MARGINAL CAPABILITY LANDS OF THE CHILCOTIN

by

WILLIAM JOHN WATT

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Department of Soil Science
The University of British Columbia
Vancouver 8, Canada

Date July 29, 1974

ABSTRACT

Capability inventory surveys have been conducted in the province for several years. Inherent in this program is the collection of baseline data on the physical environment of the area. The capability information (CLI) is valuable for land resource planning, especially in areas where little resource development has occurred. The mechanism of collection and the utility of capability data were examined in the Chilcotin area of British Columbia in an attempt to develop a land use plan. A reconnaissance terrain survey was conducted. The survey relied heavily on air photo interpretation and used landforms as the physical base. Five terrain types, based on soil and other landscape characteristics were identified and characterized in the study area. Detailed ground information was collected from a representative site on each terrain type. The information was used to characterize the terrain type and make resource capability interpretations for agriculture, forestry, wildlife and recreation. The capability of these resource sectors were evaluated for the purpose of preparing a land use plan for the terrain types within the area. The plan identified integrated resource use as the optimal type of resource development.

The study provides a guide to integrated management of the area. Resource conflicts were identified and supplemental information requirements were noted.

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WALTER L. KUBIENA

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INTRODUCTION

Large areas in British Columbia have limited capability lands for agriculture, forestry, wildlife and intensive recreation because of restrictions related to climate and soil. It is necessary to understand these limited capability areas if their potential is to be utilized. These areas are limited in their single resource utility, but could be more productive under integrated resource use. This study explores the techniques of data gathering and evaluation for the purpose of optimizing land use to its potential in an area of limited capability lands in British Columbia. This province has highly variable climate and terrain.

Such a limited capability area[1] in the Chilcotin was selected. A methodology for the collection of information in areas of limited access is presented as an aid to determine the type of development and management required to obtain an optimum sustained output from the agriculture, forestry, wildlife and recreation resource sectors. The assemblage of specialized information is organized by a land classification system which was used to map, correlate and provide derivative interpretations.

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[1]Classed as a limited capability area by the Canada Land Inventory (CLI). Capabilities are Class 5 and 6 (Class 4 to 6 for Big Game) under the seven class CLI classification system.

The information is assembled using soils as the integrater. The usefulness of soils as the common denominator in bridging the animate and inanimate world was suggested by Jenny [1941]. The gathered information is organized into soil based terrain units. The information is evaluated in relation to capability potential for the resource sectors and the subsequent land use plan attempts to optimize the output from the unit area in qualitative terms. Land use decisions are based entirely on physical environmental characteristics. The inventory of the physical resource information provides the comprehensive base for land evaluation and land use planning.

DESCRIPTION OF THE STUDY AREA

The general discussion which follows defines the location and describes the environment of the area. The description of the environment presents the physiography, bedrock and surficial geology, climate, vegetation soils and present land use. The introductory remarks are brief but will provide a perspective of the physical environment which is investigated in detail.

Location

The area is located in the west half of National Topographic Series sheet 92-0 as shown in Figure 1. It extends one degree North from 51° North Latitude and one degree west from 123° West Longitude. The center of the area is located 250 kilometres north of Vancouver and 110 kilometres south west of Williams Lake.

Physiography

The two dominant physiographic features are the Fraser Plateau covering the northeastern two-thirds of the area and the Coast Mountains in the south west [Holland, 1964]. They are outlined in Figure 2. Level to rolling topography is characteristic of the Fraser Plateau in the area. Elevations range from 915 metres to 1675 metres ASL with

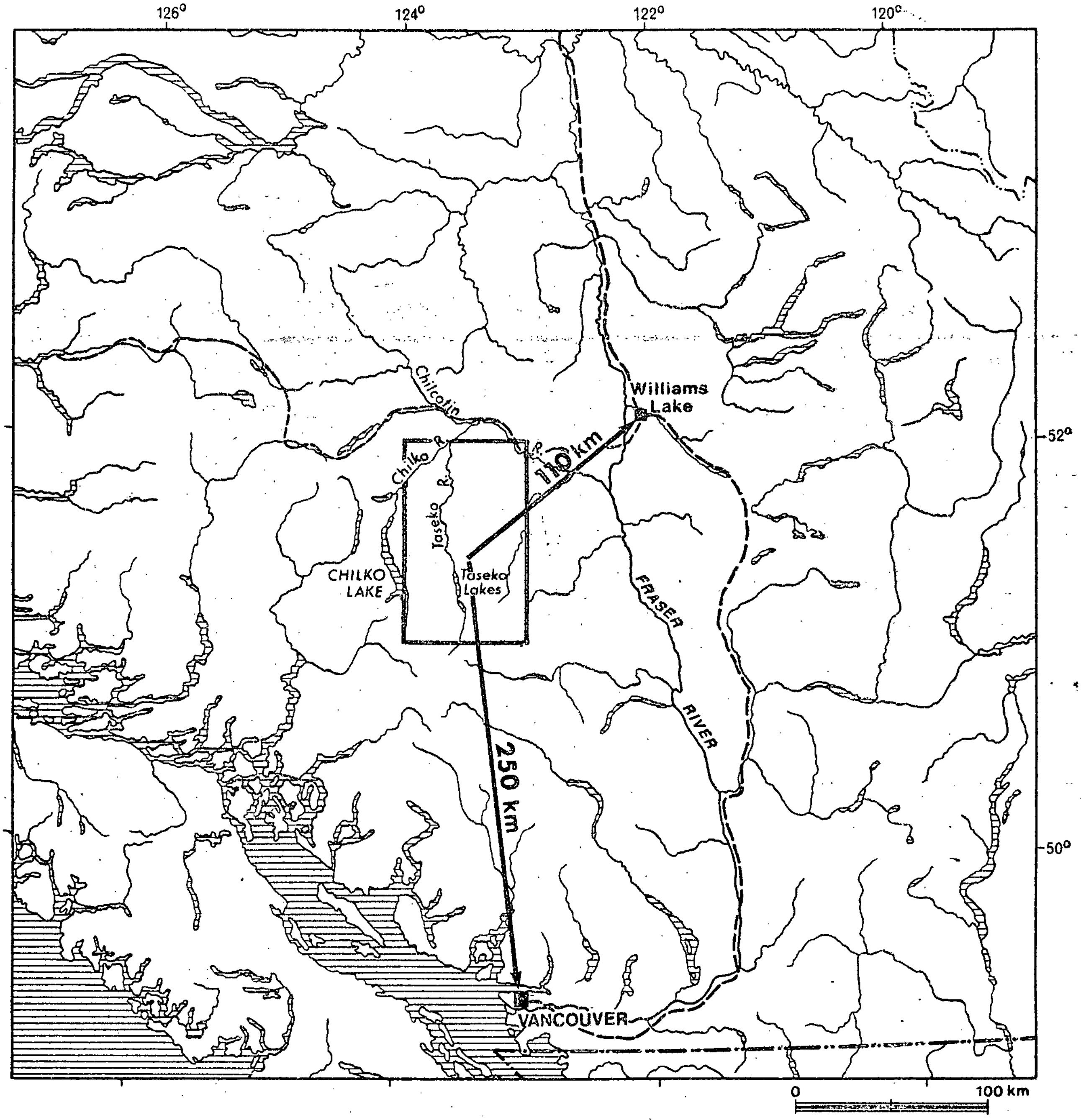
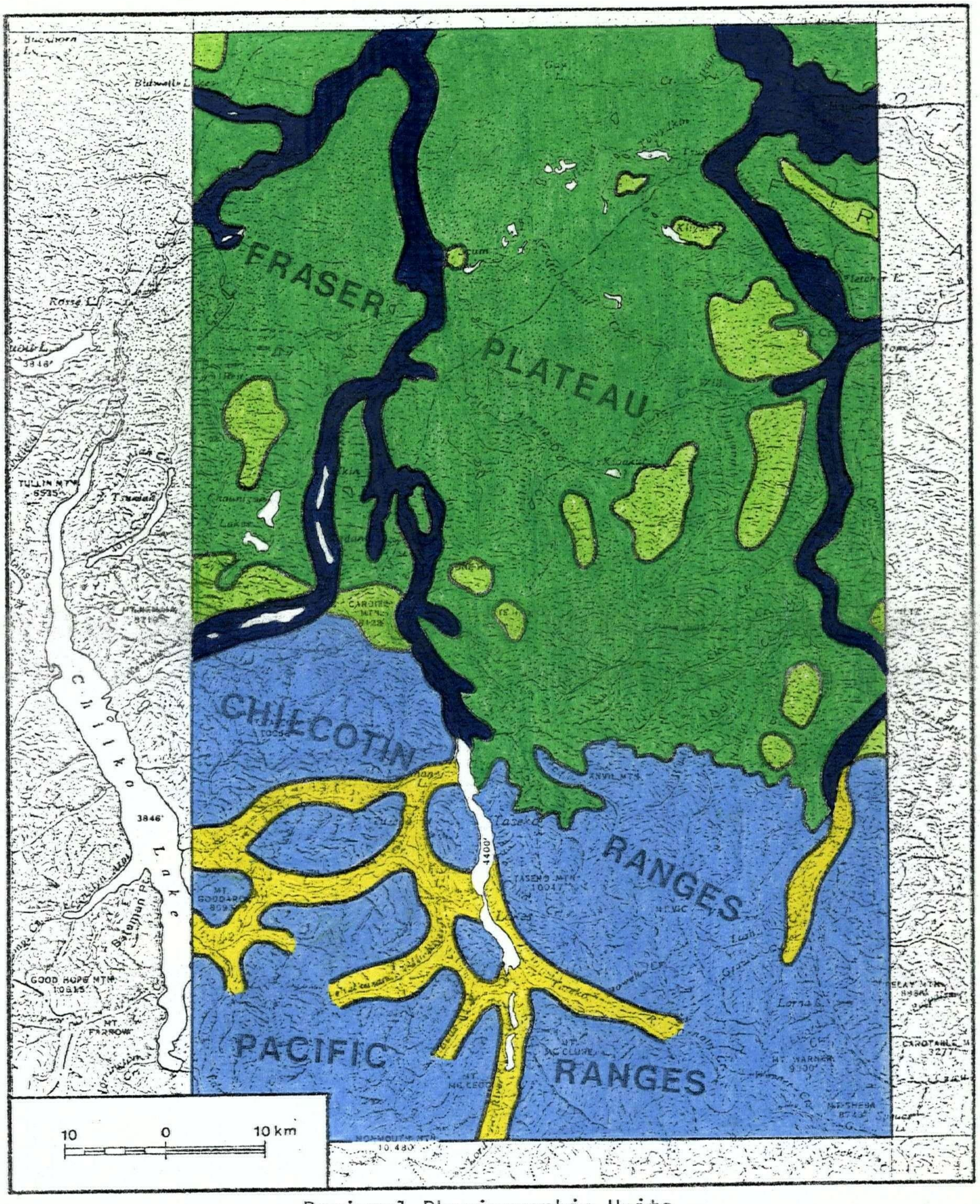


Figure 1 Location of the Study Area in Relation to Vancouver and Williams Lake



Regional Physiographic Units

plateau

hilly plateau

plateau valley

mountain valley

mountains

major boundary

regional boundary

Figure 2 Physiography of the study area. Major physiographic features after Holland [1964]. Regional physiographic features based on topographic expression of the landscape the increase occurring towards the Coast Mountains. A number of hilly areas are found throughout the plateau. The plateau surface is incised deeply by the Chilcotin, Chilko and Taseko Rivers. The valleys are narrow and steep-sided. The Coast Mountains are sub-divided into the Chilcotin and Pacific Ranges by Holland [1964]. The Chilcotin Ranges are dominant in the study area. Both ranges are characterized by high rugged mountains, alpine and cirque glaciers and narrow steep-sided valleys. The Chilcotin Ranges, where they adjoin the plateau, are erosional remnants of the uplifted and inclined plateau which form rounded peaks. Towards the Pacific Ranges the mountains become progressively higher in relief and more rugged. Sharp peaks occur singly or along ridges in the glacially sculptured mountains. The few large catenary shaped valleys that occur in the mountains were modified by large valley glaciers.

Geology

The bedrock was mapped by Tipper [1961] . Underlying the Pleistocene and recent surficial deposits of the plateau are olivine basalt, andesite and related tuffs and breccas of Upper Miocene and possibly younger age. Pre-Miocene volcanic and sedimentary bedrock is common to the hilly areas. In the Chilcotin Ranges, the bedrock is dominantly:

1. varicoloured andesitic pryoclastic rocks, intercalated in places with gray, greenish gray and mauve massive or porphyritic flows and

2. interbedded shale and graywacke or graywacke and conglomerate.

In the Taseko Mountain -- Mount Vic -- Anvil Mountain locality:

1. quartz monzonite and granite,
2. diorite and granodiorite and
3. andesite and basalt are the dominant bedrock types.

The Pacific Ranges are characterized by:

1. greenish granodiorite and diorite with indistinct to prominent gneissosity, many granite and aplite dykes and
2. non-foliated coarse grained biotite granite and quartz diorite.

The area was glaciated during the Pleistocene. Glacier ice from sources in the Coast Mountains advanced over the plateau in a northerly direction [Tipper, 1971]. The proportion of granitic and dioritic type rocks, in the coarse fragments of the till, increases towards the ice source. Where the ice has moved over basaltic bedrock the compacted basal till becomes higher in clay content than the till near the mountains. Ablation features are common on the plateau. Large meltwater channels occupied the main river valleys.

Climate

The climate is strongly influenced by the Coast Mountains. The westerly winds lose most of their moisture in passing over the mountains. Because of this rain-shadow effect, the area is distinctly dry. Summers are short and cool while long cold winters result from the arctic air masses invading the plateau [Kendrew and Kerr, 1955].

The climate becomes cooler with increasing elevation. The Chilcotin River Valley at Hanceville has a significantly warmer and drier climate than the adjacent plateau. On the plateau at 1000 m ASL, the mean annual temperature is 2.2°C. Mean annual precipitation is 34 cm of which 60 per cent is rainfall. The mean annual temperature decreases with higher elevation on the plateau and humidity increases. Winter conditions are prolonged and summers are short. Above 2000 m, alpine conditions prevail. Both temperature and precipitation are low. Windy conditions prevail.

A number of climate stations with temperature and precipitation records are located on the Fraser Plateau. The Big Creek station located in the area was used to characterize the climate of the various segments of the plateau studied.

