larix laricina</u> collected from the east fan. It also provides a rough date of active continuous flow through several of the channels.

Canopy cover throughout the fan was more open and tree height shorter in 1934 than results from the 1976-77 field survey. An example of this occurred in a fire scar observed in the central portion of the fan. A cover of young tree seedlings and shrubs among remnant mature <u>P. glauca</u> had grown into a dense, nearly even height forest by 1976. A scar collected from this site dated the fire at 1909.

By 1949 the fire stand had matured to the sapling stage, many of the east fan channels had been reduced to intermittent flow or abandoned scars, and major land areas in the south-east corner of the fan had been eroded away (Fig. 13). A portion of the <u>Picea/Larix</u> dominated forest at the head of the central island ("C", Fig. 13) and an island of mature <u>P. glauca</u> at the toe of the west fan had also been removed. Beaver dams

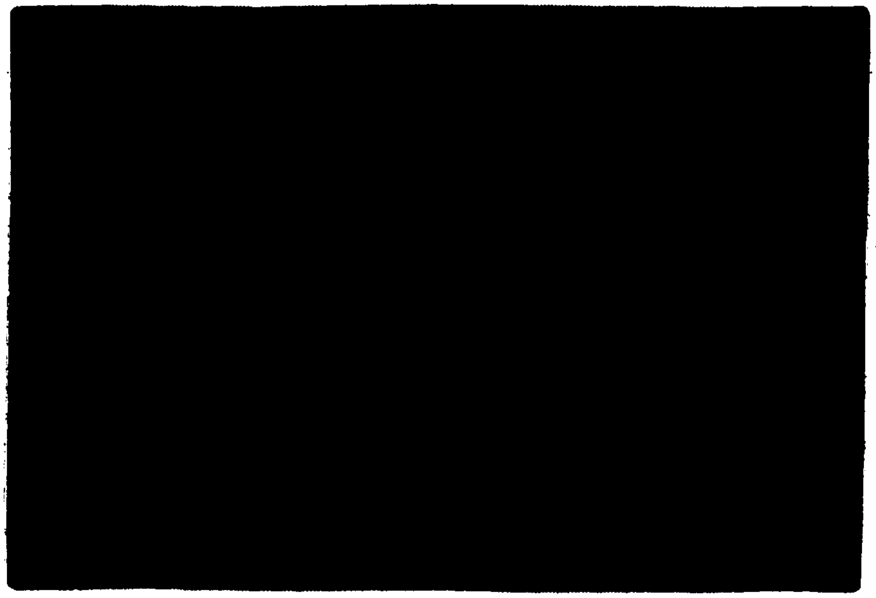


Fig. 12. 1934 aerial photograph, Prairie Creek alluvial fan, N.W.T. (--- abandoned gravel channels; —— continuous flow).

COLOURED PICTURE

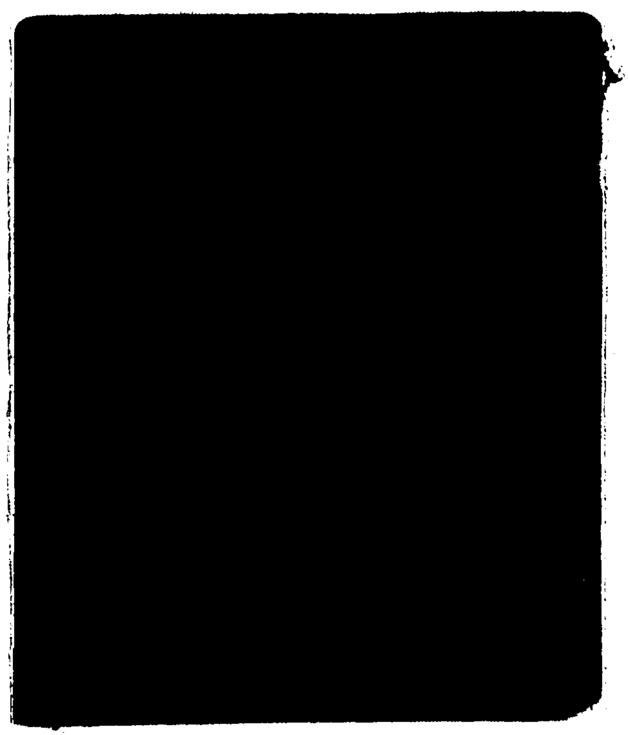


Fig. 13. 1949 aerial photograph, Prairie Creek fan, N.W.T. (--- abandoned gravel channels; —— continuous flow C * central island).

in the lower east portion of the fan were visible on the photographs in similar locations to those observed in 1977. Flow direction of the South Nahanni River had migrated northward; Prairie Creek flow had been directed towards the west fan.

The reflectance of abandoned channels had decreased by 1961, suggesting that the colonization of *Picea glauca* seedlings and *Dryas drummondii* was progressing. Continuous flow occurred west of the central island. On the west fan a scar (Fig. 14, 1) appeared in a formerly vegetated area of the *Juniperus horizontalis*/*Arctostaphylos uva-ursi*/ lichen community. This scar was colonized by a 50% *D. drummondii* cover in 1976.

The 1974 aerial photograph resembled the 1976 study site. Areas of coarse sand splays were visible on the south-east corner of the west fan (Fig. 15, 1) providing evidence for former sheet flow. Major destruction of this area of the fan by floodwaters was evident from the removal of land mass and the formation of a remnant island (Fig. 15, 2). Scar faces near the upstream portions of the island, flood scars and abandoned channels were visible. Vegetated islands near the fan head were also destroyed by flood waters (Fig. 15, 3). Rotational slumping at the western fan head (Fig. 15, 4) had been initiated through floods undermining the clay outcrop.

Fluvial Regime

Discharge Pattern

No flow recording station has been established on Prairie Creek. Variation in flow is however critical to the formation and changing

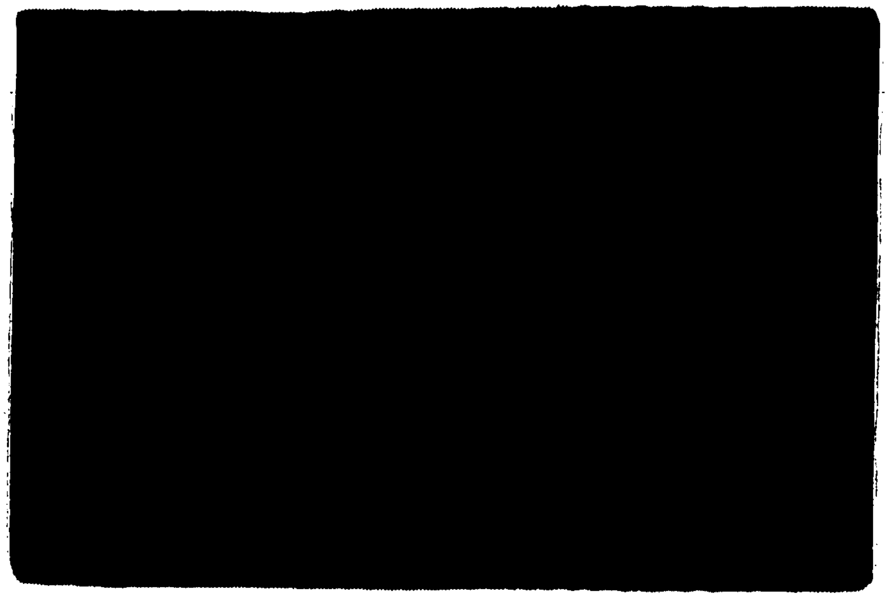


Fig. 14. 1961 aerial photograph, Prairie Creek fan, N.W.T. (--- abandoned gravel channels; continuous flow; areas where major erosion or deposition has occurred; see text).

COLOURED PICTURE

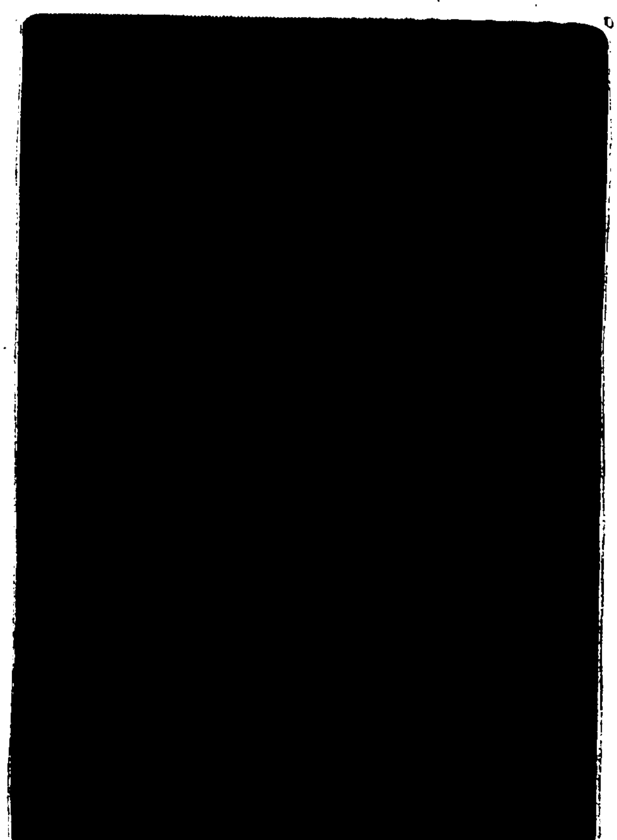


Fig. 15. 1974 aerial photograph, Prairie Creek fan, N.W.T. (--- abandoned channels; continuous flow; areas where major erosion or deposition has occurred; see text).

character of the fan surface. The flow in the South Nahanni River also influences the surface of the study area through erosion and deposition cycles. Two recording stations have been established by Inland Waters Branch, Environment Canada, along the South Nahanni River: at Virginia Falls (Station 10EBQ01), and near the Hot Springs above Claussen Creek (Station 10EC001). The latter is located approximately 2 km south of the mouth of Prairie Creek. The data from this station were examined to identify magnitude and trends in flow pattern on the South Nahanni River.

Flow records were examined for the available period of 19[illegible] to 1975 inclusive. Data reported from the earlier years were incomplete.

A discussion of the flow pattern in Prairie Creek will be limited to descriptive observations recorded during the summer field season of 1976 and spring period of 1977.

Ice Conditions

Two major factors which influence the growth and survival of vegetation in the riparian habitats are extent and date of major flood events and duration of the ice-free period. Freeze-up has occurred between October 5 and November 1 during the last 15 years. Break-up dates range from March 31 to May 20.

The physical influence of ice break-up on vegetation was observed during the spring of 1977, and indirect evidence of its influences examined during the summer of 1976.

The south-east corner of the west fan provides an example of the influence that ice duration has on plant growth. This area was covered with table ice long after the remainder of the fan had been released from its snow cover. Flowering dates for different species lagged from two to four weeks in open areas on this site. Silt trapped in the ice was also abundant on the surface. Subsequent ponding of water created bare silt areas prone to wind erosion; annuals colonized these areas. Similar shelf and table ice was observed along the toe of the fan on the South Nahanni River shoreline. Following break-up large chunks of shelf ice remained as stagnating blocks along the east fan toe. Snow melt, even beneath a dense forest canopy, exceeded ice melt and removal by several weeks.

Physical damage was observed by ice establishment around the base of trees. Branches near the ice surface would melt free by differential solar melting but branches entrapped below the surface would be vulnerable to snappage under the weight of collapsing ice undermined by basal water flow. The above effect and the influence of moving ice physically battering trees was observed during the 1977 ice break-up period. Both ice and wood debris carried by the flow scarred trees along the route of the flooding. The ice flow was backed up at First Canyon during this period, extending the influence of ice and debris damage beyond the expected line of flow.

The influence of freeze-up was not observed on the fan.

Flooding

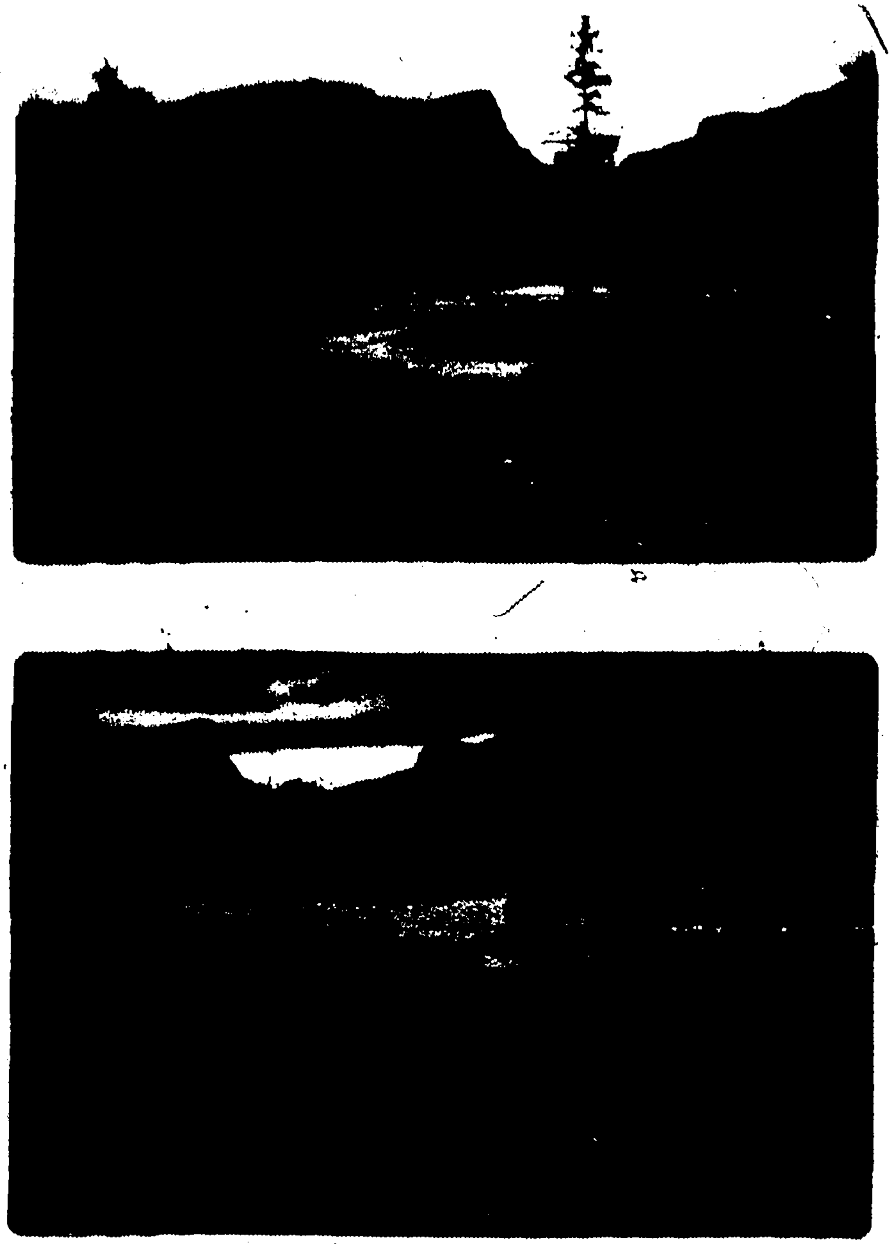
Flood events were similar in effect to ice break-up events. Physical damage including removal of individuals was caused by flood debris battering against plants and through undermining of the stream bank resulting in slumpage. Recession of the east bank of the west fan was observed following major flood events during the summer of 1976.

Scars were aged for individuals of Picea glauca and Larix laricina to estimate dates of former flood events. Problems with aging are discussed in Strang (1975). From the cross-section data, major flood events were indicated for 1895, 1909, 1916, 1922, 1940, 1954, 1957, 1964 and 1972. Many of these dates were supported by reports in the literature (Strang 1975, Parker et al. 1973).

The flow record available (1960-1975) included two major flood events. The flood of largest magnitude occurred in 1964 with a second damaging flood in 1972. An examination of the records revealed that in all but two years, peak flow occurred in June with low flow most commonly occurring in March. This corresponds to maximum snow melt and to flash response from rapid convection rainfall runoff from the watershed.

The June 1976 event occurred within 8 hr of the three day rainfall. Both Prairie Creek and the Nahanni River levelled to overbank flow. Photo pair Fig. 16 illustrates the change in flow regime during this period. A few vegetated surfaces were temporarily drowned but those were restricted to tolerant Salix bars, silt pockets of annual Compositae species and the edges of Juniperus horizontalis terraces. The flood marked the peak flow possible before major vegetated areas would be inundated.

Abandoned channels on the west fan were observed to have minor flow during this period. Subsurface flow was also visible where it exited and formed two pools of clear water in headward eroded channels on the west fan. The bedload of the South Nahanni River and Prairie



COLOURED PICTURE

Fig. 16. Photographic pair illustrating erosive action of the 1976 flood, Prairie Creek fan, N.W.T.

Creek were actively moving during this flood as indicated by a loud grinding of rolling cobbles and by changed bedforms following the flood. Active scouring and physical damage of vegetation was thus possible within the streambed, contributing to the absence of seedlings on the exposed gravel bar within the annual flood zone.

The silt load of both Prairie Creek and the South Nahanni River increased during the flood. This was most noticeable in Prairie Creek which flowed crystal clear during low flow. The suspended sediments in part originated along the clay banks near the far head Mudballs of gravel in a clay matrix also formed near this location. The disintegration of these forms provided a seedbed for a Rorippa sp. and a Senecio sp. Flood rafted debris also provided both an immediate colonization surface (where an intact mat of vegetation was transported and deposited) and longterm seedbed.

Fig. 17 provides an example of the annual flow pattern. It is suspected that subsurface flow correlates to stream flow and has a significant influence on the composition, growth and survival of vegetation.

Soils

The alluvial soils of Prairie Creek have developed over [illegible]-deltaic limestone and dolomitic outwash. The soils are calcareous, low in organic matter, and vary in texture from sand to silty clay loam. Many display cumulic layering with horizonation weak to absent. Physical and chemical properties of 11 soil profiles, associated with the major community types are presented in Table 6. Soils are classified into three soil orders: Regosolic, Gleysolic and Brunisolic.

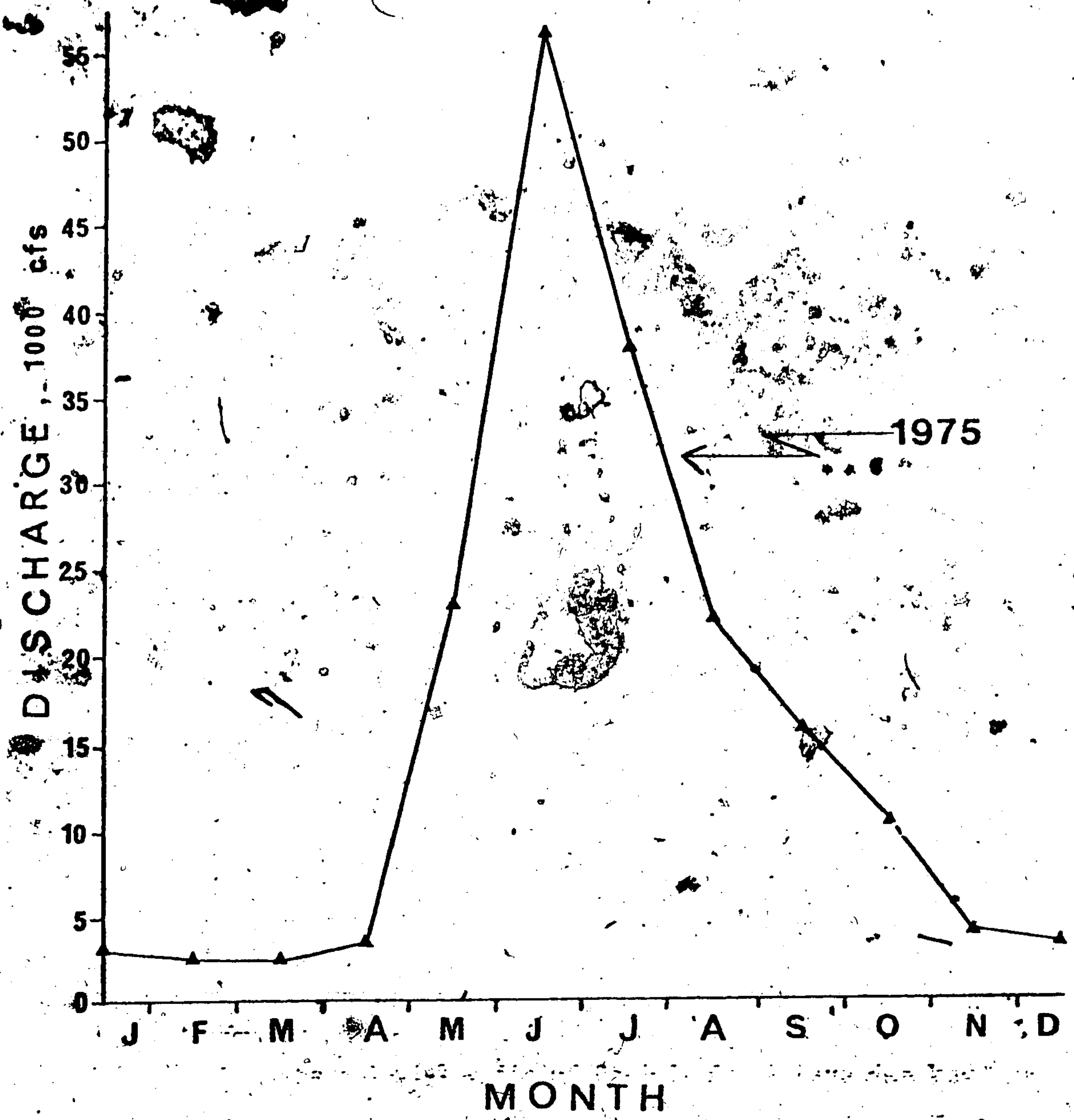


Fig. 17. Mean monthly discharge for the South Nahanni River above Clausen Creek, Station 10EG-1, 1975.

Table 6. Physical and Chemical properties of soil profiles beneath 11 plant community types, Prairie Creek alluvial fan, N.W.T. (refer to text for sampling and analyses methods).

	Community Type	Soil Type	Horizons	Depth (cm)	Texture	pH	%O.M.	P ppm	K me/100g	Colour	%water 1/3b	%water 15b
Heath Communities	Dd	OR	Ck	[illegible]	[illegible]	[illegible]	[illegible]					
	Jh/Ca	CR	Ck_1	[illegible]	[illegible]	[illegible]	0.02	1.7	.31	10YR 3/1m	25	18
			Ck_2	6-13	s	[illegible]	0.02	1.2	.28	2.5YR 3/2m	14	[illegible]
			Ck_3	13-24	sil	7.7	6.1	2.1	.28	2.5[illegible]/2m	11	[illegible]
			$L-H_b$	19,21,24	o			7.0	.60	2.5Y 3/2m		
			Ck_4	24-54	sil	7.8	5.2	1.8	.33	2.[illegible] 4/2m	11	3
			Ck_5	54+	G/R							
	Auu/Jh/ Lichen	OR	LFH	2-0	o	8.4						
			Ck	0-50+	s/sl/G	7.9	0.01	[illegible]0	.25	2.5YR 3/2m	12	07
Scrub Communities	Sa-1/ Eq	RG	Cg	0-20	sil	[illegible]	1.2	0.8	.19	2.5Y 4/2m	35	12
			Cg	20-70+	sil	8.1	0.8	0.4	.14	10YR 4/2m	33	10
	Bet-Sa/ Eq	OR	Ck_1	0-5	s	8.4	1.1	[illegible]	.24	2.5YR 3/2m	16	12
			Ck_2	5-15	sl	8.7	0.1	0.5	.15	10YR 3/2m	14	6
			Ck_3	15+	G							
Woodland/ Savannah Communities	Pg-Ll/ Jh/Ca-s	EMB	LF	9-0	o	8.0						
			Ah	0-2	o	7.6		1.1	.80			
			Aej	2-4	l	7.6		1.0	.50			
			Bm	4-19	sl	7.8	1.7	2.5	.40	10YR 3/1m	28	18
			H	19-19.5	o	7.6		7.0	.35	2.5Y 3/2m		
			Ck_1	19.5-23	[illegible]	8.3	7.5	1.6	.25	2.5YR 3/2m	15	11
			Ck_2	23-65	[illegible]	7.5	8.2	2.6	.25	10YR 3/1m	14	4
			Ck_3	65-100	sl	8.0	7.8	0.8	.40	10YR 3/1m	20	10
			Ck_4	100-133	sicl	8.0	7.8	0.0	.75			
			Ck_5	133+	G/R							
	Cl-Pg/ Sa/Auu	OR	LF	3-0	o	7.6						
				0-75	sil	7.7	1.9	2.9	.45	2.5Y 4/2m	14	07
				75-85	G							
				85-96	sl	7.8	1.5	2.5	[illegible]	[illegible]5Y 4/2m	11	05
				96-100	G							
	Pg/Ra/ Lb	CR	LF	5-0	o	8.2						
			Ck_1	0-2	sil	8.0	6.0	3.0	.35	2.5Y 4/2m	35	18
			$F-H_b$	2-15	o	8.2		7.0	.85	10YR 3/2m		
			Ck_1	15-28	sil	7.9	3.2	7.6	.24	10YR 3/1m	28	12
			$F-H_b$	28-29	o			10.5	.40	10YR 3/2m		
			Ck_1	29-75	sil	7.9		1.3	.2	2.5Y 4/2m	24	9
			$F-H_b$	75-76	o			5.2	.35			
			Ck_2	76-100+	sl	8.0		2.2	.24	2.5Y 4/2m	12	8
	Pb-Pg/ Al/Eq	GCR	L-H	4-0	o							
			Cg	0-6	sil	8.2	3.2	3.5	.48	10YR 4/2m	3[illegible]	22
			$F-H_b$	6-12	o	8.3		13.7	.48			
			Cg	12-16	sil	8.2	2.0	3.0	.34		28	18
			$F-H_b$	16-18	o	8.3		11.7	.53			
			Cg	18-24	sil	8.2		1.9	.26		26	16
			$F-H_b$	24-28	o	8.3		11.3	.32			
			Cg	28-100+	sil/			.8-1.9/	.20/			
			$F-H_b$		o			10.6-11.7	.42			

Table 6 (continued)

Community Type	Soil Type	Horizons	Depth (cm)	Texture	pH	%O.M.	P ppm	K me/100g	Colour	%water 1/3b	%water 15b
Pb-Pg/ Cs/Lb	GCR	L-F	2-0	o	8.3						
		Cgk	0-5	sil	8.4	3.2	4.3	.50		35	26
		F-H_b	5-6	o	8.2		15.0	.85	2.5Y 3/2m		
		Cgk	[illegible]10	sil	8.4		4.2	.42		32	24
		F-H_b	10-15	o	8.2		15.0	.90			
		Cgk	15-17	sil	8.3	2.2	4.1	.42		28	20
		F-H_b	17-22	o	8.2		15.0	.85	2.5Y 3/2m		
		Cgk	22-28	sil	8.3	3.5	4.1	.36		28	20
		F-H_b	28-29	o	[illegible]		16.0	.85			
		Ck/F-H_b	29-100+	sil/o	7.9-8.0	[illegible]	2.4-14.9	.32-.48			
Pg/Ra/ Eq	CR	LF	2-[illegible]	o	8.2						
		Ck_1	0-5	sil	8.0	3.2	3.2	.46	10YR 3/2m	24	[illegible]
		F-H_b	5-6	o			12.5	.50			
		Ck_2	6-10	sil	7.9	2.1	3.2	.26	2.5Y 4/2m	20	14
		F-H_b	10-11	o			12.5	.51			
		Ck_2	11-12	sil	7.9	2.0	3.0	.24	2.5Y 4/2m	20	14
		F-H_b	12-16	o			11.0	.55			
		Ck_3	16-50	sil		2.0	1.3	.25	2.5Y 4/2m	18	10
		Ck_4	50-60	sicl		1.9	1.1	.29	2.5Y 4/2m	16	6
		Ck_5	60-75	sl		0.6	0.9	.29	2.5YR 3/2m	20	16
		Ck_6	75-78	sil		1.3	1.0	.30	2.5Y 4/2m	20	14
		F-H_b	78-79	o			7.0	.70	2.5Y 4/2m		
		Ck_6	79-85	sil		1.1	0.9	.29	2.5Y 4/2m	18	10
		Ck_7	85-87	s		0.5	0.6	.21	[illegible].5YR 3/2m	18	14
		Ck_8	87+	sicl		1.[illegible]	2.2	.40	10YR 3/1m	18	8

* Dd=*Dryas drummondii* ct., Jh/Ca=*Juniperus horizontalis* ct., Auu/Jh/Lichen=*Arctostaphylos uva-ursi*-*J. horizontalis*/Lichen ct., Sa-i/Eq=*Salix interior*/*Equisetum* ct., Bet-Sa/Eq=*Betula*-*Salix*/*Equisetum* ct., Pg-Ll/Jh/Ca-s = *Picea glauca*-*Larix laricina*/*J. horizontalis*/*Carex scirpoidea* ct. , Ll-Pg/Sa/Auu=*L. laricina*-*P. glauca*/*Salix*/*A. uva-ursi* ct., Pg/Ra/Lb=*P. glauca*/*Rosa acicularis*/*Linnaea borealis* ct., Pb-Pg/Ai/Eq =*Populus balsamifera*-*P. glauca*/*Alnus incana*/*Equisetum* ct., Pb-Pg/Cs/Lb=*P. balsamifera*-*P. glauca*/*Cornus stolonifera*/*Linnaea borealis* ct., Pb/Ra/Eq=*P. balsamifera*/*R. acicularis*/*Equisetum* ct.;

\+ OR=Orthic Regosol; CR=Cumulic Regosol; RG=Regosolic Gleysol; EMB= Eluviated Melanic Brunisol
GCR=Gleyed Cumulic Regosol

** s=sand, sil=silt loam, sl= sandy loam, o=organic, vfs=very fine sand, sicl=silty clay, G=gravel, Si= silt
R=rock

Two major categories of soils were present: shallow Orthic Regosols over the Prairie Creek gravel deposits; deeper Cumulic Regosols, Gleysols, and Brunisols on or near the South Nahanni Levee deposits.

The Orthic Regosols were most commonly associated with the heath communities. The LFH horizon varied from 0 to 3 cm in depth, overlying sand, silt or gravel deposits. Depth of gravel varied with the presence and age of active and abandoned channels. Surficial calcium carbonate precipitates and desiccation cracking were visible on the older exposed surfaces with loess deposits and micro dune features occurring on younger deposits in the southeast portion of the west fan. Free carbonates were detected throughout the solum with corresponding high pH (7.5-8.7, $\bar{x}$=7.9). Available phosphorus and potassium were low. Moisture retention and available moisture, the latter measured gravimetrically in the field, were low. Percentage clay was minimal. These factors are reflected in the dominance of drought tolerant plants including Dryas drummondii, Arctostaphylos uva-ursi, terricolous lichens and xerophytic bryophytes.

The South Nahanni influenced deposits provide more mesic substrates. Along the toe of the fan, the surficial materials consist of series of alternating fine, coarse and fibric bands. Schematic profiles of two soil excavations illustrate a sample of observed variations in the levee Cumulic Regosols.

Cumulic Regosols

Soil pit 3 (Fig. 18) was excavated in a Juniperus horizontalis/Carex scirpoidea heath community on a site largely influenced by Prairie Creek flooding. From 25 to 60% of the

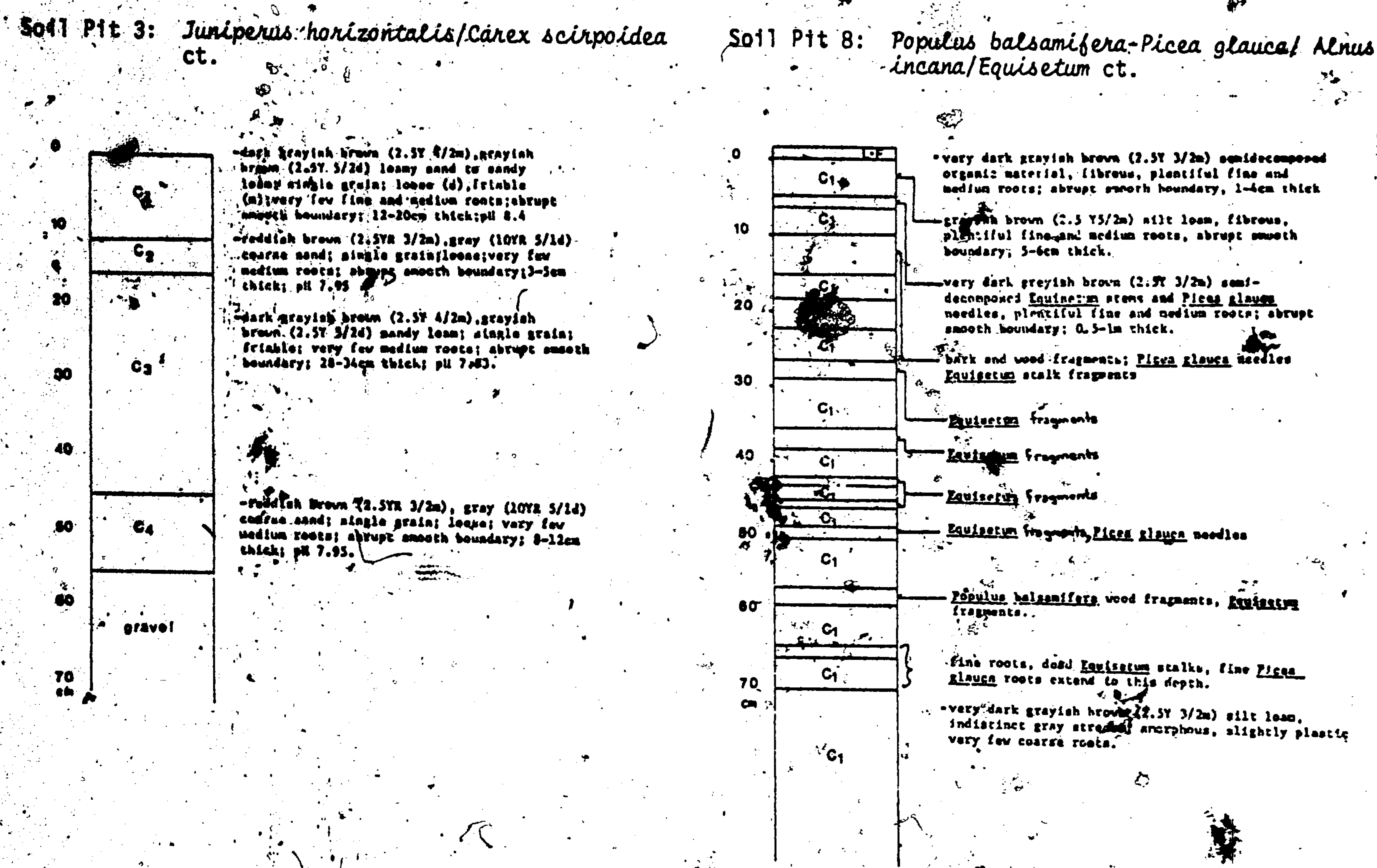


Fig. 18. Cumulic Regosolic profile of a Juniperus horizontalis/Carex community type and a Populus balsamifera Picea glauca/Alnus incana/Equisetum community type.

surface lacks any plant cover. The surface topography reflects the recent abandonment of three distributary channels which carry flow only during major flood events. Spring observations also revealed that the prolonged presence of river ice delays germination and restricts the length of the growing season. The horizons were composed of coarse material dominated by the sand fraction (sand, sandy loams). Fibric lenses were absent suggesting that frequent flood intervals restricted the growth of a continuous plant cover, the surficial materials being prone to severe drought or wind erosion provided a poor seed bed, or flood events initially scoured and removed formerly vegetated surfaces.

Soil pH decreased from 8.4 for surface horizons to 7.8 below 24 cm (Table 6). In contrast potassium, phosphorus, and percent organic matter increased with depth, corresponding with the transition to a finer textured substrate. The available moisture in the solum corresponded to soil textures with coarser materials providing more xeric zones.

In contrast to the soils beneath the heath communities, Soil Pit 8 (Fig. 18) provides an example of a site dominated by organics and South Nahanni River silts. Overbank flow from the South Nahanni River was the primary factor developing the Gleyed Cumulic Regosol, with minor filling and scouring by Prairie Creek during severe flood events. Fibric horizons were dominated by Equisetum and Populus balsamifera fragments. Stalks, leaves, bark and wood components could be distinguished. Picea glauca needle litter provided a minor contribution to the buried organics. Fraction size and species composition imply deposition of the surficial materials in quiet waters (low velocity sheet flow or ponding). A film of dust on an unbroken herbaceous cover, the current unscarred overstory of Populus balsamifera and Picea glauca, raised silt deposition mantling tree trunks up to 16 cm in depth and no evidence for fluvial scour, indicate the continuation of fluvial deposition at low velocities.

