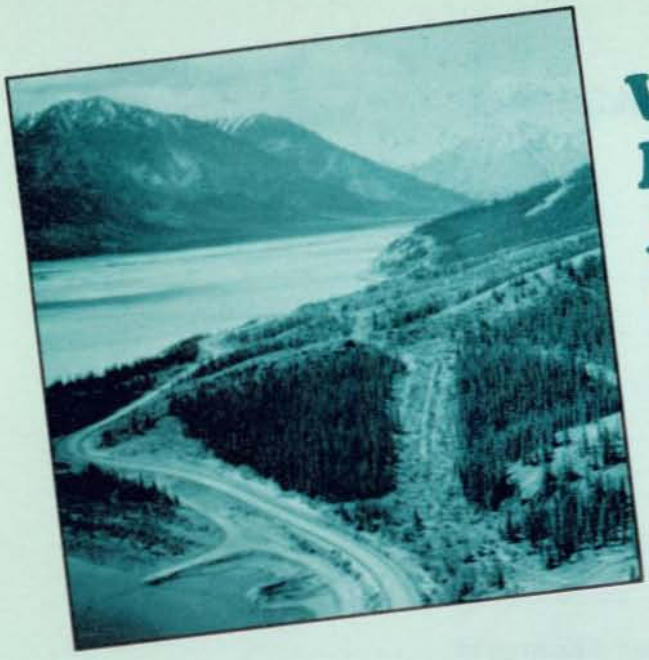
ISSN-0705-3274



Vegetation Types and Environmental Factors Associated With Foothills Gas Pipeline Route, Yukon Territory

(Maps and Legend)

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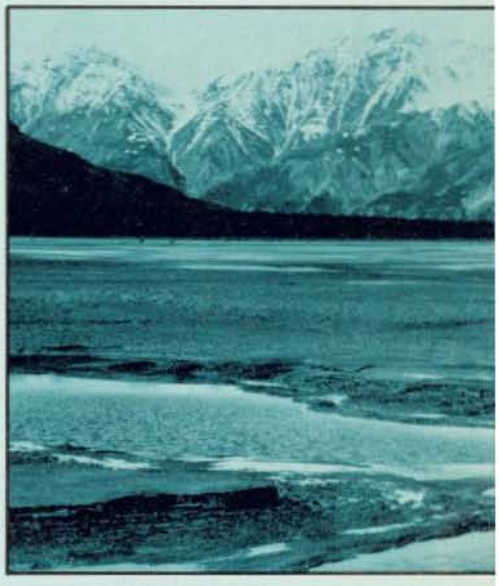

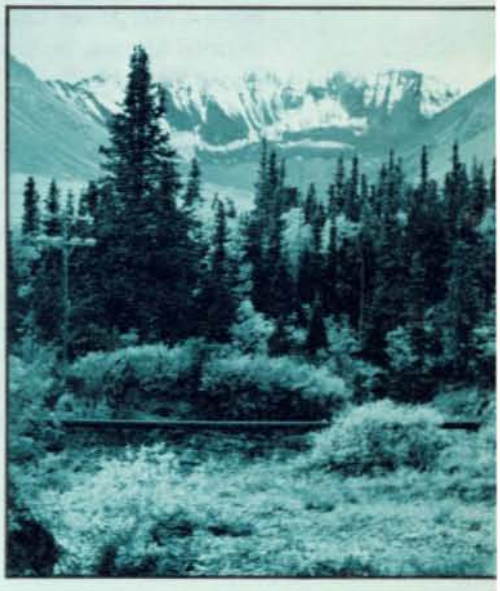

Victoria, B.C., BC-X-205, December, 1980

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Acknowledgments

It is a privilege to acknowledge the assistance of Dr. L. Orloci and his group with planning and execution of the vegetation survey. Assistance in producing the maps was provided by Vaartnou & Sons Enterprises Ltd., and Miss Dawn State. At various stages, reviews were undertaken by Professor M.A.M. Bell, Drs. G.W. Douglas, S. Eis, E.T. Oswald and J.P. Senyk; their valuable suggestions are much appreciated.

Dr. Rudy Klassen, Canada Geological Survey, Calgary, provided surficial geology maps; Dr. Owen Hughes, Canada Department of Energy, Mines and Resources, Calgary, helped with equipment and shared his expertise. Messres. Mike Romaine, C.E. Brown, Canada Department of the Environment, Messres. Edo Nyland and Don Schuler, Yukon Forestry Service, and R.A. Owens, L.W. Bouckhout and Court Fouks, Foothills Pipe Lines (Yukon) Ltd., contributed in various ways to facilitate completion of this report. To them and to many others who remain unnamed are extended thanks.

Thanks are owed also to Miss Dawn State and Miss Kathleen Alexander for technical assistance, and to Dr. E.T. Oswald and Mr. A. MacEwan and K. Friesen, PFRC, for reviewing the manuscript.

The Federal Department of the Environment and Foothills Pipe Lines (Yukon) Ltd., Calgary, Alberta, funded the project. Foothills made available black and white photo mosaic, aerial photographs, base maps and pertinent reports. The excellent cooperation of all is very much appreciated.

● Only limited number of maps available.

Summary

The Report and the complementary Maps of Vegetation Types are the result of a survey in 1978, along the Alaska Highway, Yukon Territory, from the B.C. border near Watson Lake to Beaver Creek, near the Alaska border. Cover/abundance values were estimated for 335 species in 323 plots. From the same locations, information was obtained on associated environmental factors; namely, occurrence of permafrost in September, generic soil type, soil texture, thickness of the L - H or O layers, exposure, slope, erosion potential, drainage class, buoyancy, sensitivity of site to disturbance by construction and ranges of pH values. The results clearly indicate a close relationship of vegetation composition to environmental conditions.

The 28 maps (1:50000) show the distribution of vegetation types and/or phases in an 818 km long, 6 km wide belt centered on the Foothills Pipelines (Yukon) Ltd., gas pipeline as proposed in October, 1978. The report contains the descriptions of 25 vegetation types within which a total of 68 phases are identified.

The contents of this report are being offered for predictive use in the applications where site sensitivity or other ecological conditions have to be assessed, and as a framework for a more complete ecological inventory.

Résumé

Le rapport et les cartes complémentaires des types de végétation sont le résultat d'un relevé effectué en 1978 le long de la route de l'Alaska, du Territoire du Yukon, à partir de la frontière de la Colombie-Britannique, près du lac Watson, jusqu'au ruisseau Beaver, près de la frontière de l'Alaska. Les valeurs couverture/abondance furent évaluées chez 335 espèces en 323 placettes. A partir des mêmes endroits, on a obtenu des renseignements touchant les facteurs environnementaux qui s'y rattachent; mentionnons la présence du pergélisol en septembre, le type générique du sol, sa texture, les horizons L, H ou O, l'exposition, la pente, l'érosion potentielle, la catégorie de drainage, la flottabilité, la vulnérabilité de la station aux dégradations dues à la construction et les gammes des valeurs pH. Les résultats indiquent nettement un rapport serré de la composition végétale aux conditions de l'environnement.

Les 28 cartes (échelle 1:50000) montrent l'aire de dispersion des types de végétation et/ou leurs phases dans une large ceinture de 818 km de longueur sur 6 km de largeur, centrée sur le pipeline de la Foothills Pipelines (Yukon) Ltd., proposée en octobre 1978. Le rapport contient les descriptions de 25 types de végétation à l'intérieur de 68 phases identifiées.

Les éléments de ce rapport sont offerts pour aider les utilisations prévues en des applications où la vulnérabilité du sol ou d'autres conditions écologiques doivent être évaluées, et comme structure de base pour un relevé écologique plus complet.

Cover: Example of landscapes that might be traversed by the proposed gas pipeline in the southern Yukon.

1. Transportation corridor (Alaska Highway, WW II pipeline and public utilities) along the western shores of Kluane Lake.
2. White spruce forest in the valley of the Shakwak Trench.
3. Talus above the Alaska Highway in the Rancheria River Valley.
4. Slims River Delta at the southern end of Kluane Lake. In the background Kluane Ranges.
5. Picturesque lake near Jakes Corner.
6. Rancheria River Valley. Visible are remnants of forest fire a decade ago.
7. Mountain forest near Bear Creek. In foreground, torrent exposed WW II pipeline. In background, ramparts of Mt. Archibald.

Introduction

Literature reviews (Douglas 1974; Vaartnou in Foothills 1976a; Oswald and Senyk 1977; Orloci and Stanek 1980) reveal the lack of vegetation and environmental data applicable to and suitable for environmental impact assessment of projects such as the gas pipeline through the southern Yukon proposed by Foothills Gas Pipe Lines (Yukon) Ltd. There are publications dealing with vegetation mapping in the areas of concern (Douglas 1974a, 1977, 1979) but only a small part of the mapped area coincides with that of the pipeline corridor.

Day's (1962) reconnaissance soil survey along the Takhini and Dezadeash Valleys (from approximately Whitehorse to east of Haines Junction) provides some information on vegetation associated with certain soils.

To fill the obvious need for baseline data, in 1978, an accelerated survey of vegetation and selected environmental factors during the Alaska Highway was undertaken.

The specific objectives include, but are not necessarily limited to:

- description of plant communities occurring in the region surveyed.
- production of a map or maps showing the distribution of described plant communities in a 6 km wide corridor centered on the proposed pipeline route.
- description of the relationship between plant communities and soil type, presence of ice rich soils, presence of soils susceptible to rapid erosion and/or the presence of soils particularly difficult to revegetate.

The survey must be looked upon as preliminary, directed at exposing certain basic patterns in vegetation composition and environmental variation in the surveyed area. Some of the many details have yet to be revealed, based on further sampling and data analyses.

Methods

The survey took place during the 1978 growing season and was restricted to a narrow, about 900 km long belt centered on the Alaska Highway from the Alaska border to west of Watson Lake.

The sampling design utilizes nested stratification (SCADA Associates 1978); ecoregions (Oswald and Senyk 1977) and terrain types (Foothills 1976) are the strata; the plots are randomly located on both sides of the highway in preferably undisturbed stands.

The vegetation data for 355 species in 323 plots are cover/abundance (C/A) values based on the Braun-Blanquet method. Details of the survey method and statistical evaluation, using cluster analysis and multivariate analysis, are contained in Orloci and Stanek (1980). The estimation is based on the Braun-Blanquet method. The cover/abundance (C/A) scores are in the form of alpha/numeric symbols. Transformation to a purely numerical code, necessary for computer processing, are based on van der Maarel's scale (Westhoff and van der Maarel 1978):

C/A scores*	.r+i2345
Code	0123578 9

*.	- species missing
r	- up to a few individuals
+	- species occasional
i	- species abundant, low cover (up to 5%)
2	- species very abundant, low cover (up to 25%)
3,4,5	- high cover (up to 50%, 75%, 100%, respectively)

"Cluster analysis' supplies the information for type recognition.

The objects on which the clustering is performed are the transformed C/A scores of the vegetation within the plots. The clustering algorithm uses the sums of squares as the fusion criterion (Orloci 1978).

A "vegetation type" is coherent as a group and is characterized by the presence of constant species (the group elements are releves; a 'releve' is a record of the vegetation within a plot). A group is said to be coherent if it can be represented by a single stem in a given dendrogram. Dendrograms map the fusion pattern through which the releves in the sample are aggregated into increasingly larger groups in cluster analysis. A species is considered constant in the type if it is present in at least 80% of the plots in the sample.

Types are described by characteristic combination of species present in at least 50% of the plots assigned to each type. "Phases" and "Subphases" are recognized within the types and represent coherent groups characterized by locally frequent species. Complete lists of species are kept at the Pacific Forest Research Centre in Victoria.

Depending on the level at which the types are recognized, lower or higher, "classification efficiency" may be achieved. Classification efficiency is measured as the ratio,

$$CE = SSB/SST \quad \text{or} \quad CE\% = 100 \times CE.$$

SSE signifies the between groups sum of squares. SST is a measure of the total sum of squares.