Vegetation

The vegetation in the study area progresses from open grassland to lodgepole pine and Engelmann spruce forests to alpine tundra herbs and forbes in the alpine. The approximate distribution is given in Figure 3. The grassland and adjacent forest fringe is in the Cariboo aspen -- lodgepole pine -- Douglas fir parkland zone [Krajina, 1965]. In Figure 3 this zone is subdivided into Cariboo aspen parkland and

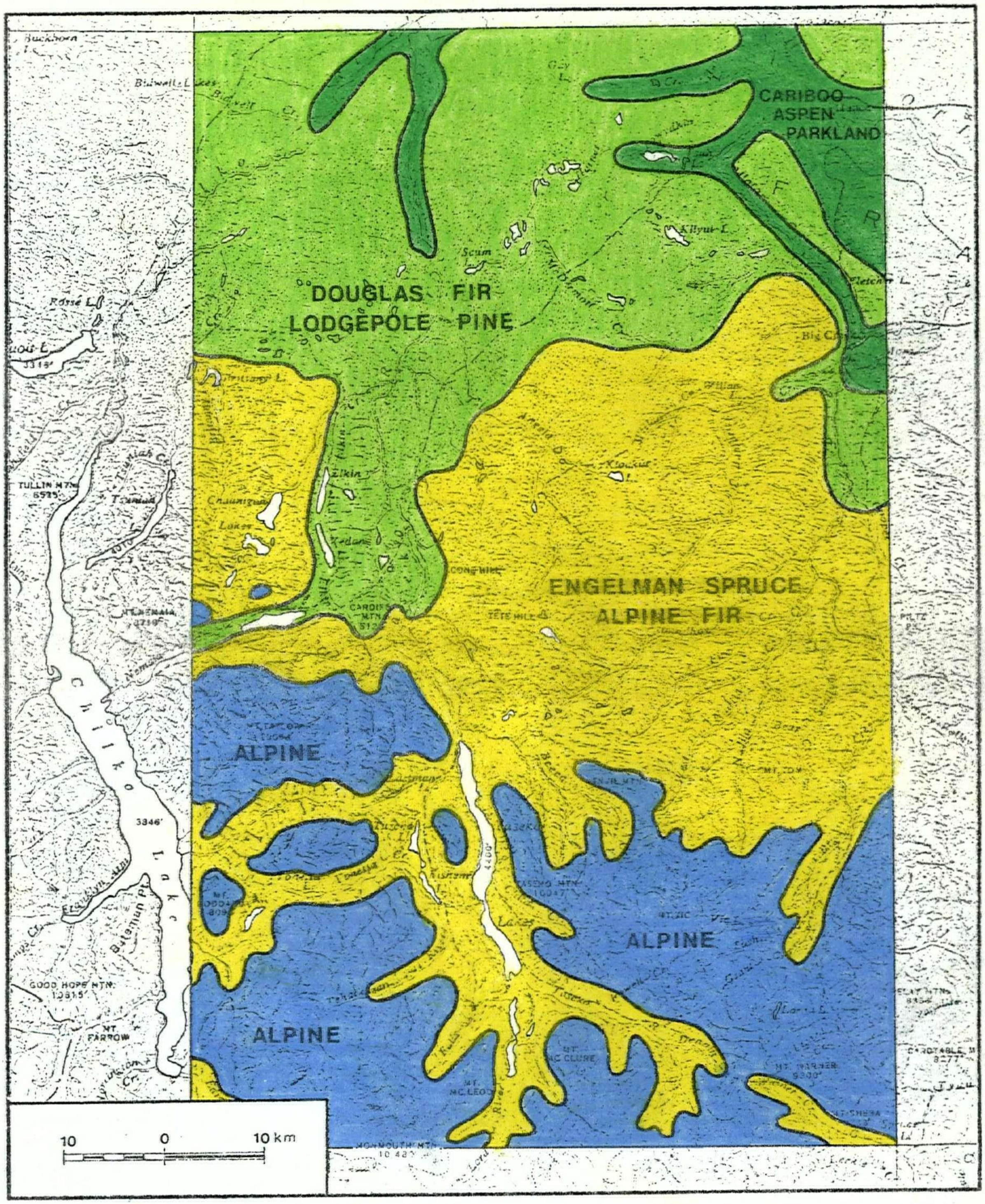


Figure 3 Vegetative Zones Modified from Krajina [1965]

Douglas fir -- lodgepole pine. The former is a mixed grassland-forest occurring in valleys and adjacent plateaus and the latter is on the plateau forested with lodgepole pine. The third zone illustrated, corresponds to the Engelmann spruce -- subalpine fir zone [Krajina, 1965] and it occurs at higher elevation than the first zone. Lodgepole pine is the dominant tree species in these zones, chiefly the result of fire history. Spruce forests occur on soils with higher moisture content which may be less susceptible to fires. The alpine tundra zone occurs above 1675 m ASL and is dominated by heath and herbaceous vegetation.

Soils

An exploratory soil survey was done in the area by the author. From the information collected, the distribution of the major soils was derived.

A wide range of soils was identified in the area. Luvisolic soils are most common on the plateau and Brunisolic soils are most common in the mountains. Orthic Gray Luvisols occur on sandy loam and finer textured parent materials up to 1450 m ASL elevation. Above 1450 m ASL, the Gray Luvisols are classified in the Brunisolic Subgroup. In the larger plateau valleys and many steep southery exposed slopes below 1200 m ASL elevation Chernozemic soils occur on sandy loam and finer textured parent materials. Coarser parent materials within the plateau have Brunisolic soils (usually Orthic Eutric Brunisols) developed on them. Gleysolic and shallow Organic soils occur in localized wet depressional areas of hill and swale topography. A very limited number of observations were made on soils in the mountain region. These observations indicated that Brunisolic and Regosolic soils are the most common.

Present Land Use

Land use in the area is not intensive, with the major part the area left in its natural state. Much of the area is in forest and alpine. Ranching is confined to river valleys and around lakes, where alluvial soils and meadows are used for both wild and cultivated hay production. The forest range is utilized adjacent to meadows and river valleys. Fencing is localized around ranch headquarters and privately owned lands.

Ranching is the main industry in the area. Tourism, mineral exploration and logging are other industries in operation locally throughout the area. Permanent residents derive their living from one or more of these activities. Twenty-two resident holdings are based in the area and there are two Indian Reserves. Resident holdings are the permanent residences of people whose primary income is derived in the area, not including the labour force employed in the various industries. Sixteen of the holdings are ranches. Six of the ranches are self-supporting. An additional seven rely on outside income. Three of the sixteen achieve this additional income through recreational activities, one through a store, three through off ranch labor and one mainly from outside non-resident investments. There are five fishing resorts or camps in the area and five big game guiding services. Four of the latter are run in conjunction with the fishing camps. Mineral exploration is confined mainly to the mountainous area in the southwest. Some interest in copper exploration has developed on the plateau with only one prospect located at present. Active exploration and inventory of several prospects southeast of Upper Taseko Lake are currently underway. With only small deposits of rich copper ores, the mineral potential of the area is considered low.

Little logging activity is associated with the area. Most of it occurs along the Chilcotin River Valley where mature Douglas fir is harvested. Some salvage logging has occurred in and adjacent to a recent burn on the plateau west of Big Creek (terrain type 4). The area is serviced via a forest service access road.

There are no service centres in the area which provide more than one basic service [Weir, 1964]. Two ranches have small stores with a Post Office. Alexis Creek, the closest multi-service center, has several stores, motels and garages.

The main service center for the region is Williams Lake which is an average road distance of 120 km from the closest population centers in the area, Big Creek, Hanceville, Stoney Indian Reserve and the Chilco Ranch. Electricity is available in the northeast corner of the area, and telephone service is available on the eastern edge of the area as far south as Big Creek.

METHODS AND MATERIALS

Field Methods

An inventory of the physical resources was undertaken in the area described using a landform base. On 1:63,360 black and white aerial photography recurring patterns of soil and associated vegetation were identified on the landform base. For simplicity these areas are called "terrain types." The terrain type is similar to the "land system" of Lacate [1969] and "terrain system" of Valentine [1971]. The main difference in the approach used was the greater emphasis on parent materials and recurring pattern of soils. This allowed a better understanding of the land resource in that soils are used as the correlative tool among the terrain types recognized and serve as the physical base for many of the resource interpretations.

The characteristics of the terrain types in the recognizable landforms were checked on the ground. The ground checks were selective due to limited access. A large number of ground checks were made to increase the reliability of the photo interpretation. Detailed site information was collected at "type" localities for major soils occurring in the area. At these sites, referred to as terrain sites, the basic field information on soils, vegetation and related features was obtained. The descriptions for each site were compiled by standardized methods. Soils were described according to The System of Soil Classification for Canada [1970]. Vegetation was identified both by common names and by the scientific names derived from Beil

[1972], Hubbard [1969] and Lyons [1952]. This site information represents the information input required for the comprehensive physical characterization of the terrain type.

Components of the physical environment integrated by soils are climate biota, geology, surface form and time. The study was restricted to a specific physiographic region and to a specific climatic regime. Careful description of soils was made as soils serve as a focal point for land description. Soils integrate the physical environment and served as the correlative tool by which similar areas may be compared.

A description of the land is not complete without an understanding of the integrations of the component factors. The most important integration is the relatively static criteria which form the base for the terrain types. These are the landform and soils. The landforms are an integration of parent material (geologic material, unconsolidated surface deposits) and slope. Soils are a function of parent material, topography, climate, biota and time. Soil integrates a comprehensive information base. The logical classification of soils allows for a wide range of interpretive uses. Both landforms and soils are meaningful in terms of resource utilization. They are relatively stable features of the landscape. As such they show little change as a result of minor environmental changes (for example, forest fires eliminate vegetation which is not, therefore, stable).

Laboratory Methods

Physical Analysis

Bulk density and coarse fragment content: An excavation technique was used for determining bulk density and coarse fragment content. The soil was sampled by horizon. A level surface was prepared. Then 300 cc or more of soil was excavated from the central area without disturbing the residual soil. The hole was lined with a thin plastic (Saran Wrap) leaving no air pockets between the film and the surrounding soil. The plastic was filled level to the top of the hole with water in order to measure the volume of the excavated soil. A 500 graduated cylinder was used for all measurements. The excavated soil was placed in a plastic bag and labelled for transport to the laboratory for drying and weighing. Air dry weights were recorded and used for calculations of bulk density and coarse fragment content. Bulk density of the whole soil was determined by dividing the air-dry weight of soil by the volume of the excavation. The bulk density of the less than 2 mm fraction uses the same division of soil weight by soil volume except that the weight and volume of coarse fragments was subtracted from the respective values for the whole soil. Per cent coarse fragment content was calculated by division of weight of coarse fragments by weight of the whole soil multiplied by 100.

Particle Size Analysis

Particle size analysis was done on the less than 2 mm fraction by employing the pipette method [Black, 1965] and using the apparatus described by Clark and Green [1961]. Organic matter was removed by hydrogen peroxide treatment [Black, 1965]. Samples from two sites were treated with sodium dithionite-citrate procedure [Mehra and Jackson, 1960] to remove free iron oxides.

Chemical Analysis

Measurement of pH: The pH was measured in a 1:1 soil to water ratio [Atkinson *et al*., 1958] and in a 1:2 soil to 0.01 M calcium chloride ratio [Schofield and Taylor, 1955], using a Beckman Zeromatic pH meter.

Organic matter: The organic matter content was determined by wet oxidation, Walkley-Black method [Black, 1965]. The pH varied widely so all soils were done by this method.

Determination of total nitrogen: Nitrogen was determined by the macro-Kjeldahl method [Atkinson *et al*., 1958].

Exchangeable cations and exchange capacity: Exchangeable cations were determined using the method outlined by Atkinson *et al*. [1958]. The extracting solution used was 1.0 N ammonium acetate at pH 7.0. Exchangeable calcium, magnesium, potassium and sodium were determined with an atomic absorption spectrophotometer (Techtron Type AA-5).

Cation exchange capacity was determined by direct distillation of absorbed NH_3 into boric acid and titration with standard sulfuric acid using bromphenol blue indicator [Atkinson et al., 1958].

Base saturation: Base saturation was calculated as the amount of the cation exchange capacity that was satisfied by exchangeable calcium, magnesium, potassium and sodium, and is presented as a percentage.

Oxalate extractable iron and aluminium: Samples ground to pass through a 100 mesh seive were extracted using the acid ammonium oxalate procedure of McKeague and Day [1966]. Iron and aluminium in the extract were determined with a "Techtron Type AA-5" atomic absorption spectrophotometer.

Easily-soluble phosphorus: The easily soluble phosphorus was determined by the Bray method [Atkinson et al., 1958]. The extracting solution removes the acid-soluble plus adsorbed phosphorus.

The detailed taxonomic soil descriptions for each terrain site are presented along with chemical and physical analysis in Appendix I. These were a strictly technical presentation and the information was used indirectly in the text.

Native forage productivity: The native grazing potential of the area was classified using the tentative five class system of Runka's [1973]. Herbage was clipped from plots of 4.05 sq m [1] in area and at

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[1]Plots were 3.7 ft radius with area of exactly one mil acre or 4.046, 856, 422, 4 sq m.

3 cm above the ground surface to measure annual production. The plots were clipped in mid August. Clippings were bagged for transport to the laboratory where the samples were air dried and weighed. Sub-samples were oven dried at 60°C for 24 hr and weights were adjusted and expressed as kilograms per hectare.

The single selective plot method was used to save time without the loss of accuracy of single or few replicates of random plot locations.

The stocking rate for domestic livestock is based on animal units. The animal unit represents a 450 kg animal which required 300 kg dry weight of forage per month. Under range conditions, management requires a 45 per cent carry over of forage which represent 135 kg more per animal unit month (AUM). Thus, a production of 435 kg of forage dry weight per hectare will sustain a stocking rate of one AUM per hectare or one hectare per AUM.

Capability Classification Analysis

Capability interpretations were based on all known and inferred information relating to the resource sector concerned. The degree of subjectivity in the capability ratings is related to the balance between known and inferred information. Capability classification for agriculture forestry, wildlife and recreation sectors uses the nationally approved seven class system (CLI, report #1, 1970; #2, 1965; #4, 1967; #6, 1969 and #7, 1970).

Guidelines to the information collected and used for agriculture, forestry and wildlife -- ungulates -- have been compiled by Runka [1973], Kowall [1971] and Blower, [1973] respectively for British Columbia outlining departure from national methodology. In addition, climatic data was collected and interpreted for agriculture, forestry and recreation by the B.C. Land Inventory (CLI), [1972]. Data from these sources were brought together for land assessment purposes.

