ECOLOGY OF THE SOUTH NAHANNI AND FLAT RIVER AREAS

CONFIDENTIAL

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by

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A report submitted by the Canadian Wildlife Service
to the National and Historic Parks Branch

Edmonton, Alberta
November 15, 1971

TABLE OF CONTENTS

Table of Contents (Cont'd)

LIST OF ILLUSTRATIONS

List of Illustrations (Cont'd)

List of Illustrations (Cont'd)

List of Illustrations (Cont'd)

LIST OF TABLES

INTRODUCTION

"The sun slid down the sky and shadows swung and deepened but time, for me, had lost its meaning, for I myself was lost in fascination of this place of wild, chaotic beauty. I climbed over the rocks on either side into shadowy, dripping clefts where ferns and mosses glistened in the never-ending rain: I came out again into the hot sunshine and hunted on the beaches for fossils of strange, queer water beasts, and then crossed over to lie on the sun-warmed rocks of the north shore. The best view was from there, where the shining rim of the Falls cut across the cloudless blue: the drop to the pool was broken by a step springing out from the southern precipice and widening to the north like the step of a turret stair; from this step sprang a glistening tower of rock that reached far above the upper step or rim and cut the Falls in two. A cloud of spray, glittering against the afternoon sun, wreathed and twisted around the sharp peak of this limestone pillar: that would be where the cataract hurled itself against the rock before taking the final plunge. A fine picture it made and a most tumultuous din, for the Nahanni here was at least as big, I thought, as the Rhône at Lyon.

"The trail climbed high and then dropped gently towards the river, and from a little bare hill we got our first sight of the upper Nahanni, stretching on into the evening between low, forested banks, calm and beautiful like a great lake. We looked around for a good landing place, found one and blazed it for future reference; then we fell to on blueberries, cranberries and raspberries till we were stuffed and lay contentedly on the little knoll, watching the sun set behind low mountains and the shift and play of its light over the calm water." (Patterson, 1966, pp. 74 and 81.)

These word paintings of the great Virginia Falls (Figs. 1 and 2) and the South Nahanni River reflect the aura of sheer wonder and delight experienced by Patterson and Faille, two men alone in a rugged wilderness so beautiful and awe-inspiring that even such prose becomes inadequate to describe it. This was the summer of 1927, and the Nahanni country was unmapped and known to few people. Forty-four years later the Nahanni is still a wilderness, and if those two young men had stood on the fossil-strewn beaches below the falls, if they had canoed through The Gate past Pulpit Rock, or if they had climbed to the alpine meadows of the Tlogotsho Range yesterday, they would have noticed no change, except perhaps for a set of contrails from a high flying jet aircraft. It is this wilderness setting that is to be preserved by those who seek to make the area a National Park.

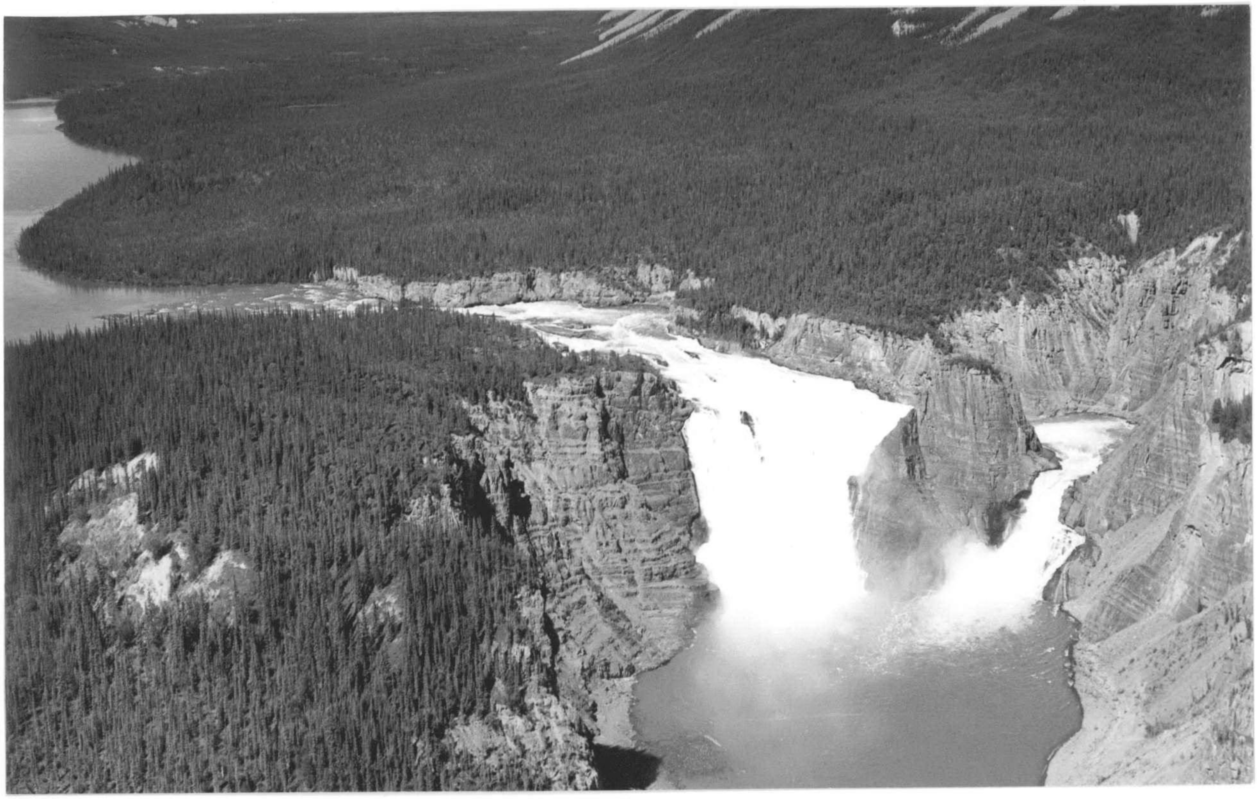
In the spring of 1970, the National and Historic Parks Branch asked the Canadian Wildlife Service to conduct a biological survey of the South Nahanni and Flat River regions so that they could use the information in planning the establishment of a National Park in the area. The area had been examined officially by Park Service personnel (Baker, 1963, 1965; Brooks and Eidsvik, 1963). The Park Service's Planning Division conducted a more detailed reconnaissance of the area in 1969, and as a result of this survey tentative boundaries for a proposed National Park were drawn up (National Parks Service, 1970).

Fig. 1. Virginia Falls.

(Photo: W. D. Addison, 6 July, 1966.)

Fig. 2. The 300 foot vertical drop of Virginia Falls generates a summer long mist that wets a wide area round the plunge pool.

(Photo: W. D. Addison, 23 July, 1966.)



Those boundaries served as a reference for the survey conducted by the Canadian Wildlife Service.

The field party left Fort Simpson by jet boat on 24 June, 1970. They travelled the Liard and South Nahanni Rivers to Virginia Falls and up the Flat River to the impassable rapids just beyond Irvine Creek. They inspected areas surrounding the rivers between Nahanni Butte and Seaplane Lake in a Bell 47G 3B-1 helicopter. This first phase of the field work was terminated on 4 July, 1970, so that the participants could return to their various projects.

On 9 September, 1970, George Scotter left Nahanni Butte in a scow piloted by Dick Turner of Nahanni Butte and travelled upriver to Deadmen Valley. Norman Simmons and geologist Richard Tinsley of Canada Tungsten Ltd. flew by Bell 206 "Jet Ranger" helicopter from Tungsten to meet them there on 11 September. They then inspected the area from the mouth of First Canyon west and northwest to Tungsten. The survey was terminated on 13 September when George Scotter returned to Nahanni Butte by boat and Norman Simmons and Richard Tinsley returned to Tungsten. Because of other project commitments, both periods available for field work were seriously inadequate.

George Scotter accompanied Gerry Lee of the National and Historic Parks Branch and a film crew into the region from 13 September through 20 September, 1971. The trip provided an opportunity to collect additional ecological data from the region.

ACKNOWLEDGEMENTS

To Harry Armbruster, Moise Antoine, Dick Turner, and Richard Tinsley, members of our field teams, belong much of the credit for the smooth operation of the survey. All were experienced field men who performed their tasks in a cool, cheerful, relaxed manner that helped make our work pleasant. The dangers of the Nahanni are no less now than they have ever been, but due to the skills of these men, they were taken in stride.

M. H. Drinkwater, Director of the Northern Forest Research Center, Canadian Forestry Service, loaned us Stephen Zoltai's services for compilation of vegetation and landform maps. Superintendent Paul Kwaterowsky of the Territorial Game Management Division and Game Management Officer Max Trennert offered Moise Antoine's services. Superintendent Walter Moore and Forest Management Officer Bernie Gauthier of the Mackenzie Forest Service provided access to their records on the survey area and kindly offered the use of the Forest Service cabin at Deadmen Valley.

David Ellis, an employee of Peñarroya Canada Ltd. at the Peñarroya prospect site on Prairie Creek, carefully recorded the sightings of large mammals, on 1:250,000 scale maps, made by him and his colleagues in the area between 61°N and 62°30'N, north and south of the prospect.

William D. Addison gave us detailed records of fish collections and mammal sightings made by him and his wife during their trip through the South Nahanni River watershed in the summer of 1966. He also offered us access to his many fine photographs of the area, some of which are included in this report.

We interviewed Gus and Mary Kraus, long-time residents of Nahanni Butte and the Hot Springs at the mouth of First Canyon, and Albert Faille, a well known prospector who began travelling through the survey area in the 1920's and probably knows the two rivers like no other man yet alive. Gus and Mary Kraus, Albert Faille, and Dick and Vera Turner are keys to much of our knowledge about the Nahanni - they are part of the Nahanni.

Don Turner, Nahanni Butte resident and big game hunting outfitter, generously flew George Scotter from Nahanni Butte to Fort Simpson and flew back with a mechanic when our boat's engine failed near the mouth of the Liard River in July, 1970. He also provided us with valuable information about the survey area he has flown over and hunted in for years.

Pilots Steve Harrison and Sid Baird of Frontier Helicopters at Watson Lake, Yukon Territory, are both skilled in mountain flying. They cheerfully and dextrously performed the difficult but necessary canyon flying and mountain top landings without incident.

Nat J. Simpkins of the Water Quality Subdivision, Inland Waters Branch, Department of Energy, Mines and Resources, took the time to translate the cryptic water quality data, routinely issued by his branch, into the interesting, readable description of the waters of the South Nahanni and Flat Rivers that appears in this report. Nat Rutter, Geological Survey of Canada, reviewed the chapter on geology and made helpful comments that have been reflected in the text. Tom Barry, a Canadian Wildlife Service ornithologist, read our section on

birds and offered useful comments on the bird list. Ragna Baumann and Howard Samoil of the Canadian Wildlife Service spent long, tedious hours hand-coloring maps for the report and otherwise being of valuable assistance to the authors. Clint Jorgensen of the Canadian Wildlife Service and N. B. Schultz of the Canadian Forestry Service did all map drafting and lettering work.

W. J. Cody and other staff members of the Plant Research Institute, Canada Department of Agriculture, assisted in identifying and in verifying the identification of vascular plants. George W. Argus, Department of the Environment, and John H. Hudson, W. P. Fraser Herbarium, provided expert assistance with the *Salix* and *Carex* genera, respectively.

HISTORY

The glaciers were in full retreat 15,000 years ago, and the Pacific coast of North America, with its abundant fish and game, probably seemed like a paradise to the hunting tribes that had been lured from Asia across the Bering Strait to the new continent. Probably among the latest immigrants were the Athapaskan people. Their linguistic kinship with the peoples of eastern Asia can still be discerned (Jenness, 1955).

Some tribes having the Athapaskan lingual stock remained in northwestern Canada, while some moved south into the southwestern United States. An old woman told Father Petitot once that "Long before the white men appeared amongst us, my mother told me that a star had appeared in the west southwest and that many of our people followed it. Since that time we are separated from each other. The Montagnais [Algonkians of northeastern Quebec] are in the south; their arrows are no good. The Loucheux [Athapaskans of the lower Mackenzie valley] are in the north; their women are unhandy and no good. But the Denes, the real men, we remained in the Rocky Mountains, and it is not long since we came here to the banks of the Mackenzie" (Duchaussois, 1937). The Mackenzie River basin supported a scanty population of migratory Athapaskans because of the limited resources of the area. They were isolated from centers of more advanced culture.

Two of the 14 Athapaskan-speaking tribes, the Slave and the Nahanni*, travelled and camped in the South Nahanni and Flat River areas

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* A term meaning "people over there far away" (Jenness, 1955). Jenness spells the word "Nahani."

at least as early as the eighteenth century. The distribution of both tribes in the 1700's was influenced by the invading Cree. The Slave Indians, so named by the contemptuous Cree, were pushed into the eastern slopes of the Mackenzie Mountains by these invaders (Jenness, 1955).

The Mackenzie Mountains, like the Mackenzie River valley, have proven barren fields for archaeologists, apparently because the Slaves and Nahannis were migratory peoples and, until recently, never stayed long enough in one place to leave extensive remains. One of the least known of the mountain people are the Nahannis. It is known that in the 18th century the Crees massacred many of the Nahannis residing in the upper Liard River valley and forced the survivors into the mountains to the north. In more recent times, a band of Nahannis called the Esbataottine or Goat Indians occupied the land along the Beaver River in the Yukon Territory and along the South Nahanni River. This band included, or was closely related to, a band at the headwaters of the Keele [Gravel] River (Jenness, 1955).

Presently the Nahanni Indians are found in and around the communities of Liard River, Ross River, and Whitehorse, Yukon Territory (Indian Affairs Branch, 1968). Slave Indians occupy several villages from Fort Norman south along the Mackenzie, Liard and Hay Rivers, including Nahanni Butte at the mouth of the South Nahanni River.

The death knell of the nomadic ways of the Slave and Nahanni Indians first sounded in the early 1800's by the establishment of trading posts or "Forts" along the Mackenzie River valley by the

North West Company and, later, the Hudson's Bay Company. The post at Fort Simpson was established in 1804 and much later named after Sir George Simpson, a Governor of the Hudson's Bay Company. Fort Liard was established in 1805. Nahanni Butte was settled much more recently.

The trading posts destroyed the independence of the Athapaskans of the Mackenzie valley. Many of the Slaves settled around the trading posts of Fort Simpson and Fort Liard, and Nahannis settled near Ross River and along the Pelly River, and slowly gave up their old ways.

In the Mackenzie Mountains, however, as recently as the early 1900's, the Nahannis of the Ross and Pelly Rivers were careful not to approach too closely to the headwaters of the two rivers because of the evil spirits in the form of gigantic Indians who were supposed to inhabit the mountains of the divide. Perhaps these "spirits" were the 100 or so Indians, called Mountain Men, who hunted and trapped around the headwaters of the Keele and South Nahanni Rivers. Explorer J. Keele thought these were a superior class of men, perhaps because they were among the few who were able to cling to their old independent ways in the face of the advancing white man. They may have been Nahannis; if not they were Slaves. In any case, Keele said they moved back and forth along the Keele River valley on trading journeys to and from the trading post at Fort Norman (Keele, 1910).

Perhaps the first white men to see the Nahanni or Flat River region were A. R. McLeod and J. M. McLeod. Unfortunately the report of A. R. McLeod's winter journey of 1823 is missing. Journals covering

J. M. McLeod's exploration in 1823 and again in 1824 are preserved in the Hudson's Bay Company's Archives.

By the late 1850's, Protestant missionaries had already been in the Fort Simpson area. The first Catholic priest came in 1858 and found their influence among the Indians strong. A Catholic mission was established in 1894 and Catholicism slowly became the most influential religion among the Indians of the area (Duchaussois, 1937). A Roman Catholic mission was established later at Fort Liard.

The thread of history of the South Nahanni and Flat River areas becomes easier to follow from about 1890 on. Charles Camsell (1954) described life in the area of the Hudson's Bay Company posts at Fort Liard and Fort Simpson between 1890 and 1900. He also described his trips through the Mackenzie Mountains and comments on the Indians he met en route. Duchaussois (1937) and other Catholic missionaries described their life with Indians in and near settlements in the early 1900's.

Perhaps the most famous commentary about the area in the early 1900's is a book, The Dangerous River, written by adventurer R. M. Patterson and first published in 1954. At that time the Nahanni River country was shrouded in myth and mystery, and this aura prevails even today. One author wrote that the Indians occupying the area were "a hardy and virile people, but have suffered much from white influence. They are hostile to strangers, and many white pioneers have been done to death by them. This tribe [Nahanni] was for many years under the complete domination of one woman, supposed to be partly of European descent" (quoted by Patterson, 1966, p. 18).

The stories of gold in the South Nahanni area in the early 1900's, tales of the beauty and danger of the South Nahanni River, and the myths surrounding the white prospectors, trappers, and hunters who imprudently got into trouble when they followed the river were all woven together to form the modern legend of the Nahanni. Patterson tells it well.

> "The Nahanni? There was gold in there somewhere - coarse gold and lots of it away up beyond those deep canyons. Deadmen's Valley was tucked away in there some place - hadn't I heard of it? A valley between two canyons where the McLeods were murdered for their gold in 1906. No man ever knew what happened to them, but they were found - at least their skeletons were - tied to trees, with their heads missing. Laugh that one off! And enough men had disappeared in there since then that it was considered best by men of sense to leave the Nahanni country alone. But there was another lunatic who meant to try his luck in there - I would most likely run into him on the way down the Mackenzie. Albert Faille, his name was; he'd been trapping on Beaver River near the outlet of the Great Slave and now he's got the Nahanni bug into his head. Red Pants, the Indians called him because he always wore great, heavy work pants of scarlet stroud. He's pulled out with his canoe just a couple of days ago, and with them red pants on him a blind man couldn't miss him ....
>
> "The Nahanni, they said, was straight suicide. The river was fast and bad, and if a man ever did get through those canyons what would he find in that little-known country of the Yukon divide? Gold - gold without end, guarded quite likely by horned devils for all anybody knew to the contrary, but certainly by the wild Mountain Men - Indians who never came in to any trading post either in the Yukon or in the Northwest Territories. They lorded it over the wild uplands of the Yukon-Mackenzie divide and made short work of any man, white or Indian, who ventured into their country. Just ask the Indians here or better still the Indians at Fort Wrigley. Why, you couldn't bribe them with all the marten in the North to go back west more than thirty miles from the Mackenzie! No - we'd better all have another drink and be sensible and forget about the South Nahanni ...." (Patterson, 1966, pp. 20 and 21.)

Slave Indians had been living near the junction of the South Nahanni and Liard Rivers long before Patterson came to the area. In the early 1900's, they were established in two villages about 14 miles apart. One was on the South Nahanni River at the foot of Nahanni Butte; the other, called Netla, was located on the Liard River about 12 miles upstream from its junction with the Nahanni. In 1942, the Kraus family came to the Butte and settled. Other white trappers and prospectors had been living there since the 1920's; men like Field, Rollier, and McNeill. The Turner family came to the Butte in 1948 after having trapped and prospected in the area for 16 years. Dick Turner set up a trading post there that lasted until 1969. In 1965, the Krauses decided the Butte was too crowded and moved to the hotsprings at the mouth of First Canyon. There Gus Kraus built the log home they occupied until 1971. (Pers. comm., Fr. H. Posset, Fort Simpson, 27 May, 1971.)

The recent history of the area makes relatively dull reading. It is told by anthropologists making economic surveys of Fort Simpson, Fort Liard, Nahanni Butte, and Tungsten (Higgins, 1969). But the myth prevails, enhanced by colorful residents of the area like Albert Faille and Gus Kraus. Long-time Nahanni Butte resident Dick Turner has written a history of his days in the Nahanni area, but it has yet to be published. Perhaps he will show us a chronicle of the area that will become a classic text for those who wish to separate fact from myth about that fascinating country.

Presently, the South Nahanni and Flat River areas are unoccupied by man except for three populated areas. At the headwaters of the Flat

River is the predominantly non-Indian mining community of Tungsten. The population ranges from about 120 to 170 persons. The fluctuation is due to the cyclic nature of the mining activity conducted by Canada Tungsten Ltd. Nahanni Butte has a predominantly Indian population that ranged from 53 to 61 between 1957 and 1969. The mining settlement on Prairie Creek fluctuates widely in population from less than five individuals to over 100.

CLIMATE

The climate of the area as a whole is continental with short warm summers and long cold winters. Even though high temperatures have been recorded in the Flat and South Nahanni River valleys, the growing season is short and never free from the danger of frost. At Fort Simpson, there is an average frost-free season of only 70 to 75 days (Raup, 1947).

June and July are pleasant summer months in the South Nahanni and Flat River areas with practically no darkness and temperatures reaching into the low eighties. At both Tungsten (elevation ± 4,250 feet) and the Peñorroya site (elevation 2,852 feet), mean daily minimum temperatures have been above freezing in June through August. July is the warmest month of the year (Tables 1 and 3, and Figs. 3 and 4).

The coldest month of the year is January. There are only about five hours of sunshine, and temperatures have dipped as low as -55°F. The temperature in January rarely rises above zero.

June, July, and August are the months of greatest rainfall, with July usually being the wettest month (Tables 2 and 3 and Figs. 5 and 6). The total precipitation for the average year is 23 inches. Figure 6 and Table 3 show precipitation in 1970, an untypical year, in the Prairie Creek area. Rainfall was 21 inches, but much of it (8 inches) fell during a short period in August, causing a flood that destroyed expensive property at the prospect site.

Snow may fall over the headwaters of the Flat River during every month but June, July, and August. The month that averages the greatest amount of snowfall is November (29 inches). The total snowfall for the average year is 100 inches. Farther east of the divide, snowfall is generally much lighter and snow depth is a considerably less important limiting factor to wildlife. During 1970, 28 inches of snow fell in the Prairie Creek area, most (10 inches) during October.

Small watercourses may begin to freeze as early as mid-September, and ice may begin to form on the larger streams in October. The high mountain lakes may be frozen over by the end of October.

By June, little snow remains on the mountains. The South Nahanni River ice usually breaks up in late April, but the river is not navigable until mid-May. The Flat River may break up about the same time.

TABLE 1. Temperature records for Tungsten, Northwest Territories. (Unpubl. Ministry of Transport, Meteorological Branch, data.)

Mean Daily Maximum Temperatures (Degrees F)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										26.9	3.1	9.9
1967	- 4.0	6.5	10.8	33.4	46.3	61.4	61.3	60.4	48.7	32.3	23.0	
1968	- 0.8	14.2	24.2			59.4	64.2*	53.8*	44.5	30.5	17.4	- 3.4*
1969	-17.5	7.3	20.5		47.1	64.9	58.2	50.6*	45.5	35.6	11.8	16.0
1970	- 1.6	16.6	23.9			56.1	59.4	57.5	43.0	31.4*	7.6	- 1.0
1971	- 9.0	15.3	15.9									
$\bar{\bar{X}}$	- 6.6	12.0	19.1	(33.4)	46.7	60.4	60.8	55.6	45.4	31.3	12.6	5.4

Mean Daily Minimum Temperatures (Degrees F)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										16.8	-14.1	-12.6
1967	-19.9	-14.2	-16.0	8.0	27.0	36.8	40.6	39.3	32.6	22.0	1.7	-12.1
1968	-20.6	- 6.1	7.7			38.8	40.4*	38.5*	29.8	13.6	- 3.8	-21.5
1969	-35.4	-13.7	- 2.0		28.0	37.2	40.2	33.6	29.5	16.8	- 2.4	0.7
1970	-16.5	- 4.6	1.2			37.5	39.9	36.5	30.1	15.0*	- 8.7	-20.0
1971	-30.0	- 6.7	-10.1									
$\bar{\bar{X}}$	-24.5	- 9.1	- 3.8	(8.0)	27.5	37.6	40.3	37.0	30.5	16.8	- 5.5	-13.1

TABLE 1. (Cont'd)

Mean Daily Temperatures (Degrees F)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										21.9	- 5.5	- 1.4
1967	-12.0	- 3.9	- 2.6	20.7	36.7	49.1	51.0	49.9	40.7	27.2	12.4	
1968	-10.7	4.1	16.0			49.1	52.3*	46.2*	37.2	22.1	6.8	1.7
1969	-26.5	- 3.2	9.3		37.6	51.1	49.2	42.1*	37.5	26.2	4.7	8.4
1970	- 9.1	6.0	12.6			46.8	49.7	47.0	36.6	23.2*	- 0.7	-10.5
1971	-19.5	4.3	2.9									
$\bar{\bar{X}}$	-15.6	1.5	7.6	(20.7)	37.2	49.0	50.6	46.3	38.0	24.1	3.5	0.4

Extreme Maximum Temperatures (Degrees F)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										42	34	24
1967	22	29		49	60	74	70	72	68	39	36	
1968	34	46	38		62	67	74			38	30	36*
1969	5	25	31		62*	83*	72*	68	56	51	35	28
1970	28	35	39			68	73		54	42	33	31
1971	29	37	29									

TABLE 1. (Cont'd)

	Extreme Minimum Temperatures (Degrees F)											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										-13	-33	-42
1967	-42	-38	-36	-6	19	28	32	31	19	6	-31	-32
1968	-47	-55	-14		12	29	34*	31*	18*	- 6*	-20	-43
1969	-49	-37	-23		22	29*	34*	27*	17*	- 5	-42	-16
1970	-44		-26			28			6		-35	-45
1971	-52	-44	-30									

*Incomplete data

TABLE 2. Precipitation records for Tungsten. (Unpubl. Ministry of Transport, Meteorological Branch, data.)

Total Precipitation in Inches and Number of Days
Having 0.01 Inch or More Precipitation (in brackets)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										3.34 (24)	2.63 (15)	1.32 (19)
1967	1.02	1.46 (11)	0.13 (2)	0.67 (6)	0.54*	2.66 (9)	3.19 (22)	2.78 (15)	2.16 (13)	1.73 (9)	2.14 (14)	1.08 (11)
1968	0.60 (7)	0.30 (3)	0.60 (6)			4.41	3.15 (14)	2.40	4.14			0.58 (6)
1969	0.32 (3)	0.09 (2)	0.49 (3)			1.83	5.87	4.49	1.54 (8)	1.25	4.77	0.81 (12)
1970	1.01 (16)	1.82 (12)	1.35 (13)			2.51 (16)	4.31	3.68	2.64 (15)	3.70 (16)	1.81 (11)	1.92 (15)
1971	2.48 (8)	1.44 (11)	0.82 (11)									
$\bar{\bar{X}}$	1.09	1.02	0.68			2.85	4.13	3.34	2.62	2.50	2.84	1.14

TABLE 2 (Cont'd)

	Total Snowfall in Inches and Number of Days Having 0.1 Inch or More Snowfall (in brackets)											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1966										25.0 (22)	26.3 (15)	13.2 (19)
1967		14.6 (11)	1.3 (2)	6.7 (6)	0.5*	0.0	0.0	0.0	2.3 (3)	13.7 (7)	21.4 (14)	10.8 (11)
1968	6.0 (7)	3.0 (3)	6.0 (6)			0.0	0.0	0.0	12.4			5.8 (6)
1969	3.2 (3)	0.9 (2)	4.9 (3)			0.0	0.0	trace	4.9 (2)	4.2 (4)	47.7	8.1 (12)
1970	10.1 (16)	18.2 (12)	13.5 (13)			0.0	0.0	trace	1.1 (3)	36.2 (15)	18.1 (11)	19.2 (15)
1971	24.8 (8)	14.3	8.2 (11)									
$\bar{\bar{X}}$	11.02	10.20	6.78			0.0	0.0	trace	5.18	19.78	28.38	11.42

*Incomplete data

TABLE 3. Temperature (degrees F) and precipitation (inches) records for the Peñarroya prospect, Northwest Territories, 1970.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean daily maximum temperature		18.4	27.7	39.6	52.2	63.9	66.1	62.5	48.1	33.6	7.8	
Mean daily minimum temperature		- 8.2	- 1.6	12.7	30.2	38.7	41.3	39.0	30.3	12.8	- 6.5	
Mean daily temperature		5.1	13.1	26.2	41.2	51.3	53.7	50.8	39.2	23.2	0.7	
Maximum extreme daily temperature		42	44	52	64	77	78	80	61	52	31	
Minimum extreme daily temperature	-45	-38	-35	0	20	26	32	28	-1	-14	-37	
Total precipitation and number of days 0.01 inch or more		0.28 (3)	0.03 (1)			3.36 (11)	4.24 (10)	8.06 (14)	2.81 (17)	1.10 (11)	0.68 (6)	
Total snowfall and number of days 0.01 inch or more		2.8 (3)	0.3 (1)						8.1 (3)	10.1 (9)	6.8 (6)	

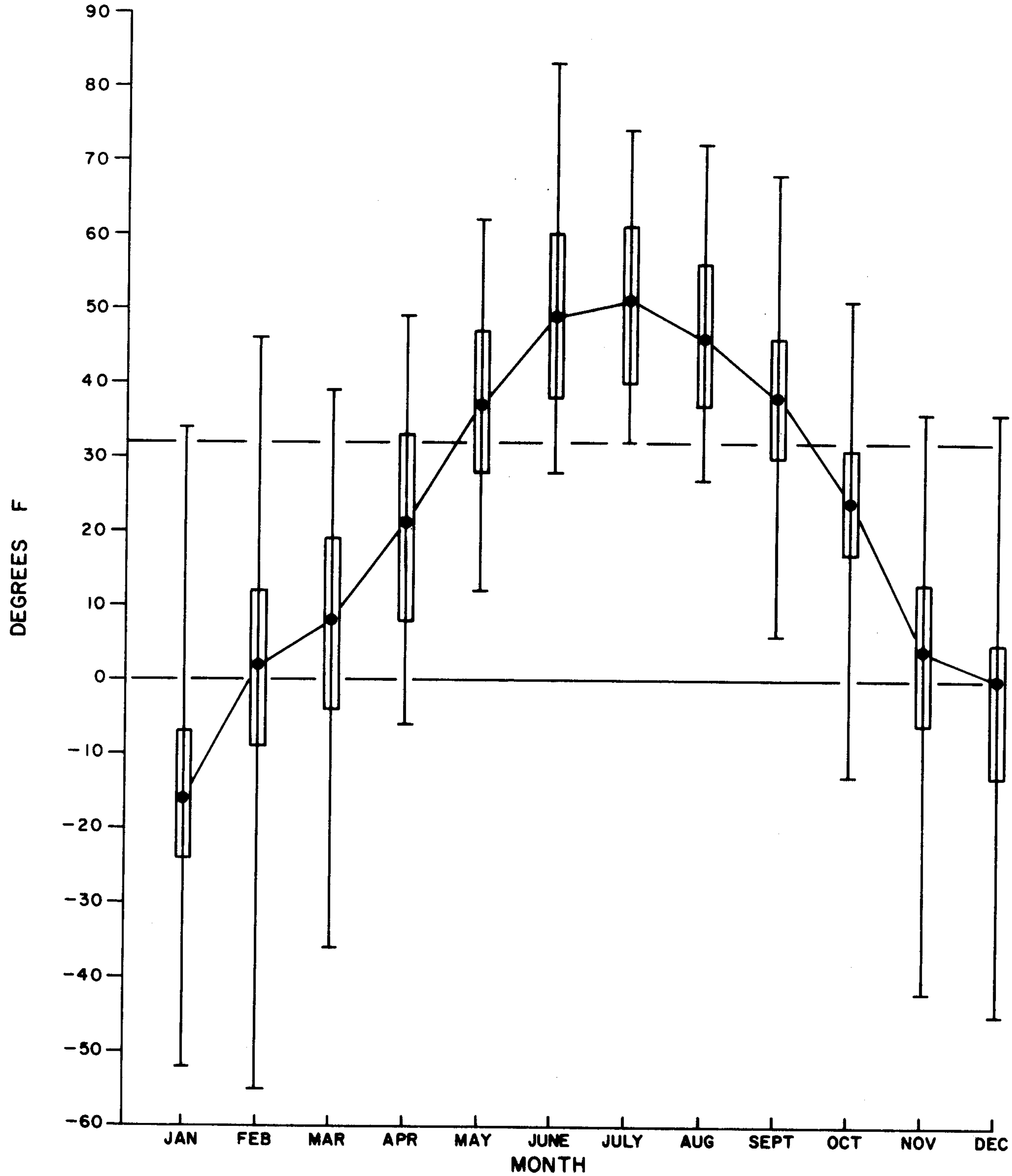


Figure 3 - Daily temperature means and extremes at Tungsten, Northwest Territories, as shown in Table I (Unpublished data, Meteorological Branch, Ministry of Transport). Curve connects monthly means. Bars indicate mean monthly maximum and minimum temperatures. Verticle lines show extreme maximum and minimum temperatures during the years indicated in Table I.