The "fidelity" of a species in a type is measured as a function of relative frequencies,

$$FV = PW \times (1 - PO) \quad \text{or} \quad FV\% = 100 \times FV$$

PW is the relative frequency of a given species within a given type. PO signifies the relative frequency of the same species outside the type. Relative frequencies are determined according to

$PW = FW/NW$ or $PW\% = 100 \times PW$ and $PO = FO/NO$ or $PO\% = 100 \times PO$.

The following definitions apply; FW - the number of plots occupied by a given species within the type, NW - the number of all plots within the type, FO - the number of occupied plots outside the type and NO - the number of all plots outside the type.

The "specificity" of a species to a type is measured by

$$SV = FV/PW = 1 - PO \quad \text{or} \quad SV\% = 100 \times SV$$

for $PW > 0$.

The mean (M) of C/A and the standard deviation (SD) describe the "performance" of the species in the types.

Nomenclature of vascular species is primarily according to Hulten (1968) and Welsh (1974), that of non-vascular species is primarily according to Crum et al. (1973), and Hale and Culberson (1970).

The survey for environmental factors was conducted at the time of the vegetation survey. Thickness of the active layer was measured, soil texture permitting, to a depth of 1 metre. Where applicable, the information is based on five random records per plot. In this report, permafrost is termed frozen ground persisting into late September which could not be penetrated by hand drilling to a depth of 10 cm.

Soil types are defined according to Canada Soil Survey (1978) and were determined on existing or dug horizon exposures and soil auger drillings.

Texture is determined on soil material from exposed representative exposures up to several metres thick, using sieves and standard aggregate analysis of particles smaller than 0.05 mm, the intent being to assess the overall conditions important for pipeline construction. Texture classes are defined by diameter in mm as follows: gravel and stones > 2; sand .05-2; silt .002-.05; clay < .002.

Soil pH is determined on a 1:1 slurry of .01 M $CaCl_2$ solution and soil fine fractions from a composite of five random subsamples per plot, each core taken to a depth from 25-50 cm, soil texture and permafrost permitting.

Slope is measured in degrees; level 0-½; gentle 1-5; moderate 6-24; strong 24-35; steep 35.

Six drainage classes are recognized, based on subjective estimtes in early summer and fall; excessive, excessive to moderate, moderate, moderate to impeded, impeded, impeded to wet, and wet.

Erosion potential and sensitivity ratings of soils (Table 1) are adapted from Foothills (1978) and Klohn Leonoff Consultants 1977a. Erosion potential is rated as being nil, low, medium or high; low is applied to areas of level terrain and gentle slopes; medium, where there are gentle and moderate slopes of fine-grained soils, gentle slopes of ice-rich soils, moderate to steep slopes of relatively stable soil, slopes of ravines and gullies, etc.; high, where there are fine-grained or ice-rich soils on moderate to steep slopes or in stream beds.

The sensitivity ratings in Table 1 account for the potential behaviour of each soil type in relation to a range of engineering concerns; the lowest sensitivity rating is 1 in bedrock and the highest is 6

Table 1. Soil Sensitivity Ratings of soil types with regard to sensitivity to disturbance by pipeline construction.

Rating	Soil Type	Comments on Properties and/or behavior
1	Bedrock	ice lensing very infrequent and generally freeze/thaw stable.
2	Sand, or sand and gravel with a minimum of finer particles	ice lensing very infrequent, very little frost heave, thaw stable, highly resistant to erosion, slide stable.
	Till (well graded)	ice lensing infrequent, may frost heave, generally thaw stable, highly resistant to erosion, no problems with seismic susceptibility, generally slide stable.
3	Sand or sand and gravel with silt or silt and clay	ice wedges occasional, ice layers infrequent, may frost heave, occasional strength loss, settlement owing to thaw, moderate to high resistance to erosion, generally no problems with seismic susceptibility, occasional slides.
4	Clay	occasional ice wedges and layers occur, probable frost heaving, occasional thaw settlement, high resistance to erosion, generally little problem with seismic susceptibility, occasional slides.
5	Silt	occasional ice wedge and layers, probable frost heaving, occasional strength loss and settlement owing to thaw, low resistance to erosion, moderate susceptibility to seismicity, occasional flow slides.
6	Peat or highly organic soils	occasional massive ice lensing, probable frost heaving, considerable strength loss and some settlement upon thawing, in flat terrain generally high resistance to erosion and no slides.

in organic soils and peat.

The tree measurements consist of age borings at ground level, diameter at breast height (DBH) and total tree height; however, they are based on insufficient replicates within each plot.

The vegetation units were interpreted and mapped from black and white air photo stereo-pairs (scale 1:24,000), and true color aerial photos (scale 1:46,000).

Results

Description of the Ecoregions

Appendix A contains a brief environmental characterization of each of the five surveyed Ecoregions (Fig. 1); namely, Wellesley Lake - 9 (Alaska border to White River), Ruby Range - 8 (White R. to Takhini R.), Lake Laberge - 5 (Takhini R. to Helen Lake KP 630), Pelly Mountains - 4 (Helen Lake KP 630 to Swift R. KP 700), Liard R. - 2 (Swift R. KP 700 to Yukon-B.C. border). Because of its small representation, Ecoregion 10 has not been separated.

Descriptions of Vegetation Types and Phases by Ecoregion

Appendix B contains the surveyed vegetation types (numbered and coded) with information on the sample size, characteristic combinations of species, the mean of C/A values (M), and the standard deviation (SD), the relative frequency of a given species within a given type (PW), the fidelity of a species in a type (FV), specificity of a species to a type (SV), identified phases and subphases, and the estimated environmental factors.

The vegetation and environmental data constitute a complement to the vegetation type maps. The vegetation units are derived by a fully automated clustering procedure outside of conventional terminology of synsystematics (Barkman et al. 1976). In the classification hierarchy of Krajina (1965), the Biogeoclimatic Region is the major kind of community with Zones and Subzones; however, the vegetation zonations in the Yukon are yet undefined. In context, reported vegetation units could be looked upon as subordinate divisions of any future Subzones.

Vegetation Type Maps

The appended 28 Vegetation Type Maps (scale 1:50000) cover five Ecoregions.

The maps show the boundaries of vegetation types and/or phases (the term phase is provisional) in a 6 km wide belt centered on the 818 km long pipeline route as proposed in October 1978; the number, name and code of each vegetation type appearing on the individual map sheets are the same as those in "Descriptions of Vegetation types and Phases by Ecoregion" in Appendix B.

Because of the frequently scattered occurrence of the phases within a vegetation type, the limitations of the mapping scale (1 cm^2 = 250 ha) and lack of ground truthing (gathering of information for air photo interpretation), few of the 68 phases and none of the subphases are mapped.

Discussion

At the time of the survey, in 1978, the planning of the pipeline route had not been completed, and most of the area tentatively identified as possible locations, within limits, were virtually inaccessible. Instead, the Alaska Highway was used as a reference base for sampling of vegetation and environmental factors; its right-of-way is located in terrain favored by the engineering design and, for obvious reasons, avoids crossing of wetlands. Thus, the sample locations are prestratified to a degree, ultimately providing information specific to the immediate highway vicinity, whereas the mapping of the vegetation types of the pipeline route as proposed by the Proponent in October, 1978, relied on photo interpretation and extrapolation of the survey results.

The sampling design (Orloci and Stanek 1980) relied on terrain types shown on an uncontrolled photomosaic. This was the cartographic information available, showing useful detail over the whole length of the survey area. The resulting difficulties were associated with transfer of sampling points from map to field and measuring distances, further complicated by drifting or missing km markers along the highway. The decision to use 323 sample plots was affected by recognized monetary restrictions and time constraints; a sample of this size was deemed sufficiently large to capture the entire range of compositional variation in the survey area, notwithstanding that some species, types or lesser environmental gradients in the area may have been

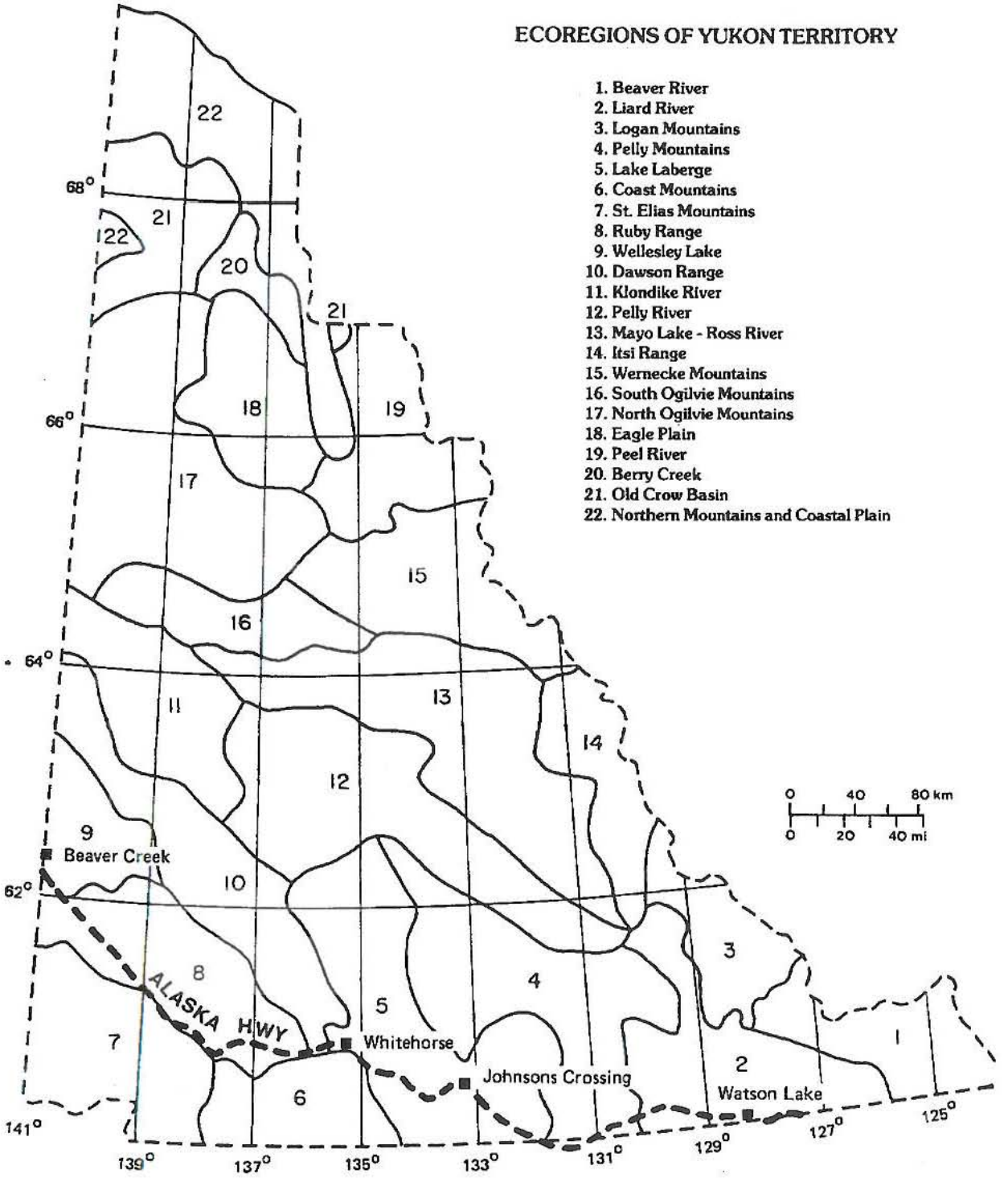

Figure 1. Ecoregions of Yukon Territory after Oswald and Senyk 1977.
Dashed line indicates position of the Alaska Highway.

Fig. 2. "Salt crust basin" in the Haines Junction area, Ecoregion 8. The vegetation in the immediate vicinity of the basin contains halophytes; the surrounding white spruce and poplar stands belong mainly to Vegetation Type 9 and its Variants.

left undetected.

Twenty-five types and a total of 68 phases have been described or identified. All types are well defined and differ significantly in species composition and distribution of specific subsets of the sampled environmental factors. The phases are more homogeneous than the types, but are far too numerous to have the same practical utility.