The capabilities presented for each resource sector were arrived at independently by specialists. The agriculture capapability was done by the author and is in the form of a preliminary map at the scale of 1:126,720. Capability classification of the area under study for forestry, big game and recreation was obtained from preliminary 1:126,720 maps. Waterfowl capabilities were obtained from a published 1:250,000 map for Taseko Lakes [CLI, 1970].

The capability classification system for the CLI program is based on the physical limitations of the land to support the activities of each resource sector [CLI Report #1, 1970]. Agriculture and forestry are based mainly on soil limitations. In all sectors except forestry, the classification is based on the range of activities, crops or habitat. The capability decreases with the severity of the limitations. The forestry sector bases capability on productivity and each class represents a specific productivity range for adapted tree species. In agriculture the range of crops is the basis for the capability classification. The soil has no limitations for agriculture if all climatically adapated crops may be grown and as the limitations increase the range of possible crops decreases. The wildlife and recreation sector's classification is based on land capability. The wildlife capability classification is based on two main groups of species which occur across Canada: big game and waterfowl. The land capability is based on the degree of environmental limitations for each group, which have their own requirements. The recreation capability classification is based on the range of outdoor activities which can be undertaken in an area. These activities are either land based or shoreline based in the case of water centred activities. Sub-classes denote positive aspects of the land for recreation, not limitations as for the other sectors.

DISCUSSION

Land is comprised of a series of inter-related stratigraphic components. The components may be integrated in various ways depending on the viewpoint to demonstrate functional environmental relationships. Geology and climate are primary independent components in the sense of Alvis, [Wertz and Arnold, 1972]. Time is an abstract component which facilitates interactions between the basic components to produce secondary components. Secondary components are dependent on and related to primary components. The second order components are landforms and organisms. Landforms in the genetic sense are an integration of bedrock, surficial materials and slope. These provide the physical base for the mapping of the terrain types. Landforms integrate basic components of the land and are also identifiable on aerial photographs. Organisms are the plant and animal life associated with the land. Soil-vegetation relationships are more easily studied than soil-animal relationships because plants are spatially fixed throughout life whereas animals are mobile. Soils, as a function of parent material, topography, climate, organisms and time, most completely integrate the land components.

Interpretations are facilitated by considering soil as an integrator of the stratigraphic land components. Land capability for sustaining life is an interpretation based on soil and climatic factors. Soil factors include slope, fertility and position.

Climatic factors include heat and moisture. Hydrology is included into the land description through integration of soil and climate factors. Soil drainage, permeability and infiltration capacity are examples of hydrologic information incorporated in soil description. The amount and state of water in the terrain type is described by climatic information. Interpretations related to land use can be based mainly on soil factors with supplemental information on basic land components desirable.

This physical base is useful for assessing the response of the land to utilization practices. Land sensitivity can be determined when more information is gathered -- information which has direct relationship to land use as outlined by Leven et al. [1974]. The base is also useful in socio-economic studies since the units are small and activities and changes are easily studied at the local level. The terrain types sustain uses that are related to their inherent capabilities.

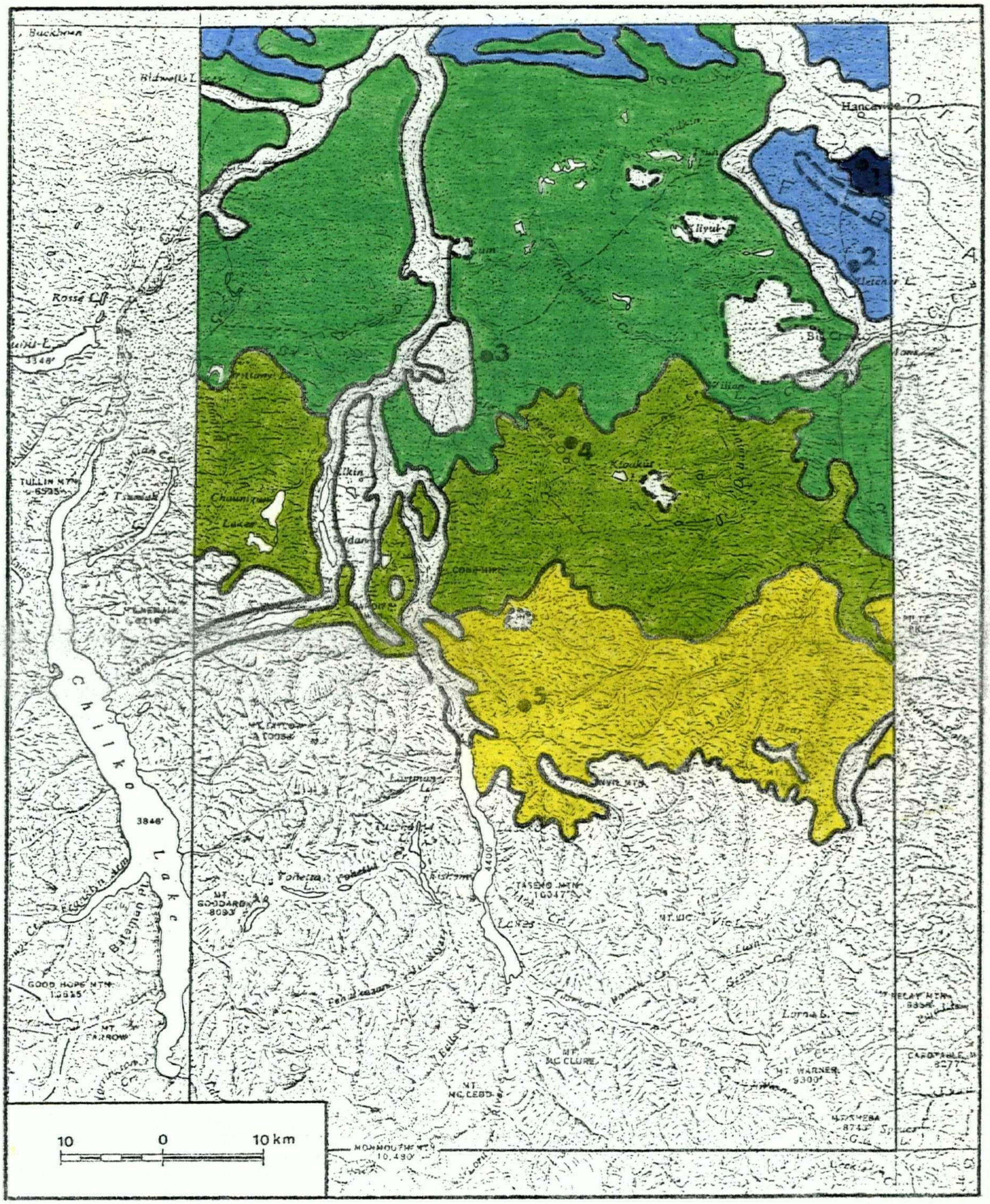
The soil resources and capabilities for agriculture, forestry, big game, waterfowl and recreation are presented for five of the seven recognized terrain types in the study area. The five terrain types studied in detail represent 45 per cent of the 7,726 km^2 of the study area. The terrain types are identified numerically with increasing elevation. They are on the level to rolling plateau. The distribution of the terrain types and location of terrain sites are illustrated in Figure 4. The remaining 55 per cent of the 7,726 km^2 is comprised of mountainous and hilly terrain types. The mountain and valley terrain types as illustrated in Figure a and b are not studied in detail because their complex variation over short distances has not been adequately inventoried and a larger scale of mapping would be required.

Climate is discussed in relationship to the data from data from the Big Creek station (Table I). Discussion of the data in this table is presented in the climate section of terrain type two and the climate of all the other terrain types is discussed relative to this data.

Discussion of each terrain type includes sections on site inventory and land evaluation. The site inventory states location, present land use, soil resources vegetation and climate based on site observation. The land evaluation presents the capability ratings for each resource sector and discussion on the limitations of each. Data used in the evaluation of the terrain types is presented in Tables I, II, III, and IV. The order is consistently agriculture, forestry, big game, waterfowl and recreation. Following the presentation of inventory and evaluation, a discussion on physical land use in the area is presented.

Legend to Figure 4

Terrain Type	Topography	Elevational Range (metres)	Aerial Extent KmxKm
1	Gently undulating to gently rolling	945-1035	17
2	Gently undulating to gently rolling	1035-1160	231
	Gently rolling to strongly rolling	1035-1250	104
3	Gently undulating to gently rolling	1100-1370	1670
4	Undulating to moderating rolling	1370-1525	870
5	Gently undulating to moderating rolling	1500-1800	535
Valley	Steeply sloping irregular valley sides with stair-stepped terraces	475-1035	4000
Mountains	Steeply sloping irregular regular rocky ridges and valleys of high relief	900-3000	



—— Terrain type boundary

----- Topographic variant boundary

●5 Sample site

Figure 4 Location of the Sample Sites and Distribution of the Terrain Types

TABLE I

Climate Data from Big Creek

(51° 44' North Latitude, 123° 02' West Longitude, 1134 metres ASL Elevation)

Element	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
Mean Daily Temp	-11.61	-6.22	-2.83	2.61	7.72	11.11	13.72	13.11	9.44	3.56	-4.22	-9.22	2.28
Mean Daily Max.Temp.	-4.67	1.28	4.33	9.78	15.78	18.61	21.94	21.06	17.44	10.67	2.00	-2.78	9.61
Mean Daily Min.Temp.	-18.56	-13.78	-10.0	-4.56	-0.39	3.56	5.50	5.22	1.44	-4.17	-10.39	-15.67	-5.11
No.Days with Frost	31	28	31	29	19	6	1	1	12	27	30	31	246
Mean Rainfall	1.27	0.25	0.25	0.50	2.35	5.18	3.25	4.62	2.64	1.19	0.20	0.15	20.24
Mean Snowfall	26.9	17.8	21.3	11.7	5.8	T	0	0	1.0	7.1	18.3	27.2	137
Mean Total Precipitation	2.82	1.80	2.21	1.63	2.95	5.21	3.25	4.62	2.72	1.91	2.03	2.07	34.00
No.Days with Measureable Rainfall	*	*	*	1	5	8	6	8	6	3	1	*	38
No.Days with Measureable Precipitation	7	5	5	4	5	8	6	8	6	5	6	7	72

T Trace

* Rainfall -- occasionally but not every year

Source: Canada Department of Transport, 1967

Figure 5 Illustrations of the Mountain and Valley Terrain Types

(a) Mountain terrain type showing the Lord River valley in the background

(b) Narrow steep-sided Taseko River valley incising flat lying plateau basalts

Land capability analysis procedures use all available information on renewable resource potential to identify the sector with the highest potential. A measuring tool for resource potential is the capability rating. Sectors having the same capability class rating are considered equal with the exception of big game. Big game has been dropped one class because it represents an extensive use of the available resource. This is a qualitative evaluation of the sector capabilities. The positive aspect of man's interference creates a further imbalance as a result of the different responses of the sectors to management. Man's direct input into agriculture which makes this sector out-produce all other sectors is stimulated by the satisfaction of human needs being realized. The other sectors are subject to less interference by man and their lower production is sustained without human input while the goods are readily used by man. The CLI capabilities are used as the measuring tool in land evaluation which identifies the sector with the highest capability.

The physical land allocation uses several concepts as planning tools. These concepts have developed through observation and measurement of land resources to different management systems.

Land use planning requires tools. These tools provide the answers to the what and why of planning land use. Planning considers tomorrow's needs today. These needs are viewed differently by management and by producer. Management is conservation oriented to provide long-term human benefit. Management comprises a comprehensive base which includes goods and services required by local and regional population. The producer specializes in the development and exploitation of the land resource. The producer is concerned with producing goods or services immediately marketable.

Planning bridges the gap between management and the producer. Strategies may favour either in the course of time. Presently, attention is focused on strategies favouring management. In the past, the producer had few restrictions in developing the land resource. Increasing population and an awareness that the fixed land resource varies considerably in capability to provide goods and services is prompting a shift in outlook. One example of this shift is the legislation in British Columbia to protect land which has high agricultural capability. The capability of land resources to provide returns is a factor to be recognized in planning. Planning should recognize these capabilities for the output of goods and services to maximize public welfare.

The end result of planning strategies depends on interaction of the land resource and human considerations. In regions of high capability, returns to the producer could be high. This situation leads to increasing development without adequate consideration for the land resource which produces the wealth. Strong strategies such as zoning are required where the land resource capability for vital needs is scarce. The agricultural land reserve system in British Columbia is an example where a land resource is protected from short-term irreversible damage. In areas of high capability, the land resource use is highly specialized and stable. In areas of low capability, on the other hand, the land can only marginally supply goods and must rely on a wide resource base for production in a competitive system strongly influenced by production from high capability uses. Thus different strategies are required for the management of low capability resources.

Each physical resource has its unique capability for specific uses. Interactions of physical, biological, chemical and environmental components combine to produce the capability. The alteration of one component through use has an effect on the other components. The land use plan which manipulates the interactions to yield a result greater than any single component is favoured. Integrated land use will yield greater returns than single land use.

Integration of the land resource component capabilities to yield returns from each capability sector is the principle behind multiple land use. The term "integrated" is preferrable to "multiple," in that it has a stronger connotation of comprehensive approach and an understanding of the resource component interactions. In an area of low capability, extensive areas are required for the production of goods and services. The terrain types in this study are examples. The integrated approach to planning is based on the five resource sectors discussed.

Alternative methods of management are available in integrated land use. All resource sectors are considered and the sector or combination of sectors which contribute the maximum benefit, is selected in the physical land use plan. An exclusive use is identified when the capability of one sector is significantly higher than the other sectors, and when it is combined with a lack of the specific resource to supply human need. More commonly, a combination of uses is identified which, when combined, produces a greater return than for separate, individual uses. These multiple uses may be ranked according to a heirarchial system such as primary, secondary and incidental use. Primary use identifies the most important use in the system. When management practices conflict, the one favouring the primary use is adopted. The main considerations are based on degree of conflict, as very few different uses are truly compatible. Careful selection of management criteria creates harmony between uses by reducing paths of conflict. While the secondary use is a less importent use than the primary use, it is still capable of producing a significant contribution to the supply of human need. Incidental use is a use which is not necessarily planned, but occurs as a result of the overall plan. It can be considered a favourable side effect. An example are the dugouts which are made to supply water for livestock in pastures and which create a habitat for waterfowl production without additional management input.