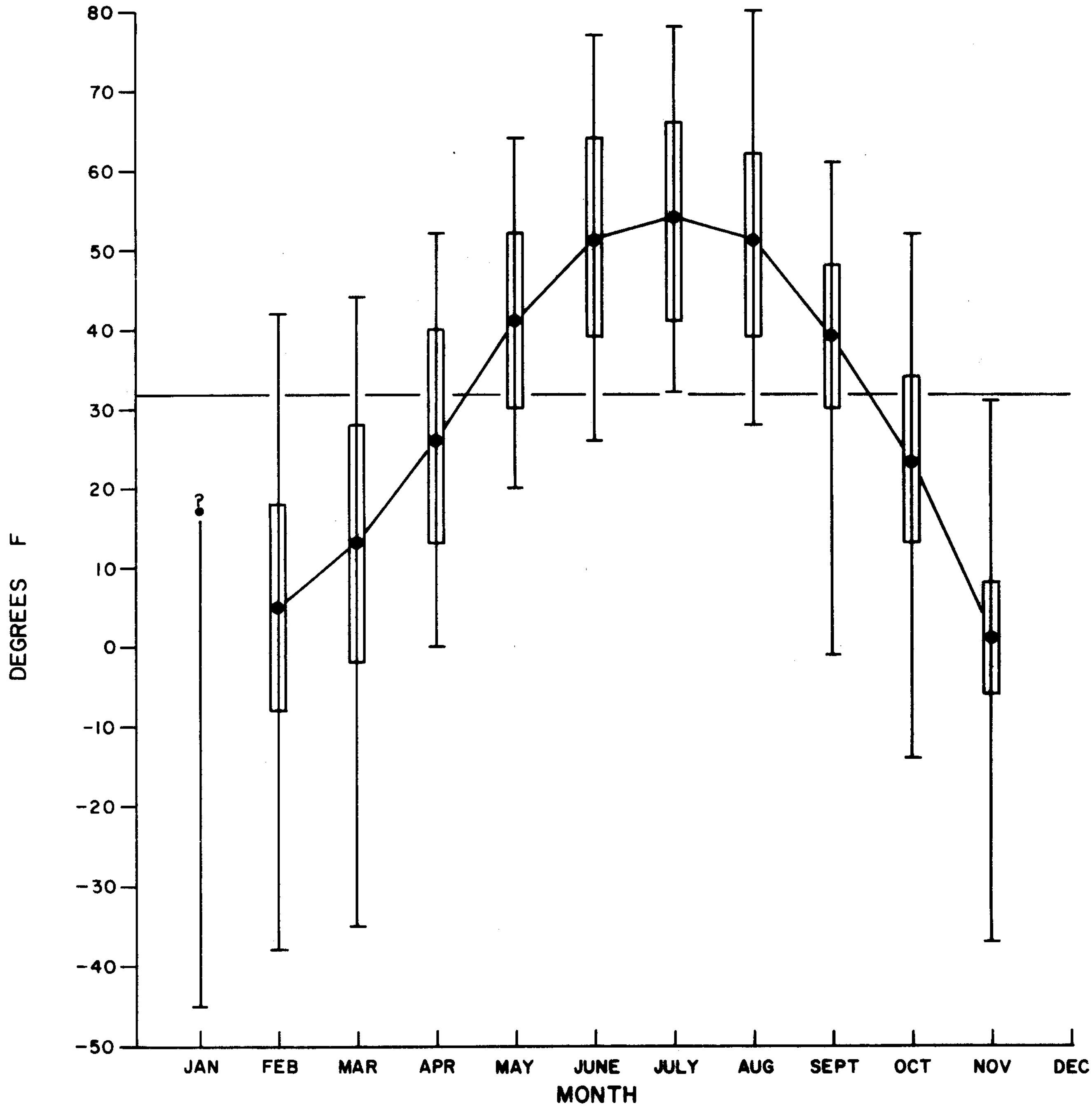


Figure 4 – Daily temperature means and extremes at Peñarroya Limited prospect, 1970, as shown in Table 3 (Unpublished data, Meteorological Branch, Ministry of Transport). Curve connects monthly means. Bars indicate mean monthly maximum and minimum temperatures. Verticle lines show extreme maximum and minimum temperatures. Operations suspended in December and January.

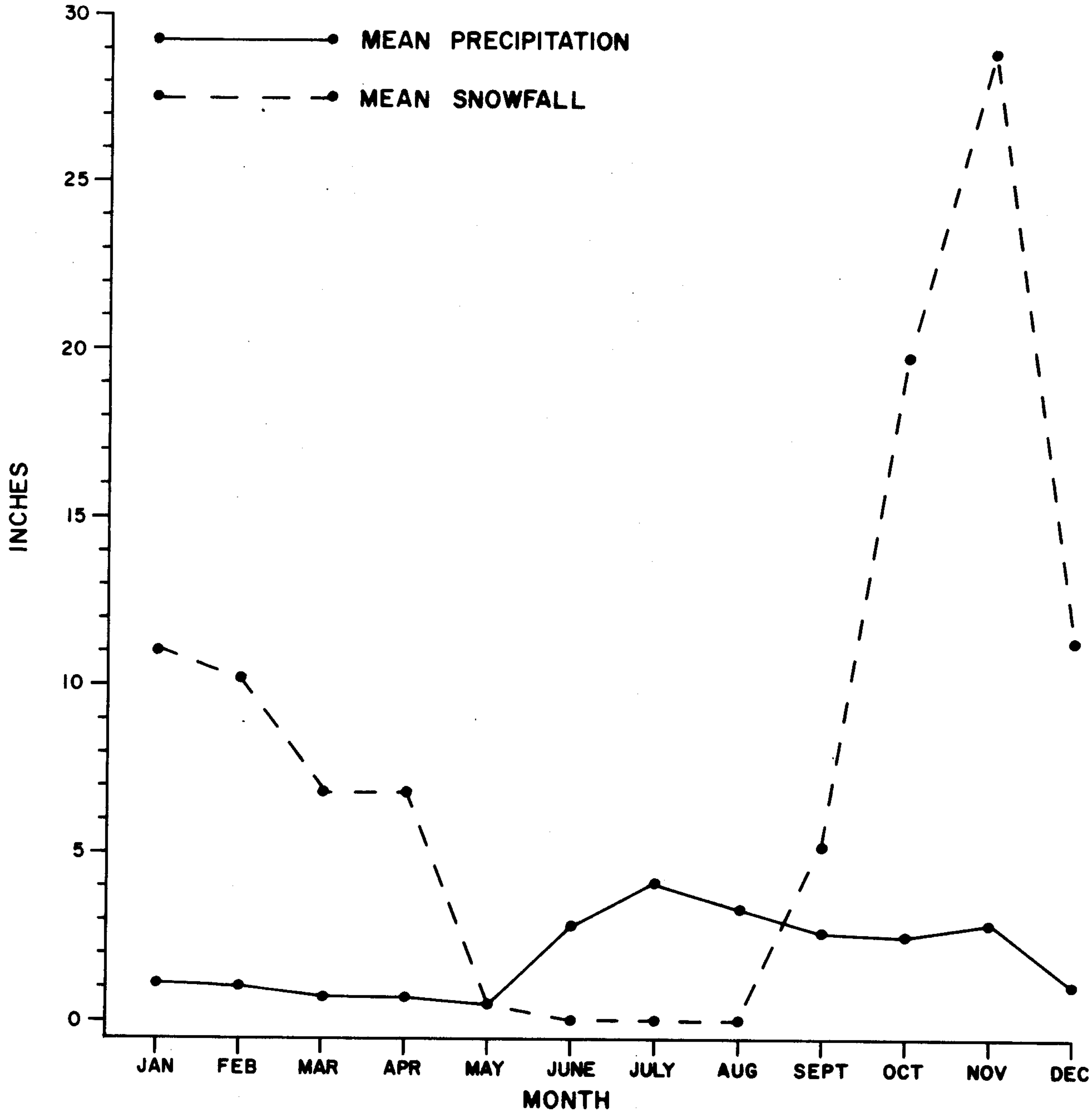


Figure 5 — Mean precipitation and mean snowfall at Tungsten, as shown in Table 2 (Unpublished data, Meteorological Branch, Ministry of Transport.)

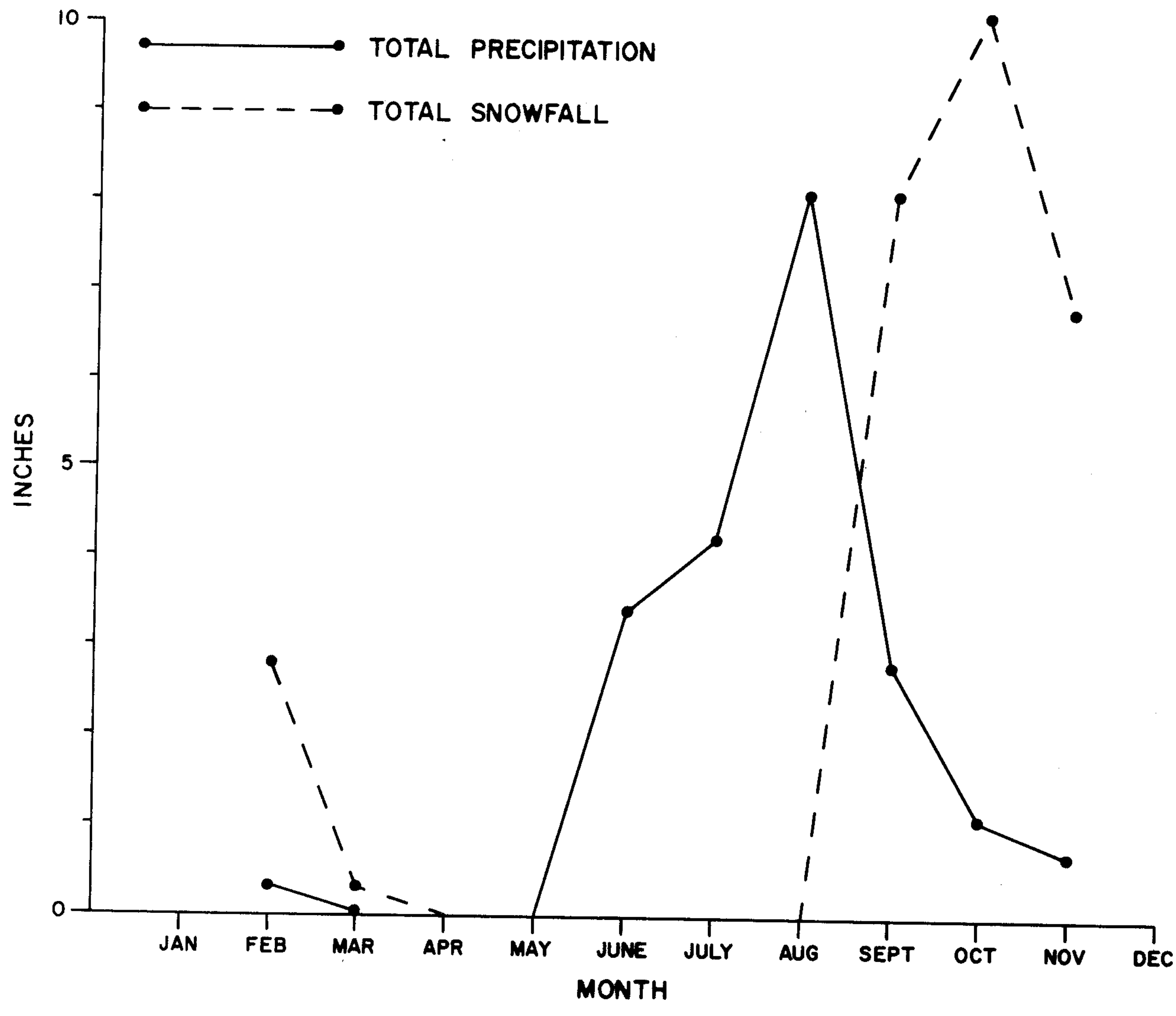


Figure 6 – Total precipitation and snowfall at the Peñarroya Limited prospect, 1970, as shown in Table 3 (Unpublished data, Meteorological Branch, Ministry of Transport.)

GEOLOGY

Location and General Description of the Mackenzie Mountains and Liard Plateau

The mountains west of the Mackenzie River, Northwest Territories, are largely composed of sedimentary rocks. The geological subdivisions of this area are shown in Fig. 7. The Mackenzie Mountains subdivision is composed of north-trending thrust sheets, faulted folds, and broad elongated uplifts and depressions. The major thrust faults and axial planes of the large folds dip either east or west.

The Liard Plateau subdivision is an area of broad, even-topped ranges of hills, rising to about 4500 feet. The folds which form this plateau strike north. The northern part of the plateau has a higher relief than the southern. The South Nahanni River cuts deeply into the beds which form the plateau (Bostock, 1948).

The headwaters of the South Nahanni River and its largest tributary, the Flat River, are near the Yukon border, at around 3500 feet elevation. The South Nahanni River flows southeastward for 250 miles and joins the Liard River at Nahanni Butte. In the area of the proposed National Park, the river descends from an elevation of 2000 feet at Rabbitkettle Lake to around 600 feet at Nahanni Butte. Peaks generally range from 4500 to 6000 feet in elevation, but the Ragged Range in the northwest rises to over 9000 feet.

Most of the Mackenzie Mountain and Liard Plateau areas show the effects of glaciation. Glacial erosion is manifested by precipitous cirques and pinnacles in the mountains and by scouring in the lower Liard Plateau (Bostock, 1948). Glacial deposition is evident in the kame terraces or moraines in the Flat River valley (Gabrielse, Roddick, and Blusson, 1965). Remnants of glaciers are still present in the higher mountains, especially in the Ragged Range.

Geologic History of the Nahanni and Flat River Areas

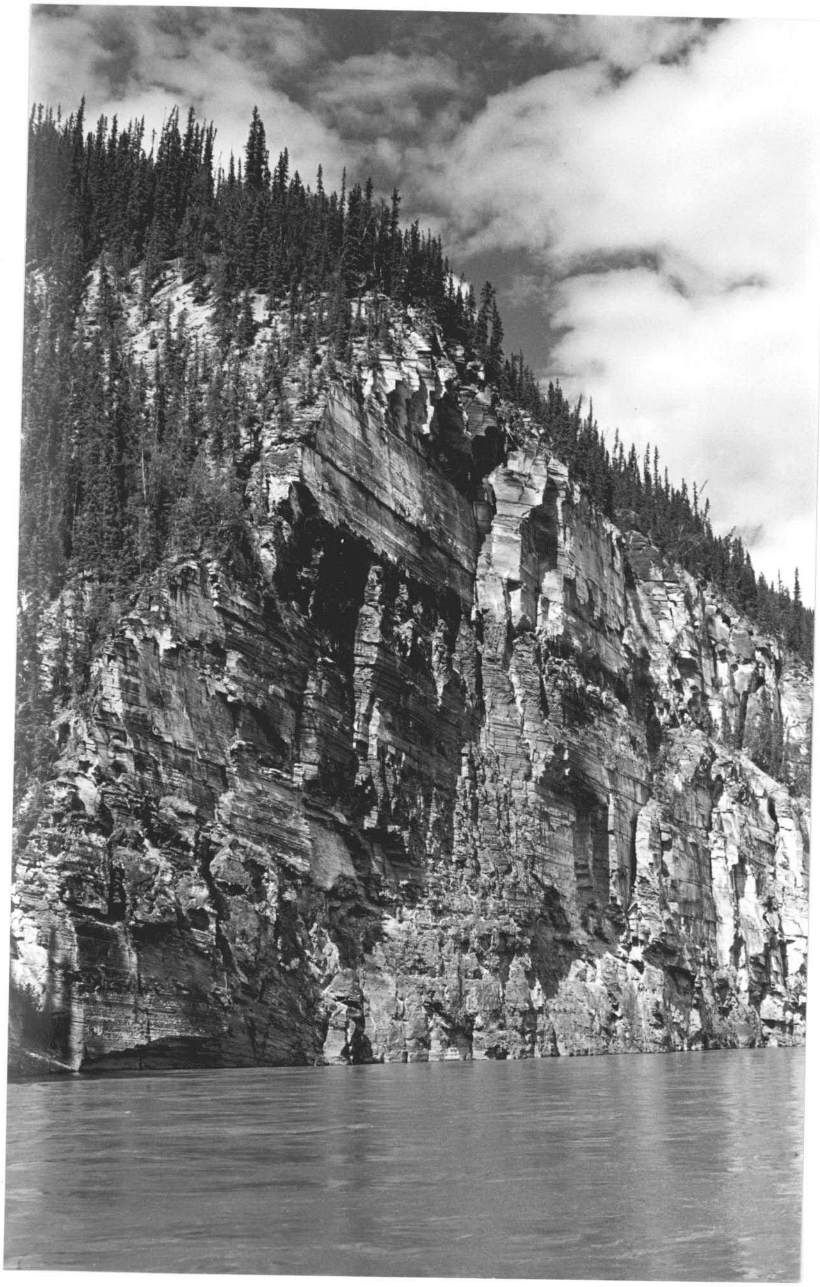
Paleozoic era

During the Paleozoic Era, the sea flowed into and out of a wide, shallow trough that existed where the Mackenzie Mountains are now. Successive layers of detritus were deposited from the highland to the west into these vast but shallow inland seas. These layers formed the Ordovician, Silurian, Devonian, and Carboniferous beds which are found today in the South Nahanni River area (Fig. 8) (Dunbar, 1952; Dowling, 1922).

At the dawn of this era, life had already existed on earth for many millions of years, and all the great branches of the animal kingdom were represented. Trilobites were the dominant creatures of Cambrian seas, and their fossils can be found in the Mackenzie Mountains today. Primitive fish appeared in the Ordovician Period and the shallow inland waters swarmed with a rich variety of invertebrates. The marine invertebrates continued to predominate throughout much of the remainder of the era. Coral reefs may have occurred in clear water over what is now the South Nahanni region. Fossil corals are evident in the rocks of the gravel bars lining South Nahanni River.

Fig. 8. Sedimentary layers exposed along the South Nahanni River near Big Bend.

(Photo: N. M. Simmons, 1 July, 1970.)



Mesozoic era

The Nahanni and Flat River areas may have been elevated above sea level during Triassic and early Jurassic times. No formations from these periods are evident there. During the Jurassic time, a new geosyncline or trough took form along the course of the present Rocky and Mackenzie Mountains. During the Cretaceous Period sediments from the rising highlands to the west were deposited into the arctic waters that had spread southward through much of the trough. The final retreat of the sea in the late Cretaceous left a vast swampy lowland over which western streams spread thick non-marine sediments during the final stages of the period. (Dunbar, 1952.)

Toward the end of the era, the floor of the great geosyncline, so recently covered by the Cretaceous sea, became the scene of folding and thrusting on a colossal scale, and the Rocky Mountain and Mackenzie Mountain systems were formed.

According to Dowling (1922), the mountains north of 60°N latitude appear to have been uplifted between late Cretaceous and early Eocene (Cenozoic Era) times. The main ridges of the Mackenzie Mountains originated with the compression of a thin sheet of stratified crust. The compression from the west caused crumpling and folding and produced Rocky Mountain type thrust fault blocks which progressed from west to east and which cut across the great Cordilleran geosyncline. Intrusions of granitic batholiths, possibly during Cretaceous times, were associated with the movements of the earth's crust and are found west of the Mackenzies in the Selwyn Mountains of Yukon, in the Ragged Range, and near the headwaters of the South Nahanni and Flat Rivers. Metalliferous by-products of the igneous activity are found in the mountain region and probably account for some of the mineralization in this area also. (Dowling, 1922; Dunbar, 1952.)

During the early Mesozoic Era, reptiles came into their own. "Dinosaurs soon possessed the lands, while sea monsters splashed and slithered through the waves, and winged dragons took to the skies" (Dunbar, 1952, p. 309). For more than 100 million years they held undisputed dominance. But the end of the Cretaceous proved to be a great crisis in the history of life. The reptilian dynasty suddenly collapsed.

Cenozoic era

The features of the modern landscape unfolded during this last era of geologic time. Renewed uplift and erosion occurred during the earlier Cenozoic periods, increasing the relief in the western mountains of the continent and producing the peneplanes and terrace-like surfaces of the plateaus as well as such drainages as the Nahanni and Flat River Valleys.

During the Pleistocene period of the Cenozoic Era, the Mackenzie Mountains and Liard Plateau were covered by the Cordilleran Glacier Complex, flowing west toward the Pacific and east toward the Laurentide Ice Sheet which covered central and eastern Canada (Dunbar, 1952). According to Gabrielse, Roddick, and Blusson (1965), the entire area was glaciated by alpine and valley glaciers and by at least two ice sheets. Ice moved to the southeast down the South Nahanni and Flat River Valleys and sculptured the scene we view today (Figs. 9 and 10).

Fig. 9. The glaciated South Nahanni River valley, looking southeast toward the Dall, Arnica, Funeral, and Headless Ranges from Sunblood Mountain.

(Photo: W. D. Addison, 22 July, 1966.)

Fig. 10. The upper South Nahanni River valley, looking west-northwest from Sunblood Mountain.

Exposed in the foreground are light-colored limestones of the Sunblood formation. The trees on the near slope are alpine fir. (Photo: W. D. Addison, 22 July, 1966.)

The huge reptiles of the Mesozoic had died out, and in the Cenozoic Era the way was open for mammals to begin their conquest of the world. It was in the Pleistocene Age that mammals, such as the mountain sheep, mountain goats, and caribou we see in the Nahanni area today were forced by growing ice sheets to flee from their Eurasian homelands to ice-free havens in Alaska (Banfield, 1961; Buechner, 1960). From there they moved into the Mackenzie area. Others, such as rodents, were on the North American continent as early as the Paleocene Epoch.

Structural Geology

Two groups of geologists have mapped the areas shown in Fig. 7. The Sibbeston Lake and Virginia Falls maps (to the right of the junction of maps shown in Fig. 7) were compiled by Douglas and Norris (1960), and the Flat River and Glacier Lake maps (on the left in Fig. 7) were made by Gabrielse, Roddick, and Blusson (1965). Different interpretations of the formations are evident in Fig. 7 at the junction of the two sets of maps. Generally, however, the two groups of geologists agree that most of the beds near the map junction are Ordovician and Silurian, possibly overlain by some Devonian beds. Gabrielse, Roddick, and Blusson mapped in the glacial and alluvial deposits, while Douglas and Norris omitted these except in the lower South Nahanni River "splits".

Yohin Syncline and Liard Range

A tourist travelling up the South Nahanni River would encounter progressively older geologic strata until he saw the Cretaceous intrusions of the Ragged Range. The lowest 24-mile stretch of the river flows through a wide, gravel-covered valley. The Yohin Syncline or downward fold (Fig. 11, cross-sections A-B and C-D) in the Mackenzie Plain is the first structure crossed after leaving Nahanni Butte. This is a broad, simple fold trending north, with flanks dipping 20° and sloping gently south. The Cretaceous St. John Group and Carboniferous Mattson formation form the core of this syncline. They are underlain by Mississippian Flett, Clausen, and Yohin formations. The simple syncline divides into several folds toward the southeast, including the Twisted Mountain Anticline (Fig. 12), or upward fold, and the Bluefish Syncline. The same formations are found to the south in the Kotaneelee Syncline which forms Yohin Ridge (Fig. 11, cross-section E-F). Some of the oldest coals found in western Canada (Carboniferous, as compared with others which are Mesozoic and Tertiary in origin) are found in seams as thick as 6 feet on Mattson and Flett Creeks in the Liard Range (not shown in Fig. 7). Data from a 4-foot-thick coal seam on a creek flowing into the Jackson River shows a definite Paleozoic spore assemblage (Hacquebard and Barss, 1957).

Tlogotsho Plateau

West of the Liard Range and south of the South Nahanni River lies the Tlogotsho Plateau, a broad, saucer-shaped monocline of Carboniferous beds that dip gently south (Fig. 11, cross-section EE-FF).

Nahanni Plateau

The flat Devonian, Ordovician and/or Silurian beds of the Nahanni Plateau, cut 3500 feet deep for 12 miles by First Canyon (Fig. 13),

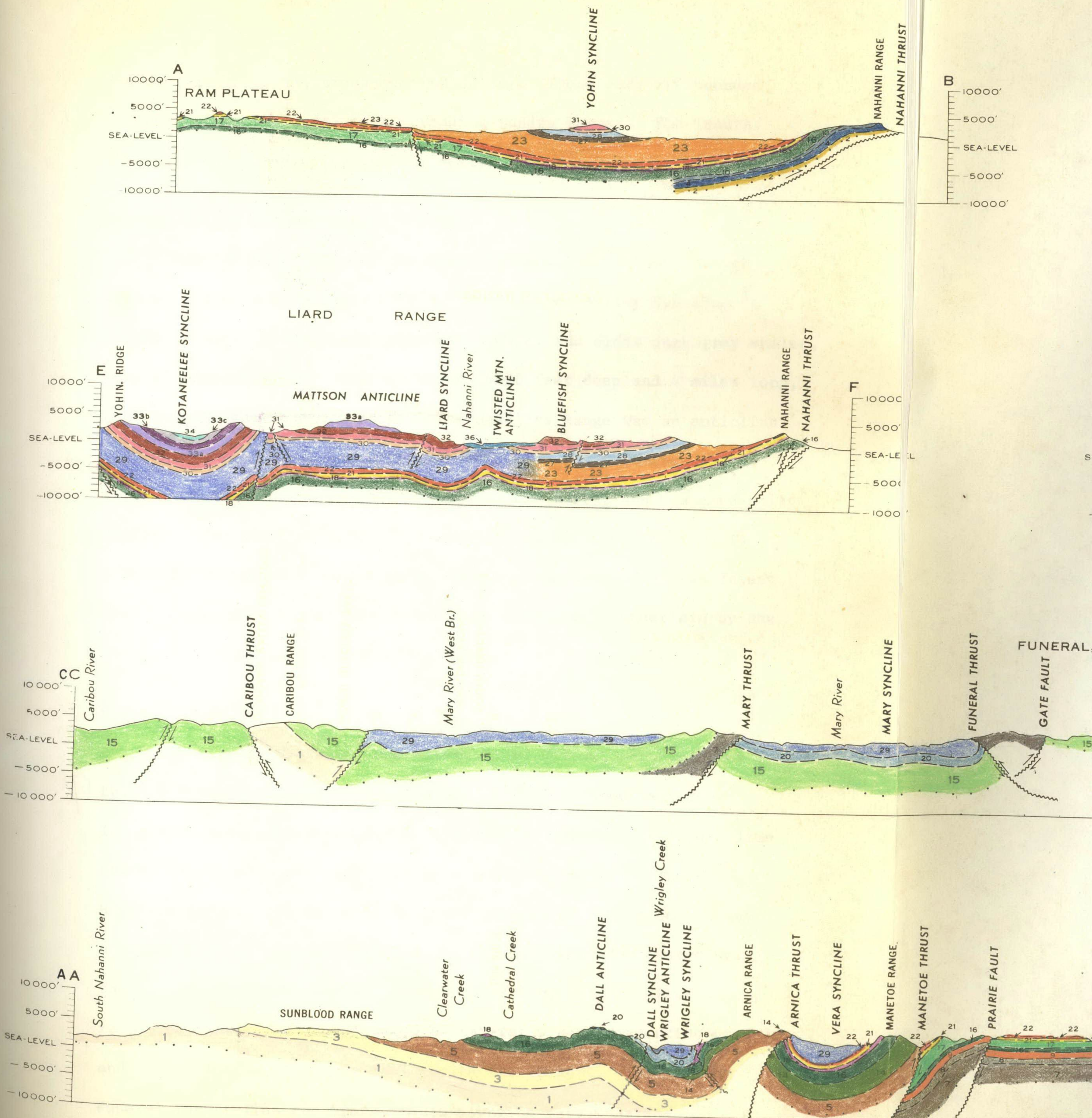
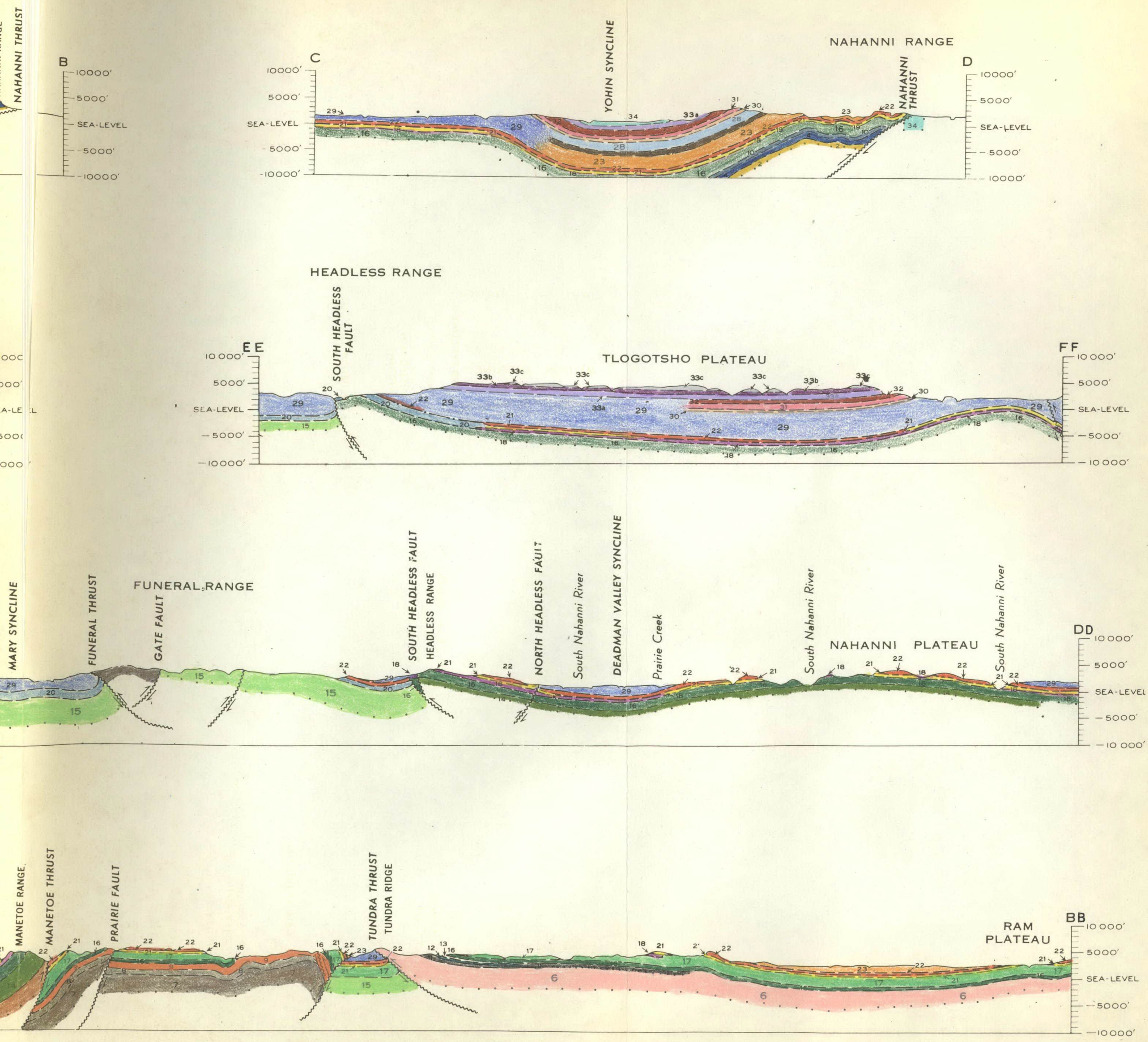


Fig. 11 Cross-sections of the South Nahanni River.


NAHANNI THRUST
B
10000'
5000'
SEA-LEVEL
-5000'
-10000'
C
YOHIN SYNCLINE
NAHANNI RANGE
NAHANNI THRUST
D
HEADLESS RANGE
SOUTH HEADLESS FAULT
EE
TLOGOTSHO PLATEAU
FF
MARY SYNCLINE
FUNERAL THRUST
FUNERAL RANGE
GATE FAULT
SOUTH HEADLESS FAULT
HEADLESS RANGE
NORTH HEADLESS FAULT
South Nahanni River
DEADMAN VALLEY SYNCLINE
Prairie Creek
South Nahanni River
NAHANNI PLATEAU
South Nahanni River
DD
MANETOE RANGE
MANETOE THRUST
PRAIRIE FAULT
TUNDRA THRUST
TUNDRA RIDGE
RAM PLATEAU
BB

are awesome (Fig. 11, cross-section CC-DD). These beds are bounded on the west by the long, north-trending Tundra Thrust. The Tundra Thrust is an east-dipping fault underlying Tundra Ridge to its east.