The reviewers of this report raised a few points which should be mentioned here; Betula glandulosa is the most common shrub birch in the Yukon, yet reference is only made to Betula glandulifera; Abietinella abietina is synonymous with Thuidium abietinum; Aulacomnium palustre occurs in many plant groups, yet Aulacomnium turgidum is perhaps more common but not mentioned; Salix scouleriana does not appear in the vegetation survey, although it is common along the surveyed corridor; Carex rostrata is not listed in the survey results, although it occurs in many wet sedge stands in the southern Yukon; several rare species are not mentioned. These specifics were not followed-up by the authors, mainly because of the additional field work required to clarify the issues. However, the above note should serve to draw the reader's attention to passages of this report which could be in question.

One should also mention the occurrence, particularly in Ecoregion 8, of saline sites, the soils of which exhibit a distinct salt crust formation, and of soils in steep southern, well drained exposures, the profile of which could be best described as chernozemic in character. The harmonization of these soils with the soil classification system used here was not attempted, because it would lead beyond the scope of this report.

The survey area traverses five ecoregions. These major landscape units and results (Orloci and Stanek 1980) incidate a reasonably sharp and

significant group structure which these impose on the vegetation types. Therefore, one can assume that the compositional gradients among the ecoregions, primarily the edaphic and climatic influences, justify the treatment of the ecoregions as separate entities. Beyond this fact, these units may also be viewed as segments of a continuum. The ordering of the ecoregions in this continuum is strictly and coincidentally geographical.

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Fig. 3. Landscape near Koidern, Ecoregion 8, traversed by World War II pipeline right-of-way. Re-invasion by trees and shrubs was prevented by herbicide spraying favoring monocotyledons.

Appendix A

Environmental Characterization of Ecoregions

Ecoregion 9 - Wellesley Lake

The generally low lying terrain, at altitudes of about 600 m, is characterized by a cold continental climate and widespread permafrost. Both winter and summer precipitation exceed those recorded in the other parts of the survey area. Moraines, tills, glaciofluvial and glaciolacustrine deposits are common.

Cryosols (soils with permafrost) occur with the highest frequency. Brunisols, less common, are confined to the warm sites. Regosols are the least frequent in the sample. The gravel/stone content in the soil tends to be low in contrast to the silt/clay content. The organic content in the upper soil horizon (Ah layer) rarely exceeds 5%, and the organic horizon (O or L, F and H layers) is rarely deeper than 2 cm . Generally, in June, the frozen ground is located close to the soil surface, but is much deeper in September. The permafrost tends to be ice-rich. The modal slope angle is near zero, and soil drainage tends to be impeded. Erosion potential is medium in most parts, though, owing to permafrost, site sensitivity tends to be high.

The zonal vegetation is mainly a taiga type. Picea mariana is the most widespread tree. It is an indicator of premafrost.

On the warm sites, the vegetation is boreal in character and Picea glauca forms primary stands. Populus balsamifera is a frequent companion. Other prevalent species include Viburnum edule, Rosa acicularis, Mertensia paniculata and Drepanocladus uncinatus. Whereas Picea mariana is almost always stunted, Picea glauca may attain a height growth in excess of 20 m at maturity on the most productive sites. Salix alaxensis and Carex aquatilis characterize some wetlands. These have, just as the Picea glauca stands, low representation in the sample.

Ecoregion 8 - Ruby Range

This is by far the most heterogenous of the ecoregions in the survey area and it has the longest intercept with the Alaska Highway. Moderate altitudes (about 800 m), foothill conditions and a severe rainshadow effect are characteristic. The climate is harsh, continental and substantially drier than in Ecoregion 9. Intrusive and metamorphic rocks are widespread, sometimes exposed, but most often covered under deep mantles of morainal, glaciofluvial, or lacustrine deposits. Colluvial and alluvial deposits affect local areas.

Brunisols and Cryosols are the two most frequent soil types. Regosols and Gleysols are less frequent. In contrast on Ecoregion 9, the soils tend to be coarser and better drained, organic matter content appears to be lower and the organic horizons tend to be less deep. The incidence of soils without a frozen horizon in June or September increases drastically. Southerly exposures are more frequent and level terrain is less frequent. The sites tend to be less sensitive.

Widespread occurrence of communities dominated by Picea glauca are characteristic. The forest canopy tends to be open and productivity is generally low. Picea mariana occurs in a mixture with other species on wet sites. Arctostaphylos rubra and Aulacomnium palustre are constant companions. On moist and mesic sites Abietinella abietina, Carex concinna and Drepanocladus uncinatus, individually or jointly, characterize the ground cover. Shepherdia canadensis, Arctostaphylos uva-ursi and Festuca altaica are principal elements in the community on well-drained sites.

Salix arbuscula and other species of Salix form secondary stands after fire. Salix glauca and S. myrtillifolia, with companions such as Aulacomnium palustre and Carex aquatilis, characterize an early successional stage on wetlands. On gravel fields of floodplains, Dryas drumondii is an early colonizer, and on the warm terrace slopes, rock outcrops and on some colluvial slopes, Agropyron yukonense (could be Agropyron boreale var. alaskanum or A. alaskanum) and Calamagrostis purpurascens are components in a community mosaic. Populus tremuloides and Populus balsamifera are common on the warm sites and after fire. Pinus contorta is rare, mainly

confined to the eastern fringes of the region.

Ecoregion 5 - Lake Laberge

About 30% of the survey area lies with Ecoregion 5. The landscape is characterized by dissected plateaus, rolling hills, generally low altitudes (700 m), rainshadow effect and harsh winter temperatures. Large areas of terrain are overlain by morainal, glaciofluvial and glaciolacustrine deposits. Fine-textured sands are common. Alluvial deposits occur locally.

Brunisols are the most prevalent soil type, and Regosols are the second most frequent. Cryosols, Gleysols and Organic soils occur with low frequency. The soils tend to be coarser than in Ecoregion 8. The silt or clay content is low. The frozen soil horizon tends to be situated deeper than in Ecoregion 8. Most soil profiles have no premafrost within the sampling depth. The slopes tend to be moderately steep. The erosion potential is medium to low and the sites are less sensitive than in Ecoregion 8.

Primary stands are dominated by Picea glauca, which is considered the climatic climax tree. Pinus contorta invades the well-drained sites following fires. Secondary stands are often formed by Populus tremuloides on warm sites and on finer textured soils. On the steep, south-facing slopes of river terraces, grasslands occur in a mosaic with stands of dwarfed Populus tremuloides. Picea mariana is characteristic of some wetlands, but these have low representation.

Ecoregion 4 - Pelly Mountains

About 10% of the survey area lies within Ecoregion 4. Whereas the relief is dominated by the Cassiar Mountains and the Dease Plateau, the altitudes covered by sampling are generally below 900 m. Intrusive, volcanic and metamorphosed sedimentary rocks underlie the terrain in the mountains. The plateau is built of mainly sedimentary rocks. Deep deposits of morainal and other glacial origin cover much of the surface. Alluvial and colluvial materials affect local areas.

The mean annual precipitation is estimated to lie between 375 and 625 mm. This is higher than in Ecoregions 8 and 5. The mean annual temperature is believed to be between -4° and -6°C at low altitudes.

The trend, established in the sample of the preceding Ecoregions 9, 8 and 5 in shifting frequency distributions, has been reversed on several variables. Soil texture, for example, is now finer, and the organic horizon depth greater. The depth to frozen ground in June is smaller and the slope tends to be steeper. Soil drainage is more impeded and the erosion potential is increased. The site sensitivity has also increased.

Whereas much of the Ecoregion 4 lies at high altitudes, the sample has covered mainly the low altitudes, where Picea glauca is the dominant tree. Typical companions which are abundant or have high cover include Hylocomium splendens, Vaccinium vitis-idaea and Pleurozium schreberi in moist and mesic sites, or Salix planifolia and Aulacomnium palustre on wet sites. Extensive secondary stands of Pinus contorta occupy the coarse, well-drained soils, and Populus tremuloides occur in warm site on finer soils. Picea mariana is confined to wetlands. Abies lasiocarpa occurs sporadically, as do Populus balsamifera and Betula papyrifera.

Ecoregion 2 - Liard River

About 10% of the survey area lies within this ecoregion. It includes the Liard Plain and Dease Plateau at elevations of about 750 m. The bedrock is mainly sedimentary or metamorphic. Deep deposits of glacial origin cover the terrain. Locally, rock outcroppings occur, and some areas are affected by alluvial deposits. The climate is cold, continental, and more precipitation is received than in Ecoregion 4.

In comparison with Ecoregion 4, the soil texture tends to be finer, the organic matter content higher, and the organic horizon depth deeper. Exposures are more frequently northerly, and slopes are generally not as steep. The erosion potential is lower, and the soils are better drained. There is no substantial change in the distribution of site sensitivity. The Brunisolic soils continue to be the most widespread type.

The zonal vegetation is boreal in character. Picea glauca is dominant in primary and old secondary stands. Pinus contorta colonizes the coarse soils in sites affected by fire. Populus tremuloides forms secondary stands of finer soils in warm sites. Populus balsamifera occurs in floodplains. Picea mariana and Larix laricina are characteristic in some wetlands and the Salix shrub types in others. Betula papyrifera occurs sporadically in the different sites.

Fig. 4. Landscape in the Beaver Creek area, Ecoregion 9. The valley is occupied by black spruce stands, Vegetation Type 4, similar in appearance to those of water-logged treed bogs; however, here the organic soil layer (peat) is frequently less than 45 cm deep; permafrost is always present; the active layer fluctuates between 30 to 60 cm. The taller growing white and black spruces are components of Vegetation Type 1. The generally southern exposures of the slopes support mixed stands of white spruce and poplars, Vegetation Type 2, and its Variants, which apparently favor warmer sites where permafrost does not occur or is at greater depth than 1 m.

Appendix B

Vegetation Types, Phases and Subphases Surveyed in 1978

Type 1: Picea mariana-Ledum groenlandicum-Hylocomium splendens (PLH)
Sample size: 74 species: 11 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Picea mariana	3.2	0.2	100	21	21
Hylocomium spendens	5.7	0.6	100	16	16
Ledum groenlandicum	3.3	0.5	91	72	79
Vaccinium vitis-idaea	2.9	0.4	91	29	32
Mertensia paniculata	1.6	0.3	82	60	73
Salix glauca	1.5	0.3	73	8	11
Empetrum nigrum	1.7	0.5	64	23	36
Vaccinium uliginosum	1.4	0.4	64	17	27
Calamagrostis canadensis	1.1	0.3	54	26	48
Equisetum scirpoides	1.3	0.4	54	11	20
Picea glauca	1.4	0.5	54	40	74
Abietinella abietina	2.0	0.6	54	40	74
Peltigera aphthosa	1.4	0.4	54	32	59

Phases: (i) Empetrum nigrum (PLHe) (5 plots)
(ii) Festuca altaica-Abietinella abietina-Rhytidium rugosum (PLHa) (5 plots)
(iii) Carex vaginata (PLHc) (1 plot)

Type 1 Dominant *Picea mariana* tree height is approximately 14 m at 100 years of age and average *DBH* ca. 13 cm.