The plan for the land resource assumes maximized sustained utilization. The plan identifies the uses which achieve full utilization of the capability. The land use plan projects more intensive resource use than at present. The use of resources becomes more efficient with time as increasing pressures effectively point out resource scarcities and management experience aids in efficiency.

The physical land use plan is compiled using the physical capabilities. In the plan for each terrain type, the physical plan optimizes sustained returns by means of conservation oriented management and utilization practices. The plan includes social values only where specific needs are high and land resource bases capable of supplying these needs are scarce. Generally, the plan will point out the most efficient means of obtaining maximum returns from the land resource without resource degradation.

Assumptions used in the capability analysis to rank capabilities among resource sectors do not achieve a heirarchy. Man plans land use for his benefit. The result is land use that yields the greatest returns, with respect to his needs, takes precedence over other uses.

The intensity of land use increases with the capability for each resource sector. The higher the capability, the more management options are open for each sector. The productivity on low capability land may have a higher type of production than on high capability land, but the products of the high capability lands are more diverse. The intensity of land use in a given sector may not increase uniformly with capability.

The intensity of land use in a specific capability class is not the same for each resource sector. The heirarchial order showing decreasing intensity of land use by sector is -- agriculture, forestry, wildlife and recreation. Ranking the sectors according to importance varies from region to region. In areas with abundant agricultural land but very few forests, the forests would be very important as local needs would be high. The physical land use land must attempt to balance the land use according to human needs in addition to physical capability.

The maximum sustained production results from proper management of the land resource. Integrated land use is advocated where the sum of the parts is greater than the whole. Simple land use is more pragmatic where the whole is greater than the sum of the parts. A physical land use plan is presented for each terrain type based on these principles in addition to an overview of the area as a whole.

Results

The terrain type and terrain site information gathered in the inventory is assessed to yield their capabilities. Information from many sites is used to evaluate the physical resource capabilities. Agricultural and forestry capabilities are correlated directly with soils. This relationship can be adjusted to fit the terrain type. Big game, waterfowl and recreation capability is assessed at the terrain type level. These sectors rely on variation in the landscape in the process of capability classification since a number of site requirements need to be met.

The terrain type is a continuum of terrain sites. Any given terrain site can vary from the general nature of the whole type. These variations and the homogenuity of the terrain types are stated. Terrain types four and five are examples of heterogeneous landscape units which as described and discussed as an entity. Terrain types represent a lateral extent in the order of square kilometers whereas terrain sites are the small or point samples of the landscape which are collectively used to characterize the terrain type. A representative terrain site was selected for description and sampling purposes. Small localized inclusions occur within the terrain types but are not identified. The terrain type is the main unit used for classifying land. Terrain types are described independently and the differentiating factors are qualities of the land resource.

Terrain types are used as standard units in characterizing the impact of different resource management practices. Comparison of different resource sectors is also possible because output is measured from the same area or a recognized portion of the terrain type, as in the case of wetlands. Physical land use plans are designed with all resource sectors and environmental parameters considered on the same unit area. Projected capability utilization by different land use plans allows for evaluation of the optimal land use allocation. The standard base for studying land qualities and capabilities is essential in order to compare different land use alternatives.

Site Discussion

Terrain Type 1

Site location: 51° 52' 35" North Latitude. 123° 2' 45" West Longitude. Located on spring and fall range of the Chilco Ranch 5.7 km at 140° from ranch headquarters.

Present land use: The present land use on terrain type 1 is spring and fall range belonging to a large ranch holding. The area was fenced to aid in management of the grassland area. This was part of the largest area of this limited and critical range type for domestic livestock in the area. The presence of "weed" species on these rangelands suggest over utilization in the past, and possibly at present. No range seeding or other practices, except fencing to control grazing, were apparent.

Position: Figure 6 (a & b) shows the gently undulating till plain in a broad shallow dip of the plateau adjacent to the Chilcotin river valley and gradually widening towards the southeast. The soil pit is at 990 M elevation on a 5 per cent northeast facing slope.

Figure 6 Terrain Type 1: (a) Two landscape pictures of the terrain type showing the open grassland with irregular clumps of trees

Figure 6 Terrain Type 1: (b) A view of the sample site looking south towards a ridge on the plateau, (c) The color infrared picture similar to 5(b) contrasts the vegetation with the ground surface and shows the surface stoniness associated with this terrain type

Figure 6 Terrain Type 1: (d) A closeup of the vegetation showing the sparse grass cover in the late summer after spring grazing

Geology: The gravels and cobbles in the morainal deposits increase with depth and become more homogeneous. The majority relate to the olivine basalt and andesite mapped in the area and are dominantly vesicular. In the vicinity the soils are relatively deep but the gradation of the material in the soil pit with depth suggests a depth of one to two metres to bedrock. The ice movement was northerly [Tipper, 1971].

Vegetation: The site is located in parkland vegetation with the sample site in a large opening of grassland (Figure 6 c,d,e). Trees (lodgepole pine, aspen, and Douglas fir) occur in slight depressions, especially along runoff channels which feed into the few small to medium ponds in closed depressions. The grassland area appears to be heavily grazed, resulting in a relatively high incidence of "weed" species. The dominant vegetation is listed below with common and scientific names and relative abundance at the site.

Sandburg's bluegrass	*Poa secunda*	abundant
White Pussytoes	*Antennaria* spp.	abundant
Pasture wormwood	*Artemesia frigida*	abundant
Alkali bluegrass	*Poa juncifolia*	common
Long Plumed Purple avens	*Geum triflorum*	common
June grass	*Koeleria cristata*	common
Needle and thread	*Stipa comata*	common
Fleabane	*Erigeron*	few
Blue bunch wheatgrass	*Agropyron spicatum*	occasional

The ground cover ranges from 30 to 70 per cent (Figure 6 d). From the sample plot which was subject to light spring grazing, the annual available herbage production was 739 kg/ha.

Climate: The climate at this site is actually warmer in the summer and has a longer frost free period relative to the climate as characterized by the station at Big Creek [Canada Department of Transport, 1967]. The growing degree days (>6°C) are significantly higher at this lower elevation and thus the evapotranspiration is much higher. Without irrigation, the climate restricts the range of crops to drought resistant forage crops. Under irrigated conditions, the range of adapted agricultural crops include hardy vegetables in localized sites, cabbage, cauliflower, potatoes, alfalfa, red alsike, broome grass, sweet clover, timothy, oats and barley. The agricultural climates of the terrain types is presented in Table III. The frost free period is estimated to be 60 to 75 days. The range of growing degree days greater than 6°C is 235 to 271 days. The daily temperature fluctuation is relatively high.

The mean annual precipitation is estimated as less than 34 cm. The May to September precipitation is estimated at 16.5 cm. Supplemental water, in the form of irrigation, is essential to attain optimal production and range of crops climatically adapted to this terrain type.

Soils: The soils represented by this terrain type are well drained, moderately permeable, have medium runoff and medium to rapid infiltration. The surface horizon is dark colored with a 4.7 per cent organic matter content. Thus surface is underlain by a dense clay horizon which is plastic when wet, hard when dry, and it is less permeable that the surface horizon. The bulk density increases greatly with depth. The chemical characteristics of the soil show it to be high

TABLE II

Forage Yield and Grazing Capability for the Terrain Types

Terrain Type	Range Type	Forage Yield kg/ha	Grazing Capability Class*
1	Grassland	740	2
2	Forest Range	350	3
3	Forest Range	120	5
4	Forest Range	180	4
	Meadow	1820	1
5	Forest Range	90	5
	Meadow	1790	1

*Runka (1973)

TABLE III

Agricultural Climate for Each Terrain Type

Terrain Type	Climate Class	Frost Free Period Days	Growing Degree Days Above 6°C	May to Sept Precipitation Centimetres
1	3	60-75	235-270	16
2	5	30-50	170-235	16
3	5	30-50	170-235	19
4	6	< 30	114-170	21
5	6	< 30	114-170	~24

Source: B.C. Land Inventory, Climatology Report #1 and climate capability maps (unpublished) for 920/NW, 920/SW, and May to September precipitation map (unpublished) for 920.

in bases, especially calcium and magnesium, with a neutral reaction. The soil fertility status with respect to macro nutrients is high.

Physical capability: The sector capabilities, presented in Table IV, show the information given on the capability maps for each sector.

The agriculture capability of this soil is moderate to prime when irrigation is utilized. Due to the overriding climatic aridity, the dryland capability of this site is limited. Under irrigation, the main limitations are stoniness, which interferes with cultivation and climate. The climatic limitation, which becomes evident once irrigation eliminates the effect of aridity, is a combination of insufficient heat units during the growing season and minimum temperatures which retard plant growth. These Class 3 sites limit the range of crops to (1) adapted vegetables, in favoured local sites, (2) forage crops such as alfalfa, red alsike, brome grass, sweet clover, and timothy, and (3) cereal crops such as oats and barley. Under dryland farming practices drought resistant forage crops can be grown.

In its present state, the native grasses had an annual dry matter production of 740 kg/ha based on a plot where some spring grazing had occurred. This places the site into Class 2 in the tentative land capability for grazing classification. The site was considered in poor condition as evidenced by the near absence of bluebunch wheatgrass and the abundance of pasture wormwood.

The forest capability of this site and terrain type is Class 7. The main limitation is climatic aridity and high salt

TABLE IV

Physical Land Capability of Terrain Types

Capability Rating	Terrain Types				
	1	2	3	4	5
Agriculture	4^6-3^4	5	5	6^8-5^2	6^8-7^2
Forestry	7	6	6	6 - 7	6 - 7 - 5
Big Game	5	4^7-$3W^3$	3^6-4^4	3^6-4^4	4
Waterfowl	4*	2 to 6*	5, 6*	4, 5*	6, 5*
Recreation	6U	6U	6U	6U	5U

*Waterfowl capabilities refer to the wetlands within the terrain type.

Source: Published (CLI, 1970 Taseko Lakes) and unpublished CLI capability maps.

concentration in localized areas. The base saturation of the soil is greater than 100 per cent.

The land capability for big game production at this site had moderately severe limitations. Open grass parkland does not provide cover vegetation for game species such as deer. The site had little suitability ungulates which may be partially due to ranching activity in the area. Climatic aridity is the main limitation at this site. Thus the growth of suitable food is restricted, and soil moisture content is low. The snow depth restricts ungulate movement and the availability of food plants.

Where waterbodies occur, this terrain type has moderate limitations to the production of waterfowl. The main limitations are reduced marsh edge and inundation. The reduced marsh edge is governed by the local low relief topography. Low relief is a major factor affecting the inundation limitation. Excessive water level fluctuation is common on this landscape. Depressions ponding the water are closed with intermittant surface drainage only under high water conditions. The water level drops during the summer due to evaporation and water percolation into the soil. Deeper ponds would reduce these natural limitations. The waterfowl capabilities have a range of Class 1 to 4 on this terrain type.

The recreation capability is Class 6 for this upland site. It will support a sustained low total annual use, based on dispersed activities. These activities are associated with positive recreational aspects such as topographic patterns, upland wildlife and significant vegetation.

Capability analysis: The analysis of capabilities for this terrain type identify moderate capabilities for agriculture and waterfowl. As these values are peculiar to separate components of the terrain type, the area may be subdivided to show areas of moderate agriculture and moderate waterfowl. Under the good management assumptions of the CLI capability classification system this division is deemed reasonable.

Terrain Type 2

Location: 51° 47' 30" North Latitude. 123° 04' West Longitude. Approximately 1.9 km by road north of Fletcher Lake.

Present land use: This site is Crown land with natural forest cover. As rangeland, it would be considered secondary range, that is, range to be used only if no other range which livestock prefer is available. This site is presently used by wildlife, the extent of which is uncertain. Distance to water is significant as the topography is of low relief with few occurrences of suitable water supply. A fishing resort and private recreational holding occur on Fletcher Lake 1.5 km to the south.

Position: The selected sample site is positioned on the mid to upper region of a 4 per cent south facing slope. The elevation is approximately 1140 m.

Geology: The bedrock is overlain by a thick mantle of glacial deposits [Tipper, 1971 & Heginbottom, 1972]. The surficial materials are compacted ground moraine containing, in the greater than 2 mm fraction, a mixture of vesicular basaltic and sub-rounded andesitic gravels and cobbles. Cobbles and boulders are of infrequent occurrance at the site.

Vegetation: The site is located in the Cariboo aspen-lodgepole pine-Douglas fir parkland zone [Krajina, 1965]. The forest canopy is nearly closed. Lodgepole pine dominates and the occasional aspen is observed. The ground-cover of pinegrass is relatively uniform (Figure 7). The dominant vegetation is listed below.

Lodgepole Pine	*Pinus contorta*	abundant
Pinegrass	*Calamagrostis rubescens*	abundant
Kinnikinnick	*Arctostaphylos Uva-ursi*	common
Bedstraw	*Galuim* spp.	common
Pea vines	*Lathyrus* spp.	common
Aspen	*Populus tremuloides*	few
Wild rose	*Rosa* spp.	few

The herbage clipped from a plot at this site yielded 350 kg/ha. No disturbance which would indicate grazing was observed. The productivity is similar to the pinegrass range used in studies by McLean [1972].

Climate: The climate at this site is represented by the records from the long term atmospheric environment station located at Big Creek (51° 44' North Latitude, 123° 12' West Longitude; elevation 1133 m ASL). This station is several kilometres south of the

Figure 7 Terrain Type 2: The Lush Pinegrass Vegetation is Seen in the Sunlight that Penetrates Through the Nearly Closed Lodgepole Pine Canopy

selected sample site, but it is representative of the terrain type. Selected data from this station is presented in Table I (page 25).

Frost occurs in every month of the year and the frost free period is between 30 and 60 days. The mean daily temperatures are above freezing for seven months and are greater than 6°C for five months. Based on the monthly means, no thermal growing degree days, greater than 18°C, occur for as long as a month. Thermal periods, if any, would occur during the frost free period. The daily temperature is high, varying as much as 15°C. This difference creates highly variable temperature regime for plants to adjust to in a daily cycle. The cool night temperatures reduce evaporation and soil temperature.

The annual precipitation is low, averaging 34 °C. The mean May to September precipitation is 18.5 cm. A moisture defiict is a significant limitation to optimal plant growth, although coniferous trees survive in this arid environment. The annual snowfall averages 140 cm.

Soils: The soils at this site and the terrain type it represents are well drained, have moderately slow permeability, medium to slow runoff and slow infiltration. The surface is protected by a thin mat of organic litter. This litter overlies a moderately dense mineral horizon of silt loam texture. The next horizon is more dense and has a higher clay content. It has accumulations of clay in pores. This tends to restrict water movement and root and air penetration. Loss of nutrients through leaching is reduced and the water holding capacity is increased. The coarse fragment content, varies laterally and vertically.