Deadmen Valley and the Headless Range

West of First Canyon, the South Nahanni River flows through several channels in Deadmen Valley. The Deadmen Valley Syncline is topped by upper Devonian and possibly younger and older dark grey shales. West of Deadmen Valley, Second Canyon, 4000 feet deep and 4 miles long, cuts through the Headless Range. The Headless Range was an anticline of middle Devonian and older limestone, shale, and dolomite, which tilted westward in the south, eastward in the north, and was eventually faulted. The southern part of the Headless Range dips east and is underlain on the west by the steep east-dipping South Headless Thrust. The northern part of Headless Range dips west and is underlain by the steep, west-dipping North Headless Fault.

Funeral Range

Continuing upstream, one enters Third Canyon, which crosses through Funeral Range for 12 miles and is 3000 to 4000 feet deep. The north-trending Funeral Range, composed of Devonian and older limestone, shale, dolomite, and sandstone beds that underlie those of the Headless Range, is bounded by downward converging faults on its east and west flanks. The western Funeral Thrust is a major east-dipping fault. The southern part of the Funeral Range, near Meilleur Creek, is a broad anticline, complicated by several small, discontinuous folds and thrust faults, the Gate Fault being the largest. West of the Funeral Thrust lies the broad, south-plunging Mary Syncline.

LEGEND FOR FIGURE 7 (LEFT SIDE)

PLEISTOCENE AND RECENT

36 — Unconsolidated glacial and alluvial deposits

CRETACEOUS

35 — Quartz monzonite, granodiorite; minor granite and diorite

35a — Hornblende diorite

35b — Rusty weathering granodiorite

DEVONIAN AND (?) MISSISSIPPIAN

34 — Black shale, locally pyritic; minor thin beds of black limestone; recessive weathering

MIDDLE DEVONIAN

31a — Undivided HEADLESS, LANDRY, AND ARNICA FORMATIONS: highly fossiliferous limestone and minor shale; dolomite; dolomite breccia

29 — MANETOE FORMATION: coarse-grained cream and light grey dolomite; coarse-grained limestone; crypto-grained, laminated dolomite

28 — ARNICA FORMATION: medium and dark grey, banded dolomite; dolomite breccia

LOWER DEVONIAN

27 — SOMBRE FORMATION: light and medium grey, banded dolomite; silver-grey dolomite

Legend for Figure 7 (Cont'd)

LOWER DEVONIAN (?)

26 CAMSELL FORMATION: buff limestone breccia; interbedded grey and buff weathering dolomite and limestone

SILURIAN AND DEVONIAN

25 DELORME FORMATION: buff, grey, cinnamon weathering dolomite and limestone; locally limestone breccia in upper part may be correlative with 26

UPPER ORDOVICIAN AND SILURIAN

24 WHITTAKER FORMATION: dark grey dolomite, light grey limestone, commonly cherty

ORDOVICIAN AND SILURIAN (Mainly)

23 Black, pyritic shale, locally slaty or phyllitic; thin-bedded, black, argillaceous limestone; grey and black chert; calcareous siltstone; black, cherty dolomite

23a Hornfells, includes Devonian and (?) Mississippian

MIDDLE AND (?) EARLY UPPER ORDOVICIAN

22 Dark and light grey dolomite; pink, mottled limestone; orange-brown sandstone

22a Vesicular mafic flow or flows

22b Undivided 22 and 21

22c Undivided 22 and 24

Legend for Figure 7 (Cont'd)

CAMBRIAN AND ORDOVICIAN

21 Orange weathering, grey limestone; minor siltstone

CAMBRIAN AND/OR ORDOVICIAN

20 Grey, slaty, argillaceous limestone; buff, calcareous slate; well-banded, buff limestone

LOWER, MIDDLE, AND (?) UPPER CAMBRIAN

19 Red, buff, yellow, and grey weathering dolomite, siltstone, sandstone, limestone

MIDDLE AND (?) UPPER CAMBRIAN

18 Wavy banded, silty limestone; platy impure limestone; siltstone; limestone; shale; locally includes 16 and 20

17 Buff and orange weathering, dolomitic siltstone; silty dolomite; calcareous sandstone; stromatolitic dolomite; shale

LOWER AND/OR MIDDLE CAMBRIAN

16 Bright yellow and orange weathering silty and sandy dolomite; grey limestone; minor sandstone and shale

LOWER CAMBRIAN

15b Sandstone; sandy and silty dolomite; dolomite; argillite; minor quartzite and impure limestone

15c Dolomite and limestone; sandy dolomite and dolomitic sandstone

Legend for Figure 7 (Cont'd)

15d	Cherty calc-silicate rocks; may locally include metamorphosed 16 and 18
15e	Thin-bedded, dark brown to black pyritic argillite; calcareous shale; minor limestone

CAMBRIAN AND/OR EARLIER

13a	13a white, pink, purple quartzite and sandstone; slate; calcareous sandstone; minor pebble conglomerate; 13b crypto-grained, mottled, mauve, pink, banded limestone and dolomite, locally silty and sandy; minor quartzite and brick red to purple shale; 13c deep blood red weathering, iron-flecked, grey to green interbedded quartzite; siltstone; argillite; minor fine conglomerate; 13d buff to red weathering, light grey dolomite

CAMBRIAN AND EARLIER

12	12a phyllite; slate; fine-grained quartzite; siltstone; argillite; 12b agglomerate; conglomerate; tuff; green and maroon weathering vesicular volcanic rocks; chlorite schist
11	Dark shale and slate, gritty quartzite, calcarenite; quartz-pebble conglomerate; sandstone; maroon, green and buff shale and slate; minor limestone and phyllite
9	Recessive weathering, dark grey shale and siltstone
8	Orange weathering, dolomitic sandstone; sandy dolomite; includes mafic flow near top of unit east of Grizzly Bear Lake
7	Mudstone; green and buff-brown siltstone; conglomeratic mudstone; conglomerate; maroon weathering siltstone; slate; iron-formation

Legend for Figure 7 (Cont'd)

Orange and buff-orange weathering buff, grey dolomite, locally sandy and cherty; minor laminated buff and orange weathering siltstone; conglomerate; slate

Geological boundary (defined, approximate and assumed) . . . .

Drift boundary . . . .

Limit of geological mapping . . . .

Bedding (horizontal, inclined, vertical, overturned) . . . .

Foliation inclined, vertical . . . .

Plunge of lineation 15

Fault (defined, approximate, assumed); solid circle indicates downthrow side . . . .

Thrust fault (defined, approximate, assumed; arrow indicates direction of dip . . . .

Anticline (defined, approximate) arrow indicates direction of plunge . . . .

Syncline (defined, approximate) arrow indicates direction of plunge . . . .

Anticline, syncline (overturned) . . . .

Location of measured section . . . .

Fossil locality . . . . F

Mineral prospect or occurrence . . . . Cu X

Springs (hot, cold). . . . . H.S.⊕ C.S.⊕

Intermittent stream . . . .

Marsh . . . .

Glacier . . . . Gl

Contours (interval 500 feet) 4500

Height in feet above mean sea-level 9097

Mineral Symbols

Copper . . . . Cu

Lead . . . . Pb

Silver . . . . Ag

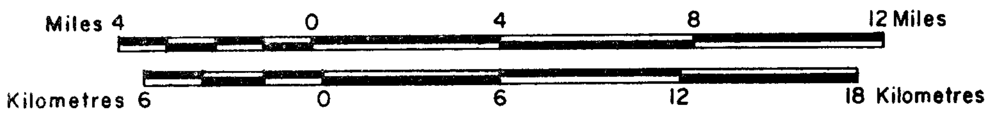
Tin . . . . Sn

Tungsten . . . . W

Zinc . . . . Zn

Geology by H. Gabrielse, J. A. Roddick, and S. L. Blusson, 1963.

Cartography by the Geological Survey of Canada, 1964.



LEGEND FOR FIGURE 11 AND FIGURE 7 (RIGHT SIDE)

PLEISTOCENE AND RECENT

36 Alluvial sands and silts of Liard and lower South Nahanni Rivers

LOWER CRETACEOUS

34 FT. ST. JOHN GROUP: dark grey shale; siltstone

CARBONIFEROUS

MATTSON FORMATION

33a Lower part: grey sandstone; shale; coal

33b Middle part: grey to brown sandstone

33c Upper part: grey sandstone; limestone; shale

32 FLETT FORMATION: grey fossiliferous, crinoidal and argillaceous limestone; grey shale; sandstone

31 CLAUSEN FORMATION: fissile black shale; thin limestone

30 YOHIN FORMATION: thinly bedded sandstone; silty limestone

UPPER DEVONIAN

28 Black fissile shale; mudstone; limestone

27 Calcareous siltstone; silty mudstone

CARBONIFEROUS AND DEVONIAN

29 Dark grey shale (may include equivalents of map-units 20 to 28, 30 to 32, and possibly some older beds)

Legend for Figure 11 and Figure 7 (Cont'd)

23	SIMPSON FORMATION: black fissile shale; thinly bedded siltstone	29

MIDDLE DEVONIAN

22	NAHANNI FORMATION: bioclastic, thick bedded limestone; shale; dolomite	29
21	Dark grey, calcareous shale; argillaceous limestone	29
20	Shale (equivalent to undivided map-units 17 and 21)	29
19	Massive limestone (equivalent to map-unit 18)	29
18	Coarsely recrystallized, massive dolomite	29
17	Argillaceous, thinly bedded limestone; dark grey shale (equivalent to map-units 16 and 18)	29
16	Fine-grained black and grey dolomite	29

DEVONIAN (?) AND EARLIER

14	Dolomite (undivided map-units 11, 12, and 13)	DEVONIAN, SILURIAN, AND ORDOVICIAN: 15
13	Fine-grained grey dolomite	DEVONIAN, SILURIAN, AND ORDOVICIAN: 15
12	Cryptograined black dolomite	DEVONIAN, SILURIAN, AND ORDOVICIAN: 15
11	Fine-grained grey dolomite	DEVONIAN, SILURIAN, AND ORDOVICIAN: 15

DEVONIAN, SILURIAN, AND ORDOVICIAN

15	Limestone; shale; dolomite (may include equivalents of map-units 3, 5, 8, 9, 14, 16, and possibly some younger beds)

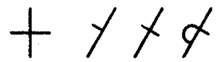
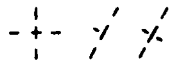
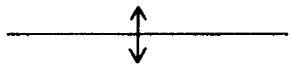
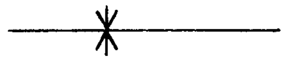
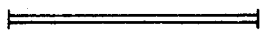
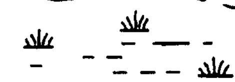
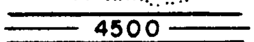
Legend for Figure 11 and Figure 7 (Cont'd)

10	Silty dolomite; sandstone
9	Thinly bedded shale
8	Includes coarse-grained sandstone
7	Includes orange and pink weathering, grey limestone

ORDOVICIAN AND SILURIAN

6	Grey and buff weathering dolomite and limestone
5	Grey, graptolitic shale; thinly bedded limestone
4	Massive, grey, argillaceous dolomite
3	Dark grey limestone; massive dolomite; shale
2	Cryptocrystalline, pink dolomite; orange and pink weathering sandstone
1	SUNBLOOD FORMATION: cryptograined orange and pink weathering limestone

15

Rock outcrop	x
Geological boundary (approximate, assumed, uncontrolled)	
Limit of geological mapping	
Bedding, measured (horizontal, inclined, vertical, overturned)	
Bedding, estimated (horizontal, inclined, vertical)	
Fault (approximate, assumed)	
Fault (direction of dip, downthrown side)	
Anticline, plunging	
Syncline, plunging	
Location of measured stratigraphic sections	
Mineral occurrence	X
Well, abandoned	Ø
Intermittent stream	
Marsh	
Glacier	
Contours (interval 500 feet)	
Height in feet above mean sea-level	9097

Mineral Symbols

Copper	Cu
Lead	Pb
Silver	Ag
Tin	Sn
Tungsten	W
Zinc	Zn

Geology by W. B. Brady, R. J. W. Douglas, P. Harker, D. J. McLaren, D. K. Norris, B. R. Pelletier, D. F. Stott, 1957: C. O. Hage, 1944.

Compiled by R. J. W. Douglas and D. K. Norris, 1960.

Cartography by the Geological Survey of Canada, 1960.

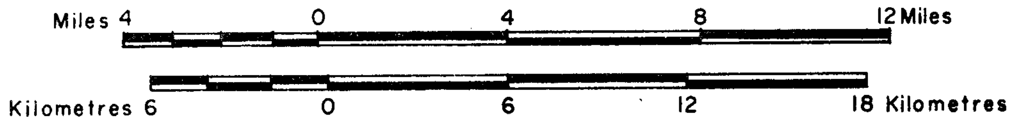


Fig. 12. Twisted Mountain, South Nahanni River.

(Photo: N. M. Simmons, 25 June, 1970.)

Fig. 13. First Canyon, South Nahanni River.

(Photo: N. M. Simmons, 26 June, 1970.)

Manetoe and Arnica Ranges

North of the river and the Mary Thrust lies the long, narrow Manetoe Range, bounded on the east by the Manetoe Thrust and on the west by the Vera Syncline (Fig. 11, cross-section AA-BB). The Vera Syncline is faulted and folded on its east flank where it is crossed by the South Nahanni River near its southern end. West of the Vera Syncline lies the Arnica Range, a west-dipping series of strata underlain by the Arnica Thrust on its east side. The Arnica Range is composed of beds which are horizontal at the crest, but which dip from 30^{o} to 40^{o} on the west flank and even more steeply where cut by an east-dipping thrust fault. The Manetoe and Arnica Ranges are composed of the same middle Devonian map units as Headless Range and Nahanni Plateau.

South of the South Nahanni River and west of Funeral Range lies a moderately west-dipping monocline topped by Upper Devonian shales, a continuation of the Manetoe and Arnica Ranges. This monocline is underlain by the Mary Thrust on the east, which may be a continuation of the Manetoe Thrust.

Caribou Range

The Caribou Range, probably composed of Devonian and older limestone, shale, dolomite, and sandstone, is a north-trending, east-dipping monocline, bounded on the east by a west-dipping fault and on the west by the east-dipping Caribou Thrust. Near the Flat River the strata dip steeply and are folded sharply near the Caribou Thrust.

Clearwater Depression and the Sunblood Range

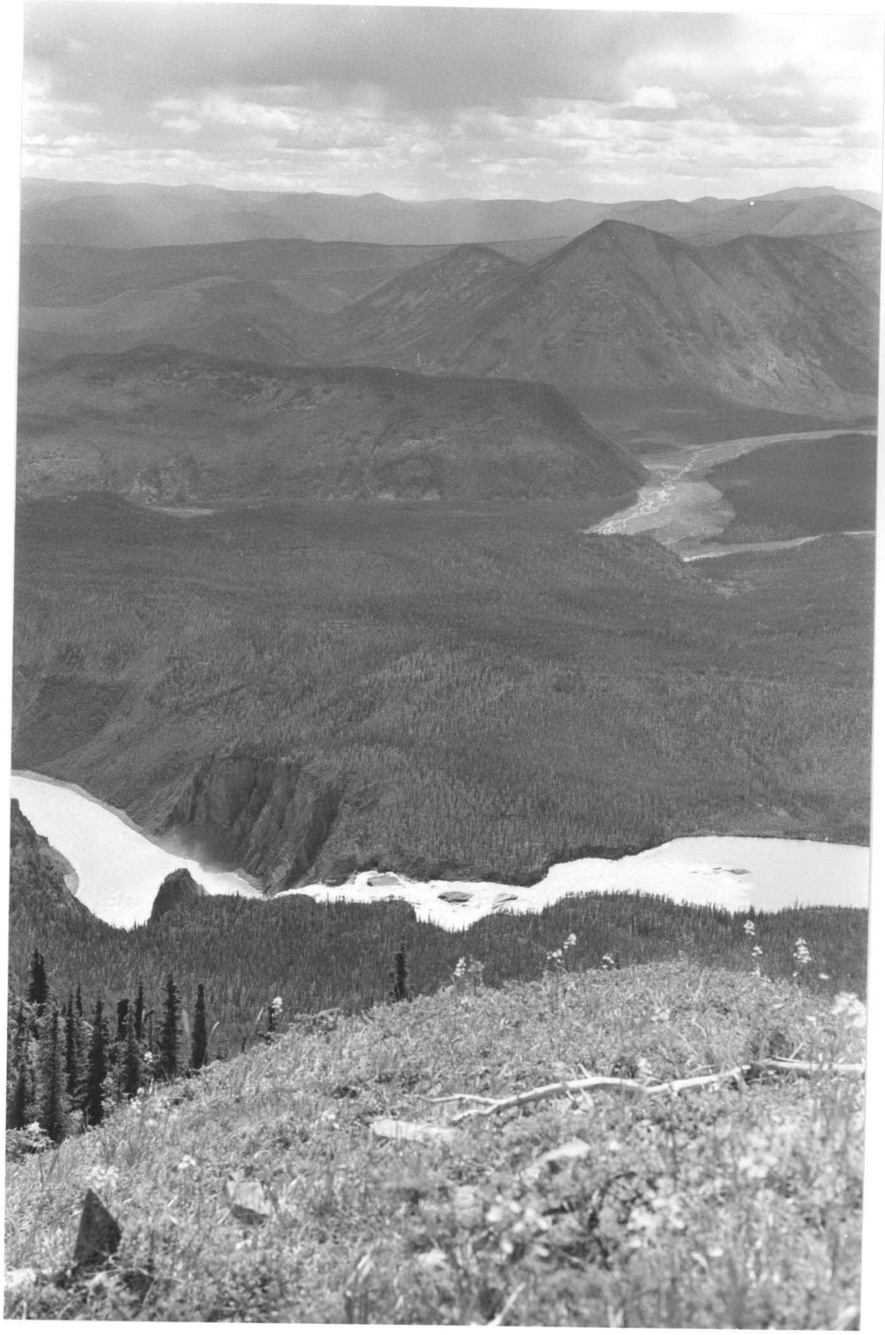
North of the South Nahanni River and west of the Arnica Range lies the Clearwater Depression, divided by two curved folds, the Wrigley and Dall Anticlines and Synclines. These are formed largely of Devonian strata. The southern end of the Dall Anticline forms the Dall Range. The Sunblood Range, southwest of the Clearwater Depression, is a northwest-trending monocline with Ordovician and Silurian strata dipping about 20° NW, bounded on the east by the Dall Range and a northeast-trending fault (Fig. 11, cross-section AA-BB). The divided waters of spectacular Virginia Falls, 100 yards high and 200 yards wide, flow over the lower beds of this Sunblood formation, the oldest known formation in the Virginia Falls and Sibbeston Lake map area (Fig. 14). (Douglas and Norris, 1960.)

Upper Flat and South Nahanni river areas

Above Virginia Falls, the South Nahanni River winds slowly through a broad, glaciated valley (Fig. 15). Here, west of the Sunblood Range, the structures are largely north- to northwest-trending folds of Ordovician and Silurian beds with moderately steep limbs, locally broken by west-dipping thrust faults (Fig. 7). Tightly compressed folds of clay-bearing strata are common, and some beds are overturned to the northeast or east. South of Rabbitkettle Lake are southeast-plunging folds. Two Cretaceous batholiths and numerous stocks or smaller granitic bodies are located in the Flat River map-area. Three granitic stocks outcrop southwest of the South Nahanni River. (Gabrielse, Roddick, and Blusson, 1965.)

Fig. 14. Virginia Falls flows over the lower beds of the Sunblood formation, the oldest formation in the area.

The view is toward the south from Sunblood Mountain. Marengo Creek is in the center right. Rain is falling over the Flat River valley near the horizon. (Photo: W. D. Addison, 22 July, 1966.)



The Ragged Range, rising 6000 feet above the South Nahanni River valley, is a tightly folded group of resistant beds, containing widespread Cretaceous granitic intrusions, and Cambrian and earlier metamorphic rocks. The topography is rugged and shows extensive alpine glaciation (Fig. 16). Large snow fields and small glaciers are still present. (Gabrielse, Roddick, and Blusson, 1965.)

Waters

River depth and flow

The volume, speed, and depth of the South Nahanni and Flat Rivers vary a great deal with the seasons. The lowest rates of flow generally occur during the months of March and April and the highest rates during May, June, July, and August.

Two flow gauges have been in operation on the South Nahanni River since 1967, one above Clausen Creek and the other above Virginia Falls. Twenty-one measurements have been recorded at each gauge over the 4-year period (pers. comm., Mr. A. Wilson, Water Survey of Canada, February 8, 1971).

At Clausen Creek, the volume of flow ranged from 1240 ft^3/sec on March 10, 1969, to a high of 46,200 ft^3/sec on June 25, 1968. Mean velocities varied from .85 mph to 5.13 mph. The depth of the South Nahanni at this point varied as much as 4.51 feet during 1969-70.

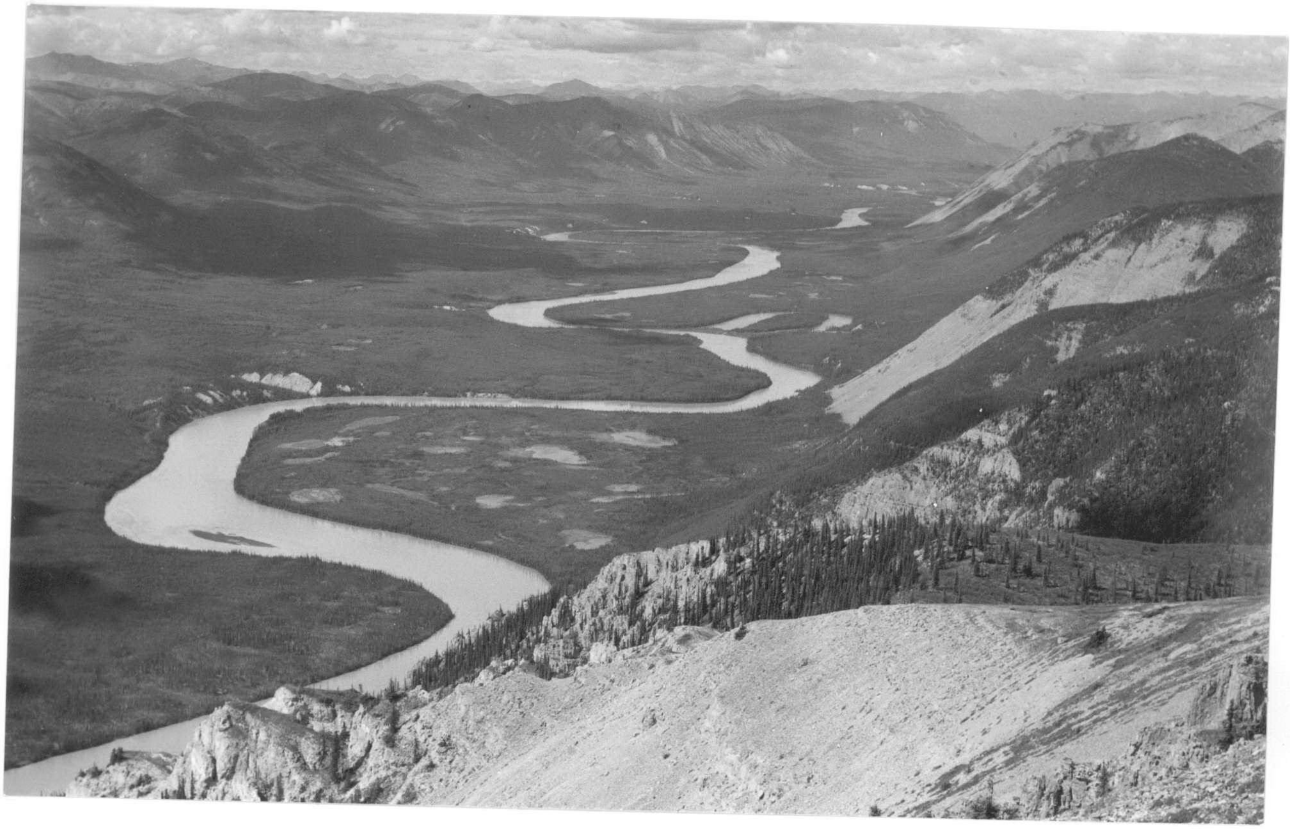
Above Virginia Falls, where the river gradient is less steep, the volume of flow is lower than it is below the falls. The volume varied from 860 ft^3/sec on March 11, 1969, to 36,700 ft^3/sec on June 28, 1968. Mean velocities varied from 0.17 mph to 2.54 mph. The

Fig. 15. Above Virginia Falls, the South Nahanni River winds slowly through a broad, glaciated valley.

The view is to the northwest from Sunblood Mountain toward the Dome Peak area of the Ragged Range. (Photo: W. D. Addison, 22 July, 1966.)

Fig. 16. The Ragged Range, between Mount Harrison Smith and Mount Ida.

(Photo: N. M. Simmons, 13 September, 1970.)



depth at the gauge above the falls varied as much as 5.77 feet over the 4-year period.

Seventeen measurements were recorded on a gauge at the mouth of the Flat River during the 4-year period. Being a tributary of the South Nahanni, the Flat River carries only a fraction of its volume. The volume of flow of the Flat River varied from a low of 410 ft^3/sec on April 4, 1968, to a high of 15,200 ft^3/sec on June 28, 1968. Mean velocities varied from 0.94 mph to 4.77 mph. The depth of the Flat River varied as much as 4.81 feet during this period.

Water quality

"Samples of water from the South Nahanni and Flat Rivers have been submitted to the Water Quality Laboratory at Calgary over the past two years, representing the spring run-off, normal summer flow, and the autumn flow, just before freeze-up. The South Nahanni is sampled under the International Hydrological Decade program and the Flat River is being monitored for effects of mining in the area.

"One of the most significant qualities of these rivers is the very low temperature range typical of northern waters. The temperature varies between 33 and 52 F, depending on the season. Because of their turbulence and subsequent mixing with the air above them, these waters will always contain a high level of oxygen since low temperatures increase the dissolving power of water for oxygen. Oxygen supply would never then be a limiting factor in maintaining a fish population and populations of other oxygen-dependent organisms. On the other hand the low temperature of the water would inhibit the growth rate of both fish and their food supply, so that these streams are sparse in biological activity compared with warmer waters.

"The total amount of minerals dissolved in these waters compare quite favorably with any of the other streams in the eastern Rocky Mountains Watershed. The Nahanni carries about the same dissolved load as the Bow River above Calgary, Alberta, and the Flat River carries about one-third less. These mineral loads vary with the seasons and are highest when the flow rates of the streams are lowest. Like the rivers to the south, these waters are hard because of their association with limestone. They contain no significant amount of common salt. Growth-limiting metals such as copper and zinc are not present in sufficient amounts to affect the growth of microflora such as bacteria and algae. There is very limited evidence that the natural background of mercury may be higher than it is in southern waters.

"Levels of nutrients available for vegetative growth are not in balance. The waters contain carbon in available form as well as some available nitrogen. However, the other major nutrient, phosphorous, exists in very limited quantities. Any plant growth will be limited to the availability of phosphorous. Pollution by phosphates would stimulate some vegetative activity, but this would be limited to organisms tolerant of low temperatures.

"During the spring run-off and periods of active rainfall, these streams carry quite high sediment loads. It would appear then that natural erosion takes place quite freely and that the soils of the watershed are easily erodible. The river beds will probably contain considerable amounts of silt along their edges and moving sand bars in the main streams. During these periods the color of the water intensifies from pigments leached out of the vegetation in the area. The color and turbidity subside as the flow rate drops." (Simpkins, N. J., pers. comm., 11 May, 1971.)

Springs

One of the most interesting features of the Nahanni and Flat Rivers system is the presence of several thermal mineral springs. Their temperatures are higher than river water temperatures. Two types of thermal springs are found in the area: normal thermal springs, where the waters are heated by passing through the earth at great depths, and "anomalous" thermal springs, which probably are heated by the chemical reaction of the water with minerals in the bedrock through which they pass. The springs at Clausen Creek are a good example of normal springs, while the springs at Hole-in-the-Wall Lake are probably of the anomalous type. Most or all of the springs are saline, their salinity varying with the size and depth of their underground flow system. (Brandon, 1965.)

Large thermal springs are located along the south bank of the South Nahanni River at Gus Kraus's homestead (Fig. 17), just upstream from Clausen Creek and below First Canyon. The dark grey limestone of the middle Devonian Nahanni Formation forms the limb of an anticline plunging gently southeast, the southern end of the Nahanni Plateau. The river has cut a steep cliff from the limestone, which is lined at the base with sand and gravel alluvium. The spring waters leak upward from the alluvium in several locations. The main source is a channel along the edge of the rock wall, 100 yards from the river. A natural pool 25-30 feet in diameter is formed by water bubbling upward into an area of river mud; this pool has been extended by a small dam. The flow of water from the main pool has been measured at 300 gallons per minute. The temperature of the pool has been measured at 95 F, and one measurement in the channel which flows to the river was 98 F (Brandon, 1965). William D. Addison (pers. comm., 26 April, 1971) said that he measured the water temperature at the source of the spring and found it to be 98 F on 29 July, 1966. He suspects that Brandon's reading of 95 F reflected the presence of snow meltwater or other seepage. The main mineral constituent is sodium chloride, and the water has an odor of hydrogen sulphide. Brandon concludes that water percolates into the limestones higher in the Nahanni Plateau, enters a deep flow system and gains heat from depths below 5000 feet, and that the flow system reaches a point of natural discharge at the foot of the plateau escarpment. The hydrogen sulphide also indicates a gain of heat from an exothermic chemical reaction (Brandon, 1965).

Rabbitkettle Hotsprings (Fig. 18) in the South Nahanni Valley occurs in the northern Flat River map-area. These springs have formed a spectacular terraced, flat-topped deposit of tufa or calcium carbonate. This circular deposit, about 225 feet in diameter, rises 90 feet above the Rabbitkettle River. Successive terraces from 6 inches to 12 feet thick produce a layer-cake like structure. The main spring comes from a pool about 12 feet in diameter near the center of the top terrace.

Fig. 17. The Hotspring near Clausen Creek, below the mouth of First Canyon.

Patterns of profuse algal growth show in the foreground.

(Photo: W. D. Addison, 2 August, 1966.)

Fig. 18. Rabbitkettle Hotsprings form a spectacular terraced deposit of calcium carbonate.

(Photo: N. M. Simmons, 12 September, 1970.)

The water temperature of the spring has been measured at 69 F. (Gabrielse, Roddick, and Blusson, 1965.)

Another warm spring is located at Hole-in-the-Wall Lake at the headwaters of a tributary which enters the South Nahanni at Rabbitkettle Hotsprings. This area has towering cliffs of Cretaceous granitics to the west and appears to emerge from the same Ordovician and Silurian formations as do Rabbitkettle Hotsprings, though almost no deposits are present. Brandon (1965) believes that the absence of halophytic or salt-loving flora around the spring and the high elevation (nearly 4000 feet) of the discharge point indicate that these springs emerge from a small flow system. He says the heat is probably derived from an exothermic chemical reaction, and that the Chebotarev (1955) sequence of bicarbonate-to-sulphate-to-chlorite metamorphism has occurred.

Several warm springs are located near the Flat River, downstream from Seaplane Lake. They also emerge from Ordovician and Silurian beds. They may be warmed by a geothermal gradient between the limestone and the nearby Cretaceous granitics. Old Pots Mineral Spring, located at $61^{o}31$ 1/2'N, $126^{o}30$'W, gushes in great volume to fill a large pond, and several high-walled deposits of tufa, or "pots", are present. Wild Mint Springs, near McLeod Creek at $61^{o}25$ 1/2'N, $126^{o}35$'W, have deposited dolomitic material containing both calcium and magnesium salts (Figs. 19 and 20).

Turquoise Mineral Lake, fed by a mineral spring north of its west end, is located just east of Seaplane Lake (Fig. 21). Limonite, carbonates, and possibly more sulphates are present.

Fig. 19. Wild Mint Springs have deposited dolomitic material that has formed brittle-walled pools of clear, warm water.

(Photo: N. M. Simmons, 12 September, 1970.)

Fig. 20. Lush vegetation surrounds one of the picturesque pools at Wild Mint Springs.

The dark vegetation in the center foreground is wild mint (*Mentha arvensis*). (Photo: N. M. Simmons, 12 September, 1970.)

Minerals

Canada Tungsten Mining Corporation is operating a productive, open-pit tungsten and copper mine at the headwaters of the Flat River. An occurrence of lead and zinc has been reported by Fort Reliance Minerals Ltd. to be associated with a north-trending fault on Prairie Creek. This outcrop consists of silver-bearing galena and sphalerite in a gangue of quartz and calcium carbonate with minor azurite and malachite staining (Douglas and Norris, 1960). Cadillac Exploration Company and Peñarroya Canada Ltd. have operated an exploratory underground prospect at the site on Prairie Creek, north of the South Nahanni River between Second and Third Canyon (Fig. 21).

Mineral deposits of interest to biologists are found at the many mineral "licks", where moose, sheep, and caribou frequent the locations to eat the soil. No extensive studies of the soil at these licks have been made to determine what minerals the animals favor. One such mineral lick on the Flat River (61°27'N, 125°41 1/2'W, Fig. 22) appears to have been the bottom of an old glacial lake (see Fig. 30 for mineral lick locations). The minerals, which were apparently deposited by water which had passed through limestone, are carbonates - probably calcium carbonate - with some iron but no chlorides.