Environmental Factors

Permafrost	frequent, generally at depth 25-60 cm
Soil type	in permafrost areas Static Cryosols generally gleyed, and Organic Cryosols; otherwise Dystric Brunisols frequently gleyed, Terric Mesic Humisols and Fibrisols.
Soil texture	generally fine grained (silt/clay); boulders/gravel/sand below talus slopes or on recent floodplains
	LFH horizon (L = litter, F = decomposing organic matter, H = humic substances) and/or O horizone (O = organic soil, peat) 5-30 cm thick; peat generally shallow
Soil pH	4.9 - 6.4
Exposure	mostly SW
Slope	level to moderate
Erosion potential	low to high
Drainage	moderate to impeded
Sensitivity	5-6 on account of fine grained soils with permafrost

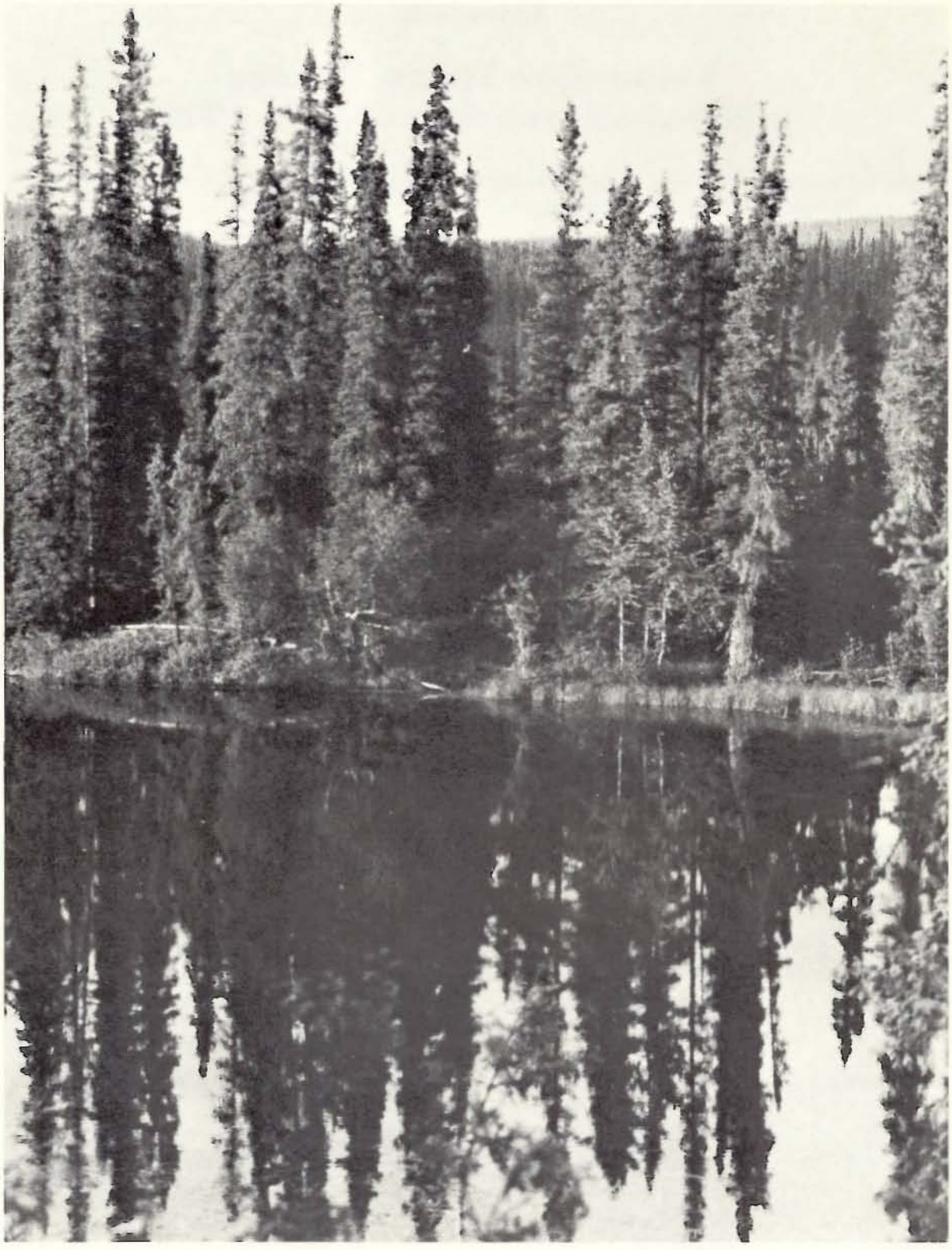

Fig. 5. In Ecoregion 9, the presence of water bodies affects the distribution of permafrost. Along the shore, permafrost is absent; this apparently affects the growth of trees (mainly white spruce, Vegetation Type 1). With distance from the lake, the permafrost table appears at between 30 to 60 cm depth, and the height growth of trees decreases.

Type 2: Picea glauca-Viburnum edule-Drepanocladus uncinatus (PVD)

Sample size: 18 species; 2 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Picea glauca	6.5	2.1	100	68	68
Viburnum edule	3.0	0.0	100	93	93
Rosa acicularis	2.5	0.7	100	78	78
Mertensia paniculata	2.0	0.0	100	57	57
Drepanocladus uncinatus	2.5	0.7	100	100	100

Phase: (i) Populus balsamifera-Alnus incana (PVDa) (1 plot)
(ii) Alnus crispa-Hylocomium splendens (PVDh) (1 plot)

Type 2 The height of sampled dominant *Picea glauca* is ca. 17 m at 100 years of age. The *DBH* is ca. 16 cm.

Environmental Factors

Permafrost	none found at 1 m.
Soil type	Eutric Brunisols; some gleying occurs
Soil texture	mainly gravel/sand
	LFH horizon 2-9 cm thick
Soil pH	6.9 - 7.0
Exposure	level or southern
Slope	level to moderate
Erosion potential	low to medium, generally low
Drainage	moderate to excessive
Sensitivity	2

Fig. 6. Revegetation of areas disturbed by highway construction in Ecoregion 9. The original vegetation surrounding the lake apparently consisted of white spruce (Vegetation Type 2). On the far shore, the natural replacement consisted of dominant willows (similar to Vegetation Type 3); the regrassed highway right-of-way is shown in the foreground.

Type 3: Salix alaxensis-Carex aquatilis (SC)

Sample size: 43 species: 2 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Salix alaxensis	3.0	0.0	100	93	93
Salix glauca	4.0	1.4	100	18	18
Salix myrtillifolia	2.0	0.0	100	71	71
Potentilla fruticosa	2.0	0.0	100	36	36
Calamagrostis canadensis	2.5	0.7	100	50	50
Carex aquatilis	2.5	0.7	100	93	93
Equisetum palustre	4.5	3.5	100	93	93

Phases: (i) Equisetum palustre (SCe) (1 plot)
(ii) Picea glauca-Aulacomnium sp. (SCp) (1 plot)

Type 3 Trees are rarely more than 3 m high at maturity. Their diameter seldom exceeds a few centimeters.

Environmental Factors

Permafrost	frequent, at depth of 60-70 cm.
Soil type	Gleyed Static Cryosols; and Organic Cryosols, generally Terric or Fibric
Soil texture	high silt or sand content
	LFH horizon up to 6 cm, occasionally deeper
Soil pH	6.5 - 7.6
Exposure	mainly SE
Slope	gentle to moderate
Erosion potential	moderate
Drainage	impeded to wet
Sensitivity	5 - 6

Type 4: Picea mariana-Ledum palustre-Eriophorum vaginatum - Aulacomnium palustre (PLEA)

Sample size: 94 species: 15 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Picea mariana	3.2	0.2	100	27	27
Salix glauca	2.4	0.1	100	33	33
Aulacomnium palustre	6.5	0.4	100	67	67
Hylocomium splendens	2.7	0.2	100	20	20
Ledum palustre	3.3	0.4	93	87	94
Equisetum scirpoides	2.3	0.2	93	50	54
Eriophorum vaginatum	2.9	0.3	93	68	73
Potentilla fruticosa	1.8	0.2	87	46	53
Vaccinium uliginosum	2.9	0.4	87	40	46
Rubus chamaemorus	1.7	0.2	80	64	80
Empetrum nigrum	1.9	0.3	80	43	54
Pedicularis labradorica	1.7	0.2	87	69	79
Vaccinium vitis-idaea	1.9	0.3	80	21	26
Sphagnum sp.	4.0	0.7	80	69	86
Betula glandulifera	2.0	0.4	73	64	88
Arctostaphylos rubra	1.9	0.4	67	40	60
Oxycoccus microcarpus	1.3	0.3	60	52	87
Calamagrostis canadensis	1.1	0.3	53	25	47

Phases: (i) Calamagrostis canadensis-Petasites sagittatus (PLEAp) (8 plots)
(ii) Rhododendron lapponicum (PLEAr) (3 plots)
(iii) Carex membranacea (PLEAc) (4 plots)

Fig. 7. The *Carex membranacea* Variant of Vegetation Type 4 on an outwash plain north of Beaver Creek, Ecoregion 9. The isolated clumps of trees are black spruces which propagated naturally by layering. Permafrost is always present, the active layer being relatively shallow (25 to 30 cm). Over vast areas, the distribution of tree clumps appears to follow a geometrical pattern (visible from aerial photographs). Lacking a better explanation, one could seek the cause in the thaw-freeze action associated with polygons.

Type 4 The height of observed mature trees rarely exceeds 6 m. *DBH* tends to be less than 10 cm.

Environmental Factors

Permafrost	in all soils at depth from 30 to 66 cm
Soil type	Organic or Static Cryosols, always gleyed or wet; organic soil usually Terric or Fibric
Soil texture	mainly silt with clay; sandy/gravelly soils also occur
	LFH or O horizon 13-45 cm, occasionally deeper
Soil pH	4.5 - 6.8
Exposure	North or level
Slope	level to gentle
Erosion potential	low to medium
Drainage	impeded to wet
Sensitivity	5-6

Fig. 8. Disturbed by highway construction, the edge of a white and black spruce stand (Vegetation Type 7) near Morley River, Ecoregion 8, is exposed to thawing of permafrost. This causes the "drunken" appearance of the trees and the invasion of the original ground cover by sedges and grasses.

Type 5: Picea glauca-Arctostaphylos rubra-Rhododendron lapponicum-Aulacomnium palustre (PRA)

Sample size: 112 species: 22 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Arctostaphylos rubra	2.9	0.1	100	65	65
Potentilla fruticosa	2.0	0.2	91	81	89
Vaccinium uliginosum	2.7	0.2	91	85	93
Aulacomnium palustre	4.5	0.5	86	75	87
Equisetum scirpoides	2.3	0.3	82	67	82
Picea glauca	2.3	0.3	82	17	21
Rhododendron lapponicum	2.0	0.3	77	77	100
Salix glauca	1.9	0.3	77	28	36
Hedysarum aplinum	1.5	0.2	77	51	66
Vaccinium vitis-idaea	1.6	0.3	68	57	84
Dryas integrifolia	1.5	0.3	64	51	95
Eriophorum vaginatum	1.5	0.3	64	62	97
Ledum groenlandicum	2.1	0.4	64	52	81
Picea mariana	2.0	0.4	64	60	94
Pedicularis labradorica	1.2	0.2	59	58	98
Hylocomium splendens	1.8	0.4	54	38	70
Carex concinna	1.1	0.2	50	31	62

Phases: (i) Picea mariana-Rhytidium rugosum (PARAr) (5 plots)
(ii) Picea mariana-Ledum palustre (PARAp) (6 plots)
(iii) Picea glauca-Carex dioica (PARAc) (4 plots)
(iv) Picea glauca-Lupinus arcticus (PRAl) (7 plots)

Type 5 The height of sampled dominant *Picea mariana* and *Picea glauca* at 100 years of age is ca. 14 m. The *DBH* is ca. 13 cm.

Environmental Factors

Permafrost	all in soils 25-100 cm and deeper
Soil type	Static and Organic Cryosols, frequently gleyed
Soil texture	high sand and silt content; gravel/stones in floodplain areas
	LFH or O horizon 8-45 cm and deeper
Soil pH	5.8 - 7.8
Exposure	varies
Slope	level to gentle
Erosion potential	medium
Drainage	moderate to wet
Sensitivity	5-6 owing to permafrost

Type 6: Salix glauca (S)

Sample size: 100 species: 11 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Salix glauca	4.3	0.5	100	37	37
Salix myrtillifolia	2.8	0.7	73	61	84
Aulacomnium palustre	3.6	1.1	64	49	77
Salix alaxensis	1.5	0.4	64	56	88
Arctostaphylos rubra	1.4	0.4	64	35	55
Carex aquatilis	2.1	0.7	64	60	94
Picea glauca	1.3	0.4	54	10	19

Phases: (i) Equisetum pratense (Se) (3 plots)
(ii) Salix myrtillifolia-Arctostaphylos rubra-Carex aquatilis-Aulacomnium paluste (Sa) (5 plots)
(iii) Salix myrtillifolia-Arctostaphylos rubra-Salix brachycarpa-Carex aquatilis (Sc) (3 plots)

Type 6 Dominant Picea glauca may attain a height of 7 m and a *DBH* of 5 cm.