Fig. 19 provides a sketch of two additional profile types. Pit 12 contained an interesting combination of coarse and very fine material with a 1 to 3 cm layer of volcanic ash located at a depth of 54 cm below the current surface. The areal extent of the deposit was not examined. It was identified in two soil excavations.

Volcanic Ash

Volcanic glass	60%
Calcite	30%
Pyroxene, Hornblende	tr
Olivine	tr
Plagioclase (very fine)	tr
Quartz	0-tr

The ash may be an extension of the White River Ash deposit. The geographical extent has been documented by Lerbekmo et al. (1969). Similar volcanic ash deposits have been found on alluvial fans in western Alberta (Rutter 1977 pers. comm.)

Soil Pit 10 (Fig. 19) displays a combination of coarse and fine textured bands separated by buried litter. The soil pit was located in an abandoned braided channel. The origin of the sand and gravel layers are attributed to the scouring action of Prairie Creek flow. Silty loam and silty clay loam deposition was observed along the toe of the east fan during the spring of 1977 in areas where similar soil textures dominated the soil profile. Local pocket deposits identified

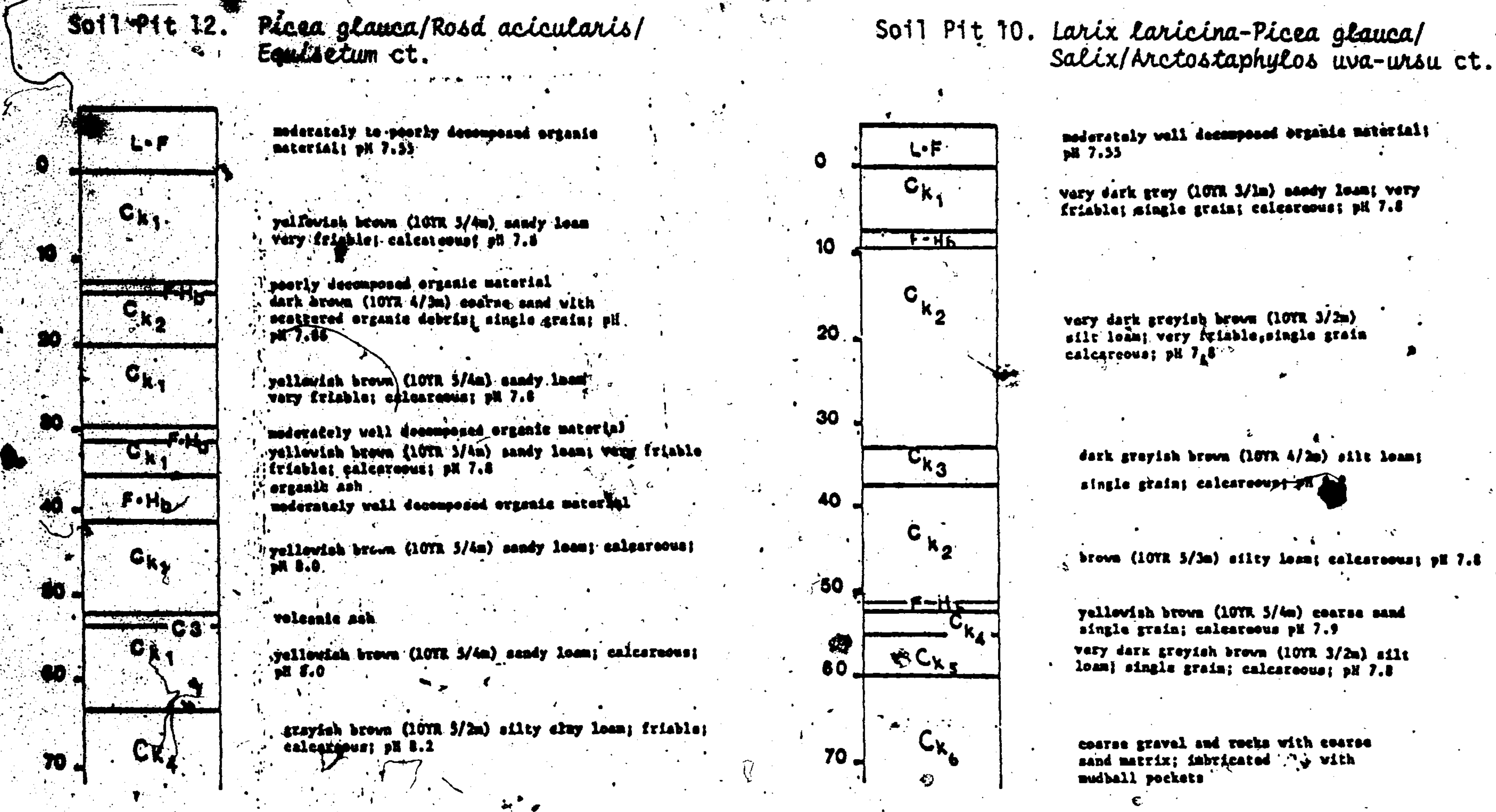


Fig. 19. Cumulic Regosolic profiles of a Picea glauca/Rosa acicularis/Equisetum community type and a Larix laricina-Picea glauca/Salix/Arctostaphylos uva-ursi community type.

as clay mud balls were visible near the base of the soil profile. Modern mud balls of similar composition were observed near the head of the fan following a major flood event of 1976.

As indicated earlier, several soil profiles recorded a history of past fire. Both buried charcoal and ash residue horizons were encountered throughout the alluvial fan. Ash layers ranged from 0.5 cm to 14 cm in thickness with the larger zones combining ash with fibric material. A soil pit excavated within a *Larix laricina*-*Picea glauca*/*Salix*/*Arctostaphylos uva-ursi* ct in the central portion of the fan, revealed a history of a former fire with buried ash residue 51 cm below the modern surface and charcoal fragments occurring closer to the surface.

Juvenile stages of soil formation were observed on a number of sites where recent flooding had not occurred. An Ah horizon bordered by a narrow leached zone and mottled subsurface layers was observed on one occasion in an *L. laricina*-*P. glauca*/*Salix*/*A. uva-ursi* community.

Gleying was noted in the profiles beneath a *Populus balsamifera*-*P. glauca*/*Alnus incana*/*Equisetum* community occurring in areas of saturated deposits along the South Nahanni River cutoff.

The soils also provided a record of scour and deposition, both potentially harsh on the vegetation, through exposure, removal or suffocation of roots.

Soil temperature variation at 10, 30 and 60 cm depths beneath a *P. glauca*/*Juniperus communis* forest community and the *J. horizontalis*/*Carex* heath community are displayed in Fig. 20. Both were located in areas of silty loam surficial deposits. Temperature fluctuations

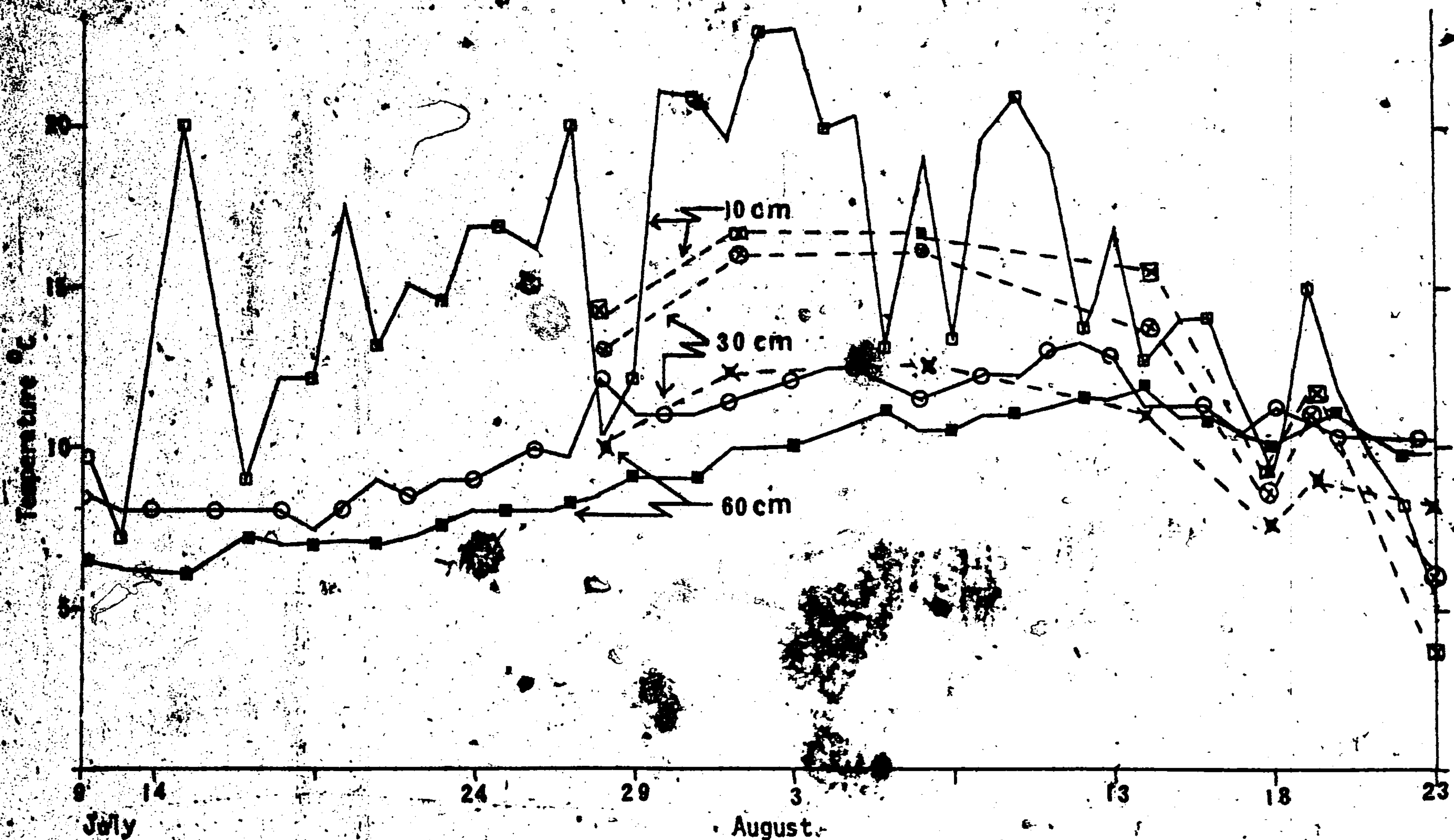


Fig. 20. Mean soil temperatures at varying depths beneath a _Picea glauca/Juniperus communis_ community type (—) and a _Juniperus horizontalis/Carex_ community type(---).

dampened rapidly with depth. Surficial temperatures varied a maximum of 13° C in one 24 h period.

Meteorological Observations

Temperature

Fig. 21 shows weekly mean maximum, mean minimum and mean temperatures for Prairie Creek alluvial fan from June 21 to September 17 1976. The values are based on readings taken at 6 hr intervals. Minimum and mean temperatures were lowest in the late August-early September and highest in Early August. Maximum temperatures deviated from this trend reaching peak temperatures in late July and recording the lowest values in mid-August.

The monthly mean temperatures in July and August on the fan were compared to the data from the surrounding meteorological stations. From this limited information, the temperature corresponds most closely to Watson Lake.

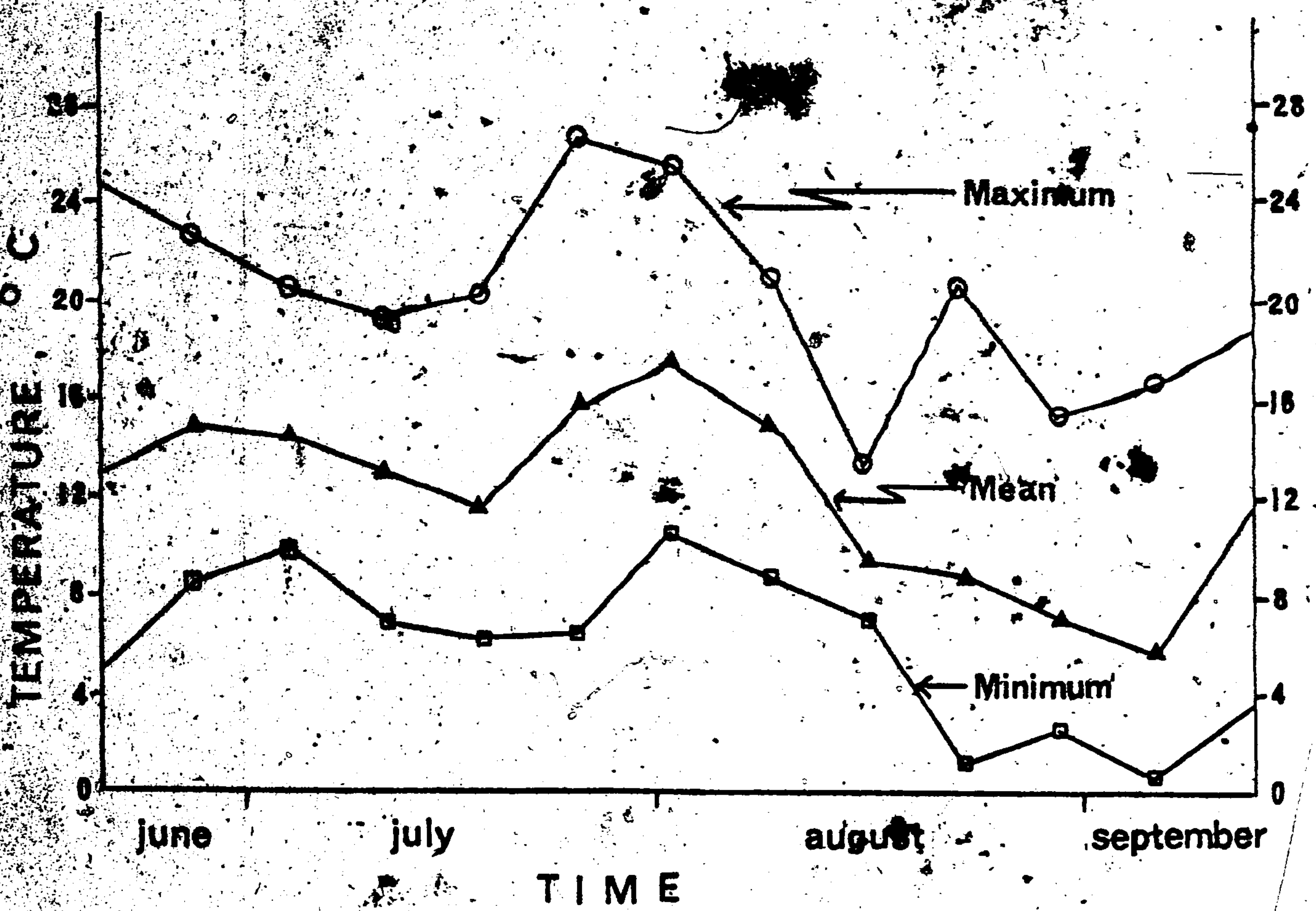


Fig. 21. Mean weekly maximum, minimum and mean temperature (°C) 1.3m above ground at Prairie Creek alluvial fan 2 June-17 June 1976.

Table 7. Mean monthly temperatures July and August for Prairie Creek fan and vicinity (Environment Canada 1977).

	July °C	August °C	Year
Prairie Creek Fan*	13	13	1976
Watson Lake	13	13	1976
	15	15	1941-1970
Fort Simpson	17	16	1976
	16	15	1941-1970
Tungsten	10	10	1976
	12	10	1941-1970
Little Doctor Lake	16	9	1976

* present study

Evidence for the presence of cold air drainage was observed throughout the summer of 1976. Early morning fog in the valley occurred on 11 days from July 19 to September 12 inclusive.

Table 8 identifies the number of days with freezing temperatures at the adjoining meteorological stations in 1976. July is the only month free from frost. Deadmen Valley may receive additional frost.

Table 8. Number of days with freezing temperatures in 1976 at selected sites in NWT and Yukon (Environment Canada 1977)

Site	J	F	M	A	M	J	J	A	S	O	N	D
Watson Lake, Yu	31	29	31	29	12	02	0	01	07	26	29	31
Tungsten, NWT	31	M	31	30	23	M	0	05	16	31	30	31
Fort Simpson, NWT	31	29	31	24	05	01	0	0	06	28	30	31
Nahanni Valley, NWT	30	29	31	28	M	0	0	M	M	M	M	M

During still clear evenings cooled air ponds in the valley. The narrow canyon outlets are inadequate to drain off the cold air (Zalowsky 1976). Dendrological evidence further suggests the presence of a frost pocket on the Prairie Creek fan. The frequent presence of the 'candelabra' tree form, where lateral buds assume dominance, suggest frequent incidence of terminal bud death by unseasonal frosts (Clayford et al. 1959). Heavy laden crowns of mature white spruce snapped off or bent over by their weight indicate the occurrence of a distress cone crop, initiated by frost stimulation of the reproductive buds. Zalowsky (1967 cited in Scotter and Henry 1977) states that distress cone crops occur 1-2 years after an early autumn or late spring frost. Frost rings (Panshin and de Veeuw 1973), frost-cankers, burls (Zalowsky 1976) and bark inclusions initiated by frost injury were observed on cross-sections of sampled trees. These provide further evidence for the presence of a frost pocket together with the observations of inhibited healing of scars induced by flood damage.

Precipitation

Total precipitation during the field season in 1976 was 29 cm. Precipitation occurred on 41% of the days, exceeding 2.5 cm on only one day. Late afternoon showers were most common, often associated with electrical discharge over the Headless Range to the WNW. Flood events occurred on two occasions following a continuous two day downpour of 7.62 cm on July 2-3 and 3.22 cm on July 17-18.

The 1976 monthly record of precipitation for Fort Simpson and Watson lake is presented in Table 5 (see Regional Climate). Snowfall for this season is presented in Table 9.

Table 9. Total snowfall (cm) for Watson Lake and Fort Simpson 1975-1976 (Environment Canada 1977)

Station	J	F	M	A	M	J	J	A	S	O	N	D
Watson Lake, Yuk	81	91	84	36	0	0	M	0	0	0	8	15
Fort Simpson, NWT	58	86	91	T	0	0	M	0	0	T	T	13

Observations during the spring of 1977 identified the presence of lingering snow beneath the denser white spruce canopy of the South Nahanni River levee forests. The open fan was snow-free with only local areas of small snow patches beneath creeping juniper and young white spruce clumps. Exception to this occurred following two spring snowfalls which covered the entire fan surface. The river ice, up to 2 m in depth, also influenced the snow-free period of plant communities located on the southeast corner of the west fan. This ice did not leave the area during the spring field period from mid April to May 9 1977.

Wind

Wind velocity data for a portion of the 1976 field season are presented in Appendix 1. Maximum values reached 27 km/hr.

Blowing sand and silt were seen on several occasions both on Prairie Creek fan and adjoining river bars. Incipient sand dune features occurred in areas of concentrated fines on the open fan and along the South Nahanni River. Indirect evidence for high wind speeds included the frequency of blow down areas and tree breaks within the levee forests and uprooted trees on the open fan and on the pinnacle near the fan head.

Winds were predominantly from the NW with the SW winds occurring during periods of less intensity. Chinook winds occurred during September (Marsh pers. comm., 1976).

Relative Humidity

Table 10 presents mean, mean maximum and mean minimum weekly values. Amplitude was greatest during the last two weeks of July and August during periods of highest maximum temperatures (Fig. 21). Daily values decreased during mid-day rising to a maximum at midnight.

Table 10. Weekly mean relative humidity June 22 to September 6, 1976, Prairie Creek fan, N.W.T.

week beginning	June 22	June 28	July 05	July 12	July 19	July 26	August 02	August 09	August 16	August 23	August 30	Sept 06
Max.	92	86	91	86	98	96	95	98	98	98	99	100
Min.	27	33	35	32	34	29	35	40	57	30	35	33
Mean	60	60	63	59	66	62	65	69	77	64	67	65
Amplitude	66	53	56	55	64	67	60	58	41	67	65	64

Vegetation/Flora

Flora

The vascular flora of Prairie Creek alluvial fan consists of 190 species within 42 families (Appendix 2). Compositae is the largest family with 24 species, followed by Graminaea (19 species), Salicaceae (14 species) and Cyperaceae (14 species). Forty-five bryophytes in 18 families (Appendix 3) and 88 lichens (Appendix 4) were collected and identified.

Species rich genera include Carex, Equisetum, Salix, Erigeron, Aster, Antennaria, Betula, and Calamagrostis. Species with the highest frequency in sample quadrats are Picea glauca, Rosa acicularis, Juniperus horizontalis, Arctostaphylos uva-ursi and Carex scirpoidea.

Phytogeography

The flora of Prairie Creek alluvial fan was classified into seven main geographic distribution types (Table 11). Species were assigned to the distribution type or province (Gleason and Cronquist 1968) which best described the major area of their range.

A. Widespread Species

Widespread species are those whose distribution is not restricted to one or two vegetation provinces. For example they may occur in the Northern Conifer Province (Boreal), Eastern Deciduous Forest Province, Grassland Province and Crodilleran Forest Province as defined by Gleason and Cronquist (1968). As implied by their representation in several vegetation provinces their ranges extend over many physiographic and climatic variations. Their distribution is global (3%), restricted to the Northern Hemisphere (14%), or extended throughout North America (12%).

Some of the more common species on Prairie Creek such as Arctostaphylos uva-ursi, Equisetum pratense, Equisetum arvense and Potentilla fruticosa belong to this phytogeographic distribution type.

Table 11. Phytogeographical affinities of 182 vascular species from Prairie Creek alluvial fan, N.W.T.

A. WIDESPREAD (29% of flora)

a. Global (3%)

Equisetum arvense
Deschampsia caespitosa
Rorippa islandica
Potentilla norvegica
Triglochin palustris
Poa pratensis

b. Widespread Northern Hemisphere (14%)

Calamagrostis neglecta
Goodyera repens
Gymnocarpium robertianum
Chenopodium capitatum
Carex capillaris
Potentilla fruticosa
Epilobium angustifolium
Hippuris vulgaris
Pyrola secunda
Galium boreale
Equisetum hiemale
Hierochloe odorata
Rosa acicularis
Pyrola asarifolia
Pyrola chlorantha
Equisetum pratense
Equisetum sylvaticum
Equisetum fluviatile
Galium triflorum
Arctostaphylos uva-ursi
Hordeum jubatum
Epilobium adenocaulon
Salix bebbiana
Aster ciliotatus

c. North American Widespread (12%)

Agrostis scabra
Smilacina stellata
Corydalis aurea
Fragaria virginiana
Achillea nigrescens
Achillea lanulosa
Equisetum fluviatile
Solidago canadensis
Prunus virginiana
Rubus strigosus
Lathyrus ochroleucus
Senecio indecorus
Cornus stolonifera
Actaea rubra
Senecio pauperculus
Hieracium scabriusculum
Rubus pubescens
Salix interior
Glyceria striata
Geocaulon lividum
Cypripedium calceolus

B. ARCTIC MONTANE (20% of flora)

Equisetum variegatum
Cystopteris fragilis
Woodsia glabella
Carex scirpoidea
Eriophorum scheuchzeri
Tofieldia pusilla
Polygonum viviparum
Saxifraga aizoides
Astragalus alpinus
Pinguicula vulgaris
Calamagrostis purpurascens
Oxytropis varians
Vaccinium uliginosum
Ranunculus hyperboreus
Trisetum spicatum
Carex glacialis
Carex saxatilis
Saxifraga oppositifolia
Astragalus eucosmus
Epilobium latifolium
Cassiope tetragona
Lesquerella arctica
Carex membranacea
Primula stricta
Rhododendron lapponicum
Antennaria isolepis
Calamagrostis lapponica
Empetrum nigrum
Salix alaxensis
Festuca altaica

TABLE 11. (cont.)

b. Arctic Montane North America (4%) (including Greenland in some cases)

Dryas integrifolia
Anemone parviflora
Saxifrage tricuspidata
Salix arbusculoides
Juncus albescens
Taraxacum lacerum
Arnica alpina ssp. *angustifolia*
Arnica alpina ssp. *attenuata*
Antennaria densifolia

C. CORDILLERAN (17% of flora)

a. Cordilleran with representation in Eurasia (5%)

Aster alpinus
Juncus arcticus
Thalictrum alpinum
Androsace chamaejasme
Aster sibiricus
Erigeron lonchophyllus
Artemisia frigida
Arctostaphylos rubra
Selaginella selaginoides

b. Cordilleran restricted to North America (12%)

Salix lasiandra
Agropyron violacium
Juncus albescens
Arnica alpina ssp. *tomentosa*
Crepis elegans
Braya humilis ssp. *richardsonii*
Alnus incana
Campanula aurita
Bromus pumpellianus
Hedysarum mackenzii
Salix brachycarpa
Carex filifolia
Solidago decumbens var. *oreophila*
Linum lewesii
Salix scouleriana
Betula occidentalis
Delphinium glaucum
Dryas drummondii
Danthonia intermedia
Astragalus tenellus
Parnassia montanensis

D. BOREAL/MONTANE (29% of flora)

a. Circumpolar Boreal/Montane (9%)

Carex aquatilis
Alnus crispa
Parnassia palustris
Juniperus communis
Calamagrostis canadensis
Juncus alpinus
Moneses uniflora
Allium schoenoprasm
Corallorrhiza trifida
Erigeron acris
Calypso bulbosa
Gentiana acuta
Cypripedium guttatum
Boschniakia rossica
Cornus canadensis
Oxytropis varians

b. Boreal/Montane North America (8%)

Carex aurea
Habenaria obtusata
Populus tremuloides
Salix planifolia
Betula papyrifera
Elymus innovatus
Habenaria hyperborea
Shepherdia canadensis
Elaeagnus commutata
Ledum groenlandicum
Mertensia paniculata
Linnaea borealis
Oxytropis splendens
Salix novae-angliae

Table 11. (cont.)

BOREAL

c. Boreal/Montane North and South America (.5%)

Anemone multifida

d. Boreal North America (11%)

Juniperus horizontalis
Populus balsamifera
Minuartia dawsonensis
Salix myrtillifolia
Carex concinna
Listera borealis
Ribes oxycnathoides
Castilleja raupii
Viburnum edule
Erigeron acris
Larix laricina
Picea glauca
Tofieldia glutinosa
Cypripedium passerinum
Orchis rotundifolia
Aquilegia brevistyla
Hedysarum alpinum
Salix rigida
Salix pseudomonticola
Lobelia kalmii
Oryzopsis pungens

E. GREAT LAKES FOREST/ BOREAL (2%)

a. North America

Habenaria orbiculata *
Carex eburnea
Aralia nudicaulis

Lonicera dioica

F. GRASSLAND NORTH AMERICA (3%)

Symphoricarpos occidentalis
Antennaria campestris
Agropyron trachycaulon
Aster pansus
Zygadenus elegans *

G. RESTRICTED DISTRIBUTION IN NORTH AMERICA (.5%)

Elymus sibiricus

---

* also montane, open woods/heaths/grasslands

B. Arctic Montane Species

Arctic Montane species are those whose distributions are concentrated in northern (arctic, subarctic, northern boreal) and mountainous regions. This represents 20% of the vascular flora. The distribution of 30 of these species was circumpolar to the northern hemisphere; eight species were restricted to North America with local disjuncts in Greenland (Table 11).

Many of these species were characteristic of heath communities on Prairie Creek alluvial fan where micro-climatic variation is large, wind desiccation severe, and winter snow cover minimal. These include Lesquerella arctica, Primula stricta, Antennaria isolepis, A. densifolia, Taraxacum lacerum, Arnica alpina ssp. angustifolia and ssp. attenuata, Tofieldia pusilla, Astragalus alpinus, Oxytropis varians, the Carices and the grasses. Salix alaxensis is dominant in tall scrub communities on the fan. The remainder of the species occurred infrequently in local pockets on Prairie Creek fan.

C. Cordilleran Species

Cordilleran[3] species are those whose distribution is largely restricted to the major mountain ranges, and adjacent lowlands of North America. Nine species also occurred in mountainous areas of Eurasia. Seventeen percent of Prairie Creek fan flora was assigned to the Cordilleran species group.

---

3. Cordillera - a group of mountain ranges or range forming the main mountain axis of a continent; in North America refers to the mountain ranges separating the Pacific Ocean and the Central Lowlands (Prairies)(American Geological Institute 1962).

Dryas drummondii, the dominant pioneer gravel colonizer on Prairie Creek fan, falls into this geographic distribution, as do many of the fan compositae species. Most of the species in this list were abundant on Prairie Creek fan reflecting its location in a mountainous area characterized by a calcareous gravel substrate, severe zeric microclimate and proximity to the surrounding alpine uplands of the Nahanni Range.

D. Boreal/Montane Species

These species are those whose distribution is concentrated in northern forests with some representation in mountainous (montane) areas. Twenty-nine percent of the Prairie Creek flora were listed in this group.

Many of Prairie Creek's forest trees, shrubs and herbs are associated with the boreal forests throughout North America or worldwide. Boreal/montane associations are frequent (8%). The dominant tree species on the fan, *Picea glauca*, *Larix laricina* and *Populus balsamifera* are boreal North American in distribution. The common understory species of *Cornus canadensis*, *Elymus innovatus* and *Carex concinna* represent boreal distributions.

E. Great Lakes Forest/Boreal Species

Rowe (1972) identified these forest regions. The distribution of four (2%) Prairie Creek species (Table 11) was concentrated in these forest regions. *Carex eburnea* was the only species common on the fan.

F. Grassland Species

The grassland geographic distribution is restricted to North America. Five Prairie Creek fan species including two compositae, one lily, one grass and one shrub are common North American grassland species. They occurred in heath communities on the fan.

G. Restricted Distribution

Hultén (1968) maps the distribution of Elymus sibiricus as mid-Asiatic with local disjunct populations in Alaska, and southwestern N.W.T./northern Alberta. It is an introduced species to North America, restricted in habitat to roadsides and clearings (Fig. 22).

H. Other

Four lichens from the fan were of particular phytogeographic interest for their restricted North American ranges. Peltigera neckeri, Polybastia sendneri and Gisleria sp. have not previously been collected in North America. Leptogium papillosum was a first collection record in Canada.

Tortella inclinata is a first record for Nahanni National Park. It is the most common moss on Prairie Creek fan, restricted to the dwarf shrub communities. Its present and quaternary distribution has been discussed by Miller (1976) who recognizes it as a glacial disjunct (Fig. 23).

In summary the fan is a mixing ground for species of many geographical affinities.

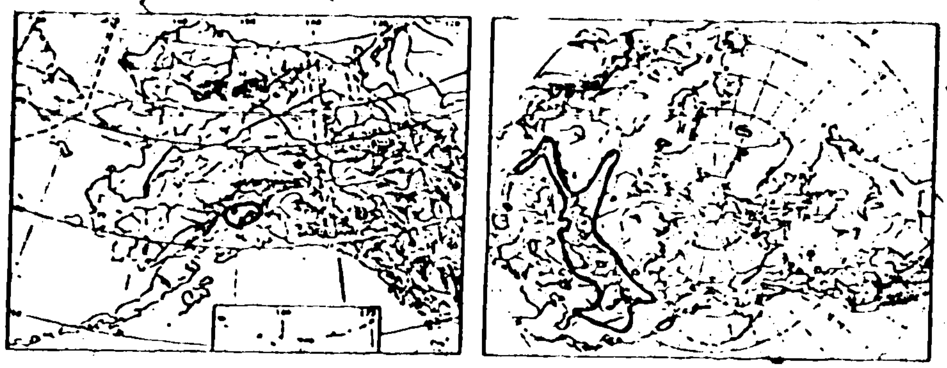


Fig. 22. Distribution map of Elymus sibiricus (after Hultén 1968).

Fig. 23. Distribution map of Tortella inclinata (• = present and ▲ = quaternary distribution (Miller 1976)).

I. Rare and Restricted Disjunct Populations

Kershaw (1976) studied the Canadian flora to document species present in this country in such small numbers or such restricted habitats that they could disappear (International Union for Conservation of Nature 1966). Two orchids of the Prairie Creek flora were listed (Table 12).

Fourteen species were included as restricted disjunct populations in Canada but common in part of their range. Species with abundant representation on the fan included *Dryas drummondii* and *Hedysarum mackenzii*. More restricted populations on the fan were *Rhododendron lapponicum* and *Primula stricta*.

TABLE 12. Rare species and restricted populations from Prairie Creek alluvial fan, N.W.T.

RARE SPECIES (after Kershaw 1976)

Cypripedium guttatum

Cypripedium passerinum

RESTRICTED DISJUNCT POPULATIONS BUT COMMON IN PART OF THEIR RANGE

Arnica tomentosa

Erigeron compositus

Erigeron elatus

Erigeron lonchophyllus

Lesquerella arctica

Elaeagnus commutata

Rhododendron lapponicum

Calamagrostis purpurascens

Elymus sibericus

Hecysarum mackenzii

Tofieldia pusilla

Primula stricta

Dryas drummondii

Salix brachycarpa

Habitat Preference Types

Habitat preference types for 121 vascular species of the Prairie Creek flora were identified from the floras (Table 13).[4] Representation from both xeric and saturated environments were present on the fan. Only 8% of the flora was characteristic alluvial flat/river valley species, with an additional 6% common stream bank species. A large representation (5%) of disturbed habitat types (roadsides/clearings) existed, adapted to the continual surficial disruption through flooding and scouring. Both calciphiles and saline tolerant species were represented on the fan.

Larix laricina, characteristic of bog/swamp habitats in the north, provided an exception on Prairie Creek fan. Its distribution was restricted to xeric silt/sand mantled gravel sites which displayed no visible saturation throughout the growing season.

The variety of habitat preference types reflects the diversity of physical site characteristics found on the restricted area of the alluvial fan surface.

4. These were the more common species whose habitat preferences could be identified in the floras.

TABLE 13. Species habitat preference.

DAMP FORESTS	**ROCKS/CLIFFS/SANDY SLOPES**
Equisetum pratense	*Calamagrostis purpurascens*
Gymnocarpium robertianum	*Elymus innovatus*
Galium triflorum	*Carex eburnea*
Mertensia paniculata	*Cystopteris fragilis*
Aquilegia brevistyla	*Juniperus horizontalis*
Selaginella selaginoides	*Cassiope tetragona*
Cornus canadensis	
Pyrola asarifolia	**ROADSIDES/CLEARINGS**
Solidage canadensis var. *salebrosa*	
Listera borealis	*Elymus sibiricus*
Habenaria obtusata	*Rorippa islandica*
Habenaria orbiculata	*Potentilla norvegica*
Goodyera repens	*Achillea lanulosa*
Orchis rotundifolia	*Hordeum jubatum*
Calypso bulbosa	*Poa pratensis*
Cornus stolonifera	*Chenopodium capitatum*
Ribes oxycanthoides	*Epilobium glandulosum* var. *adenocaulon*
DRY FORESTS	*Hieracium scabriusculum*
Carex concinna	**SWAMPS/BOGS**
Populus tremuloides	
Actaea rubra	*Equisetum fluviatile*
Shepherdia canadensis	*Equisetum palustre*
Linnaea borealis	*Glyceria striata* var. *stricta*
	Danthonia intermedia
STREAM BANKS	*Carex membranaceae*
	Carex rostrata
Salix planifolia	*Triglochin palustris*
Salix myrtillifolia	*Tofieldia glutinosa*
Salix brachycarpa	*Cypripedium calceolus*
Salix alaxensis	*Cypripedium passerinum*
Salix interior (sand bars)	*Habenaria hyperborea*
Alnus incana	*Corallorrhiza trifida*
Calamagrostis neglecta	*Gentiana acuta*
Deschampsia caespitosa	*Pinguicula vulgaris*
Hierochloe odorata	*Erigeron acris*
Carex rostrata	*Senecio pauperculus*
Hippuris vulgaris	*Vaccinium uliginosum*
	Betula glandulosa
	Larix laricina

TABLE 13. (cont.)