Caves

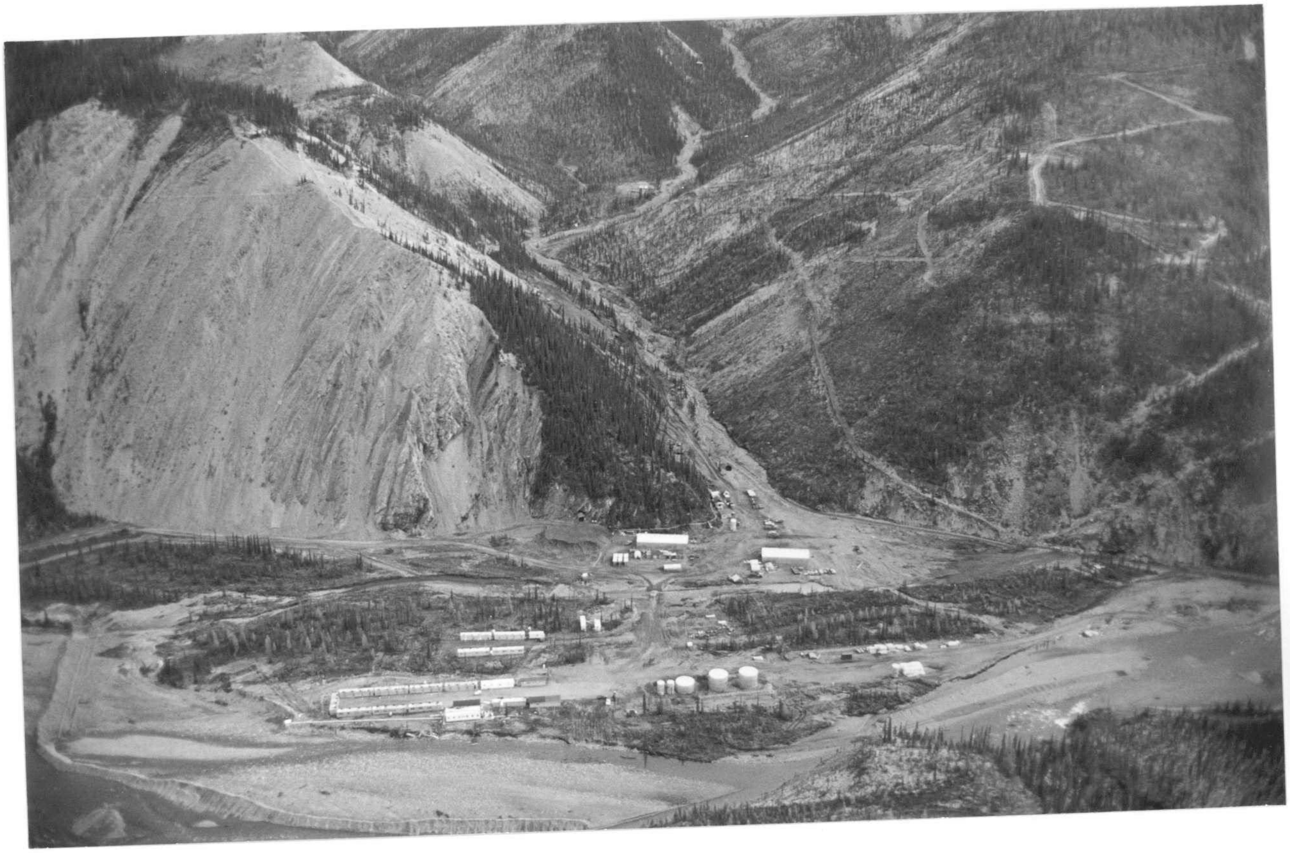
There are many caves in the Lafferty Creek and First Canyon areas, most of them shallow, but a few quite deep. Originally these caves were underground galleries resulting from erosion that took

Fig. 21. The Peñarroya prospect on Prairie Creek.

The creek channel had just been altered by the flood of August, 1970, which damaged many of the structures in the foreground. The camp has been moved to higher ground. (Photo: N. M. Simmons, 13 September, 1970.)

Fig. 22a. A mineral lick on the south bank of the Flat River frequented by moose, Dall sheep, and woodland caribou.

This area may have been the bottom of an old lake bed. The hills are eroded portions of mud slides from the steep slope on the left. (Photo: N. M. Simmons, 12 September, 1970.)



place along fractures and faults. The caves became exposed as streams cut through the terrain and slopes collapsed (Schroder, 1971).

In July and August of 1970, a speleological party led by Jean Poirel investigated over 150 of the caves. Their investigations were cursory and only a few caves of possible interest to tourists were found, but the team speculated that extensive cave systems exist in the area (Jubert and Poirel, 1971).

One of the most interesting caves explored measured 20 feet by 15 feet at the entrance. A large tunnel, damp and completely smooth-floored, led into the mountain. From the main tunnel led a complex network of passages. Even after three days of exploration, the Poirel team did not consider their work in the cave complete.

Another cave, perhaps even more fascinating, was found by Poirel and his team members during the summer of 1971. It contains stalactite and stalagmite formations (Fig. 22b) and the skeletal remains of a large number of Dall sheep (Fig. 22c).

Fig. 22b. Stalactite and stalagmite formations with unusual colors are found in a limestone cave in the First Canyon area.

(Photo: G. W. Scotter, 14 September, 1971.)

Fig. 22c. The discovery of 93 Dall sheep skeletons in the same cave may be of major paleozoological interest.

(Photo: G. W. Scotter, 14 September, 1971.)

GEOMORPHOLOGY

The latest continental glaciers that sculptured much of the terrain did not intrude far into the South Nahanni and Flat Rivers area. The hummocky moraine in the eastern part of the map area probably marks their most westerly extent. Sections of the Nahanni and Flat Rivers and the Prairie Creek valley probably supported valley glaciers that produced wide but steep-sloped valleys. Near the peaks of many mountain ridges, amphitheater-like, scalloped scars of cirque glaciers are evident. Ice from most of these cirque glaciers probably did not reach the main valley glaciers.

Erosion by running water produced narrow and deep, steep-walled valleys and canyons. During the spring flooding period rivers are especially effective agents in removing the debris accumulated from crumbling bedrock faces. Some of this debris is deposited in alluvial flats and fans, only to be carved into new channels by suddenly flooding rivers.

The map of the geomorphology of the proposed National Park area was based on interpretation of aerial photographs (Fig. 23). It includes a classification of relative relief classes, landforms, and materials.

The mapping units are expressed by five broad relief classes, based on surface gradient of the landform, as well as on the length of the slopes. The relative relief classes are very low relief (V), low relief (L), moderate relief (M), high relief (H), and precipitous relief (S).

Landforms have been separated into 12 divisions. Ridges (R) and plateaus (P) are the most common upland landforms. Ridges consist of at least two slopes, oriented in opposite directions. Plateaus are elevated areas of generally low relief, being erosional remnants of uplifted plains. Hills (H) consist of complex patterns of ridges, slopes, and valleys, which can be identified only by more detailed investigation. Slopes (S), as mapped, are mainly oriented in one direction only, and are generally concave, although some may be precipitous. Valleys (V) consist of pairs of opposite slopes and the lowlands enclosed by them. Terraces (T) mark the floor of ancestral valleys which were left after the valley was re-excavated by renewed erosion. Some of these terraces were subsequently dissected by creeks (Td). In the eastern part of the area hummocky dead-ice moraine is found (Md). A great number of knobs and depressions characterize this landform, resulting in a complex pattern of sags and swells. Alluvium collects on floodplains or rivers (A) or in fan-shaped (Af) low hills at the mouths of valleys. Flat portions of some valleys may be covered by thick accumulations of peat, forming wet organic terrain (O). Recent landslides (L) often leave long-lasting scars on the mountainsides.

Materials were mapped on the basis of seven divisions. Most of the surface materials covering the bedrock were derived locally from the weathering of the bedrock, and were transported only short distances by glaciers, gravity, or running water. Colluvial materials (C) result from slope wash and downslope movement of rocks by gravity.

The composition depends on the character of the bedrock, but usually it is a stony material, where clay, silt, and sand particles are mixed in equal proportions. Scree (S) or talus material is bedrock, broken into finer fragments. Till (T) is the debris deposited by glaciers and may have composition similar to the colluvial materials, except that it may contain rocks foreign to the locality. The till of the continental glaciers found in the eastern part of the area is a clay-rich, sparsely stony material.

Alluvium (A) was deposited by flooding rivers, and its texture depends on the speed of the current at a given location. Generally, fine sand interbedded with organic debris is found on the floodplains of larger rivers, although locally gravel bars may occur. Swift creeks prone to flash floods usually deposit much gravel and rock rubble. Fluvial deposits (F) are laid down in the beds of rivers and creeks, and consist of well-sorted sand and gravel materials. Peaty organic materials (O), being poorly decomposed parts of plants, accumulate on poorly drained flats. Bedrock (R) is exposed in certain sections of the area.

Perennially frozen ground occurs in some peat deposits and on some lower slopes. Permafrost is common above the timber line, as indicated by polygonal and sorted boulder patterns.

VEGETATION

The vegetation of the South Nahanni and Flat River regions is poorly known, with detailed descriptions of plant cover available from only two small areas. Raup (1947) thoroughly described the vegetation of the Glacier (Brintnell) Lake region (Fig. 24). After two months of intensive collection, he reported a total of 283 species and varieties of plants from the region. The vascular flora of a hotsprings near Hole-in-the-Wall Lake was studied by Arnold (1961). Porsild (1961) reported on 105 taxa collected by Arnold from that region. In addition, Hirvonen (1968) published forest inventory map sheets (see map sheet S 93-15 and S 93-16) for the eastern portion of the proposed national park site.

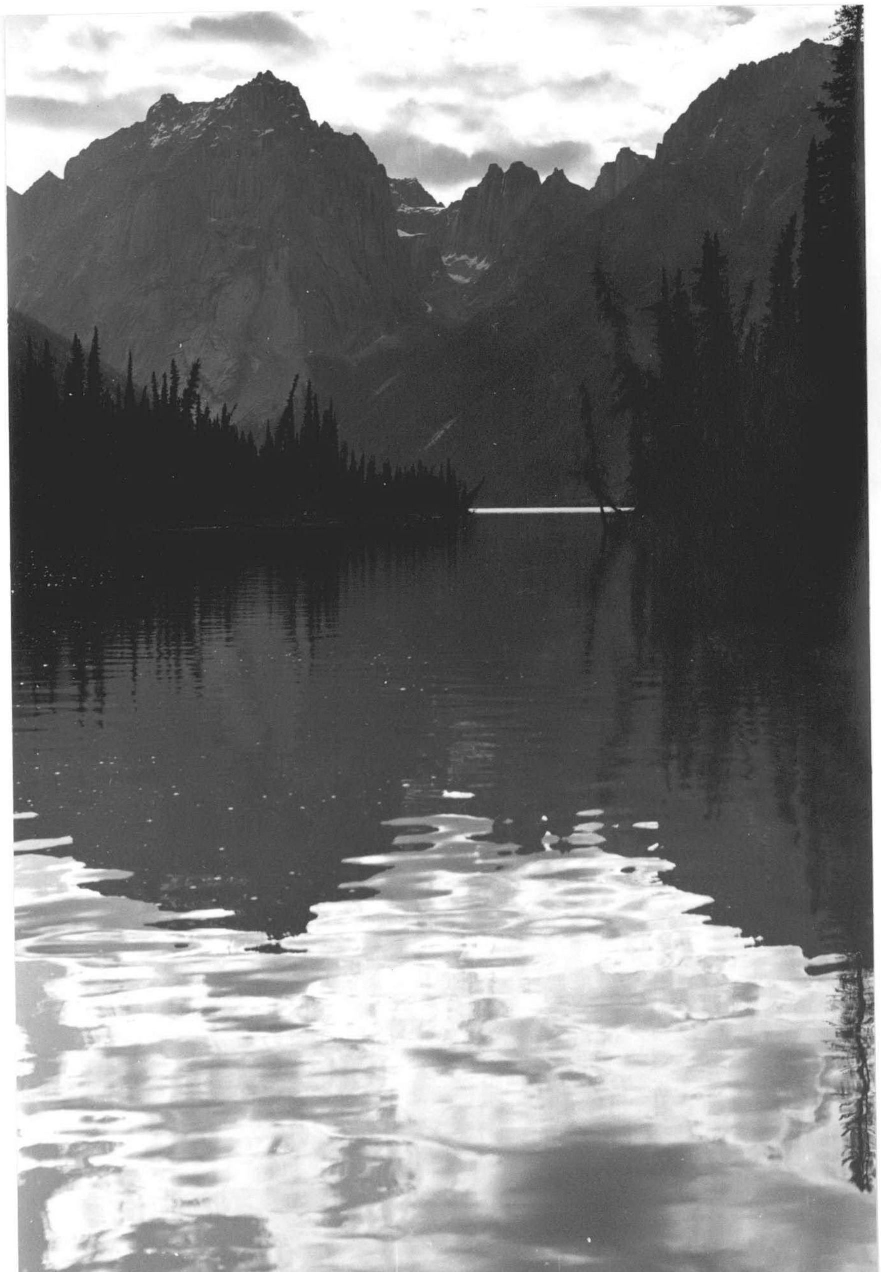
Jeffrey (1961, 1964) published descriptions of forest types along the Lower Liard River. Several of those types are also found in the South Nahanni and Flat River Regions. Jeffrey (1961) reported the collection of 15 species from Virginia Falls on the South Nahanni River.

Other botanical work related to the area, though not carried out within the proposed boundaries, includes that by Porsild (1951) in the southeastern Yukon, on the east slope of the Mackenzie Mountains (Porsild, 1945), and by Porsild and Crum (1961) on the flora of Liard hotsprings.

The vegetation of the South Nahanni and Flat River areas is characterized by boreal and alpine plant species. An altitudinal transition is shown from the closed forests in the lowlands to alpine

Fig. 24. Black spruce borders the shore of Glacier Lake.

The view is to the west-northwest toward Mount Sir James MacBrien. (Photo: W. D. Addison, 10 July, 1966.)



tundra on the mountains. The tree line is at about 3,900 feet on south and west facing slopes, but occurs at about 3,600 feet on the north and east slopes. The influence of aspect is illustrated in the occurrence of vegetation: north and east slopes carry a vegetation that would be found at higher elevations on the south and west slopes.

The broad vegetation types are outlined on Fig. 25, based on the occurrence, growth form, and density of forest stands. The broad vegetation types were delineated from aerial photographs. An attempt was made to show the potential forest form, even though the present forest cover may reflect recent disturbances.

Dense growth of tall trees (map symbol: 1) occurs on valley bottoms, especially on floodplains. White spruce (*Picea glauca*) and balsam poplar (*Populus balsamifera*) are the dominant species in undisturbed stands (1:M), often with dense shrub layers of alder (*Alnus incana*), squashberry (*Viburnum edule*), and wild rose (*Rosa acicularis*). Even-aged stands of trembling aspen (*Populus tremuloides*) may occur in some bottomlands (1:M) with only a few scattered white spruce. Alder (*Alnus crispa*) and wild rose are common in the shrub layers. The regenerating forest stand after fire (1f:M) usually consists of trembling aspen and white birch (*Betula papyrifera*), with some white and black spruce (*Picea mariana*). Dense, tall white spruce may grow on some alluvial flats in nearly pure stands (1:C), or with a few white birch. The forest floor is usually covered with feather mosses.

The most widespread forest growth is the somewhat open stands of trees that reach a height of 30 to 50 feet at maturity (map symbol: 2). In undisturbed stands white spruce dominates, growing with a mixture of trembling aspen (2:M). At higher altitudes and on north slopes black spruce becomes more prominent (2:C), growing in mixture with white spruce, lodgepole pine (Pinus contorta), or jack pine (Pinus banksiana). Alder (Alnus spp.) and Labrador tea (Ledum groenlandicum) are found in the shrub layer. Just below the tree line alpine fir (Abies lasiocarpa) is found growing in mixture with black and white spruce. On some dry, south- or west-facing slopes pure stands of lodgepole or jack pine may grow.

After fires, lodgepole or jack pine may regenerate (2f:C) on suitable sites, although white and black spruce, in mixture with white birch (2f:M) are far more common. Alder (A. crispa) is a common shrub species in such areas. The initial vegetation on landslide scars is willow, with some white birch and conifers, such as white and black spruce and pine (2s:M). On rocky slopes scattered white spruce and lodgepole or jack pine may grow (2r:C). Lodgepole pine stands are more common in the western portion of the proposed park while jack pine stands are present from Nahanni Butte to Virginia Falls.

Open forests of scattered, stunted trees occur in different areas (map symbol: 3) because of soil-rock-water relationships. These trees seldom reach the height of 30 feet at maturity. Open coniferous stands (3:C) occur below the tree line, especially on north- and east-facing slopes. These consist mainly of stunted, scattered black spruce, alpine fir, and lodgepole or jack pine. Outcrops of solid or fractured bedrock present a poor environment for plant growth (Fig. 26). In such places scattered white and black spruce or lodgepole and jack pine may grow (3r:C). On peat deposits, black spruce

Fig. 26. Outcrops of limestone of the Sunblood Formation below Virginia Falls, South Nahanni River.

(Photo: W. D. Addison, 19 July, 1966.)

trees may grow as open, stunted muskeg forests (3w:C). After fires have burned these scattered, stunted forest stands, the regeneration may favour the coniferous species of black spruce or lodgepole and jack pine (3f:C) or a mixture of conifers with white birch (3f:M).

A widely occurring type is the open black spruce and reindeer lichen forest. The soil is generally heavy (loam to clay) and is covered by shallow (1.5 ft.) peat. Permafrost usually occurs at 4 feet below the surface (3p:C). This condition is common on gentle north- or east-facing slopes and on other lower slopes where the gradient is less than 10 per cent.

Treeless areas (map symbol: 4) occur as the result of unfavourable environmental factors. Some bottomlands are subject to frequent flooding and deposition of alluvial silt and sand which kills the vegetation (4a). In such places willows and alder may grow, although large areas are completely devoid of vegetation. On steep mountain slopes bedrock outcrops and loose scree prohibit tree growth. These areas are usually devoid of vegetation (4r), save for some grasses or dwarf shrub species. Alpine tundra is found (4t) on the higher mountains, and is characterized by mountain avens (Dryas spp.), ericaceous shrubs, sedges, and grasses (Fig. 27). The high water table in some wetlands prohibits the growth of trees (4w), and supports sedges, cottongrass (Eriophorum spp.) (Fig. 28), and some low shrub vegetation.

Vegetation associated with hotsprings in the region is often luxuriant (Fig. 29). However, only scant attention was paid to the flora of those sites because of the limited time available. Major floristic and ecological studies of those sites should be undertaken to document their status before development or visitor use commences.

Fig. 27. Alpine tundra plateau, Tlogotsho Range.

$61^{o}11'N$, $124^{o}34'W$. (Photo: N. M. Simmons, 2 July, 1970.)

Fig. 28. Cottongrass growing below the mouth of the Flat River.

(Photo: N. M. Simmons, 1 July, 1970.)

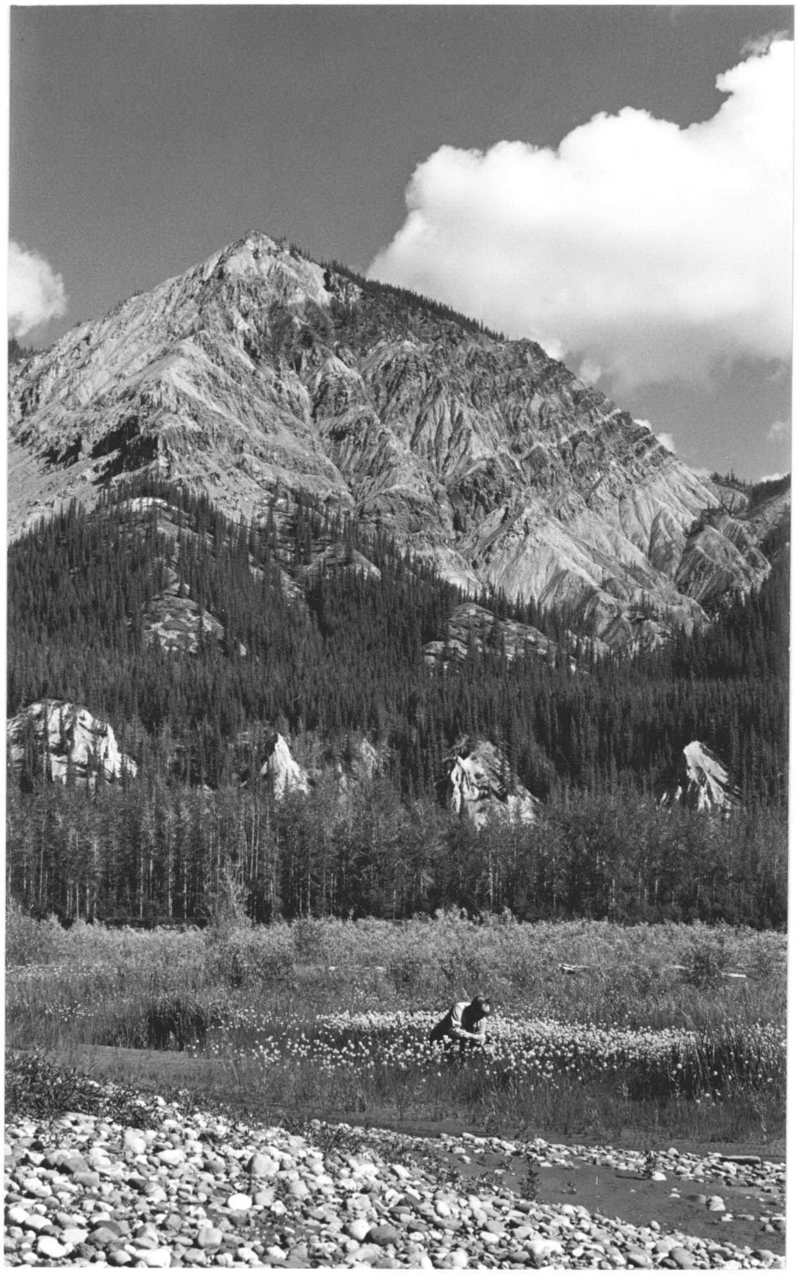
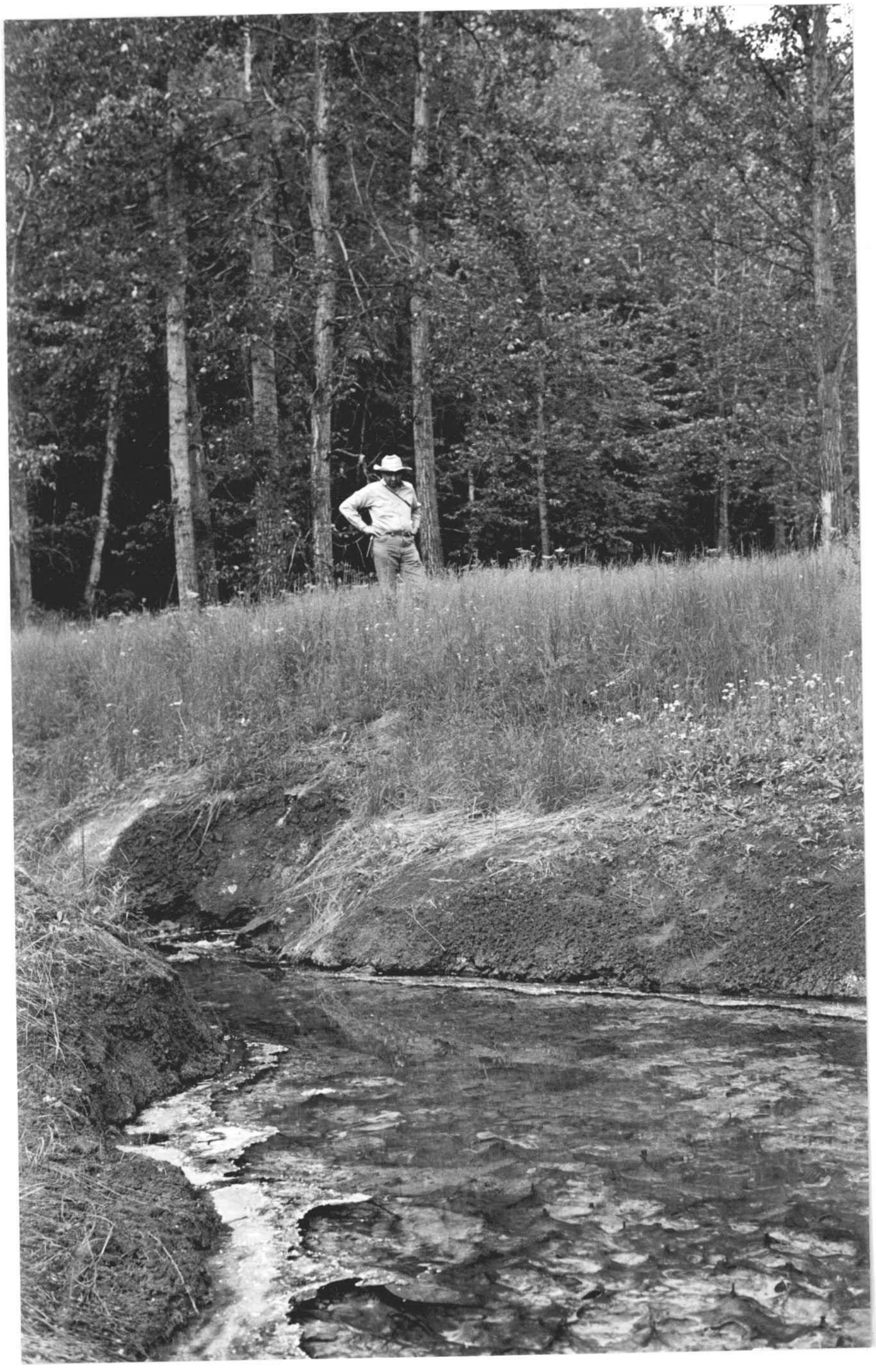


Fig. 29. Luxuriant vegetation at the Hotsprings near the former Kraus residence.

(Photo: N. M. Simmons, 26 June, 1970.)



CONFIDENTIAL

Since data on the vegetation of the proposed National Park site were so scanty, an attempt was made to collect as many species as possible during our brief visits. Collection sites west of the entrance to First Canyon are considered to be within the Mackenzie Mountain phytogeographic province as defined by Porsild and Cody (1968). Sites to the east of the entrance to First Canyon, such as the hotspring near Kraus's cabin and Yohin Lake, are considered to be in the sixth phytogeographic province that they defined. The collection of vascular plants comprised 368 taxa. Of those timber oat grass (Danthonia intermedia), sedge (Carex peckii), red clover (Trifolium pratense), parsnip (Pastinaca sativa), and yellow monkey-flower (Mimulus guttatus) are believed to be additions to the flora of the District of Mackenzie. According to the checklist prepared by Porsild and Cody (1968), 46 species are the first collections from the Mackenzie Mountains. Other plants in the collections, such as diapensia (Diapensia obovata), are significant range extensions.

Since the collection makes a valuable addition to the knowledge of plant distribution in the proposed National Park site and in northern Canada, an annotated list of the plants follows. Collection numbers cited for each species are Scotter's. Data on the collection sites, referred to by a number within brackets in the annotated list, are included at the end of the list. Brief comments are included on the abundance and distribution of many of the plants within the region. New records for the District of the Mackenzie or the Mackenzie Mountain region are so indicated.

Annotated List of Vascular Plants

POLYPODIACEAE

Athyrium filix-femina (L.) Roth. spp. *cyclosorum* (Rupr.) C. Chr. 17429 (50). Sole occurrence noted near a hotspring; previously reported by Porsild (1961) from the same general area.

Cystopteris fragilis (L.) Bernh. 12349 (4), 12510B (14), 12700 (28), 12941 (41), 17424 (36). Moist rock ledges and slopes.

Dryopteris austriaca (Jacq.) Woynar 17428 (50). Sole occurrence noted was near a hotspring; previously reported from the District of Mackenzie only near Canada Tungsten Mine (Cody and Porsild, 1968).

Dryopteris disjuncta (Ledeb.) Morton 12904 (39). Moist woods near a hotspring.

Dryopteris fragrans (L.) Schott s. lat. 12894 (38), 17432 (38). Collected on sunny, rocky slopes. Sole occurrence noted.

Dryopteris robertiana (Hoffm.) C. Chr. 12343 (4), 12499 (14). Fairly common in woods and shrubby areas.

Matteuccia struthiopteris (L.) Todaro var. *pensylvanica* (Willd.) Morton 12336 (3). Rare on the floodplains of the South Nahanni River. The only previous records from the District of Mackenzie were those by Jeffrey (1961) and Cody (1963).

Woodsia glabella R. Br. 12342 (4), 12510A (14), 12613 (22), 12798 (32). An occasional species which seems to prefer calcareous, rocky, habitat.

EQUISETACEAE

Equisetum arvense L. (incl. *E. calderi* Boivin) 12248 (1), 12860B (33). Common on floodplains and in a number of other habitats.

Equisetum fluviatile L. (*E. limosum* L.) 12260 (1). Seen along a stream from a hotspring and on floodplains.

Equisetum hyemale L. var. *affine* (Engelm.) A. A. Eaton (*E. prealtum* Raf.) 12312 (2). Commonly seen on recent floodplains and in balsam poplar forests; previously known from several sites on the Liard River, but not from the South Nahanni River drainage.

Equisetum palustre L. 12405 (8). Seen on mud and silt bars.

Equisetum pratense Ehrh. 12298 (2), 12860 (33). A common species on floodplains and in balsam poplar and white spruce forests.

Equisetum scirpoides Michx. 12316 (2), 12943 (41). Found in coniferous forests.

Equisetum sylvaticum L. var. *pauciramosum* Milde 12675 (26). An occasional species of depressions from lowland forest to alpine regions.

Equisetum variegatum Schleich 12807 (32). A single collection from a coniferous forest.

LYCOPODIACEAE

Lycopodium annotinum L. s. lat. 12552 (18), 12659 (26). Found from lowlands to the alpine region.

Lycopodium complanatum L. s. lat. 17433 (38). Infrequent in shrub zone near treeline.

Lycopodium selago L. 12638 (23), 12686 (27). Sole occurrences noted, both in alpine tundra.

PINACEAE

Abies lasiocarpa (Hook.) Nutt. 12896 (38). Sole collection made, although it may be present near treeline throughout much of region.

Juniperus communis L. var. *depressa* Pursh 12373 (6), 12806 (32). Dry open slopes and in some mixed wood forests.

Juniperus horizontalis Moench 12367 (6), 12815 (32). Dry and rocky slopes; previously known from the east flank of the Mackenzie Mountains (Raup 1947) but not from the interior.

Larix laricina (Du Roi) Koch 12493 (14). A widespread but never abundant species in the area.

Picea glauca (Moench) Voss s. lat. 12395 (7), 12706 (29). Widespread throughout the area, with the best development on old floodplains.

Picea mariana (Mill.) B.S.P. 12436 (9). A common tree throughout the region.

Pinus banksiana Lamb. 12234 (42), 12238 (45), 12239 (45), 12240 (46). Scattered in the eastern portion of the South Nahanni region. All samples showed indications of hybrid derivations.

Pinus contorta Dougl. var. *latifolia* Engelm. 12231 (20), 12232 (14), 12233 (42), 12235 (43), 12236 (34), 12237 (44), 17434 (52). A common tree in the Flat River region and along the Liard Range (Jeffrey, 1961; Cody 1963) with more scattered distribution along the South Nahanni River.

TYPHACEAE

Typha latifolia L. 12644 (24). Seen only on the shore of Yohin Lake. The nearest collection within the District of the Mackenzie was at Fort Simpson (Cody, 1961).

SPARGANACEAE

Sparganium minimum (Hartm.) Fries 12767 (30). First collection from the Mackenzie Mountains; found in association with hotspring pools.

SCHEUCHZERIACEAE

Triglochin maritimum L. 12656 (24), 12722 (30), 12742 (30). First collections from the Mackenzie Mountains; found in association with hotspring pools and on the shore of Yohin Lake.

Triglochin palustre L. 12275 (1), 12540 (17), 12911 (39). Fairly common near hotsprings and in natural salt lick areas.

GRAMINEAE

X Agrohordeum macounii (Vasey) Lepage (Agropyron trachycaulum X Hordeum jubatum) 12536 (17). Sole occurrence noted, but to be expected wherever the parents are found together; it is known from several sites along the Liard River (Cody, 1963).

Agropyron pectiniforme R. & S. 12832 (33). Introduced plant, collected from Nahanni Butte.