Environmental Factors

Permafrost	occasionally found (30-95 cm deep)
Soil type	in permafrost areas Gleyed Static Cryosols, otherwise Gleyed Cumulic Regosols and Humic Gleysols
Soil texture	mainly sand/silt; gravel/stones/clay also present in lesser amounts
	LFH horizon 4-20 cm thick
Soil pH	5.7 - 7.7
Exposure	level or northern
Slope	level to gentle
Erosion potential	low to high
Drainage	impeded to wet
Sensitivity	2-5

Fig. 9. Open, treed bog-like stand of black and white spruces (Vegetation Type 5) on a former flood plain, Ecoregion 8. Permafrost is present; generally, the organic layer is shallower than 45 cm; the mineral soil consists of gravel and cobbles.

Type 7: Picea glauca-Arctostaphylos rubra-Abietinella abietina (PAA)

Sample size: 75 species: 19 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Abietinella abietina	4.6	0.4	100	80	80
Picea glauca	3.9	0.4	95	22	23
Arctostaphylos rubra	2.3	0.4	79	47	59
Hylocomium splendens	3.7	0.7	74	54	73
Ledum groenlandicum	2.7	0.5	68	56	82
Hypnum procerrimum	2.3	0.4	68	63	93
Salix glauca	1.3	0.2	63	21	33
Vaccinium vitis-idaea	1.7	0.3	63	51	81
Empetrum nigrum	1.4	0.3	58	52	90
Geocaulon lividum	1.1	0.2	58	48	83
Hedysarum alpinum	1.1	0.2	58	36	62
Mertensia paniculata	1.2	0.2	58	38	66

Phases: (i) Picea mariana-Ledum groenlandicum-Vaccinium uliginosum (PAAp) (5 plots)
(ii) Alnus crispa-Ledum groenlandicum-Viburnum edule (PAAv) (4 plots)
(iii) Type (PAAt) (6 plots)
(iv) Ledum groenlandicum-Carex concinna (PAAc) (4 plots)

Type 7 The height of sampled dominant *Picea glauca* is ca. 14 m at 100 years of age and *DBH* is ca. 13 cm.

Environmental Factors

Permafrost	frequent, generally at depth of 33-50 cm
Soil type	in permafrost areas Organic and Static Cryosols; otherwise Brunisols and occasional Regosols
	all soils frequently gleyed
Soil texture	mainly sand/silt with some gravel and clay
	LFH or O horizon 4-40 cm and deeper
Soil pH	5.7 - 7.7
Exposure	generally level to SW
Slope	level to moderate, occasionally steep
Erosion potential	medium, occasionally high
Drainage	moderate to impeded
Sensitivity	5-6 due to permafrost

Type 8: Picea glauca-Carex concinna (PC)

Sample size: 89 species: 22 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Picea glauca	5.2	0.4	100	25	25
Carex concinna	1.5	0.2	77	48	62
Drepanocladus uncinatus	1.9	0.3	68	52	76
Peltigera canina	1.4	0.3	59	36	60
Salix glauca	1.3	0.3	54	17	31
Epilobium angustifolium	1.2	0.3	54	36	67
Linneae borealis	1.2	0.2	54	45	83
Hylocomium splendens	3.0	0.7	54	38	70

Phases: (i) Solidago decumbens-Epilobium angustifolium-Hylocomium splendens-Peltigera canina (PCp) (8 plots)
(ii) Salix arbusculoides-Lupinus arcticus-Epilobium angustifolium (PCl) (4 plots)
(iii) Shepherdia canadensis-Hedysarum alpinum (PCs) (3 plots)
(iv) Linnaea borealis-Hylocomium splendens-Peltigera aphthosa (PCh) (7 plots)*
*Subphases: 1. Tomenthypnum nitens (4 plots)
2. Unnamed (3 plots)

Type 8 The height of sampled dominant *Picea glauca* is ca. 17 m at 100 years of age. The *DBH* is ca. 16 cm.

Environmental Factors

Permafrost	occasionally found (45-100 cm deep)
Soil type	in permafrost areas Static Cryosols present, otherwise Brunisols, occasionally Regosols, mostly Cumulic, are found; on moderate to impeded sites gleying occurs
Soil texture	mainly sand/silt; with gravel/clay present in lesser amounts
	LFH horizon up to 20 cm thick
Soil pH	5.7 - 7.7
Exposure	generally north
Slope	generally gentle, occasionally steep
Erosion potential	generally medium
Drainage	generally moderate, but ranges from excessive to impeded
Sensitivity	generally 2-3, occasionally 4-5

Type 9: Picea glauca-Arctostaphylos uva-ursi (Festuca altaica) (PAF)

Sample size: 123 species: 44 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Arctostaphylos uva-ursi	4.8	0.4	95	83	87
Picea glauca	2.4	0.2	82	18	22
Epilobium angustifolium	1.6	0.2	75	61	81
Salix glauca	2.2	0.3	70	26	37
Shepherdia canadensis	1.8	0.3	66	55	83
Populus tremuloides	2.6	0.4	61	59	97
Festuca altaica	1.8	0.3	61	50	82
Anemone multifida	1.2	0.2	59	55	93
Rosa acicularis	1.2	0.2	54	38	70
Ceratodon purpureus	1.3	0.2	54	49	91
Peltigera canina	1.2	0.2	52	33	63

Phases: (i) Populus balsamifera-Lupinus arcticus-(Salix alaxensis) (PAFb) (18 plots)
(ii) Festuca altaica-Pletigera canina (PAFf) (13 plots)
(iii) Populus tremuloides-Achillea borealis (PAFa) (8 plots)
(iv) Populus tremuloides-Bromus pumpellianus-Solidago decumbens (PAFs) (2 plots)
(v) Populus tremuloides-Fragaria virginiana-Peltigera canina (PAFp) (3 plots)

Type 9 The height of sampled dominant *Picea glauca* is ca. 10 m at 100 years of age. The *DBH* is ca. 12 cm.

Fig. 10. White spruce stands (Vegetation Type 8) are among the most productive forest types in Ecoregion 8. Though permafrost is occasionally present at a depth of between 40 to 100 cm, the trees appear to benefit from seepage.

Environmental Factor	
Permafrost	extremely rare
Soil type	where drainage is moderate to excessive, mainly Eutric Brunisols with trend towards Melanic Brunisols; also Cumulic Regosols. Gleying and Gleysols occur where drainage is impeded.
Soil texture	mostly sand/silt, often with clay and little gravel
	LFH horizon up to 20 cm deep
Soil pH	5.6 - 8.3
Exposure	north and south
Slope	level to gentle, occasionally steep
Erosion potential	low to medium, high on steep slopes
Drainage	generally low
Sensitivity	generally 2-3

Fig. 11. Landscape at Bear Creek Summit, Ecoregion 8. In the foreground, a pioneer community consisting of willows and some elements of Vegetation Type 10 occupies an eroded stream channel. The torrent exposed also a section of a small pipeline. The subalpine white spruce stand is similar in composition to Vegetation Type 9 or, where willows predominate, to Vegetation Type 6. In the background are the ramparts of Mount Archibald, Kluane Ranges.

Type 10: Dryas drummondii (D)

Sample size: 11 species: 1 plot

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Erysimum inconspicuum	2	—	—	100	—
Erigeron purpuratus	2	—	—	100	—
Crepis elegans	2	—	—	100	—
Chamaerhodos erecta	2	—	—	100	—
Populus balsamifera	2	—	—	100	—
Epilobium latifolium	2	—	—	99	—
Dryas drummondii	8	—	—	98	—
Oxytropis campestris	2	—	—	96	—
Tortula ruralis	2	—	—	82	—

Environmental Factors

Permafrost	none found at 1 m.
Soil type	Cumulic Regosol
Soil texture	mainly gravel and stones; very little sand no LFH horizon
Soil pH	—
Exposure	level
Slope	level
Erosion potential	high (river floodplain)
Drainage	wet
Sensitivity	3

Type 11: Artemisia frigida-Agropyron yukonense-Calamagrostis purpurascens (AAC)

Sample size: 48 species: 7 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Artemisia frigida	4.0	0.7	100	99	99
Agropyron yukonense	2.1	0.7	71	68	96
Calamagrostis purpurascens	1.7	0.5	71	70	99
Pulsatilla patens	1.4	0.4	71	67	94
Rosa acicularis	1.4	0.4	71	45	63
Lecidea rubiformis	1.8	0.7	71	70	99
Carex filifolia	2.3	0.7	71	71	100
Caloplaca cirrochroa	2.0	0.9	57	57	100
Erigeron caespitosus	1.1	0.4	57	57	100
Linum perenne	1.1	0.4	57	57	100
Penstemon procerus	1.4	0.6	57	56	100

Phases: (i) Carex stenophylla-Festuca brachyphylla-Cetraria nivalis (AACc) (1 plot)
(ii) type (AACt) (3 plots)
(iii) Arctostaphylos uva-ursi-Erigeron caespitosus-Caloplaca cirrochroa (AACa) (3 plots)

Fig. 12. Pioneer community of *Artemisia frigida - Agropyron yukonense - Calamagrostis purpurascens* (Vegetation Type II) on regosols of the Sheep Mountain slopes above Kluane Lake, Ecoregion 8. The road cut started the renewed movement of the soil.

Environmental Factors

Permafrost	none found at 1 m.
Soil type	predominantly Cumulic Regosol often over bedrock
Soil texture	mainly gravel/sand/silt; small amounts of clay often present
	LFH horizon 2-5 cm deep
Soil pH	7.5 - 8.1
Exposure	southern
Slope	generally steep
Erosion potential	generally high
Drainage	excessive
Sensitivity	ranges from 2 to 5 in areas susceptible to solifluction

Type 12: Calamagrostis purpurascens-Tortula ruralis (CT)

Sample size: 57 species: 7 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Calamagrostis purpurascens	2.7	0.2	100	100	100
Tortula ruralis	2.6	0.6	86	79	92
Potentilla hookeriana	1.4	0.5	71	71	100
Potentilla pennsylvanica	1.4	0.4	71	71	100
Saxifraga tricuspidata	2.8	0.9	71	71	100
Cetraria nivalis	1.4	0.6	57	50	88
Cladonia chlorophaea	1.1	0.4	57	48	84
Anemone multifida	1.1	0.4	57	57	100
Antennaria rosea	1.0	0.4	57	57	100
Artemisia frigida	1.7	0.8	57	57	100
Carex filifolia	1.4	0.6	57	57	100
Erigeron compositus	1.1	0.5	57	57	100
Festuca brachyphylla	1.6	0.6	57	57	100
Penstemon procerus	1.1	0.4	57	57	100
Polemonium pulcherrimum	1.1	0.4	57	57	100

Phases: (i) Saxifraga tricuspidata (CTs) (4 plots)
(ii) Artemisia alaskana-Agropyron yukonense (CTa) (2 plots)
(iii) Festuca altaica (CTf) (1 plot)

Environmental Factors

Permafrost	none found at 1 m.
Soil type	Regosols, Regosols on Bedrock, or Bedrock
Soil texture	mainly rock/stones; often sand and some silt
	LFH horizon up to 2 cm
Soil pH	6.3 - 7.8
Exposure	generally southern
Slope	usually steep
Erosion potential	generally medium to high
Drainage	generally excessive
Sensitivity	generally 1 but 3-5 where there is danger of slides

Fig. 13. A lodgepole pine stand, Vegetation Type 23, which originated after fire about 100 years ago; Liard River, Ecoregion 2.