ALLUVIAL FLATS/RIVER VALLEYS

Juncus alpinus
Agropyron violaceum
Agrostis scabra
Hedysarum mackenzii
Hedysarum alpinum
Astragalus tenellus
Epilobium latifolium
Dryas drummondii
Antennaria pulcherrima
Aster sibiricus
Descurainia sophiodes
Chenopodium capitatum
Salix lasiandra
Shepherdia canadensis
Elaeagnus commutata
Populus balsamifera

HEATHS/MEADOWS/GRASSY SLOPES

Carex aurea
Carex filifolia
Calamagrostis canadensis
Bromus pumpellianus
Agropyron violaceum
Calamagrostis lapponica
Juncus albescens
Allium schoenoprasum
Zygadenus elegans
Juniperus communis
Arctostaphylos rubra
Anemone parviflora
Anemone multifida
Delphinium glaucum
Parnassia palustris
Galium boreale
Smilacina stellata
Fragaria virginiana
Lesquerella arctica
Rhododendron lapponicum
Arnica alpina ssp. *angustifolia*
Aster alpinus
Antennaria pulcherrima
Artemisia frigida
Taraxacum lacerum

PREFERENCE FOR CALCAREOUS SOILS

Selaginella selaginoides
Carex concinna
Calamagrostis purpurascens
Larix laricina
Carex eburnea
Carex glacialis
Woodsia glabella

PREFERENCE FOR SALINE SOILS

Primula stricta

WIDE ECOLOGICAL TOLERANCE

Festuca altaica
Equisetum arvense
Potentilla fruticosa
Epilobium angustifolium
Corydalis aurea

Classification

Cluster Analysis

Similarities of quadrat clusters within each level of the dend gram derived from the Clustan 1C program (Wishart 1975) using quantitative (cover values) were identified. The synthesis table derived from the Cornell CEP 3 (Twinspan) program assisted in selecting which coefficient levels in the Clustan output were most useful in classifying vegetation into community types.

Division at the 3 coefficient level was selected to indicate compositionally similar groups of quadrats. Fig. 24 highlights the 13 quadrat groupings which separated out at this level. Cluster 1 was unclustered at coefficient 10; cluster 13 at coefficient 6 and cluster 10 at coefficient 5.9. The remainder of the quadrat clusters separated out at or near coefficient 3. Compositionally no quadrat group at this level is noticeably distinct from all others. The dominant species (highest cover and frequency in each cluster are listed in Fig. 24. In two cases a lower level of division was selected to name community types (ct) where:

1. two structurally distinct cts were grouped together at coefficient level 3 (Dryas drummondii heath ct and Picea glauca/D. drummondii savannah ct at coefficient level 2.4)
2. two quadrat groups separating at coefficient level 2.0 occupied distinct habitats and displayed variable species dominance (Cornus stolonifera/Potentilla fruticosa/Arctostaphylos uva-ursi and Betula/Salix/Equisetum scrub cts).

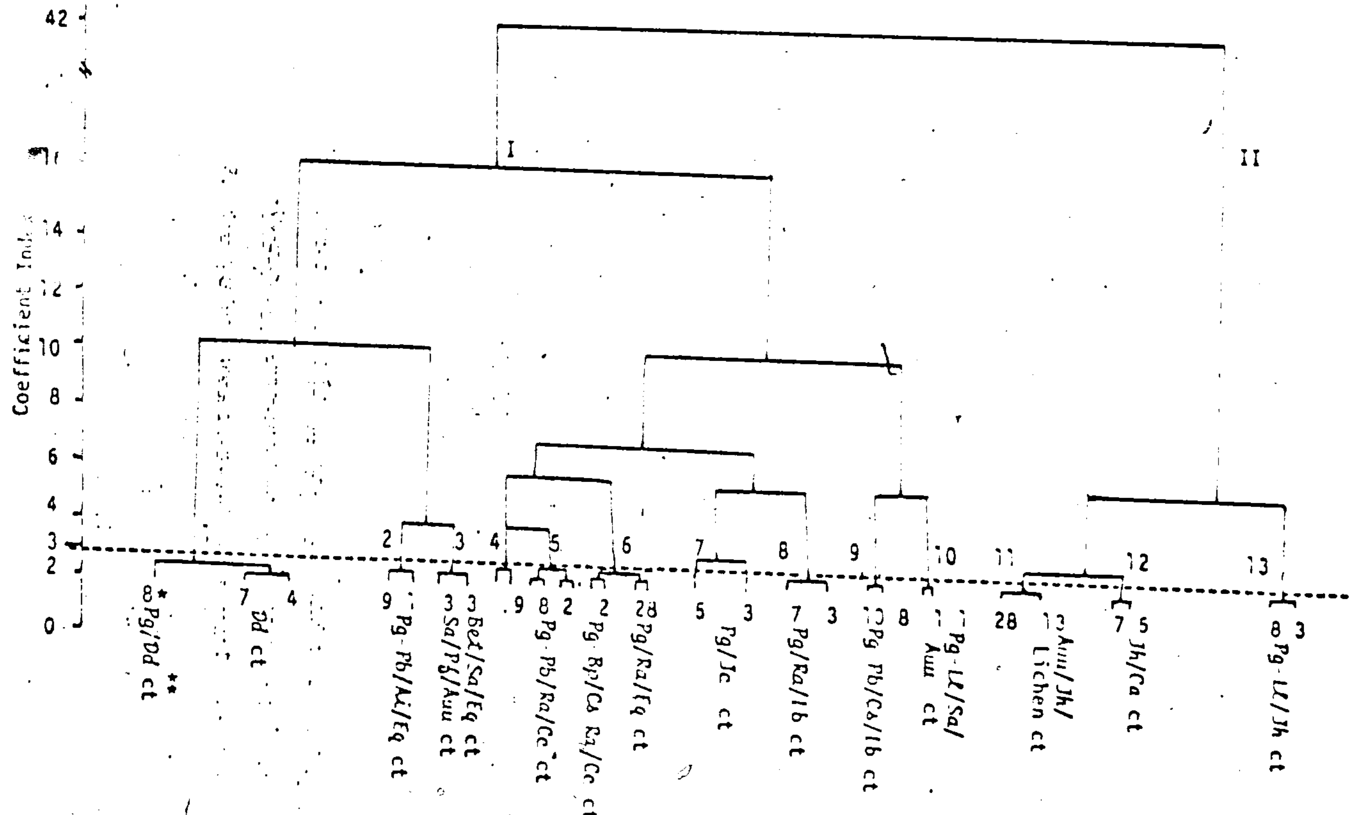


Fig. 24. Cluster dendrogram of Prairie Creek flora (*no. of quadrats; **abbreviations defined in Appendix 7).

The initial cluster division occurred at coefficient 40. This division was indicative of two compositionally distinct quadrat groupings.

One cluster was dominated by quadrats representative of two heath cts (Arctostaphylos uva-ursi/Juniperus horizontalis/ Lichen ct, J. horizontalis/Carex ct) and one woodland ct (Picea glauca-Larix laricina/J. horizontalis/Carex scirpoidea ct). A. uva-ursi and J. horizontalis occurred with the greatest frequency (100%) in all quadrats in this cluster. The quadrats were located on xeric to mesic sites with silt/sand over gravel depths ranging from 2 to 80 cm. All quadrat sites experience infrequent flooding.

The quadrats of the second cluster included Dryas drummondii dominated quadrats (Dryas drummondii ct. and P. glauca/D. drummondii ct), two scrub cts (Salix/Potentilla fruticosa/A. uva-ursi ct, Betula-Salix/Equisetum ct) and eight forest cts (P. glauca/ Rosa acicularis/Linnaea borealis ct, P. glauca/Juniperus communis ct, P. glauca/R. acicularis/Equisetum ct, P. glauca-Populus balsamifera/Alnus incana/Equisetum ct, P. glauca-Betula papyrifera/ Cornus stolonifera-R. acicularis/Cornus canadensis ct, P. glauca P. balsamifera/Rosa acicularis/C. canadensis ct and the P. glauca-L. laricina/Salix/A. uva-ursi ct.)(Fig. 24). The unifying features in this cluster were less distinct. Quadrats were representative of both frequently flooded and flood-free sites.

Community Types

Community types were grouped by structure into four units for discussion purposes: heath[5] (dwarf shrub), scrub, savannah/woodland and forest. These groups in addition to a barrens (<10% vegetation cover) were used in the cartographic display of plant communities on the fan (Map 1).

Quadrat data, general field knowledge and the results from the Clustan 1C program contributed to the designation and descriptions of each community type. Transitional quadrats (with characteristics common to other clusters) were present in most of the clusters, reflecting a weakness of classification methods. The transitional characteristics of these quadrats were not included when describing community types.

The heath communities occupy the largest area on Prairie Creek alluvial fan. They occur on Regosolic soils characterized by a shallow desiccated silt mantle over an extensive gravel basement in areas which largely escape the influence of the South Nahanni River. Extensive bare areas are present in these communities. Legumes, Carices and Composites are well represented. Terricolous lichens are common in the group. Bryophytes are less well represented, restricted to the moister crevasses on the desiccated surfaces.

The scrub communities were minor in terms of total areal coverage on the fan but significant in terms of successional processes. The Salix interior/Equisetum hyemale ct formed on the deep South

5. Heath - "a community usually occurring in cool climates, often dry, usually without trees and uncultivated, characterized by low shrubby plants mostly in the family Ericaceae", (Hanson 1962).

Nahanni shoreline silts.[6] Species composition consisted of those tolerant to annual inundation of flood waters and deposition of fine silts and sands. No soil development was observed. The other scrub communities were more diverse in terms of species composition and habitat characteristics. They occupied fan and river deposits; channels, channel bars, forest openings and edges; xeric and moist sites; flooded and flood free surfaces. Dwarf shrubs, Graminoids and Carices formed the low strata in these communities. Bare ground cover varied from 0 to 60% of the surface. Bryophytes and lichens were of minor significance in this group.

The savannah/woodland and forest communities were the predominant community types along the South Nahanni River, extending onto the fan where surficial silt depth permitted successful tree growth.

Community Descriptions

Heath Communities

Juniperus horizontalis, *Arctostaphylos uva-ursi* and *Dryas drummondii* are the most prominent species in the three heath communities: *Juniperus horizontalis*/*Carex* community type (ct), *Arctostaphylos uva-ursi*/*Juniperus horizontalis*/Lichen ct, and *Dryas drummondii* ct. These three diagnostic species are ubiquitous pioneer shrub species on exposed arid sandy and gravelly barrens in the montane regions of many western North American mountains (Hulten 1968; Hettinger *et al*. 1973) with the range of *J. horizontalis* and *A. uva-ursi* extending throughout the non-arctic regions of Canada. All three

6. Not included in the Clustan 1C program.

species root in one favorable locality and extend prostrate stems over less favorable sites.

The heath communities occur where calcareous sand, sandy loam and silty loam deposits range from 0 to 50 cm in depth, underlain by coarse gravel (.2 to 7.5 cm), cobbles (7.5 to 25 cm) and stones (25 to 60 cm). Precipitation rapidly percolates through these permeable coarse materials. The silty loams on the older surfaces have developed polygonal desiccation patterns where gravel is within 10 cm of the surface. Soil pH ranged from 7.6 to 8.5; carbonates were calculated as 78%.

The dwarf shrub structure (woody perennials <1 m in height) facilitates silt abrasion and desiccation of the plants from the prevailing NNW winds. Trees growing within the heath communities frequently displayed stunted growth, tip die back and candelabra growth form (Fig. 25).

Graminoides and Compositae occur in the Dryas drummondii ct, occurring on recently abandoned flood channels and in the frequently inundated Juniperus horizontalis/Carex ct. In contrast a xerophytic cryptogamic stratum, legumes and carices dominate the Arctostaphylos uva-ursi/J. horizontalis ct on the older abandoned channels and channel bars.

1. Dryas drummondii ct

The D. drummondii ct (Map 1) is frequent on both recently abandoned gravel channels and older xeric channel bar surfaces throughout the alluvial fan. Flood rafted material, sand and gravel splays, channel bedform patterns and the historic aerial photographic

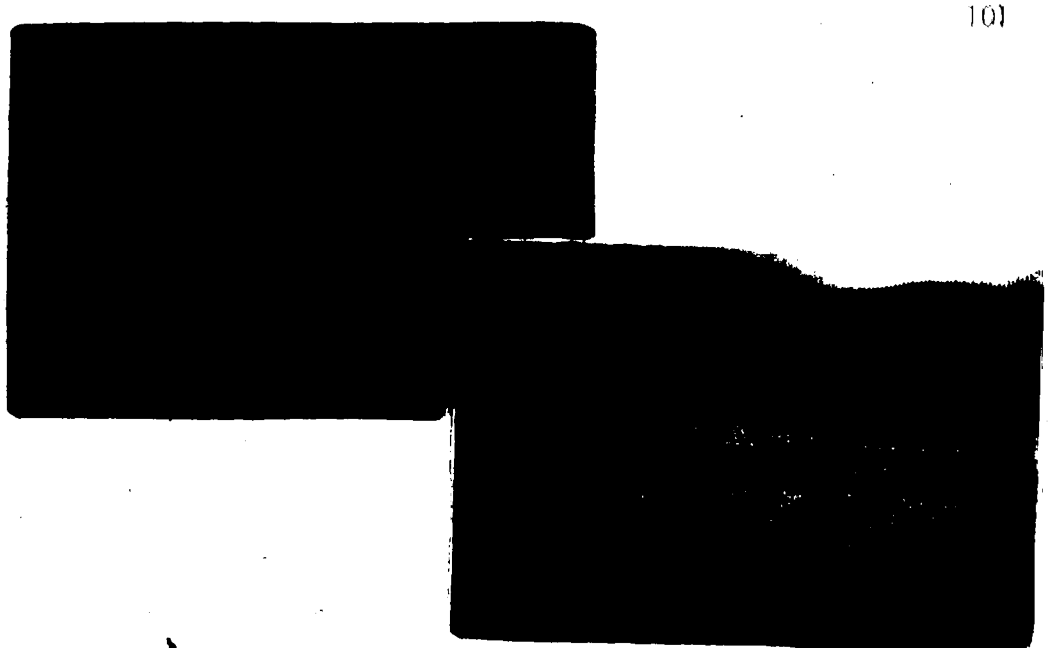


Fig. 25. *Picea glauca* frequently displayed stunted growth, tip die back, candelabra growth form, carpenter ant damage, flood and fire scarring.

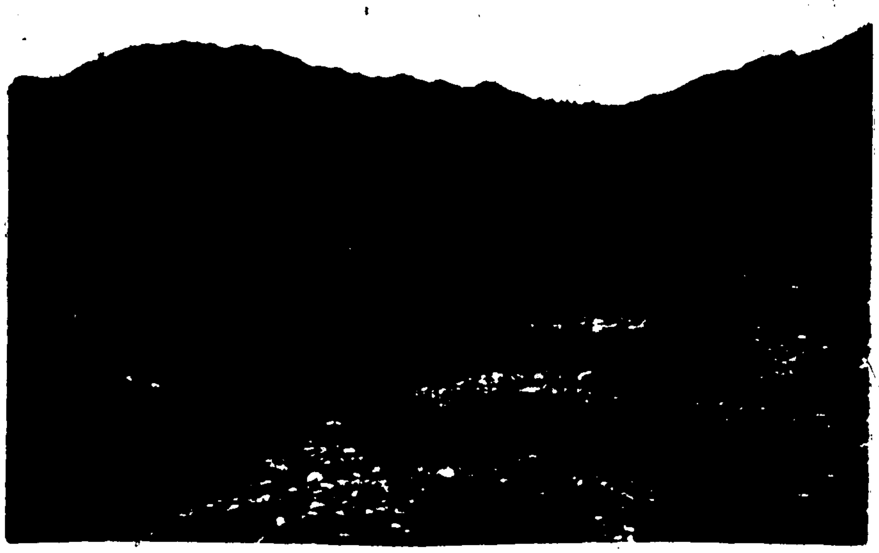


Fig. 26. *Dryas drummondii* community on abandoned terraces and stream beds, Prairie Creek fan.

COLOURED PICTURE

record provides evidence of former inundation by floodwaters on all of the sites. Surface gravels are characteristic of this ct.

The Dryas drummondii ct is distinguished by a dominance of D. drummondii (Fig. 26) which was recorded having a cover of 16 to 80% in the sample quadrats placed in this ct. Scattered Picea glauca, Larix laricina, Populus balsamifera and Betula papyrifera seedlings and saplings are associated with the Dryas (Table 14). Picea seedlings are locally abundant in the scour channel of the west fan.

Within these flood scoured gravel surfaces, floristic richness is relatively high (14 shrub, 20 herb species) with plants occurring as scattered individuals in samll silt and sand pockets. Potentilla fruticosa occurs most frequently followed by Solidago decumbens, Arctostaphylos uva-ursi and Carex scirpoidea. These vascular species are characteristic of disturbed xeric sites in boreal and montane areas of North America (Hultén 1968).

Lichens and bryophytes are sparse to absent (Appendix 6).

2. Arctostaphylos uva-ursi/Juniperus horizontalis/Lichen ct

The A. uva-ursi/J. horizontalis/Lichen ct has developed on the channel bars and terraces of Prairie Creek fan west of the current active channels (Map 1). Gravels lie close to the surface (2 to 50 cm, mean depth of 20 cm). A whitish grey carbonate precipitate mantles the desiccated surface silts and silt loams. In situe charred wood fragments provide evidence for past fires. The presence of a moderately diverse lichen mat (including Fulgensia bractaeta, Cetraria cuclata, C. nivalis, Cladonias and Thamnolias) reflect the

Table 14. Plant cover classes in the Dryas drummondii heath ct and the Picea glauca/D. drummondii savannah ct.

Species	*Dryas drummondii* heath ct											*Picea glauca/D. drummondii* savannah ct							
Quadrat No.	128	57	59	73	124	80	55	67	56	64	146	1	58	61	178	20	145	65	28
Dryas drummondii	3	4	4	5	3	5	6	5	5	3	3	1	2	2	4	3	4	1	3
Potentilla fruticosa	3	1	1	+	+	+	+		R		1	1	+	+	1	R	+		
Solidago decumbens	1	+	+	3	1	+	3	+	1	2	3	1	1	+	+	R	+	+	+
Picea glauca	1	+	+	3	1	+	3	+	1	2	3	1	1	1	+	3	+	1	1
Populus balsamifera	+	+	+	+	+	+	+	+	+	1	1	3	+	+	+	1	+	+	
Arctostaphylos uva-ursi	+	1	1		1	+	1	+	R			+	+		1				
Larix laricina	+		1		1			1		1		3	+	+					
Galium boreale	+		+	+	+			+		+	+				+			+	+
Carex scirpoidea	1	2			1		1	+	+	+	1			1	2		+	1	1
Antennaria pulcherrima	+		+									+		+	+	+	+		
Elymus innovatus	3	+			+			+			2	+	+						+
Senecio pauperculus	+	+		+					+		+		+	+		+			
Hedysarum mackenzii	+	+		+			+						+		+				
Carex filifolia								+		+		+	+		+				
Hedysarum alpinum	+	+		+							+						+	R	+
Juniperus horizontalis	+	+	+		+							4	2	+	+				
Aster sibiricus	+					+													
A. alpinus	+				+		+			+									
Betula occidentalis	+	1	+																
Cornus stolonifera	+	+	+						+										
Betula papyrifera		+		+			+	+		R									
Juniperus communis						+	+							+		R			
Carex eburnea		+	+		+														
Salix alaxensis				+				+			2		+						
Lesquerella arctica		+							+										R
Arnica alpina						+		+								+			
Erigeron compositus												+	+	+		+		+	
E. hyssopifolius												+	+		+	+	+		
Hieracium scabriusculum												+		+					+
Astragalus alpinus														+	+		+		
Oxytropis varians												+	+	+					
Antennaria densifolia												1		1	+	1		1	
A. campestris												1	1	+		+			
Rosa acicularis		+	+		+				1										
Salix interior					+														
Goodyera repens	+																		
Smilacina stellata	+	+	1																
Zygadenus elegans									+	+									
Braya humilis														+		+			
Alnus crispa												+	+						
Alnus incana				+				+											

Table 14. Continued.

Species	*Dryas drummondii* heath ct — Quadrat No. 128	57	59	73	124	60	55	67	56	64	146	*Picea glauca/D. drummondii* savannah ct — 1	58	61	178	20	145	65	28
Shepherdia canadensis												1							
S. pseudomonticola	+																		
Equisetum pratense						+													
Fragaria virginiana									+										
Carex aurea											+								
Pyrola asarifolia												+							
Salix arbusculoides						+		+											
Dryas integrifolia												+							1
Oxytropis splendens																			+
Betula glandulosa																			R
Agropyron trachycaulon																		+	
Epilobium latifolium																		+	
Descurainia sophioides														+					
Erigeron acris																			+
Carex concinna																R			
MOSS	+														+		+	+	1
LICHEN		+	1	1		1				+		1	+	1	+	+	+	1	3
BARE	4	3	3	3	4	4	4	5	3	4	3	+	1	1	1	2	3	3	1

absence of recent flooding (Crum 1976).

Three trees, 16 shrub and 62 herb species were recorded in quadrats sampling this community (Appendix 5). Arctostaphylos uva-ursi and Juniperus horizontalis occur with the highest quadrat frequency (100%) and account for the major plant cover in this community (Fig. 27). Carex filifolia and C. scirpoidea, Elymus innovatus, 22 species of Compositae and 7 legumes visually dominate the herb layer. Dryas drummondii is present where gravels are closer to the surface.

Picea glauca seedlings are locally abundant adjacent to seed trees which are widely scattered throughout this community. The seed trees are predominantly stunted (≤ 3 m).

A depauperate bryophyte cover has established in this ct with the greatest density in the moist crevasses of the desiccation cracks.

3. Juniperus horizontalis/Carex ct

This community type occurs on silt mantled channel bar surfaces located adjacent to the dry gravel drainage channels of the west fan and the north east fan (Fig. 27). Surface sands and silts vary from 25 to 50 cm (mean 40 cm) in depth. Banding of silt and sand layers was evident in areas close to the toe of the fan. Subsurface flow at 25 cm to 1 m depth was observed following major precipitation events and during spring melt. Wind blown deposits were evident in scattered pockets. Flood deposited coarse sands and silts and flood rafted debris were present in most quadrats placed in this ct. Shelf ice was observed to rest over much of this, melting in situe during

Table 15. Plant cover in the *Arctostaphylos uva-ursi*/*Juniperus horizontalis*/Lichen ct and the *J. horizontalis*/*Carex* ct.

Table 15. Plant species cover in the Arctostaphylos uva-ursi/Juniperus horizontalis/Lichen ct and the J. horizontalis/Carex ct.

Species	Arctostaphylos uva-ursi/Juniperus horizontalis/Lichen ct.																												
	Quadrat No.																												
	12	30	35	15	51	34	25	21	22	24	31	33	36	29	40	38	45	37	17	18	23	19	16	11	8	10	14	42	43
Arctostaphylos uva-ursi	4	4	2	2	2	3	4	4	3	4	4	1	4	1	4	4	2	4	4	+	+	1	+	1	1	1	2	1	3
Picea glauca	+	+	+	+	1	1	+	+	+	+	+		+	+	+		3	1	2	2	3	+	+				+	+	1
Juniperus communis	+		+	+	+	+	+	+	+	+	+		+	+			+	3	+	3	+	+		+	1	+	+		
Carex eburnea				+	+	+	+	+	+	+	+	+	+		+		+			+		+						+	+
Senecio pauperculus	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+			+			+	+	+	+		+
Carex filifolia	1	+	+	3	3	3	1	1	1	1	1	1	1	3	3		3	1	3	3	3	1					3	1	3
Juniperus horizontalis	+	1	+	2	+	1	+	+	2	+	1	+	1	+	1	+	1	1	+	+		+	3	1	+	1	2	1	1
Carex scirpoidea	1	1	2	1	1	2	1	1	2	1	1					2		+		1	+		+		1	2	1	1	1
Potentilla fruticosa	+		+		+	+	+	1	+	+		+	+		+	+	+		+		+		1	+	+	+	+	+	
Solidago decumbens				+	+		+		+	+		+			+					+	+	+			+		+	+	+
Elymus innovatus	+			+			+	+	+	+				+				+		+		+	+	1			+	+	+
Carex concinna		+		1		+		+	+		+				+					+		+	2				1		+
Alnus incana	+		▪					+	+							+													
Alnus crispa				1	+	+	+											+		+							+	+	
Shepherdia canadensis	+				+							+					+	+			+			+				+	+
Dryas drummondii	+	3	3	+	+	+	+	+		+	3	3	3	+	+	3	+	3	+	3	+		+				+	+	+
D. integrifolia				+	+			+		+			3		+	+	+			+								+	+
Oxytropis splendens		+	+		+		+	+	+		+			+	+		+	+			+		+	+			+	+	
O. varians	+	+		+		+																							
Carex membranacea	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+							
Lesquerella arctica			+		+		+		+	+		+	+		+	+	+	+		+	+					+			
Antennaria campestris	+		+		+		+		+				+			+		+			+				+		+		
A. pulcherrima	1		+	1	+			1			1			+	1		+		1				+		+		+		
A. densifolia	2	1	1	2	1			1	1		1			1	1	1	1		2	2				+	2	2	2		
Betula glandulosa	+	+	+				+	+					+				+	+											
B. pumila var. glandulifera	+			+		+							+					+		+		+		+		+	+	+	+
Aster sibiricus		+	+	+																+							+		
Aster alpinus				+	+	+	+	+	+	+	+		+	+								+					+	+	+
Betula occidentalis	+	+	+	1	+	+			+	+	+	+		+	+					+	+	+					+	+	+
Antennaria isolepis	+		+	+	+		+		+		+	+			+	+								+	+	+			
Arnica alpina			+	+	+		+	+		+	+					+		+					+	+	+	+			
Solidago canadensis	+					+		+		+						+								+	+	+			
Zygadenus elegans							+									+			+	+			+	+	+	+			
Rhododendron lapponicum																													
Cypripedium calceolus		+	+		+										+														
Danthonia intermedia		+	+		+	+						+																	
Aster ciliolatus																								+		+			
Aster pansus		+								+	+					+													
Erigeron compositus	+			+		+	+	+								+								+		+			
E. elatus																									+				
E. lonchophylos				+	+										+	+								+	+	+			
Senecio indecorus																+									+	+			
Tofieldia pusilla								+	+		+				+	+	+			+	+								
Artemesia frigida	+		+	+	+																								
Erigeron hyssipifolius			+			+	+			+	+	1	+	+			+	+											
Agrophyron trachycaulon									+		+		+							+									
Agrostis scabra																													
Pedicularis labradoricum									+	+		+				+													
Castilleja raupii	+			+				+									+						+						
Achillea lanulosa	1	+		+		+		+										+		+									
A. nigrescens																		+		+									
Anemone parviflora						+		+		+	+						+	+										+	
Rosa acicularis						+		+		+		+					+	+											
Fragaria virginiana																	+	+	+										
Smilacina stellata	+			+			+		+	+			+		+												+	+	
Lonicera dioica																													
Hedysarum mackenzii																							+						
Corydalis aurea	+		+		+																								
Crepis elegans							+	+		+		+																	
Cornus stolonifera																							4					+	
Geocaulon lividum																													+
Salix arbusculoides																							+					+	
Populus balsamifera							+				+																		
Cypripedium passerinum												+			+													+	+
Larix laricina																+	+												
Galium trifolium			+	+			+	+																					
Carex aurea	+																						+						
Linnaea borealis																													
Populus tremuloides																													
Cypripedium guttatum																													
Glyceria striata		+	+																										
Rorippa islandica																													
Parnassia montanensis																													
Saxifrage aizoides								+																					
S. tricuspidata	+																			+									
S. oppositifolia				+																						+	+		
Hieraclum scabriusculum						+		+					+	+															
Astragalus alpinus									+		+					+										+	+		
A. tenellus													+		+														
A. eucosmus													+				+												
Lathyrus ochroleucus																													
Primula stricta																													
Hordeum jubatum																													

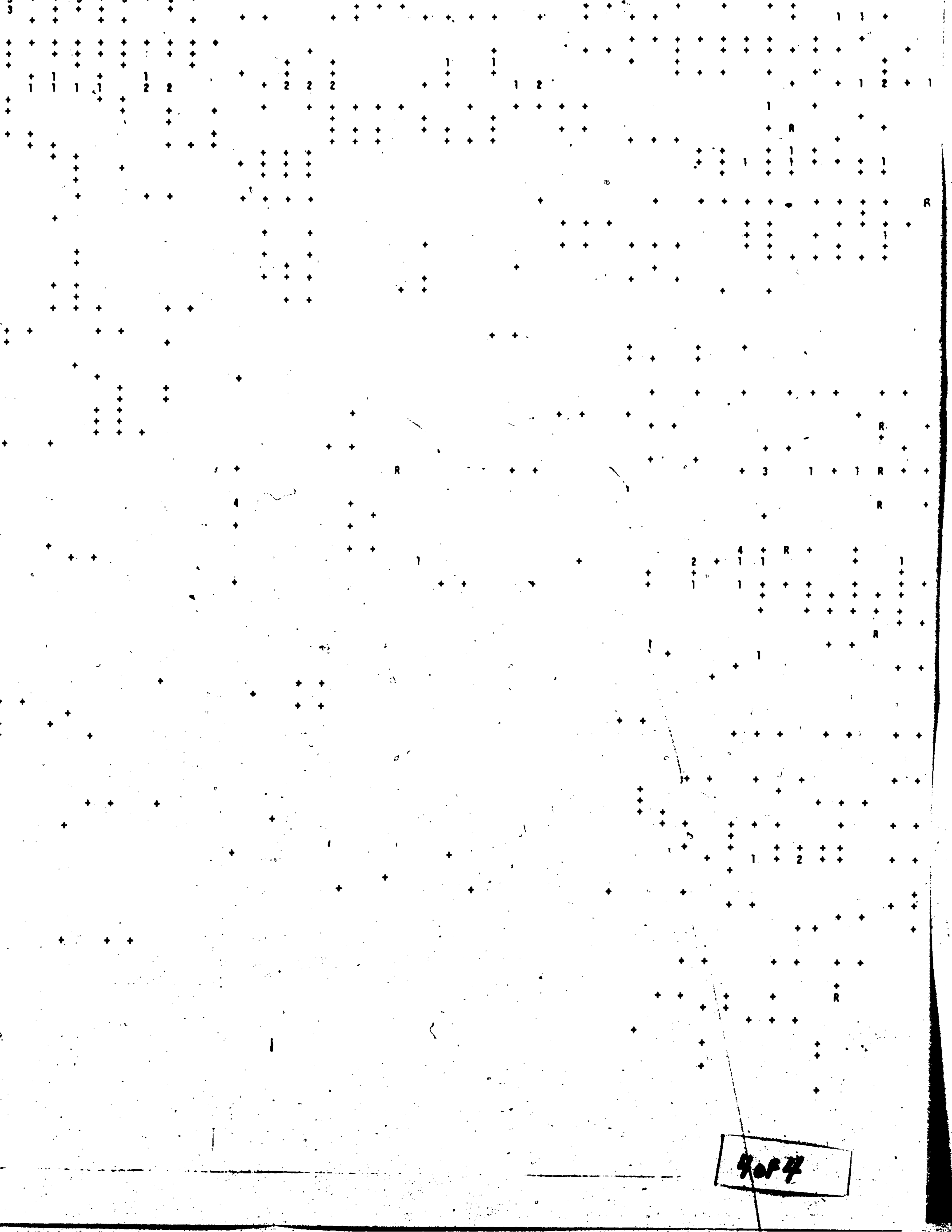
ostaphylos uva-ursi/
and the J. horizontalis/

/Lichen ct. — Juniperus horizontalis/Carex ct

3	36	29	40	38	45	37	17	18	23	19	16	11	8	10	14	42	43	66	26	27	44	32	13	7	50	46	39	41	47	52	3	6	49	68	4	5	136	164	172	2	9
	4	1	4	4	2	4	4	+	+	1	+	1	1	1	2	1	3	2	1	2	1	1	+	2	3	1	4	3	3	3		1	2	1	1	+	1	+	+	2	2
	+	+	+		3	1	2	2	3	+	+				+	+	1	1	+	+	+	+	1		+	+	+	+	+	+	1	3	+	1	+	+	+	+	1	+	+
	+	+			+	3	+	3	+	+		+	1	+	+			3	+	1		+	+	+	+		1	2	1	2	1	2		1	1	1	1	1	+	1	1
	+		+		+			+		+						+	+		+	+	+	+	+		+	+	+		+		+			+	+		1		+	1	
	+	+	+	+	+	+			+			+	+	+	+		+			+		+	+	+		+	+	+	+					+	+	+	+	+	+	+	+
	1	3	3		3	1	3	3	3	1					3	1	3		3	3	3	3	3	1	3	1	1	+	3	3			+								+
	1	+	1	+	1	1	+	+		+	3	1	+	1	2	1	1	2	1	2	4	+	+	2	1	1	1	4	4	4	3	3	4	4	4	3	3	2	2	2	3
				2		+		1	+		+		1	2	1	1	1	1	1		2			1		1	1	1	+	2	1	+	2	3	2	1	+	1	1	2	1
	+		+	+	+		+		+		1	+	+	+	+	+		+	+	+	+		+		+							2	+	1	1	2	2	1	1	+	1
			+					+	+	+			+		+	+	+							+	+	+			+			+	+		+	+		+	+	+	+
		+				+		+		+	+	1			+	+	+	+	+	+	+			+	+		+	1	1	+	+	2	2	2	+	1	3	2	2	2	2
			+					+		+	2				1		+				+			+				2	2	3	2		+	+	2	1	1	+	+		+
				+																												+	+						+		
						+		+							+	+			+								+	+	+	+											
					+	+			+			+				+	+	R			+				+	+	+				+			+		1	+				
	3	+	+	3	+	3	+	3	+		+				+	+	+	+	+	+	+	+		1	+	+	3	+	+	+		+		+	+	1	+	3		R	
	3		+	+	+			+								+	+	+								+	+			+		+		+	+						
		+	+		+	+			+		+	+			+	+			+	+	+	+		+		+		+	+						+		1	1	+		
	+	+	+	+	+	+	+	+	+	+																		+	+	+	+	+	+	+		+		+			
	+		+	+	+	+		+	+					+								+			+	+	+			+		+	+	+	+	+	+			+	
	+			+		+			+				+		+					1		1						+		+									+		
		+	1		+		1				+		+		+					+		+								+	+	+		+		+			+		
		1	1	1	1		2	2				+	2	2	2				+	+			1	2											+		+	1	2	+	1
	+				+	+																																			
	+					+		+		+		+		+	+	+	+	+			+		+	+	+	+								1		+					
								+							+				+			+																+			
	+	+								+					+	+	+		+	+		+			+	+								+	R				+		
		+	+					+	+	+					+	+	+			+	+	+						+	+	+							+				
			+	+								+	+	+																	+	+		+	1	+					
				+		+					+	+	+	+																	+	+	1	+	1	+	+	+	1		
				+								+	+	+																		+		+	+			+	+		
				+			+	+			+	+	+	+										+					+		+	+	+	+		+	+	+	+		R
																																						+			
			+																						+	+	+						+	+			+	+	+	+	
												+		+															+				+	+		+			1		
																			+						+	+		+	+	+			+	+			+		+		
				+								+		+																				+	+	+	+	+	+		
				+									+										+						+												
												+	+	+					+									+		+											
			+	+														+	+													+		+							
				+									+	+																											
			+	+	+			+	+																																
	+	+			+	+																+	+																		
	+							+																				+			+		+								
																												+	+		+										
				+																																					
					+						+																														
						+		+																					+		+		+		+	+	+		+	+	
						+		+																																	
					+	+										+									+	+		+										+			
					+	+																							+	+									R		+
					+	+	+																																+		
	+		+												+	+																		+	+					+	
																													+		+										
											+							R					+	+									+	3		1	+	1	R	+	+
											4					+																							R		+
																	+																	+							
											+					+																									
			+													+	+																+	+	R	+		+			
				+	+														1							+					2	+	1	1				+		1	
																													+		+									+	
											+									+	+			+					+		1		1	+	+	+		+		+	+
																																		+		+	+	+	+	+	
																																		+		+	+	+	+	+	
																																								+	+
																																							R		
																																					+	+			
																														+				1							
																																	+							+	+
								+																								+									
														+	+																										
												+																													
	+	+																																							
														+	+																										
				+																																					
																												+	+												
	+		+																																						
	+				+																												+	+	+		+	+		+	+

Dryas drummondii	+	3	3/	+	+	+	+	+		+	3	3	3	+	+	3	+	3	+	3	+		+				+	+		
D. integrifolia				+	+			+		+			3		+	+	+			+								+	+	
Oxytropis splendens		+	+		+		+	+	+		+			+	+		+	+			+		+	+			+	+		
O. varians	+	+		+		+																								
Carex membranacea	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+								
Lesquerella arctica			+		+		+		+	+		+	+		+	+	+	+		+	+					+				
Antennaria campestris	+		+		+		+		+				+			+		+			+				+		+			
A. pulcherrima	1		+	1	+			1			1			+	1		+		1				+		+		+			
A. densifolia	2	1	1	2	1			1	1		1			1	1	1	1		2	2				+	2	2	2			
Betula glandulosa	+	+	+				+	+					+				+	+												
B. pumila var. glandulifera	+			+		+							+					+		+		+		+		+	+	+	+	
Aster sibiricus		+	+	+																+							+			
Aster alpinus				+	+	+	+	+	+	+	+		+	+								+					+	+	+	
Betula occidentalis	+	+	+	1	+	+			+	+	+	+		+	+					+	+	+					+	+	+	
Antennaria isolepis	+		+	+	+		+		+		+	+			+	+								+	+	+				
Arnica alpina			+	+	+		+	+		+	+					+		+					+	+	+	+				
Solidago canadensis	+					+		+		+						+								+	+	+				
Zygadenus elegans							+									+			+	+										
Rhododendron lapponicum																							+	+	+	+				
Cypripedium calceolus		+	+		+										+															
Danthonia intermedia		+	+		+	+						+																		
Aster ciliolatus																								+		+				
Aster pansus		+								+	+					+														
Erigeron compositus	+			+		+	+	+								+								+		+				
E. elatus																									+					
E. lonchophyloos				+	+										+	+								+	+	+				
Senecio indecorus																+														
Tofieldia pusilla								+	+		+				+	+	+			+	+				+	+				
Artemesia frigida	+		+	+	+																									
Erigeron hyssipifolius			+			+	+			+	+	1	+	+			+	+												
Agrophyron trachycaulon									+		+		+							+										
Agrostis scabra																														
Pedicularis labradoricum									+	+		+				+														
Castilleja raupii	+			+				+									+						+							
Achillea lanulosa	1	+		+		+		+										+		+										
A. nigrescens																		+		+										
Anemone parviflora						+		+		+	+						+	+												
Rosa acicularis						+		+		+		+					+	+										+		
Fragaria virginiana																		+	+											
Smilacina stellata	+			+			+		+	+			+		+															
Lonicera dioica																											+	+		
Hedysarum mackenzii																														
Corydalis arurea	+		+		+																		+							
Crepis elegans							+	+		+		+																		
Cornus stolonifera																														
Geocaulon lividum																							4					+		
Salix arbusculoides																													+	
Populus balsamifera							+				+												+					+		
Cypripedium passerinum												+			+															
Larix laricina																+	+											+	+	
Galium trifolium			+	+			+	+																						
Carex aurea	+																						+							
Linnaea borealis																														
Populus tremuloides																														
Cypripedium guttatum																														
Glyceria striata		+	+																											
Rorippa islandica																														
Parnassia montanensis																														
Saxifrage azoides								+																						
S. tricuspidata	+																													
S. oppositifolia				+																+						+	+			
Hieracium scab[illegible]um						+		+																+						
Astragalus alp[illegible]													+	+												+	+			
A. tenellus									+		+					+														
A. eucosmus													+		+															
Lathyrus ochroleucus													+				+													
Primula stricta																														
Hordeum jubatum																														
Trisetum spicatum																														
Poa pratensis																														
Androsace chamaejasme																														
Gentiana acuta					+												+	+		+										
Bromus pumpellianus								+	+							+									+					
Hedysarum alpinum			+																											
Rubus strigosus																														
Orchis rotundifolia																							+							
Pyrola asarifolia																														
Calamagrostis canadensis																														+
C. neglecta																												+		
C. purpureus																														
Agropyron violacium																														
Lobelia kalmii																														
Campanula aurita																														
Fragaria virginiana																+		+	+											
Salix pseudomonticola																														
Parnassia palustris																														
Habenaria hyperborea																														
Goodyeara repens																														
Habenaria obtusata																														
Minuarti dawsonensis																														
Topfieldia glutinosa																														
Ledum groenlandicum							+																							
Equisetum variegatum																														
MOSS																														
LICHEN																														
BARE																														

3 OF



4 of 7

Fig. 27. Heath communities: (a) Arctostaphylos uva-ursi/Juniperus horizontalis/Lichen ct illustrating the desiccated surface (b) J. horizontalis/Carex ct.

the spring. The resulting water ponding contributes to lack of lichen growth in this ct.