Agropyron sericeum Hitchc. (A. trachycaulum sensu Porsild, 1943). 12548 (17), 12830 (33). Occasional on sand bars and disturbed areas.

Agropyron trachycaulum (Link) Malte var. novae-angliae (Scribn.) Fern. 12257 (1), 12937 (41). Found on riverbanks and dry open sites.

Agropyron trachycaulum (Link) Malte var. trachycaulum 12276 (1), 12909 (39). From openings near a hotspring.

Agropyron violaceum (Hornem.) 12354 (4), 12380 (7), 12817 (32). River bars and openings.

Agrostis exarata Trin. 12258 (1), 17420 (48). Occurrences noted near warm and cool springs; otherwise known in Mackenzie District only from above a hotspring at Tungsten at the headwaters of the Flat River (Cody and Porsild, 1968).

Agrostis scabra Willd. 12828 (33). Opening near hotsprings.

Arctagrostis arundinacea (Trin.) Beal 12836C (33), 12912 (39). Occasional near hotsprings and on floodplains.

Beckmannia syzigachne (Steud.) Fern. 12529B (16), 12826 (33). Wet ground near a hotspring and near rivers. First collection from the Mackenzie Mountains; previously known from the lowlands of the Mackenzie and Liard Rivers (Raup, 1947).

Bromus ciliatus L. 12322 (3), 12834 (33), 12910 (39). Infrequent in openings near hotsprings.

Bromus pumpellianus var. *arcticus* (Shear) Porsild 12286 (2), 12379 (7). From clearing near cabins; collection No. 12379 is the first collection recorded from the Mackenzie Mountains.

Calamagrostis canadensis (Michx.) Beauv. 12255 (1), 12836 (33), 12895 (38), 12918A (39). Common throughout the area.

Calamagrostis lapponica (Wahlenb.) Hartm. 12863 (34). Openings near hotsprings.

Calamagrostis purpurascens R. Br. 12377 (7). From a white spruce - balsam poplar community.

Danthonia intermedia Vasey 12285A (2). New to the District of Mackenzie; the map in Hulten (1968) indicates collection sites in south central Yukon, northern British Columbia, and at Lake Athabasca in northern Alberta.

Deschampsia caespitosa (L.) Beauv. 12364 (5), 12477 (13), 12717 (30), 12938 (41), 17425 (49). Occasional on floodplains and at a hotspring.

Elymus innovatus Beal 12360 (5), 12434 (9), 12776 (31), 12816 (32), 12932 (40), 12933 (40). Infrequent from floodplains to alpine communities.

Elymus sibiricus L. 12829 (33). Infrequent at Nahanni Butte (Cody, 1963).

Festuca altaica Trin. 12580 (21). Sole occurrence noted in an alpine tundra community but probably fairly common in the area.

Festuca baffinensis Polunin 12624B (22). From alpine tundra; sole occurrence noted.

Festuca brachyphylla Schultes 12893 (38). Occasional in alpine tundra.

Glyceria striata (Lam.) Hitchc. var. stricta (Scribn.) Fern. 12272 (1), 12553 (18), 12727 (30), 12865 (34), 17422 (48). Moist soil near hot-springs and floodplains; otherwise known in the adjacent area from along the Liard River and at Tungsten at the headwaters of the Flat River.

Hierochloe alpina (Swartz) R. & S. 12666 (26), 12669 (26), 12703 (28). Occasional in alpine tundra.

Hierochloe odorata (L.) Wahlenb. 12441 (10). Along bank of the South Nahanni River.

Hordeum jubatum L. 12529A (16). First collection from the Mackenzie Mountains; probably introduced here.

Phalaris arundinacea L. 12833 (33), 17421 (48). Drainage ditch near airfield and near a hotspring. The collection from the hotspring is the first from the Mackenzie Mountains.

Phleum pratense L. 12827 (33). Introduced grass at Nahanni Butte.

Phragmites communis Trin. var. berlandieri (Fourn.) Fern. 17437 (53). A sole collection from the shore of a small lake; Cody (1963) first reported this species from Yohin Lake.

Poa alpigena (Fries) Lindm. 12513 (14). Gravelly site near Virginia Falls.

Poa alpina L. 12266 (1), 12281 (2). Openings near hotsprings.

Poa glauca Vahl s. lat. 12247 (1), 12317 (3), 12320 (3), 12530 (16), 12624A (22), 12777 (31), 12818A (32), 12831 (33). A fairly common plant with wide ecological tolerance.

Poa palustris L. 12259 (1), 12270 (1), 12318 (3), 12321 (3). Collected only at a hotspring and a nearby opening.

Schizachne purpurascens (Torr.) Swallen 12323 (3). First collection from the Mackenzie Mountains; otherwise known in Mackenzie District from Great Bear Lake, the Slave River lowlands and the Liard River.

Sphenopholis intermedia (Rydb.) Rydb. 12287 (2), 12319 (3), 12835 (33), 12836B (33), 12864 (34). Found in meadows, on stream banks, and near hotsprings. First collections from the Mackenzie Mountains; other collections from Mackenzie District have been from the Great Slave Lake lowlands and along the Liard River.

Trisetum spicatum (L.) Richt. s. lat. 12271 (1), 12280 (3), 12284 (2), 12378B (7), 12668 (26). A fairly common species with wide ecological tolerance.

CYPERACEAE

Carex aquatilis Wahlenb. 12404 (8). Seen in shallow water of marshes, and streams.

Carex canescens L. 12402 (8), 12479 (13). Along streambanks and floodplains.

Carex capillaris L. 12515 (14). Collected near Virginia Falls.

Carex concinna R. Br. 12378 (7). Opening in mixed forest.

Carex diandra Schrank 12724 (30), 12726 (30). On border of a hotspring; sole occurrence noted.

Carex eburnea Boott. 12283 (2), 12324 (3), 12376 (7), 12512 (14), 12819 (32), 12889 (36), 12931 (40). Collected from various dry and rocky sites.

Carex franklinii Boott. 12518 (14). Sole occurrence noted; collected near Virginia Falls.

Carex glacialis Mack. 12523 (14), 12578A (21). Found near Virginia Falls and in an alpine tundra community.

Carex interior Bailey 12729 (3). From hotspring ponds. This is the second record of this species for District of Mackenzie. It was first reported by Thieret (1961) from around a marly lake at Mile 61 Enterprise - Mackenzie River Highway.

Carex limosa L. 12646 (24). Sole occurrence was noted near Yohin Lake.

Carex macloviana d'Urv. 17431 (38). Sole occurrence noted on the gravelly shore of Hole-in-the-Wall Lake.

Carex membranacea Hook. 12522A (14), 12625A (22). Noted in wet habitats.

Carex microchaeta Holm 12667 (26). Wet meadows in alpine tundra.

Carex misandra R. Br. 12577B (21), 12626 (22), 12701 (28). Alpine tundra habitats.

Carex nardina Fries 12578 @21), 12702 (28). Dry sites in alpine tundra.

Carex peckii E. C. Howe 12282 (2). Dry site near clearing. First collection from the District of the Mackenzie. This is a North American species which is found across Canada from Quebec to the Peace River country. The map in Hulten (1968) also indicates two isolated sites in Yukon and Alaska.

Carex petricosa Dewey 12522B (14), 12579 (21). Collected from near Virginia Falls and in alpine tundra.

<u>Carex rostrata</u> Stokes 12716 (30), 12866 (34), 17417 (48). Collected from hotsprings but noted in other habitats.

<u>Carex saxatilis</u> L. var. <u>major</u> Olney (<u>C. physocarpa</u> Presl) 12522A (14), 12551 (18). Moist habitats.

<u>Carex scirpoidea</u> Michx. 12514 (14), 12516 (14), 12577A (21), 12594 (21), 12718 (30), 12723 (30), 12725A (30), 12818B (32), 12820 (32). Fairly common with rather wide ecological tolerance.

<u>Carex viridula</u> Michx. 12728 (30), 12878 (35). Associated with hotspring sites. First collections from the Mackenzie Mountains.

<u>Eleocharis palustris</u> (L.) R. & S. 12478 (13). First collection from the Mackenzie Mountains; from a muddy shore of an island in the South Nahanni River.

<u>Eriophorum angustifolium</u> Honck. 12625B (22), 12680 (26). Alpine tundra habitats.

<u>Eriophorum brachyantherum</u> Trautv. & Mey. 12521 (14). Sole collection near Virginia Falls.

<u>Eriophorum scheuchzeri</u> Hoppe 12480 (13), 12633 (23). Wet habitats.

<u>Eriophorum triste</u> (Th. Fries) Hadac & Love 12627 (22). Wet alpine tundra habitat.

<u>Eriophorum vaginatum</u> L. 12407 (8), 12665 (26). Wet habitats.

<u>Kobresia hyperborea</u> Porsild 12623 (22). Rocky slopes in alpine tundra.

<u>Scirpus caespitosus</u> L. ssp. <u>austriacus</u> (Pall.) Asch. & Graebn. 12723A (30), 12725B (30). Wet place at a hotspring.

<u>Scirpus microcarpus</u> Presl 12252 (1). Wet habitat near hotsprings.

<u>Scirpus validus</u> Vahl 12265 (1), 17436 (53). Wet habitat near hotsprings and on the shore of a small lake.

LEMNACEAE

Lemna minor L. 12649 (24). Collected in Yohin Lake.

JUNCACEAE

Juncus alpinus Vill. ssp. nodulosus (Wahlenb.) Lindm. 12473 (13), 12714 (30), 12719A (30). Wet habitats.

Juncus balticus Willd. var. alaskanus (Hulten) Porsild 12299 (2), 12359 (5), 12542 (17). Wet habitats including river flats.

Juncus balticus var. littoralis Engelm. 12720 (30). First collection from the Mackenzie Mountains; from hotspring ponds.

Juncus bufonius L. 12251 (1), 12837 (33), 12838 (33). Wet habitats.

Juncus castaneus Smith 12519 (14). Wet habitat near Virginia Falls.

Juncus nodosus L. 12719 (30), 12721 (30), 12874B (34). First collections from the Mackenzie Mountains; from hotspring ponds.

Luzula confusa Lindb. 12682 (27), 12687 (27). From a heath community in alpine tundra.

LILIACEAE

Allium schoenoprasum L. var. sibiricum (L.) Hartm. 12339 (3), 12462 (12). From moist meadows and gravel pavement near rivers.

Lloydia serotina (L.) Rchb. 12622 (22). Sole collection from alpine tundra.

Maianthemum canadense Desf. var. interius Fern. 12304 (2). Collected from a white spruce - balsam poplar forest.

Smilacina stellata (L.) Desf. 12242 (1), 12771 (30). Both collections were from hotspring areas.

Tofieldia coccinea Richards. 12595 (22). Infrequent in alpine tundra.

Tofieldia glutinosa (Michx.) Pers. 12715 (30). First collection from the Mackenzie Mountains; from a hotspring site.

Tofieldia pusilla (Michx.) Pers. 12350 (4), 12433 (9), 12496 (14), 12796 (32). Infrequent in most habitats.

Zygadenus elegans Pursh 12348 (4), 12588 (21), 12811 (32). Forest openings to alpine tundra.

ORCHIDACEAE

Corallorhiza trifida Chat. 12459A (11). Noted in white and black spruce forests.

Cypripedium calceolus L. var. *parviflorum* (Salisb.) Fern. 12369B (6), 12481 (14). Infrequent in moist habitats.

Cypripedium guttatum Sw. 12448 (10). Sole occurrence noted; collected from a white spruce forest on an old floodplain.

Cypripedium passerinum Richards. 12289 (3), 12389 (7). Infrequent in moist white spruce and balsam poplar stands.

Goodyera repens (L.) R. Br. 12459B (11), 12524 (15). Associated with heavy moss cover in white spruce forests.

Habenaria hyperborea (L.) R. Br. 12406 (8), 12420 (8), 12758 (30), 17415 (48). Infrequent in moist habitats.

Habenaria obtusata (Pursh) Richards. 12412 (8), 12525 (15), Mossy habitats in a spruce forest.

Orchis rotundifolia Banks 12396 (7). Moist habitat in a spruce forest; first collection from the Mackenzie Mountains.

SALICACEAE

Populus balsamifera L. 12398 (7). Common on juvenile soils of floodplains and terraces.

Populus tremuloides Michx. 12564 (20). Present in fire disturbed regions.

Salix alaxensis (Anderss.) Cov. var. alaxensis 12547 (17). From mineral lick area.

Salix alaxensis (Anderss.) Cov. var. longistylis (Rydb.) Schneid 12468 (13). Growing on juvenile soils of an island.

Salix arbusculoides Anderss. 12393 (7). Lowland forest site.

Salix arctica Pall. 12621 (22), 12634 (23). Fairly common on dry alpine tundra.

Salix barrattiana Hook. 12597 (22). Sole occurrence noted in an alpine meadow.

Salix bebbiana Sarg. 12508 (14), 12869 (34). Fairly common from river flats to dry forest habitats.

Salix brachycarpa Nutt. ssp. niphoclada (Rydb.) Argus 12511 (14). Riverbank habitat; first collection from the Mackenzie Mountains.

Salix candida Fluegge 12753 (30). From edge of hotspring ponds; first collection from the Mackenzie Mountains.

Salix glauca L. var. acutifolia (Anderss.) Schneider 12374 (6), 12487 (14), 12501 (14), 12502 (14), 12635 (23). Found in thickets along riverbanks to alpine tundra.

Salix interior Rowlee. 12465 (13), 12466 (13), 12467 (13), 12472 (13). Common colonizing shrub on new alluvium. First collection from the Mackenzie Mountains.

Salix lasiandra Benth. 12471 (13), 12536 (17), 12549 (17). Common riparian shrub on new alluvium; first collection from the Mackenzie Mountains.

Salix monticola Behh. (*S. padophylla* Rydb.) 12393 (7), 12890 (36). Along rivers and streams at low elevations.

Salix myrtillifolia Anderss. 12438 (10), 12447 (10), 12485 (14), 12554 (18). Moist areas in spruce forests.

Salix novae-angliae And. 12773 (30). Collected from a hotspring site.

Salix pedicellaris Pursh 12651 (24). Muskeg site near Yohin Lake.

Salix planifolia Pursh spp. *planifolia* 12679 (26). Collected from alpine tundra.

Salix reticulata L. 12490 (14), 12575 (21). Fairly frequent in alpine tundra; also collected from Virginia Falls.

Salix rigida Muhl. (*S. mackenzieana* Barratt) 12469 (13), 12541 (17). Found on an island and in a natural salt lick area; otherwise known in District of Mackenzie from the lowlands of the Liard and Mackenzie Rivers.

MYRICACEAE

Myrica gale L. 12645 (24), 12884 (35). Fairly frequent in muskegs and in shallow water. Collection number 12884 is the first reported from the Mackenzie Mountains.

BETULACEAE

Alnus crispa Ait. 17410 (25). Fairly common on floodplains and in mixed forests.

Alnus incana (L.) Moench. 12313 (2), 12423 (8). First collections from the Mackenzie Mountains. A common species of floodplains and lowlands.

Betula glandulosa Michx. 12507 (14), 12925 (40). A common species at high elevations and occasional in spruce forests.

Betula papyrifera Marsh. var. *commutata* (Regel) Fern. 12936 (41). Seen in mixed forests and on floodplains.

Betula papyrifera var. *neoalaskana* (Sarg.) Raup 12872 (34). Seen in mixed forests, burnt-over areas and on floodplains.

URTICACEAE

Urtica gracilis Ait. 12329 (3). From thickets near a cabin; probably introduced here.

SANTALACEAE

Geocaulon lividum (Richards.) Fern. 12370 (6). Infrequent on dry forest sites.

POLYGONACEAE

Polygonum viviparum L. 12365 (6), 12443 (10), 12517 (14), 12812 (32). Fairly frequent throughout much of the area.

Rumex occidentalis Wats. 17413 (48). Infrequent in moist habitats; also noted at Yohin Lake.

CHENOPODIACEAE

Chenopodium berlandieri Moq. var. *zschackei* (Murr.) Zobel. 12254 (1), 12847 (33), 12915 (39). An introduced species near settlements.

Chenopodium capitatum (L.) Asch. 12244 (1), 12461 (11). Seen in artificial clearings, disturbed sites, and along riverbanks.

CARYOPHYLLACEAE

Arenaria dawsonensis Britt. 12793B (32), 12877 (35), 12879 (35). Moist sites at low elevations.

Arenaria rossii R. Br. 12631 (23), 12779 (31).

Arenaria rubella (Wahlenb.) Smith 12695B (28), 12704 (28), 12793A (32). Scree slopes and dry ridges in the alpine tundra.

Arenaria uliginosa Schleich 12695A (28). Sole occurrence noted in alpine tundra.

Cerastium beeringianum Cham. & Schlecht. 12598 (22).

Melandrium apetalum (L.) Fenzl spp. attenuatum (Farr) Hara 12602 (22). Sole occurrence noted; collected from alpine tundra.

Melandrium taylorae (Robins.) Tolm. 12556 (19). First collection for the Mackenzie Mountains; sole occurrence was in a recently burnt-over area.

Silene acaulis L. var. exscapa (All.) DC. 12568 (21), 12609 (22), 21677 (26). Fairly frequent in alpine tundra.

Stellaria crassifolia Ehrh. 12887 (35). Sole collection was at a hotspring site.

Stellaria laeta Richards. 12615 (22), 12705A (28), 12778 (31). Occasional on alpine tundra.

Stellaria monantha Hulten 12606 (22), 12705B (28). Occasional on stony habitats in alpine tundra.

CERATOPHYLLACEAE

Ceratophyllum demersum L. 12643 (24). This is only the second record for the District of the Mackenzie; Thieret (1962) recorded it from Mile 38.5S of the Yellowknife Highway.

NYMPHAEACEAE

Nuphar variegatum Engelm. 17430 (51). Noted on a few small lakes above Virginia Falls and at Yohin Lake. This is the first collection from the Mackenzie Mountains.

RANUNCULACEAE

Aconitum delphinifolium DC. ssp. _delphinifolium_ 12608 (22). Moist habitat in alpine tundra.

Actaea rubra (Ait.) Willd. 12274 (1), 12732 (30), 12746B (30). Noted on terraces, in mixed forest, and near hotpsrings.

Anemone multifida Poir. 12460B (11). Collected from an open, south facing slope.

Anemone parviflora Michx. 12310 (2), 12355 (4), 12375 (6), 12425 (8), 12504 (14), 12604 (22). Fairly frequent in a variety of habitats.

Aquilegia brevistyla Hook. 12557 (19), 12746A (30). Noted in a recently burnt-over area and in a meadow near a hotspring. Flowering July 3.

Delphinium glaucum S. Wats. 12765 (30). Sole occurrence noted; flowering July 3.

Ranunculus macounii Britt. 12264 (1). Sole occurrence noted.

Thalictrum alpinum L. 12591 (21). Infrequent in alpine meadows.

FUMARIACEAE

Corydalis aurea Willd. 12243 (1). Sole occurrence noted.

CRUCIFERAE

Arabis hirsuta (L.) Scop. ssp. _pycnocarpa_ (Hopkins) Hulten 12246 (1), 12295 (2), 17419 (48). Infrequent around a small clearing, trails to a cabin, and near a hotspring. Collection No. 17419 is the first from the Mackenzie Mountain region.

Brassica campestris L. (B. rapa L.) 12328 (3). An introduced weed.

Braya humilis (C. A. Mey.) Robins. 12261 (1), 12267 (1), 12361 (5), 12440 (10), 12460A (11), 12802 (32), 12790 (32), 12919 (39), 12921 (39), 12947 (41). Fairly frequent in a variety of habitats.

Braya purpurascens (R. Br.) Bge. 12781A (21). Sole occurrence noted; from alpine tundra.

Capsella bursa-pastoris (L.) Medic. 12268 (1), 12327 (3), 12901 (39). An introduced weed.

Descurainia richardsonii (Sweet) O. E. Schulz 12250 (1). From a clearing near a cabin.

Draba alpina L. 12600 (22). Stony habitat in alpine tundra.

Draba bellii Holm 12619 (22), 12781B (31), 12788 (31). Stony habitat in alpine tundra.

Draba cana Rydb. (D. lanceolata Royle) 12880 (35), 12885 (35). Collected from a hotspring site.

Draba cinerea Adams 12730 (31). From a stony habitat in alpine tundra.

Draba fladnizensis Wulfen 12692 (28). From rocks and scree slopes in alpine tundra.

Draba lactea Adams 12589 (21). Collected from alpine tundra.

Draba lonchocarpa Rydb. 12603 (22), 12693 (28), 12694 (28), 12708 (29), 12713 (39), 12785 (31). Frequent on rocks and scree slopes of alpine tundra.

Draba sp. 12618 (22). A new species presently being described.

Erysimum cheiranthoides L. 12325 (3). Collected from a clearing around a cabin.

Lepidium bourgeauanum Thell. 12385 (7). An introduced weed; collected near a cabin at Deadmen's Valley.

Lepidium densiflorum Schrad. 12842 (33). Introduced weed at Nahanni Butte.

Lesquerella arctica (Wormskj.) S. Wats. ssp. *arctica*. 12503 (14), 12583 (21). Rock faces and dry slopes.

Parrya nudicaulis (L.) Regel 12599 (22), 12612 (22), 12620 (22). Occasional in alpine tundra communities.

Rorippa islandica (Oeder) Borbas 12528 (16). Moist habitat near the Flat River.

DROSERACEAE

Drosera rotundifolia L. 12653 (24). Associated with a peatbog near Yohin Lake.

SAXIFRAGACEAE

Mitella nuda L. 12305 (2), 12736 (30). Growing near streams from hotsprings.

Parnassia kotzebuei Cham. & Schlecht. 12491 (14). Collected from a wet meadow near Virginia Falls.

Parnassia palustris L. var. *neogaea* Fern. 12411 (8), 12739 (30), 12743 (30), 12770 (30). Frequent at hotsprings and occasional in wet meadows and along streams.

Ribes glandulosum Grauer 12417 (8). Infrequent in mixed forests at low elevations.

Ribes hudsonianum Richards. 12558 (19), 12922 (39). Infrequent in recent burns, mixed forests, and along streams.

Ribes lacustre (Pers.) Poir. 12908 (39). Along stream and in mixed forests.

Ribes oxyacanthoides L. 12427 (8), 12775 (30), 12918D (39). Occasional in mixed forests.

Ribes triste Pall. 12918B (39). Fairly frequent in spruce forests and along streams.

Saxifraga aizoides L. 12439 (10), 12890B (36), 17423 (36). Along streams; infrequent.

Saxifraga caespitosa L. s. lat. 12605 (22). Infrequent in alpine tundra habitats.

Saxifraga cernua L. 12691 (28). Infrequent in moist habitats.

Saxifraga nivalis L. 12697 (28). Sole collection from a dry, stony slope.

Saxifraga oppositifolia L. 12345 (4), 12567 (21), 12607 (22), 12810 (32), 12920 (39). Rather frequent in a variety of habitats.

Saxifraga tricuspidata Rottb. 12356 (4), 12372 (6), 12573 (21), 12786 (31), 12890A (36). Frequent on rock ledges and dry ridges.

ROSACEAE

Amelanchier alnifolia Nutt. 12296 (2). Frequent in some balsam poplar and mixed forests.

Dryas drummondii Richards. 12362 (4), 12445 (10). On gravel bars; abundant in limited areas.

Dryas integrifolia Vahl 12497 (14), 12581 (21), 12822 (32). Frequent in alpine tundra and in other habitats.

Dryas octopetala L. 12672 (26). Infrequent in alpine tundra.

Fragaria virginiana Duchesne ssp. *glauca* (S. Wats.) Staudt 12256 (1), 12306 (2), 12311 (2), 12861 (33). Frequent in natural and artificial openings at Nahanni Butte and at hotsprings.

Geum aleppicum Jacq. var. *strictum* (Ait.) Fern. 12752 (30), 12862 (33). No. 12752 is the first collection from the Mackenzie Mountains.

Potentilla biflora Willd. 12630 (23). Rocky slope in alpine tundra.

Potentilla elegans Cham. & Schlecht. 12681 (27). Rocky slope in alpine tundra.

Potentilla fruticosa L. 12388A (7), 12823 (32). A frequent species with wide ecological tolerance.

Potentilla hyparactica Malte var. *elatior* (Abrom.) Fern. 12685 (27). Alpine tundra.

Potentilla ledebouriana Porsild 12572 (21), 12616 (22), 12709 (29). Occasional in alpine tundra on scree slopes and ridges.

Potentilla norvegica L. 12273 (1), 12334 (3), 12546 (17), 17414 (48). Occasional in most habitats at low elevations.

Potentilla palustris (L.) Scop. 12650 (24). In shallow water of Yohin Lake.

Potentilla pennsylvanica L. 12535 (17), 12848 (33). Dry sites in disturbed areas.

Prunus virginiana L. 12307 (2). Common near a hotspring and hotspring stream; the only other records of this species occurring in the District of Mackenzie are those of Thieret (1961) from along the Enterprise - Mackenzie River Highway.

Rosa acicularis Lindl. 12315 (2), 12852 (33). Frequent on floodplains, terraces, and mixed forests.

Rubus acaulis Michx. 12492 (14). Seen in moist meadows and thickets.

Rubus chamaemorus L. 12663 (26). Peat bog in alpine tundra.

Rubus pubescens Raf. 12293 (2). Frequent on floodplains and terraces and in mixed forests.

Rubus strigosus Michx. 12308 (2), 12505 (14), 12789 (32), 12900 (39). Frequent on juvenile soils of floodplains and terraces.

Sorbus scopulina Greene 12907 (39). Sole occurrence noted; the only other District of Mackenzie collections are from adjacent to the Liard River.

Spiraea beauverdiana Schneider 12670 (26). Bog habitat in alpine tundra.

LEGUMINOSAE

Astragalus alpinus L. 12413 (8), 12561 (19). In a burnt-over area and a forest opening.

Astragalus americanus (Hook.) M. E. Jones 12768 (30). First collection from the Mackenzie Mountains; the nearest sites to this are along the Liard River.

Astragalus canadensis L. [*A. americanus* sensu Jeffrey (1961)] 12841 (33), 12856 (33). Sole occurrence noted was at Nahanni Butte (see Cody 1963a: 119).

Astragalus eucosmus Robins. 12399 (7), 12449 (10). First collection from the Mackenzie Mountains; the nearest records for this species are from Fort Simpson where it has been collected several times.

Astragalus tenellus Pursh 12428 (8). First collection from the Mackenzie Mountains; previously known in the District of Mackenzie from along the Slave, Hay, Mackenzie, and Liard Rivers.

Astragalus umbellatus Bge. 12632 (23), 12710 (29), 12783 (31). Infrequent in alpine tundra.

Hedysarum alpinum var. _americanum_ Michx. 12294 (2), 12366 (6), 12384 (7), 12509 (14). Frequent in mixed forests and along riverbanks and gravel bars.

Hedysarum mackenzii Richards. 12381 (7), 12390 (7), 12596 (22), 12797 (32), 12803 (32). Frequent along riverbanks and in rocky areas. Flowering June 27.

Lathyrus ochroleucus Hook. 12309 (2). Infrequent in thickets and mixed forests.

Lupinus arcticus S. Wats. 12409 (8). Infrequent on moist and dry habitats on mountain slopes and along rivers and streams.

Melilotus alba Desr. 12850 (33). An introduced plant at Nahanni Butte.

Melilotus officinalis (L.) Lam. 12335A (3), 12905 (39). An introduced plant.

Oxytropis deflexa (Pall.) DC. var. _foliolosa_ (Hook.) Barneby. 12400 (7). Along a riverbank.

Oxytropis hyperborea Porsild 12463 (13), 12569 (21), 12640 (23). Seen from sandy sites on islands in the South Nahanni River to alpine tundra.

Oxytropis jordalii Porsild 12690 (28). Infrequent in dry habitats of alpine tundra.

Oxytropis maydelliana Trautv. 12688 (28). Infrequent in alpine tundra.

Oxytropis pygmaea (Pall.) Fern. 12610 (22), 12689 (28), 12782 (31). Fairly frequent in alpine communities.

Oxytropis varians (Rydb.) Hulten 12403 (8), 12429 (8). Collected near Meilleur Creek; first collection from the Mackenzie Mountains.

Oxytropis viscidula (Rydb.) Tidestr. 12383 (7), 12387 (7), 12450 (10). Fairly frequent along riverbanks.

Trifolium pratense L. 12326 (3). An introduced plant collected from near a cabin site; first collection for the District of Mackenzie.

Vicia americana Muhl. 12416 (8). Collected from a stream bank; first collection from the Mackenzie Mountains.

LINACEAE

Linum lewisii Pursh 12795 (32). Sole occurrence noted; collected from a dry, open habitat.

EMPETRACEAE

Empetrum nigrum L. var. *hermaphroditum* (Lge.) Sor. 12489 (14), 12944 (41). Fairly frequent in lodgepole and jack pine forests and in other habitats.

VIOLACEAE

Viola nephrophylla Greene 12748 (30). Found at a hotspring site; first collection from the Mackenzie Mountains; other collections from the District are from lowland situations.

Viola rugulosa Greene 12241 (1), 12245 (1). Abundant near a hotspring; the only other Mackenzie District collection is that of Jeffrey (1961) from along the Liard River.

Viola tricolor L. 12333 (3). Occasional in an abandoned garden and around a cabin; an escape from cultivation.

ELAEAGNACEAE

Elaeagnus commutata Bernh. 12391 (7). Fairly frequent along riverbanks.

Shepherdia canadensis (L.) Nutt. 12394 (7). Frequent on floodplains and terraces; often associated with white spruce and balsam poplar forests.

ONAGRACEAE

Epilobium angustifolium L. 12392 (7). Fairly common on disturbed sites. Flowering June 27.

Epilobium glandulosum Lehm. var. adenocaulon (Haussk.) Fern. 12746C (30). Sole occurrence noted at a spring.

Epilobium latifolium L. 12363 (5). Fairly frequent on gravel bars along the river.

Epilobium palustre L. 12728B (30), 12751 (30). Frequent around hotspring pools.

HALORAGACEAE

Hippuris vulgaris L. 12875 (35), 12906 (39). Collected from hotspring streams.

Myriophyllum exalbescens Fern. 12731 (30), 12876 (35). First collections from the Mackenzie Mountains; from shallow water of hotspring pools.

ARALIACEAE

Aralia nudicaulis L. 12314 (2), 12918C (39). Fairly frequent in a mixed white spruce and balsam poplar forest at this one location.

UMBELLIFERAE

Cicuta _mackenzieana_ Raup 12759 (30). First collection from the Mackenzie Mountains; growing in a meadow near a hotspring; the nearest known sites for this species are from along the Liard River.

Heracleum _lanatum_ Michx. 12741 (30). Wet meadows near hotspring pools.

Pastinaca _sativa_ L. 12249 (1). Introduced plant, new to the flora of the District of Mackenzie.

Sium _suave_ Walt. 12647 (24). Growing in shallow water of Yohin Lake.

CORNACEAE

Cornus _canadensis_ L. 12279 (2). Common in several forest habitats.

Cornus _stolonifera_ Michx. 12290 (2). Common on a floodplain and a terrace at this one site.

PYROLACEAE

Moneses _uniflora_ (L.) Gray 12426 (8), 12435 (9), 12526 (15). Infrequent in spruce forests.

Pyrola _asarifolia_ Michx. 12397 (7), 12824 (32). Infrequent in white spruce and balsam poplar and white spruce forests.

Pyrola _grandiflora_ Radius 12347 (4). Sole occurrence noted; from a white spruce forest.

Pyrola _secunda_ L. var. _secunda_ 12300 (2), 12415 (8), 12825 (32). Fairly frequent on floodplains and terraces with white spruce or mixed forests.

Pyrola _secunda_ var. _obtusata_ Turcz. 12346 (4), 12418 (8), 12437 (9). Fairly frequent in spruce forests.

Pyrola virens Schweigg. 12407B (8). Occasional in white spruce forests.

ERICACEAE

Andromeda polifolia L. 12500 (14). From a wet meadow near Virginia Falls.

Arctostaphylos rubra (Rehd. & Wils.) Fern. 12422 (8), 12571 (21), 12711 (39). Occasional from lowlands to alpine tundra.

Arctostaphylos uva-ursi (L.) Spreng. 12388 (7). Occasional in opening on south facing slopes and in lodgepole and jack pine forests.

Cassiope tetragona (L.) D. Don ssp. tetragona 12506 (14), 12574 (21). Frequent in alpine tundra and occasional at other sites such as Virginia Falls.

Cassiope tetragona (L.) D. Don ssp. saximontana (Small) Porsild 12576 (21), 12660 (26). Collected from alpine tundra.

Kalmia polifolia Wang. 12664 (26). From wet meadows in alpine tundra; first collection recorded from the Mackenzie Mountains.

Ledum decumbens (Ait.) Lodd. 12662 (26). Occasional in alpine tundra.