Type 13: Pinus contorta-Arctostaphylos uva-ursi-Festuca altaica-Peltigera aphthosa (PAFP)

Sample size: 113 species: 25 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Pinus contorta	4.4	0.5	92	70	76
Festuca altaica	2.4	0.3	80	53	66
Peltigera aphthosa	1.8	0.2	80	34	43
Arctostaphylos uva-ursi	2.6	0.4	76	49	64
Linnaea borealis	2.0	0.3	72	31	43
Picea glauca	1.5	0.3	60	19	31
Rosa acicularis	1.2	0.2	60	31	52
Cladonia arbuscula	1.4	0.3	60	48	80
Vaccinium vitis-idaea	2.2	0.5	52	32	62

Phases: (i) Cladonia cariosa-Peltigera canina (PAFPc) (12 plots)*
(ii) Type (PAFPt) (13 plots)
*Subphases: 1. Cladonia cucullata (6 plots)
2. Cladonia cariosa (3 plots)
3. Alnus (1 plot)
4. Carex Concinna (2 plots)

Type 13 The height of sampled dominant *Picea glauca* is ca. 12 m at 100 years of age, with a *DBH* of ca. 16 cm. *Pinus contorta* tree height is ca. 15 m at 100 years of age, with a *DBH* of ca. 17 cm.

Environmental Factors

Permafrost	none found at 1 m.
Soil type	generally Eutric and Dystric Brunisols; occasional Regosols and Humic Gleysols, with impeded drainage
Soil texture	mainly sand; substantial amounts of gravel, some silt present
	LFH horizon up to 20 cm thick
Soil pH	5.1 - 7.4
Exposure	generally southern
Slope	usually level to moderate, occasionally strong
Erosion potential	generally low
Drainage	generally moderate to excessive
Sensitivity	generally 2, 4-5 where sand dunes exist

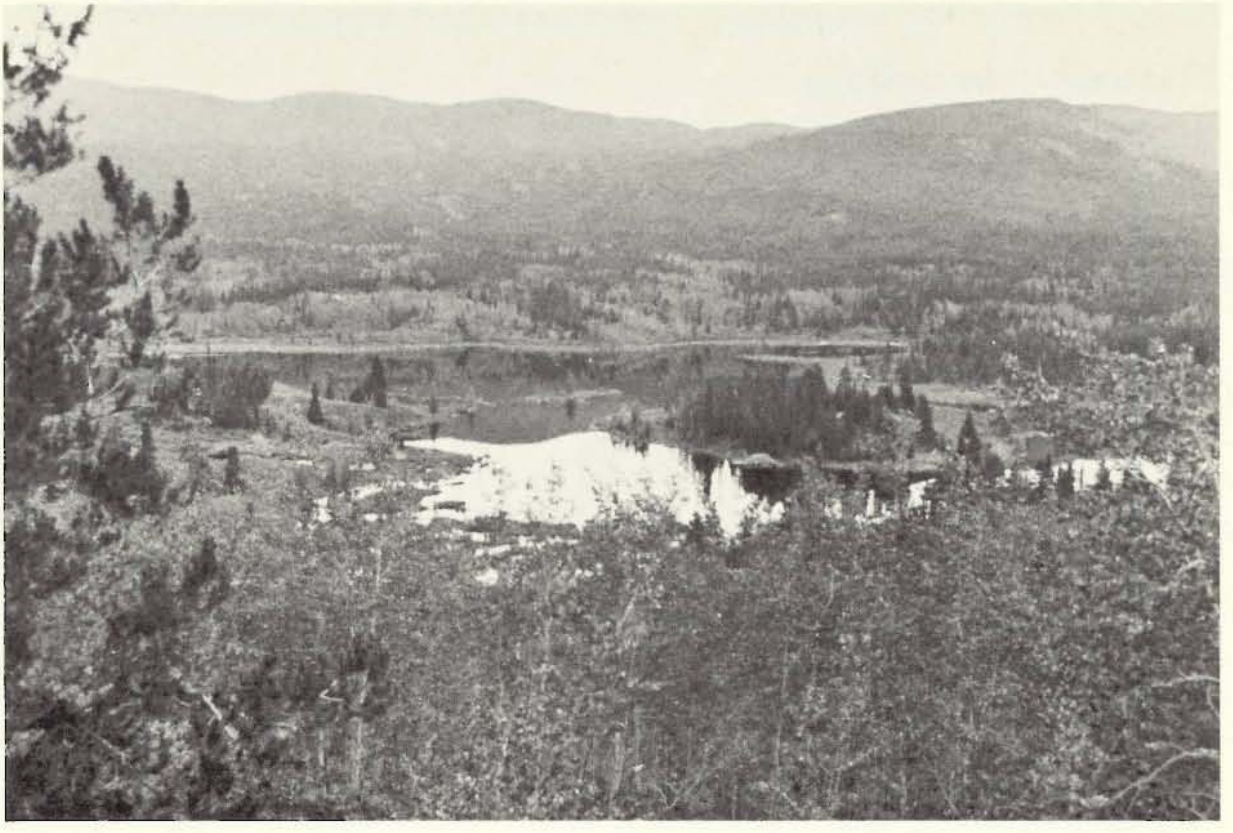

Fig. 14. In the foreground, a trembling aspen stand, Vegetation Type 14; the coniferous stands in the middle and background belong mainly to Vegetation types 15 and 16; Wolf Lake, Ecoregion 5.

Type 14: Populus tremuloides-Arctostaphylos uva-ursi-Shepherdia canadensis-Epilobium angustifolium (PASE)

Sample size: 76 species: 18 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Populus tremuloides	6.0	0.2	100	82	82
Arctostaphylos uva-ursi	3.7	0.4	100	67	67
Epilobium angustifolium	2.1	0.1	100	73	73
Linnaea borealis	2.4	0.3	83	37	45
Shepherdia canadensis	2.3	0.4	78	55	71
Rosa acicularis	1.6	0.3	72	39	54
Drepanocladus uncinatus	1.6	0.3	72	57	79
Salix glauca	1.4	0.3	61	32	52
Lupinus arcticus	1.4	0.3	61	42	69
Mertensia paniculata	1.1	0.2	56	36	64

Type 14 The height of sampled dominant *Populus tremuloides* rarely exceeds 15 m. The *DBH* tends to be less than 20 cm.

Phases: (i) Salix bebbiana-Ceratodon purpureus-Peltigera canina (PASEp) (4 plots)
(ii) Drepanocladus uncinatus (PASEd) (14 plots)*
* Subphases: 1. Vaccinium vitis-idaea (6 plots)
2. Hylocomium splendens (3 plots)
3. Viburnum edule (4 plots)

Environmental Factors

Permafrost	none found at 1 m.
Soil type	generally Eutric Brunisol; occasional Regosol or Bedrock
Soil texture	mainly gravel/sand/silt; occasionally 28-35% clay
	LFH horizon up to 9 cm deep
Soil pH	5.9 - 7.6
Exposure	north and south
Slope	generally level to moderate, occasionally steep
Erosion potential	low to medium, occasionally high
Drainage	moderate to excessive
Sensitivity	1 - 2

Type 15: Picea glauca-Arctostaphylos rubra-Aulacomnium palustre (PAAP)

Sample size: 137 species: 24 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Aulacomnium palustre	3.7	0.5	83	80	96
Arctostaphylos rubra	2.2	0.3	79	63	80
Salix glauca	2.2	0.4	75	44	59
Picea glauca	2.1	0.3	71	26	37
Salix myrtillifolia	2.9	0.5	71	66	93
Equisetum scirpoides	1.5	0.2	67	59	88
Peltigera aphthosa	1.6	0.3	67	25	37
Carex concinna	1.1	0.2	54	44	81
Ledum groenlandicum	1.7	0.4	54	47	87

Phases: (i) Gentiana propinqua-Potentilla fruticosa (PAAPg) (10 plots)
(ii) Carex aquatilis-Equisetum arvense (PAAPc) (5 plots)
(iii) Picea mariana-Empetrum nigrum-Hylocomium splendens (PAAPp) (9 plots)*
* Subphases: 1. Ptilium crista-castrensis (4 plots)
2. Polytrichum commune-Sphagnum (5 plots)

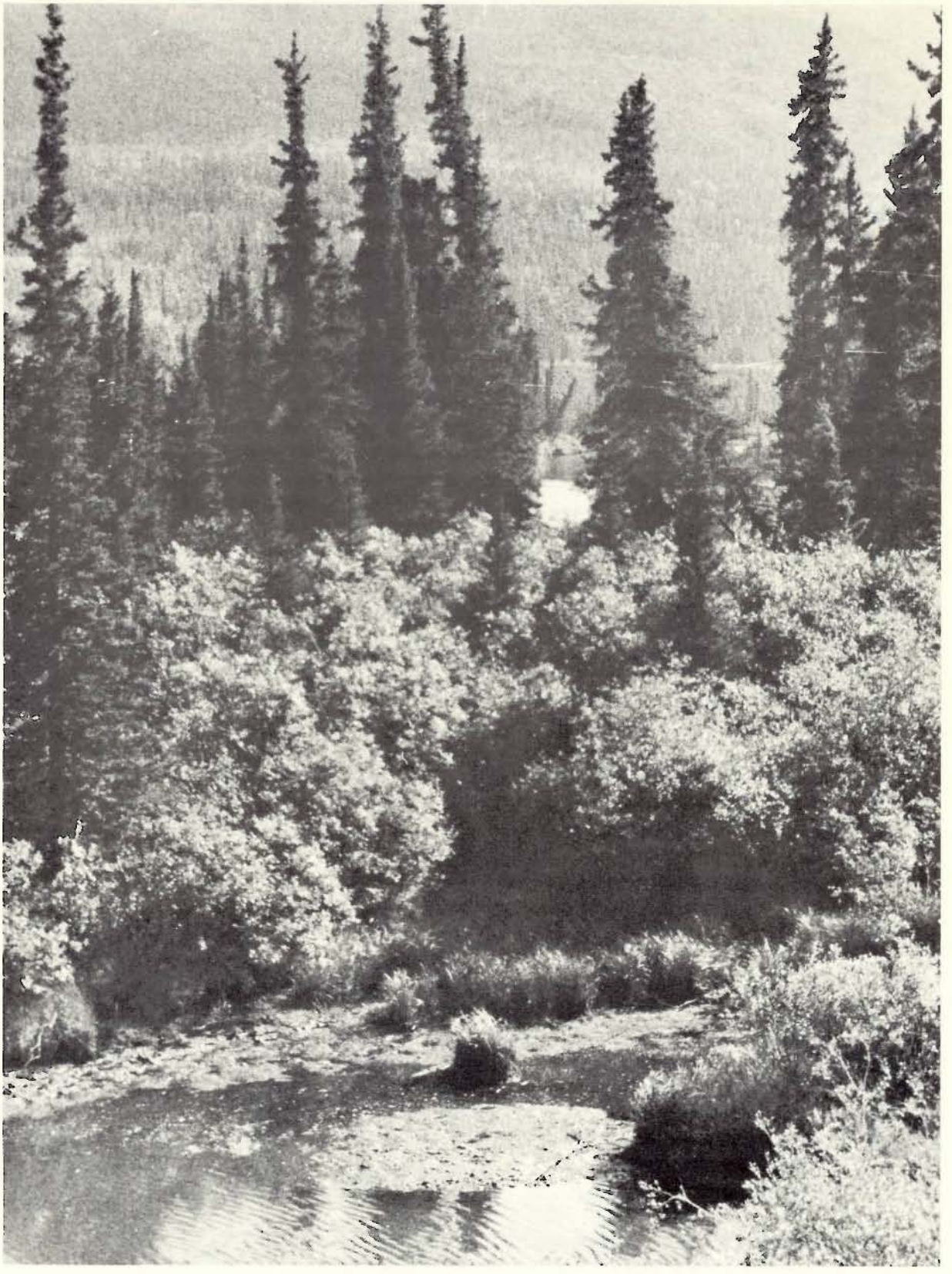

Fig. 15. White spruce stand (Vegetation Type 18) fringed by vigorous willows and sedges (Vegetation Type 20) adjacent to the Rancheria River, Ecoregion 4.