Juniperus horizontalis, Carex scirpoidea and Elymus innovatus occurred in 100% of the quadrats with J. horizontalis contributing the major plant cover averaging between 26 to 50%. Cross sections of the Juniper revealed ages up to 88 yr .

Elymus innovatus is an opportunistic rhizomatus species frequently colonizing sandy soils in the western boreal and low montane zone of North America (Hultén 1968). Carex scirpoidea is a common sedge of moist arctic and boreal meadows Arctostaphylos uva-ursi, Potentilla fruticosa and Juniperus communis are important shrubs in terms of frequency and cover. These are common species on xeric and disturbed habitats in the boreal and montane regions of North America (Hulten 1968).

Three tree, 18 shrub and 67 herb species occur in this ct (Appendix 5, Table 15). The diversity of plant species is greater than in the A. uva-ursi/J. horizontalis/Lichen ct. Seventeen Compositae, 11 grasses, six carices and six orchids are noticeable components in this ct. The grasses and carices dominate the herb layer resulting in a grassland landscape.

Scrub Communities

Salices dominated the three scrub communities: Salix interior/Equisetum hymenale[7], Salix-Betula/Equisetum and Salix/Potentilla

7. This ct was not included in Cluster and Ordination analyses as the species composition was restricted to three species.

fruticosa/Arctostaphylos uva-ursi communities (Appendix 5, Table 16). Shrub birch are common in areas of shallow to moderately deep silts and exposed gravels. Salix interior is a frequent riparian shrub in the boreal forest; S. alaxensis is a common pioneer species on river alluvium, till deposits, subalpine shrub thickets and alpine tundra in northwestern North America and the Kenai Peninsula (Argus 1973). S. pseudomonticola is a common boreal forest species beneath Populus balsamifera canopies and along drainage channels in Picea glauca forests.

Equisetum is the most prominent member of the herbaceous forb stratum. Cryptogamic species are rare to absent.

The S. interior/E. hymenale ct occupies the deep silts along the South Nahanni River. The Betula/Salix/Equisetum ct occurs on moderately deep silts deposited by the South Nahanni River and Prairie Creek. The Salix/P. fruticosa/A. uva-ursi ct is associated with Prairie Creek gravels along the Picea glauca and Larix laricina dominated forests and on older abandoned drainage channels which bisect forest and heath communities.

1. Salix interior/Equisetum hymenale ct

S. interior is the most successful pioneer colonizer of the frequently flooded channel bars along the South Nahanni River (Fig. 28). This ct occurs at the toe of the east fan and at the base of the low ridge separating Prairie Creek from Dry Canyon (Map 1). S. interior successfully survives the addition of annual increments of silts and sands.

The soils are saturated during spring thaw and following major

Table 16. Plant cover classes in three scrub community types.

Species	Bet/Sa/Eq* ct			Sa/Pf/Auu* ct			Sa-i/Eq* ct		
	Quadrat No. 173	163	171	137	148	138	190	191	192
Betula glandulosa	2	1	2	2	1	1			
Salix alaxensis	2	1	2		3	1			
S. pseudomonticola	2	2	1			2			
Equisetum arvense	3	1	+		+	+			
Populus balsamifera	+	1	+	1	2	2			
Potentilla fruticosa	1	1	+	2	2	1			
Arctostaphylos uva-ursi	+		+	2	1	1			
Picea glauca			+	2			2	+	3
Salix arbusculoides	+			1	2	2			
Cornus stolonifera	1		1	2		+			
Carex scirpoidea	1	1	1	1					
Parnassia palustris			+	+	1	+			
Elymus innovatus	+	1	+	1					
Carex concinna			+	1	1	1			
Salix interior	+						3	5	4
Rosa acicularis			+	2	2				
Equisetum hymenale				+	+		3	1	1
E. variegatum	1	1				+			
Smilacina stellata	+			+	+				
Habenaria hyperborea			+	+		+			
Solidago decumbens			+	+		+			
Salix rigida					2	1			
Pinguicula vulgaris	+			+					
Equisetum pratense	+			+					
Achillea lanulosa					+	+			
Viburnum edule					1	1			
Juniperus horizontalis				1	+				
Galium boreale				+		+			
Hedysarum alpinum				+		+			
H. mackenzii				+	+				
Selaginella selaginoides	+	+							
Alnus incana	1	+							+
Dryas drummondii					+	1			
Betula pumila	1	1							
Calamagrostis canadensis	+	+							
Erigeron lonchophyllus			+						
Antennaria pulcherima				+	+				
Aster alpinus				+					
Juniperus communis				+					

Table 16 Continued.

Species	Bet/Sa/Eq* ct			Sa/Pf/Auu* ct			Sa-i/Eq* ct		
	Quadrat No. 173	163	171	137	148	138	190	191	192
Carex eburnea				+					
Senecio pauperculus				+					
Rubus strigosus					+				
Shepherdia canadensis					1				
Vaccinium uliginosum	+								
Gentiana acuta						+			
Eleagnus commutata						+			
Betula occidentalis	+								
Salix brachycarpa					+				
Fragaria virginiana					+				
MOSS	+						+	2	3
LICHEN					+				
BARE	3	3	3	2	2	2	6	6	5

*Bet/Sa/Eq=*Betula/Salix/Equisetum*; Sa/Pf/Auu= *Salix/Potentilla fruticosa/Arctostaphylos uva-ursi*; Sa-i/Eq=*Salix interior/Equisetum*.
Quadrats placed in the Sa-i/Eq ct were not included in the Cluster Analysis and the Ordinations.

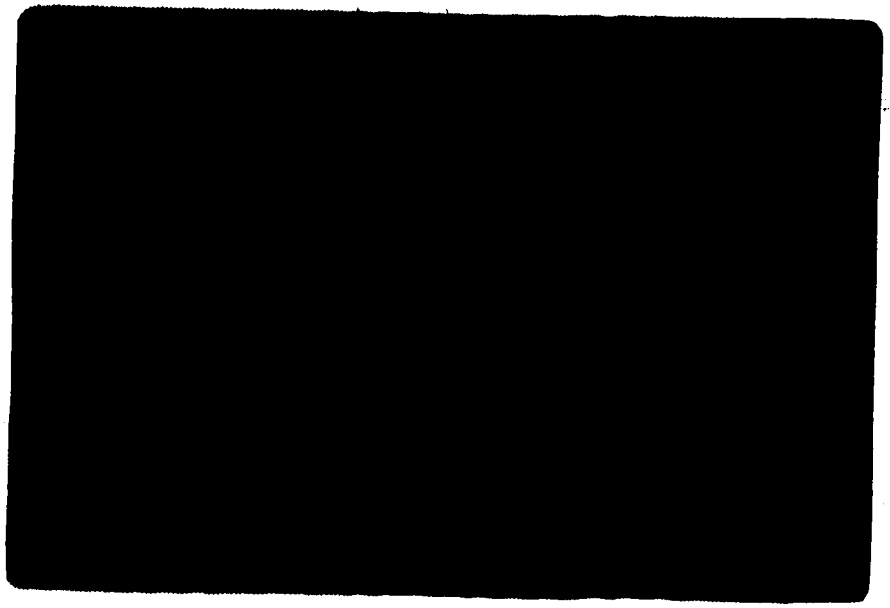


Fig. 28. Photograph along the toe of Prairie Creek fan of a <u>Salix interior</u> community type.

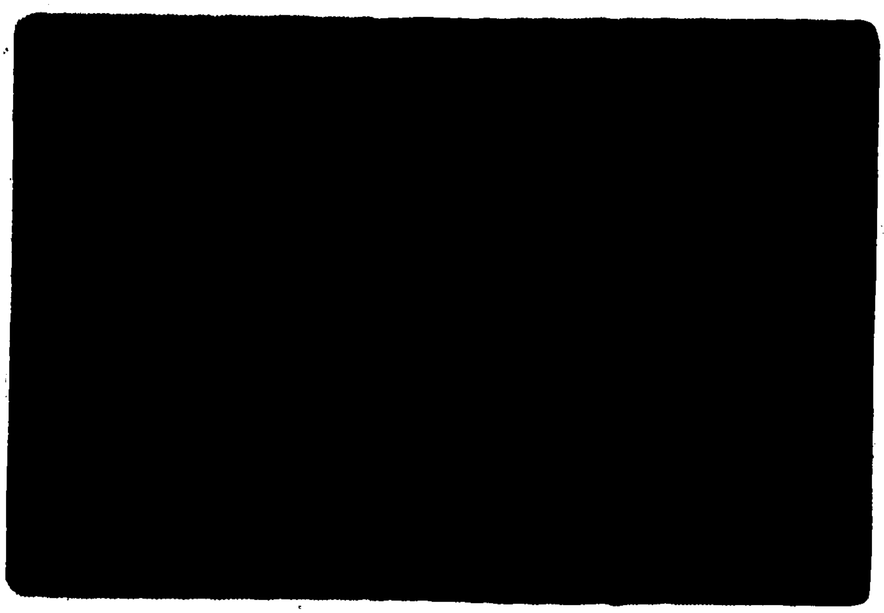


Fig. 29. Salix/Potentilla ruticosa/Arctostaphylos uva-ursi shrub community along the east fan.

COLOURED PICTURE

rainfall events. They remain moist throughout the summer drought period. Surface moisture is maintained by overbank flow, downslope and throughflow seepage.

Cryptogams are absent to sparse on these frequently flooded deep silts.

Salix interior extends to 4 m in height. Alnus incana was the only additional shrub successful in colonizing this frequently flooded environment. Individual alder reached a maximum height of 2.1 m. Their density increased with a decrease in flood intensity and frequency. Young Picea glauca seedlings and saplings were also present beneath the S. interior canopy. Seedlings showed no visible signs of stress, protected from desiccation by the shrub cover, and adapting the incremental silt deposition by developing an adventitous root system. Equisetum hymenale was the only herb component within this ct.

2. Betula/Salix/Equisetum ct

Salix alaxensis and S. pseudomonticola are the most prominent species in this ct forming a collective cover between 16 and 26% (Table 16; Map 1).

Both the South Nahanni River and Prairie Creek periodically inundate this ct during spring break up and during major flood events. Flood debris lay trapped at the base of willows and suspended up to .3 m in their branches.

Soil auger probing indicated greater than 1 m depth of fines over the gravel basement. This surface material was dominated by the silt fraction with local surface splays of coarse sand and gravel. A clay fraction contributed to the formation of a muck surface when saturated. The surficial silts were moist below 5 cm throughout the summer. Throughflow is thought to maintain this moist condition.

Willow and shrub birch occur in scattered clumps, with Salices extending to 3.2 m in height. Two tree species, 12 shrubs and 14 herbs occur in this ct. Populus balsamifera is the dominant tree seedling and sapling. Decadent spruce from 2 cm to 7 cm in height and dead leaders on young P. balsamifera (1.2 m in height) reflect stress.

Potentilla fruticosa is a primary component of the shrub layer. It occurs with a scattered distribution. Equisetum arvense and E. variegatum dominate the sparse forb layer with patches of Elymus innovatus and Carex scirpoidea occurring on slightly drier microsites. Cryptogams are rare to absent.

3. Salix/Potentilla fruticosa/Arctostaphylos uva-ursi ct

This ct occurs in the moist peripheral edge of the forests on Prairie Creek gravels and silts, and on abandoned channels bissecting forest communities (Fig. 29; Map 1). Emplaced flood rafted material is common, providing a good seed bed for the tree seedlings. The absence of lichens and abundance of bare surface silts or exposed gravel splays suggest that this ct is regularly inundated by flood waters. Soils are sandy to sandy loam in texture with depths extending from 10 to 50 cm to gravel. No buried organic horizons were uncovered.

The willow complex includes six species dominated by Salix arbusculoides. These deeper rooting shrubs are characteristic of moist habitat. Damp silts were encountered 10 cm below the surface. The Salices grew in scattered clumps.

Populus balsamifera and Picea glauca seedlings less than .6 m in height are very numerous (36 seedlings/100 m^2 but few survive to sapling stage. The surviving Picea glauca occur as widely scattered slow growing individuals (mean dbh increment of 5 cm over 120 yr).

The shrub component is represented by 17 species, the herb layer by 24 species, varying in composition from quadrat to quadrat (Appendix 5). Rosa acicularis, Cornus stolonifera and Viburnum edule are most common on abandoned channels bissecting forests. Shade tolerant herbs including Mertensia paniculata and Parnassia palustre cluster at the base of these scattered shrubs. P. palustre, Selaginella selaginoides, and Pinguicula vulgaris occupy local moist microsites of ground water discharge along the base of shallow terraces where shade is provided by the shrubs. Drier sites support opportunistic species including Arctostaphylos uva-ursi, Juniperus horizontalis, Dryas drummondii, a variety of composites, sedges and grasses. The cover of J. horizontalis and A. uva-ursi each vary from 1 to 5% with A. uva-ursi occurring with greater frequency in the sample quadrats. Patches of Dryas drummondii occur on gravel splays. Elymus innovatus and Carex concinna were the most prominent forbs.

Savannah/Woodland Communities

Two community types were classified as savannah/woodland communities: Picea glauca/Dryas drummondii ct and P. glauca-Larix laricina/Juniperus horizontalis/Carex scirpoidea ct. They are described below.

1. Picea glauca/Dryas drummondii ct

This savannah ct occurs on older abandoned channel bars where gravel lies between 2 to 40 cm (mean depth of 10 cm) below the surface. Red and black ant colonies are common. The average bare gravel/silt surface per quadrat ranged from 6 to 15%.

The scattered Picea glauca were often stunted, weakened by extensive carpenter ant chambers and tip die back (Fig. 25). Three tree species have successfully colonized this ct along with 10 shrub and 18 herb species (Appendix 5).

D. drummondii formed the dominant cover with patches of Juniperus horizontalis occurring in areas of deeper surface silts. The other eight shrub species are scattered throughout the ct. Five legumes, ten composit and three sedge species dominate the herb layer.

A xerophytic cryptogamic stratum including Cladonias, Fulgensia bracteata and Ceratodon purpureus occupied the desiccated surface.

2. Picea glauca-Larix laricina/Juniperus horizontalis/Carex scirpoidea ct

This woodland ct occurs at the interface between the South Nahanni River levee and the Prairie Creek fan gravels, and forms wooded islands among the Arctostaphylos uva-ursi/J. horizontalis/Lichen ct (Fig. 30). Evidence of fire (charred wood, ash, fire scars) was

Fig. 30. Photograph of a *Picea glauca-Larix laricina/Juniperus horizontalis/Carex scirpoidea* ct (S.E. corner of west fan).

observed in many of the sample quadrats. Butt swell on the trees is infrequent reflecting the past history of flood silt and sand deposition. Buried organic layers were uncovered in some quadrats. Flood channels marked by adjacent flood scarred trees and flood scours and sand splays run through this ct. Both Prairie Creek and the South Nahanni River floods contribute to the cyclic deposition-erosion processes in the western zone with Prairie Creek providing the origin of silt for the eastern fan components of this ct. Recent flood abrasion and deposition on the plants and surface scours and splays were observed in some quadrats. This included areas near the toe of the west fan and on the central island (Map 1). Silt and sand depths over gravel ranged from over one metre to two centimetres (mean 60 cm). Terraces were observed running parallel to adjacent channels.

Four trees, 20 shrub and 41 herb species were recorded in this ct (Appendix 5, Table 17). Tree density and age, and plant species composition in the quadrats representing this ct varied with location on the fan. Open to moderately dense stands of _Picea glauca_ and _Larix laricina_ with an average of 1440 stems/ha of _P. glauca_ and 740 stems/ha of _L. laricina_ , were recorded on the west fan sites. Sixty-eight percent of the stems are less than 10 cm dbh. The larger _P. glauca_ reach a maximum sampled age of 268 yrs at 31 cm dbh (Appendix 6). with depressed growth 104 to 110 yr B.P. The majority of _L. laricina_ over 150 yr of age are wholly or partially rotten from butt rot and are frequently infested with carpenter ants. Many are deformed with renewed or multiple leaders and twisted stems. Their boles

Table 17. Plant cover classes in the Picea glauca-Larix laricina/ Juniperus horizontalis/ Carex scirpoidea ct.

Species	Quadrat # 122	120	121	181	100			59	53	165	166
Arctostaphylos uva-ursi	1	2	2	3	1	1	1	2	3	3	2
Picea glauca	+	1	2	3	1	+	1	2	2	3	1
Larix laricina	+	+	1	1	2	1	+	1	+	1	1
Juniperus horizontalis	2	3	3	1	3	3	4	3	3	4	4
Carex scirpoidea	+	1	+	+	1	1	+	2	+	2	1
Rosa acicularis	1	1	1	1		+		+	1	1	1
Elymus innovatus	+	1	2		1		1	1		1	2
Carex concinna	+	2		+		+		1	1	1	1
Cornus stolonifera	1	1	1	1		1	1		2	1	+
Galium boreale		+	+				+	+	+	+	+
Potentilla fruticosa	1	1		1			1		1	1	1
Cypripedium passerinum	+			+	+		+	+	1	1	+
Carex filifolia			1	1	1	1	1	+	+	+	+
Pyrola assarifolia	+	+		+		+	1	+	+		+
Shepherdia canadensis		1		1			1	1	1	1	
Juniperus communis	1	1	+	1		1		1	1		
Carex eburnea	+	+		+				+	+	+	+
Senecio pauperculus		+		+					+	+	
Linnaea borealis	1	2	1	1				+	+		+
Fragaria virginiana		+	+					+	1	+	+
Smilacina stellata	+	+	+	+				+			
Hedysarum mackenzii		+	+						+	+	
Antennaria pulcherima	+	+	+	+							
Tofieldia pusilla	+	+			+	+			+		
Pyrola secunda	+			+		+	+	1			
Viburnum edule	+			1		1	1				
Geocaulon lividum	+			+			+	+			
Solidago decumbens		+			+		+	+	+		
Arctostaphylos rubra	1	+									
Salix alaxensis	1		1								
Salix pseudomonticola			+	+							
Parnassia palustris	+	+						+			
Aster alpinus		+		+							
Dryas drummondii		+							+		
Habenaria hyperborea							+				R
Alnus incana	+									1	
Ledum groelandicum		+	+								
Erigeron campestris	+					+					
Cornus canadensis				+							+
Equisetum pratense	+								+		
Rubus pubescens			1								
Tofieldia glutinosa	+	+									+
Betula papyrifera			2								
Salix interior		+									
Populus balsamifera				+							
MOSS	4	4	5	3	3	4	4	4	4	4	4
LICHEN	+	+	+	1	+	+	+			+	
BARE								+			

are frequently bent at the base in the direction of former flood flow.

Arctostaphylos uva-ursi, *Juniperus horizontalis* and *Linnaea borealis* were prominent in the shrub layer of this ct. *Rosa acicularis*, *Cornus stolonifera* and *Juniperus communis* were also common shrub species in sampled quadrats located on the west fan. Carices were prominent. A 26 to 75% bryophyte cover and a 16 to 50% lichen cover was characteristic.

Quadrats placed in the eastern fan *P. glauca/L. laricina/J. horizontalis/C. scirpoidea* ct were dominated by *L. laricina* growing on a shallow (40 cm) silt layer over fan gravels. An average of 4633 *L. laricina* stems per ha was calculated for this area. Mature *L. laricina* and *P. glauca* do not attain the height nor age of trees growing on the South Nahanni River levee. A maximum height of 12.6 m was recorded for a 146 yr old *P. glauca* in this ct. The success of young *L. laricina* beneath the upper canopy indicates that this species will continue to dominate the tree component of this ct in the near future.

A. uva-ursi, *J. horizontalis*, *Lonicera dioica*, and *Potentilla fruticosa* were characteristic shrub species. *Fragaria virginiana*, *Carex scirpoidea*, *Cypripedium passerinum* and *Aster ciliolatus* are the more frequently occurring forbs. *Elymus innovatus* was abundant where canopy was greatest.

The cryptogram cover was less in the eastern phases of this ct with a corresponding larger bare surface area.

Forest Communities

Eight major forest community types were sampled. Larix laricina, Populus balsamifera and Picea glauca represent the three major tree species in the forests.

L. laricina is associated with shallower silt deposits and more frequent flood events. P. balsamifera inhabit the damp deep silts along the South Nahanni River, the moist silts adjacent to upland slopes, and areas flooded by the activities of Castor castrensis. Mature P. glauca dominated forests are restricted to sites with moderate to deep silts, less frequent flood events and mesic conditions.

1. Picea glauca - Larix laricina/ Salix/ Arctostaphylos uva-ursi ct.

The P. glauca-Larix laricina/Salix/Arctostaphylos uva-ursi ct is dominated by L. laricina and P. glauca (Appendix 5). The roots of the P. glauca are embedded in thick silt deposits that frequently exceed 2 m in depth. The origin of much of this silt is the South Nahanni River. This ct is predominantly located on the east fan at the interface of the South Nahanni River silts and Prairie Creek deposits (Map 1). Evidence of recent flooding is infrequent.

L. laricina is a subdominant species within the ct with an average sampled density of 650 stems per ha, in contrast to the sampled density of 2560 stems per ha for P. glauca. P. glauca ranged up to 245 yr and 23 m in height; L. laricina extended to 16 m in height and ages up to 226 yr.

Regeneration and sapling success is generous as indicated in Appendix 5. S. alaxensis and S. pseudomonticola dominate the shrub

Table 18. Cover classes for species in the Picea glauca/Larix laricina/Salix/Arctostaphylos uva-ursi community type.

Species	143	140	142	147	144	126	125	168	141	160	159	87	134	127	155	167	175	123	157	135
Linnaea borealis	+			+	1	11	22	11	++	11	2 2	11	2		1	+	1	+		
Juniperus horizontalis	1		1	+			1	2	+	+	+	+	2	+	5	2	1	1	1	
Cornus stolonifera	+		+	3	+	+		1	1						1	1		+	1	
Geocaulon lividum	+		+			1	+	+		+	+	+		+	+	+	2	+		+
Pyrola asarifolia				+		+	+	+		+	+	1	+	+	+		+			+
Salix arbusculoides		+																		
Populus blasamifera		4		+	+		2	1	+						+					
Cypripedium passerinum	+		1			1	+	+	+	+	+			+			1	+		
Larix laricina			+	1	+		4				+	+	2	3	+	2		1	3	
Galium borealé		+	+	+						+		+						+	+	
Potentilla fruticosa	+	+	+	2	+	+	1	2	1	1	2	+	+		2	+	1	1	1	1
Solidago decumbens		+						+												
Elymus innovatus							+	2		+	+				+	+	4	1		
Carex concinna								+				+	+	2		+	1			+
Alnus incana							+		4	1	1						+			
Shepherdia canadensis							+	+						+	+	+				
Juniperus communis				1	1	+				1		1	1			1		3		
Carex eburnea						+	+	+			+	+		1	+		+	+		+
Rosa acicularis	+		+	1	1	2	1	+	1	2	1	+	2	1	+	1	+			+
Senecio pauperculus										+	+	+				+				
Anenome parviflora						+	+				+				+					
Arctostaphylos uva-ursi						+	1	2		1	4	1	+		1	1		1		3
Picea glauca	3		4	2		4	2	4	1		4	4	1	4	2	1				2
Betula papyrifera																				
Viburnum edule																				
Cornus canadensis																				
Pyrola secunda																				
Equisetum pratense																				
Rubus pubescens																				
Mitella nuda				+			+		+									+		
Fragaria virginiana	+					+	+	+		+		+	+	+	+			+		
Salix alaxensis		+		2				2						+			+	+		1
Equisetum arvense		4									+									
Salix pseudomonticola	+	2	+	1	1			2	+	+			+		1	+				
Parnassia palustris		+			+		+	+	+	+	+		+	1	+			+		
Habenaria hyperborea			1		+	+		+					+	+	+		+	+		
Carex scirpoidea		+	+	+									+	+						
Arctostaphylos rubra	2		1		1		+		+	2		+		1	+	+				
Antennaria pulcherrima						+	+	+					+	+	+			+		+
Tofieldia pusilla			+		+		+	+					+	+	+	+		2		
T. glutinosa					+	2							+	+	+					
Salix interior						1							+				+			
Orchis rotundifolia					+						+		+	+			+			
Goodyera repens					1	1	+						+			+				
Ledum groenlandicum					+				+	2	+				+					2
Equisetum variegatum			+		+				4					+	+		1	+		
Pinguicula vulgaris													+		+	1	+	1		
Actaea rubra				1	1							+						1		
Betula glandulosa			+	1							+									
Smilacina stellata												+	+					+		
Hedysarum mackenzii											+									
Betula pumila																			2	
Aster alpinus								+									+	+		
Betula occidentalis			1	1	1															
Dryas drummondii																		+		
Carex filifolia															+				+	+
Salix planifolia			+															+		
Equisetum palustris		+																		
Zygadenus elegans																		+		
Danthonia intermedia																		+		
Alnus incana																		+		
Anenome multifida				+																
Calamagrostis neglecta				1																
C. canadensis				+																
Gentiana acuta					+															

Table 18 Continued

Species	Quadrat No. 143	140	142	147	144	126	125	168	141	160	159	87	134	127	155	167	175	123	157	135
Eriophorum scheuchzeri																				
Carex saxatilis												+						1+		
MOSS	3	1	2	2	2	2	2	2	2	2	2	2	2	4	3	4	3	4	2	2
LICHEN	+	+	+	+	+	+	1	1	1	1	1	1	+	+	+	+	+	1	1	+
BARE	1	1	1	+	+	+						+	+				1		+	+

cover beneath the tree canopy. Rosa acicularis and Linnaea borealis, two boreal forest shrub species are also common in this ct. The drier more open sites support mats of Arctostaphylos uva-ursi, scattered Potentilla fruticosa, Elymus innovatus and Fragaria virginiana.

2. Picea glauca/Juniperus communis ct

The P. glauca/J. communis ct occupies deep (2m) very well drained alluvial deposits on both the east and west fan. It occurs on the South Nahanni River levee (Map 1). Flooding is a frequent influence as evidenced by unconsolidated surficial silt splays on the surface. Severe bank erosion from flood waters has exposed roots and toppled trees where the community occurs along the South Nahanni River shoreline A high frequency of sand lenses is visible in the Cumulic Regosolic soils in this ct. Shoreline seepage occurs along the gravel/sand interface.

The P. glauca/J. communis ct is an open forest of tall spruce (mean height of 25 m) with an average density of 1560 stems per ha (Appendix 6). Trees ranged in age up to 240 yrs. The boles of the trees are frequently buried up to 60 cm, Many remain standing long after death. Clumps of saplings survive within the deadfall pockets.

Sixteen shrubs dominated by J. communis, Linnaea borealis and patches of Rosa acicularis were recorded in this ct. Cornus stolonifera was a frequent but less prominent species in the sampled quadrats. Thirty-three forbs formed the forb layer. Equisetum arvense and sedges are dominant in this layer (Appendix 5, Table 19). Bryophytes and lichens are few to moderate. Unvegetated sand and silt splays are scattered among this ct.

Table 19. Plant cover classes in the Picea glauca/Juniperus communis and the P. glauca/Rosa acicularis/Linnaea borealis cts.

Species	*Picea glauca/Juniperus communis* Quadrat No.							*Picea glauca/Rosa acicularis/Linnaea borealis*										
	86	103	107	101	96	99	105	97	82	77	80	110	81	76	92	131	108	132
Linnaea borealis	3	2	3	2	2	1	2	2	5	1	1		3	+	+	+		+
Juniperus communis	+		+	1	4	2	3	2	2	1	2	1	2	4	3	3	3	3
Picea glauca (<2m)	+	1	4	4	2	1	1	+	2	1	+		+	1	2	2	2	2
Rosa acicularis	+	1	+	+	+	+	4	+	1	1	1	1		3	3	2	1	3
Shepherdia canadensis	3	+	2		1	2	2	+	+	+	+		+	+	+		+	
Carex concinna	1	+	+	+	+	+		+		+	+		1	1	1			+
Viburnum edule	1	1	1		1	+	+	+	+					+	1	+		
Cornus canadensis	1	1	1	1	1	1	1	1						+	+			
Equisetum arvense								+	+	1	+	+	1	1	+	1	1	+
Salix pseudomonticola	1	+	+		+	+	1	+										+
Cornus stolonifera	+	+	+	+	+	+	1	+	+	+	+		+	1	+	+	+	+
Nitella nuda			+		+	1		+		+	+	+						
Carex eburnea		+		+	1	1								+	+			+
Arctostaphylos uva-ursa				1			+	+			+			+	+	+		+
A. rubra	+	+		+	+	+								+	+			
Lonicera dioica	+			+			+		+						+	+		
Geocaulon lividum			+	+		1	1	+							+	+		
Pyrola asarifolia					+	+	+	+							+	+	2	+
Habenaria hyperborea	+	+	+	+	+			+	+	+	1	+	+					
Juniperus horizontalis			+		+								+	R	+	+	1	
Pyrola secunda			+		+								+	+	+	+	+	
Salix arbusculoides	R		+			+								R		+		
Populus balsamifera			+		R		+	R	+	+					+	+		+
Cypripedium passerinum			+			+		+							+		+	+
Larix laricina					1			+	+					1				
Aster ciliolatus										+		+		+		+		+
Goodyera repens								+	+		+	+	+					
Pyrola chlorantha	+		+	+	+		+											
Equisetum pratense	—		+			+		+		+								+
Galium boreale	+		+		+													+
Potentilla fruticosa						R		R						1	+	+		+
Elymus innovatus						+		+		+				+				+
Erigeron hyssopifolius			+	+					+	+	+		+					
Carex scirpoidea							+	+		+								
Antennaria pulcherima				+	+											+		+
Orchis rotundifolia				+	+		+										+	
Betula glanduloca	+			+								+						
Smilacina stellata			+		+											+		+
Ledum groenlandicum	+	+		+		+												
Alnus incana		+	+								+		+					
Rubus pubescens	+		+			+		+										
Anemone parviflora	+	+			+			+										
Zygadenus elegans					+	+								R		+		
Fragaria virginiana					+										+			+
Parnassia palustris								+		+								+
Carex aurea	+		+	+														
Equisetum scirpoidea	+				+													
Salix bebbiana	R	+																
Agropyron trachycaulon				+	+													
Carex capillaris							+	+										
Empetrum nigrum					+		+											
Hedysarum mackenzii					+			+										
Calamagrostis neglecta						+		+										
Solidago decumbens										+	+							
Senecio pauperculus					+													+
Pinguicula vulagris																+		+
Ledum groenlandicum																+		+
Habenaria obtusata	+																	
Gentiana acuta	+																	
Selaginella selaginoides								+										
Tofieldia pusilla				+														
Equisetum variegatum												+						
Dathonia intermedia														+				
Bromus pumpellianus														+				
Arnica alpina														1				
Aster sibiricus														+				
Carex filifolia																+		
Mertensia paniculata															+			
Salix myrtillifolia		+																
Amelanchier alnifolia	R																	
Vacinium uligmocum					+													
Salix alaxensis		R																
Solidago canadensis					R													
MOSS	6	6	5	6	5	6	6	6	3	2	1	+	+	2	3	3	2	2
LICHEN	+	1	+	+	+	2	+	+						+		+		
BARE									+	+	+	1	+	1	+	+	1	+

3. Picea glauca/Rosa acicularis/Linnaea borealis ct

This community (Fig. 31) has extensive representation on well drained mesic alluvial deposits on both the east and west fan. All of the sampled quadrats possessed indications of historical flooding in the soil profile record; most were fire stands. The survival and build-up of a moderately thick feathermoss ground cover suggests a recent flood-free history. Total silt depths ranged from 60 cm to over 2 m.

P. glauca is the most prominent member of this ct with a mean quadrat density ranging from 725 stems per ha to 6700 stems per ha. Tree ages ranged from 120 to 350 yr (Appendix 6). Larix laricina is a common younger associate occurring at low mean stand densities of 25 to 280 stems per ha. Populus balsamifera is a less frequent and older component in this P. glauca dominated community. Fallen and decaying P. balsamifera boles provide evidence for a change in dominance in most of the quadrats.

An open to moderately closed forest canopy permits the success of a diversified shrub component including 22 sun and shade tolerant species. Rosa acicularis displays a marked dominance exceeding the cover and frequency of other shrubs. Juniperus communis is also a prominent member of this component (Table 19).

Linnaea borealis is the most abundant dwarf shrub. Cornus canadensis with an average cover ranging from 1 to 5% and Carex concinna occurred in all sampled quadrats in this ct. Hylocomium splendens, Pleurozium schreberi and Ptilium cristacastrensis are common bryophyte components. The lichen Peltigera canina is an

Fig. 31. Photograph of a mature Picea glauca/Rosa acicularis/Linnaea borealis community forming a band along the South Nahanni River levee.

infrequent component in the ground cover.

4. Populus balsamifera-Picea glauca/Alnus incana/Equisetum ct

This ct occurs on mesic sand, silty loam and silty clay loam deposits interspersed with buried litter layers. Moisture is maintained through sub-surface flow. Drainage is poor, restricted by a hardpan layer and an increased clay fraction with depth. Silt accumulation has buried the root collar of the dominant mature *P. balsamifera* and the sub-dominant *P. glauca* trees.

Geographically this ct is located in linear bands along the South Nahanni River levee and on abandoned channel bars (Map 1).