Ledum groenlandicum Oed. 12357 (4), 12821 (32). Common in black and white spruce forests.

Loiseleuria procumbens (L.) Desv. 12671 (26), 12684 (27). Fairly frequent in alpine tundra.

Rhododendron lapponicum (L.) Wahlenb. 12369A (6), 12592 (21), 12614 (22). Fairly frequent in alpine tundra; occasional at lower elevations.

VACCINIACEAE

Oxycoccus microcarpus Turcz. 12883 (35). Sole occurrence noted.

Oxycoccus quadripetalus Gil. 12648 (24). Peat bog habitat near Yohin Lake.

Vaccinium uliginosum L. s. lat. 12451 (10), 12945 (41). In bogs from lowlands to alpine tundra.

Vaccinium vitis-idaea L. var. minus Lodd. 12368 (6), 12892 (37), 12903 (39). 12939 (41). A common plant in spruce forests.

DIAPENSIACEAE

Diapensia obovata (Fr. Schm.) Nakai 12676 (26), 12685A (27). These collections extend its known range well to the south from the Richardson Mountains.

PRIMULACEAE

Androsace chamaejasme Host s. lat. 12351 (4), 12587 (21), 12902 (39), 12940 (41). Rocky habitats from low mountain slopes to alpine tundra.

Lysimachia thyrsiflora L. 12655 (24). Sole occurrence noted; from shallow water of Yohin Lake; the nearest collection is from along the Mackenzie River halfway between Fort Simpson and Fort Providence.

Primula egaliksensis Wormsk. 12494 (14). Occasional in a wet meadow near Virginia Falls.

Primula stricta Hornem. 12452 (10), 12494A (14), 12741 (30). Occasional in wet meadows and along riverbanks.

GENTIANACEAE

Gentiana acuta Michx. 12733A (30), 12843 (33), 12927 (40). Occasional in moist meadows and along streams. First collection from the Mackenzie Mountains, but known from the adjacent Liard and Mackenzie River lowlands.

Gentiana glauca Pall. 12661 (26), 12683 (27). Meadows of the alpine tundra; infrequent.

Gentiana propinqua Richards. 12455 (10), 12498 (14), 12563 (20), 12733B (30), 12799 (32), 12853 (33). Occasional in a variety of habitats.

MENYANTHACEAE

Menyanthes trifoliata L. 12745 (30). Occasional in ponds and shallow lakes.

BORAGINACEAE

Mertensia paniculata (Ait.) G. Don 12303 (2), 12410 (8). Occasional on floodplains and terraces.

LABIATAE

Mentha arvensis L. var. villosa (Benth.) Stewart. 12772 (30), 12867 (34), 12913 (39), 17426 (50). Abundant at hotsprings.

SCROPHULARIACEAE

Castilleja pallida (L.) Spreng. ssp. caudata Pennell 12470 (13). Infrequently noted; collected from an island in the South Nahanni River.

Castilleja raupii Pennell 12358 (5). Infrequently noted; collected from a gravel bar.

Mimulus guttatus DC. 12754 (30), 12769 (30), 12868 (34), 12881 (35). New to the flora of the District of the Mackenzie; in the distribution map for this species given in Hulten (1968), the nearest collection sites to those recorded here are in the southern Yukon.

Pedicularis labradorica Wirsing 12432 (9), 12458 (11), 12658 (26). An occasional plant in black spruce forests and alpine tundra.

Pedicularis lanata Cham. & Schlecht. 12593 (21), 12611 (22), 12628 (22), 12673 (26), 12784 (31). Frequent in a variety of alpine habitats.

Pedicularis sudetica Willd. s. lat. 12484 (14). Sole occurrence noted was at Virginia Falls.

Veronica americana (Raf.) Schwein. 12763 (30), 17418 (48), 17426 (50). Abundant surrounding hotspring pools; Porsild (1961) reported this species as new to the District of Mackenzie on the basis of a specimen collected by Arnold in a hotspring meadow at Hole-in-the-Wall Lake.

OROBANCHACEAE

Boschniakia rossica (Cham. & Schlecht.) Fedtsch 12444 (10), A parasitic plant growing on the roots of *Alnus crispa*.

LENTIBULARIACEAE

Pinguicula vulgaris L. 12442 (10), 12734 (30), 12800 (32). Infrequent in moist habitats.

Utricularia minor L. 12757 (30). In hotspring pools. First collection from the Mackenzie Mountains; other District of Mackenzie collections are from about Great Slave and Great Bear Lakes.

Utricularia vulgaris L. 12652 (24), 12738 (30), 12756 (30). From hotspring ponds and a shallow lake. First collections from the Mackenzie Mountains, but known from the adjacent lowlands of the Mackenzie River.

PLANTAGINACEAE

Plantago major L. 12340 (3). Sole occurrence noted in a forest opening.

RUBIACEAE

Galium boreale L. 12292 (2), 12495 (14), 12801 (32). Occasional on floodplains and terraces. Flowering June 26.

Galium trifidum L. 12550 (18), 12764 (30). Infrequent in moist habitats such as muskegs and meadows.

Galium triflorum Michx. 12263 (1), 12730 (30). Infrequent on floodplains and terraces and at a hotspring; the only other Mackenzie Mountain collection is from about the hotspring at Tungsten but it is known from a number of sites along the Liard River (Cody 1961; Jeffrey 1961).

CAPRIFOLIACEAE

Linnaea borealis L. var. americana (Forbes) Rehd. 12278 (2). A fairly common species in forests.

Lonicera dioica L. var. glaucescens (Rydb.) Butters 12291 (2). On floodplains and terraces at this one location.

Viburnum edule (Michx.) Raf. 12301 (2). Frequent in mixed forests on floodplains and terraces in the eastern portion of the region.

CAMPANULACEAE

Campanula aurita Greene 12344 (4), 12488 (14), 12532 (16), 12813 (32). Infrequent in forest opening and on grassy slopes.

Campanula rotundifolia L. 12851 (33). Sole occurrence noted was at Nahanni Butte.

LOBELIACEAE

Lobelia kalmii L. 12740A (30), 12760 (30), 12766 (30), 12871 (34), 12891 (36). Common in hotspring areas. New to the Mackenzie Mountains;

other District of Mackenzie collections are from about Great Slave Lake, at the foot of the Nahanni Range just north of Fort Simpson, and near a lake between the southern extremeties of the Franklin Mountains.

COMPOSITAE

Achillea nigrescens (E. Mey.) Rydb. 12297 (2), 12424 (8), 12566 (20). Infrequent along rivers and in lowlands. Flowering June 26.

Achillea sibirica Ledeb. 12858 (33), 12899 (39), 17435 (1). Occasional near settlents at Nahanni Butte and a hotspring.

Antennaria densifolia Porsild 12570 (21), 12642 (23), 12707 (29), 12926 (40). Occasional on alpine tundra and floodplains.

Antennaria monocephala DC. 12601 (22), 12699 (28). Occasional on alpine tundra.

Antennaria nitida Greene 12474 (13). Sole occurrence noted on an island in the South Nahanni River. First collection in the Mackenzie Mountains.

Antennaria pulcherrima (Hook.) Greene 12791 (32). Sole occurrence noted on a mountain slope.

Arnica alpina (L.) Olin ssp. *angustifolia* (J. Vahl) Maguire 12584 (21), 12636 (23), 12674 (26), 12696 (28). Frequent on dry alpine sites.

Arnica alpina (L.) Olin ssp. *attenuata* (Greene) Maguire 12386 (7). Sole occurrence in an artificial clearing. First collection from the Mackenzie Mountains.

Arnica amplexicaulis Nutt. 17416 (48). Sole occurrence noted along a stream from a cool spring; this is only the second report of the species from the District of Mackenzie. The species was first reported by Porsild (1961) from Hole-in-the-Wall Lake.

Arnica chamissonis Less. ssp. foliosa (Nutt.) Maguire 12735 (30). Sole occurrence at a hotspring site.

Arnica louiseana Farr. ssp. frigida (Meyer) Maguire 12353 (4), 12808C (32). Dry, rocky habitats; infrequent occurrence.

Artemisia arctica Less. 17411 (47). Noted only once in the alpine zone, growing between large rock blocks.

Artemisia biennis Willd. 12330 (3). Occasional in a disturbed site near a cabin. Sole occurrence noted.

Artemisia frigida Willd. 12457 (11), 12934 (41). Occasional on dry, open slopes with southern exposure. First collections from the Mackenzie Mountains; known nearby from the Liard and Mackenzie river valleys.

Artemisia tilesii Ledeb. var. tilesii 12538 (17). Infrequent on sandy sites.

Artemisia tilesii var. elatior (T. & G.) Rydb. 12269 (1), 12277 (1), 12924 (39). Infrequent on a terrace near a hotspring.

Aster alpinus L. ssp. vierhapperi Onno 12520 (14), 12928 (40). Infrequent on dry, open sites.

Aster ciliolatus Lindl. 12857 (33), 12898 (39). Infrequent in thickets and mixed forests.

Aster ericoides L. 12935 (41). Sole occurrence noted on a dry, open slope. First collection from the Mackenzie Mountains, but known from along the Mackenzie River valley.

Aster franklinianus Rydb. 12755 (30), 12870 (34). From hotspring sites. First collections from the Mackenzie Mountains; the nearest collections are from along the Liard River and at Fort Simpson.

Aster sibiricus L. 12382 (7), 12414 (8), 12464 (13), 12482 (14), 12844 (33), 17438 (33), 12923 (39), 12942 (41). Fairly frequently associated with riparian vegetation and in meadows.

Aster sp. 17412 (48). This white-flowered aster was found near a stream from a cold spring; the collection requires additional study before it can be identified to species.

Bidens cernua L. 12873 (34). Infrequent near hotspring pools; elsewhere in the District of Mackenzie this species is known from Tungsten, about Great Slave Lake and along the Slave River.

Chrysanthemum integrifolium Richards. 12586 (21), 12637 (23). Infrequent on rocky slopes of the alpine tundra zone.

Crepis elegans Hook. 12408 (8), 12537 (17), 12562 (19). Infrequent on gravelly sites. First collections from the Mackenzie Mountains, but known from banks along the Mackenzie River.

Erigeron angulosus Gaud. var. *kamtschaticus* (DC.) Hara 12559 (19). Sole occurrence was noted in a recently burned-over area.

Erigeron elatus (Hook.) Greene 12560 (19). Infrequent in moist habitats.

Erigeron grandiflorus Hook. 12792 (32). Sole occurrence was noted on a gravelly floodplain. First collection from the Mackenzie Mountains.

Erigeron hyssopifolius Michx. 12430 (8), 12533 (16), 12565 (20), 12590 (21), 12639 (23), 12794 (32). Fairly frequent in rocky habitats from riverbanks to alpine tundra.

Erigeron lonchophyllus Hook. 12544 (17), 12839 (33), 12855 (33). Infrequent in moist habitats. First collection from the Mackenzie Mountains, known from the Mackenzie valley as far north as Norman Wells.

Erigeron philadelphicus L. 12262 (1), 12302 (2), 12331 (3), 12840 (33). Infrequent in moist habitats.

Matricaria matricarioides (Less.) 12854 (33). An introduced plant at Nahanni Butte.

Petasites palmatus (Ait.) Gray 12678 (26). Sole occurrence was noted at a bog in the alpine tundra zone. First collection from the Mackenzie Mountains.

Petasites sagittatus (Pursh) Gray 12849 (33). Fairly common at the margins of meadows and bogs.

Senecio lugens Richards. 12352 (4), 12585 (21), 12808B (32). Infrequent from low elevations to alpine tundra. Flowering June 26.

Senecio pauperculus Michx. 12332 (3), 12335B (3), 12476 (13), 12749 (30). Fairly frequent in moist habitats at low elevations.

Senecio resedifolius Less. 12617 (22). Infrequent in rocky habitats in alpine tundra.

Senecio yukonensis Porsild. 12657 (26). Rare in alpine tundra.

Solidago canadensis L. var. salebrosa (Piper) Jones 12341 (3), 12475 (13), 12761 (30), 12774 (30), 12845 (33), 12897 (39). Fairly frequent in moist habitats.

Solidago decumbens Greene var. oreophila (Rydb.) Fern. 12846 (33), 12859 (33), 12930 (40). Occasional throughout the area.

Solidago multiradiata Ait. s. lat. 12371 (6), 12419 (8), 12446 (10), 12453 (10), 12641 (23), 12808A (32). Rocky sites from lowlands to alpine tundra.

Taraxacum officinale Weber 12337 (3). An introduced weed from a clearing.

Data on collection sites

1 Plant communities around hotspring and stream
850' elev.
61° 16', 124° 03'
June 26, 1970

2 Plants along trails near hotsprings
850' elev.
61° 16', 124° 03'
June 26, 1970

3 Plants in clearing around a cabin
850' elev.
61° 16', 124° 03'
June 26, 1970

4 Plants on rock ledge and surrounding white spruce forest
875' elev.
61° 16', 124° 03'
June 26, 1970

5 Gravel bar on South Nahanni River
900' elev.
61° 17', 124° 04'
June 26, 1970

6 White wash spring
950' elev.
61° 18', 124° 05'
June 26, 1970

7 Deadmen Valley, near cabin
White spruce and black cottonwood community
1,050' elev.
69° 15', 124° 30'
June 27, 1970

8 Along Meilleur Creek
White spruce and black cottonwood community
1,100' elev.
61° 15', 124° 34'
June 27, 1970

9 Black spruce, feather moss, and lichen community
1,300' elev.
61° 17', 124° 47'
June 28, 1970

10 White spruce community, along bank of river.
1,300' elev.
61° 25', 124° 55'
June 28, 1970

11 Black spruce and white spruce forest with open south facing slopes
1,500' elev.
61° 26', 124° 54'
June 28, 1970

12 Gravel pavement near river
1,300' elev.
61° 26', 124° 55'
June 28, 1970

13 Island in Nahanni River
1,350' elev.
61° 32', 125° 20'
June 28, 1970

14 Vicinity of Virginia Falls, South Nahanni River
1,800' elev.
61° 37', 125° 44'
June 29, 1970

15 Mature spruce and feather moss community, Flat River
1,500' elev.
61° 33', 125° 25'
June 20, 1970

16 Open lodgepole pine community, Flat River
1,750' elev.
61° 33', 125° 27'
June 30, 1970

17 Mineral lick area, Flat River
1,800' elev.
61° 27', 125° 42'
June 30, 1970

18 Spruce muskeg, Flat River
1,825' elev.
61° 28', 125° 51'
June 30, 1970

19 Burned-over area, Flat River
1,850' elev.
61° 33', 126° 30'
June 30, 1970

20 Burned area,
birch, lodgepole, and black poplar stand
1,800' elev.
61° 21', 124° 43'
June 30 and July 1, 1970

21 Alpine community
5,100' elev.
61° 20', 124° 43'
July 2, 1970

22 Alpine community
4,800' elev.
61° 20', 124° 20'
July 2, 1970

23 Alpine community
3,700' elev.
61° 27', 124° 05'
July 2, 1970

24 Shore of Yohin Lake
712' elev.
61° 12', 123° 46'
July 2, 1970

25 Wind-blown sandy area
2,450' elev.
61° 07', 123° 42'
July 2, 1970

26 Alpine community
4,100' elev.
61° 08', 124° 27'
July 2, 1970

27 Alpine community
5,050' elev.
61° 11', 124° 33'
July 2, 1970

28 Alpine community
4,500' elev.
61° 32', 125° 03'
July 3, 1970

29 Alpine community, Sunblood Mountain
5,000' elev.
61° 46', 125° 44'
July 3, 1970

30 Mineral springs, Flat River region
2,500' elev.
61° 25', 126° 36'
July 3, 1970

31 Alpine community
5,200' elev.
61° 25', 125° 05'
July 3, 1970

32 Dry canyon
1,800' elev.
61° 15', 124° 23'
July 3, 1970

33 Nahanni Butte
600' elev.
61° 03', 123° 24'
July 5, 1970

34 Mineral springs region south of the Flat River
2,500' elev.
61° 25', 126° 36'
Sept. 12, 1970

35 Mineral springs region north of the Flat River
1,900' elev.
61° 23', 126° 44'
Sept. 12, 1970

36 Rabbitkettle Hotsprings
2,000' elev.
61° 56', 127° 11'
Sept. 12, 1970

37 Mature spruce forest, Seaplane Lake
2,400' elev.
61° 24', 126° 49'
Sept. 12, 1970

38 Hole-in-the-Wall Lake
3,900' elev.
61° 46', 127° 16'
Sept. 12, 1970

39 Plant communities from around springs
850 ' elev.
61° 16', 124° 03'
Sept. 10, 1970

40 Floodplain near mouth of Prairie Creek
1,400' elev.
61° 16', 124° 26'
Sept. 10, 1970

41 Dry canyon
1,700' elev.
61° 15', 124° 23'
Sept. 11, 1970

42 Low lying area near the South Nahanni River
775' elev.
61° 15', 123° 46'
Sept. 9, 1970

43 West of Marengo Falls
2,000' elev.
61° 39', 125° 45'
Sept. 12, 1970

44 Treeline community
4,200' elev.
61° 28', 124° 37'
Sept. 12, 1970

45 Burned area
750' elev.
61° 09', 123° 40'
Sept. 13, 1970

46 Floodplain above the South Nahanni River
700' elev.
61° 06', 123° 24'
Sept. 13, 1970

47 Crevice between rock blocks in the alpine area
3,500' elev.
61° 08', 123° 45'
Sept. 14, 1971

48 Along stream near "Old Pots" spring
2,500' elev.
61° 31' 30, 126° 29'
Sept. 16, 1971

49 Gravel bar near Hell's Gate Rapids
1,400' elev.
61° 34', 125° 29'
Sept. 17, 1971

50 Hotsprings near Hole-in-the-Wall Lake
4,200' elev.
61° 47', 127° 18'
Sept. 18, 1971

51 Small lake northwest of Virginia Falls
1,850' elev.
61° 37' 30, 125° 46'
Sept. 18, 1971

52 Pine forest on rock outcrop above the South Nahanni River
2,350' elev.
61° 17', 124° 06'
Sept. 19, 1971

53 Small lake north of Yohin Lake
710' elev.
61° 13', 123° 45'
Sept. 19, 1971

54 Along shore of Glacier Lake
2,900' elev.
62° 05', 127° 34'
Sept. 16, 1971

55 Along stream from a cool spring above the Flat River
3,000' elev.
61° 39', 127° 42'
Sept. 16, 1971

FAUNA

Fish

Even today, most of the lakes, streams, and rivers of the South Nahanni and Flat River drainages are lightly fished. Only around Nahanni Butte has there been any continuous effort to catch fish. The natives make short trips from that community to net fish for food for themselves and their dogs. One of the most heavily fished areas is the mouth of Bluefish Creek where it joins the South Nahanni River. Here there is a fish population far larger than one would expect from the size of the creek (Addison, pers. comm., 26 April, 1971).

Therefore, little is known about the general distribution and abundance of fish species in these rivers. The most recent publication on the fish of northwestern Canada, written by McPhail and Lindsey (1970), has served as documentation for the ten species of fish listed in Table 4 as "expected" in the South Nahanni and Flat River areas. Their records are based on a search of collections in the National Museum of Canada and other major museums. One collection from the South Nahanni and Flat River areas was not used in their book: that made by W. D. and W. E. Addison between June 28 and August 7, 1966. The species collected by the Addisons are listed in Table 4. The identifications were made by W. D. Addison and verified by W. B. Scott or E. J. Crossman of the Royal Ontario Museum. The Addisons collected fish under adverse conditions during a self-financed canoe and backpack trip from Glacier Lake to Nahanni Butte. Nevertheless, their collection

TABLE 4. The fish of the South Nahanni and Flat River drainage areas.

Species	Expected[1]	Observed	Date	Location
Lake whitefish *Coregonus clupeaformis*		X	28-29 June, 1966	Headwaters Flat River (Addison, 1971)*
			October, 1966	Hot Springs, Kraus residence (caught by G. Kraus)*
Dolly Varden *Salvelinus malma*	X	X	2 July, 1966	Headwaters Flat River (Addison, 1971)*
			3 August, 1966	Hot Springs (Addison, 1971)*
			29 June, 1970	Nahanni-Flat River junction
Lake trout *Salvelinus namaycush*	X	X	28-29 June, 1966	Headwater lakes of Flat River (Addison, 1971)*
			7-8 July, 1966	Glacier (Brintnell) Lake (Addison, 1971)*
Inconnu *Stenodus leucichthys*		X	1 Aug., 1966	Hot Springs (Addison, 1971)*
Arctic grayling *Thymallus arcticus*	X	X	28-29 June, 1966	Headwaters Flat River (Addison, 1971)*
			7 July, 1966	Glacier (Brintnell) Lake (Addison, 1971)*
			25 July, 1966	Prairie Creek (Addison, 1971)*
			27 June, 1970	Prairie Creek
Northern pike *Esox lucius*	X	X	2 Aug., 1966	Hot Springs (Addison, 1971)*
			6 Aug., 1966	Nahanni Butte (Addison, 1971)*

TABLE 4. (Cont'd)

Species	Expected[1]	Observed	Date	Location
Lake chub <u>Couesius plumbeus</u>	X	X	7 Aug., 1966	Headwaters of Flat River (Addison, 1971)*
Spottail shiner <u>Notropis hudsonius</u>	X	X	7 Aug., 1966	Bluefish Creek, near Nahanni Butte (Addison, 1971)*
Longnose dace <u>Rhinichthys cataractae</u>	X			
Longnose sucker <u>Catostomus catostomus</u>	X	X	2 Aug., 1966	Hot Springs (Addison, 1971)*
			7 Aug., 1966	Bluefish Creek, near Nahanni Butte (Addison, 1971)*
			29 June, 1970	Nahanni-Flat River junction
White sucker <u>Catostomus commersoni</u>		X	29 June, 1970	Nahanni-Flat River junction
Trout-perch <u>Percopsis omiscomaycus</u>	X	X	7 Aug., 1966	Bluefish Creek, near Nahanni Butte (Addison, 1971)*
Slimy sculpin <u>Cottus cognatus</u>	X	X	25 July, 1966	Prairie Creek (Addison, 1971)*

[1]Expected to be present according to McPhail and Lindsey (1970).

*Addison, W. D. Pers. Comm., 26 April, 1971. Specimens in Royal Ontario Museum, Department of Ichthylogy and Herpetology. Accession number 1183.

may well be the best for this area, and it may have resulted in range extensions for inconnu and a subspecies of lake whitefish. (Addison, W. D. pers. comm., 26 April, 1971.) Longnose and white suckers, arctic grayling, and Dolly Varden were caught during our ecological survey in the summer of 1970.

Addison noted that residents of Tungsten, at the headwaters of the Flat River, occasionally catch burbot (Lota lota) in a small lake near the settlement. He failed to collect this species, and McPhail and Lindsey (1970) did not list it as occurring in the South Nahanni and Flat River areas. Addison was surprised that he did not find longnose dace in the area. McPhail and Lindsey (ibid.) imply that this species should be found there.

Gus Kraus told Addison that yellow walleye (Stizostedion vitreum) are found in the lake on McLeod Creek where Tyerman's cabin is located (see Fig. 30). Addison was unable to confirm this observation. This would constitute an important range extension for this species.

Probably the most popular fish with sport fishermen in the South Nahanni River area is the beautiful and lively arctic grayling. Grayling fishing is good in Prairie Creek and in several lakes in the river valley. Contrary to popular opinion, the grayling is also well established in the heavily silted waters of the valley (ibid.). Generally, the grayling are not large but they are delicious and provide good sport.

Arctic grayling are sensitively balanced in their habitat and cannot cope well with man's encroachment. Their slow growth and ease of capture make them susceptible to local extirpation (McPhail and

Lindsey, 1970). Pollution of their environment by upstream mines and mills might well be intolerable to grayling as well as other fish species. Such a possibility should be carefully considered when management plans for the area are drawn up.

Birds

The Mackenzie Mountains will be an exciting area for the dedicated birdwatcher for a long time to come. A list of year-long resident and breeding birds has yet to be published for that area, or even a small part of the area such as the South Nahanni drainage. Records of breeding range extensions are not difficult to establish. During the spring months, the lakes and streams of the Nahanni and Flat River drainages serve as resting places for birds migrating to and from the Mackenzie River Delta area. Sightings of such birds as the whistling swan and the Canada goose floating in a snye or standing on a gravel bar cannot fail to stimulate awed comments from the spring traveller.

We did not make a systematic attempt to identify and list the birds in the South Nahanni and Flat River areas. Journal notes on bird observations made by Simmons since 1966 were combined with our observations during the survey and with sightings recorded by Godfrey (1966) to make up our bird list (Table 5).

The criteria for the column headed "Expected" in Table 5 were maps of breeding ranges drawn by Godfrey (1966). Only a single date and location of an observation is given opposite each bird checked in the "Observed" column, though many birds may have been observed in

TABLE 5. Birds of the South Nahanni and Flat River drainage areas.

Species	Expect-ed	Observ-ed	Date	Location	Status
Common loon *Gavia immer*	X	X	21 July, 1969	Seaplane Lake	N**
Red-necked grebe *Podiceps grisegena*	X				
Horned grebe *Podiceps auritus*	X	X	12 Sept., 1970	Near Nahanni Butte	N
			15 Aug., 1968		
Whistling swan *Olor columbianus*		X	25 June, 1970	South Nahanni River 62° 53'N, 126° 40'W	M*
Canada goose *Branta canadensis*	X	X	17 Sept., 1967	Near Nahanni Butte	
Mallard *Anas platyrhynchos*	X	X	26 June, 1970	Kraus' Hotsprings	N
Pintail *Anas acuta*	X	X	15 Aug., 1968	Near Nahanni Butte	N
Green-winged teal *Anas carolinensis*	X	X	28 June, 1970	Flat-Nahanni junction	N
Blue-winged teal *Anas discors*	X				
American widgeon *Mareca americana*	X	X	3 July, 1970	Wild Mint Springs	N
Shoveler *Spatula clypeata*	X	X	12 Sept., 1970	Yohin Lake	N
Canvasback *Aythya valisineria*	X				
Greater scaup *Aythya marila*	X	X	17 Sept., 1967	Near Nahanni Butte	N

TABLE 5. (Cont'd)

Species	Expected	Observed	Date	Location	Status
Lesser scaup *Aythya affinis*	X	X	Aug., 1968	Near Nahanni Butte	N
Common goldeneye *Bucephala clangula*	X	X	5 Aug., 1952	Glacier (Brintnell) Lake (Flook, 1953)	N
Bufflehead *Bucephala albeola*	X				
White-winged scoter *Melanitta deglandi*	X				
Surf scoter *Melanitta perspicillata*	X	X	12 Sept., 1970	Yohin Lake	N
Common merganser *Mergus merganser*	X	X	29 June, 1970	Flat-Nahanni River junction	N
Red-breasted merganser *Mergus serrator*	X				
Goshawk *Accipiter gentilis*	X	X	23 July 1969	Deadmen Valley	N
Sharp-shinned hawk *Accipiter striatus*	X	X	21 July, 1969	Peñarroya site	N
Red-tailed hawk *Buteo jamaicensis*	X	X	Aug., 1968	Nahanni Butte	N
Golden eagle *Aquila chrysaetos*	X	X	16 Aug., 1968	Deadmen Valley	N
Bald eagle *Haliaeetus leucocephalus*	X	X	12 Sept.,	Tyerman's cabin McLeod Creek	N
Marsh hawk *Circus cyaneus*	X	X	16 Aug., 1968	Flat-Nahanni junction	
Pigeon hawk *Falco columbarius*	X				

TABLE 5. (Cont'd)

Species	Expect-ed	Observ-ed	Date	Location	Status
Sparrow hawk <u>Falco</u> <u>sparverius</u>	X				
Blue grouse <u>Dendragapus</u> <u>obscurus</u>	X	X		Mouth of South Nahanni River (Godfrey, 1966 p. 107)	N
Spruce grouse <u>Canachites</u> <u>canadensis</u>	X	X	3 July, 1970	Wild Mint Springs	N
			14 Sept., 1970	First Canyon	
Ruffed grouse <u>Bonasa</u> <u>umbellus</u>	X	X	27 June, 1970	Mouth of Meilleur River	N
Willow ptarmigan <u>Lagopus</u> <u>lagopus</u>	X	X	3 July, 1970	Sunblood Mountain	N
Rock ptarmigan <u>Lagopus</u> <u>mutus</u>	X				
White-tailed ptarmigan <u>Lagopus</u> <u>leucurus</u>	X	X	June, 1970	Near Dry Canyon	N
Sharp-tailed grouse <u>Pedioecetes</u> <u>phasianellus</u>	X	X	Sept., 1967	Loon Lake	N
Sora <u>Porzana</u> <u>carolina</u>	X	X	Sept., 1967	Nahanni Butte	
American coot <u>Fulica</u> <u>americana</u>		X	2 July, 1970	Yohin Lake	
Common snipe <u>Capella</u> <u>gallinago</u>	X				
Spotted sandpiper <u>Actitis</u> <u>macularia</u>	X	X	3 July, 1970	Wild Mint Spring	N
Solitary sandpiper <u>Tringa</u> <u>solitaria</u>	X				

TABLE 5. (Cont'd)

Species	Expect-ed	Observ-ed	Date	Location	Status
Wandering tattler *Heteroscelus incanus*		X	2 July, 1970	61°20'N, 124°28'W	N
Lesser yellowlegs *Totanus flavipes*	X	X	July, 1970	Mountain peak 61° 21'N, 124°19'W	N
Herring gull *Larus argentatus*		X	Sept., 1970	2 miles below Virginia Falls	
Mew gull *Larus canus*	X	X	29 June, 1970	2 miles below Virginia Falls	N
Bonaparte's gull *Larus philadelphia*	X	X	29 June, 1970	2 miles below Virginia Falls	N
Arctic tern *Sterna paradisaea*	X	X	29 June, 1970	2 miles below Virginia Falls	
Great horned owl *Bubo virginianus*	X	X	Aug., 1968	Deadmen Valley	N
Hawk owl *Surnia ulula*	X				
Great gray owl *Strix nebulosa*	X				
Long-eared owl *Asio otus*	X				
Short-eared owl *Asio flammeus*	X				
Boreal owl *Aegolius funereus*	X				
Common nighthawk *Chordeiles minor*	X	X	28 June, 1970	Second Canyon	N
Belted kingfisher *Megaceryle alcyon*	X	X	29 June, 1970	Virginia Falls	

TABLE 5. (Cont'd)

Species	Expected	Observed	Date	Location	Status
Yellow-shafted flicker *Colaptes auratus*	X	X	17 Sept., 1967	Seaplane Lake	N
Pileated woodpecker *Dryocopus pileatus*	X				
Yellow-bellied sapsucker *Sphyrapicus varius*	X	X	26 June, 1970	Kraus' Hotsprings	N
Hairy woodpecker *Dendrocopos villosus*	X	X	Aug., 1968	Deadmen Valley	N
Downy woodpecker *Dendrocopos pubescens*	X				
Black-backed three-toed woodpecker *Picoides arcticus*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Northern three-toed woodpecker *Picoides tridactylis*	X				
Eastern kingbird *Tyrannus tyrannus*	X				
Eastern phoebe *Sayornis phoebe*	X				
Say's phoebe *Sayornis saya*	X			Seen in Ft. Simpson (Godfrey, 1966)	N
Yellow-bellied flycatcher *Empidonax flaviventris*	X				
Traill's flycatcher *Empidonax traillii*	X				
Least flycatcher *Empidonax minimus*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Western wood pewee *Contopus sordidulus*	X				

TABLE 5. (Cont'd)

Species	Expected	Observed	Date	Location	Status
Olive-sided flycatcher *Nuttallornis borealis*	X				
Horned lark *Eremophila alpestris*		X		Yohin Lake, 2 July, 1970	
Violet-green swallow *Tachycineata thalassina*		X	30 June, 1970	North shore, Flat River 61°27'N, 125° 50'W	N
Tree swallow *Iridoprocne bicolor*	X	X	26 June, 1970	Kraus' Hotsprings	N
Bank swallow *Riparia riparia*	X		July, 1970	Seen in Ft. Simpson	
Barn swallow *Hirundo rustica*	X				
Cliff swallow *Petrochelidon pyrrhonota*	X	X	28 June, 1970	Second Canyon	N
Gray jay *Perisoreus canadensis*	X	X	28 June, 1970	Virginia Falls	N
Common raven *Corvus corax*	X	X	28 June, 1970	Flat-Nahanni River junction	N
Common crow *Corvus brachyrhynchos*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Black-capped chickadee *Parus atricapillus*	X	X	2 July, 1970	Deadmen Valley	N
Boreal chickadee *Parus hudsonicus*	X				
Red-breasted nuthatch *Sitta canadensis*	X			Seen in Ft. Simpson (Godfrey, 1966)	
American robin *Turdus migratorius*	X				
Varied thrush *Ixoreus naevius*	X				

TABLE 5. (Cont'd)

Species	Expected	Observed	Date	Location	Status
Hermit thrush *Hylocichla guttata*	X				
Swainson's thrush *Hylocichla ustulata*	X				
Townsend's solitaire *Myadestes townsendi*	X	X	3 July, 1970	Sunblood Mountain	N
Ruby-crowned kinglet *Regulus calendula*	X	X		Nahanni Mountains (Godfrey, 1966)	N
Bohemian waxwing *Bombycilla garrulus*	X				
Northern shrike *Lanius excubitor*	X				
Red-eyed vireo *Vireo olivaceus*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Warbling vireo *Vireo gilvus*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Tennessee warbler *Vermivora peregrina*	X				
Orange-crowned warbler *Vermivora celata*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Yellow warbler *Dendroica petechia*	X				
Magnolia warbler *Dendroica magnolia*	X				
Myrtle warbler *Dendroica coronata*	X				
Bay-breasted warbler *Dendroica castanea*	X				

TABLE 5. (Cont'd)

Species	Expect-ed	Observ-ed	Date	Location	Status
Blackpoll warbler _Dendroica striata_	X				
Palm warbler _Dendroica palmarum_	X				
Ovenbird _Seiurus aurocapillus_	X			Seen at Liard Hotsprings (Godfrey, 1966)	
Northern waterthrush _Seiurus noveboracensis_	X				
Wilson's warbler _Wilsonia pusilla_	X				
American redstart _Setophaga ruticilla_	X				
Red-winged blackbird _Agelaius phoeniceus_	X	X	15 Aug., 1968	Nahanni Butte	N
Rusty blackbird _Euphagus carolinus_	X				
Brown-headed cowbird _Molothrus ater_	X	X	2 July, 1970	Yohin Lake	
Western tanager _Piranga ludoviciana_	X	X	27 June, 1970	Deadmen Valley	N
Rose-breasted grosbeak _Pheucticus ludovicianus_	X				
Purple finch _Carpodacus purpureus_	X			Seen in Ft. Simpson (Godfrey, 1966)	
Pine grosbeak _Pinicola enucleator_	X				
Pine siskin _Spinus pinus_	X				

TABLE 5. (Cont'd)

Species	Expect-ed	Observ-ed	Date	Location	Status
Red crossbill *Loxia curvirostra*	X			Seen in Ft. Simpson (Godfrey, 1966)	
White-winged crossbill *Loxia leucoptera*	X				
Savannah sparrow *Passerculus sandwichensis*	X				
Slate-colored junco *Junco hyemalis*	X	X	6 Aug., 1952	Glacier (Brintnell) Lake (Flook, 1953)	N
Chipping sparrow *Spizella passerina*	X	X	28 June, 1970	Flat-Nahanni River junction	N
White-crowned sparrow *Zonotrichia leucophrys*	X	X	Aug., 1968	Deadmen Valley	N
White-throated sparrow *Zonotrichia albicollis*	X				
Fox sparrow *Passerella iliaca*	X				
Lincoln's sparrow *Melospiza lincolnii*	X			Seen in Ft. Simpson (Godfrey, 1966)	
Swamp sparrow *Melospiza georgiana*	X				
Song sparrow *Melospiza melodia*		X	3 July, 1970	Wild Mint Springs	N

* M = migrating
**N = nesting

the South Nahanni and Flat River areas on several occasions. The "Status" column was checked if a species was known to have nested in the general area described in this report.