As is typical of Orthic Grey Luvisols, this soil is low in organic matter content. The base status is high judged by the dominance of exchangeable basic cations. The wide carbon to nitrogen ratio, 34 to 1, in the surface mineral horizon, suggests little microbial activity in breaking down organic materials and a low nitrogen status in the soil. In the major plant rooting zone the soil reaction is slightly acid.

Physical capability: The soil capability for agriculture at this site is Class 5. The main limiting factor is climate. A combination of insufficient heat units and minimum temperature, which retards plant growth, adversely affects crops during the growing season. In addition, a minor subclass soil limitation due to stoniness is noted. The overall climatic aridity at this site does not affect the capability, but it is a limitation to productivity of adapted crops.

The native grazing capability of this terrain type is Class 3 on the basis of a herbage yield of 350 kg/ha. The dominant herb is pinegrass. Early in the growing season it is highly nutritious although as it matures it becomes somewhat unpalatable to cattle. At present, little or no grazing by domestic livestock occurs at this site.

The average annual productivity of this site is 2.1 - 2.2 m^3/ha based on plot measurements. Lodgepole pine is the preferred species. The major limitation is climate. This site represents a terrain type which was classified as Class 6 for forestry, but the plot results indicate the productivity is on the upper limit of this class.

This terrain type is classified as 70 per cent Class 4 for deer and moose, and 30 per cent Class 3 for moose. Moderately severe limitations are due to low soil moisture holding capacity which affects development and growth of vegetation. Another factor on this terrain is the high snowfall which affects the mobility of ungulates during the winter. Few browse species are evident and stocking is low in the vicinity of the sample site. Saskatoon berry is the most common browse plant available.

The waterfowl capability is Class 7 on the majority of this terrain type. The gently rolling topography restricts the development of wetlands. In low lying areas, the lack of waterflow results in poor quality habitat. The few wetlands classified on this terrain type are usually moderate to limited capability (Class 4 to 6). The medium soil texture has moderately good water retention. This is suitable for the development of wetlands by construction of check dams along intermittant drainage channels.

The recreation capability for this terrain type is low. The topography does not allow for the viewing of the landscape. The monotanous extent of lodgepole pine-pinegrass vegetation is the main positive feature of this terrain type. The positive aspects of this Class 6 terrain type are topographic pattern, upland wildlife and significant vegetation.

Capability analysis: The agricultural and big game capabilities are limited. However big game has a significant component of moderate wintering capability whereas the agriculture capability is straight Class 5. Based on physical capability values, the area would be allocated to big game.

Small sub-units of the terrain type would be allocated to waterfowl based on its capability merits. The waterfowl capabilities are mainly site specific, and range from prime to Class 6. All localized prime, moderate and limited waterfowl capability areas are allocated to that sector.

Terrain Type 3

Location: 51° 42' North Latitude, 123° 38' West Longitude. This site is situated to the south side of the military engineer's road to the Taseko River, 5 km southwest of the New Meadow Fishing and Hunting Camp.

Present land use: Natural forest occurs on terrain type three. Lodgepole pine dominates and the stocking ranges from 550 - 800 trees per hectare, at ages greater than 90 years. The site is located 5 km from a series of lakes which have two hunting and fishing camps associated with them. Moderate and limited moose and deer summer habitat occurs adjacent to the lakes. Some utilization of the forest range occurs adjacent to grassy south aspects of small hills and sedge meadows.

Position: The sample site is on a nearly level plain at 1275 m ASL elevation. Figure 8a illustrates the landscape of the terrain type.

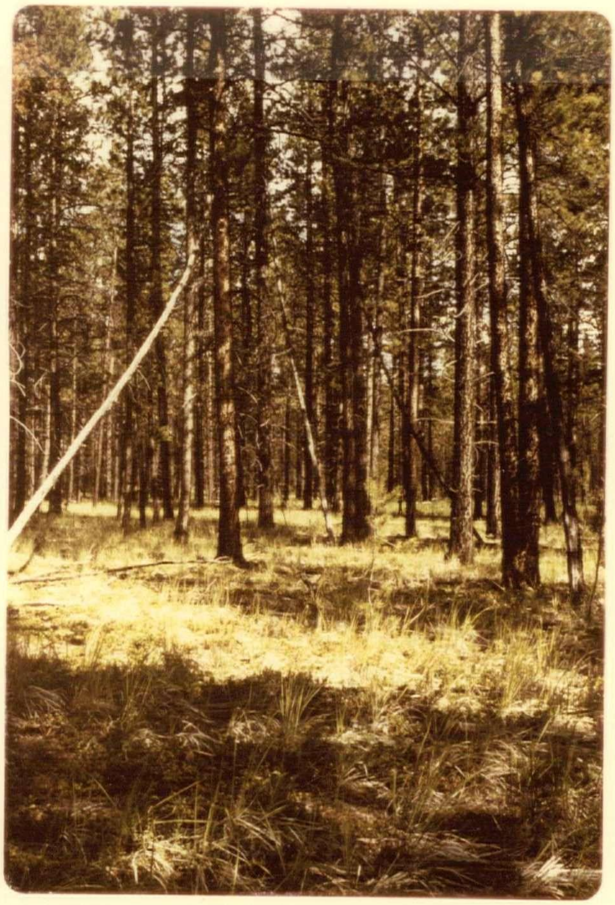


Figure 8 Terrain Type 3:
(a) The low relief of the plateau surface is seen along the road
(b) The low growing ground vegetation receives sunlight through the lodgepole pine canopy

Figure 8 Terrain Type 3: (c) The sparse ground vegetation found on terrain type 3 under the lodgepole pine forest

Geology: A deep mantle of Pleistocene glacial material blankets the area. The surface is featureless as no streamlining or channel patterns occur in the vicinity of the site. The material has undergone some sorting by water as evidenced by the low clay content and the occurrence of sand lenses within the section. Coarse fragments are dominantly sub-rounded andesitic with some basaltic, granitic and sedimentary rock types also being present. This material blankets a compact ice-deposited morainal material at depth which varies laterally. Exposures of the ice-deposited materials are rare in this terrain type. Where the topography is more variable and hilly, bedrock may be near the surface.

Vegetation: The site is located on the upper elevational limit of the Cariboo aspen-lodgepole pine-Douglas fir parkland [Krajina, 1965]. Lodgepole pine is the dominant species as a seral climax. Fire scarred Douglas fir veterans occur sporadically in the area. The canopy is nearly closed and the ground cover is in the 60 to 80 per cent range (Figure 8 b,c).

The dominant vegetation is listed below:

Lodgepole pine	*Pinus contorta*	abundant
Wild rose	*Rosa* spp.	common
Kinnikinnick	*Arctostaphylos Uva-ursi*	common
Pinegrass	*Calamagrostis rubescens*	abundant
Dryland sedge	*Carex concinnoides*	common
Spirea	*Spirea* spp.	common
Pea vine	*Lathyrus* spp.	common
Fireweed	*Epilobuim arrgustifolium*	common
Yarrow	*Achillea millefolium*	common
Shepherdia	*Shepherdia canadensis*	common
Juniper	*Juniperua communis*	common
Saskatoon berry	*Amelanchier* spp.	occasional
Lichens		occasional

Herbage production at this site is measured to be 120 kg/ha.

Climate: Climate at this site is cooler and more humid than at Big Creek. The change in climate, however, is not of great significance. The frost free period is 30 to 60 days. Daily minimum temperatures during the growing season are close to freezing. Both the mean annual and the May to September precipitation are estimated to be slightly higher than at the Big Creek station. Evapotranspiration is estimated to be slightly lower, yet a significant moisture deficit occurs during the growing period.

Soils: The soils of this terrain type, are well drained, rapidly permeable and have slow runoff and rapid infiltration. The soil is gravelly and moderately coarse textured. Coarse fragment content ranges between 20 and 50 per cent. Sand content ranges between 50 and 65 per cent with silt sized particles accounting for 35 per cent. Coarseness of texture reduces the moisture holding capacity of the soil, and, this terrain type is subject to more droughtiness than terrain type 2. Although the climate is more moist and cooler, the edaphic effect is a more arid environment for plant growth.

The coarse textured mature of the mineral materials of the soil also affects its chemical properties. This soil is more acid in reaction and it has a lower capacity to retain or attract cations. Lack of a dense clay enriched subsurface horizon reduces the soil water holding capacity and fertility; however, the significant increase in clay content of this horizon is very beneficial. Without the clay enriched horizon, this soil would not respond as well to management and it would have to be left in its natural forested state. The organic matter content is very low, less than one per cent, even in the surface mineral horizon, and likewise the level of nitrogen is inferred to be very low.

Physical Capability: The agriculture capability at this site is limited to Class 5 by climatic factors. Low heat unit accumulation combined with minimum temperatures, which adversely affect plant growth, are the two most significant climatic factors. The moderately coarse textured soils will severely influence the productivity of suitable crops due to low water storage capacity combined with a water deficit during the peak growing period. The most significant soil limitation is adverse stoniness which affects cultivation.

The measured herbage productivity at this site is 120 kg/ha. For native grazing, the carrying capacity is low and its capability is Class 5 in the grazing system. The low productivity is due to both low stocking and poor growth.

The main limitations of this site for the growth of commercial forests are adverse climate and low soil moisture holding capacity. The capability is Class 6. The May to July precipitation is 11 cm or less. Plot measurements for forest capability on this soil indicate a mean annual increment of 1.4 to 1.7 m^3/ha which is in the mid-Class 6 range of productivity.

The big game capability of this terrain type is classified as 60 per cent Class 3 and 40 per cent Class 4. The landscape has enough variability to provide localized areas of quality habitats with the low forest stocking providing cover. Drainageways and depressions have a greater quantity of browse. These are small and are scattered throughout the area yet extensive enough to justify a Class 3 rating. The water occupies the smaller depressions for short intervals and during the spring runoff. The snow depth may limit mobility and the availability of food plants to big game such as moose and deer. This is the main limitation. The low soil moisture capacity may also limit the development and growth of vegetation.

The overall capability for waterfowl of this terrain type is Class 7. This is due to the generally flat topography that limits the development and the permancy of wetlands. In addition, the precipitation rapidly infiltrates into the soil or runs off during the early spring while it is no use to waterfowl. The limited wetlands in this terrain type range from limited to low in capability. The significant limitations are reduced marsh edge, fertility and free-flowing water. The number of wetland areas on this terrain type are few and small.

This terrain type has the same recreation capability as Site 2. The two positive aspects are topographic patterns and significant vegetation.

<u>Capability analysis</u>: The big game capability is higher on this terrain type than the other sectors. Thus no conflicts are involved in allocation to big game. Agriculture and waterfowl capabilities are limited.

Marginally, big game has the highest capability for this terrain type. A significant inclusion of limited capability is complexed with the moderate capability.

Terrain Type 4

Location: 51° 39' North Latitude, 123° 28' West Longitude.

Present land use: The area surrounding site four has been recently logged where mature timber occurred and salvaging was done in an adjacent burn. Sedge meadows in the area are used for grazing and for wild hay production. Two guest ranch holdings are located to the east with one of the holdings having title to some of the better sedge meadows adjacent to the site. The large Chilco ranch has holdings to the south of the site and grazing leases for the surrounding area to the west and north. Moderate and limited moose and deer habitat occurs within the landscape represented by this site.

Position: The sample site is located on a gently undulating to rolling plateau surface 1490 m in elevation. The soil sample site is on the mid-position on a 4 per cent south-southeast facing slope.

Geology: A mantle of hummocky and ridged ground moraine of undetermined depth is characteristic of this terrain type and site (Figure 9a). The drainage pattern is deranged. Most small depressions are sites of water ponding, resulting in the growth of sedges and mosses which decompose to form peat deposits. These peat deposits vary from 40 cm to several metres thick. In the near vicinity of the site, the ground surface was strewn with boulders of vesicular basaltic, andesitic and dioritic rock types. No particular pattern or relative proportion of the area so affected was discernable. The basaltic and andesitic rock types dominate the coarse fragments of the surficial deposit.

Vegetation: The site is in the lower elevation of the Interior Subalpine. Lodgepole pine pioneers burned over areas and spruce are found in isolated pockets adjacent to areas of high ground water tables. Spruce regeneration is common around the circumference of sedge meadows and along intermittent drainage channels. Some regeneration of spruce occurs under the lodgepole pine. The stocking density and age of the lodgepole pine varies considerably. The typical ground cover is shown in Figure 9 a,b. Where there is canopy closure, the ground cover is very sparse. It consists mainly of juniper, kinnikinnick, sheperdia and lichens. Ground cover ranges between 20 to 40 per cent. Pinegrass and arnica occur under openings in the canopy. The distribution of twin flower is primarily governed by the occurrance of decayed wood from incompletely burned trees. Vaccinium occurs sporadically. Willow is primarily associated with the wetter conditions surrounding the meadows, but the occasional plant appears under the forest. The dominant vegetation is listed below:

Figure 9 Terrain Type 4: (a) The hummocky land surface is shown with a small meadow area common to the closed depressions on this terrain type

Figure 9 Terrain Type 4: (b) The ground vegetation is shown in the two pictures. Pinegrass and kinnickinnick are the most common plants

Lodgepole pine	*Pinus contorta*	abundant
Juniper	*Juniperus communis*	common
Shepherdia	*Shepherdia canadensis*	common
Pinegrass	*Calamagrostis rubescens*	common
Vaccinium	*Vaccinium caespitosum*	common
Kinnikinnick	*Arctostaphylos Uva-ursi*	common
Arnica		occasional
Lichens		occasional
Willow	*Salix* spp.	occasional
Dryland sedge	*Carex concinnoides*	common to occasional
Spirea	*Spirea* spp.	occasional

The annual native herbage production at this site was measured at 181 kg/ha. In an adjacent site, located on a shallow organic soil, the herbage yielded 1817 kg/ha.

Climate: This site is located in a cooler and more humid climate than the Big Creek station and the other sites previously discussed. The annual mean temperature is lower and the frost free period is less than 30 days. A short growing season combined with low minimum temperatures during the frost free period make this site unfavorable for the growth of forage crops. The May to September precipitation is higher than the Big Creek station value. Annual snowfall is also higher. A slight moisture deficit may occur at this site, but the overriding influence of low temperatures is dominant.