The *P. balsamifera/P. glauca/A. incana/Equisetum* ct consists of closed canopies of 150 yr old trees ranging in density from 4000 to 28500 stems per ha. Openings supporting *P. glauca* within the 1 to 4 cm diameter class are frequent. Mean diameter of trees sampled was 13 cm; mean height was 14.8 m for *P. balsamifera*. The density of *P. glauca* ranged from 1050 to 2050 stems per ha with mean heights of 12 m and mean diameters of 35 cm (Appendix 6). Tree density decreases towards the central portions of the communities associated with extensive deadfall. This could be detected on photographs produced by density slicing (Fig. 32). These patches of deadfall, caused by root rot were associated with increased shrub cover. Burl damage was observed in some quadrats, thought to be a reflection of frost damage.

Three tree species, 17 shrub and 27 herb species were recorded in sample quadrats representative of this ct (Appendix 5, Table 20).

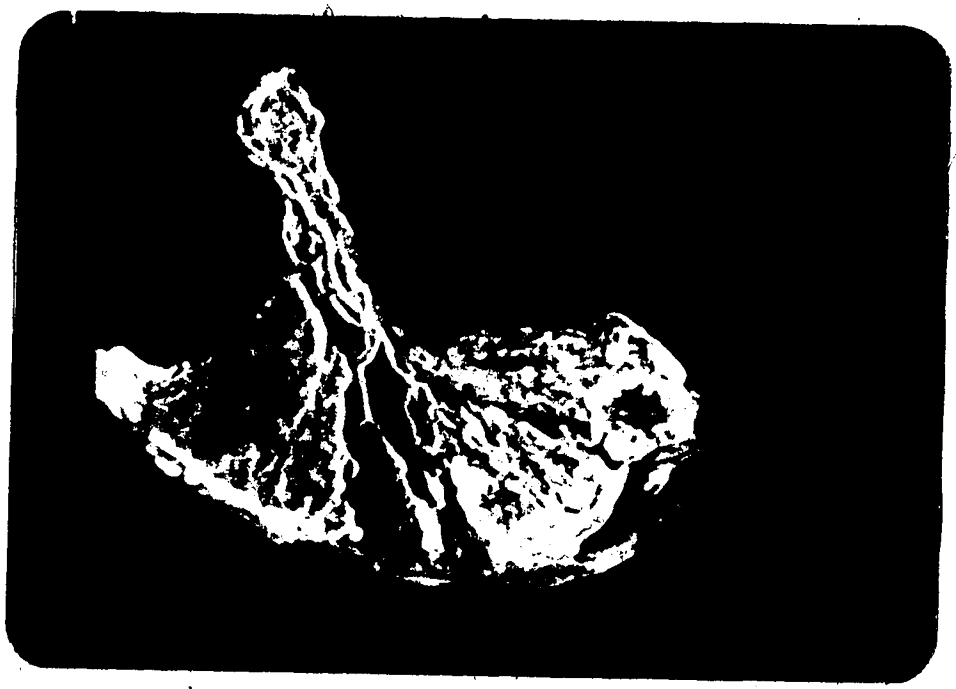


Fig. 32. Density slicing of an aerial photograph of the fan illustrates density of forest cover on the fan. The dense levee forests are displayed in white; dwarf shrub communities appear orange and exposed gravel appears black.

Table 20. Plant cover classes in the Populus balsamifera-Picea gluaca/Alnus incana/Equisetum ct.

Species	Quadrat No. 113	111	91	98	109	83	85	93	102	104
Pyrola secunda	1	+	+					2		
Mitella nuda								+		
Equisetam arvense				3	4	2				
Salix pseudomonticola				2	+			+		
Habenaria hyperborea			+							
Carex scirpoidea									1	1
Arctostaphylos rubra								+		
Orchis rotundifolia						+				
Ledum groenlandicum			+							
Equisetum variegatum						2				
Hedysarum mackenzii							+			
Dryas drummondii						+				
Salix myrtillifolia				1						
Rosa acicularis	+	+	+	1		+				
Linnaea borealis	1	2	+			+		2	1	1
Juniperus horizontalis								+		
Cornus stolonifera				1	1	3				
Geocaulon lividum	1	+	+			+	+	+		
Salix arbusculoides					+	2				
Populus balsamifera			+	+	+	1	+	1		
Cupripedium passerinum							+			
Laris laricina								+		
Galium boreale	+	+				+	+			
Solidago decumbens	1	1	+			1	+	1	+	+
Elymus innovatus						1	+			
Carex concinna								+		
Shepherdia canadensis			+							
Juniperus communis	1	1	+			+		1		
Carex eburnea		2								
Senecio pauperculus	+		1		1	+	2	4	4	
Arctostaphylos uva-ursi							+			
Picea glauca		2	+		1	1		1		
Equisetum hyemale					+					
MOSS	3	3	3	3	3	4	4	4	3	3
LICHEN	+				+				+	
BARE	2	1		+		+		+		+

The tree seedling component is sparse, largely restricted to a few scattered Populus balsamifera and Picea glauca. Alnus incana is the most successful tall shrub followed by mature Salix pseudomonticola and Cornus stolonifera. Prominent associates in the forb layer include Equisetum (E. arvense and E. pratense) and sedges. Parnassia palustre and Ledum groenlandicum are infrequent in moist depressions. Potentilla fruticosa, Solidago decumbens and S. canadensis, Senecio pauperculus, and Elymus innovatus occur on drier slopes of the fluvial deposits. Litter cover is high.

5. Picea glauca/Rosa acicularis/Equisetum pratense ct.

The P. glauca/R. acicularis/E. pratense ct (Fig. 33) is the most extensive forest community type on the south-east fan. They occur on poor to moderately drained alluvial silt and silty-clay loam deposits arranged in alternating horizons with buried L-H layers (Map 1).

Below a thin feathermoss carpet, 20 cm of sandy silt has been deposited over a thick well preserved layer of feathermoss. This pattern duplicates observations on the south shore flood plain of the South Nahanni River (Scotter and Henry 1977). A large amount of South Nahanni River debris provides evidence for the partial origin of localized deep silt and sand deposits. It also occupies areas dissected by recent and antecedent broad and narrow vegetated distributaries indicating its origin within the active alluvial fan. The community type is free from annual flood water scouring, although the stand boundaries are frequently abandoned fluvial channels.

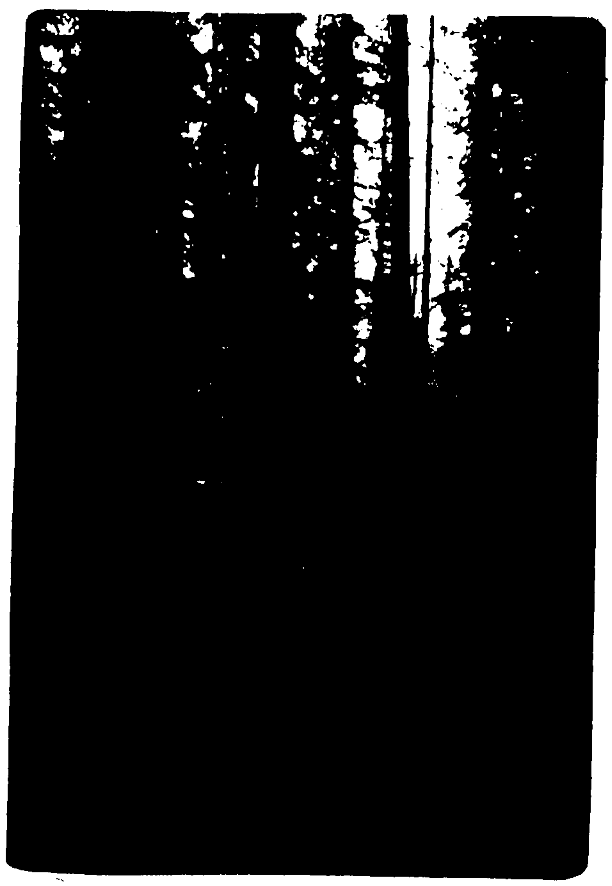


Fig. 33. Photograph of the *Picea glauca/Rosa acicularis/Equisetum* community type.

Light sheet flow and backwater siltation is visible in a number of the stands. Picea glauca up to 140 yrs of age (Appendix 6) and 28 m in height form the dominant overstory. The presence of butt-swell shown by the P. glauca indicates that their establishment and growth has occurred on a stabilized surface. A decrease in annual ring size is evident in recent years throughout the stands.

The average number of stems per ha for P. glauca and P. balsamifera was estimated at 1080 and 140 respectively. Total basal area for the stands averages 26.8 m^2/ha; maximum contribution was from the larger diameter trees. Pockets of younger P. glauca (65 y of age) occur in canopy openings with successful younger regeneration occurring beneath the canopy. Decadent Populus balsamifera up to 47 cm in diameter remain standing in some areas above a forest floor strewn with poplar deadfall.

Twenty-eight herb, 17 shrub and the seedlings of four tree species were recorded for this ct. Picea glauca accounted for the most prominent tree regeneration (Appendix 5).

Rosa acicularis dominated the shrub layer with a mean average cover between 6 and 15% (Table 21) with patches of Juniperus communis occurring locally. Equisetum pratence is the most prominent herb. Cornus canadensis contributed less in total cover but was widespread throughout. Pockets of orchids (Cypripedium sp., Goodyera repens, Habenaria hyperborea, H. obtusata and Orchis rotundifolia) occurred locally, reflecting variation in topography and soil.

Table 21. Plant species cover classes in the Picea glauca/Rosa acicularis/Equisetum ct and the Picea glauca-Betula papyrifera/Cornus stolonifera-Rosa acicularis/Cornus canadensis (Pg-Bp/Cs-Ra/Cc) cts.

Species	P. glauca/R. acicularis/Equisetum Quadrat No. 115	118	116	88	133	117	114	79	106	78	Pg-Bp/Cs-Ra/Cc 62	54
Equisetum pratense	4	6	6		2	4						
Rubus pubescens	4	+	+			2					+	
Rosa acicularis	4	1	1		2	2	+		+	1	1	
Linnaea borealis		+				1	2		+			
Juniperus horizontalis						1	+		+			
Cornus stolonifera	1	+	+		+	1					+	
Geocaulon lividum	+	+	+		+	+						
Pyrola asarifolia		+	+				+			+	+	
Salix arbusculoides						1				4	+	1
Populus balsamifera	2					+						+
Cypripedium passerinum			+							+		
Larix laricina							1			2		
Galium boreale											+	
Solidago decumbens									+			
Elymus innovatus								+	1			
Carex concinna								+				
Alnus incana						1					+	
Shepherdia canadensis								+				
Juniperus communis						1	5	1	+	+		
Carex eburnea						+						
Arctostaphylos uva-ursi							+					
Picea glauca		4	4		4		2		+	+	1	+
Festuca altaica											+	
Actaea rubra										+		
Hedysarum alpinum							+					
Mertensia paniculata				+							1	1
Alnus incana										+		
Pyrola secunda					+	+			2		2	
Cornus canadensis				+		1				+	6	
Viburnum edule					+	1	+			+	+	
Betula papyrifera											4	
Mitella nuda						+					+	
Fragaria virginiana						+					+	
Salix alaxensis						+						3
Parnassia palustris							1			+		
Habenaria hyperborea							1					
Carex scirpoidea						+		+				
Arctostaphylos rubra							+	+	+			
Tofieldia glutinosa								+				
Salix interior	1											
Orchis rotundifolia			+									
Ledum groenlandicum										+		
Equisetum variegatum												+
Erigeron hyssopifolius								+				
Smilacina stellata	+			+								
Dryas drummondii							+					
Viola sp.										R		
Salix myrtillifolia										+		
Calamagrostis canadensis												+
Equisetum arvense					1							+
Salix pseudomonticola						1			+	+		2
MOSS	5	4	4	4	4	4	4	4	4	4	5	5
LICHEN	+	+	+	+	+	+	+	+	+	+	+	+
BARE												

6. Picea glauca-Betula papyrifera/Cornus stolonifera-Rosa acicularis/ Cornus canadensis community type.

The P. glauca-B. papyrifera/C. stolonifera-R. acicularis/ C. canadensis ct occupies an upper Prairie Creek terrace adjacent to the steep slope of the Nahanni Plateau (Map 1). Seepage from the slope, a dense bryophyte mat and closed forest canopy, maintains a moist herb layer and damp soil solum. Silt and buried L-H layers beneath the feathermoss, indicate past flood burial of a vegetated surface. Deciduous leaf litter was visible among the buried organics. Gravel lay .5 m below the present duff surface. Buried charcoal and fire scars support the classification of the community as a fire stand.

Scattered Picea glauca accompany birch in the overstory. Tall Salix arbuscula, Cornus stolonifera, and Viburnum edule dominate the shrub layer (Appendix 5, Table 21). A nearly continuous cover of Cornus canadensis dominates the herb stratum. Deciduous leaf litter is abundant.

7. Picea glauca-Populus balsamifera/Rosa acicularis/Cornus canadensis ct

Three geographically separated locations (Map 1) are dominated by this community type:

1. along the toe of the west fan
2. at the base of the NW fan lake sediments
3. at the foot of the NE slope

Underground through-flow was observed within or adjacent to all three sites with the NW and NE sites receiving subsurface seepage from the adjacent slopes. Depth to gravel ranged from 10 cm to 1 m A history of periodic flooding is evident within each stand in the form of silt stockings on the boles of trees, scarred trunks, flood debris lodged around their base, barren silt splays. Cumulic Regosols of buried sand, silty loam and duff material suggest a history of anastomosis or periodic overbank flow followed by continuous flood-free periods. Buried duff material is dominated by deciduous leaves and Equisetum, reflecting a former moist soil climate. Topographic depressions (up to .7 m in depth of former channels) remain visible within this ct.

Picea glauca are dominant in the canopy and understory within the ct. Standing dead, fallen and decadent Populus balsamifera serve as a legacy of their former success (Fig. 34). Twenty to 30% of the P. balsamifera canopy is decadent. Stand density ranges from 2200 to 5000 trees per hectare with heights rising to 25 m. Large annual growth rings were recorded in extracted cores indicative of the absence of moisture stress.

Numerous Picea glauca seedlings and saplings have successfully colonized the open forests. Of the 21 shrubs Cornus stolonifera, Arctostaphylos uva-ursi, and Juniperus horizontalis account for the largest cover. Cornus canadensis, Smilacina stellata and Carex scirpoidea are the most frequent herbs in the 44 species herb layer (Appendix 5). Species composition in this layer varied from quadrat to quadrat (Table 22). An average of 26 to 50%

Fig. 34. Photograph of the Picea glauca-Populus balsamifera/ Rosa acicularis/Cornus canadensis community type.

Table 22. Plant cover classes in the Picea glauca-Populus balsamifera/Cornus stolonifera/Linnaea borealis ct and the Picea glauca-Populus balsamifera/Rosa acicularis/Cornus canadensis ct.

P. balsamifera/C. stolonifera/L. borealis ct.

Species	70	71	180	150	84	48	156	74	177	149	179	182	161	162
Picea glauca	3	+	3	1	+	1	+	2	3	1	1	3	3	3
Cornus stolonifera	1	4	1	3		+	1	2	2	2	2	2	2	1
Rosa acicularis	+	+	+	1		1		1	1				1	1
Viburnum edule			+			+		R						
Linnaea borealis	1	+	+	+	+	1	1	1	1	1	1	+	+	+
Populus balsamifera	+	+	+	1		R					+	+	2	1
Elymus innovatus			+	+	+		+				+		1	+
Carex concinna		+	+	+				+			1	1		
Cornus canadensis	+	+					+							
Potentilla fruticosa	+	+				+	2	+			1		1	2
Solidago decumbens				+		+			+	+			+	+
Alnus incana	+	2		+		2		2	2					
Arctostaphylos uva-ursi	1	1	+	+	+	1		3	2	1	2	1	+	2
Shepherdia canadensis		+		+		R								1
Juniperus communis				1	+	+					1	1	+	
Juniperus horizontalis	3	4				4	1	2		1	+		1	1
Geocaulon lividum	+			+				1	2					
Pyrola secunda														
Cypripedium passerinum	+	+	+							2				
Galium boreale						+		+			+		+	
Salix alaxensis							+						+	
S. pseudomonticola							+					+		
Parnassia palustris	+				+					+		+	R	
Equisetum arvense					1			+	+			R	1	1
E. pratense	+	+	+	+			+		+					
Pyrola asarifolia		+				+			+					
Carex eburnea		+		+				+						+
Senecio pauperculus	+					+							R	R
Anemone parviflora							R						+	
Betula occidentalis						+				+	+		R	
Salix arbusculoides						+								
Equisetum variegatum							+							
Mitella nuda					+									
Fragaria virginiana	+					+	+		+				R	+
Betula papyrifera						R		+	1					
Larix laricina	1					1	+				+			
Lonicera dioica							+		+					
Arctostaphylos rubra											+	+		
Achillea lanulosa							+			+				
Moneses uniflora									+		+			

P. glauca-P. bals[illegible] *C. canadensis* ct.

Species	176	158	75	[illegible]	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Picea glauca	3	3	+	3	3	3	3	[illegible]	3	1
Cornus stolonifera	+	+		+	+	2	+	2	2	2
Rosa acicularis	1	+		+	+	+		+		
Viburnum edule	+	+	+	+	1	1				
Linnaea borealis	5	1	1	1	[illegible]	+	1		4	
Populus balsamifera	+	1				+				+
Elymus innovatus			+			+		R		+
Carex concinna	+		+	+	+	+	+		1	
Cornus canadensis	1	+	+	1	1	+	1	1	1	1
Potentilla fruticosa		+				1	+	1	2	
Solidago decumbens			+					+		+
Alnus incana	2	2	1	3	2	1	2	2	1	
Arctostaphylos uva-ursi	+		+			+				
Shepherdia canadensis	+									
Juniperus communis	+		2						+	
Juniperus horizontalis										
Geocaulon lividum										
Pyrola secunda				+						
Cypripedium passerinum			+						+	
Galium boreale	+			R	R					
Salix alaxensis									1	3
S. pseudomonticola			+					1	1	2
Parnassia palustris	+	+	+			+				R
Equisetum arvense	1		+			+				+
E. pratense	+					R	1			
Pyrola asarifolia	+	+				+	+			
Carex eburnea							+		+	
Senecio pauperculus										
Anemone parviflora	+	+								
Betula occidentalis										
Salix arbusculoides		2				+				1
Equisetum variegatum										+
Mitella nuda										2
Fragaria virginiana										
Betula papyrifera						1				
Larix laricina	1									
Lonicera dioica							R			
Arctostaphylos rubra										
Achillea lanulosa						+				
Moneses uniflora										

Species	72	63	154	152	170	130	151	112	153
Picea glauca	1	1	3	3	1	1	2	2	2
Cornus stolonifera	4	1	+	+	1	1	1	1	1
Rosa acicularis	2	1	1	+	1			4	3
Viburnum edule	+	1	+	+	1			+	1
Linnaea borealis		+	1					+	
Populus balsamifera	1	3	+	+				+	3
Elymus innovatus	+								
Carex concinna	+			+	+	+			+
Cornus canadensis	+	1	1	1	+	1	+	1	1
Potentilla fruticosa									
Solidago decumbens	+								
Alnus incana	+							2	
Arctostaphylos uva-ursi	2							+	
Shepherdia canadensis	+	+	+					2	
Juniperus communis	+							3	
Juniperus horizontalis									
Geocaulon lividum		+	+		+			1	
Pyrola secunda			+	+	+	+			+
Cypripedium passerinum	+		+	+	+				
Galium boreale									
Salix alaxensis	+								
S. pseudomonticola									
Parnassia palustris			+	+		1			+
Equisetum arvense			1	+	+	+			
E. pratense			+		+				
Pyrola asarifolia		+	+	+		+			
Carex eburnea	+		+						
Senecio pauperculus	+								
Anemone parviflora									
Betula occidentalis							+		
Salix arbusculoides	+		+		1				
Equisetum variegatum									
Mitella nuda			+						
Fragaria virginiana	+								
Betula papyrifera									
Larix laricina									
Lonicera dioica	+			+					
Arctostaphylos rubra									
Achillea lanulosa									
Moneses uniflora									

Table 22. Continued

Species	*P. glauca/ P. balsamifera/C. stolonifera/L. borealis* ct.														*P. glauca-P. balsamifera/R. acicularis/ Cornus canadensis* ct.																		
Quadrat No.	70	71	180	150	84	48	156	74	177	149	179	182	161	162	176	158	75	89	90	129	169	174	183	139	72	63	154	152	170	130	151	112	153
Actaea rubra							+									+		+	+														
Carex scirpoides	+		+			+		+		1			R	+																			
C. filifolia							+				1	2							+														
Smilacina stellata		+	+				+	+	+		+		+	+						+									+				
Salix bebbiana		+		+		+																				+			+		+		
Agropyron trachycaulon		1		+		+		+			+															+							
Erigeron elatus					+	+	+	+																									
Elaeagnus commutata		+			+		2																			+							
Zygadenus elegans		+						1																	+								
Aster alpinus					+					+	+		R		+																		
Dryas drummondii								1	+		+			+												+	+					+	
Hedysarum alpinum											+		+	+												+	+		+				
Solidago canadensis													+	+												+							
Erigeron lonchophyllus										+			R	+																			+
Rubus pubescens															+			+	+				+										
Antennaria pulcherrima															+					+	R				2								
Orchis rotundifolia										+																							
Pinguicula vulgaris													+																				
Hedysarum mackenzii			+						+					+																			
Habenaria hyperborea					+					+							+							+	+								
Goodyera repens								+																	+								
Oryzopsis pungens								+																	+								
Antennaria isolepis						+																											
Viola sp.						+																											
Hieracium scabriusculum		+																															
Ribes oxyacanthoides		+																															
Dryas integrifolia					+																												
Tofieldia pusilla							+																										
T. glutinosa							+																			+							
Erigeron hyssopifolius				+																													
Danthonia intermedia								+																									
Arnica alpina		+																															
Castilleja Raupii																																	
Thalictrum alpinum																																	
Ledum groenlandicum																	+																
Cypripedium calceolus																																	
Gentiana acuta																									+								
Carex aurea																									+								
Equisetum hyemale																									R								
MOSS	3	4	3	4	4	3	2	4	5	2	3	4	4	3	3	4	3	2	3	4	4	4	3	4	3	4	5	4	3	4	3	3	3
LICHEN	1		1			1		1	1		2			+		+	+		+	3	+		1	+	+	+	+	+		+		5	
BARE		+		+		R		2	2	1	+														+	+							

bryophyte mat was recorded for this ct. Much of it occurred on decaying logs and around the base of Populus balsamifera.

8. Picea glauca-Populus balsamifera/Cornus stolonifera/Linnaea borealis ct

A mature P. glauca-P. balsamifera/C. stolonifera/L. borealis community occupies a raised terrace near the fan head. A series of buried litter, silt and sand lenses form a cumulic regosolic soil beneath a 10 to 12 cm litter layer. Depth to gravel exceeds 1m. There is no evidence of recent flood water inundation.

Populus balsamifera accounts for 75% of the forest canopy, Picea glauca 16% and Larix laricina 9%. No signs of decadence were observed in the P. balsamifera crowns. All species were identified within the sapling and seedling layers although P. glauca seedlings up to 10 cm were dominant. Fire scars were observed on the L. laricina but no cross-sections for dating the event were removed.

Beneath the 20 m deciduous forest canopy, a dense shrub layer forms scattered pockets. Drought tolerant Shepherdia canadensis occurs along the forest edge, with a 30% cover of Cornus stolonifera and Viburnum edule associating with Rosa acicularis in the stand interior. Linnaea borealis, P. balsamifera and P. glauca seedlings, and Cornus canadensis are the most prominent species in the dwarf shrub/herb strata. Ten species of herbs were recorded for this stand with an average of 3 species/$1m^2$.

Litter occupies 50% of the forest floor reflecting the deciduous nature of the canopy. Hylocomium splendens and Peltigera canina are the most prominent species among the abundant bryophyte and sparse lichen component.

Ordination

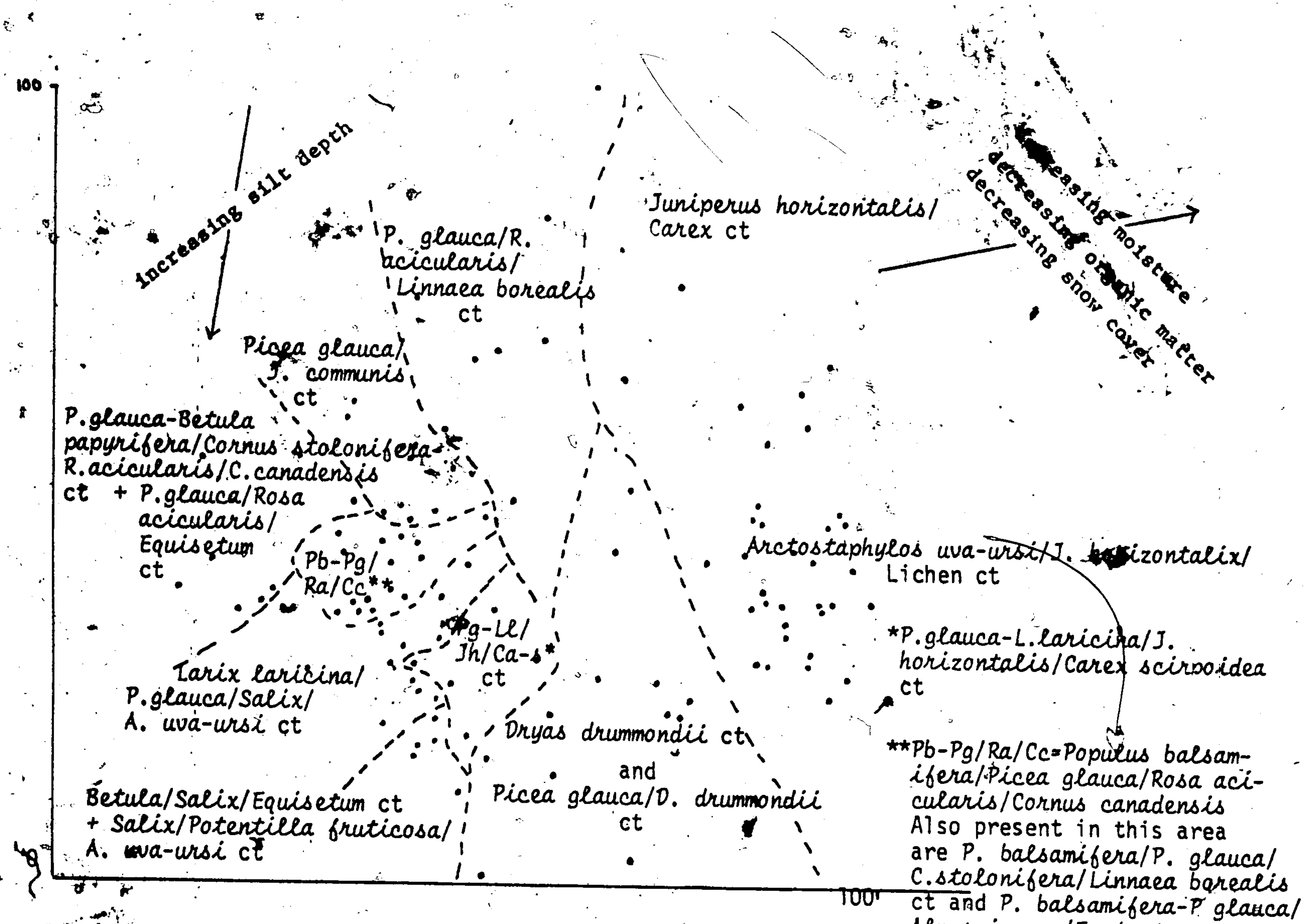
Bray-Curtis and Reciprocal Averaging indirect ordinations yielded similar patterning of plots along two axes when the same end points were selected. A narrow field of distribution was provided by Reciprocal Averaging along the y-axis and by Bray-Curtis ordination along the x-axis. For illustrative purposes the presentation used end points selected by Reciprocal Averaging for presentation of ordinated quadrats along the x-axis. Two centrally located quadrats along this axis were selected as end points in a Bray Curtis ordination along the y-axis.

Quadrats representing the heath communities were concentrated on the right-hand side of the two-dimensional ordination field. Forested quadrats were distributed across the left-hand portion of the ordination field. Quadrats within community types or groups of community types derived from Cluster Analysis were delineated on the ordination field (Fig. 35).

The arrangement of community types along the x-axis corresponds to a number of parallel gradients: 1. decreasing moisture 2. decreasing organic matter 3. decreasing snow cover 4. increasing exposure (to wind, blowing sand and snow) and desiccation stress 5. increasing pH.

A less distinct gradient of increasing silt depth is represented along the y-axis.

There is not a clear linear succession gradient. However, quadrats representing pioneer heath communities tend to occur



*P. glauca-L. laricina/J. horizontalis/Carex scirpoidea ct

**Pb-Pg/Ra/Cc=Populus balsamifera/Picea glauca/Rosa acicularis/Cornus canadensis
Also present in this area are P. balsamifera/P. glauca/ C. stolonifera/Linnaea borealis ct and P. balsamifera-P. glauca/ Alnus incana/Equisetum ct

Fig. 35. Ordination of Prairie Creek fan plant communities denoting environmental trends

in the lower right portion of the ordination field and quadrats representing mature climax forest communities cluster in the left half of the field.

The environmental gradients and successional trends are reflected in species response patterns as well as community type response. These response patterns graphically approximate the ecological amplitude for these species on the fan. Character vascular species from the major community types were selected from a differential table of the 183 100 m^2 quadrats and their cover values graphically presented on the same ordination field as the community types (Fig. 36).

Three character vascular species were chosen from the heath communities: Senecio pauperculis, Betula occidentalis, and Dryas drummondii. These species were all restricted to areas where gravel was within 30 cm of the surface. The opportunistic composite species, Senecio pauperculis, is restricted to the upper right portion of the ordination field similar to the heath communities and the Picea glauca/Alnus incana/Equisetum ct. In the field it was present on gravel stream beds and pockets of silt. The pioneering dwarf shrub, Dryas drummondii, is clustered in the lower right portion of the ordination field corresponding to the heath communities. D. drummondii was dominant on bare gravel bars and abandoned stream beds where both inundation and moisture stress are prevalent.

Betula occidentalis is a characteristic member of both the heath

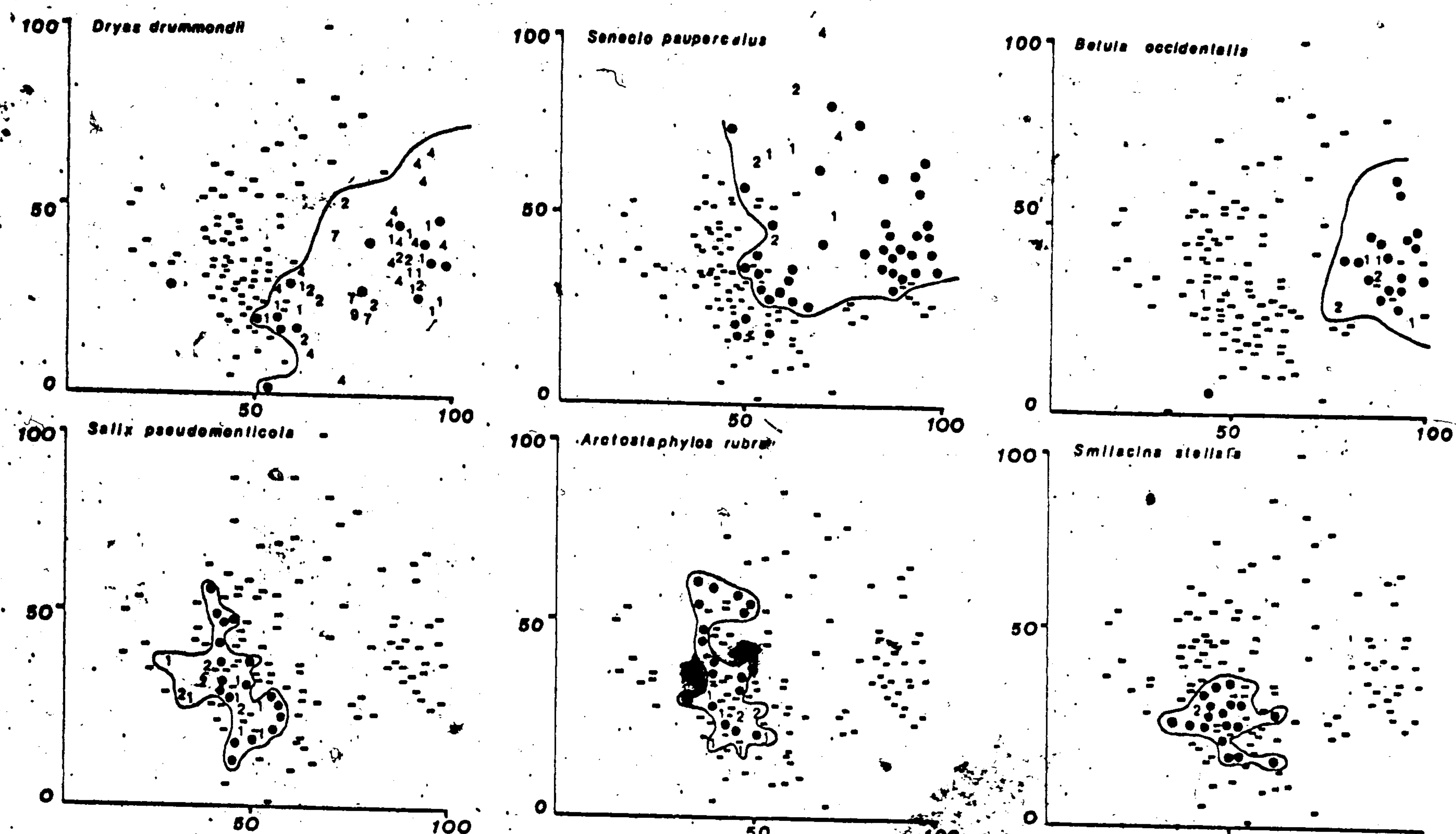


Fig. 36. Percent cover (Braun-Blanquet indices) of character species on the ordination field. D.drummondii, S.pauperculus, B.occidentalis are character species for the heath cts; S.pseudomonticola, A.rubra, and S.stellata are characteristic of scrub ct.)

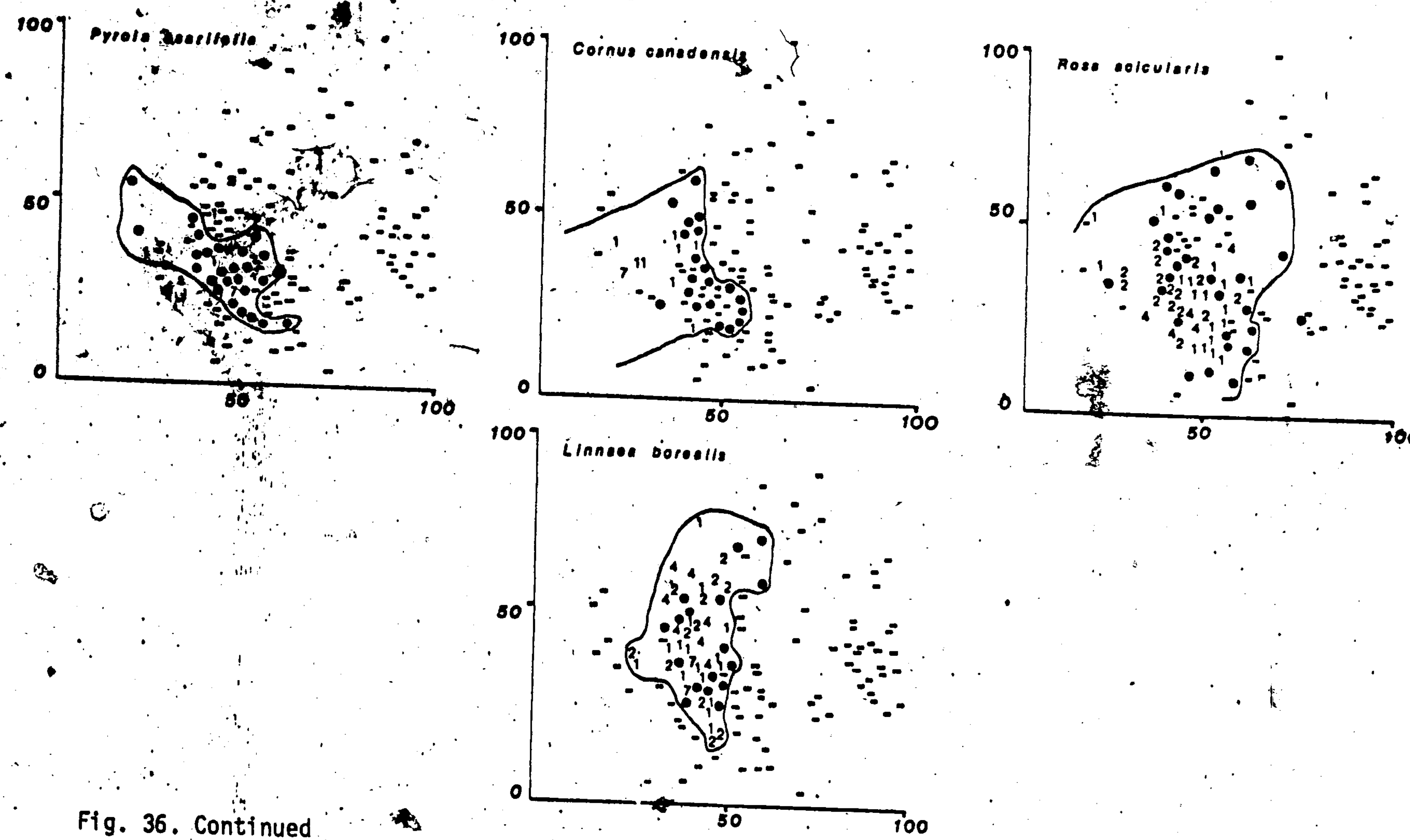


Fig. 36. Continued
P.asarifolia, C.canadensis, R.acicularis and L.borealis are character sp. of the forest, savannah/woodland cts.

and scrub communities. Its distribution is concentrated on the right-hand side of the ordination field.