On July 2, 1970, Scotter saw an American coot on Yohin Lake. This is northwest of its known nesting range, though its northern range is not well known (Godfrey, 1966). Earlier the same day, he saw a wandering tattler beside a small alpine stream above the South Nahanni River (61° 20'N, 124° 28'W). This sighting was well east of the known breeding range of this bird (Godfrey, 1966). Hilah Simmons has seen the wandering tattler in the Little Dal Lake area (about 62° 45'N) in the Mackenzie Mountains in July. The tattler probably nests there and in the Nahanni area. Godfrey (ibid.) admits that the breeding range is poorly known. It is known to breed along the mountain streams and meadows of Alaska, the Yukon Territory, and British Columbia. The few nests seen have been on gravel bars of high mountain streams.

The adult herring gulls listed in Table 5 were seen feeding below Virginia Falls with a group of mew and Bonaparte's gulls and a few arctic terns. They were just outside their known breeding range, but this may be of no significance as we could not be sure whether they had nested nearby. They are widely distributed throughout northwestern Canada during the breeding season.

A horned lark was seen at Yohin Lake on 2 July, 1970. Its breeding range in the Mackenzie District is not well known but it has not been seen nesting in the Nahanni area.

Violet green swallows were seen in nest holes and swarming in the air on June 20, 1970, at Swallow Cliffs on the Flat River. This sighting was well east of the known breeding range of the bird, according to Godfrey (1966). It is known to be a summer resident of the Yukon Territory, British Columbia, and southwestern Alberta.

A song sparrow was seen at Wild Mint Springs near the Flat River on July 3, 1970. This was quite a distance north of the known breeding range of the species (Godfrey, 1966).

Mammals

We can expect to find 42 species of mammals in the Flat and South Nahanni River valleys. At least 31 of these species have been observed there and are listed in Table 6. The criterion for the mammals listed as "Expected" in the area is Hall and Kelson (1959).

Donald R. Flook of the Canadian Wildlife Service accompanied Colonel H. Snyder's expedition to Glacier (Brintnell) Lake in August, 1952 (Flook, 1953). Flook observed one species, the collared pika, that Hall and Kelson (1959) did not show as occurring in the South Nahanni and Flat River areas. Phillip M. Youngman (1968) of the National Museum of Canada recorded a collection of collared pika that was made above The Gate on the South Nahanni River in 1937.

Quite a few of the observations listed in Table 6 were made by Youngman who collected mammals in the Flat River headwaters area in 1963. He also had access to collections made by other mammalogists at Glacier Lake and along the South Nahanni River. Besides the pika, he listed two other species not shown by Hall and Kelson (1959) as occurring in the area: the water shrew and the tundra vole.

Two other species, the mule deer and the white-tailed deer, have been observed near the south shore of the lower South Nahanni

TABLE 6. Mammals of the Flat and South Nahanni River drainage areas.

Species	Expect-ed	Observ-ed	Date	Location
Masked shrew *Sorex cinereus*	X	X	June, 1963	Flat River (Youngman, 1968)
Vagrant shrew *Sorex vagrans*	X	X	June, 1963	Ft. Simpson and Nahanni River Mountains by Hall and Kelson (1959); Glacier Lake Youngman, 1968
Water shrew *Sorex palustris*		X	1937	Glacier Lake (Youngman, 1968)
Arctic shrew *Sorex arcticus*	X			Ft. Liard is nearest collection
Pygmy shrew *Microsorex hoyi*	X			
Little brown myotis *Myotis lucifugus*	X	X	27 June, 1970	Deadmen Valley
Collared pika *Ochotona collaris*		X	Aug., 1952	Glacier Lake (Flook, 1953)
Snowshoe rabbit *Lepus americanus*	X	X	3 July, 1970	Wild Mint Springs
Least chipmunk *Eutamias minimus*	X	X	27 June, 1970	Deadmen Valley
Woodchuck *Marmota monax*	X			
Hoary marmot *Marmota caligata*	X	X	Aug., 1952	Glacier Lake (Flook, 1953)
Arctic ground squirrel *Spermophilus undulatus*	X	X	3 July, 1970	61°25'N, 125°4'W
Red squirrel *Tamiasciurus hudsonicus*	X	X	26 June, 1970	Kraus' Hotsprings

TABLE 6. (Cont'd)

Species	Expect-ed	Observ-ed	Date	Location
Northern flying squirrel *Glaucomys sabrinus*	X	X	1937	Glacier Lake (Youngman, 1968)
Beaver *Castor canadensis*	X	X	27 June, 1970	Meilleur River
Deer mouse *Peromyscus maniculatus*	X	X	3 July, 1970	Deadmen Valley cabin
Bushy-tailed wood rat *Neotoma cinerea*		X	1971	Cave in First Canyon (Seen by Poirel and party during July and August)
Northern red-backed mouse *Clethrionomys rutilus*	X	X	June, 1963	Flat River (Youngman, 1968)
Gapper's red-backed mouse *Clethrionomys gapperi*	X			
Heather vole *Phenacomys intermedius*	X			
Meadow vole *Microtus pennsylvanicus*	X	X	June, 1963	Flat River (Youngman, 1968)
Tundra vole *Microtus oeconomus*		X	1937	Glacier Lake (Youngman, 1968)
Long-tailed vole *Microtus longicaudus*	X	X		The Gate, Nahanni River, and Glacier Lake (Hall & Kelson, 1959)
Yellow-cheeked vole *Microtus xanthognathus*	X			
Muskrat *Ondatra zibethicus*	X	X	2 July, 1970	Yohin Lake
Northern bog lemming *Synaptomys borealis*	X	X	June, 1963	Flat River (Youngman, 1968)

TABLE 6. (Cont'd)

Species	Expect-ed	Observ-ed	Date	Location
Meadow jumping mouse Zapus hudsonicus	X			
Porcupine Erithizon dorsatum	X	X	Aug., 1952	Glacier Lake (Flook, 1953). Sign seen in Dry Canyon, September, 1971
Coyote Canis latrans	X			
Gray wolf Canis lupus	X	X	1 July, 1970	Flat-Nahanni River junction
Red fox Vulpes fulva	X	X	27 June, 1970	Meilleur River
Black bear Ursus americanus	X	X	3 July, 1970	Mouth Prairie Creek
			15 Sept., 1971	
Grizzly bear Ursus arctos	X	X	12 Sept., 1970	Wild Mint Springs
Marten Martes americana	X	X	1937	Glacier Lake (Youngman, 1968)
Fisher Martes pennanti	X	X		Occasionally trapped in Nahanni Butte area
Ermine Mustela erminea	X	X	10 Sept., 1970	Deadmen Valley
Least weasel Mustela rixosa	X			
Mink Mustela vison	X	X		Commonly trapped by Nahanni Butte people

TABLE 6. (Cont'd)

Species	Expected	Observed	Date	Location
Wolverine *Gulo luscus*	X	X	22 Aug., 1968	Mouth of Prairie Creek
Striped skunk *Mephitis mephitis*	X			
River otter *Lutra canadensis*	X	X	1953	Mouth of South Nahanni River (Youngman, 1968)
Lynx *Lynx canadensis*	X	X	27 June, 1970	Meilleur River
Mule deer *Dama hemionus*		X	July, 1964	Mouth of Flat River (Youngman, 1968)
White-tailed deer *Dama virginiana*		X	6 Sept., 1970	Seen by Mary Kraus at Hotsprings
Moose *Alces alces*	X	X	30 June, 1970	Flat River, 61°28'N, 125°57'W
Woodland caribou *Rangifer tarandus*	X	X	8 Sept., 1970	Virginia Falls area 61°49'N, 126°9'W
Mountain goat *Oreamnos americanus*	X	X	16 Sept., 1971	Hole-in-the-Wall Lake
Dall sheep *Ovis dalli*	X	X	29 June, 1970	1 1/2 mile east of Virginia Falls

River by the Kraus family and other local residents. A specimen from a white-tailed deer was collected at the old Kraus residence by the Territorial Game Management Division and is now in Yellowknife. William D. Addison (pers. comm., 26 April, 1971) saw a white-tailed deer just downstream from the mouth of Wrigley Creek, between Hell's Gate and the mouth of the Flat River on the South Nahanni River, in July, 1966. Sterling Pickering observed two deer, unidentified as to species, on the bank of the South Nahanni River about 30 miles north of Glacier Lake during the summer of 1971.

The general distribution of several species of large mammals most likely to be seen by a tourist is shown in Fig. 31. Other species, such as the wolf, wolverine, and lynx are widely and thinly distributed, and little is known about the locations of the denning sites which may serve as the foci of their ranges.

Figure 31 is intended to illustrate, among other points, the paucity of our knowledge about the seasonal distribution and abundance of the most important large mammal species. However, aerial surveys in the Nahanni Range and in the mountain block west of the Flat River in the Loon and Seaplane Lakes area enable us to plot the seasonal ranges of Dall sheep in those locations (Simmons, 1969). We also have information about the seasonal distribution of woodland caribou based on reports by geologists working in the Canada Tungsten and Peñarroya areas. Most of the caribou, sheep, grizzly bear, and moose sightings made north and south of the Peñarroya site were made by surveyor David Ellis (pers. comm., September, 1970). Non-resident hunter kill data collected by the Canadian Wildlife Service (Simmons, 1968) also added to our knowledge about game mammal distribution.

The Flat River and parts of the South Nahanni drainage have some of the finest beaver habitat in the Mackenzie Mountains. The Flat River beaver population is particularly impressive. During a late afternoon trip up the Flat River in June, 1970, we saw and heard beaver frequently between the river mouth and its junction with Irvine Creek.

The South Nahanni and Flat River drainages are the northernmost areas in the Mackenzie Mountains where black bear are seen with any regularity. Black bear sightings have been made as far north as the Keele River, but such observations are rare. Grizzly bears are occasionally seen throughout the area of Fig. 31.

Moose are found throughout both the Flat and South Nahanni River valleys. Perhaps the best moose habitat is along the Flat River between the mouth of the Caribou River and Seaplane Lake. This area has burned over several times, particularly in the widespread fires of 1948 and 1971.

Woodland caribou occupy the upper Flat River valley, the upper South Nahanni River valley, and the upper Prairie and Wrigley Creek areas year-long. They also can be seen elsewhere throughout the entire Flat and South Nahanni River areas west of 124^{o} west longitude, but only occasionally. Only a few river travellers will be lucky enough to see this animal east of the junction of the Flat and South Nahanni Rivers.

Within the area shown in Fig. 31, only the mountain blocks on either side of the Flat River above Seaplane Lake support appreciable numbers of mountain goats. Nahanni Butte resident and big game hunting outfitter Don Turner estimated that the mountain block southwest of Loon Lake supports about 100 goats, but Canadian Wildlife Service surveys indicate that the population may be less than that (Simmons, 1969).

Dall sheep are thinly distributed in nearly all the alpine tundra areas covered by Fig. 31. The densest populations in the map area probably occur in the Manetoe, Tundra, Headless, and Tlogotsho Ranges north and south of Deadmen Valley and in the Nahanni Range north of Nahanni Butte (Fig. 32). The alpine tundra areas provide both summer and winter Dall sheep habitat, though their range shrinks to the best vegetated, windblown areas in the winter. A tourist travelling the South Nahanni River in the summer is most likely to see Dall sheep at the two mineral licks in Deadmen Valley.

Residents of the Northwest Territories hunt and trap mammals west of 124° west longitude only rarely. They have preferred to remain within easy travelling distance of their villages since about 1945. The Northwest Territories Game Division has recently been trying to encourage natives of Fort Simpson and Nahanni Butte to trap furbearing mammals in the Flat River and upper South Nahanni River areas, but so far their program has met with little success.

The Mackenzie Mountains was made a game preserve, set aside to protect the hunting grounds of Indian trappers, in 1938. However, since World War II, only a few Indian hunters and trappers ventured into the Mackenzie Mountains and then only infrequently. The Mackenzie

Fig. 32. Dall sheep females and lambs in the Tlogotsho Range.

$61^{o}11'N$, $124^{o}34'W$. (Photo: N. M. Simmons, 2 July, 1970.)

Mountains Game Preserve was therefore abolished in 1953 (Stevens, 1958). Non-residents have been permitted to hunt big game mammals in the South Nahanni and Flat River regions since 1964 (Fig. 33). Don Turner has an exclusive right to conduct hunter outfitting operations within that drainage system (Simmons, 1968). His operation is small and the area is under-harvested. Up until 1970, Turner used only boats and hiking to get his hunters to their game. In 1967, his hunters stayed within a 6-mile radius of his base camp on Loon Lake, and in 1968 his hunters killed all their game within a 10-mile radius of the same camp. Now Turner uses a Super Cub aircraft on oversized tires to distribute his hunters widely throughout his area (ibid.).

Nearly all the mountain goats killed in the Mackenzie Mountains between 1965 and 1968 came from Turner's area. Even so, only 14 goats were reported to have been killed during the 4-year period.

Between 1965 and 1968 a total of 37 hunters killed only 19 Dall sheep in Turner's area. Dall sheep hunter success in his area was below average, a reflection of the low density of the sheep population near Loon Lake. Success has improved since he began using an aircraft and hunting in the mountains north and south of Deadmen Valley and Nahanni Butte.

Turner's hunters killed only nine caribou between 1965 and 1968. Caribou were rarely seen in the area of his Loon Lake camp. Sixteen moose were killed by his hunters during the same period. Moose are commonly seen along the Flat and South Nahanni Rivers in the fall. Had the moose been a more desirable trophy animal, more would have been killed.

Fig. 33. Hunters near Deadmen Valley, South Nahanni River.

(Photo: G. W. Scotter, 11 September, 1970.)

Ten grizzly bears were killed in the Loon Lake area between 1965 and 1968. This is a much sought after trophy, but this animal is nowhere common in the Mackenzie Mountains. Eight black bears were killed by Turner's hunters. The number of black bears killed in that area is probably related to their desirability as trophies and not to their availability (Simmons, 1968).

Few wolves and wolverine were killed by non-resident hunters. These species the hunters consider "targets of opportunity", desirable but not subject to systematic hunting.

Turner will continue to underharvest his area for a long time to come. The high overhead cost of operations and the difficulty of transporting even small groups of people to hunting areas will preclude the large scale systematic hunting programs conducted in the provinces and the United States. Since Turner has an exclusive right to conduct hunts for non-residents in his large area, the encroachment of other outfitters will not become a problem. Turner is likely to care for his area wisely as the wildlife and scenic beauty of the area are now major sources of his income.

A DISCUSSION OF THE PARK PROPOSAL

The survey of the South Nahanni and Flat River areas conducted by the National Park Service resulted in a written proposal that parts of the two river systems be set aside as a National Park (National Parks Service, 1970). Boundaries were proposed, a theme was suggested, and development of the area was discussed. It is this proposal that we wish to comment on; the suggestions have been based on our ecological survey of the area.

Park Boundaries

The establishment of boundaries for a National Park encompassing the most interesting portions of the South Nahanni River drainage poses a dilemma. Ideally the boundaries should enclose entire ecological units, but when the main river flows from northwest to southeast, bisecting north-south trending mountains, and when the area must be kept narrow because of surrounding mineral claims (Fig. 21), this ideal cannot be realized. The straight-line, point-to-point boundary, using bench marks as pivot points where possible, that was proposed by the National Parks Service may be the most practical choice in some areas.

Suggested boundary extension

Figure 30 shows the park boundaries as drawn by the National and Historic Parks Branch (National Parks Service, 1970). It also shows our suggestions for extensions of the boundary to include additional areas we feel may be worthy of National Park status. The extended boundaries enclose 1) The Yohin Lake - Sand Blowout area; 2) Tlogotsho

Dall sheep range; 3) an area of warm mineral springs and unusual vegetation; and 4) an area including an unusual mineral spring, beautiful glacier-fed lakes, and spectacularly rugged glacier country.

1. Yohin Lake (known locally as Jackfish Lake) and the Sand Blowout. Yohin Lake (Fig. 34a) is rimmed with "floating bog" type vegetation that is most interesting from a botanical viewpoint. This area is within the northwestern limits of vegetation zone 6 as described by Porsild and Cody (1968).

The lake also supports a relatively large population of nesting waterfowl and passerine birds. Within the proposed park area, it supports the richest variety of bird life and is a birdwatcher's paradise. By including the area within the proposed National Park, the diversity of plant and bird life to be enjoyed by visitors can be significantly increased.

One possible barrier to the protection of this area from destructive use may be the desirability of the lake as a waterfowl hunting area for residents of Nahanni Butte.

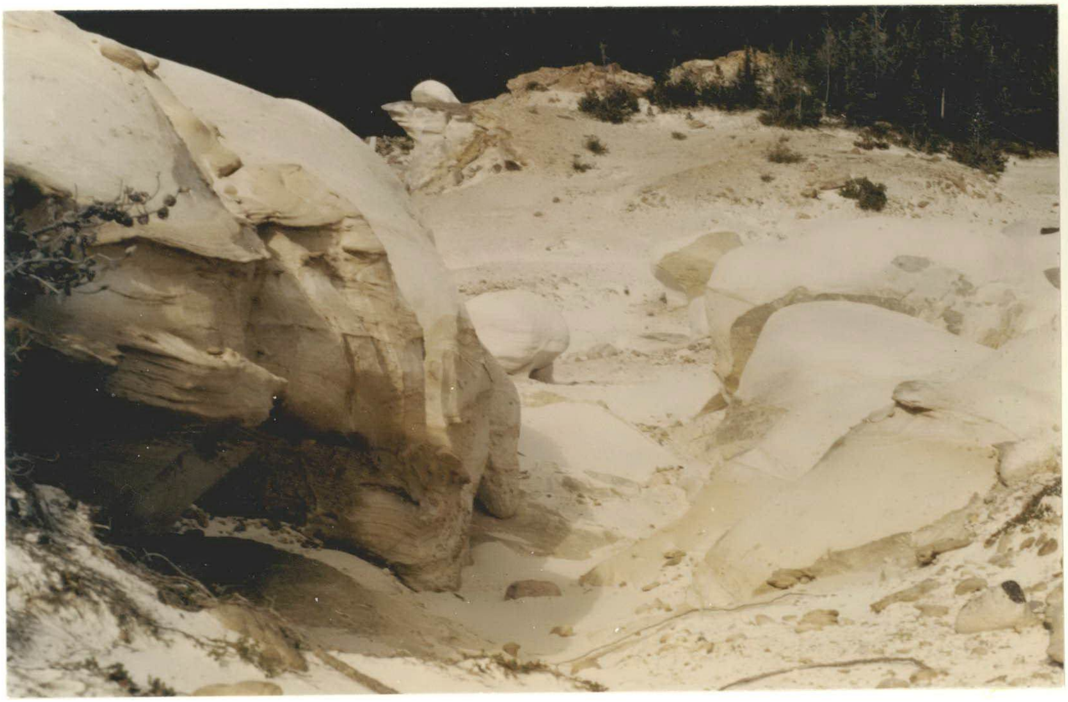
The Sand Blowout (Fig. 34b) is a unique area where fine-grained sandstone has been wind-eroded into unusual shapes. The eroded arches, pedestals, and caves stand surrounded by a floor of powder-fine sand and thousands of small round balls of sandstone about the size of marbles. The area looks like a plot of desert habitat high above the river valley, hot and forbidding, fringed by cool evergreens which provide a surprising contrast.

Fig. 34a. Yohin Lake, with its numerous islands, is extremely interesting from a botanical and ornithological standpoint.

(Photo: G. W. Scotter, 14 September, 1971.)

Fig. 34b. The Sand Blowout.

The Sand Blowout, near Yohin Lake, is a unique area where fine-grained sandstone has been wind-eroded into unusual shapes. The eroded arches, pedestals, and caves stand surrounded by a floor of powder-fine sand and thousands of small round balls of sandstone about the size of marbles. (Photo: G. W. Scotter, 2 July, 1970.)



Some Indians of the area have a superstitious fear of the Blowout. They feel that a person visiting the area runs the risk of being swallowed up by the sand. This belief may stem from the story that an Indian once saw a moose venture onto the sand only to disappear without a trace (G. Kraus, pers. comm., June, 1968).

Presently the Sand Blowout is little known, even though it is clearly visible from the South Nahanni River, and very few of those who know of it have actually made the long hike up to the Blowout. This is fortunate, because the beauty of the area could easily be destroyed. The sandstone is soft and a visitor can hardly control his urge to carve his initials on the unusually shaped formations. We could not dissuade our helicopter pilot from leaving evidence of his visit on the top of one of the sandstone knobs.

2. Tlogotsho Dall sheep range. Because of the beauty of the animal and the rugged habitat that it traditionally occupies, the white Dall sheep promise to be a major feature of a National Park in this area. The sighting of a Dall sheep by a tourist may occur only once during his tour of the South Nahanni River, but it is an event which will be long remembered as a highlight of the visit.

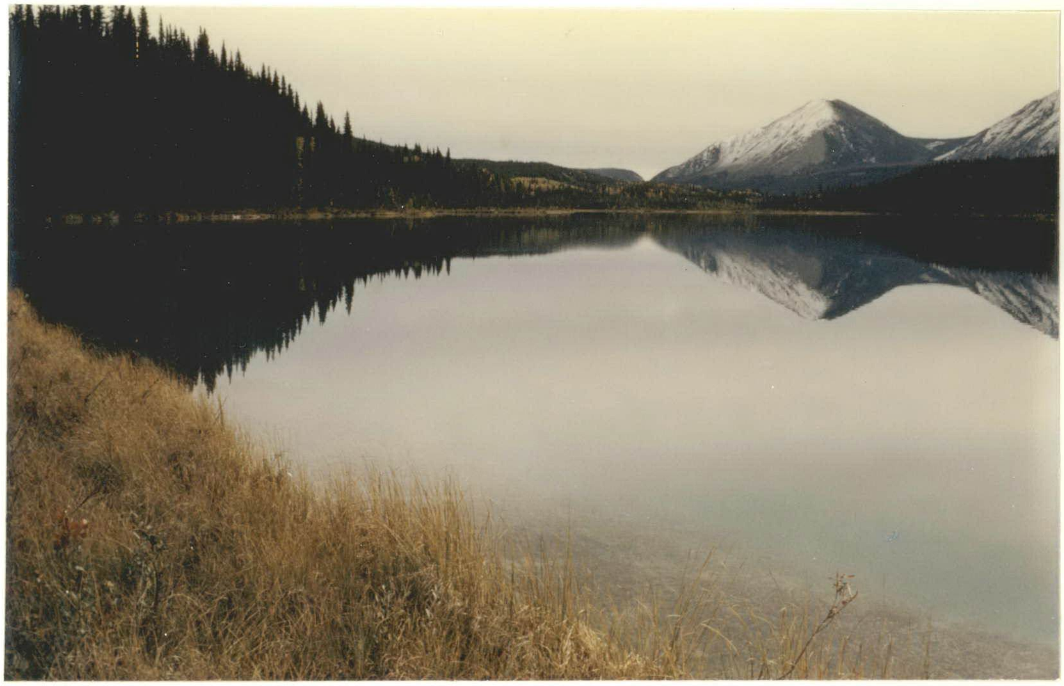
Unfortunately, most of the best Dall sheep habitat is excluded by the originally proposed park boundaries. Only the Tlogotsho Range, Headless Range, and Nahanni Plateau contain reasonably good sheep range, but the boundaries include only fringes of this habitat. A boundary change to include more sheep range north of the river is not feasible because of the Peñarroya prospect. We suggest, therefore, that the boundary be moved south to include more of the Tlogotsho Range. The alpine tundra plateaus, fringed by steep slopes, provide excellent habitat for the sheep. They are seen frequently in that area (Fig. 32). It could be that our suggested boundary extension includes year-round habitat for at least ewes and their young. Rams are more mobile and probably move in and out of the area enclosed by our boundaries. It would not be difficult to determine the year-long range of the females and young, and this should be done by the Canadian Wildlife Service as soon as possible.

Park visitors could hike out from Deadmen Valley to the Tlogotsho sheep range in a long summer day, camp near the alpine tundra, and spend a pleasant day or two hiking the gentle ridges and watching for sheep.

3. Warm mineral springs. The microenvironments created by the warm-water mineral springs, ponds, and lake (Fig. 35) in the area between Seaplane Lake and Irvine Creek are of considerable interest because plants and invertebrates belonging to more temperate regions may have survived as relics from earlier periods when the climate generally was warmer. Such areas are refugia for plants and animals, disjunct from their main ranges.

Fig. 35. Beautiful turquoise Mineral Lake is fed by a mineral spring.

(Photo: N. M. Simmons, 12 September, 1970.)



The mineral springs also support interesting nesting populations of waterfowl and passerine birds, and they are apparently attractive to mammals. Wild Mint Springs was the location of the first recorded sighting of a nesting song sparrow (Table 5) west of Fort Simpson to the south-central Yukon and north of the Finlay River headwaters in British Columbia (Godfrey, 1966). During out visit to the little-known spring last summer, we saw the tracks of a variety of large mammals around the ponds. Wolves had bedded beneath the spruce trees that grow up through the mineral deposits. Moose and caribou left their tracks in the mud below the ponds. Grizzly and black bears also left tracks by the southern edge of the largest pool. Later we saw two grizzly bears that had churned up the ground as they dug for roots and had left their long hairs on rubbing trees.

The beauty of the mineral ponds is breathtaking. The waters are crystal clear and bordered with a variety of flowering plants (Fig. 20). Mineral Lake is a brilliant turquoise blue, like a precious stone set in a sea of dark green. An interesting sight at the springs is the encasement of trees, bones, and other items in the minerals left by the water. This feature, described with embellishment by Gus Kraus, is what attracted our attention to the area in the first place.

These areas require special managerial care. The mineral walls of the ponds, especially those at Wild Mint Springs, are brittle and crumble easily. Marks made in the slowly solidifying mineral deposits are preserved for long periods. The beauty of these areas could be easily spoiled by careless visitors. This year a cabin was built at Wild Mint Springs, and the pristine quality of the area is already marred. These areas should be the object of major floristic, faunistic, and ecological studies before visitation is allowed.

4. Glacier-fed lakes and Rabbitkettle Hotsprings. "Bare of trees and covered with thick, golden mats of reindeer moss, the easy rhythm of the rolling sedimentary hills is suddenly broken by towering domes and pinnacles of granite, rising in sheer majesty 4,000 to 5,000 feet above the surrounding land. A series of interconnected icefields form a frozen backbone along the western flanks of the range ...." (Milton, 1962, p. 36). So wrote an enthusiastic mountain climber who hiked the alpine passes and climbed the cliffs around Hole-in-the-Wall Lake in the Ragged Range (Fig. 36). He was awed not only by the majesty of the towering cliffs and glaciers, but also by the feeling that he was an explorer in an area never before walked by man. He erroneously described the Hole-in-the-Wall Lake area as unentered and unknown before 1960.

His was an easy mistake to make, for few have experienced the rugged beauty of the Ragged Range (Fig. 37). Even to fly

Fig. 36. Glacier north of the Flat River and west of Hole-in-the-Wall Lake.

(Photo: N. M. Simmons, 23 July, 1970.)

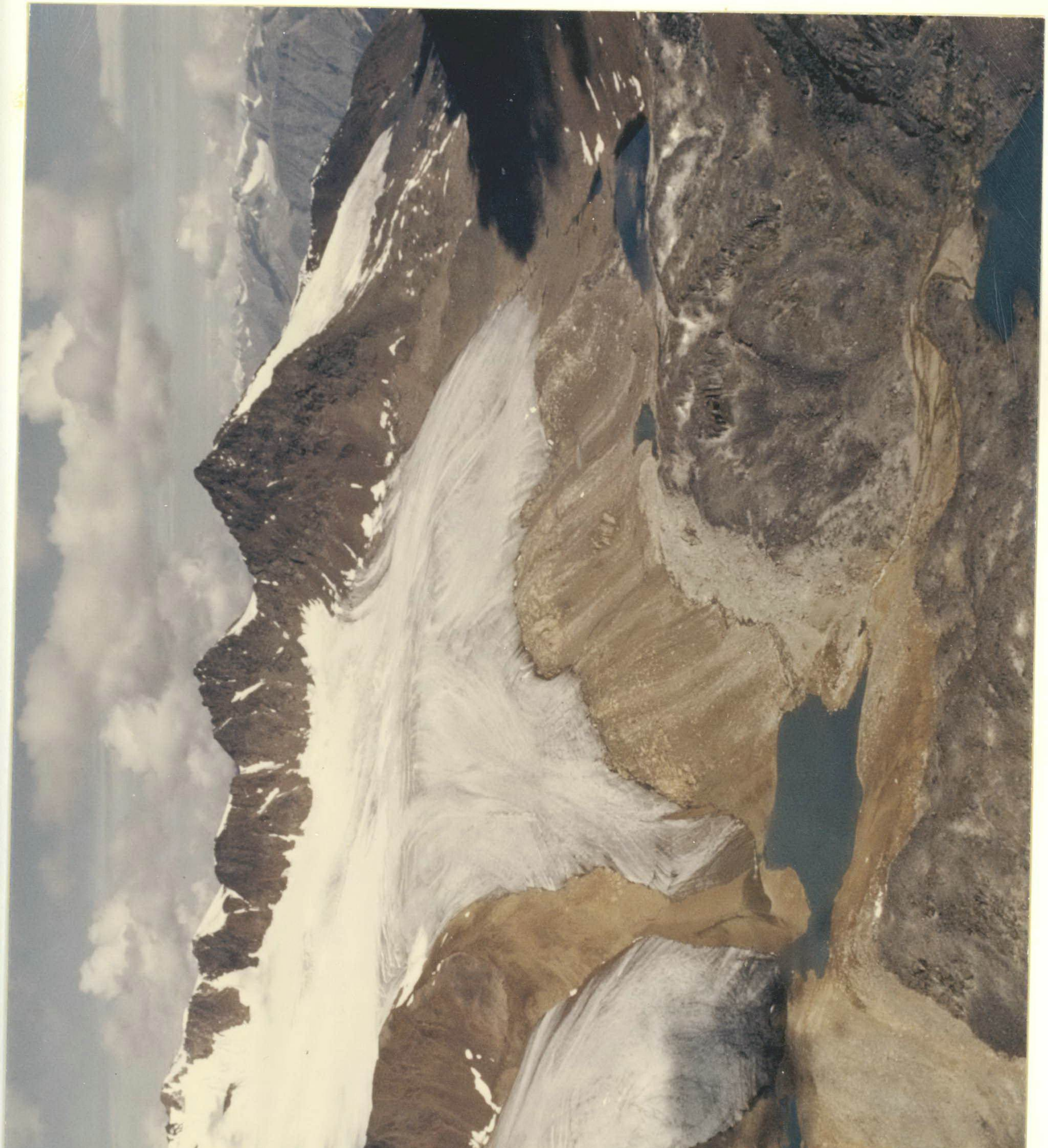


Fig. 37. Glacier west-northwest of Mount Sidney Dobson.