Soils: The dominant soils in this terrain type are moderately well to well drained due to a combination of the groundwater table position and permeability. They have moderate permeability, slow to medium runoff and medium infiltration. They are associated with mineral soils with poorer drainage and organic soils.

Dominant mineral soils are loamy in texture with subsurface horizon which is enriched in translocated clays. Coarse fragments range from 25 to 60 per cent in the soil and the variation is lateral and vertical. The surface horizon is less dense than the underlying horizons and the parent material.

The surface horizon has a higher organic matter content than the previous two sites. However, it drops off immediately with soil depth. The carbon-nitrogen ratio is wide, a suggestion of possible nitrogen deficiency and low microbial activity near the surface. The ratio narrows in the subsurface horizons where there is very little organic matter. Soil reaction is very strongly acid at the surface but, with depth, becomes only slightly acid. The exchangeable cations in the surface 30 cm of the soil are low. Potassium is low, except for the surface horizon. Nitrogen levels are low.

The associated soils comprise a small but important component of imperfectly to very poorly drained soils. They occur in depressional areas in the low relief hummocky landscape. These associated soils, which account for 10 to 25 per cent of the terrain type, may be divided into two types. One, the drier of the two soils, is found in drainage-ways which are flooded intermittently by moving water -- mostly during spring runoff. Later in the summer, these soils retain a high moisture status due to subsurface seepage. Areas such as these are characterized by Gleysolic soils with peaty surfaces varying from a few centimeters to over 40 centimeters. Modal development of soils is the Orthic Gleysol and textures are usually gravelly loams with moderate surface stoniness. Vegetation is mainly sedges

(*Carex aquatilis* and *C. rostrata*) and groundbirch (*Betula glandulosa*). The second type of soils occupy depressions which pond water. These soils are organic and are usually less than 2 m deep; commonly only a metre or less in depth. Drainage ranges from poor to very poor due to high water tables. Flooding occurs during spring runoff and the waters pond for considerable periods. The dominant vegetation is sedges. In some areas, groundbirch and willow shrubs (*Salix* spp.) occur. The soils are classified as Terric Mesisols as they are less than 1.3 m deep and are composed of semi-decomposed organic materials. A whitish gray band of volcanic ash is found between 35 and 50 cm from the surface and it varies between 1 and 3 cm in thickness. The soil reaction is medium to strongly acid with pH averaging one unit higher above the volcanic ash layer, than below. The major soil with the two associated soils, described above, occur throughout this terrain type.

Physical capability: The agricultural capability at this site is classified as Classes 6 and 5 the latter accounting for only 20 per cent of the area. The main limiting factor is climate, due to generally low temperatures during the growing season which severely lowers the heat unit accumulation. The elevation, 1490 m, may well account for the cool temperatures. The twenty per cent inclusion of Class 5 capability appears as anomoly to the climatic information. Local areas of a lower stoniness limitation and enhanced by relatively good water supply are deemed cultivatable for a very limited range of forage crops. Several localities were observed at similar sites where timothy and clover were well established and productive. This growth must not overshadow the fact that 80 per cent of the area is rated as Class 6. Most of the area is of variable stoniness, but native grazing is available.

The associated organic and gleysolic soils in the vicinity of the site were classified in capability Class 6. The major limitation being climate, with additional adverse wetness due to high ground water table. The overriding climatic limitation restricts and limits improvement of these soils. Both the thermal properties and the topographic position of these soils make them more susceptible to frosts than neighbouring mineral soils.

The productivity of both the mineral soil and the associated shallow organic soil were measured. The mineral soil has a natural annual herbage production capability to 180 kg/ha. This measurement is considered slightly higher than the average productivity. In the grazing capability this has a Class 4 rating. The stocking of herbs is sporadic and uneven, but usually occurring in areas of canopy openings. Some herb species grow in a prostate position which allow them to miss being grazed. In contrast, the herbage productivity of the shallow organic sedge meadow was 1800 kg/ha. Many such meadows are used as wild hay meadows by the local ranchers. The sedges are coarse and scabrous but highly nutritous when immature. Based on productivity, the meadows have Class 1 grazing capability.

The forest capability at this site is severely limited. Climatic limitations such as aridity and low temperatures predominate.

Projected May to July precipitation for the area is 14 cm. Soil stoniness may interfere with tree density and growth. The area is rated Class 6 and 7 for lodgepole pine. A meadow portion of the terrain type is Class 7 due to excessive wetness which precludes the growth of commercial forests.

The capability for big game is the same as Site 3. The microtopography is hummocky which creates variation in habitat types. Good quality browse grows around the margins of organic meadows on gleysolic soils and also on gleyed soils. Deep snow limits the winter range utilization. The principal big game species are moose and deer.

The waterfowl capability of this terrain type is limited. The majority is Class 7 due to topography limitations. The microtopography is hummocky and produces numerous depressions in which water ponds. Most depressions are filled with organic sediments. This limits the natural waterfowl capability to the larger waterbodies and fast flowing streams. Such wetlands are placed in Class 4 and 5. The main limitations are reduced marsh edge, free-flowing water and fertility.

The vegetation pattern and landscape variation are the main positive recreational aspects of this terrain type and the capability is Class 6 for upland recreation. Recreation activities such as cross-country skiing, horseback riding, snowshoeing and auto-toboganning are adaptable to the area. The cold winter climate may detract from the attractiveness of the winter activities.

Capability analysis: The wildlife capabilities are the highest for this terrain type. Big game is allocated to the majority of the terrain type. Waterfowl is allocated to localized moderate and limited sites. The other sector capabilities are Class 6 for this area.

Terrain Type 5

Location: 51° 24' North Latitude, 123° 32' West Longitude. This location is 7.25 km northeast of the lower end of Taseko Lakes.

Present land use: The land use on this terrain type is forest and wildlife. At the site a ranch using meadows for wild hay production is in existence. Horses are used to supply power for hay production. Fall grazing follows hay production on the meadows. The forest remains undeveloped and wildlife is sparse throughout the terrain type.

Position: The sample site is on the crest of a low ridge of the gently undulating to rolling plateau (Figure 10 a). The undulations have a frequency of 3 to 5 per km, with an amplitude of 1 to 4 m. The elevation is 1570 m.

Geology: The bedrock is mantled by a moderately thick deposit of hummocky and ridged ground moraine. The ice flow during glaciation was northerly. Drainage is poorly integrated. The low relief provides low stream gradients. Many small closed depressions are filled with organic peat deposits of variable depth, 0.4 to several metres in thickness, and many intermittent drainage channels have shallow peat deposits, less than 1 m in depth. A number of rock types are represented in the coarse fragments of the surficial deposits. The dominant rock types are granitic, granodioritic and andesitic.

Vegetation: This site is located in the interior subalpine [Krajina, 1965]. Lodgepole pine dominates burned over areas, and it is presently the dominant tree species (Figure 10 b,c). Spruce regeneration occurs around the margins of meadows. The canopy is nearly closed. Spruce occurs as understory. Sparse understory consists mainly of shepherdia, crow-berry and kinnikinnick. The main herbs are bluegrass, pinegrass, dryland sedge, and lichen. Low willow shrubs (*Salix* spp.) line the margins of the wet meadows and drainage ways. These occur mainly on the wet mineral soils. Dominant vegetation is listed below.

Lodgepole pine	*Pinus contorta*	abundant
Shepherdia	*Shepherdia canadensis*	common
Crow-berry	*Empetrum nigrum*	common
Kinnikinnick	*Arctostaphylos Uva-ursi*	common
Pine grass	*Calamagrostis rubescens*	few
Dryland sedge	*Carex concinnoides*	common
Bluegrasses	*Poa* spp.	common
Antennaria		few
Lichens		few
Willow	*Salix* spp.	common

The measured annual native herbage production at this site was measured at 92 kg/ha. In the adjacent organic meadows and drainageways, dense stands of sedges (*Carex* spp.) with some sunflowers

Figure 10 Terrain Type 5:

(a) A portion of a vertical serial photograph showing the terrain type in the top half of the picture

(b) The ground vegetation is sparse under lodgepole pine. A sedge meadow can be partially seen through the trees

(*Arnica* spp.) occur. The herbage clipped from this type yielded 1788 kg/ha.

Climate: This site is the coolest and most humid climate of all the sites studied. Temperatures are low and the daily minimums throughout the short growing period are close to, or at, the freezing point. The moisture effectiveness is high due to low evaporation associated with the cool temperatures, especially in the May to September period. Summer precipitation minimizes the moisture deficit for agricultural crops, but it is not adequate for the moisture demands of a coniferous forest. The low daily minimum temperatures are the dominant environmental constraint. Current commercially grown agricultural crops are not adapted to this harsh environment.

Soils: Soils are characterized by dominantly mineral soils. Associated soils are described following the discussion of the major soil of the terrain type. The major soil is well drained and has rapid permeability, slow runoff and rapid infiltration. These drainage characteristics are common to soils with gravelly loam textures. Except for a horizon of clay accumulation, the particle size analysis indicates a dominance of sand and silt sized particles with less than 10 per cent clay. The accumulation of clay is low, but it does improve the physical water holding properties of the horizon. The bulk density of this horizon is also higher which reduces root penetration, relative to the surface horizons. Coarse fragment content ranges from 20 to 50 per cent and it varies vertically and laterally.

The organic matter content of the soil is low, as is the total nitrogen content. The carbon to nitrogen ratio is narrower for this soil than for the soils of Sites 2,3, and 4. Soil reaction is more acid and it ranges from strongly acid at the surface to slightly acid at 1 m. The cation exchange capacity is higher than for similar and finer textured soils from other comparable sites. Evidence of increased amorphous materials in the soil may account for this as treatments were required to remove these materials for particle size analysis. The exchange complex is dominated by basic cations. Available phosphorus is not a limiting fertility factor. Nitrogen may be a limiting fertility factor.

The associated soils occur in lower positions of the terrain type in the same relationship as in the terrain type discussed for Site 4. The soils have the same morphology as related positions discussed in Site 4. The margins of the low wetter areas support a low dense shrub cover of willows (*Salix* spp.), but the dominant vegetation is sedges. The Gleysolic soils in the intermittant drainageways dry out more in late summer and are not as peaty as similar sites in Site 4. The range of morphology of gleysols in this terrain type is greater than in terrain type 4. Organic soils are commonly deeper than those at Site 4. Larger meadows are used for the production of wild hay. The deeper organic soils are classified as Typic Mesisols.

Physical capability: The climate of this terrain type is severe. It limits the agricultural capability to native grazing or, at best, improved range. The agriculture capability rating is Class 6 with a minor inclusion of Class 7. Generally a low temperature during the growing season, severely lowering heat unit accumulation is the main climatic limitation. Frosts occur every month of the year. The soil is moderately stoney with 15 to 25 per cent coarse fragments in the surface 20 cm and moderately coarse textured. Areas of excessive stoniness are classified Class 7. These account for up to 20 per cent of the area. Adjacent to the sample site, organic and gleysolic soils occur in depressions. Near this site, shallow organic soils are rated Class 6. These soils are used for wild hay production.

The native grazing potential of these mineral soils is very low -- Class 5 in the grazing capability system. Plot data indicate annual dry matter production of 90 kg/ha. A variety of herbs accounts for this limited production. The herbs occur sparsely and sporadically in association with woody shrubs (Figure 10 c). In contrast, the productivity of the sedges growing on the shallow organic soil in a natural drainage way is 1790 kg/ha. There appears to be no summer grazing on these sites, and the meadows in the immediate vicinity of the site are used for wild hay production. The native sedge production on the meadows in this area is variable and the plot data may be interpreted as an indication that natural annual productivity is in the range of 1500 and 2000 kg/ha.

The severe climatic limitations are responsible for the Class 6 forest capability at this site for lodgepole pine. At this elevation, the winters are long and the growing season is short. Frosts may occur at anytime during the growing season and generally low temperatures adversely affect the growth of commercial forests. The moderately coarse textured soil with its moderately low moisture holding capacity may cause periods of soil moisture deficiency. The associated organic soils support no trees and are classified as Class 7. The forest capability rating for this area is a complex including Classes 6, 7 and 5. The Class 5 component of the area corresponds to areas having increased soil moisture due to seepage and finer soil texture variants.

Class 4 capability for big game is mapped in this terrain type. The high elevation and short growing season are moderately severe limitations for big game production. The landscape is similar to site 4. The majority of browse is confined to transitional areas between forest and sedge meadows of poorly to imperfectly drained soils. The principle browse species being willow shrubs (*Salix* spp.). Snow depth is the main limitation for moose and deer at this site.

Class 7 waterfowl capability is associated with the soils of the terrain type. Waterfowl capability is severely limited and is associated with the small lakes and margins. The hummocky to rolling topography of the landscape results in accumulation of water in closed depressions. The ones that do not fill in with organic deposits are rated capability Class 5 and 6. Topographic features that adversely affect development of optimum marsh conditions along the edge of water areas are the most limiting factor. These are followed by insufficient nutrients in the soil and insufficient water for optimum plant growth. In the case of streams, fast or excess waterflow inhibits development of marsh habitat along the stream edge. Also where a buildup of peat occurs, the lack of water flow results in poor quality habitat.

The continuity of the open meadows interspersed with forests at this site make it more attractive to recreational activities than Site 4. The area is considered attractive for activities such as nature interpretation, primitive camping, horseback riding, showshoeing, corss-country skiing, auto-tobogganing, upland hunting, walking and hiking. The intensity of use would be low due to the present factor of remoteness to population centres, especially in the winter time. This terrain type is predominantly Class 5 for recreation on the basis of significant small surface waters and the upland and wetland wildlife.

Capability analysis: The recreation capability is the same as that for big game and is based in part on wildlife viewing which improves the capability into the limited category. Localized areas of limited waterfowl are recognized in the analysis where they occur.

Physical Land Use Allocation Plan

The land use plan attempts to organize the resource utilization of the study area to provide maximum integrated benefit. The land use plan is based on qualitative physical resource variables assuming present economics and technology. Resource sector interrelationships are considered to assess the optimal land use, whether it be simple or integrated. The qualitative resource evaluation restricts the use of economic comparisons.

The quality of the physical land use plan is evaluated both from the general and the specific levels of detail. The general plan organizes resource use on a regional basis while the specific plan does so at the terrain type level. The general approach provides an overview which is essential for correlating land use among terrain types. Also, the pattern of land use is appraised from a regional basis for optimal resource utilization.