Differential species in the left portion of the ordination field included characteristic boreal forest species chosen from the forest community types: Cornus canadensis, Linnaea borealis, Rosa acicularis and Pyrola asarifolia. These species are less tolerant of moisture and heat stress and can successfully compete beneath a closed forest canopy.

Smilacina stellata, Arctostaphylos rubra, and Salix pseudo-monticola distributions correspond to the P. glauca/Larix laricina/J. horizontalis/Carex scirpoidea and the L. laricina-P. glauca/Salix/A. uva-ursi cts. Their distribution occurs in the central mesic portion of the ordination field.

Transect TRC-E

The quadrats along each transect were ordinated by both Bray-Curtis and Reciprocal Averaging procedures. Fewer quadrats per ordination permitted a more detailed examination of floristic versus environmental gradients. One transect and its associated plots are presented to illustrate changes in plant community composition within a two-dimensional ordination field at this level.

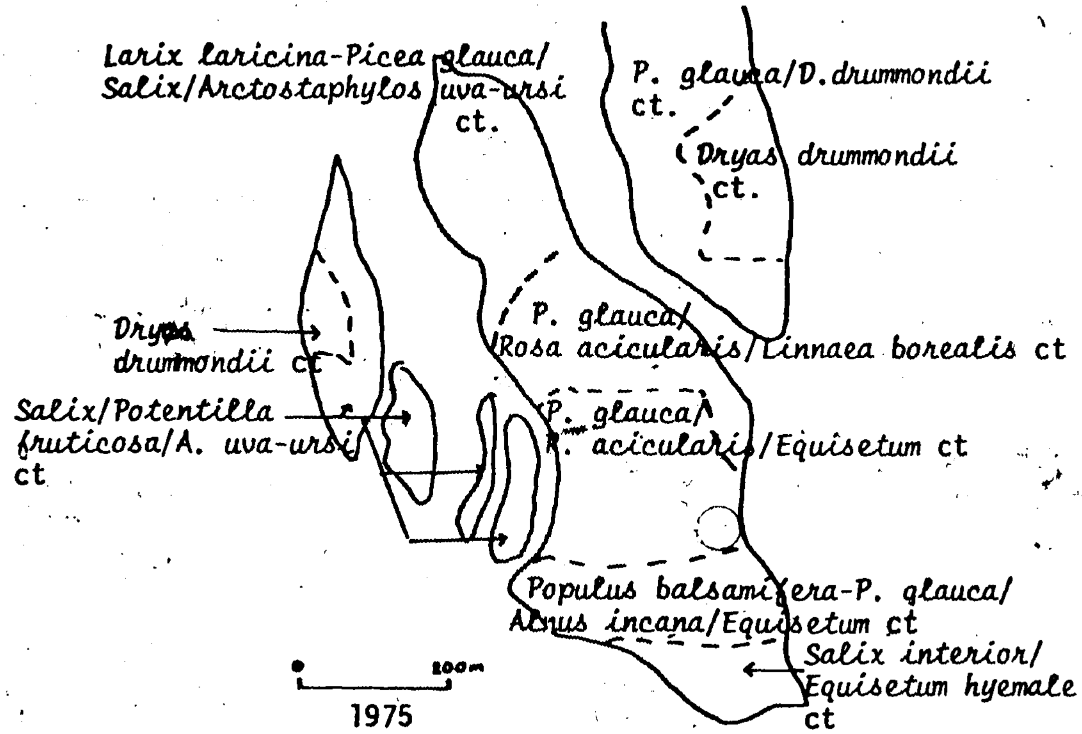
The transect chosen is located along a north-south axis from the South Nahanni River shore to the Prairie Creek gravels on the central island near the toe of the fan. Plant community types were delineated from a larger scale aerial photograph of the area

(Fig. 37). The 100 quadrats located at 30 m intervals along the transect and centrally located on the associated islands were used to index species composition and percentage cover. The reciprocal averaging ordination field, based on dissimilarity to four objectively chosen end points, was used to order the quadrat data.

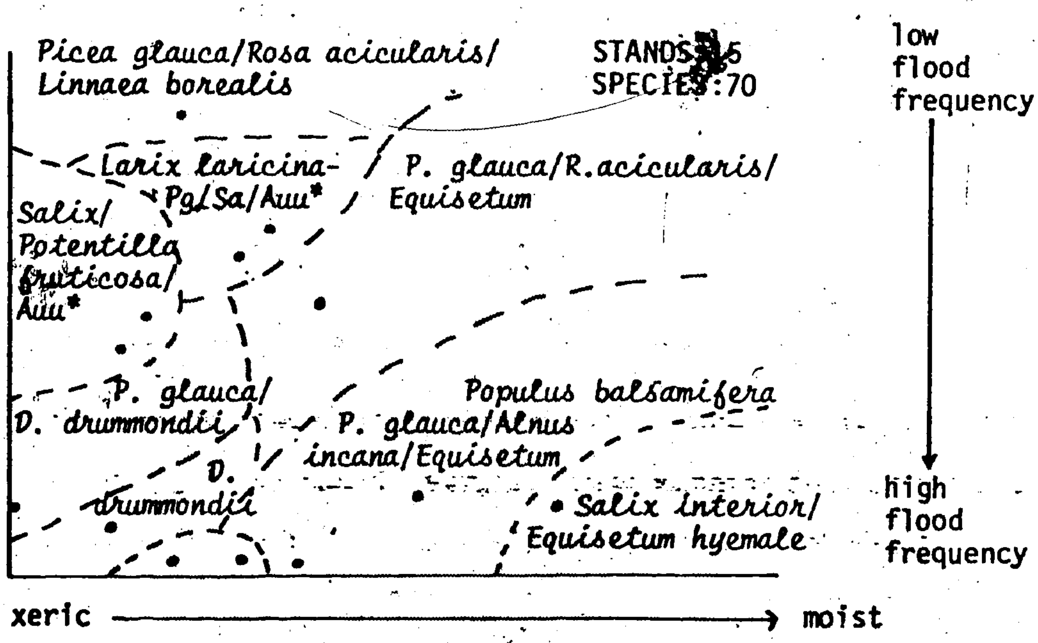
The arrangement of the quadrats corresponds to two gradients, an observed moisture gradient from dry surface layers in the Dryas drummondii ct to the more frequently saturated soils of the Populus balsamifera-Picea glauca/Alnus incana/Equisetum ct and the P. glauca Rosa acicularis/Equisetum ct and a second gradient defined in terms of frequency and intensity of flooding ranging from infrequently flooded P. glauca/R. acicularis/Linnaea borealis to the frequently inundated D. drummondii ct and the Larix laricina-P. glauca/Salix/Arctostaphylos uva-ursi ct (Fig. 37).

P. glauca/R. acicularis/L. borealis and Salix/Potentilla fruticosa/A. uva-ursi cts group in the upper left hand portion of the ordination field (Fig. 37). In the Salix/P. fruticosa/A. uva-ursi ct, occurring on river bars at the far south end of the island, exposed silt and sand accounted for up to 40% of the surface cover in the sample quadrats. S. alaxensis dominated the shrub layer with a mean cover value of 30%. The South Nahanni River inundates this ct during spring floods. Debris was observed up to .3 m in the Salix clumps. The Populus balsamifera component consisted of young seedlings.

The drier quadrats with Dryas drummondii and A. uva-ursi dwarf shrub strata sorted out along the lower portion of the y-axis. Exposed ground surface was abundant (accounting for up to 80% of the cover) in the D. drummondii ct. The surface was



Delineation of plant communities bisected by Transect TRC-E. and its associated quadrats.



*Arctostaphylos uva-ursi; Picea glauca/Salix A. uva-ursi

Fig. 37. Ordination of plant communities along Transect TRC-E.

scarred from former floods but no evidence for recent inundation was observed. Lichen and bryophyte layers were absent.

Quadrats of intermediate moisture regimes group in the central portion of the ordination field. Moisture loss in the herb strata was reduced through increased shading from solar radiation and protection from winds by a closed canopy of Picea glauca or through continual input from throughflow seepage. In the Picea glauca/ Rosa acicularis/Linnaea borealis ct, L. borealis and Cornus canadensis contributed to the abundant herb stratum. Picea glauca accounted for up to 90% of the forest canopy per quadrat. The density of the P. glauca ranged from 1900 to 3100 stems/ha. P. glauca of 13 m in height were aged up to 245 yr . Scattered L. laricina contributed up to 10% of the forest canopy.

Along the y-axes the position of the plots is associated with the frequency and intensity of flooding. Water flow has actively scoured, removed and redeposited material in the Populus balsamifera-P. glauca/Alnus incana/Equisetum ct. Flood debris, gravel splays and flood scarred trees provided evidence for frequent flooding. The centrally located quadrats (Fig. 37) displayed evidence of periodic flooding with local patches of bare silt colonized by opportunistic composite species. Recent scouring and deposition was not recorded. The P. glauca/R. acicularis/L. borealis ct quadrats are characterized by a continuous bryophyte mat beneath a P. glauca canopy. Although evidence for former flooding is recorded in the Cumulic Regosols in these quadrats, the frequency and date of last flood occurrence lags behind that of the other community types in the ordination field.

A composite chart of percent cover of dominant species in the transect quadrats representative of the seven community types illustrates changes in species dominance and structural composition among the cts. (Table 23). The most recently abandoned areas colonized by Dryas drummondii have few species represented in any strata. The Salix/Potentilla fruticosa/Arctostaphylos uva-ursi ct shows an increase in total plant cover realized in the shrub and forb strata.

In the least frequently flooded Picea glauca/Rosa acicularis/ Linnaea borealis forest ct the diversity of the forb stratum in the sample quadrats is threefold that of the D. drummondii ct. A continuous bryophyte mat corresponds to the closure of the tree canopy and the absence of inundation. Depth of silt to gravel increases over this progression of community types from bottom to top of the ordination field.

Table 23. Braun-Blanquet cover of dominant species along Transect TRC-E. (see text for cover ranges)

Species	Community Type Sa-i/Eq	Dd	Pg/Dd	Sa/Pf/Auu	Ll-Pg/Sa/Auu	Pb-Pg/Ai/Eq	Pg/Ra/Eq	Pg/Ra/Lb
Picea glauca(Pg)	2	2	1	1	2	2	2	2
Populus balsamifera(Pb)		+	+	2	1		+	+
Larix laricina(Ll)		1	1		1		+	+
Salix interior(Sa-i)	4	R			+		+	
S. pseudomonticola		+		1	1	+	+	1
S. alaxensis		+	+	2	1	+	+	R
Alnus incana(Ai)	+	+			1	1		+
Cornus stolonifera(Cs)		+		2	1	2	+	+
Rosa acicularis(Ra)		+		2	1	1	2	2
Potentilla fruticosa(Pf)		1	+	2	1	1		+
Juniperus communis		+		+	+	+		
Dryas drummondii(Dd)		4	2		+	1	+	
Linnaea borealis(Lb)					1	2	+	3
Arctostphylos uva-ursi(Auu)			+	3	2			
Cornus canadensis			+		1	+	1	1
Equisetum arvense(Eq-a)					1	+	3	+
E. variegatum				+	1	+	3	
E. hyemale	2			+				
Solidago decumbens					+	+	+	
Bryophyte	+			+	[illegible]	4	5	6
Lichen		+	2	3	2	+	+	+
Bare (Silt)	5	4	2	2	1	+		
No. Tree sp	1	4	3	2	4	3	4	3
No. Shrub sp.	1	8	4	13	21	15	11	16
No. Forbs	1	1	20	18	42	38	22	30

V. SYNTHESIS AND DISCUSSION

Community Pattern

Distribution of plant species on Prairie Creek alluvial fan is a response to environmental gradients associated with multiple biophysical parameters.

A mosaic pattern of discrete plant associations is evident where sharp boundaries in physical site characteristics occur. This is especially evident within the confines of recently abandoned gravel channels, on self-contained channel bars, on the well defined South Nahanni River levee deposits and in patches of recent burns. Visible changes in species composition, substrate texture, and flood frequency and intensity are compressed in space. These changes are noticeable both on aerial photographs and from transect variations. Similar discrete community groupings were noted by Jeffrey (1964) and Rostad et al. (1976) within a "Recent Floodplain" zone along the Liard River, N.W.T.

Continua occur where environmental gradients are more gradual. Small variations in topography, parent material, structural homogeneity and microclimate uniformity lead to extended transitional zones. The heath communities on the shallow silt substrate of Prairie Creek fan display these gradual shifts in community structure and composition. Douglas (1974) noted broad transitional variation among similar *Arctostaphylos uva-ursi* and *Juniperus horizontalis* dominated heath communities along the lower mountain slopes adjacent to the Slims River, Yukon and seral beach ridge communities (*J. communis*, *Arctostaphylos uva-ursi*, *Artemesia alaskana* and *Hedysarum boreale* communities) on Lake Alsek outwash fans. Substrates on these areas varied from deep mobile loess deposits to coarse gravel outwash. Rostad *et al.* (1976) and Jeffrey (1964) do not list heath communities in their studies of the Liard and Mackenzie River areas.

The major forested areas of the fan also displayed gradual transitions where fire had not played a major role in recent years. These transitions are associated with a gradual decrease in the depth to gravel. Similar transitions were not discussed for riparian forests along the Liard River (Rostad *et al.* 1976, Jeffrey 1964), or other northern boreal forests (Viereck 1970, Drury 1956, Gill 1973).

Successional Trends

Changes in species composition over time within a defined area has been noted for centuries. Anton Kerner's work along the Danube Basin in 1863 (Kerner, Ritter von Marilaum 1951) described forest regeneration from swamp explaining successional concepts under the name of "genetical relationship of plant formations". The classic description of plant succession is often attributed to Cowles' (1899) study on Lake Michigan's sand dunes. Plant Succession by Frederick Clements (1916) provided the foundation for successional community studies.

Successional processes on Prairie Creek alluvial fan differed with substrate, moisture supply, proximity to seed source, flood frequency and intensity, and other allogenic factors (e.g. fire, wind). Major differences in pioneer colonization and early seral stages corresponded most closely to substrate texture. This factor was used to examine the direction of community change over time on the fan.

Colonizing surfaces were divided into coarse (gravel) fraction size versus fines (silt and sand deposits). Four temporal phases were identified to establish four successional stages on each colonizing surface:

Substrate		Temporal Phase	Successional Stage
A. Gravel Deposits	1.	channel beds abandoned 0-20 yrs with infrequent seasonal flooding resulting in scour and silt veneering	Pioneer
	2.	channel bed and bars abandoned 20 yrs with very infrequent flooding, restricted to dispersed overbank flow leading to silt veneering but no scour	Early seral
	3.	> 20 cm silt/sand mantle over abandoned gravel beds and bars; absence of flooding	Late Seral
	4.	> 50 cm silts/sands over gravel no flooding	"Climax"[8]
B. Silt/ Sand Deposits	1.	frequently flooded channel beds and bars resulting in scour and fill	Pioneer
	2.	infrequently seasonally inundated channel bars and stream levees with moderate deposition	Early Seral
	3.	very infrequent low velocity overbank flooding resulting in minimal silt veneering	Late Seral
	4.	stable vegetated surface, no flooding.	"Climax" [8]

8. Climax refers to a community type where tree species are present as seedlings, saplings, subcanopy and canopy trees (Mueller Dombois and Ellenberg 1973) and possess a well developed bryophyte mat.

Directional change from a barren surface to a relatively stable self-perpetuating community type (climax) can be monitored by changes in plant species presence and abundance and structural changes. Several species diagnostic of communities representative of the four seral changes have successional indicator value. These are listed in Table 24.

Three successional progressions for each substrate type (gravel and silts/sands) are presented in Figures 38 and 39. Percentage cover of major strata is presented in histographs for each community type. The origin of the gravel substrate on Prairie Creek fan was predominantly Prairie Creek. Silts/sand deposits of any extent were from the South Nahanni River.

Gravel Succession

The distribution of the gravel substrate is along active and recently abandoned channels and bars of Prairie Creek east and west of the existing creek bed. Approximate ages for two abandoned channels are known from historical aerial photographic coverage. This provided a reference for establishing temporal limits for the gravel pioneer stage.

The initial colonizer of bare gravel sites is Dryas drummondii. The D. drummondii community is characterized by a 16 to 80% cover of Dryas (Table 24) with scattered Picea glauca and Potentilla fruticosa seedlings. Data collected from transects along abandoned channels indicates that colonization can begin at a very scattered

Table 24. Successional classes of Prairie Creek fan plant communities and selected vascular species indicators.

COMMUNITY TYPES

Pioneer cts

Dryas drummondii ct
Salix interior/Equisetum ct
Juniperus horizontalis/Carex ct

Late Seral cts

Picea glauca-Betula papyrifera/Cornus stolonifera-Rosa acicularis/Cornus canadensis ct
P. glauca/J. communis ct
Populus balsamifera-P. glauca/R. acicularis/C. canadensis
P. balsamifera-P. glauca/C. stolonifera/Linnaea borealis ct

Early Seral cts

P. glauca/D. drummondii ct
Arctostaphylos uva-ursi/J. horizontalis/Lichen ct
Salix/Potentilla fruticosa/A. uva-ursi ct
Betula/Salix/Equisetum ct
P. glauca-Larix laricina/Salix/A. uva-ursi ct
P. glauca/L. laricina/J. horizontalis/Carex scirpoidea ct
P. balsamifera-P. glauca/Alnus incana/Equisetum ct

Climax cts

P. glauca/R. acicularis/L. borealis ct
P. glauca/R. acicularis/Equisetum ct

EXAMPLES OF PLANT SPECIES INDICATORS

Pioneer species

Potentilla fruticosa
Dryas drummondii
Juniperus horizontalis
Hedysarum alpinum
H. mackenzii
Oxytropis splendens
Senecio pauperculus
Solidago decumbens
Equisetum hyemale
E. variegatum

Late Seral species

Betula papyrifera
Cornus stolonifera
Viburnum edule
Pyrola secunda

Early Seral

Larix laricina
Juniperus communis
Arctostaphylos uva-ursi
Zygadenus elegans
Betula glandulosa
B. pumila

Climax

Picea glauca
Rosa acicularis
Cornus canadensis
Linnaea borealis
Orchis rotundifolia

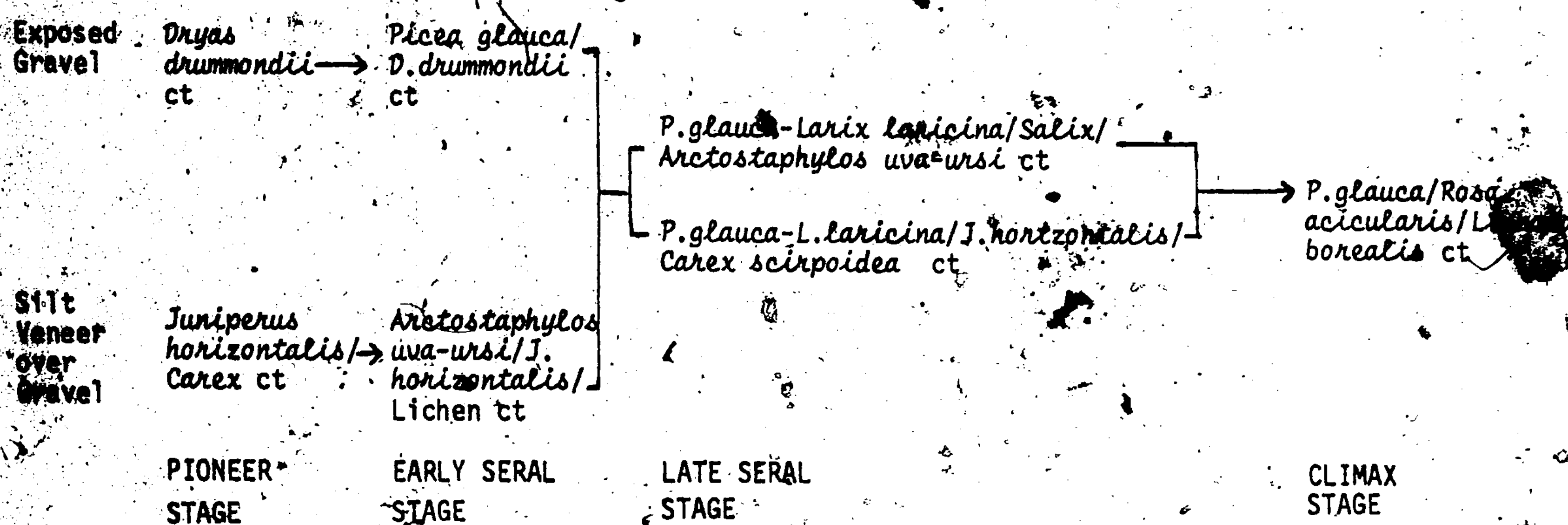


Fig. 38. Successional plant communities on gravel substrates, Prairie Creek alluvial fan, N.W.T.

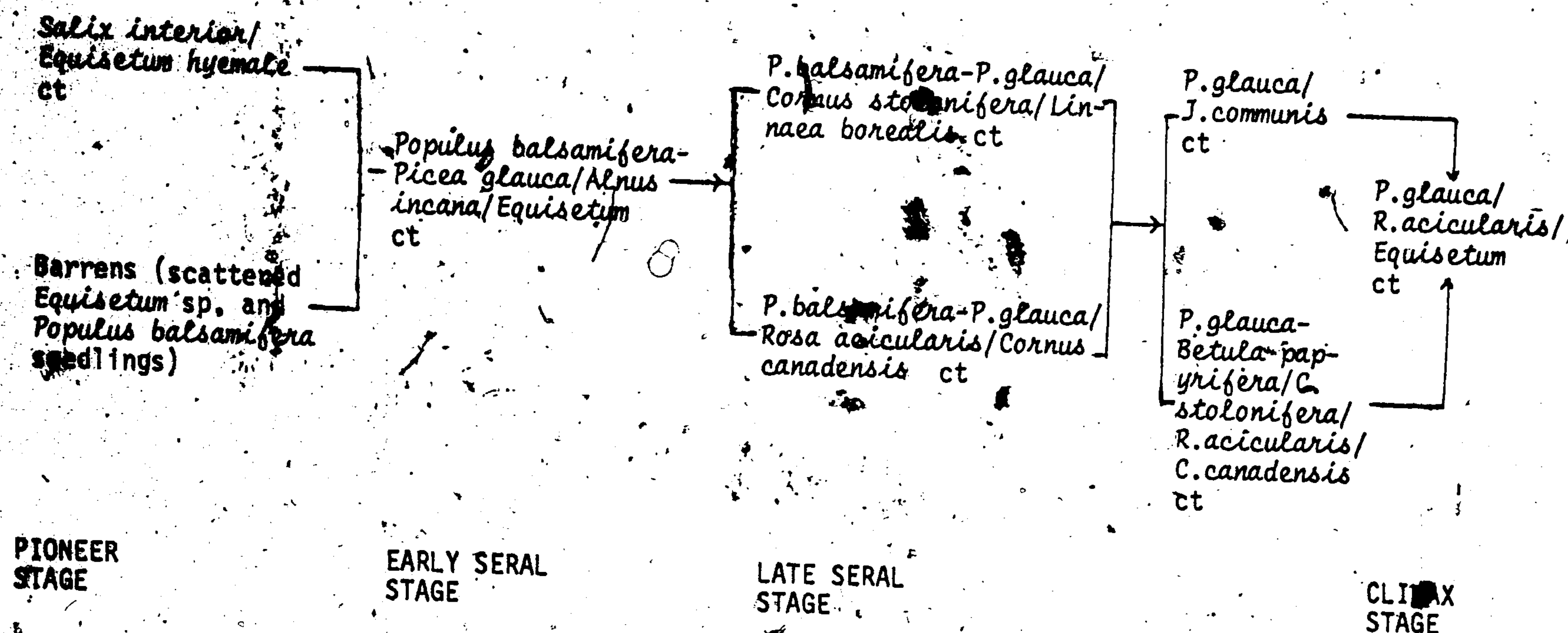


Fig. 39. Successional plant community types on silt substrates, Prairie Creek alluvial fan, N.W.T.

scale one year following major flooding. The maximum observed cover in the *D. drummondii* ct was noted on a channel actively scoured 20 yrs previously (as interpred from aerial photographic record). Similar community trends were observed by Douglas (1970) in Kluane National Park above the level of the floodplain on recent outwash fans and on stream terraces of the Slims River. *Dryas* communities on fluvial gravels are also evident along many streams in the Cordilleran province.

The early seral stage in gravel succession is marked by the presence of *Juniperus horizontalis*, *Arctostaphylos uva-ursi* and *Picea glauca*. Two communities were identified: a) where *A. uva-ursi* and *J. horizontalis* dominance exceeded *D. drummondii* (*A. uva-ursi-J. horizontalis*/Lichen ct); b) where *P. glauca* successfully established among a continuously dominant *D. drummondii* mat (*P. glauca/D. drummondii* savannah ct).

The *A. uva-ursi/J: horizontalis*/Lichen ct colonized imbricated coarse river gravels mantled by a 2 to 15 cm silt loam deposit. The *D. drummondii* cover was reduced to 10 to 15%. *J. hdrizontalis* invasion, accounting for 30 to 40% cover, occurred most rapidly where silt patches permitted rooting while runners extended over the gravel surfaces. Xerophytic bryophytes and lichens including *Ceratodon purpureus* and *Squamaria lentigera* were found in association with established Juniperus horizontalis clumps. Arctostaphylos uva-ursi increased from 30 to 60% over the early seral phase being most prominent on desiccated cracked surface silt loams veneered by a whitish-greay calcium carbonate film. A 20 to 40% lichen cover dominated by Cladonia and crustose lichens was associated with the older A. uva-ursi/J. horizontalis communities. Xerophytic bryophytes occupied the shallow depressions outlining the desiccation cracked surface. Herbaceous seedlings occurred in scattered microsites of silt pockets.

The Picea glauca/Dryas drummondii savannah ct developed most frequently in close proximity to P. glauca seed sources. The surfaces were characterized by shallow silt/sand veneer over imbricated gravels interspersed with small deep (40 cm) silt pockets. The D. drummondii cover increased from that of the pioneer stage of 60 to 90%.

Late seral stages were reflected by the establishment of a tree cover of P. glauca and Larix laricina and the supplementing of a dominant D. drummondii A. uva-ursi, J. horizontalis dwarf shrub cover by Juniperus communis. Xerophytic bryophytes are replaced by the feathermosses. The L. laricina-P. glauca/Salix/A. uva-ursi community type occupies sites thought to formerly support Picea glauca/Dryas drummondii savannah communities. This was based on comparing the historic aerial photographs to existing communities, observing intermediate communities and interpreting the historic geomorphic development of the sites. Over time with the continued absence of major flood events, the *A. uva-ursi*/*J. horizontalis*/Lichen is invaded by both *Larix laricina* and *Picea glauca*. *L. laricina* success was restricted to areas where surface silts and sands did not exceed 50 cm. Adventitious rooting patterns were frequent in the *Larix laricina*. The presence of *Larix laricina* in xeric flood-plain deposits was not expected and has not been documented for other boreal riparian habitats. *Larix laricina* is noted only as a moist swale [illegible] species (Rostad *et al.* 1976, Hettinger *et al.* 1973). Many young *Picea glauca* in the sites where *L. laricina* was a major component in the overstory, displayed signs of moisture and frost stress including multiple leaders, carpenter ant chambering and dead foliage. Annual growth of surviving trees was very slow (1 cm in 15 $\pm$ 5 yr, $n = 10$). Seedling success was best in the shade at the base of successful trees in the *P. glauca*-*L. laricina*/*J. horizontalis*/*Carex scirpoidea* ct.

The maturing of both the *P. glauca*-*L. laricina*/*J. horizontalis*/*C. scirpoidea* ct and the *L. laricina*-*P. glauca*/*Salix*/*Arctostaphylos uva-ursi* communities is accompanied by a decrease in *L. laricina*, *J. communis* and *Linnaea borealis* and an increase in *Rosa acicularis* and *Cornus canadensis*. The feathermoss layer becomes thicker, showing no evidence of periodic inundation by flood waters. The *P. glauca*/*R. acicularis*/*L. borealis* ct is thought to be a climax community where replacement of the species characterizing the community type is assured. *Picea glauca* is present as seedlings, saplings and mature trees; *Rosa acicularis* also occurs in the seedling, young and older shrub stages.

The *P. glauca/R. acicularis/Linnaea borealis* ct established on deep (< 50 cm) silt/sand deposits where moisture stress was not a limiting factor. Evidence of low velocity overbank flow in the form of silt splays could be found in many examples of this ct. Both *R. acicularis* and *L. borealis* tolerate the shade beneath the *P. glauca* canopy in contrast to *Juniperus horizontalis*, *A. uva-ursi* and *Dryas drummondii* which are less shade tolerant.

Silt Succession

Successional progression on exposed silt substrates follows a different course of events. Succession on silt surfaces along boreal meandering streams is well documented by Viereck (1970), Gill (1972) and Rostad *et al.* (1976). Along the South Nahanni River silty sand bars form in areas where backwater flow persists for extended periods of time during high flow stages.

Salix interior, a pioneer species resistant to periodic inundation and siltation, formed monocultures in several areas of the south-east fan. *Equisetum hymenale* which also survives siltation and inundation established beneath the *Salix interior* cover. Surveys along the nearby Liard and Mackenzie Rivers identified pioneer communities of *Salix lasiandra* and *S. bebbiana* on similar habitats (Rostad et al. 1976). These species were frequent on Prairie Creek fan. Picea glauca and Populus balsamifera seedling invasion is successful during this pioneer seral stage on higher terraces.

Growth and maturation of the P. glauca marks the beginning of the early seral stage of succession. Periodic siltation is counteracted by the formation of adventitious roots into silt layers above the buried organic horizons. Gill (1973) described similar adventitious rooting in floodplain P. glauca.

Salix interior is replaced by S. alaxensis, S. pseudomonticola and P. glauca in early seral stages as the Picea glauca canopy rises above the shrub layer and flood frequency is retarded. Rosa acicularis, Cornus canadensis, Equisetum arvense and E. pratense invade the shrub and herb layers. A thin leaf litter layer forms. During later seral stages these shrub and herb layers become more prominent with disappearance of Equisetum hymenale and the replacement of the early seral willows with Salix arbusculoides. The herb and cryptogram layers increase in cover.

More common successional progression on the fan silts is marked by the establishment of Populus balsamifera. Light mobile seeds of P. balsamifera and Compositae germinate on channel bar silt patches, in abandoned channel pools and on shoreline silts along protected reaches of the South Nahanni River. These form small pockets of pioneer communities.[9]

9. as these pockets on the 1976-77 Prairie Creek fan surface were <100 sq m they were only noted during the abandoned channel survey and sampled by $1m^2$ quadrats.

As flood frequency decreases, Populus balsamifera mature forming a young forest cover. This is accompanied by the establishment of a Salix alaxensis/Equisetum arvense cover in the early seral P. balsamifera/Picea glauca/Alnus incana/Equisetum ct.

The colonization of recent silt bars along braided or meandering streams by light seeded Salix spp. followed by Populus balsamifera has been reported by Viereck (1970) along the Chena River, Alaska, Douglas (1974) in Kluane National Park and Hettinger et al. (1973) on the Arctic coastal plain.

Alnus incana becomes successfully established on the South Nahanni River levee deposits in quieter [illegible] marking the transition to the P. balsamifera-P. glauca/A. incana/Equisetum early seral stage. Equisetum arvense and E. pratense form the herb layer beneath a Populus balsamifera canopy. The establishment of a litter layer and the introduction of a minor bryophyte mat accompanies the establishment of this community. Rostad et al. (1976) also observed Alnus incana invasion early in successional sequences along the Liard River as soil build-up progresses.

Late seral stages are associated with the decline of P. balsamifera (P. balsamifera/P. glauca/R. acicularis) and S. alaxensis (P. glauca/ S. arbusculoides/Equisetum arvense) and the increase of Picea glauca. Picea glauca invasion is evident during early seral stages of the Populus balsamifera stands but slower growth rates restrict them to a subordinate position for 100 to 200 yr. This trend is also reported by Rostad et al. (1976) and Viereck (1970). The development of a continuous bryophyte mat is also indicative of late seral stages.

With the death of decadent Populus balsamifera and Salix arbusculoides the stands succeed dominance to Picea glauca and Rosa acicularis. The Equisetum arvense and feathermoss cover continue to be abundant in the lower herb and cryptogram layers of the resulting climax P. glauca/R. acicularis/E. arvense ct. The absence of flared bases in this climax community results from repeated deposition following establishment (Sigafoos 1964). Both shrub, herb and bryophyte layers are dense. Cumulic surficial materials are deep with incipient soil formation present in older stands.

Hettinger et al. (1973), Viereck (1970) and Douglas (1974) all describe a similar sequence of progression although the persistance of the Equisetum strata is documented only by Viereck (1970). They also note associated cooling of soils, rise in permafrost layer and decrease in pH.

In summary the process of colonization on the Prairie Creek alluvial fan ressembles succession along boreal braided and anastomosing channel systems but offers the additional opportunity of displaying a number of seral progressions within a confined area. Exposed surfaces are gradually colonized by opportunistic compositae, shrubs and tree seedlings. Shrub layers appear to be most resilient pioneer colonizers on the fan with Dryas and Juniperus horizontalis invading the more xeric sites. Salix interior survives well in the annually inundated deposition zones along major fluvial courses.

Young Picea and Populus are also observed to be pioneer species on exposed surfaces but slower growth restricts their dominance to later seral stages. The development of a diverse herb and bryophyte strata is restricted to later seral stages, being unable to withstand annual inundations.

Management Implications

Prairie Creek alluvial fan and its vicinity were identified in the interim management guidelines for Nahanni National Park as a focal point for visitation by canoeists, backpackers, photographers and amateur or professional ornithologists and zoologists. The results from this study demonstrate the additional value of the site for viewing, studying and photographing arctic, alpine, boreal and prairie species growing together within the confines of the fan and examining pioneer to climax successional stages on both coarse fan deposits and silty river deposits. The impact of increased visitor use could be assessed by comparing future studies of the fan with this documentation of plant communities and Scotter and Henry's (1977) report on wildlife resources.

A registration patrol cabin located across the river from the fan, clear drinking water from the Creek, good fishing, and freedom from the mosquitoes on the open gravels of the fan have drawn visitors to Prairie Creek fan. Evidence of recent and past temporary camps were present on the central and east fan surfaces. Several parties during the summer of 1976 camped in the central portion of the fan in a level dry heath community. Pools adjacent to this site were frequently deep and warm enough for swimming and offered easy catches of grayling.

Studies rating the fragility of plants and soils in recreation areas is limited and ratings are difficult to extrapolate from other regions. Root and Knapik (1972) completed one of the more comprehensive surveys along the Great Divide Trail in Alberta. Within Nahanni National Park Marsh and Scotter (1975) completed trampling studies around the Nahanni Hot Springs and Rabbitkettle Hot Springs. Similar experimentation was documented for the Deadmen Valley floodplain by Scotter and Henry (1977).

Douglas (1974) assigned fragility ratings to plant communities in Kluane National Park, derived from descriptive vegetation and soil characteristics. Similar rankings were assigned for Prairie Creek communities although criteria for fragility were altered to conform with the alluvial fan characteristics. Very fragile communities were: 1) poorly drained; 2) underlain by sand or silt substrates susceptible to wind erosion that were also densely carpented by lichens; 3) lightly vegetated shoreline sites susceptible to extensive river erosion if removed.

Moderately fragile ratings refer to areas with more resistant vegetative cover or more favourable soils in terms of better drainage or loam textures. These communities would not degrade excessively with trail establishment but are less suitable for campsite use.

Resistant communities include areas where natural disturbances (e.g. flooding) would mask damage incurred by visitor use and areas with a trample resilient ground cover.