This unnamed glacier is located at 62° 2 1/2'N, 127°46' W. (Photo: N. M. Simmons, 13 September, 1970.)

over the area is an unforgettable experience. Glacier Lake (Fig. 38) and Hole-in-the-Wall Lake are deep, picturesque lakes nestled among sheer granite cliffs. The vegetation around the lakes and the hotsprings above Hole-in-the-Wall Lake is noteworthy. A study of the plant communities in association with one of the hotsprings at Hole-in-the-Wall Lake was made by Arnold (1961).

Judging from the vivid descriptions of Milton's (1962) visit to the southern part of the Ragged Range, the granite cliffs and high passes of the area present a real challenge to the dedicated mountaineer (Fig. 39). The high country is still accessible to the casual hiker who may prefer to stick to the stream valleys (Fig. 40).

Not far from the glacier area, near the junction of the Rabbitkettle and South Nahanni Rivers, is a most unusual mineral spring - Rabbitkettle Hotsprings (Fig. 41). The terraced deposit of tufa from which well the warm mineral waters of the main spring has attracted the attention of nearly every traveller passing through the Nahanni valley above the falls. Rabbitkettle Hotsprings must be regarded as one of the paramount features of the whole region.

Preservation of areas beyond the originally proposed boundaries

The development-fever prevalent in the Northwest Territories today will make it difficult to give even the area within the originally proposed boundaries National Park status. Some people of the Northwest

Fig. 38. The spectacular cliffs of Mount Sir James MacBrien tower 5,800 feet above Glacier Lake.

(Photo: W. D. Addison, 9 July, 1966.)

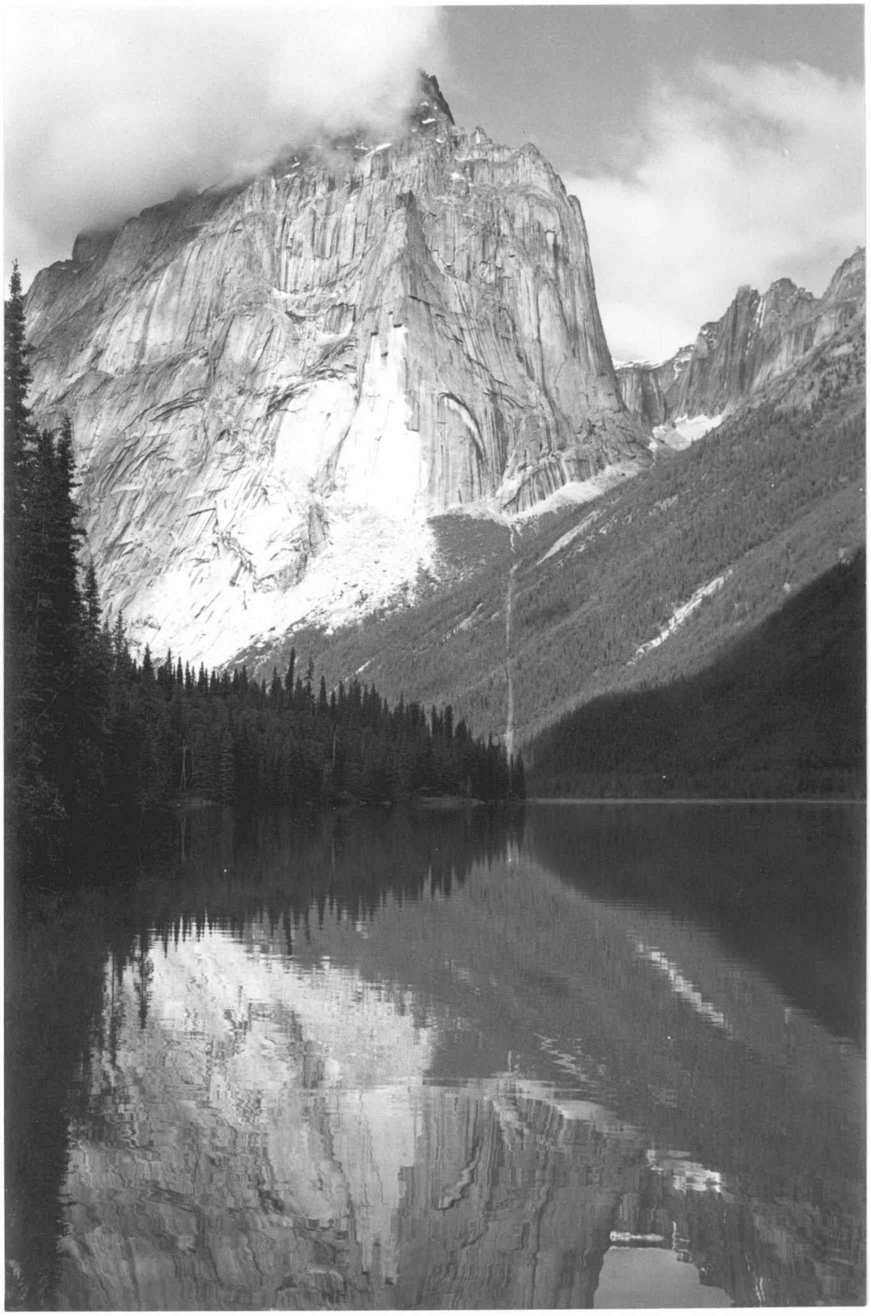


Fig. 39. Rugged glacier country in the Ragged Range.

62°2 1/2'N, 127°46'W. (Photo: N. M. Simmons, 13 September, 1970.)

Fig. 40. Brintnell Creek.

The view is toward the west from the mouth of the creek. Mount Sidney Dobson is left of center. (Photo: W. D. Addison, 16 July, 1970.)

Fig. 41. Rabbitkettle Hotsprings.

One of the spectacular features of the region is Rabbitkettle Hotsprings which is a terraced, flat-topped deposit of tufa, roughly circular in plan. It rises about 90 feet above the Rabbitkettle River and has a diameter of 225 feet. Terraces range from 1 to 12 feet in height, and a spring issues from the uppermost terrace. (Photo: N. M. Simmons, 12 September, 1970.)

Territories see the area of the proposed park as part of their bank account of mineral and hydroelectric power resources. A suggestion that the boundaries be expanded to perhaps three or four times the area covered by the original proposal would make high-level administrators and politicians blanche. However, our conviction that the areas described above should be protected from destructive use is strong. We suggest that the areas in question be withdrawn from further mineral claim staking and that the areas be carefully considered for inclusion in the National Park. As a further protective measure, the areas should be recommended as International Biological Programme sites. Such actions will give the National and Historic Parks Branch and the Canadian Wildlife Service time to examine the areas closely and to consider carefully their potential for inclusion in the National Park system.

The Park Theme and Management

A wild rivers wilderness theme

It has been proposed that the new park be given a "wild rivers" theme (National Parks Service, 1970, p. 4). It has also been suggested that the area be preserved as a wilderness and that the "traditional forms of park developments" be avoided. We wholeheartedly endorse these proposals and, to amplify them, we suggest that, in main, the South Nahanni and Flat River areas are even now well suited to provide the greatest amount of pleasure for the greatest number of people for the longest period of time. The rivers themselves permit the elderly matron to see the canyons, the falls, and the wildlife in relative comfort, while permitting the hardy young visitor to "rough it" through challenging rapids in his fragile canoe (Fig. 42). All types of people can see the area as a virtually untouched wilderness and perhaps even experience the same feelings that Patterson described exultantly in 1927 (Fig. 43).

Park facilities

A road to the Hotsprings at the mouth of First Canyon has been suggested (National Parks Service, 1970, map following p. 4). There was no elaboration on this proposition, and we fail to see the advantage of such an expensive undertaking. The river between Nahanni Butte and First Canyon is interesting and navigable. We believe that the National and Historic Parks Branch will have no mandate from the people to allow automobile traffic within the new park. Automobiles are not compatible with First Canyon or Yohin Lake. The presence of a road and automobile traffic in and near the park would detract immensely from its value as a "wild rivers wilderness".

Park headquarters and major tourist facilities should be placed at Nahanni Butte. There is already an airstrip there, and as suggested (National Parks Service, 1970), a road to Nahanni Butte could easily be built as a spur from the proposed Fort Liard road. There is a community of Indians there that could profit from the establishment of park and commercial facilities such as one or more tourist lodges at the Butte. Nahanni Butte should be the last place on the river that the bustle and clamor of civilization can be found.

Fig. 42. Challenging rapids above Virginia Falls, South Nahanni River.

The vertical drop here is about 60 feet. (Photo: W. D. Addison, 22 July, 1966.)

Fig. 43. Wilderness calm on the South Nahanni River.

Looking west-northwest up the South Nahanni River from one-half mile below the mouth of the Rabbitkettle River. (Photo: W. D. Addison, 16 July, 1966.)

Major campsite facilities such as log cabins, interpretive displays, emergency radio facilities, and fireplaces should be established at the Hotsprings at the mouth of First Canyon, at Deadmen Valley, on the Flat River near its junction with the South Nahanni River, at the mouth of the Caribou River, at Seaplane Lake, above Virginia Falls near the Water Survey of Canada cabin, and at Rabbitkettle Lake (Fig. 30). All points except Rabbitkettle Lake have had cabins on them for long periods of time and have proven to be good camp locations. All are accessible by float planes and can serve as warden patrol posts and emergency transportation centers. The campsites can be set away from the riverbanks and screened from the river by trees.

The Hotsprings (Fig. 44) is the location of the old Kraus homestead. The area has been altered by the Kraus family, but it is very picturesque. Campers there can enjoy the hotsprings and the magnificent view of the mouth of First Canyon. Nearby caves and a mineral lick, used by moose and other mammals, will also be points of interest.

Deadmen Valley has been the site of intermittent human activity for over 60 years. Ruins of old cabins with a rather macabre history are still standing there. Across from the cabin site is the gravel delta of Prairie Creek and two mineral licks used by Dall sheep. The sheep can be watched from the cabin area with binoculars.

A sod roof cabin built by Fred Sibbeston now stands near the junction of the Flat and South Nahanni Rivers. This site would be a convenient resting place for tourists wishing to travel up the Flat

Fig. 44. Hotsprings.

The hot mineralized springs near the old Kraus homestead will be a leading attraction to campers travelling the South Nahanni River. (Photo: N. M. Simmons, 11 September, 1969.)

River, or for those who want to view the falls in the morning when the sun is at the proper angle for photographs. This site is also a wildlife haven. Beaver and moose are common on this stretch of the river. The cabin site itself is a whelping area for wolves. The cabin may be worthy of preservation as a tourist attraction.

A partly built Northwest Territories Game Management Division patrol cabin now stands at the mouth of the Caribou River. A major campsite there would service tourists travelling in the southwestern half of the park. Within convenient boating distance are a major mineral lick (Fig. 22), bear dens, and cliff nests of violet-green swallows. The area is a haven for moose, beaver, and a few grizzly bear. Not far away are the formidable rapids above Irvine Creek and the Old Pots Mineral Springs.

A commercial facility could be established at Seaplane Lake for those wishing to fly to the western edge of the park and visit the mineral springs area along the Flat River. There are several old cabin sites around the lake. Fishing is good there and the scenery is beautiful.

A campground at the existing Water Survey cabin site would be well located for tourists who have made the long journey up the South Nahanni River, for those who plan to float down the river from below the falls, or for those planning to travel farther up the river. The location would be out of sight of the falls and the cataract and would therefore not detract from the wild beauty of the area.

We know little about the Rabbitkettle Lake area, but it is suggested as a major campsite because of its accessibility to aircraft and its proximity to Rabbitkettle Hotsprings and the spectacular mountains and glaciers of the Ragged Range near Hole-in-the-Wall and Glacier Lakes.

Minor campsites, consisting only of well-hidden fireplaces, tent clearings, and trash barrels could be placed at the mouth of Mattson Creek, near Yohin Lake, at Big Bend, at The Gate (Fig. 45), on Marengo Creek below Marengo Falls, near Wild Mint Springs, near Mineral Lake, at Hole-in-the-Wall Lake, and at Glacier Lake (Fig. 30). All of these sites are scenic and near points of interest to the tourist. The site at the mouth of Mattson Creek would be at the bottom of a trail leading to the Sand Blowout. The other locations are self explanatory.

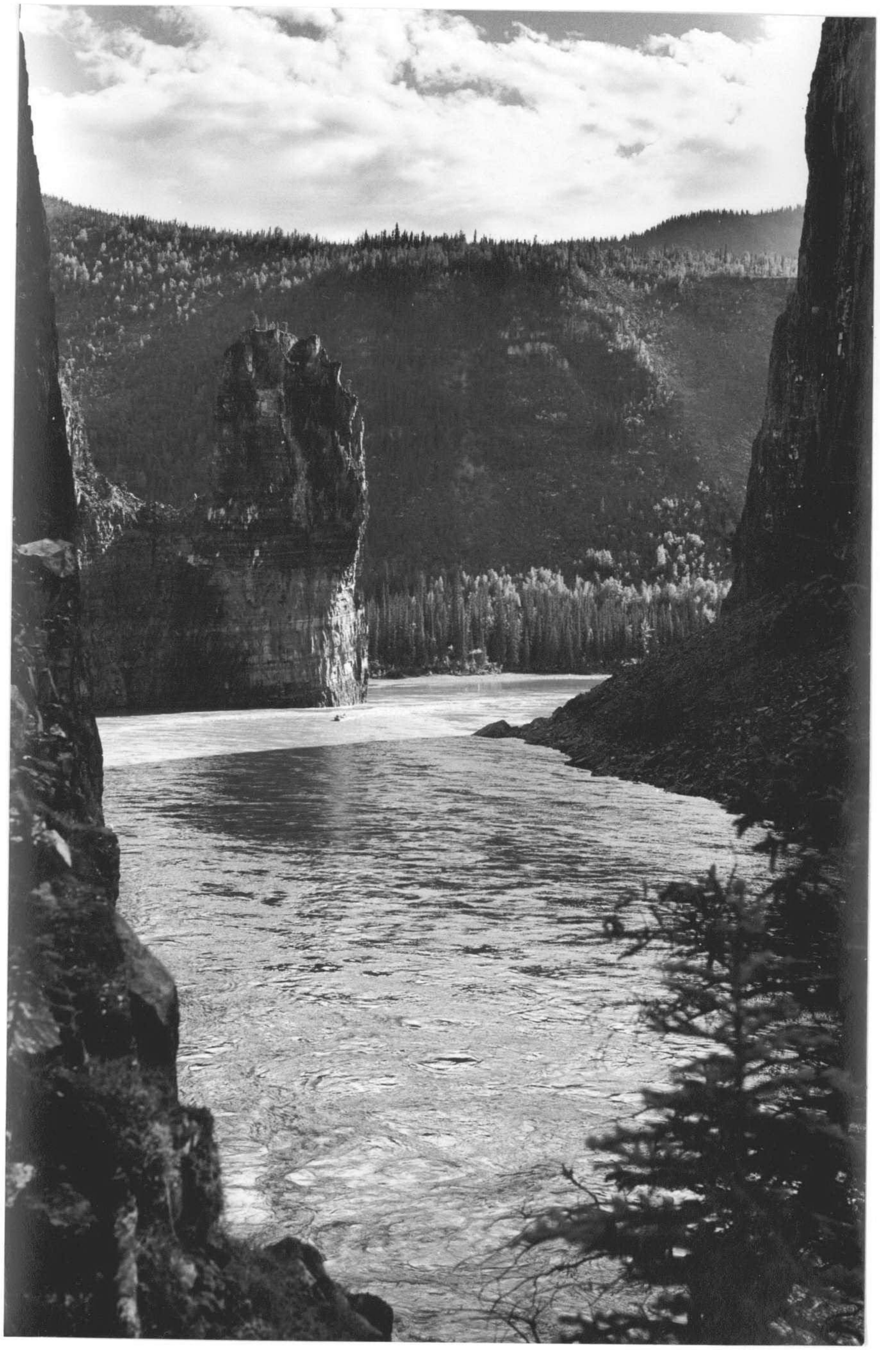
There may be a demand for mountaineering cabins on the slopes above Hole-in-the-Wall and Glacier Lakes. These could be made to blend appealingly with the area and may be attractive features, but they will be expensive to build and service. Perhaps tenting should be encouraged.

Transportation

The river, we hope, will remain the main access route. The use of canoes, kayaks, rafts, and other unpowered river craft should be encouraged. A floating trip down the South Nahanni River, perhaps even from its headwaters, would be a wonderful recreational experience. Possibly guided canoe and raft trips could be developed. The use of power boats should be restricted, perhaps to only a few tour boats owned by concessionaires. The ideal craft for comfortable guided tours

Fig. 45. Pulpit Rock at The Gate, South Nahanni River.

(Photo: W. D. Addison, July, 1966.)



on the South Nahanni and Flat Rivers is the jet pump powered boat. The shallow draft and ample power of these boats would make trips as far as Virginia Falls and up the Flat River as far as Irvine Creek safe, comfortable, and relatively fast.

Due to the remoteness of the proposed park, aircraft will play a useful role in routine and emergency transportation. Access to the Wild Mint Springs area, Hole-in-the-Wall Lake, Rabbitkettle Hotsprings, and Glacier Lake could well be by float plane. Canoeists wishing to float down-river could be brought in by float plane to a point above Virginia Falls or much farther up the river. Photographers may want to see the falls from the air.

However, the Nahanni and Flat River valleys should not become air traffic corridors, as the harassment of tourists and wildlife may result. Cruise altitude and flight path restrictions may be in order. Landing areas for visitors should probably be restricted to the Hotsprings near Kraus's former cabin, the campground above the falls, the lake where Tyerman's cabin is located, Rabbitkettle Lake, Hole-in-the-Wall Lake, and Glacier Lake.

Concessionaire-operated pack horse strings could serve a useful function at the western end of the proposed park. Horses can be brought in seasonally by truck via Watson Lake and Tungsten, and then trailed to the western edge of the park along the Rabbitkettle River or South Nahanni River. Horses have been successfully trailed from Tungsten as far as Dal and Little Dal Lakes, far north of the proposed park, by big-game hunting outfitters. Horse trails could then be made to the lakes and mineral springs in the western part of the park.

Backpack trips should be encouraged by establishing hiking trails from the rivers to such points of interest as Yohin Lake, the Sand Blowout, the alpine tundra of the Tlogotsho Range and Sunblood Mountain, Rabbitkettle Hotsprings and the other mineral springs, Glacier Lake, Hole-in-the-Wall Lake, and perhaps into the glacier country of the Ragged Range. Segments of old Indian and prospector trails as well as canoe portage routes (Fig. 46) should be put back into use.

Fires and floods

Dangerous floods do occur in the watershed, but they are not common. If cabin sites are well-planned, damage from floods will be minimal. Therefore, flood control measures will probably be unnecessary.

In the past, forest fires have had a major ecological influence on the area and a high proportion of the stands are of fire origin (Fig. 47). It is recommended that no fire control be practiced within the potential National Park site. Fires represent a natural ecological feature and since there is little property in the area to be protected they should be allowed to run their course. There is no doubt that forest fires, along with the willow stands on recent alluvial deposits, are responsible for the large moose populations within the South Nahanni and Flat River regions.

Mineral exploration and development

The presence of mineral development activity at Tungsten and on Prairie Creek and the dangers that such enterprises pose for the proposed park have been discussed in some detail (National Parks Service, 1970).

Fig. 46. The portage trail at Virginia Falls.

(Photo: W. D. Addison, 23 July, 1966.)

Exploration activities elsewhere near the planned borders are also mentioned. We agree that pollution of the rivers by the Canada Tungsten and Peñarroya operations may become serious problems. Accidental discharge of large amounts of petroleum products has already occurred on Prairie Creek. Canada Tungsten has recently constructed a new tailings disposal system which may prove satisfactory, but their waste disposal program should nevertheless be continually monitored.

Hunting and trapping

The Northwest Territories Game Management Division has left us with the impression that the residents of Nahanni Butte, Fort Liard, and Fort Simpson rarely hunt or trap within even the extended boundaries of the proposed park, in spite of the richness of the wildlife resource there. If the choice of employment by the National and Historic Parks Branch as laborers, guides, and concession operators is offered to the natives, then there should be few complaints against the loss of a hunting and trapping area which is only rarely used.

A more serious imposition would be on the big game outfitting business of Don Turner. The park would reduce the size of his outfitting area considerably. There are no suitable alternative areas in the mountains of the Northwest Territories to offer him in trade for the area taken by the park. All of Game Management Zones 12 and 19 are covered by the exclusive outfitting rights of the seven other outfitters operating in the mountains. Perhaps a boat tour concession would interest Mr. Turner. He is a skilled river boatman and is familiar with most of the park area.

Ecological and Anthropological Work Urgently Needed

Species inventory

An inventory of the vertebrate and invertebrate species in the park area is lacking and is badly needed. Such inventories have been conducted in only a few areas and cover only a few species of mammals and fish. Studies could well dovetail with work on the ecology of the mineral ponds and lakes and of the two deep lakes in the Ragged Range. Studies of plant species and plant communities should be carried out within the proposed park, with special emphasis on the Virginia Falls, Yohin Lake, and hotspring areas.

Studies of seasonal ranges of mammals

Studies of the life histories of most of the mammals and fish living within the boundaries of the proposed park have already been conducted in other areas of North America. However, little is known of the specific periodicity of phases in their life cycles in this northern environment. Studies of the seasonal range requirements of such mammals as the Dall sheep, woodland caribou, mountain goat, and grizzly bear are urgently needed. Work by the Canadian Wildlife Service on the Dall sheep and woodland caribou is already in progress in the Keele and North Redstone River valleys, but specific definition of critical range requirements is needed for the park area. Such work could conveniently fit with the current Canadian Wildlife Service research program in the Mackenzie Mountains.

Anthropological research

If action to institute anthropological research is taken promptly, there is an excellent opportunity to learn much about the history of the South Nahanni and Flat River regions from people still living in Fort Simpson, Fort Liard, and Nahanni Butte. The task of interviewing people such as Albert Faille, Dick Turner, Vera Turner, Gus Kraus, and Mary Kraus is urgent (Fig. 48).

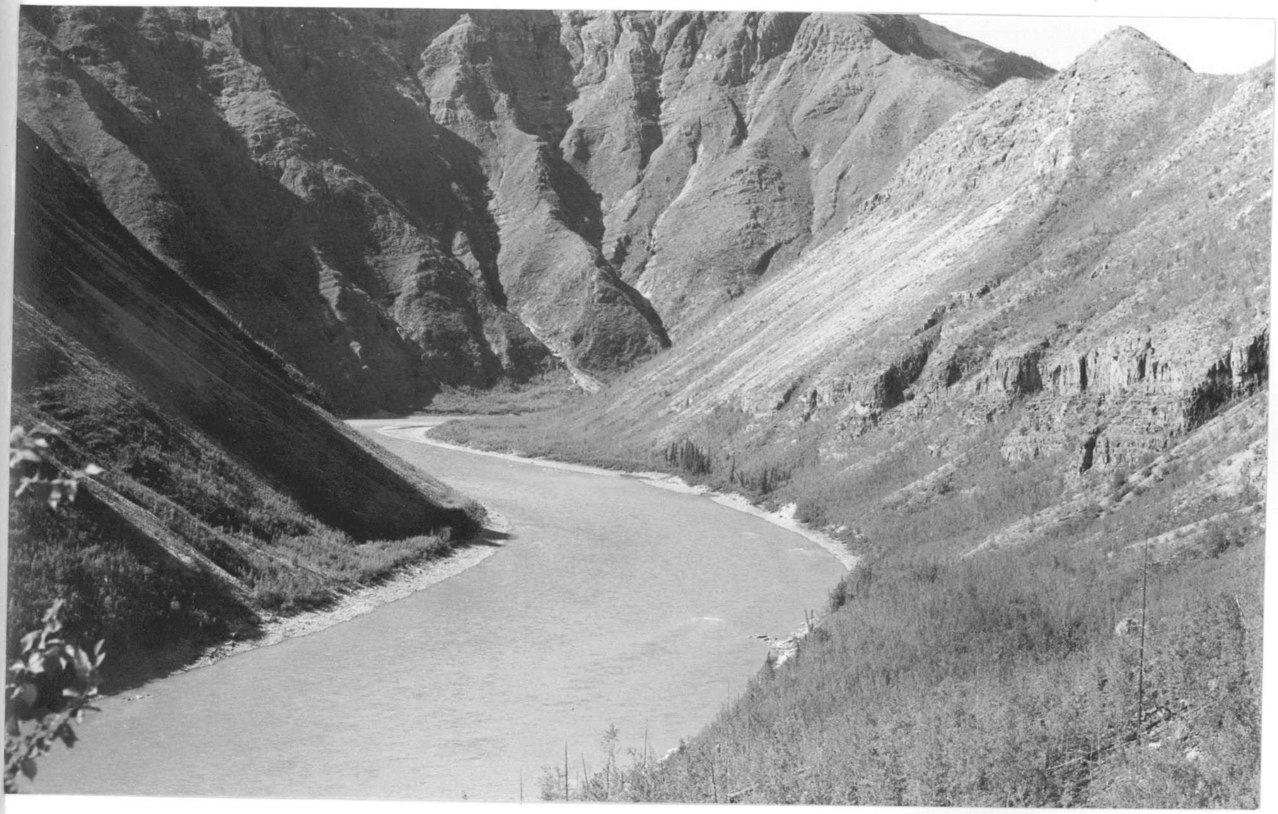
A search of church and Hudson's Bay Company records, coupled with interviews by professional anthroplogists will reveal a fascinating history covering the period since the late 1700's. There is a paucity of data available for the period before white traders first appeared on the scene, and little can be done to rectify this in the near future due to the pressing demands on museum archaeologists in more settled parts of Canada.

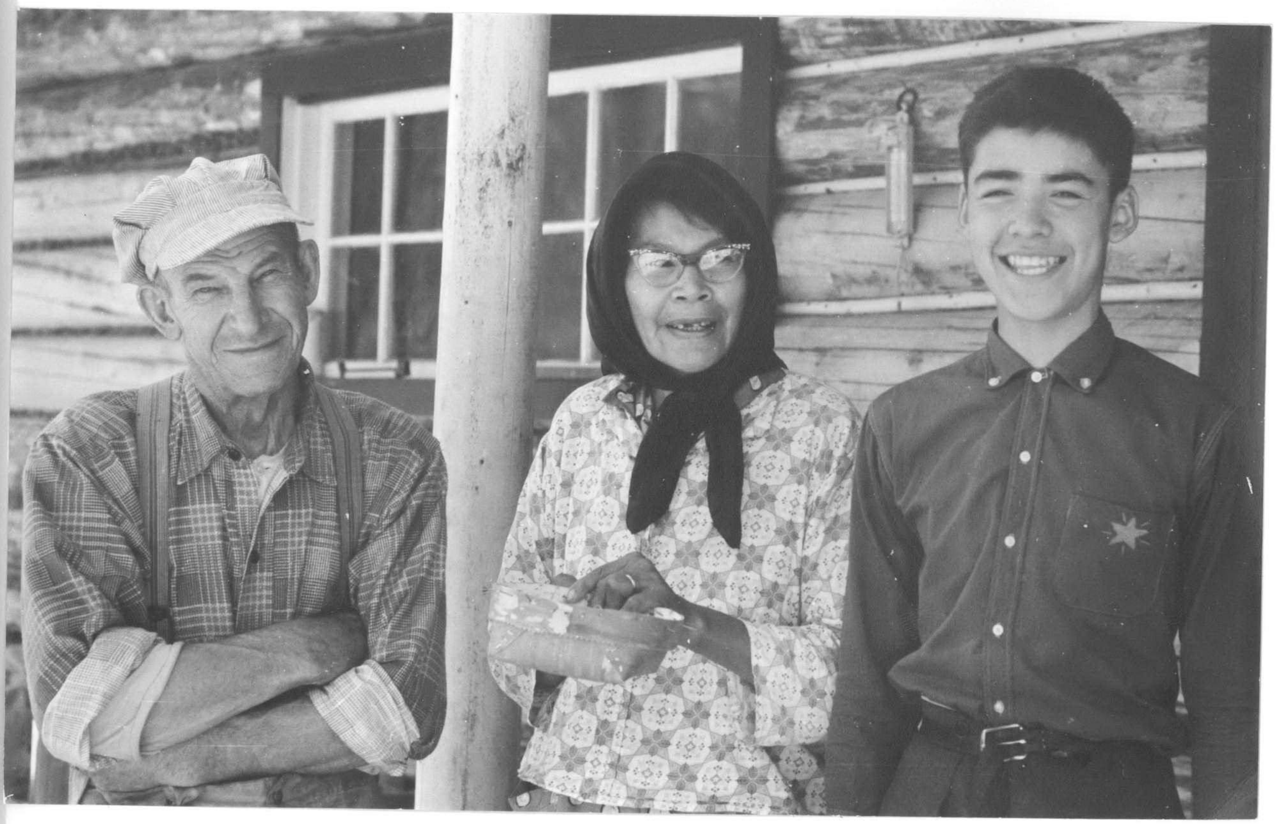
Fig. 47. Forest stand of fire origin.

The view is toward the southwest up the South Nahanni River from the mouth of Second Canyon. The area was burned during the extensive fires of 1948. (Photo: W. D. Addison, 24 July, 1966.)

Fig. 48. The Kraus family.

Left to right: Gus, Mary, and Mickey Kraus at their Hotsprings cabin. (Photo: W. D. Addison, 2 August, 1966.)





RECOMMENDATIONS

1. The Yohin Lake, Sand Blowout, Tlogotsho Dall sheep range, mineral springs, and glacier lakes areas should be withdrawn from further mineral claim staking and commercial development activity. These areas should then be considered for inclusion in the National Parks system and the International Biological Programme.

2. Roads should be constructed no closer to the extended park boundaries than Nahanni Butte, and the end of the roads now in use at Tungsten and the Penarroya site.

3. Park headquarters and major tourist facilities such as lodges and stores should be located at Nahanni Butte.

4. Major campsite facilities such as log cabins, interpretive displays, and emergency radio equipment should be established at the Kraus's old residence at the Hotsprings, at the Deadmen Valley cabin site, the site of Sibbeston's cabin on the Flat River, the proposed Game Management Division cabin site at the mouth of the Caribou River, at Seaplane Lake, above Virginia Falls at the Water Survey cabin site, and at Rabbitkettle Lake. These sites should be carefully screened from the view of river travellers.

5. Minor campsites having only well concealed fireplaces, tent clearings, and trash barrels should be placed at the mouth of Mattson Creek, near Yohin Lake, at Big Bend, at The Gate, near Marengo Falls, near Wild Mint Springs, near Mineral Lake, at Hole-in-the-Wall Lake, and at Glacier Lake.

6. The use of non-powered boats on the rivers should be encouraged over the use of motor powered craft. The use of powered boats should be confined to concessionaires and park employees, and the number of power boats on the rivers at any one time should be minimal.

7. The use of aircraft within the park should be carefully controlled so that they will not detract from the wilderness quality of the area. Landing sites within the park should be restricted to only a few locations around the periphery.

8. Backpacking should be encouraged by the establishment of hiking trails. Existing trails, especially ones of historical value, should be restored.

9. Flood- and fire-control programs should not be part of plans for this park.

10. An inventory of plants and plant communities and of vertebrate and invertebrate species in the park should be started as soon as practical.

11. Studies of the life histories of mammals and fish living within proposed park boundaries should be instituted at every opportunity. The results of studies of seasonal mammal ranges should form the basis for alteration of park boundaries if this is deemed necessary to preserve critical winter habitat.

12. Interviews by professional ethnologists of people who have travelled in the park area in the late 1800's or early 1900's should be instituted immediately.

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