The physical land capability in the area progresses from moderate in terrain type one to limited terrain type five. The resource utilization becomes more extensive with the progressively lower capability values. Use intensity of resource values relates to the degree a peculiar resource value is utilized. For example, the less intense use of a high capability resource unit may out produce the intense utilization of a limited capability resource unit yet the former is not attaining optimal production. The plan assumes the maximum intensity of the land resource utilization which can be sustained over a period of time. Sustained use is the continuing harvesting of goods and services without deterioration of the renewable resource. In rare cases a certain degree of degradation is inherent to use. However, the degradation should be minor and the expected end-point situation and envisaged use at that time should be stated. An example of slow degradation is the sedimentation in wetlands which in time may reduce the water storage to a critical value.

The productivity of the terrain types decreases with decreasing capability. The physical resource capability of the terrain types is based on limitations. The principle environmental constraint in the study area is identified as climate. The lack of variable topography and associated vegetation change is conceded to cause significant limitations to big game capability. The soils of the terrain types do not have limitations which reduce the land capability beyond that of the local climate. The inclusions of Gleysolic and Organic soils in terrain types four and five are exceptions for forestry capability. The properties of the soil influence the productivity of the terrain types. The difference between terrain types two and three is due to soil properties. Where environmental constraints are severe, the soil characteristics are not usually limiting for agricultural use. This generalization is qualified since each resource sector responds uniquely to changes in climate and soil.

Extensive type uses are recommended for most of the area with intensive utilization limited to localized sites. Agricultural cultivation is planned for terrain type one while limited or no cultivation should be attempted on the other terrain types except on favored local sites. The overall plan is to integrate resource uses to attain the highest sustained output possible. The positive aspects of integrated, primary and secondary uses are compared against negative aspects of conflicting use. Forestry and forage crops are conflicting uses whereas forestry and big game are compatible uses. Where integration is difficult due to conflicting uses, the physical capability is used for establishing trade off values between the sectors involved.

The land use plan for the area integrates the resource development for different levels of physical capabilities. The changing balance in physical capabilities is responsible for the integrated land use plan for the area. The intensity of agricultural use decreases from terrain type one to five. With the decrease in agricultural use there is a corresponding increase in big game, forestry and recreation use. This broad plan reduces man-made environmental changes in the upper regions of the watersheds which is a necessary conservation practices in the semi-arid region.

The land use plan for the area is based on agriculture, forestry, big game and recreation utilization. The plan for each terrain type is presented and shown in Figure 11. Following this, a section is written on waterfowl for the area as it occupies a special niche in the landscape which is less dependent on factors considered for the other sectors.

Cultivated agriculture is the primary use for terrain type one. The provision of adequate irrigation water is required for full development. The area is currently utilized for agriculture but only realizes a small portion of the terrain type's capability. The ponds occurring on the terrain type are not suitable for either reclamation or irrigation purposes.

The primary use for terrain type two is extensive type big game management. Portions of the area with wintering habitat are picked as the most important requirement for protection. Strips are provided for migration corridors between units of wintering habitat and fringes are left at the margins of these units. Wood production is

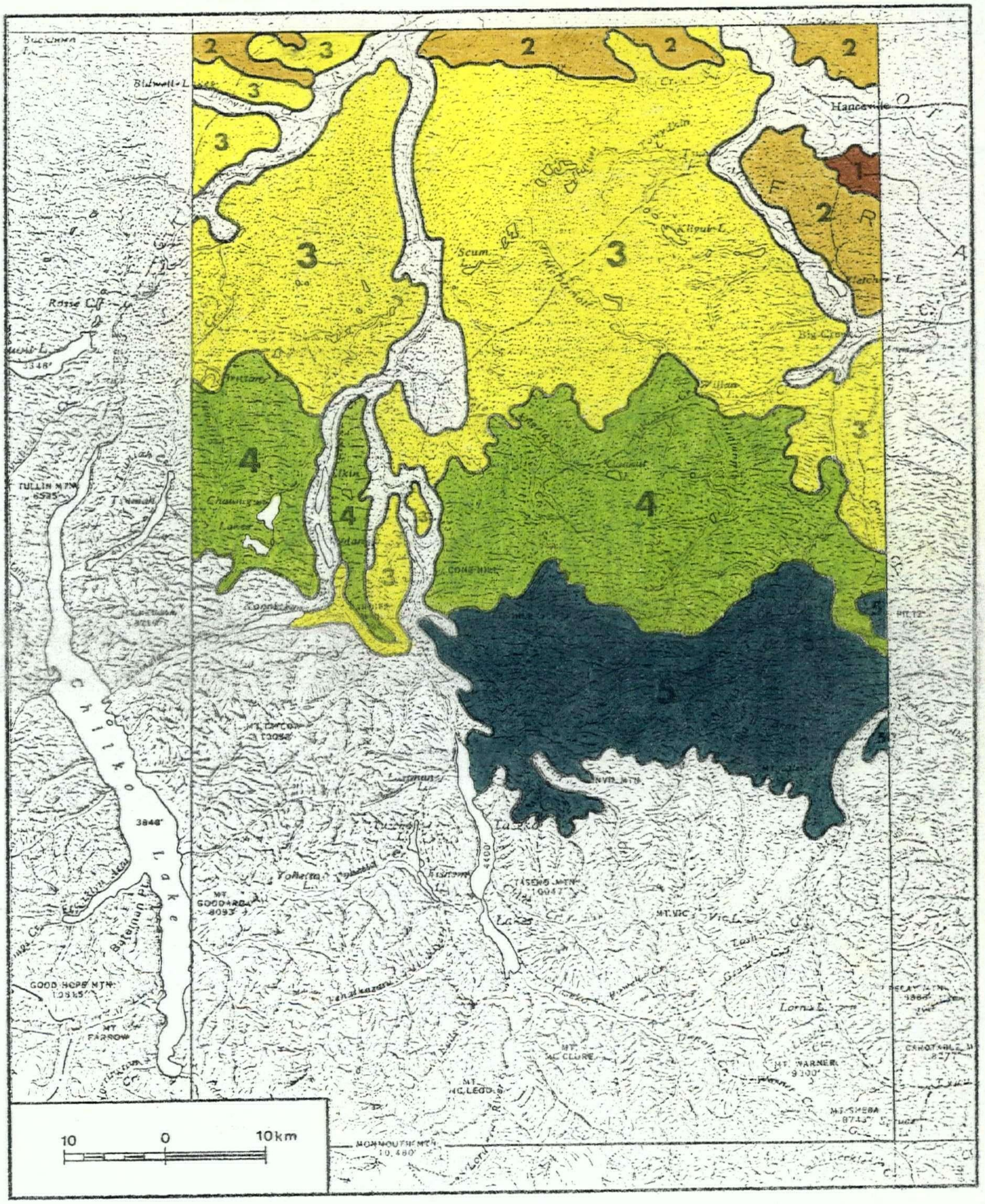


Figure 11 The Numbered Units Correspond to the Terrain Type Land Use Allocation Plan for the Area

the secondary use which is developed complimentary to the big game management. Agricultural potential in this terrain type is suited to forage crops only. Blocks of land which are not critical big game wintering habitat have their optimal utilization in forage production for pasture and hay. The use of the forest range by the domestic livestock is an extensive form of agricultural utilization. Since big game and agriculture uses are conflicting on this terrain type more detailed studies are required to identify and delineate a plan which optimizes utilization by both sectors. Minor recreational use will be of an extensive nature on this terrain type. The integrated use develops diversity in this otherwise monotonous landscape.

Land use on terrain type three is managed for integrated big game, forestry agriculture and recreation. The primary use is big game thus the other sectors are developed to be compatible with extensive wildlife management. Units of big game wintering habitat are surrounded and connected by forest reserves. Agricultural development will only occur in localized areas and native range will be utilized throughout the areas with minimum interference with the big game management. The plan for this terrain type is similar to terrain type two but the potential is lower.

The land use plan for terrain type four recognizes specific utility for the different components of the recurring landscape pattern. As a whole, the terrain type is managed for big game as the primary use. Integrated with the big game is forestry. Agriculture utilizes the sedge meadows for wild hay and grazing during the summer. Some forest range is utilized where local productivity is higher. Extensive upland recreational use is compatible with the plan for the terrain type. The low physical capabilities for this terrain type limit land use to extensive type management.

The optimum utilization of terrain type five is integrated extensive type management of all resource sectors. Big game, forestry and recreation, under extensive management, maintain efficient compatible utilization of the low physical capability of the land. Utilization of sedge meadows for wild hay and grazing is confined to sections of the terrain type with a high density of meadows and close to similar areas in terrain type four. Agricultural uses are limited to small localized areas of the terrain type due to the sensitivity of the big game production to competition. Extensive forestry and recreation are compatible with big game management.

Land use for waterfowl production is a water based land use activity. Wetland management in the area will vary with physical capability for waterfowl. Land use for waterfowl is outlined independently because there is little conflict with other resource sectors.

There are few wetlands in terrain type one. They are of moderate potential and their productivity may be increased through management inputs such as water level control. The potential water source is the water supply used for irrigation of the land adjacent to the wetlands.

The waterfowl potential is variable on terrain types two and three. The high capability wetlands can be protected and developed to utilize their full potential whereas the limited capability habitat is accepted as part of the integrated resource management system.

The wetlands in terrain types four and five have limited capability. They will have no special management inputs and are considered in the overall extensive integrated resource management of the terrain types.

The land use plan for the study area is presented in Figure 11. This small scale illustration uses the terrain type boundaries to separate the integrated resource management units discussed. Area one, which coincides with terrain type one, is managed for intensive agriculture and is not subject to integrated management other than the inclusion of several wetland areas retained for waterfowl production. Integrated resource management is attained for the remaining terrain types. Emphasis is placed on big game management. Forestry and recreation are developed in conjunction with the big game. Agriculture production is significant in terrain type two and decreases to minor importance in terrain type five which is managed primarily as wilderness area. This plan shows the type of land use required to attain optimal outputs from the physical resources.

SUMMARY AND CONCLUSIONS

Areas of limited renewable resource (agriculture, forestry, wildlife and recreation) capability are common in British Columbia. Integrated resource management appears to be a natural concept to be followed in such areas. This study focussed attention to such lands in an area west of Williams Lake in the Cariboo District of British Columbia.

Emphasis was placed on soils of the area for the inventory, evaluation and suggested land use plan. This was deemed appropriate as the area is within a peculiar zone of limiting climate and gentle topography. Soils provided the comprehensive and correlative physical base for the description of the terrain units defined. The functional relationship among soil, climate, geology, biota, topography and time provided the comprehensive base, which resulted in an integrated survey. This type of comprehensive survey can be correlated with adjacent areas regionally and even nationally.

A reconnaisance terrain survey provided the information on soil properties and distribution. Capabilities for agriculture, forestry, wildlife and recreation were integrated with the recognized soils for each terrain type. Land evaluation compared soil-capability relationships, while capability analysis compared only sector capabilities. The suggested land use plan emphasizes integrated resource utilization.

Reconnaisance scale inventory of physical resources is an efficient method of rapidly gathering information for land evaluation and planning at the regional level. The information may be used in policy development for land use in the region to aid local planning. The same inventory can be used by local planning authorities as an overview of resource potential and distribution. Different levels of inventory provide different information and when used together aid in providing continuity between local and regional needs. The reconnaisance assessment is used to identify relationships among resource uses in terms of provision of goods and services. The assessment and physical land use plan combined can be used to predict the type of information required for local planning purposes or for more detailed studies. The soil base is well suited by virtue of a heirarchial classification system which may be used for various levels of generalization.

The study provides a broad assessment of the land resources of the region. The information related to soil based terrain units facilitates updating with new and with more detailed information without disrupting the overall organization. The terrain units can be identified on the ground as well as by aerial photograph interpretation. Additional information would be beneficial for wildlife inventory. The identification of critical browse species for wildlife could be related to soils during field studies to ascertain their distribution and extent. Factors favoring or precluding the occurrence of browse species should be identified for management considerations. The soil classification system does not adequately classify sub-aqueous soils which are important for wetland classification for waterfowl. Soil and water studies in the sub-aqueous environment should be encouraged for development of a correlation between soil classification and wetland capability.

Based on the study, the following conclusions are derived.

1. Repetitive patterns of landforms and associated soils used in soil mapping and CLI classification procedures provide a standard base for resource evaluation.
2. Terrain types defined on the basis of a relatively stable component of the environment -- soils -- aids in understanding the landscape and provides a much needed correlative tool.
3. The comprehensive land base provides for integration -- thus integrated land use management can replace single resource use management.
4. Lands with near "equal" capability for agriculture, forestry, wildlife and recreation have a high potential for land use integration.
5. The evaluation methods developed in this study allow the preparation of an integrated resource management plan for limited capability lands where no one resource sector is dominant.

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A P P E N D I X   A

Soil Descriptions, Chemical and Physical Analysis of Soils
Representing Terrain Types

Site 1

Location: 51° 52' 35" North Latitude
123° 2' 45" West Longitude
990 metres ASL elevation
5 per cent northeast exposed slope.

Classification and Correlation: Orthic Dark Gray Chernozem. It is mapped as the Chimney Series as proposed by the Soil Survey Section, Canada Agriculture, 1969.

Profile Description of a Chimney Soil:

Horizon	Depth cm	
Ah	0-13	Dark grayish brown (10 YR 4/2 d),[1] very dark brown (2.5/2 m);[1] fine sandy loam to loam; weak coarse prismatic breaking to weak to moderate fine and medium granular; friable; abundant fine roots; 10% angular gravels; gradual smooth boundary; 9-18 cm thick; pH 6.23.
Bm	13-25	Brown (10 YR 4/3 d) gravelly clay; weak medium prismatic breaking to moderate medium and fine angular blocky; friable; common fine and medium roots; 30% angular gravels; clear smooth boundary; 10-15 cm thick; pH 6.55.

[1] Munsell color notations. d = dry soil color, m = moist soil color.

Horizon	Depth cm	
BC	25-35	Grayish brown (10 YR 5/2 d) gravelly loam; moderately strong fine angular blocky; firm; few roots; 74% subangular gravels; whitish carbonate accumulations on under side of gravels; clear wavey boundary, 5-15 cm thick.
Ck	35+	Light grayish brown (10 YR 6/2 d) gravelly loam; moderately strong fine to medium angular blocky; firm; 25% subangular gravels; matrix masked by accumulations of carbonates on ped surfaces and gravels; lower boundary not determined; pH 7.8.

Site 2

Location: 51° 47' 30" North Latitude
123° 04' West Longitude
1140 metres ASL elevation
4 per cent South exposed slope.