The resilience of the heath community types to trampling decreases with increased lichen cover on older surfaces. Frequently flooded zones are more tolerant to compaction, trampling and camping but are vulnerable to flash flood inundation. Forested communities with expansive Equisetum understories and moist soil profiles are not suitable for extensive visitor use. The brittle above ground stalks of Equisetum pratense and E. arvense are easily broken off by trampling. Associated feathermoss cover beneath the Equisetum carpets are also easily destroyed as documented by Marsh and Scotter (1975). These mosses are not resistant to excessive use in any community type. Forests with a Populus balsamifera canopy associated with and without flooding are resistant to trampling because of their herbaceous cover. Populus balsamifera forests are less desirable for overnight camping sites because of their tendency to rapidly deteriorate and snap during high winds common during the fall on the fan. Compaction of the silty surficial materials associated with the stands and a high moisture status could accelerate deterioration of the stands (Table 25).

Soil trafficability for Deadmen Valley floodplain is discussed in Scotter and Henry (1977). The soils on Prairie Creek fan are very similar to the floodplain soils across the river. They are rich in lime, associated with poor to moderate trafficability as it breaks down under repeated use. Surficial ponding was noted in areas compacted near campground sites on the fan silts. These surfaces were also noted to compact 2 to 4 cm below the adjacent surfaces on a trail leading to the meteorological Stevenson Screen which was checked twice a day for the 10 week research period. Most of the heath communities are underlain

Table 25. Fragility ratings of Prairie Creek fan community types.

Rating	Community Types
VERY FRAGILE	*Juniperus horizontalis/Carex* ct *Arctostaphylos uva ursi/J. horizontalis*/Lichen ct *Salix interior/Equisetum hyemale* ct
MODERATELY FRAGILE	*Picea glauca Larix laricina/J. horizontalis/Carex* ct *Populus balsamifera-P. glauca/Alnus incana/Equisetum* ct *P. glauca/Rosa acicularis/Equisetum* ct
RESISTANT	*Dryas drummondii* ct *P. glauca/D. drummondii* ct *Salix/Potentilla fruticosa/A. uva ursi* ct *Betula/Salix/Equisetum* ct *P. glauca/L. laricina/Salix/A. uva ursi* ct *P. glauca/Juniperus communis* ct *P. glauca-Betula papyrifera/Cornus stolonifera-Rosa acicularis/Cornus canadensis* ct *P. glauca-P. balsamifera/R. acicularis/C. canadensis* ct *P. glauca-P. balsamifera/C. stolonifera/Linnaea borealis* *P. glauca/R. acicularis/L. borealis* ct

by near surface gravels which are more resistant to repeated traffic than the floodplain silts of the Nahanni River. Bare gravel areas are also resistant to repeated traffic and are thus routes which could be encouraged for hiking and general access to other areas of the fan.

LITERATURE CITED

Addison, W. D. 1974. A review of the bio-physical literature pertinent to Nahanni National Park and the South Nahanni watershed. Dep. Indian Affairs North. Dev., Nat. Pks. Br. Canada. 226 pp.

American Geological Institute 1962. Dictionary of Geological Terms, Doubleday & Co. Inc, New York. 545 pp.

Argus, G. W. 1973. The genus Salix in Alaska and the Yukon. Publ. in Bot. No. 2. National Museums of Can., Ottawa, Canada. 279 pp.

Arnold, E. W. 1961. Plant communities of a hotspring in the Mackenzie Mountains, Northwest Territories. M.Sc. thesis, Dept. of Botany, University of Michigan, Ann Arbor. Unpb. 34 pp.

Bascombe, C. I. 1961. A calcimeter for routine use on soil samples. Chemistry and Industry Part II. 1826-1827.

Beaty, C. B. 1970. Age and estimated rate of accumulation of an alluvial fan, White Mountains, California, U. S. A. Amer. J. Sci. 268:50-77.

Beaty, C. B. 1963. Origin of alluvial fans, White Mountains, California and Nevada. Ann. Assoc. Amer. Geog. 53:516-535.

Bird, J. B. 1972. The natural landscapes of Canada: a study in regional earth science. Wiley Pub. of Canada Ltd. Canada. 191 pp.

Black, C. A., ed. 1965. Methods of Soil Analysis. Amer. Soc. of Agron. Inc., Madison. 2 vol.

Bloom, W. A. 1969. Geomorphology. Prentice Hall. New Jersey. 162 p.

Bliss, L. C. and J. E. Cantlon. 1957. Succession on river alluvium in northern Alaska. Amer. Midl. Nat. 58:452-469.

Blissenbach, E. 1954. Geology of alluvial fans in semi-arid regions. Bull. Geol. Soc. Amer. 65:175-190.

Boothroyd, J. C. 1972. Coarse grained sedimentation on a braided outwash fan, northeast Gulf of Alaska. Tech. Rep. No. 6-CRD.

Bostock, H. S. 1948. Physiography of the Canadian Cordillera with specific reference to the area north of the 55th parallel. Goel. Soc. Can. Mem. 247. 106 pp.

Bouyoucos, G. J. 1936. Direction for making mechanical analyses of soils by the hydrometer methods. Soil Sci. 42:225-229.

Braun - Blanquet, J. 1932. Plant sociology: the study of plant communities. (Transl. by G. D. Fuller and H. S. Conard.) McGraw-Hill, New York 438 pp.

Bray, J. R. and J. T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecological Monographs 27:325-349.

Bull, W. B. 1960. Types of deposition on alluvial fans in western Fresno County, California. Bull. Geol. Soc. Amer. 71:20 52.

Burns, B. M. 1973. The climate of the Mackenzie Valley : Beaufort Sea Vol. 1 Climatological Studies No. 24. Atmospheric Env., Env. Can. 227 pp.

Calder, J. A. and D. B. O. Savile. 1960. Studies in Saxifraga odontoloma and lyallii, and North America subspecies of S. punctata. Can. J. Bot. 38:409 435.

Canadian Soil Survey Committee, 1974. The system of soil classification for Canada. Can. Dept. Agric. 255 pp.

Chapman, H. D. 1965. Cation exchange capacity. Pages 891-901 In C. A. Black, ed. Methods of soil analysis. Part 2. Soc. of Agron. Inc., Madison.

Clayford, J. H., V. Hildahl, L. D. Nairn and M. P. H. Wheaton. 1959. Injury to trees from winter drying and frost in Manitoba and Saskatchewan in 1958. For. Chron. 35:181-290.

Clayton, J. S., W. A. Ehrlish, D. B. Cann, J. H. Day and I. B. Marshall. 1977. Soils of Canada. Can. Dept. Agric. Publ. 1544. Supply and services Canada. Ottawa. 2 vols.

Clements, F. E. 1916. Plant succession: an analysis of the development of vegetation. Carnegie Inst. Wash. Publ. 242. 512 pp.

Cody, W. J. 1963. A contribution to the knowledge of the flora of southwestern Mackenzie District, N.W.T. Can. Field Nat. 77:108-123.

Cottam, G., F. G. Goff and R. H. Whittaker. 1973. Wisconsin comparative ordination. Pages 193-221 in R. H. Whittaker, ed. Handbook of vegetation science Vol. 5 Ordination and classification of communities. Dr. W. Junk, The Hague.

Cowles, H. C. 1899. The ecological relations of the vegetation on sand dunes of Lake Michigan. Bot. Gaz. 27:95-391.

Crum, H. 1976. Mosses of the Great Lakes Forest. University Herbarium. University of Michigan. Ann Arbor, Michigan. 404 pp.

Crum, H. A., W. C. Steere, and L. E. Anderson. 1973. A new list of mosses of North America North of Mexico. Bryologist 76:85-130.

Dahlskog, S. 1966. Sedimentation and vegetation in a Lapland mountain delta. Geografiska Annaler 48A:86-101.

Dansereau P. 1957. Biogeography, an ecological perspective. The Ronald Press, New York 394 pp.

Davis, W.M. 1909. Geographical essays. Ginn and Co., Boston. 777 pp. (reprinted in 1954. Dover Pub. NY).

Day, P. R. 1965. Particle fractionation and particle size analysis. Pages 545 567 In C. A. Black, (ed.) Methods of Soil Analysis, Amer. Soc. of Agron. Inc., Madison.

Day, J. H. 1966. Reconnaissance soil survey of the Liard River valley. Research Br. Can. Dept. Agr. 71 pp.

Day, R. J. 1972. Stand structure, succession, and use in southern Alberta's Rocky Mountain forest. Ecology 53:472-478.

Department of Environment, 1973. Hydrological aspects of northern pipeline development. Pipelines Rpt. No. 73-3. prepared for Env. Soc. Comm. Northern Pipelines. 664 pp.

Dickman, S. R. and R. H. Bray. 1940. Colorimetric determination of phosphate. Ind. Eng. Chem. Anal. Ed. 12:665-668.

Douglas, G. W. 1974. Montane zone vegetation of the Alsek River region, southwestern Yukon. Can. J. Bot. 52:2505-2532.

Douglas, R. J. W. 1970. Geology and economic minerals of Canada. Dept. of Energy, Mines and Resources. Canada. 838 pp.

Douglas, R. J. W. and D. K. Norris. 1960. Virginia Falls and Sibbeston Lake map areas. N.W.T. 95F and Dept. Energy, Mines and Resources. Ottawa. 26 pp.

Dowling, D. B. 1922. Geological structures of the Mackenzie River region. Geol. Survey of Can. Summary Rept. Part B.

Drury, W. 1956. Bog flats and physiographic processes in the Upper Kuskokwim River Region, Alaska. Contr. Gray Herbarium. Harvard: 178. 130 pp.

Dunbar, C. O. 1952. Historical Geology. John Wiley and Sons, Inc., N.Y. 573 pp.

English, M. C. 1979. Some environmental and ecological aspects of the Slave River delta, N.W.T. M.Sc. thesis, Dept. of Geography, University of Alberta, Edmonton. (in preparation).

Environment Canada. 1977. Monthly meteorological observations in Canada, Ottawa.

Flook, D. R. 1952. H. Snyder and expedition: upper South Nahanni River. Aug. 1952. Unpb. Rpt. C.W.S., Edmonton. 8 pp.

Ford, D. C. 1974. Evidences of multiple glaciation in South Nahanni National Park, Mackenzie Mountains, Northwest Territories. Can. J. Earth Sciences 13:1433 1445.

Ford, D. C. 1974. Final report on the geomorphology of South Nahanni National Park. N.W.T. Parks Canada, Winnipeg. 186 pp.

Ford, D. C. 1977. The extraordinary landscape of South Nahanni. Can. Geog. J. 94:560-563.

Frissell, S. S. 1973. The importance of fire as a natural ecological factor in Itasca State Park, Minnesota. Quat. Res. 3:397 407.

Gauch, H. G. 1971. Cornell Ecology Program 4: Bray-Curtis Ordination. Cornell University. Ithaca, N.Y.

Gauch, H. G. 1975. Cornell Ecology Programs 20A, 20C, 20E and 20F: Reciprocal averaging package. Cornell Univ. Ithaca, N.Y.

Gauch, H. G. Jr., R. H. Whittaker and T. E. Wentworth. 1977. A comparative study of reciprocal averaging and other ordinations. J. Ecol. 65:157-174.

Gill D.1972.The point bar environment in the Mackenzie River Delta. Can.J.Earth Sci. 11:1382-1393.

Gill D.1973.Floristics of a plant succession sequence in the Mackenzie Delta,Northwest Territories.Polarforschung 43:55-65.

Gleason, H. A. and A. Cronquist. 1968. The natural Geography of Plants. Columbia University Press. NY 420 pp.

Grieg-Smith, P. 1964. Quantitative plant ecology. Butterworths, London. 256 pp.

Hack, J. T. and J. C. Goodlett. 1960. Geomorphology and forest ecology of a mountain region in the central Appalachians. U.S. Geol. Surv. Prof. Paper 347. 66 pp.

Hale, M. E. Jr. and W. L. Culberson. 1970. A fourth checklist of the lichens of the continental United States and Canada. Bryologist 73:499-543.

Hanson, H. C. 1962. Dictionary of Ecology, Crown Pub.Inc. U.S.A., 382 pp.

Heinselman, M. L. 1970. The natural role of fire in northern conifer forests. Pages 30-41. in The role of fire in the intermountain west. Proc. Symp. sponsored by Intermtn. Fire Res. Council and School of Forestry, University of Montana, Missoula (also Naturalist 21:14-23).

Hettinger, L., A. Janz and R. Wein. 1973. Vegetation of the Northern Yukon territory.Arct.Gas Bio.Rpt.Ser.Vol.1,Calgary, 172 pp.

Hill, M. O. 1973. Reciprocal veraging: An eigenvector method of ordination. J. Ecology 61:237-249.

Hirvonen, R. P. 1968. Report on the forest conditions in the Lower Liard River Basin, Yukon/Northwest Territories Unpb. Rpt. Northern Surv. Rep. No. 3., Dep. of Forest and Rural Development, Ottawa. 52 pp.

Hitchcock C. L. and A. Cronquist 1973. Flora of the Pacific Northwest, Univ. of Washington Press, Seattle. 730 pp.

Hook, R. B. 1968. Processes on arid alluvial fans. J. Geol. 75:438-458.

Hultén, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press. Stanford. 1008 pp.

International Union for the Conservation of Nature 1966. Red data book.

Jeffrey, W. W. 1961. Notes on plant occurrences along lower Liard River, Northwest Territories. Nat. Mus. Can. Bull. 171:32-115.

Jeffrey, W. W. 1964. Forest types along lower Liard River, Northwest Territories. Can. Dep. of Forest Pub. No. 1035. 103 pp.

Kerner, A. J. Ritter von Marilaum 1831-1898. 1951. The background of plant ecology. Ames Iowa. State College Press. 238 pp.

Kershaw, L. J. 1976. A phytogeographical survey of rare endangered and extinct vascular plants in the Canadian flora. M. Sc. thesis, Univ. of Waterloo, Waterloo Ontario. 303 pp.

Legget, R. F., R. J. E. Brown and G. H. Johnston. 1966. Alluvial fan formation near Aklavik N.W.T., Canada. Geol. Soc. of Amer. Bull. 77:15-30.

Leopold, L., M. Wolman and J. Miller. 1964. Fluvial processes in geomorphology. Freeman, San Francisco. 522 pp.

Lerbekmo, J. F. and F. A. Campbell. 1969. Distribution, composition and source of the White River Ash, Yukon Territory. Can. J. Earth Sci. 6:109-111.

Lüdi, W. 1930. Die Methoden der Suksessionsforschung in der Pflanzensoziologie. In Aberhalden, Handb. Biol. Arbeitsmeth. 11:527-728 (cited in Mueller-Dombois and Ellenberg 1974 p. 371).

Lulman, P. D. 1975. Aspen Forests of Jasper and Banff National Parks. M.Sc. thesis. Dept. of Bot. Univ. of Alberta, Edmonton. 144 pp.

Marsh, A. H. and G. W. Scotter, 1975. Vegetation survey and impact assessment of the Nahanni Hotsprings and Virginia Falls area, Nahanni National Park. Can. Wildl. Serv. Rpt. 279 pp.

McCormick, J. 1968. Succession. VIA1 Student Pb. of Graduate School of Fine Arts, Univ. of Pennsylvania. 131-132.

McKeague, J. A. Ed. 1976. Manual on Soil Sampling and Methods of Analysis. Subcommittee of Canada Soil Survey Committee on Methods of Soil Analysis. Soil Research Inst. 212 pp.

Miller, N. G. 1976. Quaternary fossil bryophytes in North America: A synopsis of the record and some phytogeographic implications Journ. Hattori Bot. Lab. 41:73-85.

Morris, M. J. 1973. Estimating understory plant cover with rated microplots. U.S.D.A. Forest Service Res. Paper Rm 104. Rocky Mt. Forest and Range Experiment Sta. Forest Serv. U.S. Dept. of Agriculture. Colorado.

Moss, E. 1959. Flora of Alberta. Univ. of Toronto Press, Toronto. 546 pp.

Motyka, J., B. Dobrzanski and S. Zowaclek. 1950. Wstepne badania nad lagami poludniowowschodniej lubelszczyzny (Preliminary studies on meadows in the southeast of the province Lobin). Univ. Mariae Curie Sklodowska Ann. Sect. E 5(13):367-447.

Mueller-Dombois, D. and H. E. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, N. Y. 547 pp.

Munsell Soil Color Charts. 1971. Munsell Color Division. Kollmorgen Corp. Baltimore, Maryland.

Murie, O. J. 1954. A Field guide to animal tracks. Houghton Mifflin Co. Boston. 374 pp.

Odum, E. P. 1971. Fundamentals of Ecology (3rd ed.). Saunders Pub, U.S.A.

Panshin, A. J. and C. de Veeuw. 1973. Textbook of Wood Technology Vol. 1. McGraw Hill Book Co., N.Y. 705 pp.

Parker, M. L. and L. A. Jozsa. 1973. Dendrochronological investigations along the Mackenzie, Liard and South Nahanni Rivers, N.W.T. Part I: Using tree damage to date landslides, ice jamming and flooding. Pages 313-464. in Hydrological Aspects of Northern Pipeline developments prepared for Environmental-Social Committee Northern pipelines Report No. 73-3. Ottawa.

Patterson, R. M. 1954. The Dangerous River. George Allen and Unwin Ltd, London. 272 pp.

Porsild, A. E., and W. J. Cody. 1968. Checklist of the Vascular Plants of continental Northwest Territories. Plant Res. Inst. Can. Dep. Agric., Ottawa. 102 pp.

Raup, H. M., 1947. Some natural floristic areas in boreal America. Ecol. Monogr. 17:221-234.

Raup, H. M., 1947. The Botany of southwestern Mackenzie. Sargentia 6:1-275.

Richards, L. A. 1965. Water retentivity of soil at specified values of matric suction. pages 131-137 n C. A. Black, ed. Methods of Soil Analysis. Part 1. Amer. Soc. Agron. Inc. Madison, Wisconsin.

Root, J. D. and L. T. Knapik 1972. Trail conditions along a portion of the Great Divide Trail route, Alberta and B. C. Rocky Mountains. Re. Council of Alberta. Rept. 72.5 43 pp.

Rostad, H. P. W., R. A. White and D. F. Acton. 1976. Soil survey and land evaluation of the Liard and Mackenzie River area Northwest Territories. Sask. Inst. of Pedology. Pub. 5173. 285.

Rowe, J. S. 1972. Forest Regions of Canada. Dept. of the Environment Canadian Forestry Service Pub. No. 1300. Information Canada, Ottawa. 172 pp.

Ryder, J. M. 1971. Some Aspects of the Morphometry of Paraglacial Alluvial Fans in south-central British Columbia Can. J. Eart Sci. 8:1252-1264.

Scotter, G. W., N. M. Simmons, H. L. Simmons, and S. C. Zoltai. 1971. Ecology of the South Nahanni and Flat River areas. Can. Wildl. Serv. unpub. rep. 186 pp.

Scotter, G. W. and W. J. Cody. 1974. Vascular plants of Nahanni National Park and Vicinity, N.W.T. Le Naturaliste Can. 101:861-891.

Scotter, G. W. and J. D. Henry. 1977. Vegetation, wildlife and recreational assessment of Deadmen Valley, Nahanni National Park. Can. Wildl. Serv. Edmonton. 288 pp.

Scotter, G. W. and H. M. Kershaw. 1978. Vegetation of Deadmen Valley, Nahanni National Park. Progress Report prepared for Parks Canada by Canadian Wildlife Service Edmonton. 136 pp.

Sigafoos, R. 1964. Botanical evidence of floods and flood-plain deposition. U.S. Geol. Survey Prof. Paper 485-A:A1-A35.

Sneath, P. H. A. and Sokal R. R. 1973. Numerical Taxonomy. Freeman. San Francisco.

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Det Kong. Danske Vidensk. Selsk. Biol. Skr. (Copenhagen) 5(4):1-34.

Spurr, S. H. 1954. The forests of Itasca in the nineteenth century as related to fire. Ecology 35:21-25.

Steere, W. C., G. W. Scotter, K. Holmen 1977. Bryophytes of Nahanni National Park and Vicinity, Northwest Territories, Canada. Can. J. Bot. 55:13:1741-1767.

Steere, W. C. and G. W. Scotter. 1978. Additional bryophytes from Nahanni National Park and Vicinity, Northwest Territories, Canada. Can. J. Bot. 56.

Stotler, R. and B. Crandall-Stotler. 1977. A Checklist of Liverworts and Hornworts of North America. Bryology 80:405-428.

Strahler, A. N., 1969. Physical Geography. John Wiley and Sons. Inc. N.y.

Strang, R. M. 1973. Succession in unburned subarctic Woodlands. Can. J. For. Res. 3:140-143.

Strang, R. M. 1975. Studies on vegetation, landform and permafrost in the Mackenzie Valley. Environmental - Social Program, Northwern Pipeline 37 pp. Ottawa. 37 pp.

Tande, G. F. 1979. fire history and vegetation pattern of coniferous forests in Jasper National Park, Alberta. Can. J. Bot. 57: 1912 -1931.

Tarnocai, C. 1973. Soils of the Mackenzie River area. Environmental Social Committee Northern Pipelines. Rep. No. 73-26, Ottawa. 136 pp.

Viereck, L. A. 1970. Forest Succession and Soil Development Adjacent to the Chena River in Interior Alaska. Arctic Alp. Res, 2: 1-26.

Viereck, L. A. and E. L. Little. 1972. Alaska Trees and Shrubs. Agriculture Handbook No. 410. Forest Service U.S. Dept. of Agriculture. Washington. 265 pp.

Walker, R. G. 1976. Facies models 3, Sandy fluvial systems. Geoscience Can. 3:101-109.

Ward, J. H. 1963. Hierarchical grouping to optimize an objective function. J. Amer. Stat. Ass. 58:236-244.

Whittaker, R. H. 1973. Introduction. In R. Tuxen, (ed.) Handbook of vegetation science. Part V. Ordination and classification of communities. Dr. W. Junk, The Hague.

Whittaker, R. H. and H. B. Gauch. Jr. 1973. Evaluation of ordination techniques. In R. Tuxen, (ed.) Handbook of vegetation science. Part V. Ordination and classification of communities. Dr. W. Junk, The Hague.

Williams, P. F. and B. R. Rust. 1969. The sedimentology of a braided river. J. Sedimentary Petrology 39:649 579.

Wishart, D. 1975. Clustan User Manual. Computer Centre. University College London. London. 124 p p.

Zalowsky, 1976. Frost damage in poplar on the prairies. For. Chron. 52:2.

Additional References

Daubenmire P. 1957. Biogeography - an ecological perspective. Ronald Press. New York.

Daubenmire P. 1968. Plant Communities. A Textbook of Plant Synecology. Harper and Row Pub.New York. 300 pp.

APPENDIX 1. A sample of wind velocity variation for Prairie Creek alluvial fan, 1976.

	August 22	23	24	25	26	27	28	29
Max.	17	15	20	6	16	10.4	18.5	12
Min.	0.8	1.2	1.8	0.6	0.8	1.	2.0	1.5
Range	16.2	13.8	18.2	5.4	15.2	9.4	16.5	10.5
Ave.(hr)	6.3	3.5	8.3	2.7	3.5	3.7	7.6	4.7
0-6	1.1	2.4	9.4	1.9	1.7	1.8	2.7	1.8
6-12	2.9	1.5	13.8	1.5	1.9	1.5	11.9	5.9
12-18	8.4	4.6	5.5	3.6	5.0	7.0	11.4	7.4
18-24	11.3	5.7	4.6	3.7	5.4	4.6	4.4	3.5

	September 1	2	3	4	5	6	7
Max.	7.2	21.2	17.5	8.2	11	8.2	[illegible]5
Min.	0.6	2.	1.6	1.2	1.6	1.0	[illegible]
Range	6.6	19.2	15.9	7.0	9.4	7.2	15
Ave.(hr)	3	8.2	5.4	3.9	4.2	2.9	4.4
0-6	2.3	2.7	5.0	2.7	2.9	2.5	1.6
6-12	1.6	6.5	5.2	4.3	3.3	1.9	2.9
12-18	3.9	13.5	8.3	5.7	3.6	[illegible]8	11.1
18-24	5.4	8.9	3.1	2.8	5.3	3.5	2.1

	11	12
Max.	8.4	5.0
Min.	1.0	1.0
Range	7.4	4.0
Ave.(hr)	2.8	2.2
0-6	2.1	1.9
6-12	2.1	1.9
12-18	5.0	2.2
18-24	3.2	2.8

Appendix 2. Vascular plants of Prairie Creek alluvial fan, Nahanni National Park, N.W.T.

POLYPODIACEAE

Cystopteris fragilis (L.) Bernh.
Gymnocarpium robertianum (Hoffm.) Newm.
Woodsia glabella R. Br.

EQUISETACEAE

Equisetum arvense L.
Equisetum fluviatile L.
Equisetum hymenale L.
Equisetum palustre L.
Equisetum pratense Ehr.
Equisetum scirpoides Michx.
Equisetum variegatum Schleich.

SELAGINELLACEAE

Selaginella selaginoides (L.) Link

PINACEAE

Juniperus communis L.
Juniperus horizontalis Moench.
Larix laricina (Du Roi) K. Koch.
Picea glauca (Moench.) Voss.

SCHEUCHZERIACEAE

Triglochin palustre L.

GRAMINEAE

Agropyron trachycaulum (Link.) Malte
Agropyron violaceum (Hornem.) Lange
Agrostis scabra Willd.
Bromus pumpellianus Scribn.
Calamagrostis canadensis L.
Calamagrostis lapponica (Wahl.) Hartm.
Calamagrostis neglecta (Ehrh.) Gertn., Mey. and Schreb.
Calamagrostis purpurescens R. Br.
Danthonia intermedia Vasey
Deschampsia caespitosa (L.) Beauv.
Elymus innovatus Beal.
Elymus sibericus L.
Festuca altaica Trin.
Glyceria striata (Lam.) Hitchc. var *stricta* (Scribn.) Fern.
Hierchloe odorata (L.) Beauv.
Hordeum jubatum L.
Oryzopsis pungens (Torr.) Hitchc.
Poa pratensis L.
Trisetum spicatum (L.) Richter

CYPERACEAE

Carex aquatilis Wahl.
Carex aurea Nutt.
Carex capillaris L.
Carex concinna R. Br.
Carex eburnia Boot.
Carex filifolia Nutt.
Carex gracialis Mack.
Carex membranacea Hook.
Carex membranacea Hook. X *Carex rostrata* Stokes
Carex microcarpus Presl.
Carex rostrata Stokes
Carex saxatilis L.
Carex scirpoidea Michx. var *scirpiformis* (Mack.) O'Neill and Duman
Carex scirpoidea Michx. var *scirpoidea*
Eriophorum scheuchzeri Hoppe
Scirpus microcarpus Presl.

JUNCACEAE

Juncus albescens (Lange) Fern.
Juncus alpinus Vill. ssp. *nodulosus* (Wahlenb.) Lindm.
Juncus arcticus Willd.

LILIACEAE

Allium schoenoprasum L. var *sibiricum* (L.) Hartm.
Smilacina stellata (L.) Desf.
Tofieldia glutinosa (Michx.) Pers.
Tofieldia pusilla (Michx.) Pers.
Zygadenus elegans Pursh.

ORCHIDACEAE

Corallorrhiza trifida Chat.
Cypripedium calceolus L. var *parviflora* (Salisb.) Fern.
Cypripedium guttatum Sw.

Cypripedium passerinum Richards.
Goodyera repens (L.) R. Br.
Habenaria hyperborea (L.) R. Br.
Habenaria obtusata (Pursh) Richards.
Habenaria orbiculata (Pursh) Torr.
Listera borealis Morong
Orchis rotundifolia Banks

SALICACEAE

Populus balsamifera L.
Populus tremuloides Michx.
Salix alaxensis (Anderss.) Cov.
Salix arbusculoides Anderss.
Salix bebbiana Sarg.
Salix brachycarpa Nutt.
Salix interior Rowlee
Salix lasiandra Benth.
Salix myrtillifolia Anderss.
Salix novae-angliae Anderss.
Salix planifolia Pursh
Salix pseudomonticola Ball
Salix rigida Muhl.
Salix scouleriana Ba[illegible]

BETULACEAE

Alnus crispa (Ait.) Pursh
Alnus incana (L.) Moench ssp. *tenuifolia* (Nutt.) Breitung
Betula glandulosa Michx.
Betula occidentalis Hook.
Betula papyrifera Marsh var. *commutata* (Regel) Fern.
Betula pumila var. *glandulifera* Regel

SANTALACEAE

Geocaulon lividum (Richards) Fern.

POLYGONACEAE

Polygonum viviparum L.

CHENOPODIACEAE

Chenopodium capitatum (L.) Asch.

CARYOPHYLLACEAE

Minuartia dawsonensis (Britt.) Mattf.

RANUNCULACEAE

Actaea rubra (Ait.) Willd.
Anemone multifida Poir.
Anemone parviflora Michx.
Aquilegia brevistyla Hook.
Delphinium glaucum S. Wats.
Ranunculus hyperborea Rottb.
Thalictrum alpinum L.

FUMARIACEAE

Corydalis aurea Willd.

CRUCIFERAE

Braya humilis (C.A. Mey.) Robins
Descurainia sophioides (Fish.) O.E.Schulz.
Lesquerella arctica (Wormsk.) S. Wats.
Rorippa islandica (Oeder.) Borb.

SAXIFRAGACEAE

Mitella nuda L.
Parnassia montanensis Fern. and Rydb.
Parnassia palustris L. var. *neogaea* Fern.
Ribes oxycanthoides L.
Saxifraga azoides L.
Saxifraga oppositifolia L.
Saxifraga tricuspidata Rottb.

ROSACEAE

Dryas drummondii Richards
Dryas integrifolia M. Vahl.
Fragaria virginiana Duchesne ssp. *glauca* (S. Wats.) Staudt.
Potentilla fruticosa L.
Potentilla norvegica L.
Prunus pensylvanica L.
Prunus virginiana L.
Rosa acicularis Lindl.
Rubus pubescens Far.
Rubus strigosus Michx.

LEGUMINOSAE

Astragalus alpinus L.
Astragalus eucosmus Robins
Astragalus tenellus Pursh

Hedysarum alpinum L.

Hedysarum mackenzii Richards

Lathyrus ochroleucus Hook.

Oxytropis splendens Dougl.

Oxytropis varians (Rydb.) K. Schum

LINACEAE

Linum lewisii Pursh

EMPETRACEAE

Empetrum nigrum L. ssp. *hermaphroditum* (Lange) Bocher

VIOLACEAE

Viola sp.

ELEAGNACEAE

Elaeagnus commutata Bernh.

Shepherdia canadensis (L.) Nutt.

ONAGRACEAE

Epilobium angustifolium L.

Epilobium glandulosum Lehm. var. *adenocaulon* (Haussk.) Fern.

Epilobium latifolium L.

HALORAGACEAE

Hippuris vulgaris L.

ARALIACEAE

Aralia nudicaulis L.

CORNACEAE

Cornus canadensis L.

Cornus stolonifera Michx.

PYROLACEAE

Moneses uniflora (L.) Gray

Pyrola asarifolia Michx.

Pyrola chlorantha Sw.

Pyrola secunda L. var. *secunda*

ERICACEAE

Arctostaphylos rubra (Rehd. and Wils.) Fern.

Arctostaphylos uva-ursi (L.) Spreng.

Cassiope tetragona (L.) Don

Ledum groenlandicum Oeder

Rhododendron lapponicum (L.) Wahlenb.

Vaccinium uliginosum L.

PRIMULACEAE

Androsace chamaejasme Host

Primula stricta Hornem.

GENTIANACEAE

Gentiana acuta Michx.

BORAGINACEAE

Mertensia paniculata (Ait.) G. Don

SCHROPHULARIACEAE

Castilleja raupii Pennell

Pedicularis labradorica Wirsing

LENTIBULARIACEAE

Pinguicula vulgaris L.

RUBIACEAE

Galium boreale L.

Galium triflorum Michx.

CAPRIFOLIACEAE

Linnaea borealis L. var. *americana* (Forbs) Rehd.

Lonicera dioica L. var. *glaucescens* (Rydb.) Buttersl.

Symphoricarpos occidentalis Hook.

Viburnum edule (Michx.) Raf.

CAMPANULACEAE

Campanula aurita Greene

LOBELIACEAE

Lobelia kalmii L.

COMPOSITAE

Achillea lanulosa Nutt.

Achillea nigrescens (E. Mey.) Tydb.

Antennaria campestris Rydb.

Antennaria densifolia Porsild

Antennaria isolepis Greene

Antennaria pulcherrima (Hook.) Greene

COMPOSITAE (cont.)

Arnica alpina (L.) Olin ssp. *attenuata* (Greene) Maguire

Arnica alpina (L.) Olin ssp. *tomentosa* Macoun

Artemisia frigida Willd.

Aster alpinus L.

Aster ciliolatus Lindl.

Aster pansus (Blake) Cronq.

Aster sibericus L.

Crepis elegans Hook.

Erigeron acris L. var. *asteroides* (Andrz.) D.C.
= *Erigeron angulosus* var. *kamtschaticus* (D.C.) Hara.

Erigeron compositus Pursh.

Erigeron elatus (Hook.) Greene

Erigeron hyssopifolius Michx.

Erigeron lonchophyllus Hook.

Hieracium scabriusculum Schwein

Senecio indecorus Greene

Senecio pauperculus Michx.

Solidago canadensis L. var. *salebrosa* (Piper) M.E. Jones

Solidago decumbens Greene var. *oreophila* (Rydb.) Fern.

Taraxacum lacerum Greene

Appendix 3. Bryophytes of Prairie Creek alluvial fan, Nahanni National Park, N.W.T.

PTILIDIACEAE

Ptilidium ciliare (L.) Hampe

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid.

Distichium capillaceum (Hedw.) B.S.G.

Distichium inclinatum (Hedw.) B.S.G.

Ditrichum flexicaule (Schwaegr.) Hampe

DICRANACEAE

Dicranella grevilleana (Brid.) Schimp.

Dicranum fuscescens Turn.

Oncophorus wahlenbergii Brid.

ENCALYPTACEAE

Bryobrittonia pellucida R.S. Williams

Encalypta sp.

POTTIACEAE

Barbula icmadophila Schimp.

Bryoerythrophyllum recurvirostrum (Hedw.) Chen

Tortella fragilis (Hook. ex Drumm.) Limpr.

Tortella inclinata (R. Hedw.) Limpr.

Tortella tortuosa (Hedw.) Limpr.

GRIMMIACEAE

Schistidium gracile

FUNARIACEAE

Funaria hygrometrica Hedw.

BRYACEAE

Anomobryum filiforme (Dicks.) Solms.
= *Pohlia filiformis* (Dicks.) Andr.

Bryum caespiticium Hedw.

Bryum creberrimum Taylor
= *Bryum cuspidatum* (B.S.G.) Schimp.

Bryum pallens (Brid.) Sw. ex Rochl.

Mniobryum wahlenbergii (Web. & Mohr.) Jenn.

Pohlia nutans (Hedw.) Lindb.

MNIACEAE

Mnium cuspidatum Hedw.

Mnium medium B.S.G.

AULACOMNIACEAE

Aulacomnium palustre (Hedw.) Swaegr.

ORTHOTRICHACEAE

Orthotrichum speciosum Nees ex Sturm

Orthotrichum anomalum Hedw.

THUIDIACEAE

Abietinella abietina (Hedw.) Fleisch
= *Thuidium abietinum* (Hedw.) B.S.G.

AMBLYSTEGIACEAE

Campylium polygamum (B.S.G.) C. Jens.

Campylium stellatum (Hedw.) C. Jens.

Cratoneuron filicinum (Hedw.) Spruce

Drepanocladus revolvens (Sw.) Warnst.

Drepanocladus uncinatus (Hedw.) Warnst.

BRACHYTHECIACEAE

Brachythecium groenlandicum (C. Jens.)

Brachythecium salebrosum (Web. & Mohr.)BSG

Tomenthypnum nitens (Hedw.) Loeske

ENTODONTACEAE

Pleurozium schreberi (Brid.) Mitt.

HYPNACEAE

Hypnum cupressiforme Hedw.

Hypnum lindbergii Mitt.

Ptilium crista-castrensis (Hedw.) De Not.

Pylaisiella polyantha (Hedw.) Grout

RHYTIDIACEAE

Rhytidium rugosum (Hedw.) Kindb.

Rhytidiadelphus triquestrus (Hedw.)Warnst.

HYLOCOMIACEAE

Hylocomium splendens (Hedw.) B.S.G.

Appendix 4. Lichens of Prairie Creek alluvial fan, Nahanni National Park, N.W.T.

Alectoria ochroleuca (Hoffm.) Massal.
Bacidia bagliettoana (Massal. & De Not.) Jatta
Bacidia sphaeroides (Dicks.) Zahlbr.
Bryoria lanestris (Ach.) Brodo and D. Hawksw.
Buellia papilata (Somm.) Tuck.