Type 15 The height of sampled dominant *Picea glauca* is ca. 11 m at 100 years of age, with *DBH ca. 10 cm.*

Environmental Factors

Permafrost	occasionally found, ranges in depth from 25-90 cm
Soil type	in permafrost areas Static, Turbic and Organic Crysols present; otherwise Humic Gleysols and Regosols mainly found, with occasional Brunisols, Humisols and Mesisols. All soils are frequently gleyed.
Soil texture	mainly gravel/sand/silt
	LFH or 0 horizon up to 40 cm and deeper, organic content of the soil occasionally ranges from 10- 100%
Soil pH	4.6 - 7.9
Exposure	north and south
Slope	level to moderate
Erosion potential	low to medium, occasionally high
Drainage	generally impeded to wet
Sensitivity	ranges from 2-6

Type 16: Picea glauca-Hylocomium splendens-Peltigera aphthosa (PHP)

Sample size: 84 species: 22 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Picea glauca	5.5	0.4	100	44	44
Hylocomium splendens	7.1	0.2	100	65	65
Peltigera aphthosa	2.8	0.1	95	47	47
Linnaea borealis	2.2	0.2	95	48	51
Pleurozium schreberi	3.5	0.5	82	67	82
Vaccinium vitis-idaea	2.2	0.4	68	45	66
Rosa acicularis	1.4	0.2	68	37	54
Dicranum undulatum	1.3	0.2	64	52	81
Geocaulon lividum	1.2	0.2	59	46	78
Abietinella abietina	1.7	0.4	55	47	85
Ptilium crista-castrensis	1.4	0.3	54	49	91

Phases: (i) Pinus contorta-Empetrum nigrum (PHPe) (11 plots)*
(ii) Populus tremuloides-Calypso bulbosa-Pedicularis labradorica (PHPc) (5 plots)
(iii) Type (PHPt) (6 plots)

*Subphases: 1. Ledum groenlandicum (4 plots)
2. Festuca altaica (7 plots)

Type 16 The height of sampled dominant *Picea glauca* is ca. 17 m at 100 years of age. The *DBH* is ca. 16 cm.

Fig. 16. Fire devastated forests in the Rancheria River Area, Ecoregion 4; only the wettest sites in the flood plain of the river escaped destruction

Environmental Factors

Permafrost	extremely rare
Soil type	in permafrost areas Cumulic Regosols; otherwise generally Eutric Brunisols with a trend towards Melanic Brunisols are found, with Dystric Brunisols and occasional Regosols also present. All soils frequently gleyed.
Soil texture	mainly gravel/sand/silt LFH horizon to 15 cm in depth
Soil pH	4.4 - 8.2
Exposure	generally southern
Slope	level to moderate
Erosion potential	generally low to medium
Drainage	ranges from impeded to excessive
Sensitivity	generally 2

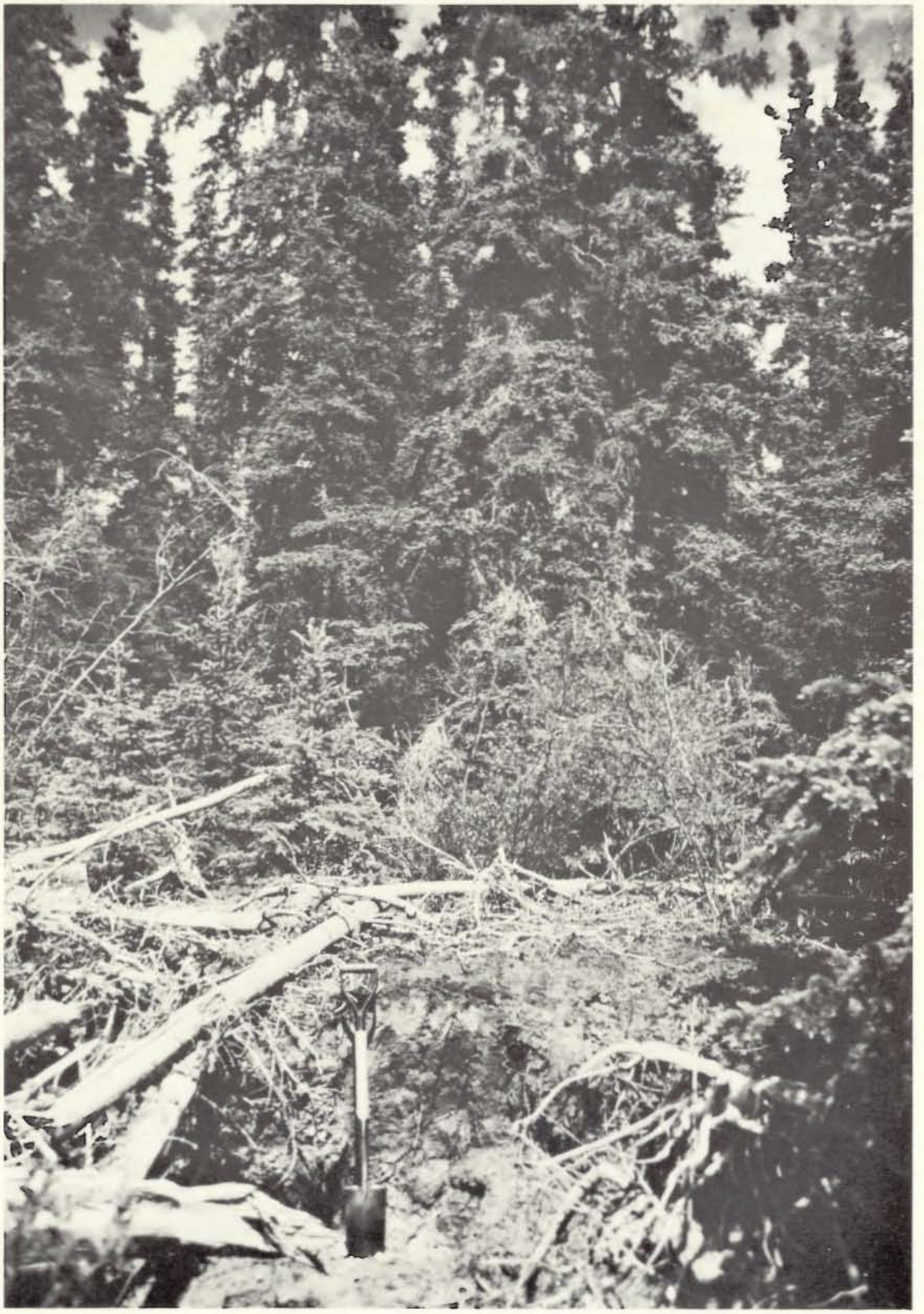

Fig. 17. Uneven-aged white spruce stand, Vegetation Type 16, disturbed by high grading and road construction. The upper layers of the mineral soil profile (Gleyed Eutric Brunisol) contain light-colored volcanic ash. North shore of Marsh Lake, Ecoregion 5.

Type 17: Picea glauca-Cornus canadensis-Hylocomium splendens-Pleurozium schreberi-Peltigera aphthosa (PCHP)

Sample size: 74 species: 10 plots

Characteristic combination of species;

Species	M	SD	PW %	FV %	SV %
Vaccinium vitis-idaea	3.6	0.5	100	46	46
Hylocomium splendens	6.7	0.5	100	50	50
Peltigera aphthosa	2.5	0.2	100	25	25
Pleurozium schreberi	3.5	0.4	100	50	50
Cornus canadensis	2.7	0.4	90	60	67
Empetrum nigrum	2.3	0.3	90	53	59
Picea glauca	3.7	0.7	90	45	50
Cetraria pinastri	1.8	0.2	90	56	62
Pinus contorta	3.2	0.8	80	43	54
Festuca altaica	1.4	0.3	70	32	46
Linnaea borealis	1.6	0.4	70	32	46
Cladonia arbuscula	1.4	0.3	70	50	71
Dicranum undulatum	1.4	0.3	60	58	83
Lupinus arcticus	1.2	0.3	60	35	58
Barbilophozia hatcheri	1.2	0.3	60	40	67
Nephroma arcticum	1.4	0.4	60	50	83
Ptilium crista-castrensis	1.4	0.4	60	45	75
Vaccinium uliginosum	1.3	0.4	60	28	47

Phases: (i) Abietinella abietina (PCHPa) (3 plots)
(ii) Mertensia paniculata (PCHPm) (4 plots)
(iii) Type (PCHPt) (3 plots)

Type 17 Dominant *Pinus contorta* may attain heights of 15 m at 100 years of age, with a *DBH* of ca. 16 cm. *Picea glauca* height is ca. 21 m at 100 years of age and the *DBH* is 24 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	mainly Dystric Brunisols, occasional Eutric Brunisols and Regosols; where drainage is impeded gleying occurs
Soil texture	mainly gravel/sand/silt
	LFH horizon up to 15 cm deep
Soil pH	4.2 - 5.9
Exposure	generally southern
Slope	generally level to moderate, occasionally strong
Erosion potential	low to medium, occasionally high
Drainage	ranges from impeded to excessive
Sensitivity	2

Type 18: Picea glauca-Salix planifolia-Aulacomnium palustre-Hylocomium splendens (PSAH)

Sample size: 63 species: 4 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Picea glauca	3.0	0.0	100	43	43
Salix planifolia	2.5	0.3	100	67	67
Mertensia paniculata	2.0	0.0	100	60	60
Mitella nuda	2.0	0.0	100	63	63
Hylocomium splendens	5.3	1.2	100	40	40
Salix myrtillifolia	2.3	0.9	75	59	79
Linnaea borealis	1.5	0.6	75	33	44
Rosa acicularis	1.5	0.6	75	55	73
Equisetum scirpoides	1.8	0.9	75	65	86
Vaccinium vitis-idaea	1.5	0.6	75	25	33
Aulacomnium palustre	2.5	1.2	75	40	53
Drepanocladus uncinatus	1.5	0.6	75	60	80
Peltigera aphthosa	1.8	0.7	75	12	16
Pleurozium schreberi	3.3	1.4	75	28	37

Phases: (i) Type (PSAHt) (3 plots)
(ii) Ledum palustre (PSAHl) (1 plot)

Type 18 The height of sampled dominant *Picea glauca* is ca. 17 m at 100 years of age. The *DBH* is 16 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	generally Humic Gleysol, occasionally Gleyed Humic Regosol
Soil texture	mainly gravel/sand/silt, occasional substantial amounts of clay
	LFH horizon up to 20 cm deep
Soil pH	5.9 - 7.1
Exposure	southern
Slope	usually gentle, occasionally strong
Erosion potential	generally medium
Drainage	impeded
Sensitivity	generally 2

Type 19: Pinus contorta-Festuca altaica-Peltigera aphthosa (PFP)

Sample size: 94 species: 11 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Festuca altaica	4.1	0.6	100	61	61
Pinus contorta	4.4	0.8	91	55	60
Linnaea borealis	2.3	0.5	82	43	52
Peltigera aphthosa	1.8	0.3	82	14	17
Epilobium angustifolium	1.5	0.3	73	47	64
Lupinus arcticus	1.3	0.3	73	47	64
Vaccinium uliginosum	1.4	0.4	64	30	47
Vaccinium vitis-idaea	1.6	0.4	64	19	30
Cornus canadensis	1.3	0.4	54	28	52
Ledum groenlandicum	1.4	0.5	54	26	48
Cladonia arbuscula	1.1	0.3	54	36	67
Drepanocladus uncinatus	1.2	0.4	54	47	87
Pleurozium schreberi	1.4	0.4	54	17	31
Pyrola secunda	1.1	0.3	54	45	83
Lycopodium annotinum	1.2	0.4	54	45	83

Phases: (i) Arctostaphylos uva-ursi-Gentiana propinqua (PFPa) (5 plots)
(ii) *Stereocaulon alpinum (PFPs) (1 plot)
(iii) Ledum groenlandicum-Lycopodium complanatum-Cladonia arubscula (PFPc) (5 plots)

*possibly synonym

Type 19 The height of sampled dominant *Pinus contorta* is ca. 19 m at 100 years of age. The *DBH* is ca. 20 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	generally Dystric Brunisol, Regosols and Eutric Brunisols also found; where drainage is impeded to wet, gleying occur
Soil texture	mainly gravel/sand/silt; occasionally 1-35% clay
	LFH horizon up to 14 cm deep
Soil pH	4.9 - 6.9
Exposure	southern
Slope	moderate to steep
Erosion potential	medium to high
Drainage	impeded to excessive
Sensitivity	generally 2-3, higher on talus slopes (4) and deltaic plains (5)