Classification and Correlation: The sampled soil is classified as an Orthic Gray Luvisol. As described, this soil is mapped as the Tyee series by the Canada Department of Agriculture, Soil Survey Section.

Profile Description of a Tyee Soil:

Horizon	Depth cm	
L-H	2-0	Loose mat of dry pine needles.
Ae	0-13	Light brownish gray (10 YR 6/2 d) brown (7.5 YR 5/2 m) silt loam; moderately weak fine platey; very friable, soft; abundant fine and medium roots; 5% coarse fragments; clear wavy boundary; 10 to 17 cm thick; pH 5.95.
Bt	13-43	Brown (10 YR 5/3 d, 10 YR 4/3 m) gravelly clay loam; moderate coarse angular blocky breaking to strong medium granular; firm, hard, very plastic; abundant fine roots; continuous moderately thick clay films; 20-75% coarse fragments; gradual smooth boundary; 23-37 cm thick; pH 6.03.
BC	43-90	Brown (10 YR 5/3 d, 10 YR 4/3 m) silt loam; moderately cloddy breaking to weak fine angular blocky; firm, hard, plastic; common to few roots; common thin clay films; 4% coarse fragments, gradual smooth boundary; 34 to 50 cm depth; pH 5.95.
Ck	90+	Brown (10 YR 4.5/3 m) silt loam; massive to cloddy; firm; 15% coarse fragments; weak effervescence with dilute HCl; lower boundary not determined; pH 7.30.

Site 3

Location: 51° 42' North Latitude
123° 38' West Longitude
1275 metres ASL elevation
level site with complete exposure.

Classification and Correlation: The soil is classified as an Orthic Gray Luvisol. It corresponds to the Shemwell soils orginally described and named during the exploratory soil survey in the map sheet.

Profile Description of a Shemwell Soil:

Horizon	Depth cm	
L	1-0	Loose mat of dry pine needles and lichen.
Bm	0-3	Brown (10 YR 5.5/3 d, 7.5 YR 4/4 m) gravelly sandy loam; structureless to very weak fine granular; loose; abundant fine and medium roots; 35% coarse fragments; gradual irregular boundary; 1 to 5 thick.
Ae	3-28	Brown (10 YR 5/3 m) gravelly sandy loam; weak fine platey; loose; abundant fine and medium roots; 35% coarse fragments; clear irregular boundary; 20 to 35 cm thick; pH 5.40.
Bt	28-54	Brown to dark brown (10 YR 4/3 m) gravelly loam; strong medium and fine angular blocky; firm; abundant medium and fine roots; 45% coarse fragments; diffuse wavey boundary; 20 to 35 cm thick; pH 5.85.

Horizon	Depth cm	
BC	54-70	Grayish brown (2.5 Y 5/2 m) gravelly sandy loam; weak medium angular blocky; friable; common roots; 30% coarse fragments; diffuse smooth boundary; 12 to 18 cm thick;pH 6.20.
C_1	70-95	Dark grayish brown (10 YR 4/2 m) gravelly sandy loam; very weak medium angular blocky; very friable; few roots; 25% coarse fragments; pH 6.4.
C_2	95-130+	Dark grayish brown (10 YR 4/2 m) gravelly sandy loam; structureless to very weak angular blocky; very friable; 25% coarse fragments; lower boundary not determined, pH 6.5.

Site 4

Location: 51° 39' North Latitude
123° 28' West Longitude
1490 metres ASL elevation
4 per cent south-south east exposed slope.

Classification and Correlation: Orthic Gray Luvisol. This is the site type for the proposed Kloakut soils as recognized by the exploratory soil survey of the map sheet.

Profile Description of a Kloakut Soil

Horizon	Depth cm	
L-H	2-0	Loose mat of raw to well decomposed needles, twigs and roots.
BM	0-5	Brown to dark brown (7.5 YR 4/4 m) gravelly loam; structureless to very weak fine granular; very friable; abundant fine and medium roots; 38% coarse fragments; gradual irregular boundary; 3-10 cm thick; pH 5.33.
Ae	5-30	Pale brown (10 YR 6/3 m) gravelly loam; very weak medium platy; very friable; abundant fine roots; 45% coarse fragments; gradual wavey boundary; 21 to 32 cm thick;pH 5.68.
BA	30-45	Brown to dark brown (10 YR 4/3 m) gravelly sandy loam; very weak medium platy to weak medium angular blocky; very friable; abundant fine roots; 55% coarse fragments; gradual wavey boundary 12 to 18 cm thick; pH 6.13.
Bt	45-65	Brown to dark brown (10 YR 4/3 m) gravelly loam; moderate medium to coarse angular blocky; friable; common roots; 50% coarse fragments; diffuse wavey boundary; 15 to 25 cm thick; pH 6.25.

Horizon	Depth cm	
BC	65-86	Brown (10 YR 5/3 m) gravelly loam; moderate medium angular blocky; friable; few roots; 30% coarse fragments; diffuse smooth boundary; 15 to 25 cm thick; pH 6.80.
C	86+	Dark grayish brown (10 YR 4/2 m) gravelly loam; moderate medium angular blocky; friable; 27 per cent coarse fragments; lower boundary not determined; pH 7.2.

Site 5

Location: 51° 24' North Latitude

123° 32' West Longitude

1570 metres ASL elevation

5 per cent slope on crest of low ridge.

Classification and Correlation: Classification is proposed as Brunisolic Gray Luvisol. This is the site type for the proposed Tete Hill soils recognized by the exploratory soil survey of the map sheet.

Profile Description of a Tete Hill Soil

Horizon	Depth cm	
L-H	1-0	Loose layer of needles and twigs.
Bm	0-12	Dark yellowish brown (10 YR 4/4 m) gravelly silt loam; structureless single grained, loose; abundant medium and fine roots; 20% coarse fragments; gradual wavy boundary; 10 to 15 cm thick; pH 5.10.
Ae	12-23	Light brownish gray (10 YR 6/2 m) gravelly loam; strong medium plately, loose; abundant fine and medium roots; 20% coarse fragments; clear, irregular boundary;5 to 15 cm thick, pH 5.05.
AB	23-25	Grayish brown (10 YR 5/2 m) gravelly silt; weak to moderate coarse platy to moderate medium angular blocky friable; roots plentiful; gradual irregular boundary; 1 to 5 cm thick.
Bt_1	25-35	Brown to dark brown (10 YR 4/3 m) gravelly loam; moderate medium angular blocky; friable firm; roots plentiful; 30% coarse fragments; few thin clay films bridging sand grains; diffuse, irregular boundary; 8 to 12 cm thick; pH 5.70.
Bt_2	35-58	Dark grayish brown to grayish brown (10 YR 4.5/2 m) gravelly loam; weak medium angular blocky, friable; plentiful to few roots; 30% coarse fragments; few very thin films on ped faces; gradual wavey boundary; 20 to 30 cm thick; pH 5.85.

Horizon	Depth cm	
BC	58-86	Dark grayish brown to brown (10 YR 4/2.5 m) gravelly sandy loam; very weak medium angular blocky; friable; few roots; 48% coarse fragments; diffuse wavey boundary;20 to 30 cm thick; pH 6.20.
C	86+	Dark grayish brown (2.5 Y 4/2 m) gravelly sandy loam; very weak medium and fine angular blocky to structureless single grained; very friable; 30% fragments; lower boundary not determined; pH 6.23.

TABLE A1

Selected Physical Properties of the Soils Under Study

Horizon	Depth	Particle Size: <2mm Fraction: Sand	Silt	Clay	Fine Clay	>2mm Fraction: Coarse Fragment	Texture Class	Bulk Density: Whole Soil	Bulk Density: <2mm Fraction*
		% by Weight						g/cc	
Site 1									
Ah	0-13	31.1	41.4	27.5	10.0	10.8	L	1.15	1.09
Btj	13-25	24.1	34.7	41.2	13.2	30.8	gC	1.39	1.21
BC	25-35	-	-	-	-	73.9	-	1.88	1.55
Ck	35+	29.9	44.0	26.1	3.6	25.6	gL	2.09	1.98
Site 2									
Ae	0-13	40.7	51.3	8.0	2.6	4.6	SiL	1.43	1.40
Bt	13-43	24.6	43.1	32.3	16.0	77.5	vg CL	1.85	1.50
BC	43-90	30.1	54.6	15.3	3.7	4.2	SiL	1.67	1.64
Ck	90+	33.6	57.8	8.6	1.8	-	SiL	-	-
Site 3									
Ae	3-28	60.0	34.1	5.9	1.5	35.7	gSL	1.41	1.21
Bt	28-54	57.8	34.6	13.9	6.3	45.0	gL	1.85	1.63
BC	54-70	55.7	36.9	7.4	2.6	-	gSL	-	-
C_1	70-95	59.9	37.3	2.8	0.2	23.9	gSL	1.81	1.68
C_2	95-130+	65.4	32.4	2.2	-	-	gSL	-	-

TABLE A1 (continued)

Horizon	Depth	Particle Size: <2mm Fraction: Sand	Silt	Clay	Fine Clay	>2mm Fraction: Coarse Fragment	Texture Class	Bulk Density: Whole Soil	<2mm Fraction*
		% by Weight						g/cc	
Site 4									
Bm	0-5	46.7	40.1	13.2	6.9	37.8	gL	1.23	1.13
Ae	5-30	50.9	38.9	10.2	2.2	45.6	gL	-	-
BA	30-45	48.9	37.7	13.5	4.7	55.6	vg L	-	-
Bt	45-65	52.1	35.9	12.1	5.1	49.8	gL	1.91	1.82
BC	65-86	50.0	36.3	13.8	7.2	30.1	gL	2.10	1.98
C	86+	49.1	37.9	13.0	-	27.2	gL	-	-
Site 5									
Bm	0-12	-	-	-	-	18.0	gSiL	1.15	1.05
Ae	12-23	39.5	50.8	9.7	1.7	-	gL	-	-
Bt_1	25-35	41.1	46.4	12.5	3.8	31.3	gL	1.82	1.66
Bt_2	35-58	47.3	43.7	9.0	3.9	-	gL	-	-
BC	58-86	63.7	33.2	3.1	1.0	48.6	gSL	1.96	1.74
C	86+	60.1	35.9	3.5	0.5	28.0	gSL	1.90	1.77

*Calculated.

TABLE A2

Selected Chemical Properties of Soils Under Study

Horizon	Depth	pH $CaCl_2$	Organic Matter	N	C/N	CEC	B.S.	Exchangeable Cations Ca	Mg	K	Na	Available P
	cm		%	%		me/100g	%	me/100g	me/100g	me/100g	me/100g	ppm
Site 1												
Ah	0-13	6.2	4.7	0.24	19.4	26.2	100+	13.13	12.44	2.30	0.10	54
Bt	13-25	6.6	2.2	0.11	19.9	29.7	100+	13.63	18.04	0.85	0.25	-
BC	25-35	-	-	-	-	-	-	-	-	-	-	-
Ck	35+	7.8	-	-	-	19.4	100+	23.88	16.45	0.36	1.04	-
Site 2												
Ae	0-13	6.0	1.7	0.05	34.0	11.2	80	6.07	2.53	0.31	0.06	-
Bt	13-43	6.0	1.2	0.04	28.8	31.8	100+	15.50	15.32	0.92	0.12	-
BC	43-90	6.0	0.3	0.02	12.5	20.5	100+	10.69	10.44	0.63	0.12	-
Ck	90+	7.3	-	-	-	19.2	100+	13.26	9.67	0.61	0.21	-
Site 3												
Ae	3-28	5.4	0.9	-	-	11.9	79	6.35	2.45	0.54	0.04	36
Bt	28-54	5.9	-	-	-	18.2	92	10.66	5.67	0.34	0.09	23
BC	54-70	6.2	-	-	-	-	-	-	-	-	-	-
C	70-95	6.4	-	-	-	8.2	95	4.96	2.59	0.14	0.06	89
Site 4												
Bm	0-5	4.4	3.4	0.08	42.1	13.0	18	1.23	0.65	0.34	0.06	-
Ae	5-30	4.7	0.5	0.03	15.0	5.9	43	1.40	0.98	0.08	0.06	-
BA	30-45	5.1	0.4	0.03	14.7	10.5	71	4.95	2.30	0.12	0.13	-
Bt	45-65	5.5	0.3	-	-	12.0	86	6.80	3.18	0.12	0.19	-
BC	65-86	6.2	0.2	-	-	11.1	98	7.87	3.58	0.13	0.17	-
C	86+	6.4	-	-	-	14.1	100+	9.75	4.77	0.15	0.24	-

TABLE A2 (continued)

Horizon	Depth	pH $CaCl_2$	Organic Matter	N	C/N	CEC	B.S.	Exchangeable Cations Ca	Mg	K	Na	Available p
	cm		%	%		me/100g	%	me/100g	me/100g	me/100g	me/100g	ppm
Site 5												
L-H	1-0	4.1	-	-	-	45.9	38	13.20	3.17	0.86	0.02	-
Bm	0-12	5.1	1.7	0.06	29.0	12.9	45	3.86	1.33	0.62	0.04	166
Ae	12-23	5.1	0.3	0.03	10.0	13.3	69	6.26	2.46	0.36	0.09	71
Bt_1	25-35	5.7	0.1	-	-	25.8	94	17.10	6.77	0.33	0.16	-
Bt_2	35-58	5.9	0.6	-	-	24.6	97	16.51	6.78	0.37	0.15	-
C	86+	6.2	-	-	-	19.8	100+	13.39	5.71	0.64	0.16	-

A P P E N D I X   I I

Common Conversion Factors

APPENDIX II

Common Conversion Factors

1 inch = 2.54 centimetres
    1 centimetre = 0.3937

1 foot = 0.3048
    1 metre = 3.2808 feet

1 mile =1.609,344 kilometres
    1 kilometre = 0.621,371,2 miles

1 acre = 0.404,685,642 hectares
    1 hectare = 2.471,054 acres

1 mil-acre = 4.046,856,422,4 square metres

1 square mile = 2.589,988,110,336 square kilometres
    1 square kilometre = 0.386,102,2 square miles

1 cubic foot per acre = 0.069,972,45 cubic metres per hectare
    1 cubic metre per hectare = 14.291,34 cubic feet per acre

1 pound per acre = 1.120,851 kilograms per hectare
    1 kilogram per hectare = 0.892,179,1 pound per acre

Source: RENNIE, P.J. 1967. Measure for measure. Forestry Branch, Department Publication No. 1195, Canada Department of Forestry and Rural Development, Queen's Printer, Ottawa.