Caloplaca cinnamomea (Th.Fr.) Oliv.
Caloplaca holocarpa (Goffm.) Wade
Caloplaca jungermanniae (Vahl) Th. Fr.
Caloplaca sinapisperma (Lam. & DC) Mah. and Gill.
Caloplaca stillicidiorum (Vahl.) Lynge

Caloplaca tetraspora (Nyl.) Oliv.
Caloplaca tiroliensis Zahlbr.
Candelariella lutella (Vain.) Ras.
Cetraria cucullata (Bell.) Ach.
Cetraria ericetorum Opiz

Cetraria halei W. and C. Culb.
Cetraria nivalis (L.) Ach.
Cetraria pinastri (Scop.) S. Gray
Cetraria tilesii Ach.
Cladina alpestris (L.) Harm

Cladina arbuscula (Wallr.) Hale and W. Culb.
Cladina mitis (Sanst.) Hale and W. Culb.
Cladina rangiferina (L.) Harm.
Cladonia acuminata (Ach.) Norrl.
Cladonia bacilliformis (Nyl.) Calla Torre and Sarnth.

Cladonia cenotea (Ach.) Schaer.
Cla[illegible]ia chloraphcea (Florke ex Somm.) Spreng
Cladonia [illegible]oniocraea (Florke) Spreng
Cladonia [illegible] (L.) Hoffm.
Cladonia gr[illegible] (L.) Willd. var. *dilatata* (Hoffm.) Vain.

C. gracilis ([illegible]ld. var. *gracilis*
Cladonia lepid[illegible] [illegible]yl.
Cladonia multiform[illegible] [illegible]err.
Cladonia phyllophor[illegible] [illegible]offm.
Cladonia pocillum (Ac[illegible]) [illegible]Rich.

Cladonia pyxidata ([illegible].) Hoffm.
Cladonia subulata (L[illegible]) Wig[illegible]
Collema sp.

Dactylina ramulosa (Hook.) Tuck.
Dermatocarpon lachneum (Ach.) A.L. Smith
Diploschistes bryophilus (Ehrh.) Zahlbr.
Evernia mesomorpha Nyl.
Evernia perfragilis Llano

Fistulariella minuscula (Nyl.) Bowler & Rundel (= *Ramalina miniscula*)
Fulgensia bracteata (Hoffm.) Ras. var. *bracteata*
F. bracteata var. *alpina* (Th.Fr.) Ras.
F. bracteata var. *deformis* (Erichs.)
Geisleria sp.

Heterodermia cf. *galactophylia* (Tuck.) W. Culb.

Heterodermia sp.
Hypogymnia austerodes (Nyl.) Ras.
Hypogymnia physodes (L.) W. Wats.
Lecanora epibryon (Ach.) Ach.

Lecanora impudens Degel.
Lecanora sp.
Lecidea decipiens (Hedw.) Ach.
Lecidea vernalis (L.) Ach.
Lecidea sp.

Lecidella glomerulosa (DC.) Choisy
Lecidella wulfenii (Hepp) Korb.
Leptogium papillosum (B. de Lesd.) Dodge
Leptogium saturninum (Dicks.) Nyl.
Microglaena sp.

Parmelia albertana Ahti
Parmelia exasperatula Nyl.
Parmelia sulcata T. Tayl.
Parmelia trabeculata Ahti
Peltigera leucophlebia (Nyl.) Gyeln.

Peltigera neckeri Mull. Arg.
Peltigera rufescens (Weis) Humb.
Peltigera spuria (Ach.) DC.
Pertusaria sp.
Phaeophyscia kairamoi (Vain.) Moberg = *Physcia kairamoi*

Physcia adscendens (Fr.) Oliv.
Physcia aipolia (Humb.) var. *alnophila* (Vain.) Lynge
Physconia muscigena (Ach.) Poelt
Polyblastia sendtneri Kremp.
Ramalina sinensis Jatta
Solorina bispora Nyl.
Solorina saccata (L.) Ach.
Squamarina lentigera (G. Web.) Poelt
Stèreocaulon tomentosa Fr.
Thamnolia vermicularis var. *subuliformis* (Ehrh.) Schaer.
Toninia caeruleonigricans (Lightf.) Th. Fr.
Toninia sp.
Usnea fulvoreagens Ras. (s. lat.)
Usnea rugulosa Vain. (s. lat.)
Usnea subfloridana Stirt. (s. lat.)

Appendix 5. Plant cover and frequency per community type for Prairie Creek fan, N.W.T.

Species	Heath cts			Scrub cts			Savannah/Woodland cts	
	Auu/Jh Lichen (41)	*Jh/Ca* (14)	*Dd* (11)	*Sa-i/ Eq-h* (3)	*Bet/Sa/ Eq* (3)	*Sa/Pf Auu* (3)	*Pg/Dd* (8)	*Pg-Ll/Jh/ Ca-s* (11)
Tree/Seedlings/ Saplings								
Picea glauca	1(85)	1(100)	2(100)	2(100)	+(33)	1(33)	1(100)	2(100)
Populus balsamifera	+(5)		+(100)		1(100)	2(100)	+(88)	+(9)
Larix laricina	+(13)	1(43)	1(45)				+(38)	1(100)
Betula papyrifera			+(45)					+(9)
P. tremuloides		R(7)						
Shrubs								
Salix pseudomonticola		+(42)	+(9)		2(100)	1(33)		+(18)
S. arbusculoides	+(5)		+(18)		+(33)	2(100)		+(45)
S. alaxensis			+(27)		2(100)	2(67)	+(13)	+(18)
S. brachycarpa						+(33)		
S. interior			R(9)	4(100)	+(33)			+(9)
S. lasiandra						+(33)		
S. planifolia						R(33)		
S. rigida						1(67)		
S. myrtillifolia								+(27)
Alnus incana	+(13)	+(21)	+(18)	+(33)	1(67)			+(18)
A. crispa	+(26)	+(21)					+(25)	
Betula glandulosa	+(20)				2(100)	2(100)	+(25)	
B. pumila	+(44)	+(14)			1(67)			
B. occidentalis	+(54)	+(29)	+(27)		+(33)			
Cornus stolonifera	+(10)	+(14)	+(36)		1(67)	1(67)		1(91)
Rosa acicularis	+(15)	+(29)	+(36)		+(33)	2(67)		1(100)
Rubus strigosus			R(7)			+(33)		
Potentilla fruticosa	+(69)	1(71)	1(82)		1(100)	2(100)	+(75)	1(64)
Eleagnus commutata						+(33)		+(27)
Shepherdia canadensis	+(36)	+(29)				+(33)	+(13)	1(55)
Viburnum edule						1(67)		+(36)
Lonicera dioica		+(14)						+(27)
Symphoricarpos occidentalis		R(14)						
Rhododendron lapponicum		R(3)						
Ledum groenlandicum	R(3)							+(18)
Juniperus Communis	1(77)	1(86)	+(18)			+(33)	+(25)	1(64)
J. horizontalis	1(100)	4(100)	+(36)			1(67)	2(50)	3(100)
Arctostaphylos uva-ursi	3(100)	2(93)	1(73)		+(67)	1(100)	+(38)	2(100)
A. rubra								+ 18)
Vaccinium uliginosum					+(33)			
Dryas drummondii	1(85)	1(71)	4(100)			1(67)	3(100)	+(18)
D. integrifolia	+(36)	+(29)					+(25)	
Linnaea borealis		+(14)						1(63)
FORBS								
Smilacina stellata	+(23)	+(21)	+(27)		+(33)	+(67)		+(45)
Tofieldia glutinosa		+(14)						+(27)
T. pusilla	+(23)	+(14)						+(45)
Zygadenus elegans	+(23)	+(71)	+(18)					+(45)
Cypripedium calceolus	+(18)	+(43)						
C. guttatum		+(14)						
C. passerinum	+(10)	1(36)						+(73)
Goodyera repens		+(14)	R(9)					+(36)
Habenaria hyperborea		+(36)			+(33)	+(67)		+(18)
H. obtusata		+(14)						+(27)
Orchis rotundifolia	R(3)							+(27)
Geocaulon lividum	R(3)	+(14)						+(36)
Minuartia dawsonensis		R(7)						
Anemone parviflora	+(31)	+(21)						+(45)
Corydalis aurea	+(8)							
Braya humilis	+(18)	+(21)					+(25)	
Descurainia sophoides							+(13)	
Lesquerella arctica	+(44)	+(57)	+(18)				R(13)	
Rorippa islandica		+(21)						
Mitella nuda								+(18)
Parnassia montanensis		R(7)						
P. palustris		R(7)			+(33)	1(100)		+(27)
Saxifraga aizoides	+(8)							
S. oppositifolia	+(8)							
S. tricuspidata	+(8)							
Fragaria virginiana	+(8)	R(7)	R(9)			+(33)		+(55)
Rubus pubescens								+(9)
Astragalus alpinus	+(8)	+(36)					+(38)	

Appendix 5

Species	Heath cts			Scrub cts			Savannah/Woodland cts	
	Auu/Jh Lichen	*Jh/Ca*	*Dd*	*Sa-l/ Eq-h*	*Bet/Sa/ Eq*	*Sa/Pf Auu*	*Pg/Dd*	*Pg-Ll/Jh/ Ca-s*
A. eucosmus	+(5)							
A. tenellus	+(5)							
Hedysarum alpinum	+(5)	1(57)	+(36)			+(67)	+(38)	+(55)
H. mackenzii	+(8)	2(57)	+(36)			+(67)	+(25)	+(36)
Lathyrus ochroleucus		+(43)						
Oxytropis splendens	+(56)	+(43)					+(13)	
O. varians	+(10)						+(38)	
E. latifolium							+(13)	
Cornus canadensis								+(18)
Pyrola asarifolia	+(5)	+(21)					+(13)	+(73)
P. chlorantha								+(9)
P. secunda								+(45)
Androsace chamaejasme	+(10)	+(57)						
Primula stricta		+(43)						
Gentiana acuta	R(3)	R(7)				+(33)		
Mertensia paniculata						+(33)		
Castilleja raupii	+(10)	+(36)						
Pedicularis labradorica	+(10)							
Pinguicula vulgaris					+(33)	+(33)		
Galium boreale	+(18)	+(64)	+(64)			+(67)	+(38)	+(64)
G. trifolium		+(21)						
Campanula aurita	+(13)	+(14)						
Lobelia kalmii		+(14)						
Achillea lanulosa	+(18)	+(57)				+(67)		+(9)
A. nigrescens	+(5)							
Antennaria campestris	+(33)	+(21)					1(50)	
A. densifolia	1(56)	+(43)					1(63)	
A. isolepis	+(33)	+(36)						
A. pulcherrima	+(38)	+(43)	+(18)			+(67)	+(63)	+(36)
Arnica alpina	+(33)	+(64)	+(18)			+(33)	+(13)	+(18)
Artemesia frigida	+(10)							
Aster alpinus	+(49)	+(36)	+(36)					+(18)
A. ciliolatus	+(8)	R(7)						+(45)
A. pansus	+(15)	+(43)						
A. sibiricus	+(18)	R(7)	+(18)					
Crepis elegans	+(10)							
Erigeron acris							+(13)	
E. compositus	+(21)	R(7)					+(63)	+(18)
E. elatus	+(10)	+(14)						
E. hyssopifolius	+(31)					+(33)	+(63)	
E. lonchophyllus	+(21)	+(14)			+(33)			(27)
Hieracium scabriusculum	+(10)	+(29)					+(38)	
Senecio indecorus	+(8)							
S. Pauperculus	+(74)	+(71)	+(45)			+(33)	+(38)	+(36)
Solidago canadensis	+(21)	+(36)						+(18)
S. decumbens	+(44)	+(64)	+(82)		+(33)	+(67)	+(63)	+(45)
Equisetum arvense					2(100)	+(67)		
E. hyemale				1(100)		+(33)		
E. pratense			R(9)		+(33)	+(33)		+(18)
E. variegatum		R(7)			2(67)	+(33)		
Selaginella selaginoides					1(67)			+(36)
Agropyron trachycaulon	+(10)	+(43)					+(13)	+(55)
A. violaceum		+(21)						
Agrostis scabra		+(21)						
Bromus pumpellianus	+(8)							
Calamagrostis canadensis		+(29)			1(67)			
C. neglecta		+(14)						
Danthonia intermedia	+(18)	+(29)						+(18)
Elymus innovatus	+(56)	2(100)	1(45)		1(100)	1(33)	+(38)	1(73)
Glyceria striata	+(5)	+(29)						
Hordeum jubatum		+(14)						
Poa pratensis		+(21)						
Trisetum spicatum		+(43)						
Carex aurea	R(3)	+(43)	R(9)					
C. concinna	+(36)	1(86)			+(33)	1(100)	R(13)	1(73)
C. eburnea	+(62)	+(50)	+(27)			+(33)		+(64)
C. filifolia	2(85)	1(36)	+(18)				+(38)	1(82)
C. membranacea	+(54)	+(64)						
C. scirpoidea	1(69)	2(100)	1(73)		1(100)	+(33)	1(63)	1(82)
BARE			4(100)	6(100)	3(100)	2(100)	2(100)	+(45)
LICHEN			+(36)			+(33)	1(100)	3(100)
MOSS			+(9)	+(33)	+(33)		+(50)	3(100)

Appendix 5

Species	Forest Ll-Pg Sa/Auu (21)	Pg/Jo (10)	Pg/Ra/Lb	Pb/Pg/At/Eq (10)	Pg/Ra/Eq (10)	Pg-Bet/CeRa/Co (2)	Pb Pg/Ce/Lb	Pb Pg/Ra Co (18)
Tree/Seedlings/ Saplings								
Picea glauca	2(86)	2(100)	2(100)	1(50)	2(100)	+(100)	2(100)	2(100)
Populus balsamifera	1(33)	+(50)	+(50)	+(60)	+(20)	+(50)	1(64)	1(55)
Larix laricina	1(62)	+(20)	+(25)	+(10)	+(20)		+(29)	+(11)
Betula papyrifera	+(5)				+(10)	2(100)		
Shrubs								
Salix pseudomonticola	1(81)	+(10)	1(88)	1(50)	+(30)	1(50)	+(14)	1(28)
S. arbusculoides	+(19)	+(20)	+(38)	+(20)	+(20)	1(100)	+(7)	+(17)
S. alaxensis	1(71)		R(13)	+(20)	+(10)	1(50)	+(14)	1(22)
S. bebbiana			+(25)		R(10)		+(21)	
S. interior	+(14)				+(10)			
S. planifolia	+(10)							
S. myrtillifolia	+(5)		+(13)	+(40)				
Alnus incana	1(24)	+(20)	+(25)	2(100)	+(10)	+(100)	1(43)	2(61)
Betula glandulosa	+(24)	+(10)	+(25)					
B. pumila	+(5)							
B. occidentalis	+(19)						+(29)	
Cornus stolonifera	1(67)	+(100)	+(100)	1(50)	+(50)	1(100)	2(93)	2(100)
Rosa acicularis	1(90)	2(100)	2(100)	+(60)	2(100)		1(64)	(78)
Potentilla fruticosa	1(95)	+(40)	+(25)	+(30)			1(57)	1(28)
Eleagnus commutata							+(21)	+(6)
Amelanchier alnifolia			R(13)					
Shepherdia canadensis	+(29)	+(70)	2(88)	+(10)	+(10)		+(29)	+(28)
Viburnum edule	+(43)	+(40)	1(88)	+(30)	1(80)	1(100)	+(21)	1(72)
Lonicera dioica	+(5)	+(20)	+(38)				+(14)	+(11)
Rhododendron lapponicum	+(5)							
Ledum groenlandicum	1(24)	+(20)	+(50)	+(30)	+(10)			+(6)
Ribes oxycanthoides						1(100)	+(7)	
Juniperus communis	1(43)	3(100)	2(88)	1(80)	2(80)		+(43)	1(22)
J. horizontalis	1(62)	+(50)	+(25)	+(20)	+(30)		2(64)	
Arctostaphylos uva-ursi	2(86)	+(50)	+(38)	+(10)	+(10)		2(93)	+(22)
A. rubra	1(62)	+(20)	+(63)	+(10)	+(30)		+(14)	
Empetrum nigrum	+(14)		+(25)					
Vaccinium uliginosum	R(5)		+(13)					
Dryas drummondii	+(10)			+(30)	+(10)		+(29)	
D. integrifolia	+(10)						+(7)	
Linnaea borealis	2(81)	2(80)	3(100)	1(70)	+(70)		1(100)	2(61)
FORBS								
Smilacina stellata	+(29)	+(20)	+(25)		+(40)		+(57)	+(11)
Tofieldia glutinosa	+(24)				+(10)		+(7)	+(6)
T. pusilla	1(48)		+(13)		+(10)		+(7)	
Zygadenus elegans	+(5)	+(20)	+(25)	+(10)			+(14)	+(6)
Cypripedium calceolus								+(6)
C. passerinum	1(48)	+(30)	+(38)	+(10)	+(20)		+(29)	+(33)
Goodyera repens	+(36)	+(33)	+(40)	+(13)				+(11)
Habenaria hyperborea	+(43)	+(50)	+(75)	+(30)	+(20)		+(14)	+(11)
H. obtusata			+(13)					
Listera borealis				+(20)	+(10)			
Orchis rotundifolia	+(29)	+(10)	+(38)	+(10)	R(10)		+(7)	+(6)
Geocaulon lividum	+(67)	+(20)	+(50)	+(60)	+(50)		+(29)	+(22)
Actaea rubra							+(7)	+(22)
Anenome multifida	+(5)							
A. parviflora	+(24)						+(14)	+(11)
Thalictrum alpinum								+(6)
Mitella nuda	+(19)	+(30)	+(50)	+(10)	+(20)	+(100)	+(7)	+(22)
Parnassia montanensis				+(10)				
P. palustris	+(48)	+(20)	+(13)	+(30)	+(30)		+(36)	+(50)
Fragaria virginiana	+(57)	+(20)	+(13)		+(30)	+(50)	+(43)	+(6)
Rubus pubescens	+(38)		+(50)		1(80)	+(100)		+(39)
Hedysarum alpinum	+(5)						+(21)	
H. mackenzii	+(5)		+(25)	+(10)			+(21)	
Viola sp.							+(7)	
Cornus canadensis	1(52)	+(20)	1(100)		1(100)	4(100)	+(21)	1(100)
Moneses uniflora							+(21)	+(17)
Pyrola asarifolia	+(62)	1(40)	+(50)	+(10)	+(60)	1(100)	+(21)	+(44)
P. chlorantha	+(10)		+(63)	1(40)				
P. secunda	+(33)	+(50)	+(25)		+(50)	1(100)		+(33)
Gentiana acuta	+(5)		+(13)		R(10)			+(6)
Mertensia paniculata		+(10)			1(20)	1(100)		
Castilleja raupii							+(7)	
Pinguicula vulgaris	+(24)	+(20)					+(7)	+(6)

Appendix 5

Forest

Species	Ll-Pg Sa/Auu (m)	Pg/Jc (p	Pg/Ra/ Lb	Pb/Pg/ Ai/Eq	Pg/Ra/ Eq	Pg Bet/ CeRa/Co	PbPg/ Ce/Lb	Pb Pg/ Ra/Ce
Galium boreale	+(33)	+(10)	+(38)	+(40)		+(50)	+(29)	+(17)
Achillea lanulosa	+(5)						+(14)	+(22)
C. neglecta	+(5)		+(25)					
C. purpurescens							+(7)	
Danthonia intermedia	+(5)	+(10)						
Elymus innovatus	1(71)	+(30)	+(25)	+(20)	+(20)		+(50)	+(28)
Festuca altaica						+(50)		
Oryzopsis pungens							+(7)	
Carex aurea			+(38)					R(6)
C. capillaris	+(5)		+(25)					
C. concinna	1(67)	1(60)	+(88)	+(10)	+(10)		+(43)	+(67)
C. eburnea	+(62)	+(30)	+(50)	1(60)	+(40)		+(29)	+(22)
C. filifolia	+(14)	+(10)					+(21)	+(6)
S. saxatilis	R(5)							
C. scirpoidea	+(29)	+(10)	+(25)	+(30)	+(20)	R(50)	+(50)	+(6)
BARE	+(14)	1(100)		1(60)			1(50)	+(11)
LICHEN	1(100)	+(20)	1(100)	+(50)	+(90)		1(50)	+(72)
MOSS	3(100)	2(100)	6(100)	2(10)	5(100)		4(100)	4(100)

Appendix 6. Age, dbh and height of major tree species and stems/ha and basal area/ha of tree species in plant communities, Prairie Creek fan, N.W.T.

Community Type	Species	No.	Age Range yrs	Dbh Range cm	Height Range m	Stems no. / ha	Basal Area m^2 / ha
Sa/Pf/Auu*	Pg	6	30-59	10-15	3-9.8	800-3700 (2200)	7-10.8 (8.1)
Pg-Ll/Jh/Ca-s	Pg	22	68-268	6-31	6.5-22	500-3859 (1440)	2.0-26.3 (12.1)
	Ll	20	86-232	14-27	9.8-16.9	200-4633 (740)	4.3-8.9 (5.9)
Pg-Ll/Sa/Auu	Pg	40	187-245	11-16	9.7-23	1900-3100 (2560)	16-23 (19)
	Ll	38	140-226	14-22	12.3-16	0-1100 (650)	0-6 (1.7)
Pg/Jc	Pg	16	110-240	10-41	8.6-31.5	800-2800 (1560)	34.8-63 (47)
	Ll	64	60-110	10-28	8-20	0-100 (25)	0-.02 (-)
	Pb	2		46-54	44-54	0-200 (50)	0-.1 (.02)
Pg/Ra/Lb	Pg		120-350	10-31	9.2-22.4	725-6700 (5400)	11-82 (55)
	Ll		100-183	14-21	14.7-16.8	25-280 (130)	.7-6.3 (4.1)
Pg/Ra/Eq	Pg	20	60-140	10-41	9-28	900-1080 (990)	24-26.4 (25.9)
	Pb	2		30-47*	17-20	130-140 (135)	.2-.3 (.25)

Appendix 6. Continued.

Community Type	Species	No.	Age Range yrs	Dbh Range cm	Height Range m	Stems no. / ha	Basal Area m²/ha
Pb-Pg/Ai/Eq	Pg	20	95-150	11-45	9.7-36.7	1050-2050 (1980)	28.6-65 (44)
	Pb	20	35-37	19-24	15.4-18	4000-28500 (17400)	4.2-15.8 (10)
Pg-Pb/Ra/Cc	Pg	38	60-70	8-25	7-22.8	4200-4650 (4400)	14.1-23 (20.8)
	Pb	38	12-32	12-32	9-25	90-202 (100)	.01-.06 (.02)
Pg-Pb/Cs/Lb	Pg	28	100-250	10-39	9-39	99-840 (770)	5.0-14.1 (9.8)
	Pb	28	100-150	20-25	14-30	1000-1800 (1670)	26-55 (38)
Pg-Bet-pap/ Cs-Ra/Cc	no data available						

*refer to Appendix 7 for a list of community types and their abbreviations.

Appendix 7. Plant community types, Prairie Creek fan, N.W.T.

HEATH COMMUNITIES

Juniperus horizontalis/Carex ct (*Jh/Ca*)
Arctostaphylos uva-ursi/J. horizontalis/Lichen ct(*Auu/Jh*/Lichen)
Dryas drummondii ct (*Dd*)

SCRUB COMMUNITIES

Salix interior/Equisetum hyemale ct (*Sa-i/Eq-h*)
Betula-Salix/Equisetum ct (*Bet-Sa*)
Salix/Potentilla fruticosa/Arctostaphylos uva-ursi ct (*Sa/Pf/Auu*)

SAVANNAH/WOODLAND COMMUNITIES

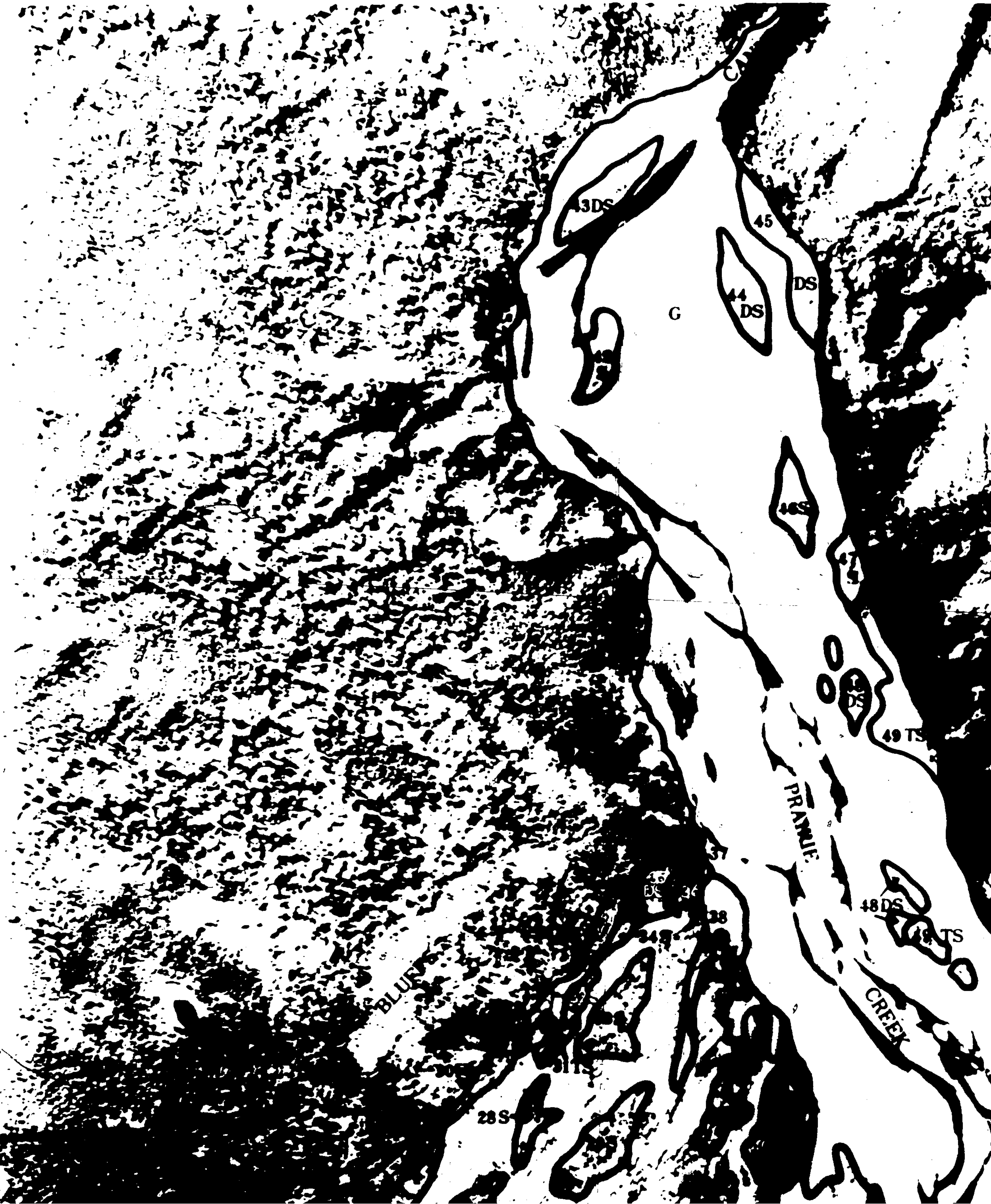
Picea glauca/D.drummondii ct (*Pg/Dd*)
P.glauca-Larix laricina/J.horizontalis/Carex scirpoidea ct(*Pg-Ll/Jh/Ca-s*)

FOREST COMMUNITIES

P.glauca-L.laricina/Salix/A. uva-ursi ct (*Pg-Ll/Sa/Auu*)
P.glauca/Juniperus communis ct (*Pg/Jc*)
P.glauca/Rosa acicularis/Linnaea borealis ct (*Pg/Ra/Lb*)
P.glauca/R. acicularis/ Equisetum ct (*Pg/Ra/Eq*)
Populus balsamifera-P.glauca/Alnus incana/Equisetum ct(*Pb-Pg/Ai/Eq*)
P.glauca-Betula papyrifera/Cornus stolonifera-R.acicularis/Cornus canadensis ct (*Pg-Bp/Cs-Ra/Cc*)
P.glauca-P.balsamifera/R.acicularis/Cornus canadensis ct(*Pg-Pb/Ra/Cc*)
P.glauca-P.balsamifera/Cornus stolonifera/Linnaea borealis ct (*Pg-Pb/Cs/Lb*)

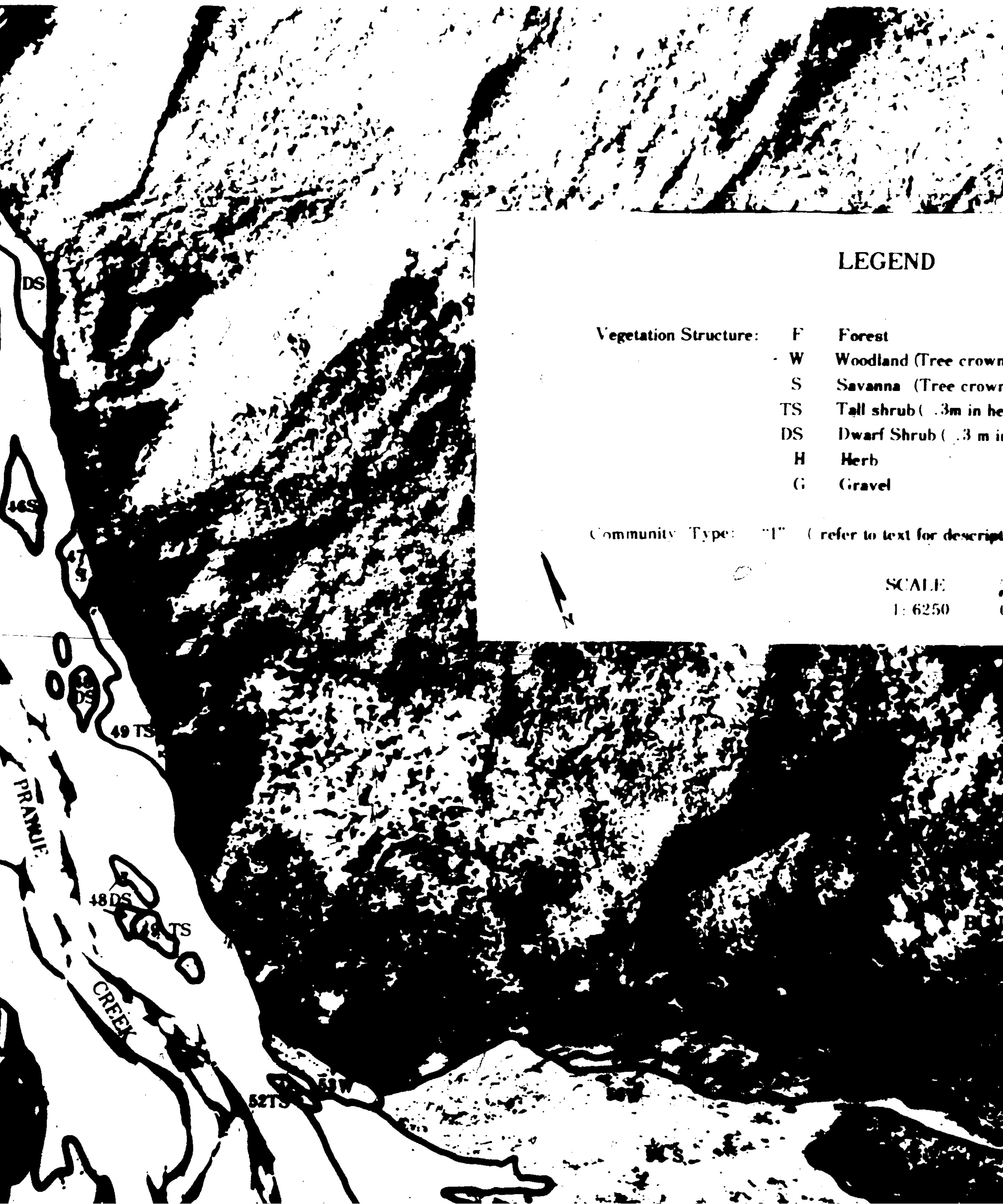
1 OF

MAP



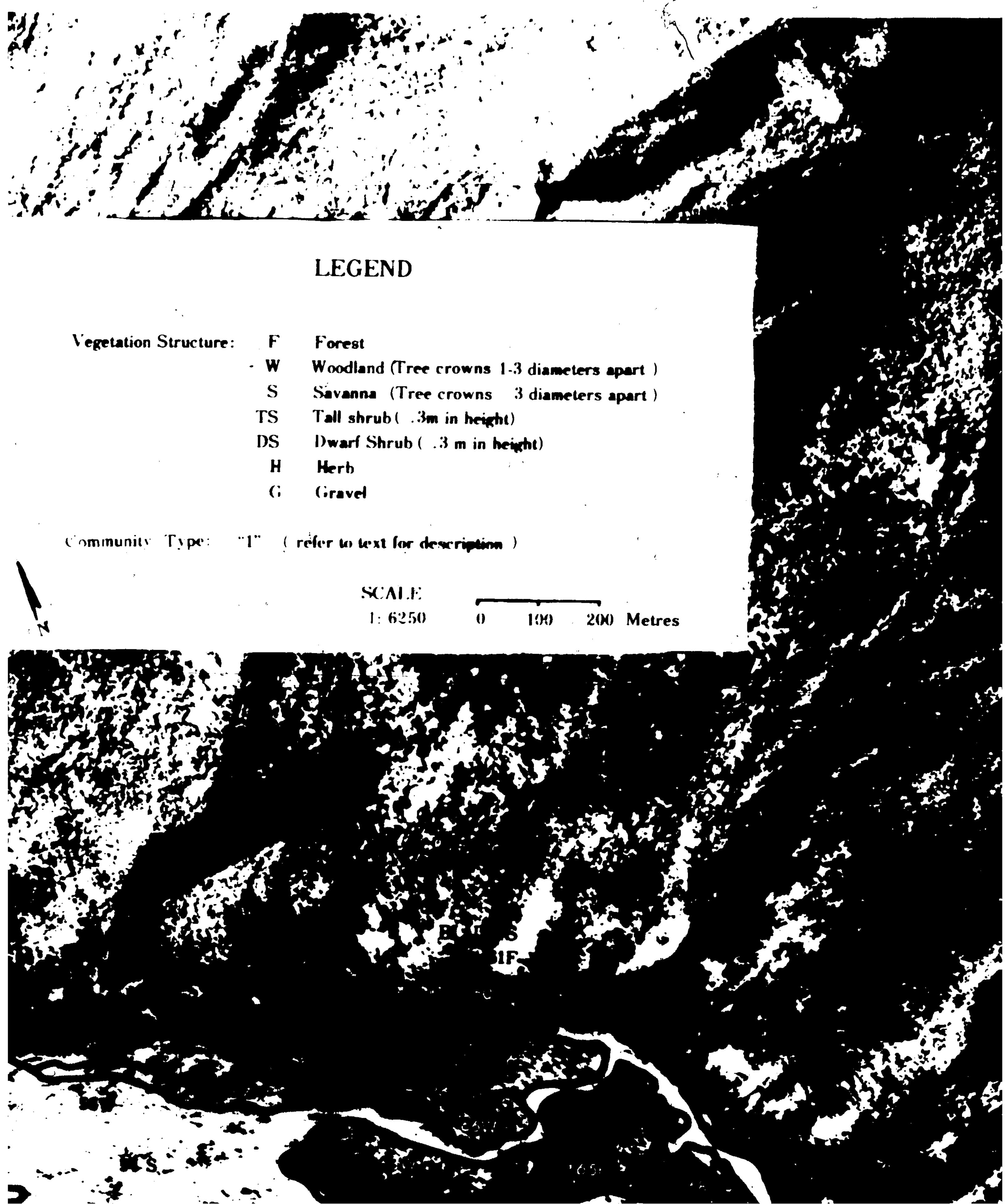
MAP I COMMUNITY TYPES

2 OF



'YPES

3 OF


LEGEND
Vegetation Structure: F Forest
W Woodland (Tree crowns 1-3 diameters apart)
S Savanna (Tree crowns 3 diameters apart)
TS Tall shrub (.3m in height)
DS Dwarf Shrub (.3 m in height)
H Herb
G Gravel
Community Type: "1" (refer to text for description)
SCALE
1: 6250
0 100 200 Metres
N

U.OF

CREEK
52 TS
53 W
G
82 S
83 S
85 W
89 TS
101 TS
102 F
110
98
108 W
117
118
121 W
127 S
128 DS
129 W
128 DS
120 DS
138 TS
139 DS
S
136
137 TS
134 TS
131 W
133
124
12 F
SOUTH
NAHANNI
RIVER

82 S
83 S
941
91TS
91W
101TS
102 F
79
RIVER
NAHANNI