Type 20: Salix-Carex aquatilis-Aulacomnium palustre (SCA)

Sample size: 86 species: 9 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Aulacomnium palustre	5.0	0.4	100	68	68
Carex aquatilis	4.1	0.8	89	85	96
Arctostaphylos rubra	1.9	0.4	78	53	68
Betula nana	2.9	0.8	78	56	72
Picea mariana	1.8	0.5	67	56	84
Salix myrtillifolia	2.3	0.8	67	59	88
Salix planifolia	2.2	0.7	67	45	67
Peltigera aphthosa	1.3	0.4	67	8	12
Sphagnum magellanicum	2.1	0.6	67	67	100
Ledum groenlandicum	1.3	0.5	56	27	48
Potentilla fruticosa	1.2	0.4	56	51	91
Abietinella abietina	1.3	0.5	56	56	100

Phases: (i) Ledum palustre-Vaccinium uliginosum-Pedicularis labradorica (SCAl) (4 plots)
(ii) Salix planifolia (SCAs) (5 plots)

Type 20 The height of sampled dominant *Picea mariana* is ca. 17 m at 100 years of age. The *DBH* is ca. 16 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	Humic Gleysols where drainage is impeded, Humisols and occasional Fibrisols where wet
Soil texture	mainly sand/silt; often with substantial amounts of gravel and clay
	LFH or 0 horizon up to 60 cm and deeper
Soil pH	5.6 - 7.5
Exposure	level to southern
Slope	level to moderate
Erosion potential	generally medium
Drainage	impeded to wet
Sensitivity	4-5 in organic soils, 2-3 otherwise

Type 21: Picea glauca-Hylocomium splendens-Peltigera aphthosa (PHPC)

Sample size: 85 species: 10 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Hylocomium splendens	5.8	0.6	100	44	44
Picea glauca	4.4	0.8	90	50	56
Linnaea borealis	2.3	0.3	90	27	80
Pyrola secunda	1.9	0.2	90	50	56
Cetraria pinastri	1.8	0.2	90	40	44
Peltigera aphthosa	1.9	0.2	90	33	37
Mertensia paniculata	1.6	0.3	80	62	78
Abietinella abietina	2.4	0.5	80	53	66
Cornus canadensis	1.9	0.5	70	47	67
Ledum groenlandicum	1.8	0.6	60	33	55
Rosa acicularis	1.2	0.3	60	49	82
Vaccinium vitis-idaea	1.8	0.6	60	16	27
Hypogymnia physodes	1.2	0.3	60	49	82
Pleurozium schreberi	2.0	0.6	60	33	55

Phases: (i) Ledum groenlandicum-Hypogymnia physodes-Pleurozium schreberi (PHPCl) (6 plots) *
(ii) Juniperus communis-Festuca altaica (PHPCj) (4 plots)

* Subphases: 1. Salix glauca (1 plot)
2. Picea mariana-Pinus contorta (2 plots)
3. Picea mariana-Vaccinium vitis-idaea (3 plots)

Type 21 The height of sampled dominant *Picea glauca* is ca. 21 m at 100 years of age. The *DBH* is ca. 26 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	mainly Eutric, occasional Dystric Brunisols; Regosols also present. All soils frequently gleyed
Soil texture	mainly gravel/sand; silt, some clay also present
	LFH horizon up to 30 cm deep
Soil pH	5.4 - 7.5
Exposure	southern
Slope	level to steep
Erosion potential	low to medium
Drainage	generally moderate
Sensitivity	2-3

Type 22: Pinus contorta-Vaccinium vitis-idaea-Hylocomium splendens-Cetraria pinastri (PVHC)

Sample size: 72 species: 14 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Pinus contorta	5.8	0.5	100	56	56
Cetraria pinastri	1.9	0.1	100	56	56
Linnaea borealis	2.4	0.2	93	32	34
Vaccinium vitis-idaea	3.4	0.5	93	40	43
Cladonia arbuscula	2.3	0.3	93	77	83
Peltigera aphthosa	2.3	0.2	93	40	43
Hylocomium splendens	3.8	0.7	86	37	43
Pleurozium schreberi	3.6	0.7	78	55	71
Cladonia ecmocyna	1.4	0.3	71	56	79
Abietinella abietina	2.2	0.6	64	42	66
Dicranum undulatum	1.4	0.3	64	56	88
Alnus crispa	2.5	0.7	64	53	83
Picea mariana	1.8	0.6	57	37	65
Arctostaphylos uva-ursi	1.2	0.3	57	42	74
Epilobium angustifolium	1.1	0.3	57	25	44
Ledum groenlandicum	1.9	0.6	57	32	56
Cladonia gracilis	1.1	0.3	57	40	70
Cladonia rangiferina	1.1	0.3	57	55	96
Stereocaulon tomentosum	1.2	0.3	57	45	79

Phases: (i) Arctostaphylos uva-ursi-Epilobium angustifolium-Festuca altaica (PVHCf) (8 plots)
(ii) Alnus crispa-Pyrola asarifolia-Abietinella abietina (PVHCa) (6 plots)

Type 22 Dominant *Picea mariana* height is ca. 17 m at 100 years of age, with a *DBH* of ca. 16 cm. *Pinus contorta* tree height is ca. 16 m at 100 years of age, with a *DBH* of ca. 20 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	commonly Dystric Brunisols, frequently eluviated, occasional Eutric Brunisols
Soil texture	mainly gravel/sand, with smaller amounts of silt
	LFH horizon up to 9 cm deep
Soil pH	4.5 - 7.0
Exposure	generally southern
Slope	level to moderate, occasionally steep
Erosion potential	generally low
Drainage	moderate to excessive
Sensitivity	generally 2

Type 23: Pinus contorta-Vaccinium vitis-idaea-Festuca altaica-Polytrichum piliferum-Peltigera canina (PVFP)

Samples size: 64 species: 7 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Vaccinium vitis-idaea	2.4	0.5	100	37	37
Epilobium angustifolium	2.1	0.1	100	53	53
Festuca altaica	4.0	0.9	100	57	57
Arctostaphylos uva-ursi	2.7	0.7	86	63	73
Linnaea borealis	2.6	0.6	86	23	27
Pinus contorta	4.4	1.1	86	34	40
Ceratodon purpureus	1.8	0.4	86	86	100
Peltigera canina	1.7	0.3	86	66	77
Polytrichum piliferum	2.0	0.4	86	74	86
Gentiana propinqua	1.3	0.4	71	71	100
Lupinus arcticus	1.4	0.4	71	60	85
Populus tremuloides	4.4	1.3	71	57	80
Pyrola secunda	1.4	0.4	71	33	46
Shepherdia canadensis	1.8	0.7	71	62	87
Cladonia chlorophaea	1.1	0.4	57	42	74
Cladonia gracilis	1.3	0.5	57	36	63
Stereocaulon tomentosum	1.1	0.4	57	40	70
Tortula ruralis	1.4	0.6	57	55	96
Salix glauca	1.1	0.4	57	48	84

Phases: (i) Pinus contorta-Tortula ruralis (PVFPt) (3 plots)
(ii) Populus tremuloides (PVFPp) (4 plots)

Type 23 The height of sampled dominant *Pinus contorta* is ca. 23 m at 100 years of age, with a *DBH* of ca. 23 cm. *Populus tremuloides* tree height is ca. 26 m at 100 years of age, with a *DBH* of ca. 28 cm.

Environmental Factors

Permafrost	none found at 1 m
Soil type	generally Eutric Brunisols; occasional Regosols and Dystric Brunisols
Soil texture	mainly gravel/sand; also some silt and very little clay
	LFH horizon up to 4 cm thick
Soil pH	5.0-7.0
Exposure	south
Slope	level to steep
Erosion potential	generally low, occasionally high
Drainage	excessive
Sensitivity	generally 2, on steep talus slopes 4-5

Type 24: Salix planifolia-Rubus arcticus-Aulacomnium palustre (SRA)

Sample size: 69 species: 4 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Salix planifolia	2.5	0.3	100	91	91
Aulacomnium palustre	6.5	0.6	100	88	88
Arctostaphylos rubra	1.8	0.7	75	66	88
Carex aquatilis	4.0	1.9	75	70	93
Mertensia paniculata	1.5	0.6	75	50	67
Pedicularis labradorica	1.5	0.6	75	68	91
Potentilla fruticosa	1.8	0.7	75	73	97
Rubus arcticus	1.5	0.6	75	75	100
Salix myrtillifolia	1.5	0.6	75	75	100

Phases: (i) Betula nana-Equisetum scirpoides (SRAb) (2 plots)
(ii) *Betula glandulifera-Sphagnum (SRAs) (1 plot)
(iii) Picea glauca-Viburnum edule-Equisetum arvense-Hylocomium splendens (SRAe) (1 plot)
* perhaps B. glandulosa

Type 24 Dwarf (< 8 m) shrubby trees on low terrain, taller (< 20 m) trees on raised ground.

Environmental Factors

Permafrost	very rarely found
Soil type	in permafrost areas Organic Cryosols occur, elsewhere Rego Humic Gleysols are found
Soil texture	mainly gravel and sand
	LFH or O horizon up to 30 cm and deeper
Soil pH	5.8 - 7.5
Exposure	generally level
Slope	level, occasionally moderate
Erosion potential	generally low
Drainage	impeded to wet
Sensitivity	3-6

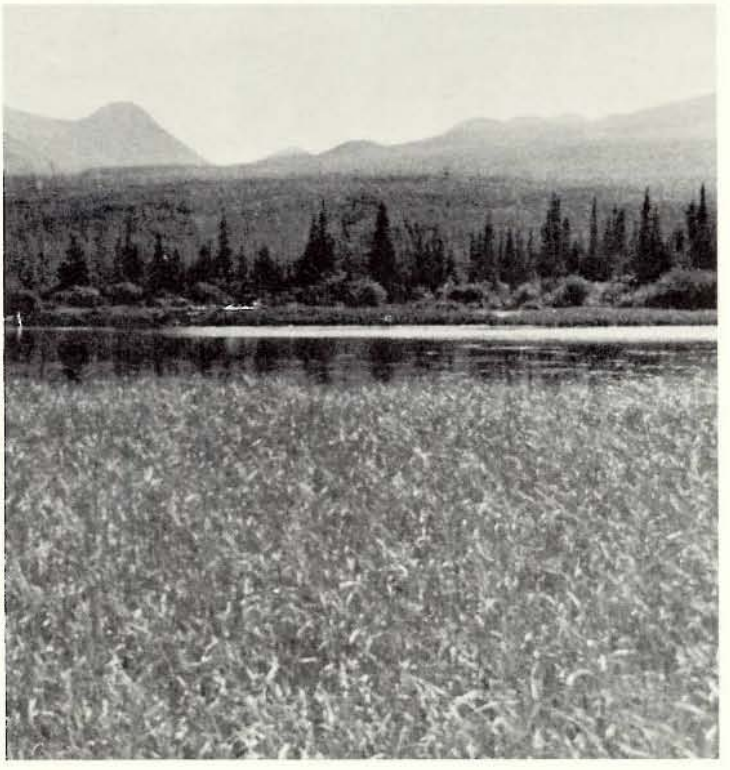

Fig. 18. Sedge marsh consisting mainly of *Carex aquatilis* (Variant of Vegetation Type 20) along the edges of oxbows, Rancheria River area, Ecoregion 4.

Type 25: Carex lasiocarpa-Equisetum fluviatile (CE)

Sample size: 3 species: 2 plots

Characteristic combination of species:

Species	M	SD	PW %	FV %	SV %
Carex aquatilis	4.0	1.4	100	91	91
Carex lasiocarpa	6.0	1.4	100	100	100

Phases: (i) Equisetum fluviatile (CEe) (1 plot)
(ii) Type (CEt) (1 plot)

Environmental Factors

Permafrost	none found at 1 m
Soil type	Terric Humisol
Soil texture	mainly silt/sand - Organic content of soil 30%
Soil pH	5.3 - 6.6
Exposure	level
Slope	level
Erosion potential	low
Drainage	wet
Sensitivity	5

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BC-X-205, December, 1980